

METRIC

DOD-F-24669/3

7 July 1986

SUPERSEDING

MIL-S-869C

14 May 1958

MILITARY SPECIFICATION

FORGINGS AND FORGING STOCK,
STEEL BARS AND BILLETS FOR NITRIDING (METRIC)

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

1. SCOPE

1.1 Scope. This specification covers alloy steel bars, billets and forgings for nitriding, and requirements for finished components.

1.2 Classification. Nitriding steel shall be of the following classes, conditions, and finishes, as specified (see 6.2).

Classes

Class A (135M) - Nitriding steel (modified)
Class B (EZ) - Nitriding steel (free machining)
Class C (N) - Nitriding steel (nickel)
Class D (135G) - Nitriding steel (standard)

Conditions

Condition 1 - As rolled, not heat treated (bars and billets)
Condition 2 - Quenched and tempered (bars and forgings)
Condition 3 - Annealed (bars and forgings)
Condition 4 - Normalized and tempered

Finishes

Type I - As forged or as rolled
Type II - Pickled or blast cleaned
Type III - Rough turned
Type IV - Cold drawn
Type V - Turned, ground and polished

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 5523, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specification and standard. The following specification and standard forms a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

SPECIFICATION

MILITARY

DOD-F-24669 - Forgings and Forging Stock, Steel Bars, Billets and Blooms, General Specification for. (Metric)

STANDARD

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection By Attributes.

(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 specified, the issues of the documents which are DoD adopted shall be those listed in the issue of the DoDISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS shall be the issue of the nongovernment documents which is current on the date of the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- E 3 - Standard Methods of Preparation of Metallographic Specimens. (DoD adopted)
- E 10 - Standard Test Method for Brinell Hardness of Metallic Materials. (DoD adopted)
- E 18 - Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials. (DoD adopted)
- E 110 - Standard Test Method for Indentation Hardness of Metallic Materials by Portable Hardness Testers.
- E 384 - Standard Test Method for Microhardness of Materials.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, 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.)

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2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or 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 General. The material furnished under this specification shall be in accordance with the requirements of DOD-F-24669 and as specified herein.

3.2 Manufacture. Steel used in the manufacture of bars, billets, and forgings shall be processed in accordance with DOD-F-24669 except it shall be manufactured by the electric furnace or vacuum induction process only. Sufficient discard shall be taken from each ingot or at the beginning and end of strand cast material to ensure freedom from piping and undue segregation.

3.3 Chemical requirements. The chemical composition of the material shall be in accordance with table I.

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TABLE I. Chemical composition.

	Ladle analysis				Check analysis tolerances, over maximum limit or under minimum limit, for size ranges shown		
	Class A (135M)	Class B (EZ)	Class C (N)	Class D (135G)	100 square inches or less	Over 100 to 200 square inches	Over 200 to 400 square inches
Carbon, percent	Min Max 0.38-0.45	Min Max 0.30-0.40	Min Max 0.20-0.27	Min Max 0.30-0.40	0.02	0.03	0.04
Manganese, percent	.40- .70	.50-1.10	.40- .70	.40- .70	1/.03	2/.04	3/.05
Silicon, percent	.20- .40	.20- .40	.20- .40	.20- .40	.05	.06	.06
Phosphorus, percent	.040	.040	.040	.040	.005	.010	.010
Sulfur, percent	.040	.060	.040	.040	.005	.010	.010
Chromium, percent	1.35-1.85	1.00-1.50	.95-1.35	.90-1.40	.05	.06	.06
Molybdenum, percent	0.30-0.45	0.15-0.25	.20-0.30	.15-0.25	.02	.03	4/.03
Nickel, percent	----	----	3.25-3.75	----	5/.03	5/.03	5/.03
Aluminum, percent	.85-1.20	.85-1.20	0.85-1.20	.85-1.20	.10	.10	.10
Selenium, percent	----	0.15-0.25	----	----	----	----	----

1/ For class B (EZ) 0.04 percent. 3/ For class B (EZ) 0.06 percent. 5/ For class C (N) 0.07 percent.
2/ For class B (EZ) 0.05 percent. 4/ For class A (135M) 0.05 percent.

