

**METRIC**  
MIL-S-46172A(MR)

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SUPERSEDING  
MIL-S-46172  
AMENDMENT 2  
15 June 1976

## MILITARY SPECIFICATION

### STEEL FORGINGS

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

#### 1. SCOPE

1.1 This specification covers steel forgings that are produced by a hot deformation process such as hammering, pressing, upsetting, extruding, or any combination of these processes (see 6.1).

1.2 Classification. The forgings are classified for inspection purposes and shall be ordered (see 6.2) on the basis of grade and condition.

##### 1.2.1 Grade.

a. Grade A forging. Mechanical properties shall be measured in the body of the forging (test coupon - see 6.6.6) as well as in the integrally-forged test metal (see 6.6.7) or

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the prolongation (see 6.6.3) at the locations shown on the applicable drawing. Correlation shall be determined by use of a value difference (see 6.6.8) between the properties of the test coupon of the forging and those of its integrally-forged test metal or the prolongation.

b. Grade A1 forging. Mechanical properties shall be measured in the body of the forging (test coupon - see 6.6.6) as well as in the integrally-forged test metal (see 6.6.7) or the prolongation (see 6.6.3) at the locations shown on the applicable drawing. Correlation shall be determined by use of a value difference (see 6.6.8) between the properties of the test coupon and those of its integrally-forged test metal or the prolongation. When the test metal or prolongation of a forging is not tested for mechanical properties, that forging shall be accepted on the basis of hardness.

c. Grade B forging. Mechanical properties shall be measured in the integrally-forged test metal or the prolongation from the forging at the locations shown on the applicable drawing.

d. Grade C forging. Mechanical properties of the forging shall be determined directly from the body of the forging (test coupon-see 6.6.6) from a selected or representative forging. Forgings not sectioned for testing shall be measured on the basis of hardness.

e. Grade D forging. Mechanical properties of the forging shall be measured on the basis of hardness only.

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1.2.2 Condition. Forgings shall be furnished in the normalized, annealed, or normalized and tempered condition unless mechanical properties are specified on the applicable drawing or in the contract or order (see 6.2).

## 2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified (see 6.2), the following specifications, standards, and handbooks of the issue listed in that 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.

## SPECIFICATIONS

MIL-P-14232 - Parts, Equipment and Tools for Army Materiel, Packaging of

## STANDARDS

## FEDERAL

FED-STD-66 - Steel: Chemical Composition and Hardenability  
 FED-STD-151 - Metals; Test Method

## MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes  
 MIL-STD-109 - Quality Assurance Terms and Definitions  
 MIL-STD-129 - Marking for Shipment and Storage  
 MIL-STD-130 - Identification Marking of U.S. Military Property

(Copies of specifications, standards, handbooks, drawings, and

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publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the Contracting Officer).

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. The issue of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A275 - Magnetic Particle Examination of Steel Forgings

ASTM E8 - Methods of Tension Testing of Metallic Materials

ASTM E10 - Method of Test for Brinell Hardness of Metallic Materials

ASTM E18 - Method of Test for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials

ASTM E23 - Methods for Notched Bar Impact Testing of Metallic Materials

ASTM E340 - Method for Macroetching Metals and Alloys

ASTM E381 - Macroetch Testing, Inspection, and Rating Steel Products, Comprising Bars, Billets, Blooms and Forgings

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

SOCIETY OF AUTOMOTIVE ENGINEERS, INC.

Aerospace Material Specification

AMS 2301 Aircraft Quality Steel Cleanliness - Magnetic Particle Inspection Procedure

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

AMERICAN WELDING SOCIETY

AWS D1.1 - Structured Welding Code

(Application for copies should be addressed to 2501 N. W. 7th Street, Miami, Florida 33125).

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.

2.3 Order of Precedence. In the event of a conflict between the text of this specification and the references cited herein, drawing requirements shall have first order of precedence, followed by the text of this specification, then the other referenced specifications and standards.

3. REQUIREMENTS

3.1 First article. The contractor shall submit a first article unless it is specifically waived in the contract (see 6.2).

No first article requirements shall be waived without review by the responsible engineering activity and approval by the responsible product assurance activity (see 6.4).

3.2 Chemical composition.

3.2.1 Chemical composition specified on drawing. When chemical composition is specified on the drawing in the invitation for bids,

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contract, or order, the composition shall be verified on the basis of ladle analysis, the chemical limits of which shall be subject to check analysis tolerances in accordance with Federal Standard NO. 66.

