MIL-B-1083D
16 October 1987
SUPERSEDING
MIL-B-1083C
3 March 1964

MILITARY SPECIFICATION

BALLS, BEARING, FERROUS AND NON-FERROUS (FOR USE IN BEARINGS, VALVES AND BEARING APPLICATIONS) GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers requirements for ferrous and non-ferrous inch balls.

1.2 Classification. The balls shall be of the following compositions and grades, as specified (see 6.2):

Compositions:		Grades:
Composition 1.....	Chrome alloy steel	Grade 3
Composition 2.....	Corrosion resistant steel	Grade 5
Composition 3.....	Carbon steel	Grade 10
Composition 4.....	Silicon molybdenum steel	Grade 16
Composition 5.....	Brass	Grade 24
Composition 6.....	Bronze	Grade 48
Composition 7.....	Aluminum bronze	Grade 100
Composition 8.....	Beryllium copper alloy	Grade 200
Composition 9.....	Nickel-copper alloy (Monel)	Grade 500
Composition 10.....	Nickel-copper-aluminum alloy (K-Monel)	Grade 1000
Composition 11.....	Aluminum alloy	
Composition 12.....	Tungsten carbide	
Composition 13.....	Premium quality bearing steel (double vacuum melted M-50)	

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards of the issue listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this specification to the extent specified herein.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commanding Officer, Naval Ordnance Station, Standardization Branch (3730), Indian Head, Maryland 20640-5000, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

SPECIFICATIONS

Federal

QQ-B-637	Brass, Naval: Rod, Wire, Shapes, Forgings, and Flat Products with Finished Edges (Bar, Flat Wire, and Strip)
QQ-N-286	Nickel-Copper-Aluminum Alloy, Wrought

Military

MIL-B-197	Bearings, Anti-Friction; Associated Parts and Subassemblies; Preparation for Delivery of

STANDARDS

Federal

FED-STD-151	Metals, Test Methods

Military

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

(See Supplement 1 for list of MS sheet form standards.)

(Copies of specifications and standards required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity).

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AEROSPACE MATERIAL SPECIFICATION (AMS)

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

(Application for copies should be addressed to the Society for Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA. 15096.)

ANTI-FRICTION BEARING MANUFACTURERS ASSOCIATION (AFBMA)

AFBMA-STD-10	Metal Balls

(Application for copies should be addressed to the Anti-Friction Bearing Manufacturers Association, Inc., 1101 Connecticut Ave. N.W., Suite 700, Washington, DC 20036.)

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

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

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A108	Steel Bar, Carbon, Cold Finished, Standard Quality
ASTM A276	Bars and Shapes, Stainless and Heat Resisting Steel
ASTM A295	High Carbon Ball and Roller Bearing Steel, Standard Specification for
ASTM B276-79	Apparent Porosity in Cemented Carbides, Standard Test Method for
ASTM D3951	Standard Practices for Commercial Packaging
ASTM E18	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials, Standard Test Methods for
ASTM E112	Determining Average Grain Size, Standard Methods for

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103.)

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 MS sheets. The individual item requirements shall be as specified herein in accordance with the applicable MS sheets. In the event of any conflict between requirements of this specification and the MS sheets, the latter shall govern (see 2.3).

3.1.1 Non-standard balls. When specified in the contract or purchase order (see 6.2.1), balls of non-standard diameters shall be supplied.

3.2 First article. When specified (see 6.2.1), a sample of the balls shall be subjected to first article inspection (see 4.4).

3.3 Material. The material shall be as specified herein.

3.3.1 Compositions.

3.3.1.1 Composition 1 balls. 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. The balls shall have a fracture grain size of 8 or finer. The balls shall be free from surface decarburization.

3.3.1.2 Composition 2 balls. Composition 2 balls shall be manufactured from corrosion resistant steel conforming to the chemical composition of UNS S44003 or UNS S44004 in accordance with ASTM A276. The balls shall have a fracture grain size 7 1/2 or finer. The balls shall be free from surface decarburization.

3.3.1.3 Composition 3 balls. Composition 3 balls shall be manufactured from carbon steel conforming to the chemical composition of UNS G10080 through UNS G10220 in accordance with ASTM A108. The balls shall be free from surface decarburization.

3.3.1.4 Composition 4 balls. Composition 4 balls shall be manufactured from selected silicon molybdenum steel of the through-hardening type as specified in Table I. The balls shall be properly heated and be free from surface decarburization.

3.3.1.5 Composition 5 balls. Composition 5 balls shall be manufactured from brass as specified in Table I.

3.3.1.6 Compostion 6 balls. Composition 6 balls shall be manufactured from bronze conforming to the chemical composition of UNS C46400 (SAE CDA464) in accordance with QQ-B-637.

3.3.1.7 Composition 7 balls. Composition 7 balls shall be manufactured from aluminum bronze as specified in Table I.

3.3.1.8 Composition 8 balls. Composition 8 balls shall be manufactured from beryllium copper alloy as specified in Table I.

