

INCH-POUND

MIL-DTL-13823D (MR)
19 November 1998
SUPERSEDING
MIL-S-13823C (MR)
4 March 1991

DETAIL SPECIFICATION

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

This specification is approved for use by the U.S. Army Research 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.

1.2 Classification. The steel should be of the following shapes and sizes as specified (see 6.2):

- a. Bars, round: 1/4 inch up to and including 4 inch diameter.
- b. Bars, square: 1/4 inch up to and including 4 inch.
- c. Flats, 1/4 inch or more in thickness: Not over 6 inches wide.
- d. Shapes of special sections: In accordance with applicable drawings.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Non-Government publications. The following documents form a part of this document 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).

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 Research Laboratory, Weapons and Materials Research Directorate, ATTN: AMSRL-WM-M, Aberdeen Proving Ground, MD 21005-5069 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- ASTM A751 Standard Test Methods, Practices, and Terminology for
Chemical Analysis of Steel Products (DoD adopted)
- ASTM E10 Brinell Hardness of Metallic Materials (DoD adopted)
- ASTM E23 Notched Bar Impact Testing of Metallic Materials (DoD adopted)
- ASTM E381 Macroetch Testing Steel Bars, Billets, Blooms, and Forgings
(DoD adopted)

(Application for copies should be addressed to the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.)

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 sample unless it is specifically waived in the contract (see 4.3, 6.2, and 6.3). No first article requirements shall be waived without review and approval by the procuring contracting officer (see 6.4).

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.

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.

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.

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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 6.2).

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
Sulfur		.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	

3.5.1 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.

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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.

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.

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

Brinell hardness	Thickness, inches	Bars and Flats		Forged and rolled shapes (average)		
		Longitudinal direction (average)				
		Standard specimen	Sub-size specimen			
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		Standard specimen	Sub-size specimen	Standard specimen	Sub-size specimen	
262	1/4 to less than 4	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	
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241		4 to 6 incl.	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	

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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

3.11 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.

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. VERIFICATION

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

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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).

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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 inches 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.

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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 $-40^{\circ}\text{F} \pm 2^{\circ}\text{F}$. 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. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of materiel is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

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 steel covered by this specification is military unique. 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 should specify the following:

- (a) Title, number and date of this specification.
- (b) Specify steel shape and size (see 1.2).
- (c) Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2).
- (d) When first article sample is required (see 3.2).
- (e) Residual metal (see 3.2.1).
- (f) Heat treatment to be used if required (see 3.5).
- (g) Permission of oxygen cutting (see 3.5.1).
- (h) Where samples for steel quality tests should be taken other than in 4.3.3.
- (i) Packaging requirements (see 5.1).

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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 <u>1/</u>
Greater than 2 to 12 feet incl. or 100 lbs. or less	1 from each 50 items or 10,000 lbs <u>1/</u>
2 feet or less or 10 lbs. or less	1 from each 100 items or 5,000 lbs <u>1/</u>

1/ Whichever is preferred.

6.3 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 inventory, and the number of items to be tested as specified in 4.3. The procuring contracting officer should also include specific instructions in acquisition documents regarding arrangements for examinations, approval of first article test results, and disposition of first articles. Invitations for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection to those bidders offering a product which has been previously acquired or tested by the Government and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior Government approval is presently appropriate for the pending contract. Bidders should not submit alternate bids unless specifically requested to do so in the solicitation.

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

6.5 Metric units. When metric units are required, units for degree Fahrenheit, 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>Multiply by</u>	<u>Equals</u>	<u>Metric equivalent</u>
degree Fahrenheit (°F)	(°F-32) x 5/9	=	degree Centigrade (°C)
square inch (in ²)	6.4516	=	square centimeter (cm ²)
inch (in.)	2.54	=	centimeter (cm)
foot-pound (ft-lbf)	1.3558	=	joule (J)

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6.6 Subject term (key word) listing.

Billets
Brinell hardness
Charpy
Combat vehicles

6.7 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.

Custodian:
Army - MR

Preparing activity:
Army - MR

Review activity:
Army - MI

(Project FORG-A257)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:		1. DOCUMENT NUMBER MIL-DTL-13823D (MR)	2. DOCUMENT DATE (YYMMDD) 981119
3. DOCUMENT TITLE STEEL: SHAPES, ROLLED OR FORGED; BARS, FLATS AND SPECIAL SECTIONS (FOR ARMOR)			
4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)			
5. REASON FOR RECOMMENDATION			
6. SUBMITTER			
a. NAME (Last, First, Middle Initial)		b. ORGANIZATION	
c. ADDRESS (Include ZIP Code)		d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)
8. PREPARING ACTIVITY			
a. NAME US Army Research Laboratory		b. TELEPHONE (Include Area Code) (1) Commercial 410-306-0725 (2) AUTOVON 458-0725	
c. ADDRESS (Include ZIP Code) Weapons & Materials Research Directorate ATTN: AMSRL-WM-M Aberdeen Proving Ground, MD 21005-5069		IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340	