3.2.2 Chemical composition not specified on drawing. The contractor shall select a steel composition which when heat treated shall meet the mechanical properties specified on the applicable drawing and when specified in the contract. The chemistry of the steel composition shall be verified on the basis of ladle analysis and the chemical limits thereof shall be subject to check analysis tolerances in accordance with FED-STD-66.

3.2.3 Certification of chemical analysis. The contractor shall furnish a certified chemical analysis of each melt of steel used in producing the forgings showing the percentage of carbon, sulfur, phosphorus, silicon and manganese (see 6.4). For alloy steels, in addition to these elements, the percentage of the alloying elements shall be shown.

3.3 Material. Forgings shall be produced from cast ingots and fabricated stock and conform to the chemical and mechanical property requirements of the detail specifications and drawings, the contract, or the purchase order. Materials shall be worked prior to and during the forging operation to such extent as to produce a wrought metallurgical structure.

3.4 Mechanical properties.

3.4.1 Required property attributes. The required mechanical

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property attributes for the different grades of forgings shall be as shown in TABLE I.

TABLE I. Forging grades and mechanical property attributes.

Mechanical property attributes		Grade				
		A	A1	B	C	D
Test coupon	FA1	Yes	Yes	No	Yes	No
	p2	Yes	Yes	NO	Yes	NO
Test metal	FA1	Yes	Yes	Yes	No	No
	p2	Yes	Yes	Yes	No	NO
Value difference	FA1	Yes	Yes	No	No	No
	p2	Yes	Yes	NO	NO	NO
Yield strength	FA1	Yes	Yes	Yes	Yes	NO
	p2	Yes	Yes	Yes	Yes	NO
Reduction of area	FA1	Yes	Yes	Yes	Yes	NO
	p2	Yes	Yes	Yes	Yes	NO
Charpy impact resistance	FA1	Yes	Yes	Yes	Yes	NO
	p2	Yes	Yes	Yes	Yes	NO
Hardness	FA1	Yes	Yes	Yes	Yes	Yes <sup>4</sup>
	p2	Yes <sup>3</sup>	Yes <sup>3</sup>	Yes <sup>4</sup>	Yes <sup>3</sup>	Yes <sup>4</sup>

## NOTES:

1. First article.
2. Production.
3. Production forgings may be evaluated by hardness values obtained from same surface area of body of forging where test coupons are taken for evaluating each forging lot.
4. Mechanical properties may be evaluated by hardness values obtained from surface of forging body.

3.4.2 Mechanical property test specimens. Test specimens for mechanical properties shall be taken from the applicable test coupon(s) and test metal at the specified locations thereof.

3.4.3 First article.

3.4.3.1 Test coupon. When a test coupon (see 6.6.6) is required, the value obtained for each of the yield strength, reduction of

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area, and Charpy impact resistance attributes for each respective test specimen shall be in compliance with the requirements of TABLE II for the yield strength specified on the applicable engineering drawing.

3.4.3.2 Test metal. When test metal (see 6.6.7) is required, the value obtained for each of the yield strength, reduction of area, and Charpy impact resistance attributes for each respective test specimen shall be in compliance with the requirements of TABLE II for the yield strength specified on the applicable engineering drawing.

3.4.3.3 Value difference. When required, a value difference (see 6.6.8) shall be calculated for each of the following three mechanical property attributes of the forging: yield strength, reduction of area, and Charpy V-notch impact resistance.

3.4.4 Production article. For each of the forgings inspected which requires an adjusted value (see 6.6.9), the adjusted value for each of the yield strength, reduction of area, and Charpy impact resistance attributes of the test metal shall be in compliance with the requirements of TABLE II for the yield strength specified on the applicable engineering drawing. For those forgings that do not require an adjusted value, all the applicable requirements listed in this specification for that forging grade shall be complied with. (see TABLE I)

3.4.5 Mechanical property requirements. When required, the mechanical properties of the forgings shall conform to the following



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requirements.

3.4.5.1 Yield strength. When required, yield strength shall be as specified on the applicable drawings, in the contract, or in the order.

3.4.5.2 Reduction of area. When required, the minimum percent reduction of area for individual specimens shall be as specified in TABLE II or as specified on the applicable drawing.

3.4.5.3 Charpy V-notch impact resistance. When required, the minimum value for individual Charpy V-notch impact resistance specimens shall be as specified in TABLE II for the average yield strength or as specified on the applicable drawing.