3.3.1.9 Composition 9 balls. Composition 9 balls shall be manufactured from nickel-copper alloy (Monel) as specified in Table I.

TABLE I. Chemical compositions (percent by weight) for material not assigned UNS numbers.

Element	Composition number						
	4	5	7	8	9	11	12
Carbon	.45-.55						
Copper		60-70	Remainder	Remainder	25-30	3.5-4.5	
Zinc		30-40				.25 max	
Tin							
Aluminum			9-14			Remainder	
Manganese	.30-.60		1.5 max			.40-1.0	
Nickel			5.5 max		65-70		
Iron			2.10-4.00			1.0 max	
Beryllium				1.80-2.05			
Nickel or cobalt or both				.20 min			
Nickel plus cobalt plus iron				.60 max			
Iron plus zinc					5.0 max		
Silicon	.90-1.15					.8 max	
Magnesium						.20-.8	
Chromium	.25 max					.10 max	
Other elements, total		.5 max			5.0 max	.15 max	.5 max
Other elements, each						.05 max	
Tungsten carbide (WC)							93.5-94.5
Cobalt							5.5-6.5
Phosphorus	.030 max						
Sulphur	.030 max						
Molybdenum	.30-.50						

3.3.1.10 Composition 10 balls. 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.

3.3.1.11 Composition 11 balls. Composition 11 balls shall be manufactured from aluminum alloy as specified in Table I.

3.3.1.12 Composition 12 balls. Composition 12 balls shall be manufactured from tungsten carbide material as specified in Table I.

3.3.1.13 Composition 13 balls. Composition 13 balls shall be manufactured from aircraft-quality steel conforming to the chemical composition of UNS T11350 in accordance with AMS 6491. The balls shall have a fracture grain size of 8 or finer. The balls shall be free from surface decarburization.

3.4 Hardness.

3.4.1 Composition 1 balls. Composition 1 balls shall have a hardness of 60-67HRC or equivalent. The balls within any unit container shall have a uniform hardness from ball to ball within three points HRC or equivalent.

3.4.2 Composition 2 balls. Composition 2 balls shall have a hardness of 58-65HRC or equivalent.

3.4.3 Composition 3 balls. Composition 3 balls shall have a minimum surface hardness of 60HRC or equivalent and shall be case hardened to the respective depth specified in Table II.

3.4.4 Composition 4 balls. Composition 4 balls shall have a hardness of 52-60HRC or equivalent.

3.4.5 Composition 5 balls. Composition 5 balls shall have a hardness of 75-87HRB or equivalent.

3.4.6 Composition 6 balls. Composition 6 balls shall have a hardness of 75-98HRB or 15-20HRC or equivalent as specified in MS 19063.

3.4.7 Composition 7 balls. Composition 7 balls shall have a hardness of 15-20HRC or equivalent.

3.4.8 Composition 8 balls. Composition 8 balls shall have a minimum hardness of 38HRC or equivalent.

3.4.9 Composition 9 balls. Composition 9 balls shall have a hardness of 85-95HRB or equivalent.

3.4.10 Composition 10 balls. Composition 10 balls shall have a minimum hardness of 27HRC or equivalent.

3.4.11 Composition 11 balls. Composition 11 balls shall have a hardness of 54-72HRB or equivalent.

3.4.12 Composition 12 balls. Composition 12 balls shall have a hardness of 87.5-90.4HRA or equivalent.

3.4.13 Composition 13 balls. Composition 13 balls shall have a hardness of 61-64HRC or equivalent.

TABLE II. Case depth requirements for Composition 3 (carbon steel) balls.

Nominal size (inch)		Minimum case depth (inch)
At least	But not	
1/64	1/16	.005
1/16	3/32	.015
3/32	1/8	.020
1/8	3/16	.025
3/16	7/32	.030
7/32	1/4	.035
1/4	3/8	.045
3/8	7/16	.055
7/16	1/2	.065
1/2	9/16	.070
9/16	3/4	.075
3/4	1-1/2	.080

3.5 Geometric quality. The basic diameter of the balls shall be as specified in the contract or purchase order. Tolerance limits for size variations and form deviations shall be in accordance with Tables III and IV and the applicable MS sheets for the respective metallic compositions and grades.

TABLE III. Tolerances by grade for individual balls.

Grade	Allowable Ball Diameter Variation	Allowable Deviation From Spherical Form
	V_D 1/	W 1/
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

1/ Tolerances in millionths of an inch.

TABLE IV. Tolerances by grade for lots of balls

Grade	Allowable Lot Diameter Variation[1]	Basic Diameter Tolerance[1]	Allowable Ball Gage Deviation[1]		Container Marking Increment[1]
			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	2/	2/	50
100	200	±500	2/	2/	2/
200	400	±1000	2/	2/	2/
500	1000	±2000	2/	2/	2/
1000	2000	±5000	2/	2/	2/

1/ Tolerances in millionths of an inch.
2/ Not applicable.