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3.4 Mechanical properties. The mechanical properties of condition 2 (quenched and tempered) bars and forgings shall be as shown in table II.

TABLE II. Mechanical properties (english conversion).

Class	Size (diameter or thickness) ^{1/} inches	Ultimate strength (min) lb/in ²	Yield point (min) lb/in ²	Elonga- tion in 2 inches (min) percent	Reduc- tion in area (min) percent	Brinell hardness number	Rockwell hardness number ^{2/}
A (135M)	Up to 1-1/2, incl	135,000	100,000	16.0	50	277 to 331	C29 to C35
	Over 1-1/2 to 3, incl	125,000	90,000	15.0	40	255 to 302 on surface 235 to 285 on test specimen	C25 to C32 C22 to C30
	Over 3 to 5, incl	110,000	85,000	15.0	40	235 to 277 on surface 217 to 255 on test specimen	C22 to C29 B96 to C25
B (EZ)	Up to 1-1/2, incl	106,000	76,000	20	50	217 to 262	B96 to C27
	Over 1-1/2 to 3, incl	102,000	74,000	18	45	212 to 248	B96 to C24
	Over 3 to 5, incl	95,000	70,000	17	40	197 to 235	B93 to B99
C (N)	Up to 3, incl	125,000	105,000	19	50	255 to 302	C25 to C32
	Over 3 to 5, incl	110,000	95,000	18	45	235 to 277	C22 to C29
	Over 5 to 8, incl	100,000	80,000	16	40	207 to 248	B95 to B100
D (135G)	Up to 1-1/2, incl	125,000	100,000	18.0	50	255 to 302	C25 to C32
	Over 1-1/2 to 3, incl	120,000	90,000	16.0	50	248 to 293	C24 to C31
	Over 3 to 5, incl	100,000	70,000	14.0	40	207 to 248	B95 to B100
	Over 5 to 8, incl	80,000	60,000	12.0	25	167 to 223	B86 to B97

^{1/} Mechanical properties of bars and forgings larger than the maximum sizes specified shall be approved by the Command or agency concerned.

^{2/} Hardness of bars 1/2 inch or less in diameter shall be determined by means of the Rockwell test.

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TABLE II. Mechanical properties (metric).

Class	Size ¹ / (diameter or thickness) millimeters	Ultimate strength (min) MPa	Yield ² / strength (min) MPa	Elongation in 2 inches (min) percent	Reduction of area (min) percent	Hardness	
						Brinell	Rockwell
A (135M)	Up to 40, incl	930	690	16	50	277-331	C29-C35
	Over 40 to 75, incl	860	620	15	40	255-302	C25-C32
	Over 75 to 125, incl	760	585	15	40	235-277	C22-C29
B (E2)	Up to 40, incl	730	525	20	50	217-262	B96-C27
	Over 40 to 75, incl	700	510	18	45	212-248	B96-C24
	Over 75 to 125, incl	655	480	17	40	197-235	B93-B99
C (N)	Up to 75, incl	860	725	19	50	255-302	C25-C32
	Over 75 to 125, incl	760	655	18	45	235-277	C22-C29
	Over 125 to 200, incl	690	550	16	40	207-248	B95-B100
D (135G)	Up to 40, incl	860	690	18	50	255-302	C25-C32
	Over 40 to 75, incl	830	620	16	50	248-293	C24-C31
	Over 75 to 125, incl	690	480	14	40	207-248	B95-B100
	Over 125 to 200, incl	550	415	12	25	167-223	B86-B97

1/ Mechanical properties of bars and forgings larger than the maximum sizes specified shall be approved by the Command or agency concerned.