3.4.5.4 Hardness. When required, hardness values for any forgings shall be as specified on the applicable engineering drawing or in the contract or order.

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TABLE II. Mechanical properties.

Yield strength (0.10 percent offset) p.s.i.	Minimum reduction of area (Single value) percent (%)		Minimum Charpy V-notch impact resistance at -40F + 2F (Single value) foot-pounds	
	Trans.	Long.	Trans.	Long.
60,000 - 69,999	40	50	55	85
70,000 - 79,999	40	50	50	80
80,000 - 89,999	40	50	45	70
90,000 - 99,999	40	50	40	60
100,000 - 109,999	40	50	35	50
110,000 - 119,999	40	50	35	50
120,000 - 129,999	40	50	35	45
130,000 - 139,999	35	45	30	40
140,000 - 149,999	30	40	25	35
150,000 - 159,999	30	40	20	30
160,000 - 169,999	25	35	15	25
170,000 - 180,000	25	35	15	20

3.4.5.5 Transverse properties. Unless otherwise specified on an applicable engineering drawing, mechanical tests shall be taken in the transverse direction, i.e., such that the lengthwise axis of the test specimen is at right angles to the grain flow of the forging. When the thickness of the sample or the forging prevents the preparation of transverse specimens, longitudinal specimens for the determination of yield strength, reduction of area, or impact resistance shall apply.

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3.5 Process controls.

3.5.1 Heat treatment. When mechanical properties are specified (see 1.2.2 and 6.2) the minimum heat treat process shall consist of normalizing, austenitizing, quenching in an agitated liquid, and tempering. The heat treatment shall be applied to the whole of the forging and never to a portion only, except when localized heat treating is specified in the drawing.

3.5.2 Repair welding. Unless approved by the Contracting Officer prior to repairing forgings, forgings shall not be repaired by welding. When welding is permitted by the Contracting Officer, with concurrence of the applicable engineering activity and responsible Product Assurance Directorate, it shall be done prior to final heat treatment. The contractor's request shall include all information necessary for analysis and decision(see 6.4). The responsible development engineer shall assist the Contracting Officer and quality control in making the repair weld decision.

3.5.2.1 Test plate. The mechanical properties of the welded test plate (see 6.4) shall be submitted with the request for repair welding. The test plate shall be prepared in accordance with paragraph 5.19 of AWS D1.1 titled "Groove Weld Plate Qualification Test for Plate of Limited Thickness". The side bend specimen call-out shall be disregarded. The welded test plate shall be the same material as the forging and shall have undergone the same heat treatment process as the forging. The

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test plate shall be of such size that three transverse tension specimens and three transverse Charpy V-notch impact specimens can be obtained. These specimens shall be tested as specified in ASTM E8 and ASTM E23, respectively. The mechanical properties of the specimens shall be in accordance with the applicable drawing.

3.6 Material soundness.

3.6.1 Surface. All forgings shall be free from cracks, forging laps, seams and shuts.

3.6.2 Internal. When specified in the contract or order (see 6.2), the soundness of steel materials used in forgings shall be determined by macroetching. For acceptance, the material shall comply with the requirements of ASTM E381 as follows:

a. Carbon steel - Equal to or better than S-3, R-2, C-3 inclusive shall be acceptable.

b. Alloy steel

36 square inches or less:

Acceptable to S-3 inclusive

to R-2 inclusive

to C-2 inclusive

Over 36 square inches:

Acceptable to S-3 inclusive

to R-3 inclusive

to C-3 inclusive

3.6.3 Cleanliness. When cleanliness is specified (see 6.2), bars and billets shall conform to the requirements of AMS 2301.

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3.6.4 Wake bar. No wake bars shall be allowed for retesting for grades A, A1, B, and C forgings except those allowed by 4.7.1.1 and 4.7.1.2. Wake bars are not necessary for grade D forgings.

3.7 Metallographic requirements. When specified in the invitation for bids, contract, or order, the austenitic grain size and metal flow patterns shall conform to the requirements of the applicable engineering drawings, if stated thereon.

3.8 Magnetic particle inspection. Unless otherwise specified in the invitation for bids, contract, or order, the forgings shall be subject to magnetic particle inspection. No cracks are acceptable. Cracks include heat treating cracks, shrink, laps, flakes, and bursts.