3.6 Surface finish.

3.6.1 Visual appearance. The surface of the balls shall be free from cracks, scratches, nicks, pits, dents, corrosion and indications of soft spots.

3.6.1.1 Visual inspection for Composition 13 balls. Tolerance limits for scratches, pits, nicks and dents on Composition 13 balls shall be in accordance with Table VI.

3.6.1.2 Carbides on finished Composition 13 balls. Carbides on the surfaces of finished Composition 13 balls shall not protrude greater than eleven (11) microinches above the ball surface.

3.6.2 Surface roughness. The surface roughness of the balls shall not exceed the value specified in the applicable MS sheets or Table V for the specified grade. Surface roughness shall be in accordance with ANSI B46.1.

TABLE V. Surface roughness by grade for individual balls.

Grade	Maximum Surface Roughness Arithmetical Average ($x10^{-6}$ inch)
3	.5
5	.8
10	1.0
16	1.0
24	2.0
48	3.0
100	5.0
200	8.0
500	1/
1000	1/

1/ Not applicable.

TABLE VI. Visual inspection limits for Composition 13 balls.

Type of defect	Acceptable limits
Pits	0.008 inch maximum dimension for single pit. Maximum of 3 permitted in any 1/4-inch diameter circle.
Scratches	0.006 inch 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 1/2-inch diameter	0.015 inch maximum dimension
Nicks, dents, and indentations on balls of 1/2-inch diameter or larger	0.024 inch maximum dimension

3.6.3 Passivation. Composition 2 balls shall be passivated and shall be capable of passing the test specified in 4.9.9.

3.7 Density. The density of the balls shall be as specified (see 3.7.1 thru 3.7.13) for the various compositions.

3.7.1 Composition 1 balls. Composition 1 balls shall have a material density of .283 lb_m/in^3.

3.7.2 Composition 2 balls. Composition 2 balls shall have a material density of .277 lb_m/in^3.

3.7.3 Composition 3 balls. Composition 3 balls shall have a material density of .284 lb_m/in^3.

3.7.4 Composition 4 balls. Composition 4 balls shall have a material density of .278 lb_m/in^3.

3.7.5 Composition 5 balls. Composition 5 balls shall have a material density of .306 lb_m/in^3.

3.7.6 Composition 6 balls. Composition 6 balls shall have a material density of .304 lb_m/in^3.

3.7.7 Composition 7 balls. Composition 7 balls shall have a material density of .273 lb_m/in^3.

3.7.8 Composition 8 balls. Composition 8 balls shall have a material density of .300 lb_m/in^3.

3.7.9 Composition 9 balls. Composition 9 balls shall have a material density of .318 lb_m/in^3.

3.7.10 Composition 10 balls. Composition 10 balls shall have a material density of .306 lb_m/in^3.

3.7.11 Composition 11 balls. Composition 11 balls shall have a material density of .101 lb_m/in^3.

3.7.12 Composition 12 balls. Composition 12 balls shall have a material density of .539 lb_m/in^3.

3.7.13 Composition 13 balls. Composition 13 balls shall have a material density of .279 lb_m/in^3.

3.8 Porosity. Composition 12 balls shall be tested in accordance with ASTM B276 for apparent porosity. Samples examined shall not exceed the specimen standards for A02, B02 and C02.

3.9 Inclusion rating. Compositions 1 and 2 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 ASTM A295. Further, fractured surfaces examined visually shall be considered defective if the following is found:

a. Presence of more than one non-metallic inclusion 1/16 to 1/8 inch long.
b. Presence of one non-metallic inclusion over 1/8 inch long.
c. Presence of porosity, pipe or internal ruptures.

Inclusion rating for Composition 13 shall be as specified in AMS 6491.

3.10 Retained austenite. The retained austenite content of Compositions 1 and 13 balls shall not exceed three percent by volume.

3.11 Eddy current inspection for Composition 13 balls. Composition 13 balls shall be inspected using the eddy current process of 4.9.13. Personnel performing the inspection shall meet the requirements of MIL-STD-410.

3.12 Ultrasonic inspection of Composition 13 bar stock. Bar stock selected for the manufacture of Composition 13 balls shall be inspected using the ultrasonic inspection procedure of the Appendix. Personnel performing the inspection shall meet the requirements of MIL-STD-410.

3.13 Workmanship. The balls shall be constructed in accordance with the requirements of this specification and the applicable MS sheets. Balls shall be free from decarburization, overtempering and indication of soft spots. Balls having basic diameters of 1/8 inch or less may be inspected by magnification not exceeding 10X power. All surfaces shall be free of seams, laps, tears, cracks and corrosion when examined with an unaided eye.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of Sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor

of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.2 Classification of inspection. The inspection requirements specified herein are classified as follows:

a. First article inspection (see 4.4).
b. Quality conformance inspection (see 4.5).

