

INCH-POUND

MIL-S-13823C(MR)

4 March 1991

SUPERSEDING

MIL-S-13823B(MR)

3 January 1977

MILITARY SPECIFICATION

STEEL: SHAPES, ROLLED OR FORGED;
BARS, FLATS AND SPECIAL SECTIONS (FOR ARMOR)

This specification is approved for use by the Army Materials Technology Laboratory, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers weldable steel bars, flats and special sections produced from billets to specified dimensions by rolling or forging, for armored vehicle components. This specification includes the minimum essential Engineering and Packaging Requirements and the necessary Quality Assurance Provisions to determine that these requirements have been met.

1.2 Classification. The steel shall be of the following shapes and sizes as specified.

Bars, round: 1/4-inch up to and including 4-inch diameter.

Bars, square: 1/4-inch up to and including 4-inch.

Flats, 1/4-inch or more in thickness: not over 6 inches wide.

Shapes of special sections: In accordance with applicable drawings.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

STANDARDS

MILITARY

MIL-STD-129 - Marking for Shipment and Storage

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, U.S. Army Laboratory Command, Materials Technology Laboratory, ATTN: SLCMT-MEE, Watertown, MA 02172-0001 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC No. A6018

AREA FORG

DISTRIBUTION STATEMENT A Approved for public release; distribution unlimited.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Non-Government 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 are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- ASTM A751 - Chemical Analysis of Steel Products, Standard Methods, Practices, and Definitions for
- ASTM D3951 - Commercial Packaging, Practice for
- ASTM E10 - Brinell Hardness of Metallic Materials, Standard Method of Test for
- ASTM E23 - Notched Bar Impact Testing of Metallic Materials, Standard Method for
- ASTM E381 - Rating Macroetched Steel, Standard Method for

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

(Non-Government standards and other publications are normally available from the organizations that prepare or 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 document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 General requirements. Steel shapes shall be in accordance with the applicable drawings, the requirements of this specification, and all referenced documents. Any conflicts are to be resolved by means of the order of precedence (see 2.3).

3.2 First article. The contractor shall submit a first article unless it is specifically waived in the contract (see 4.3 and 6.2). No first article requirements shall be waived without review and approval by the procuring contracting officer (see 6.3).

3.2.1 First article residual metal. Residual metal from the first article units shall be retained until the acceptance of the first article (see 6.2).

3.3 Chemical composition. The heat analysis of all heats shall be within the limits established by the supplier, and shall conform to the requirements

of table I. In addition, those additives or hardening agents intentionally added shall be declared. All limits established by the supplier shall be submitted in advance to the procuring contracting officer. The supplier may establish and submit separate limits for each thickness of armor to be furnished (see 6.3).

3.3.1 Carbon (product analysis). The carbon content determined by product analysis shall be limited as follows: 0.32 percent for bars and flats up to 4 inches thick inclusive and 0.34 percent for flats or special sections over 4 inches thick.

TABLE I. Chemical composition (heat analysis).

Element	Maximum range (Percent)	Maximum Limit (Percent)
Carbon	.10	.32/.34
Manganese:		
Up to 1.00% incl.	.30	
Over 1.00%	.40	
Phosphorus		.04
Sulphur		.04
Silicon:		
Up to 0.60% inc.	.20	
Over 0.60% to 1.00% incl.	.30	
Over 1.00%	.40	
Nickel	.50	
Chromium:		
Up to 1.25% incl.	.30	
Over 1.25%	.40	
Molybdenum:		
Up to 0.20% incl.	.07	
Over 0.20%	.15	
Vanadium	.10	

3.4 Heat treatment. The supplier shall select the heat treatment of the material to meet the requirements of this specification. A statement of the heat treatment to be used shall be submitted to the procuring contracting officer. All bars, flats or special sections in each lot, including samples, shall receive the same heat treatment except for such variations in tempering temperature as may be necessary to produce the prescribed hardness (see 6.3).

3.5 Heating. Except as provided elsewhere in this specification, local or general heating shall not be performed after final quenching and tempering. A detailed outline of the procedure to be used in each operation of the following processes shall be submitted in writing to the procuring contracting officer for authorization (see 6.3).

