

MIL-S-10520D(MU)

27 August 1975

SUPERSEDING

MIL-S-10520C(ORD)

17 February 1953

MILITARY SPECIFICATION

STEEL, FORGING: FOR PROJECTILE STOCK

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

1. SCOPE

1.1 Scope. This specification covers hot-rolled carbon steel for forging into projectile bodies.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

STANDARDS

FEDERAL

Fed. Test Method Std. No. 151 - Metals; Test Methods

MILITARY

MIL-STD-129 - Marking of Shipments

MIL-STD-1459 - Macrograph Standards for Steel Bars, Billets. and Blooms for Ammunition Components

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

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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.

AMERICAN SOCIETY FOR TESTING AND MATERIALS

A 370 - Mechanical Testing of Steel Products

E 30 - Chemical Analysis of Steel, Cast Iron, Open Hearth Iron,
and Wrought Iron

E 340 - Standard Method for Macroetching Metals and Alloys

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

Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.

3. REQUIREMENTS

3.1 Material. The steel shall be made by the open hearth, basic oxygen or electric furnace process, unless otherwise specified. The steel shall be fully killed.

3.2 Chemical composition.

3.2.1 The chemical composition as determined by heat analysis shall conform to table I for the grade designation specified in the invitation for bids and in the contract or order or shall conform to the heat chemistry ranges negotiated in accordance with 3.7.2 (a) or 3.7.2 (c).

Table I - Chemical Requirements ^{1/}

<u>Steel Grade</u>	<u>Carbon Percent</u>	<u>Manganese Percent</u>	<u>Phosphorus Percent</u>	<u>Sulfur Percent</u>	<u>Silicon Percent</u>
1	0.20 max	0.90 max	0.040 max	0.050 max	0.20 max
2	0.28-0.34	0.60-0.90	.040 max	.050 max	0.15-0.30
3	0.60 max	1.00 max	.040 max	.050 max	0.15-0.30
5	.65 max	1.00 max	.040 max	.050 max	0.15-0.30
6	.55 max	1.00 max	.040 max	.050 max	0.15-0.30
7	.65 max	1.30 max	.040 max	.050 max	0.15-0.30

^{1/} In the above steels, incidental elements shall not exceed the following:
Nickel 0.25%, Chromium 0.20%, Copper 0.50%, Molybdenum 0.06%.

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3.2.2 The chemical composition as determined by product analysis shall meet the specified heat chemistry requirements subject to the permissible variations shown in table II, provided that in a heat of steel the percentage of any element shall not vary above and below the range where a range is specified.

Table II - Permissible Variations for Product Analysis

<u>Element</u>	<u>Maximum Limit, or Upper Limit of Range Percent</u>	<u>Over the Maximum Limit Percent</u>	<u>Under the Minimum Limit Percent</u>
Carbon	To 0.25, inclusive	0.02	0.02
	Over 0.25 to 0.55, incl.	0.03	0.03
	Over 0.55	0.04	0.04
Manganese	To 0.90, inclusive	0.03	0.03
	Over 0.90 to 1.30, incl.	0.06	0.06
Phosphorus	To 0.040, inclusive	0.01	--
Sulfur	To 0.05, inclusive	0.01	--
Silicon	To 0.30, inclusive	0.02	0.02

3.2.3 A heat analysis of each steel, showing the percentage of carbon, manganese, phosphorus, sulfur, and silicon, shall be furnished by the steel producer.

3.3 Internal soundness. The quality and cleanliness of the steel, as indicated by macro-etch testing, shall be equal to or better than Standards A5-B3, C8 of MIL-STD-1459 with defects D1, D3, D4, D5, D6, D7, and D8 unacceptable.

3.4 Discard and identification of material.

3.4.1 Discard. The discard from the top and bottom of each ingot shall be sufficient to provide sound steel. There shall be no less than three marker ingots in each heat. These shall be the first and last usable ingots and an ingot approximately at the middle of the pouring of the heat. The mold practice used on marker ingots shall be similar to that used on all other ingots of the heat. All ingots shall have an original discard at least equivalent to the original discard on the marker ingots.