3.9 Dimensions and tolerances. Dimensions and dimensional tolerances shall be as specified on the applicable engineering drawing.

3.9.1 Draft angle. The draft angle shall be seven degrees maximum. Draft angle is additive to feature tolerance. Any matching draft angle shall be acceptable.

3.10 Surface roughness. Surface roughness shall be as specified on the applicable drawing.

3.11 Identification marking. Forgings shall be marked as specified on the drawing and in accordance with MIL-STD-130 and shall include the manufacturer's identification number and heat number or a heat code. When a heat code is used, a cross reference to the heat number shall appear on the test reports and packing slips.

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3.12 Records. The contractor shall maintain records of the chemical and physical properties for forging analysis (see 6.4).

3.13 Workmanship. The forging shall not contain defects which, due to their nature, degree, or extent, prevent the fulfillment of the requirements of this specification. The existence of defects which cannot be removed by machining the forging to its finished dimensions shall cause the forging to be rejected even if all other requirements of the specification are met.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, 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 that supplies and services conform to prescribed requirements.

4.1.1 The inspections set forth in the specification shall become a part of the contractors overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of his responsibility for assuring that all supplies submitted to the Government for acceptance conform to all requirements of the

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contract.

4.2 Quality assurance terms and definitions. The quality assurance terms and definitions used in this specification are in accordance with MIL-STD-109.

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

- a. First article inspection (see 4.5).
- b. Quality conformance inspection (see 4.6).

4.4 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the test conditions specified in the applicable test method document or paragraph(s) in the specification.

4.5 First article inspection. A first article shall be submitted for inspection in accordance with contract requirements (see 6.2.d). The first article shall be representative of the production processes to be used during quantity production. The first article shall be subjected to all inspection specified herein (see 4.5.2 and 4.6) and such other inspections as is necessary to determine that all the requirements of the contract have been met.

4.5.1 First article. Unless otherwise specified in the contract, (see 6.2.d), the first article shall consist of a minimum of one forging.

4.5.2 Inspection provisions.

4.5.2.1 Grade A and A1 forgings. Mechanical property tests: yield strength, reduction of area, Charpy impact resistance, and

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hardness; shall be conducted on the test coupon (see 6.6.6) obtained by sectioning the forging. The same tests shall be conducted on the test metal (see 6.6.7) of the forging. The mechanical properties shall comply with 3.4.3.1, 3.4.3.2, and 3.4.5.4. A value difference (see 6.6.8) shall be computed for each of the following mechanical properties: yield strength, reduction of area, and Charpy impact resistance.

4.5.2.2 Grade B forgings. Mechanical property tests: yield strength, reduction of area, Charpy impact resistance, and hardness shall be conducted on the test metal (see 6.6.7) of the forging. The mechanical properties shall comply with 3.4.3.2 and 3.4.5.4.

4.5.2.3 Grade C forgings. Mechanical property tests: yield strength, reduction of area, Charpy impact resistance, and hardness shall be conducted on the test coupon (see 6.6.6) obtained by sectioning the forging. The mechanical properties shall comply with 3.4.3.1 and 3.4.5.4.

4.5.2.4 Grade D forgings. Mechanical property tests for hardness shall be conducted on the surface of the forgings. The mechanical property shall comply with 3.4.5.4.

4.6 Quality conformance inspection. Quality conformance inspections shall be as specified in TABLE III.



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TABLE III. Quality conformance inspection.

<u>Characteristic</u>	<u>Requirement Paragraph</u>	<u>Examination or Test Paragraph</u>	<u>Test Method Paragraph</u>
Chemical composition	3.2	4.6.4.6	4.6.7.1
Dimensional	3.9	4.6.7.9	4.6.7.9
Weld repair	3.5.2	4.6.5.1	4.6.7.6
Surface soundness	3.6.1	4.6.5.2.1	4.6.5.2.1
Internal soundness	3.6.2	4.6.5.2.2	4.6.7.7
Metallographic	3.7	4.6.5.2.2.1	4.6.7.7
Cleanliness	3.6.3	4.6.5.3	4.6.7.8
Identification marking	3.11	4.6.5.4	4.6.5.4
Packaging	5.	4.6.5.6	4.6.5.6
Workmanship	3.13	4.6.5.5	4.6.5.5
Yield strength	3.4.4, 3.4.5.1	4.6.4	4.6.7.2
Reduction in area	3.4.4, 3.4.5.2	4.6.4	4.6.7.3
Charpy impact resistance	3.4.4, 3.4.5.3	4.6.4	4.6.7.4
Hardness	3.4.5.4	4.6.4	4.6.7.5

4.6.1 Inspection lot. An inspection lot shall consist of all forgings that are produced from the same individual melt of steel and produced to the same drawing; and that, if heat treated, are heat treated together by batch procedures or being passed consecutively and continuously through a continuous-type of heat treatment process.