3.5.1 Oxygen cutting. Unless otherwise specified (see 6.2), oxygen cutting shall be permitted after final heat treatment provided the procedure is such that no cracks capable of being observed with the unaided eye develop on any oxygen-cut edge.

3.5.2 Repairing. Weld repairs shall be made only when specifically authorized by the procuring contracting officer.

3.5.3 Hot forming. Unless otherwise authorized by the procuring activity, hot forming after the final quenching and tempering operations shall not be performed.

3.6 Quality. The quality and cleanliness of bars or forging stock up to and including 64 square inches in cross sectional area shall be equal to or better than macrographs S4, R2 and C3 shown in ASTM E381.

3.7 Production weldability. The steel bars, flats, or special sections shall be capable of being welded by production welding methods as demonstrated by preparation, for approval by the procuring contracting officer, of samples representing typical production weldments for the intended application. This requirement may be waived at the discretion of the procuring contracting officer upon receipt and approval of the production welding characteristics of the type of steel involved.

3.8 Mechanical properties.

3.8.1 Hardness. The average surface hardness of a minimum of four hardness tests per furnace load shall be within the range shown in table II for the applicable thickness. The diameters of Brinell hardness impressions determined on the surface of any bar, flat, special section or sample shall not vary by more than 0.15 mm respectively between the maximum and minimum values. Cross-sectional hardness tests shall be conducted on impact samples 4 inches or greater in thickness, the average of all hardness tests, both surface and cross-section, shall be within ± 0.05 mm of the range specified for the thickness involved.

TABLE II. Brinell hardness requirements.

Specified nominal thickness of bar, flat or special section (inches)	Brinell hardness range (3000 kg load)	Brinell indentation diameters (mm)
1/4 to less than 1/2	341-388	3.30-3.10
1/2 to less than 3/4	331-375	3.35-3.15
3/4 to less than 1 1/4	321-375	3.40-3.15
1 1/4 to less than 2	293-331	3.55-3.35
2 to less than 4	269-311	3.70-3.45
4 to 6 incl.	241-277	3.90-3.65

3.8.2 Impact resistance. The V-notch Charpy impact resistance shall meet the requirements of table III for the applicable hardness and thickness.

3.9 Dimensions and dimensional tolerances.

TABLE III. Minimum Charpy V-notch impact requirements (ft-lbs at $-40^{\circ}\text{F} \pm 2^{\circ}\text{F}$).

Brinell hardness	Thickness, inches	Bars and Flats			
		Longitudinal direction		Forged and rolled shapes (average)	
		Standard specimen	Sub-size specimen	Standard specimen	Sub-size specimen
262		60	30	43	22
269		57	29	41	21
277		53	27	38	19
285		50	25	36	18
293		47	24	34	17
302		42	21	32	16
311		38	19	30	15
321		34	17	28	14
331		30	15	26	13
341		27	14	23	12
352		26	13	22	11
363		22	11	20	10
375		20	10	18	9
388		18	9	16	8
	1/4 to less than 4				
241		64	32	47	23
248		60	30	44	22
255		55	28	40	20
262		51	26	37	19
269		47	24	34	17
277		43	22	32	16
285		38	19	30	15
	4 to 6 incl.				

TABLE IV. Dimensional tolerances for bars (round and square) and flats.

Specified thickness, diameter or width		Permissible variations		
Greater than (Inches)	To and including (Inches)	Plus (Inch)	Minus (Inch)	Out of round or square (Inch)
3/16	5/16	0.005	0.005	0.008
5/16	7/16	0.006	0.006	0.009
7/16	5/8	0.007	0.007	0.010
5/8	7/8	0.008	0.008	0.012
7/8	1	0.009	0.009	0.013
1	1-1/8	0.010	0.010	0.015
1-1/8	1-1/4	0.011	0.011	0.016
1-1/4	1-3/8	0.012	0.012	0.018
1-3/8	1-1/2	0.014	0.014	0.021
1-1/2	2	1/64	1/64	0.023
2	2-1/2	1/32	0	0.023
2-1/2	3-1/2	3/64	0	0.035
3-1/2	4-1/2	1/16	0	0.046
4-1/2	5-1/2	5/64	0	0.058
5-1/2	6-1/2	1/8	0	0.070
6-1/2	8-1/4	5/32	0	0.085

3.9.1 Dimensions. Bars, flats, and special sections shall comply with the dimensions shown on the drawings or specified in the contract or order.