3.4.2 Identification. All materials shall carry the heat number and all top and bottom cuts shall be identified. All material from marker ingots shall carry the ingot number in addition the heat number. The top end of the top cut and the bottom end of the bottom cut of all ingots shall be identified. All markings shall be retained on the pieces until the heat has satisfactorily passed the tests prescribed in Section 4 of this specification.

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3.5 Surface conditioning. The steel shall be suitable for the manufacture of forgings by the process specified in the inquiry or invitation for bids and in the contract or purchase order. Surface conditioning which does not affect the suitability of the material for forging by the specified process is permissible.

3.6 Dimensions and tolerances. The material shall conform to the nominal size specified in the contract or purchase order.

3.6.1 Permissible variations for dimensions and permissible deviations from roundness and straightness shall be in accordance with tables III, IV, V, VI, VII, VIII, and IX, as applicable.

3.6.1.1 When bars are specified, the material shall meet the requirements shown in tables III and V for rounds and round-cornered-squares, respectively.

3.6.1.2 When billets, or product of a rolling mill other than a bar mill, are specified, the material shall meet the requirements shown in tables IV and VI for rounds and round-cornered-squares, respectively.

NOTE: In order to utilize the maximum productive capacity of the steel industry, it may be necessary to roll rounds in sizes 3 inches and over and round-cornered-squares in sizes 3-7/8 inches and under on mill equipment that is not capable of meeting the tolerances shown in tables III and V, respectively. The tolerances shown for these size ranges in tables IV and VI are available for such instances.

3.6.2 Round-cornered-squares, whether bars, billets or other product, should be specified by square size and diagonal dimension but are not subject to square size tolerances nor weight limitations.

Table III - Permissible Variations - Rounds; Size

Nominal Diameter (inches)	Variation from Diameter (inches)		Maximum Out-of-Round ^{1/} (inches)
	Over	Under	
To 1-3/8 incl.	0.012	0.012	0.018
Over 1-3/8 to 1-1/2, incl.	0.014	0.014	0.021
Over 1-1/2 to 2, incl.	1/64	1/64	0.023
Over 2 to 2-1/2, Incl.	1/32	0	0.023
Over 2-1/2 to 3-1/2, incl.	3/64	0	0.035
Over 3-1/2 to 4-1/2, incl.	1/16	0	0.046
Over 4-1/2 to 5-1/2, incl.	5/64	0	0.058
Over 5-1/2 to 6-1/2, incl.	1/8	0	0.070
Over 6-1/2 to 8-1/4, incl.	5/32	0	0.085

^{1/} Out-of-round is the difference between the maximum and minimum diameter, measured at the same cross section.

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Table IV - Permissible Variations = Rounds; Size
(See NOTE under 3.6.1.2)

Nominal Diameter (inches)	Variation from Diameter (inches)		Maximum Out-of-Round ^{1/} (inches)
	Over	Under	
3 to 3-1/2 incl.	9/64	0	0.109
Over 3-1/2 to 4-1/2, incl.	3/16	0	0.156
Over 4-1/2 to 5-1/2, incl.	15/64	0	0.187
Over 5-1/2 to 8-1/4, incl.	9/32	0	0.218

^{1/}Out of round is the difference between the maximum and minimum diameters measured at the same cross section.

Table V - Permissible Variations = Round-Cornered-Squares: Diagonal
(See NOTE under 3.6.1.2; also see 3.6.2)

Specified Square Size (inches)	Variation from Specified Diagonal (inches)	
	Over	Under
3 to 3-1/2 incl.	0.066	0
Over 3-1/2 to 3-7/8, incl.	0.088	0

Table VI - Permissible Variations = Round-Cornered-Squares: Diagonal
(See 3.6.2)

Specified Square Size (inches)	Variation from Specified Diagonal (inches)	
	Over	Under
3 to 3-7/8 incl. ^{1/}	0.125	0
Over 3-7/8 to 4, incl.	0.0625	0.0625
Over 4 to 4-1/2, incl.	0.070	0.070
Over 4-1/2 to 5-1/2, incl.	0.078	0.078
Over 5-1/2 to 6, incl.	0.086	0.086
Over 6 to 6-1/2, incl.	0.094	0.094
Over 6-1/2 to 7, incl.	0.125	0.125
Over 7 to 8-1/2, incl.	0.156	0.156
Over 8-1/2 to 9, incl.	0.188	0.188
Over 9 to 10 incl.	0.219	0.219

^{1/}See NOTE under 3.6.1.2.