4.6.2 Mechanical property acceptance testing. In the event test

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metal (see 6.6.7) or coupon metal (see 6.6.6) is of insufficient size to accommodate at least two specimens each, additional forgings may be tested as directed by the procuring activity.

4.6.2.1 Sample forgings. Forgings (see 6.6.1) that require mechanical testing, but which are supplied in other than the final heat-treated condition, shall be sampled as directed by the procuring activity. The sample forgings (see 6.6.1) shall be given the final heat treatment and shall be tested to demonstrate the capability of obtaining the specified mechanical properties.

4.6.2.2 Test metal removal. Unless otherwise specified, test metal which is not used in quality conformance testing shall be removed before shipment of forgings.

4.6.2.3 Test values. When a value difference (see 6.6.8) is calculated, transverse and longitudinal test values shall not be intermixed.

4.6.2.4 Production change. A new set of value differences (see 6.6.8) shall be calculated and used whenever the alloy system or grade has been changed during production or whenever the heat treat procedure has been changed during production.

4.6.3 Sampling. Unless otherwise specified in the contract or in this specification, the formation, size, and presentation of lots for acceptance inspection shall be in accordance with MIL-STD-105, and shall be the responsibility of the contractor. The Government reserves the right to disapprove in its entirety, or in part, the contractor's method of presentation.

4.6.3.1 For chemical composition. One sample shall be selected

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from each melt of steel represented in the lot for comparison with the ladle analysis.

4.6.3.2 For dimensions, tolerances, and surface roughness. In an inspection lot of ten forgings or less, each forging shall be inspected. In an inspection lot of more than ten forgings, ten forgings plus one forging from each successive group of ten forgings shall be inspected. Dimensions, tolerances, and surface roughness shall be measured for conformance to the applicable drawing.

4.6.3.3 For mechanical properties. When mechanical properties are specified, the sampling plans (including 100% inspection) for Grade A, Grade A1, Grade B, Grade C, and Grade D forgings shall be as follows:

4.6.3.3.1 Grade A. One hundred percent inspection (see 4.6.4.1).

4.6.3.3.2 Grade A1. The test metal (see 6.6.7) of 20 percent of the forgings in each inspection lot shall be tested for mechanical properties. For lot sizes of ten forgings or less, the test metal of two forgings shall be tested (see 4.6.4.2).

4.6.3.3.3 Grade B. One hundred percent inspection (see 4.6.4.3).

4.6.3.3.4 Grade C. The test coupons (see 6.6.6) from a minimum of two (2) forgings in each inspection lot shall be tested for mechanical properties (see 4.6.4.4).

4.6.3.3.5 Grade D. Twenty percent of the forgings in each inspection lot shall be hardness tested (see 4.6.4.5).

4.6.4 Tests.

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4.6.4.1 Grade A forgings. The test metal (see 6.6.7) of each forging shall be tested for the mechanical properties: yield strength, reduction of area, Charpy impact resistance, and hardness. By application of value differences (see 6.6.8), computed in 4.5.2.1, adjusted values (see 6.6.9) shall be calculated for yield strength, reduction of area, and Charpy impact resistance, and shall comply with 3.4.4 for each forging. Hardness testing of the test metal of each forging shall be conducted in accordance with 4.6.7.5 and shall consist of two indentations. Individual hardness values of the test metal of each forging shall comply with 3.4.5.4. Failure of each forging to comply with both requirements (3.4.4 and 3.4.5.4) shall be cause for rejection of the forging.

4.6.4.2 Grade A1 forgings. Sampling for mechanical properties of each inspection lot shall be as specified in 4.6.3.3.2. The test metal (see 6.6.7) of each forging in the sample shall be tested for the mechanical properties: yield strength, reduction of area, Charpy impact resistance, and hardness. By application of value differences (see 6.6.8), computed in 4.5.2.1, adjusted values (see 6.6.9) shall be calculated for yield strength, reduction of area, and Charpy impact resistance and shall comply with 3.4.4 for each forging in the sample. Hardness testing of the test metal of each forging in the sample shall be conducted in accordance with 4.6.7.5 and shall consist of two indentations. Individual hardness values of the test metal of each forging in

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the sample shall comply with 3.4.5.4. Lot acceptance criterion 1 shall require that each forging in the sample comply with 3.4.4 and 3.4.5.4.