3.9.2 Tolerance. The thickness of any bar or flat, after final heat treatment, shall not vary by more than the amounts shown in table IV. Tolerances for special sections shall be as specified in the contract or purchase order.

3.10 Identification. Identification markings and records shall be such as to ensure positive identification of all bars, flats and special sections, samples and specimens, with the lot and corresponding heat from which they were produced. The key to identification symbols shall be furnished to the inspector prior to submittal of material for inspection and testing.

3.11 Information required. A statement showing the heat analysis of each heat and complete details of the heat treatment of each lot shall be furnished for the files of the procuring activity. All elements of the chemical composition shall be shown in the statement, including special additives or hardening agents, whether shown in table I or not (see 6.3).

3.12 Workmanship. Bars, plates, and special sections shall be free from injurious imperfections, including cracks, pits, porosity, laminations, segregation, and inclusions, for their intended use.

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 (examinations and tests) 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 this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall 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 ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

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

- a. First article inspection (see 4.3)
- b. Quality conformance inspection (see 4.4)

4.3 First article inspection.

4.3.1 For visual examination. Unless a sampling plan is specified by the procuring contracting officer, all bars, flats or special sections comprising the lot shall be subject to visual inspection.

4.3.2 For chemical analysis. One sample shall be selected from each heat in accordance with ASTM A751.

4.3.3 For steel quality. Unless otherwise specified (see 6.2), samples for steel quality tests shall be taken representing the top, middle and bottom of the first, middle and last usable ingots of each heat. Samples shall be sufficiently large to prepare test specimens required in 4.5.1.2.

4.3.4 For production weldability. When required, the number and size of samples shall be as specified or approved by the procuring contracting officer.

4.3.5 For mechanical properties. Samples for mechanical properties tests shall be taken at random in accordance with the contract or purchase order (recommendations are in 6.2.1). Mechanical property samples shall be of the same thickness or diameter as the bars, flats, or special sections they represent. The samples shall be either as large as the parts represented or

shall be of sufficient size to allow for the number of specimens required in 4.5.1.3.2 to be taken from them. All specimens shall be taken so that every part of the test specimen will be outside of the heat affected zone of any oxygen cut edge.

4.4 Examination.

4.4.1 Visual. Bars, flats, or special sections selected in accordance with 4.3.1 shall be visually examined for compliance with identification marking (see 3.10) and workmanship (see 3.12).

4.4.2 Dimensional. Bars, flats or special sections selected in accordance with 4.3.1 shall be dimensionally examined for compliance with dimensions and tolerances (see 3.9).

4.4.3 Preparation for shipment. Examination shall be made to determine compliance with the requirements for packaging (section 5).

4.5 Tests.

4.5.1 Test specimens.

4.5.1.1 For chemical analysis. Test specimens for chemical analysis shall be in accordance with ASTM A751.

4.5.1.2 For steel quality tests. Test specimens for steel quality tests shall be prepared as specified in ASTM E381.

4.5.1.3 For mechanical properties.

4.5.1.3.1 Surface hardness. Each furnace load of shapes, bars, flats or special sections shall be tested for surface hardness.

4.5.1.3.2 Impact specimens. At least four Charpy impact test specimens shall be taken from each sample. Specimens from samples less than four inches in thickness shall be taken from the center of the section and at a distance of two times the thickness or diameter from any quenched end as well as outside the heat affected zone of any oxygen cut edge. Specimens from samples four inches or more in thickness shall be taken one-inch below the surface and at a distance of two times the thickness or diameter from any quenched end as well as outside the heat affected zone of any oxygen cut edge. Charpy V-notch specimens shall be machined to the dimensions specified in ASTM E23, except that for material having a thickness from 7/32 to 7/16 inches inclusive, the width of the specimens shall be 5-mm (0.197 inch). The notch shall be perpendicular to the surface of the material.