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Table VII - Permissible Variations = Rounds and Round-Cornered Squares; Straightness

Deviations from straightness shall be measured over the full length of the piece and shall not exceed the figure obtained by substituting in the following formula the applicable values shown below:

$$\frac{\text{Tabulated value} \times \text{number of feet of length}}{5}$$

Nominal Diameter of Thickness (inches)	Values to be used in Straightness Formula (inches)	
	Lengths not over 20 feet	Lengths over 20 feet
Under 4	3/4	1-1/2
4 and over	1	1-1/2

Table VIII - Permissible Variations = Rounds; Length

Nominal Diameter (inches)	Variation over specified length (inches)				
	No variation under specified length				
	5 to 10 ft. excl.	10 to 20 ft. excl.	20 to 30 ft. excl.	30 to 40 ft. excl.	40 to 60 ft. incl.

HOT SHEARING

to 1 incl.	1/2	3/4	1-1/4	1-3/4	2-1/4
Over 1 to 2, incl.	5/8	1	1-1/2	2	2-1/2
Over 2 to 5, incl.	1	1-1/2	1-3/4	2-1/4	2-3/4
Over 5 to 8-1/4, incl.	2	2-1/2	2-3/4	3	3-1/4

HOT SAWING

2 to 5, incl. $\frac{1}{2}$	$\frac{1}{2}$	1-1/2	1-3/4	2-1/4	2-3/4
Over 5 to 8-1/4, incl.	$\frac{1}{2}$	2-1/2	2-3/4	3	3-1/4

$\frac{1}{2}$ Smaller sizes and shorter lengths cannot be hot sawed.

Table IX - Permissible Variations = Round-Cornered-Squares; Length

Nominal Square Size (inches)	Variation from specified length					
	Lengths up to 10 ft. incl. (inches)		Lengths over 10 to 20 ft. incl. (inches)		Lengths over 20 ft. (inches)	
	Over	Under	Over	Under	Over	Under
3 to 3-7/8, incl.	1-1/4	0	1-3/4	0	2-1/2	0
Over 3-7/8 to 5, incl.	1-1/2	0	2	0	3	0
Over 5 to 10, incl.	2	0	3	0	4	0

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3.7 Response to heat treatment.

3.7.1 Except as provided in 3.7.2, the steel shall be demonstrated by the steel producer (by quenching and tempering and testing of coupons in accordance with 4.5) to be capable of being heat-treated to meet the physical properties specified on the drawing of the projectile for which the steel is intended.

3.7.2 This requirement shall not apply under the following circumstances:

(a) When the test is specifically excepted by the projectile producer, in which case a negotiated heat chemistry range requirement, within the limits of table I, shall be substituted therefor.

(b) When Grades 1 and 2 are ordered.

(c) When steel is ordered for any projectile for which the physical property requirements are such as to not necessitate quenching and tempering, in which case a negotiated heat chemistry range requirement, within the limits of table I, shall be substituted therefor.

3.8 Workmanship.

3.8.1 The steel shall be of uniform quality and condition within the limits of good manufacturing and inspection practices; free from pipe, deep seams or cracks, excessive porosity, segregation of non-metallic inclusions, and other defects which due to their nature, degree, or extent prevent the fulfillment of other requirements of this specification.

4. SAMPLING, INSPECTION AND TEST PROCEDURES

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier 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.

4.2 Chemical analysis.

4.2.1 Heat analysis. Chemical analysis for each heat of steel may be made by the purchaser. The chemical composition thus determined shall meet the requirements of 3.2.

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4.2.2 Product analysis. Samples for product analysis shall be taken at a point midway between the center and the surface of the bloom, billet, or bar by drilling parallel to the longitudinal axis. For pieces having a cross-sectional area up to 16 square inches inclusive, the nominal diameter of the drill shall be 1/2 inch; for material over 16 square inches in cross-sectional area, the nominal diameter of the drill shall be 1 inch. Each sample shall consist of not less than two ounces of drillings.