4.3 Inspection conditions. Unless otherwise specified (see 6.2), all inspections shall be performed under the following conditions:

a. Temperature: Room ambient 20° to 25° C (68° to 77° F).
b. Altitude: Normal ground.
c. Humidity: 50 percent relative, maximum.

4.4 First article inspection. First article inspection shall be performed on the balls when a first article sample is required (see 3.2 and 6.2.1). This inspection shall be in accordance with 4.8 and 4.9 except that five sample units shall be required for this inspection. Chemical testing, fracture grain size and inclusion rating are required only for first article inspection of Composition 13 material and balls.

4.5 Quality conformance inspection. Quality conformance inspection shall be in accordance with MIL-STD-105 and as specified in Tables VII and VIII.

4.6 Quality conformance inspection sampling.

4.6.1 Sampling for visual and dimensional examination of Compositions 1 thru 12 balls. Sampling for examination shall be in accordance with MIL-STD-105 and as specified in Table VII. The unit of product for sampling purposes shall be as applicable (see 4.6.9). The balls shall also be examined for defects in dimensions. Dimensions not within the tolerances specified on the applicable MS sheets and Tables III and IV shall be classified as a defect.

4.6.2 Sampling for visual examination of Composition 13 balls. Composition 13 balls shall be visually inspected 100 percent. Surface defects not within the tolerance of acceptable limits specified in Table VI shall be cause for rejection.

4.6.3 Sampling for dimensional examination of Composition 13 balls. Sampling for dimensional examination of Composition 13 balls shall be in accordance with MIL-STD-105. Dimensions not within the tolerances specified on the applicable MS sheets and Tables III and IV shall be classified as a defect.

4.6.4 Sampling for eddy current inspection of Composition 13 balls. Composition 13 balls shall be inspected 100 percent, using the test method of 4.9.13.

4.6.5 Sampling for ultrasonic inspection of Composition 13 bar stock. Composition 13 bar stock shall be inspected 100 percent, using the Appendix procedure.

4.6.6 Certificates of quality (conformance). When specified in the contract or purchase order (see 6.2.2), 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 contractor, provided lot identity has been maintained and can be demonstrated to the Government. The certificate shall include the name of the contractor, 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 (see 6.2.2).

4.6.7 Inspection lot. An inspection lot shall be composed of balls from a single production run of balls which are offered for delivery at one time. The balls shall be of the same dimensions, made from metal material of the same type and composition, formed and fabricated under the same manufacturing processes.

TABLE VII. Quality conformance inspections.

Inspection	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

4.6.8 Quality conformance tests. Sampling for tests shall be in accordance with MIL-STD-105 and as specified in Table IX. Acceptance number shall be zero for all sample series unless otherwise specified. The unit of product for sampling purposes shall be one ball as applicable.

4.6.9 Classification of defects. Examination of defects shall be as specified in Table VIII. The unit of product for examination shall be one ball unless otherwise specified. Examination shall not be restricted to the possible classified defects listed in Table VIII.

4.7 Methods of inspection.

4.7.1 Visual and dimensional examination tests for Compositions 1 thru 12 balls. Tests shall be in accordance with 4.6.1 and Table VII.

4.7.2 Visual examination tests for Composition 13 balls. Visual inspection shall be accomplished with the unaided eye except where magnification is specified. A radius scribe shall be used as the initial determination of acceptability for defects. A 0.030 inch radius scribe shall be used on ball diameters of 1/2 inch and larger. A 0.020 inch radius scribe shall be used on balls less than 1/2 inch diameter. If the defect is detectable with the scribe, the ball shall be rejected. The ball shall also be rejected if the acceptance criteria of Table VI are not met.

4.7.3 Dimensional examination tests for Composition 13 balls. Tests shall be in accordance with 4.6.3 and Table VII.

4.7.4 Macro-examination.

4.7.4.1 Compositions 1 and 2 balls. Specimens which are approximately 3/8 inch thick (and representative of the cross section of 4 inch square rolled billets) for forged sections which are 4 inch square (used for forging and re-rolling into coils, tube rounds and bars) shall be taken from the top and bottom areas of the first, middle and last of usable ingots of a heat. These specimens shall be normalized, annealed, hardened and fractured. Each specimen should not have external indentations sufficient to guide the fracture during the examination. Fractured surfaces of specimens shall be examined in accordance with 4.6.9 and Table VIII.

TABLE VIII. Classification of defects.

Category	Defect	Inspection Method
Major		
101	Presence of more than one non-metallic inclusions 1/16 to 1/8 inch long.	Measure
102	Presence of one non-metallic inclusion over 1/8 inch 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

4.7.4.2 Composition 3 balls. Macro-examination shall be made on each heat of steel. Samples for examination shall be selected from the billets for the wire or rods used in the manufacture of the balls. Samples shall be selected in accordance with FED-STD-151, Method 321. The macro-examination shall be conducted in accordance with MIL-STD-1459. The quality of the 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. As an alternate to the macro-examination of the material, a certified chemical analysis report (certificate of conformance) submitted by the mill supplier may be acceptable (see 6.2.2).