4.5.2 Test methods.

4.5.2.1 Chemical analysis. Chemical analysis shall be conducted in accordance with ASTM A751.

4.5.2.2 Steel quality tests. Steel quality tests shall be in accordance with ASTM E381.

4.5.2.3 Production weldability. When required, tests of welded samples shall be as specified or approved by the procuring contracting officer.

4.5.2.4 Mechanical properties tests.

4.5.2.4.1 Hardness tests.

4.5.2.4.1.1 Surface hardness. All surface scale and decarburization shall be removed from locations where tests are made. Brinell hardness tests shall be conducted by making a minimum of four hardness tests per furnace load.

4.5.2.4.1.2 Cross-sectional hardness. For samples 7/16 inch or greater in thickness, cross-sectional hardness shall be determined by taking a minimum of four hardness readings at a location midway between the top and bottom surfaces of the sample and at least two times the thickness or diameter from any quenched end.

4.5.2.4.1.3 Brinell hardness tests. Brinell hardness tests shall be conducted in accordance with ASTM E10. Hardness values shall conform with 3.8.1.

4.5.2.4.2 Impact tests. Charpy V-notch impact tests shall be conducted in accordance with ASTM E23. The impact tests shall be made with the specimens at a temperature of $-40^{\circ}\text{F} + 2^{\circ}\text{F}$. The average impact value obtained from the tests of the four specimens shall be equal to or greater than the value shown in table III for the hardness as determined in 4.5.2.4.1.1 for material less than 7/16 inch thickness or 4.5.2.4.1.2 for material 7/16 inch or greater in thickness.

4.5.2.4.2.1 Defective test specimen. In the event that the fracture of a test specimen exhibits a lamination which is revealed as an open slit, or sharply defined shelves extending the full width of the fractured surface, the test specimen shall be discarded. Replacement of such specimens shall be in accordance with ASTM A751.

4.5.2.4.2.2 Certification of impact machines. Certification of impact machines shall be in accordance with ASTM E23.

4.6 Retest and rejection. Retest and rejection shall be in accordance with ASTM A751.

5. PACKAGING

5.1 Packaging and packing. Unless otherwise specified, packaging and packing for shipment shall be in accordance with ASTM D3951.

5.2 Marking for shipment. In addition to any marking specified in the contract or order, all shipments shall be marked in accordance with ASTM D3951.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The bars, flats and special sections are intended for use as components on armored combat vehicles, emplacements and the like for protection against armor piercing projectiles, bursting shell and fragments of high-explosive ammunition. Fabrication by welding will normally be involved.

6.2 Acquisition requirements. Acquisition documents must specify the following:

- (a) Title, number and date of this specification.
- (b) Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced.
- (c) Instructions for the submission of a first article including the number of units, unless the first article is waived (see 3.2, 4.3, and 6.4).
- (d) Applicable drawings or sketches showing locations and numbers of test specimens, and mechanical property requirements (see 3.8, 4.3.5, and 4.5).
- (e) The examinations and tests to be performed by the contractor and the examinations and tests to be performed by the Government.
- (f) All inspection and test data that is required including any additional or extended examinations and tests beyond the scope of this specification.
- (g) Steel composition if required (see 3.3).
- (h) Heat treatment to be used if required (see 3.5).
- (i) At whose expense a retest may be performed.
- (j) Special identification marking not covered in 3.10.
- (k) Inspection equipment, responsibility for acquisition, maintenance, and disposition thereof, if other than as specified.
- (l) Availability of inspection equipment from the Government.
- (m) Extent of contractor's responsibility for Government furnished and for contractor-required final inspection equipment.
- (n) Applicable acceptance test procedures, including frequency of sampling (see 6.2.1).
- (o) Packing and marking for shipment (see 5.1 and 5.2).
- (p) Residual metal (see 3.2.1).
- (q) When warranted, the application of MIL-I-45208.

6.2.1 Frequency of sampling. Table V shows the recommended frequency of sampling.

TABLE V. Frequency of sampling.