4.2.3 When specified, two samples for product analysis shall be furnished by the steel supplier to the purchaser. One sample shall be taken from the top end of the top bloom, billet, or bar of the first usable ingot and one sample from the bottom of the bottom bloom, billet, or bar of the last usable ingot of the heat. The samples shall be taken in accordance with 4.2.2.

4.2.4 In case a referee analysis is required and agreed upon to resolve a dispute concerning the results of a product analysis, a referee analysis shall be performed in accordance with ASTM E 30.

4.3 Macroexamination. Steel shall be tested for soundness by macroetch test. Macroetch tests shall be made on the product of the top end of the top cut and bottom end of the bottom cuts from the first, middle, and last marker ingots to determine compliance with 3.8. The test pieces for macro-etching shall show the full cross section of the material. The faces of the test pieces shall be suitably prepared and etched in accordance with ASTM E 340.

4.3.1 If all cuts from the marker ingots show compliance with requirements of 3.3 and 3.4, the entire heat will be accepted, if otherwise satisfactory.

4.3.2 In the event of the failure of the top cut of any of the three marker ingots, discard shall continue from the top end of that cut until acceptable metal is obtained. In addition, the top cut from each ingot in the heat shall be macroetched and shall be cut back where necessary until acceptable metal is obtained.

4.3.3 In the event of the failure of the bottom cut of any of the three marker ingots, discard shall continue from the bottom end of that cut until acceptable metal is obtained. In addition, the bottom cut from each ingot in the heat shall be macroetched and shall be cut back where necessary until acceptable metal is obtained.

4.3.4 In the event of the failure of the entire top or bottom cut of any ingot tested, the entire ingot shall be rejected unless the steel producer elects to inspect each end of each piece produced from the ingot by macroetch testing.

4.4 Lost identity. Should the identity, as required in this specification, of any material be lost, the material shall be rejected unless the composition and soundness of such material can be established to the satisfaction of the inspector.

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4.5 Physical requirements.

4.5.1 Quench and temper test. Except when demonstration of response to heat treatment is not required (see 3.7.2), two samples for the preparation of physical test coupons of the size shown in table X shall be selected either during rolling (or later at the steel producer's option) from each heat of grades 3, 5, 6, and 7. One sample shall be taken from the top end of the top bloom or billet of the first usable ingot and one sample from the bottom end of the bottom bloom or billet of the last usable ingot of the heat. The 3 inch round, 2-1/2 inch round and 1-3/4 inch round test coupons shall be obtained so that the axis of the tensile specimen taken midway between the center and outside of the coupon approximates the material midway between the center and outside of the ingot. The 1 inch round test coupon shall be obtained so that the axis of the tensile specimen (which coincides with the axis of the test coupon) approximates the material midway between the center and outside of the ingot. The test coupons shall be heated to a temperature above the critical range but not over 1600°F and held at that temperature for the length of time shown in table X, quenched by hand by agitating laterally in the form of a figure "8" in still oil, and tempered for the length of time specified in table X. The oil shall be a light quenching oil having a minimum Saybolt Universal viscosity of 100 seconds at 100°F. The temperature of the oil shall be maintained between 100° and 150°F. The tempering temperature shall be at the steel producers option, but in no case shall be less than 900°F. One tension test specimen shall be taken midway between the center and outside of each test coupon, except that from the 1 inch diameter coupon the tension test specimen shall be turned on center; test specimens shall conform to the largest round tension specimen obtainable in ASTM 370.

Table X - Size and Heat Treatment of Test Coupons

<u>Size of Projectile</u>	<u>Specified minimum yield strength (psi)</u>	<u>Coupon diameter and length (inches)</u>
37mm to 105mm, incl.	60,000 to 75,000, incl.	1-3/4 X 10
	Over 75,000 to 85,000, incl.	1 X 10
Over 105mm to 155mm, incl.	65,000	2-1/2 X 10
	Over 65,000 to 75,000, incl.	1-3/4 X 10
	Over 75,000 to 85,000, incl.	1 X 10
Over 155mm	60,000 to 65,000, incl.	3 X 10
	Over 65,000 to 75,000, incl.	1-3/4 X 10
	Over 75,000 to 85,000, incl.	1 X 10
<u>Coupon diameter (inches)</u>	<u>Minimum time to hold coupons at temperature</u>	
	<u>Austenitizing time (hours)</u>	<u>Tempering time (hours)</u>
1	1-1/4	1-3/4
1-3/4	1-1/2	2
2-1/2	2	3
3	2	4