In addition to the preceding tests, a hardness comparison test, conducted in accordance with 4.6.7.5 and consisting of two indentations, shall be performed on the forging surface at different, but approximately the same relative locations on each forging in the lot. Lot acceptance criterion 2 shall require that the average hardness of each forging not in the sample shall be within plus or minus 25 Brinell hardness numbers, or the equivalent thereof, of the average hardness of the sample.

Failure to comply with both lot acceptance criteria shall be cause for rejection of the inspection lot.

4.6.4.3 Grade B forgings. The test metal (see 6.6.7) of each forging shall be tested for the mechanical properties: yield strength, reduction of area, Charpy impact resistance, and hardness. Mechanical properties shall comply with 3.4.5. Failure to comply shall be cause for rejection of the forging.

4.6.4.4 Grade C forgings. Destructive sampling for mechanical properties shall be as specified in 4.6.3.3.4. The test coupons (see 6.6.6) of the forgings in the sample (which are obtained by sectioning the forgings) shall be tested for mechanical properties: yield strength, reduction of area, Charpy impact resistance, and hardness. Hardness testing of the test coupons of each forging in the sample shall be conducted in accordance

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with 4.6.7.5 and shall consist of two indentations. Lot acceptance criterion 1 shall require that the mechanical properties: yield strength, reduction of area, Charpy impact resistance, and individual hardness values of each forging in the sample shall comply with 3.4.5.

In addition to the preceding tests, a hardness comparison test, conducted in accordance with 4.6.7.5 and consisting of two indentations, shall be performed on the forging surface at different, but approximately the same relative locations on each forging in the lot. Lot acceptance criterion 2 shall require that the average hardness of each forging not in the sample shall be within plus or minus 25 Brinell hardness numbers, or the equivalent thereof, of the average hardness of the sample.

Failure to comply with both lot acceptance criteria shall be cause for rejection of the inspection lot.

4.6.4.5 Grade D forgings. Sampling for mechanical properties shall be as specified in 4.6.3.3.5. A hardness test, conducted in accordance with 4.6.7.5 and consisting of two indentations, shall be performed on the surface of each forging in the sample at approximately the same locations. Each individual hardness value in the sample shall comply with 3.4.5.4. Failure of any forging in the sample to comply shall be cause for rejection of the represented inspection lot.

4.6.4.6 Chemical composition. The chemical composition shall be determined for each heat of steel used in making the forgings for

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compliance with the requirements of 3.2 using the method of

4.6.7.1.

4.6.5 Examinations.

4.6.5.1 Weld repair. Each forging which has been repaired by welding shall be examined for compliance with 3.5.2 by the method of 4.6.7.6.

4.6.5.2 Material soundness.

4.6.5.2.1 Surface. Unless otherwise specified, the surfaces of each forging shall be visually examined for compliance with 3.6.1. Unless otherwise specified in the contract or order, the forging shall be subjected to magnetic particle inspection in accordance with ASTM A275.

4.6.5.2.2 Internal. When specified in the contract or order, the soundness of steel material used for the forgings shall be determined by macroetching to comply with the requirements of 3.6.2.

4.6.5.2.2.1 Metallographic. When specified in the contract or order, the forging section shall be subjected to macroetching to determine compliance with 3.7.

4.6.5.3 Cleanliness. When specified in the contract or order, the cleanliness of the steel material used for the forgings shall be subjected to inspection per AMS 2301.

4.6.5.4 Identification marking. Forgings shall be examined visually to determine compliance with marking requirements of 3.11.

4.6.5.5 Workmanship. Forgings shall be visually examined to

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determine compliance with the requirements of 3.13. Forgings displaying evidence of poor workmanship, such as the presence of seams, laps, injurious segregation, cracks, flakes, etc., and the presence of burrs, nicks, fins, etc. shall be cause for rejection.

4.6.5.6 Packaging. Packaging shall be examined visually and in accordance with MIL-P-14232 to determine compliance with the packaging requirements of Section 5.