<u>Length as heat-treated</u>	<u>Number of samples</u>
Greater than 12 feet	1 from each 25 items or 20,000 lbs ^{1/}
Greater than 2 to 12 feet incl. or 100 lbs. or less	1 from each 50 items or 10,000 lbs ^{1/}
2 feet or less or 10 lbs. or less	1 from each 100 items or 5,000 lbs ^{1/}

^{1/}whichever is preferred.

6.3 Consideration of data requirements. The following data requirements should be considered when this specification is applied on a contract. The applicable Data Item Descriptions (DID's) should be reviewed in conjunction with the specific acquisition to ensure that only essential data are requested/provided and that the DID's are tailored to reflect the requirements of the specific acquisition. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form 1423) must be prepared to obtain the data, except where DOD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

<u>Reference Paragraph</u>	<u>DID Number</u>	<u>DID Title</u>	<u>Suggested Tailoring</u>
3.2, 4.3	DI-FORG-80962	First Article Forging Report	---
3.3, 3.4, 3.5, 3.11	DI-P-1638	Chemical and Physical Properties For Forging or Casting Analysis Report	---

The above DID's were those cleared as of the date of this specification. The current issue of DOD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

(Copies of data item descriptions related to this specification, and identified in section 6 will be approved and listed as such in DOD 5010.12L, Vol. 11, AMSDL. Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094 or as directed by the contracting officer.)

6.4 First article. When first article inspection is required, the procuring contracting officer should provide specific guidance to offerors whether the item(s) should be a preproduction sample, a first article sample, a first production item, a sample selected from the first (how many) production items, a standard production item from the contractor's current

alternate plus unless specifically requested to do so in the solicitation.

6.5 Waivers and deviations. The procuring contracting officer shall coordinate all requests for waiver or deviation to this specification with the appropriate design and product assurance activities.

6.6 Metric units. When metric units are required, units for degree Fahrenheit, pounds per square inch, square inch, inch, and foot-pound may be converted to the metric equivalent by multiplying them by the following conversion factors:

<u>English</u>	<u>Multiplying by</u>	<u>Equals</u>	<u>Metric SI Unit</u>
degree Fahrenheit	$(F-32) \times 5/9$	=	degree Celsius (C)
pounds per square inch	6.895E3	=	Pascal (Pa)
square inch	6.452	=	square centimeter
inch	2.54	=	Centimeter (cm)
foot-pound	1.356	=	Joule (J)

Note: Conversion factors can be associated with ASTM E380 entitled "Metric Practice Guide".

6.7 Subject term (key word) listing.

Armored vehicles, steel
Steel, armor vehicles

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

6.9 Beneficial comments. Duplicate copies of beneficial comments addressed to Director, US Army Materials Technology Laboratory, ATTN: SLCMT-MEE, Watertown, MA 02172-0001 should also be sent to Director, Benet Laboratories, ATTN: SMCAR-CCB-SS, Watervleit, NY 12189-4050.

Custodian:
Army - MR

Preparing activity:
Army - MR

Review activity:
Army - EA

Project FORG-A206

User activity:
Army - AT

Agent:
Army - AR

(KBWP# ID-0250A/DISC 0138A. FOR MTL USE ONLY)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

1. DOCUMENT NUMBER MIL-S-13823C(MR)		2. DOCUMENT TITLE STEEL: SHAPES, ROLLED OR FORGED; BARS, FLATS AND SPECIAL	
3a. NAME OF SUBMITTING ORGANIZATION SECTIONS (FOR ARMOR)		4. TYPE OF ORGANIZATION (Mark one)	
b. ADDRESS (Street, City, State, ZIP Code)		<input type="checkbox"/> VENDOR <input type="checkbox"/> USER <input type="checkbox"/> MANUFACTURER <input type="checkbox"/> OTHER (Specify): _____	
5. PROBLEM AREAS			
a. Paragraph Number and Wording:			
b. Recommended Wording:			
c. Reason/Rationale for Recommendation:			
6. REMARKS			
7a. NAME OF SUBMITTER (Last, First, MI) - Optional		b. WORK TELEPHONE NUMBER (Include Area Code) - Optional	
c. MAILING ADDRESS (Street, City, State, ZIP Code) - Optional		8. DATE OF SUBMISSION (YYMMDD)	