2/ When a yield point is not exhibited, the yield strength shall be taken at 0.2 percent offset.

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3.4.1 Bars and forgings, conditions 1, 3 and 4 and cold finished bars shall be in a machinable condition within the maximum Brinell hardness numbers shown in table III. This material shall meet the mechanical properties specified in table II after proper heat treatment.

TABLE III. Brinell hardness numbers.

Class	Brinell hardness number (maximum)	
	Condition 1, 3 and 4 (bars and forgings)	Cold finished (bars)
A (135M), B (EZ), and D (135G)	229 (Rc20)	248 (Rc24)
C (N)	241 (Rc23)	255 (Rc25)

3.4.2 Class C (N), condition 2 (quenched and tempered) material, meeting the requirements of table II, shall meet the mechanical properties shown in table IV, after being given a precipitation hardening treatment at a temperature of approximately 525 degrees Celsius (°C) (975 degrees Fahrenheit (°F)) for 20 hours.

TABLE IV. Class C condition 2, mechanical properties after precipitation hardening treatment (english conversion).

Size (diameter or thickness)	Ultimate strength (min)	Yield point (min)	Elonga- tion in 2 inches (min)	Reduc- tion in area (min)	Brinell hardness number	Rockwell hardness number
	lb/in ²	lb/in ²	Percent	Percent		
Up to 3, inclusive	165,000	120,000	13	40	352 to 401	C37 to C42
Over 3 to 5, inclusive	150,000	110,000	12	35	321 to 388	C34 to C41
Over 5 to 8, inclusive	135,000	100,000	10	30	293 to 363	C30 to C38

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TABLE IV. Class C condition 2, mechanical properties after precipitation hardening treatment (metric).

Size (diameter or thickness) millimeters	Tensile strength (min) MPa	Yield ^{1/} strength, (min) MPa	Elonga- tion in 2 inches, (min) percent	Reduction area of (min) percent	Hardness	
					Brinell	Rockwell
Up to 75, incl	1140	830	13	40	352 - 401	C37 - C42
Over 75 to 125, incl	1035	760	12	35	321 - 388	C34 - C41
Over 125 to 200, incl	930	690	10	30	293 - 363	C30 - C38

^{1/} When a yield point is not exhibited, the yield strength shall be taken at 0.2 percent offset.

3.5 Heat treatment.

3.5.1 Forgings and bars, if ordered heat-treated, shall be given such uniform heat treatment as the manufacturer desires in order to obtain the mechanical properties specified in table II, except that the final tempering treatment shall be at a temperature of at least 600°C (1100°F).

3.5.2 Billets, bars, and forgings furnished in conditions 1, 3 and 4 shall be capable of being heat-treated to conform to table II, and all material furnished in accordance with this specification shall be capable of being nitrided to conform to 3.7.

3.6 Microscopic requirements. Heat-treated material shall show a homogeneous structure; that is, one in which the normal constituents are evenly distributed, free from decided segregation of any constituents, ingotism, excessive impurities, or surface decarburization on surfaces prepared for nitriding. The structure shall be predominately tempered martensite without free ferrite in sections up to 38 millimeters (mm) (1-1/2 inches).

3.7 Hardness. Classes A, B and D shall be capable of being nitrided to not less than 900 Vickers diamond pyramid hardness (DPHN) measured with a 10 kilogram (kg) load, or 83 on the 30N scale of the Rockwell superficial hardness tester. Class C shall be capable of being nitrided to not less than 850 Vickers DPHN measured with a 10 kilogram load, or 82 on the 30N scale of the Rockwell superficial hardness tester. The depth of the nitrided case shall be not less than 0.40 mm (0.015 inch) and shall not vary more than 0.050 mm (0.002 inch) in depth of case.