4.7.4.3 Composition 13 balls. Macro-examination methods of Composition 13 balls shall be performed in accordance with AMS 6491.

4.8 Dimensional examination.

4.8.1 Diameter tolerance per ball. Sample balls shall be selected in accordance with 4.6 for diameter tolerance dimensional examination (see 3.5). A minimum of 10 measurements shall be taken in random orientations of each sample ball examined. Samples not complying with specification requirements (out-of-roundness) shall be rejected.

4.8.2 Ball diameter variation. Sample balls shall be selected in accordance with 4.6 for ball and lot diameter variation dimensional examination (see 3.5). A minimum of 10 measurements shall be taken in random orientations of each sample ball examined. If samples do not comply with out-of-roundness requirements, the entire lot shall be rejected.

4.8.3 Measurement of deviation from spherical form. Acceptable methods of determining errors in spherical forms include the following: roundness measuring equipment procedures and Vee block examination procedure. Explanation and details of these methods shall be as indicated in AFBMA-STD-10. The requirements for the various material compositions and grades shall be in accordance with 3.5. Sample balls shall be selected for examination and measurement in accordance with 4.6. If sample balls do not satisfy these requirements, the entire lot shall be rejected.

4.8.4 Tolerances by grade for lots of balls. Sample balls of the same composition, grade and basic diameter shall be selected in accordance with 4.6 and dimensionally examined for conformance to the requirements of 3.5 and Table VII. A minimum of 10 measurements shall be taken in random orientations of each sample ball examined. Sample packages not complying with these requirements shall be rejected.

4.8.5 Specific diameter marking. Sample balls shall be selected in accordance with 4.6 and dimensionally examined for conformance to 3.5 and Table VII for specific diameter marking. Marking shall be within one marking increment of the average diameter of the balls in the unit container. The specific diameter shall be expressed in the marking increment specified in Table IV for the specific grade. A minimum of 10 measurements shall be taken in random orientations of each sample ball. Any unit package examined which does not comply with these requriements shall be rejected.

4.9 Tests.

4.9.1 Chemical analysis. A chemical analysis shall be made on each lot of material. The samples for analysis shall be selected from the billets, rods or wires used in the manufacture of the balls. The chemical composition shall be determined by spectrochemical analysis Method 112.2, chemical analysis Method 111.2 in accordance with FED-STD-151, or by other analytical methods which are approved. Certification of chemical analysis (conformance) from the supplier of the specified material may be considered acceptable in lieu of actual testing by the contractor (see 6.2.2).

4.9.2 Density test. Samples of each composition shall be selected in accordance with 4.6.8 and Table IX for density testing by weighing the balls in air and dividing the weight of each sample ball by the computed volume of the ball in cubic centimeters. The diameter used in computing the volume of the ball shall be determined in accordance with the procedures of 4.8.1. The weight of each sample ball shall be determined to an accuracy of 0.001 grams ($2.205 \times 10^{-6} lb_m$) or 0.10 percent of the weight, whichever is greater. Samples failing to comply with the density test requirements shall be cause for lot rejection.

4.9.3 Ball hardness. Samples of each composition shall be selected in accordance with 4.6.8 and Table IX for ball hardness testing. The test procedures shall be in accordance with ASTM E18. For hardness readings, refer to tests made on parallel flats. If any of the samples fail to comply with the ball hardness requirements, the lot shall be rejected.

4.9.4 Fracture grain size. Compositions 1, 2 and 13 balls shall be selected in accordance with 4.6.8 and Table IX and examined using the procedures detailed in ASTM E112. Balls having fracture grain sizes for Compositions 1, 2, and 13 which are not in accordance with the requirements of 3.3.1.1, 3.3.1.2 and 3.3.1.13 shall be cause for rejection.

4.9.5 Porosity test. Composition 12 balls shall be selected in accordance with 4.6.8 and Table IX, prepared and examined in accordance with ASTM B276. Sample units exceeding the conditions for A02, B02 and C02 apparent porosity shall be cause for lot rejection. Other methods of preparing sample balls for examination may be used upon approval of the procuring activity.

4.9.6 Ball surface roughness. Sample balls shall be selected in accordance with 4.6.8 and Table IX and tested in accordance with the procedures of ANSI B46.1 to verify conformance with surface roughness requirements of 3.6.2. Sample units not complying with requirements shall be cause for lot rejection.

TABLE IX. Quality conformance inspection.