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4.5.2 Retests. Retests in addition to those permitted in accordance with FED. TEST METHOD STD NO. 151 shall be permitted under the following conditions:

(a) Failure of testing equipment. A second specimen may be taken from the original coupon without reheat-treatment; or a similar coupon may be selected, heat treated, and tested in the same manner as the original coupon.

(b) Failure of heat-treating equipment. A second specimen may be taken and tested from the same coupon after reheat-treatment; or a similar coupon may be selected, heat treated, and tested in the same manner as the original coupon.

(c) Failure of the material. The heat may be resubmitted once for retest at the steel producer's option after additional top and/or bottom discard has been taken from each ingot in the heat.

4.5.3 Yield strength. Yield strength shall be determined by the extension-under-load method as described in ASTM A 370. The limiting extension-under-load shall be calculated by the following formula:

$$X = \frac{Y}{30,000,000} + 0.001 \text{ inch}$$

where:

X = limiting extension, inch per inch of gage length

Y = specified yield strength

NOTE: In making this test, the steel producer may make any number of preliminary tests for determining the proper treatment of the steel to obtain the prescribed physical properties. The preliminary tests may be considered the official tests provided they represent the material applied on the contract or order and providing all other requirements of the specification have been met.

5. PREPARATION FOR DELIVERY

5.1 Packing.

5.1.1 Except as provided in 5.1.2, heats shall be kept separate throughout manufacture to facilitate identification. Mixing of heats in a car should be avoided, but when this is necessary they shall be separated by wooden markers so that the inspector at the receiving end may properly identify them.

5.1.2 There may be a few blooms, billets or bars set aside for conditioning, that cannot be conveniently shipped with the heats to which they belong. These pieces may be shipped later provided they are properly segregated in the car and identified as to proper heat number or coded lot, and the shipping papers and inspection reports are marked to indicate the heat or coded lot identification and the chemistry of each heat or coded lot involved.

5.1.3 Material under 2-1/2 inches in diameter or width may be bundled in units convenient to handle.

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5.2 Marking for shipment.

5.2.1 Marking for shipment direct to Government installations shall be in accordance with Military Standard MIL-STD-129.

5.2.2 Each piece of material not bundled shall be legibly marked for shipment with the composition designation and the heat number.

5.2.3 Bundles shall be marked for shipment with tags containing the composition designation, heat number, and contract or order number.

6. NOTES

6.1 Ordering data. Procurement documents should specify the following:

- (a) Title, number, and date of this specification.
- (b) The steel grade (see table I).
- (c) The forging process to be used (see 3.5).
- (d) The size of material required.
- (e) The form of material (bar, billet, or other designation) for determination of applicability of tolerance tables (see 3.6.1.1 and 3.6.1.2).
- (f) Any other desired options offered herein (see 3.1, 3.7.2 (a) and 4.2.3).

6.1.1 When ordering round-cornered-squares, the square size and diagonal dimensions should be specified.

6.1.2 The attention of purchasers is invited to the possible necessity of accepting alternate tolerance requirements under the conditions described in note under 3.6.1.2.

6.1.3 The attention of purchasers is further invited to the necessity of negotiating heat chemistry requirements when the response-to-heat-treatment requirement is not applicable, as described in 3.7.2 (a) and 3.7.2 (c).

6.2 The following information is shown for the guidance of forgers:

Table XI - Approximate Corner Radii for Round-Cornered-Square Sections

Nominal Square Size (inches)	Nominal Corner Radius (inches)
3 to 3-1/2, exclusive	7/16
3-1/2 to 4, exclusive	1/2
4 to 4-1/2, exclusive	5/8
4-1/2 to 5, exclusive	3/4
5 to 8, exclusive	1-1/8
8 to 10, exclusive	1-1/2

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