3.8 Decarburization. Forgings, bars, and billets furnished to type III and V finish shall be free from decarburization.

4. QUALITY ASSURANCE PROVISIONS

4.1 The quality assurance provisions shall be in accordance with DOD-F-24669 and as specified herein.

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4.2 Sampling.4.2.1 Mechanical tests.

4.2.1.1 Bars. For the purpose of mechanical test of condition 2 material two longitudinal test specimens from each lot (see DOD-F-24669) of bars, billets or blooms shall be selected for the tests specified in DOD-F-24669.

4.2.1.2 Forgings.

4.2.1.2.1 Large forgings. Each forging weighing 455 kg (1000 pounds) or more shall be tested individually. One tension test specimen shall be taken from a prolongation on the end of the forging.

4.2.1.2.2 Small forgings. For forgings weighing less than 455 kg (1000 pounds), a tension test specimen shall be taken from a sample forging representing the lot. Test specimens shall be taken from suitable prolongations on the forgings, or at the option of the contractor, forgings in excess of the number required may be provided for tests.

4.2.1.2.2.1 For each forging weighing less than 455 kg (1000 pounds) submitted individually, one tension specimen shall be taken.

4.2.1.2.3 Multiple forgings. Where forgings are made in multiples from a single forging, that is, forged in one piece and machined or otherwise separated, individual tests of each forging need not be made, but tests of the large forging shall govern.

4.2.1.3 Condition 1 and 4 material. The samples selected in accordance with 4.2.1.1 and 4.2.1.2 shall be heat treated in full cross section and tested to determine whether the requirements of table II can be met. Hardness tests shall be performed on these two samples prior to heat treatment for compliance to table III.

4.2.1.4 Class C, precipitation hardened material. In addition to the samples required by 4.2.1.1 and 4.2.1.2 two full cross section sample pieces of class C material shall be selected to determine compliance with 3.4.2. In the case of condition 1, 3, or 4 material the sample pieces shall be heat treated to condition 2 prior to precipitation hardening.

4.2.2 Nitriding capability. Two pieces shall be selected, nitrided and examined in accordance with 3.7.

4.2.3 Microscopic examination. From each lot (see DOD-F-24669) at least one specimen shall be selected from the end of a broken tension test specimen or from the same area at the same time. An additional micro-specimen shall be taken at the surface when the surface is ordered to type V finish in order to determine whether the surface is free from decarburization (see 3.6).

4.2.4 Dimensional examination. Sampling for dimensional examination shall be in accordance with MIL-STD-105, general inspection level I, acceptance quality level 1.5.

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4.2.5 Hardness. Sampling for core and case hardness tests shall be in accordance with MIL-STD-105, general inspection level I, acceptance quality level 1.5.

4.3 Test procedures.

4.3.1 Hardness tests. Hardness tests shall be determined in accordance with ASTM E 10, ASTM E 18 or ASTM E 110. The hardness of nitrided surfaces shall be determined in accordance with ASTM E 384.

4.3.2 Microscopic examination. Samples shall be prepared in accordance with ASTM E 3 and viewed at 100 diameters for compliance with 3.6.

5. PACKAGING

(The packaging requirements specified herein apply only for direct Government acquisition.)

5.1 Preservation, packing, packaging and marking shall be in accordance with DOD-F-24669.

6. NOTES

6.1 Intended use. This material should be specified for use in machinery and ordnance applications where extremely hard wear resistant surfaces are needed.

6.2 Ordering data. In addition to the ordering data of DOD-F-24669, acquisition documents should specify the following:

- (a) Class, condition and finish required (see 1.2).
- (b) Size, shape and quantity of bars, reforging stock or forgings required.
- (c) The applicable drawing, piece number and location of marking (for forgings only).
- (d) For bars, billets and forgings in excess of 645 square centimeters (100 square inches) the acceptance criteria for macrostructure examination (see DOD-F-24669).

Custodians:

Army - MR
Navy - SH
Air Force - 99

Preparing activity:

Navy - SH
(Project FORG-0128-03)

Review activities:

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