Compound Unit of product	Characteristic	Requirement paragraph	Test procedure paragraph	Inspection level
As required	Compositions	3.3.1	4.9.1	S-1
Ball	Density	3.7	4.9.2	S-1
Ball	Hardness	3.4	4.9.3	S-2
Ball	Fracture grain size (Compositions 1, 2 and 13)	3.3.1.1 3.3.1.2 3.3.1.13	4.9.4	S-1
Ball	Porosity (Composition 12 only)	3.8	4.9.5	S-2
Ball	Surface roughness	3.6.2	4.9.6	S-2
Ball	Decarburization (Compositions 1, 2, 3, 4 and 13)	3.3.1.1 3.3.1.2 3.3.1.3 3.3.1.4 3.3.1.13	4.9.7	S-2
Ball	Case depth (Composition 3 only)	3.4.3	4.9.8	S-2
Ball	Passivation(Composition 2 only)	3.6.3	4.9.9	S-2
Billets from each heat of steel	Inclusion rating (Compositions 1, 2 and 13)	3.9	4.9.10	S-1
Ball	Retained austenite content (Compositions 1 and 13)	3.10	4.9.11	S-2

4.9.7 Decarburization. Compositions 1, 2, 3, 4 and 13 balls shall be selected in accordance with 4.6.8 and Table IX and examined for surface decarburization. Transverse sections through the center of sample balls shall be polished, microetched and examined at a magnification of 100 diameters. Test specimens exhibiting surface decarburization shall be cause for lot rejection.

4.9.8 Case depth. Composition 3 balls shall be selected in accordance with 4.6.8 and Table IX and examined for the required case depths as indicated in Table II. Transverse sections through the center of sample balls shall be polished, microetched and examined using appropriate measuring devices or instruments. Test specimens not complying with case depth requirements shall be cause for lot rejection.

4.9.9 Passivation. Composition 2 balls shall be selected in accordance with 4.6.8 and Table IX. Samples shall be immersed in distilled water at 100°F ± 5°F for a period of 1 hour, followed by air drying at 100°F ± 5°F for a period of 1 hour. This cycle shall be repeated for a total period of 24 hours. At the end of the 24 hour test period, the sample balls shall be examined for surface corrosion. A 10X power magnification shall be used for this examination. Samples exhibiting visible corrosion shall be cause for lot rejection.

4.9.10 Inclusion rating. Compositions 1, 2, and 13 material samples shall be selected from the billets for the wire or rods used in the manufacture of the balls. Selection of the billets (see 4.6.8 and Table IX) and the conduct of the inclusion rating test shall be in accordance with the applicable test requirements of ASTM A295.

4.9.11 Retained austenite. Unless otherwise specified the retained austenite content of Compositions 1 and 13 balls shall be determined by x-ray diffraction techniques.

4.9.12 Inspection for carbides on finished Composition 13 balls. A five (5) ball sample from each lap load of finished Composition 13 balls shall be inspected for raised carbides on the ball surface. The balls selected shall be inspected at 250X or greater magnification. Three (3) random fields per ball, approximately

120° apart, shall be selected for inspection. Raised carbides shall be measured 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 eleven (11) microinches, the lap load shall be rejected.

4.9.13 Eddy current inspection for Composition 13 balls.

4.9.13.1 Calibration standard. The calibration standard shall be a ball of the same material, heat treat condition and grade as the ball being inspected. The diameter of the calibration standard shall be the same as the nominal diameter of the ball being inspected. The calibration standard shall have an electrical discharge machining (EDM) notch on its surface; 0.030 to 0.032 inches long, by 0.004 inches maximum wide and 0.004 inches maximum deep. Notch dimensions shall be measured and recorded.

4.9.13.2 Residual magnetism. The calibration standard and balls to be inspected shall be checked for residual magnetism prior to inspection. All parts shall have less than 0.50 gauss before inspection.

4.9.13.3 Scanning coverage. Scanning increments shall be no greater than the diameter of the coil being used for the inspection. Scanning shall be continuous over the entire periphery of the ball surface. Inspection scanning speeds shall be the same as used for calibration. Full scanning coverage of parts being inspected shall be verified at the beginning and the end of each inspection lot. If fixturing requires adjustment, all parts inspected since the previous check shall be reinspected.

4.9.13.4 Signal and noise. The test equipment shall be set up so that the calibration standards produce a signal of 50 percent of the screen height. During inspection, sensitivity adjustments shall not be changed to compensate for drift within the machine, nor be adjusted greater than ± 10 percent from the previously established calibration. Meter deflection on the calibration standard shall be verified at the beginning and the end of each inspection lot.

4.9.13.5 Ball rejection. Calibration standards shall trip the reject signal and shall be segregated from acceptable balls. Production balls shall be rejected for any signal equal to or greater than the calibration level of the EDM notch in the calibration standards. Rejected balls shall be automatically segregated by the inspection process.

4.9.13.6 Processing after inspection. Any work done to the balls after eddy current inspection shall be cause for ball reinspection.

4.9.14 Ultrasonic inspection of Composition 13 bar stock. Composition 13 bar stock shall be inspected using the Appendix procedure.

4.9.15 Inspection of packaging. The sampling and inspection of the preservation-packaging, packing and container marking shall be in accordance with Section 5 of this specification and the applicable MS sheets.

4.10 Traceability (for Composition 13 balls only). When specified in the contract or purchase order (see 6.2.1), the contractor shall maintain records to provide traceability for each Composition 13 ball to its corresponding heat treat lot, forging lot, consumable electrode remelt number, process lot number and VIM-VAR heat of steel.

4.11 Material record requirements (for Composition 13 balls only). When specified in the contract or purchase order (see 6.2), the contractor shall maintain a Composition 13 material identification record.

4.12 Eddy current inspection record requirements (for Composition 13 balls only). When specified in the contract or purchase order (see 6.2), the contractor shall maintain an eddy current inspection record for Composition 13 balls.

4.13 Ultrasonic inspection record requirements (for Composition 13 only). When specified in the contract or purchase order (see 6.2), the contractor shall maintain an ultrasonic inspection record for Composition 13 material.

5. PACKAGING

5.1 Preservation. The balls shall be cleaned, dried, preserved and packaged in accordance with MIL-B-197. Level of packaging shall be A or industrial, as specified (see 6.2).

5.1.1 Industrial. The industrial preservation shall be in accordance with ASTM D3951.

5.2 Packing. Packing shall be Level A, B or industrial, as specified (see 6.2). The number of balls per unit container shall be in accordance with the contract or purchase order.

5.2.1 Level A, B or industrial. The balls shall be packed in accordance with MIL-B-197.

5.3 Marking.

5.3.1 Military. In addition to any special or other identification marking required by the contract (see 6.2.), each unit pack, intermediate and exterior container shall be marked in accordance with MIL-STD-129.

5.3.2 Industrial. Industrial marking shall be in accordance with ASTM D3951.

6. NOTES

6.1 Intended use. The balls covered in this specification are intended for use in bearings, bearing applications, check valves and other components utilizing balls. This specification covers the acquisition requirements for MS 3224, 3226, 19059, 19060, 19061, 19062, 19063 and 19064.

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number and date of this specification.
b. Applicable MS sheet dash number(s) (see 2.1).
c. Non-standard balls when required (see 3.1.1). When non-standard balls are ordered, cite:
   (1) Composition number required (see 3.3.1).
   (2) AFBMA Grade required.
   (3) Diameter required.
d. First article when required (see 3.2)
e. Inspection conditions if other than as specified (see 4.3).
f. Sampling when required (see 4.6.1).
g. Tests when required (see 4.9).
h. Traceability records when required (for Composition 13 balls only) (see 4.10).
i. Material records when required (for Composition 13 balls only) (see 4.11 and 6.2.1.1).
j. Eddy current inspection records when required (for Composition 13 balls only) (see 4.12 and 6.2.1.1).
k. Ultrasonic inspection records when required (for Composition 13 material only) (see 4.13 and 6.2.1.1).
l. Quantity required (see 5.2).
m. Applicable levels of preservation and packing (see 5.1 and 5.2).
n. Special marking if required (see 5.3).

6.2.1.1 Contractual record provisions. Acquisition documents should specify that the Composition 13 material, eddy current and ultrasonic inspection records (see 4.11, 4.12 and 4.13) are to be maintained for fifteen years from the date of contract or purchase order completion. Acquisition documents should also specify that the records, when requested by the Government (see 6.2.2), are to be available for delivery within three working days.

6.2.2 Data requirements. When this specification is used in an acquisition and data are required to be delivered, the data requirements identified below shall be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (CDRL), incorporated into the contract. When the provisions of DOD FAR Supplement, Part 27, Sub-Part 27.475-1 (DD Form 1423) are invoked and the DD Form 1423 is not used, the data specified below shall be delivered by the contractor in accordance with the contract or purchase order requirements. Deliverable data required by this specification are cited in the following paragraphs.

Paragraph no.	Data requirement title	Applicable DID no.
4.6.6, 4.7.4.2, and 4.9.1	Certificate of conformance	UDI-T-23191B
4.11	Material identification record	DI-QCIC-80451
4.12	Eddy current inspection record	DI-QCIC-80452
4.13	Ultrasonic inspection record	DI-QCIC-80453

(Data item descriptions related to this specification, and identified in Section 6, will be approved and listed as such in DOD 5010.12-L., AMSDL. Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Naval Publications and Forms Center or as directed by the contracting officer.)

6.2.3 First article. When a first article inspection is required, the item shall be tested as specified in 3.2, 4.4, 4.8 and 4.9. The contracting officer should include specific instructions in acquisition documents regarding arrangements for examinations and test approval of the documents' first article.

6.3 Comparison of classification. The composition classifications for all composition balls covered by this specification and the classification of similar compositions covered by MIL-B-1083C are shown in Table X.

TABLE X. Comparison classification.

MIL-B-1083C	MIL-B-1083D
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
—	13

6.4 Terminology. When used in connection with this specification, the following terms shall be defined herein.

6.4.1 Grade. The grade designation indicates the allowable out-of-roundness expressed in millionths of an inch.

6.4.2 Nominal size. The size which is used for the purpose of general identification, e.g., 1/16, 1/8, etc.

6.4.3 Basic diameter. The size ordered which is the basis to which the basic diameter tolerances apply. The basic diameter is specified in inches (decimal form).

6.4.4 Specific diameter. 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.

6.4.5 Out-of-roundness. Out-of-roundness is defined by the following characteristics and each characteristic is measured independently of the other: Diameter tolerance per ball is the difference between the largest diameter and the smallest diameter measured on the same ball.

6.4.6 Deviation from spherical form. The greatest radial distance in any radial plane between a sphere circumscribed around the ball surface and any point on the ball surface.

6.4.7 Basic diameter tolerance. The maximum allowable deviation from the specified basic diameter for the indicated grade.

6.4.8 Unit container. 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.

6.4.9 Marking increments. The standard unit steps to express the specific diameter (see 4.8.5).

6.4.10 Case depth. 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.

6.4.11 Passivation. A treatment for corrosion resistant steel to eliminate corrodible surface impurities and provide a protective film.

6.4.12 Ball Gage Deviation. The difference between the lot mean diameter and the sum of the nominal diameter and the ball gage.

6.4.13 VIMVAR. An acronym derived from "vacuum induction melt - vacuum arc remelt."

6.5 Subject term (key word) listing.

Accessories, bearing
Ball, bearing
Ball, valve
Balls, bearing
Balls, valve
Bearing rolling elements
Rolling elements, bearing

6.6 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:
Army - AT
Navy - OS
Air Force - 99

Review activities:
Army - AV, EA, AR, MI
Navy - SH
Air Force - 11, 84
DLA - IS

Agent:
DLA-IS

Preparing activity:
Navy - OS

(Project No. 3110-0724)

APPENDIX

PROCEDURE FOR ULTRASONIC INSPECTION OF COMPOSITION 13 BAR STOCK

10. SCOPE

10.1 Scope. This appendix details the procedure for ultrasonic inspection of Composition 13 bar stock selected for the manufacture of bearing balls. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS

(This section is not applicable to this appendix.)

30. PROCEDURE

30.1 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.

30.1.1 Reference test piece for bar stock 5/8-inch to 1½-inch diameter. The reference test piece shall be a bar of at least 3 feet 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 inches 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 inches in diameter. For angle scanning, a shear notch 0.0070 ± 0.0005 inches deep, axially oriented, and located at least 8 inches from the end of the bar shall be used. The notch shall be produced from a 1-inch end mill with a 0.0002-inch maximum radius. Ultrasonic reflectors shall be spaced 2 inches apart, minimum.

30.1.2 Reference test piece for bar stock 1/2-inch to 5/8-inch diameter. The reference test piece shall have all requirements of 30.1 and 30.1.1, 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-inch diameter FBH of 0.062 inch depth. For far zone testing, metal travel of 1/10 the test piece diameter shall be replaced with metal travel of 0.06 inches to a FBH of 0.020-inch diameter.

30.1.3 Reference test piece for bar stock less than 1/2-inch diameter. For bar stock less than 0.500-inch diameter, only one FBH providing 1/2 diameter travel is required in addition to the shear notch of 30.1.1.

30.2 Test set-up.

30.2.1 Longitudinal scan. While maintaining correct water path, obtain a 2-inch signal from the highest attenuated 0.020-inch FBH. Adjust sensitivity and distance amplitude control to bring near and far FBHs within ± 10 percent of a 2-inch amplitude indication. Compatibility between reference block and the material to be tested shall be established 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 percent of screen signal from the FBH with depth of 6/10 the diameter of the test piece. Compatibility shall be checked in at least three well-separated areas on the material to be tested. The gate width for near zone testing shall be set to include response from FBH with depth of 1/10 (or 0.062-inch holes) and 6/10 test piece diameter. The gate width for far zone testing shall be set to include response from FBH with depth of 4/10 and 9/10 test piece diameter. The alarm sensitivity shall be set to assure 100 percent of a 0.020-inch diameter FBH inspection level. A maximum surface scanning speed of 15 inches per second shall be used. Hash or ultrasonic noise exceeding 50 percent of the response from a FBH shall not be acceptable.

30.2.2 Loss of backface. Set instrument so the first backface reflection from the full round reference block is 80 percent of screen saturation. The first backface reflection shall be gated and set alarm at 50 percent 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.

30.2.3 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-inch signal and adjust flaw alarm for a 1-inch signal. Gate width shall be set to include the area at which the signal from the reference notch is detected. Scan speed, acceptable noise level and indexing shall be as established under longitudinal scan.

30.3 Acceptance levels.

30.3.1 Longitudinal scan. Discontinuities in excess of the response from a 0.020-inch diameter FBH at the estimated discontinuity depth shall not be acceptable.

30.3.2 Loss of back reflection. Any loss of back reflection in excess of 50 percent 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 percent of the screen adjusted for nonlinearity.

30.3.3 Angle scan. Discontinuities in excess of 50 percent of the response from the axially oriented notch shall not be acceptable.