4.6.6 Test specimens.

4.6.6.1 Tension specimens. Unless otherwise specified, tension test specimens shall be machined to the form and dimensions of the 0.500 (0.505) inch, 0.350 (0.357) inch, or 0.250 (0.252) inch diameter specimen as shown in ASTM E8. Diameters in parenthesis refer to NOTE 6 of FIG. 8 titled "Standard 0.500-in. (12.5mm) Round Tension Test Specimen with 2-in. (50mm) Gage Length", of ASTM E8.

4.6.6.2 Charpy impact specimens. Charpy V-notch impact specimens shall be machined to the form and dimensions of the standard 0.394 inch by 0.394 inch by 2.165 inch specimen shown in ASTM E23. The notch shall be oriented as shown on the applicable drawing.

4.6.7 Test methods.

4.6.7.1 Chemical composition. Chemical analysis shall be conducted in accordance with Method 111 or 112 of FED-STD-151.

In case of dispute, Method 111 shall be used for referee analysis.



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4.6.7.2 Yield strength. Yield strength shall be determined by the offset method in accordance with ASTM E8. The limiting offset shall be 0.10 percent (0.001 inch per inch of gauge length). The rate of stress application when determining the yield strength shall not exceed 100,000 pounds per square inch per minute.

4.6.7.3 Reduction of area. Reduction of area shall be determined in accordance with ASTM E8.

4.6.7.4 Charpy impact resistance. Charpy V-notch impact tests shall be conducted in accordance with ASTM E23. The temperature of the test specimen at impact shall be minus 40 degrees F plus or minus 2 degrees F.

4.6.7.5 Hardness. Hardness tests shall be conducted in accordance with ASTM E10 or ASTM E18, as applicable.

4.6.7.6 Weld repair. Each forging which has been repaired by welding shall be examined by standard methods such as magnetic particle inspection, radiographic inspection, dimensional checks, etc., to determine compliance with 3.5.2.

4.6.7.7 Macroetch. Macroetching shall be conducted in accordance with ASTM E340.

4.6.7.8 Cleanliness. Cleanliness shall be conducted in accordance with AMS 2301.

4.6.7.9 Dimensions and surface roughness. Forging dimensions shall be measured or gaged by using standard methods using appropriate instruments. Surface roughness shall be examined

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visually; in case of dispute, a Government approved measuring instrument shall be used.

4.7 Interpretation of test results.

4.7.1 Rejection. Any forging which fails any one of the quality conformance inspections or any other required inspection specified in the contract or order shall be rejected.

4.7.1.1 Obvious defects. If rejection of a forging can be traced to the presence of obvious defects (e.g non-metallic) in the failed test specimen, the test values obtained on that specimen may be disregarded subject to the approval of the contracting officer. Two wake bars (see 6.6.10) shall be substituted for the defective specimen. When the wake bars have been substituted, failure of the forging to meet specification requirements based on test results from the wake specimens shall be cause for rejection of the forging, whether or not the wake bars also exhibits defects.

4.7.1.2 Defective machined specimens, faulty test equipment, and faulty testing methods. If either a defectively machined test specimen, faulty test equipment, or faulty operation of the testing equipment results in the rejection of a forging, the test values obtained from such specimens may be disregarded subject to the approval of the Contracting Officer, and another specimen from the same forging location may be substituted for each such specimen.

4.7.1.3 Rejected lots. When a test specimen fails to comply

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with the applicable requirements of this specification for reasons other than that specified in 4.7.1, retesting and resubmission of each rejected lot shall be allowed to the extent permitted in FED-STD-151.

4.7.1.4 Check tests. From any lot of forgings found acceptable under prescribed inspection, the Government may designate any forging as a check forging. Such a forging shall be tested at a facility to be designated by the Government, and shall be subjected to any or all tests specified herein. If the forging fails to comply with the requirements of the applicable engineering drawing and Table II, two additional forgings shall be tested. If both forgings comply with all requirements, the lot shall be accepted. If either forging fails to comply with all the requirements, the lot shall be rejected.

4.7.1.5 Reporting of tests. The results of all tests and retests, chemical and mechanical, made on each forging (see 6.6.1), its test coupon (see 6.6.6), and its test metal (see 6.6.7) shall be recorded and maintained. Results shall be provided to the Government procuring activity, the Contracting Officer, or the Government representative as necessary (see also 3.12).

## 5. PACKAGING

5.1 Preservation and packaging. Cleaning, drying, preservation and packaging shall be in accordance with the manufacturer's commercial practice.

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5.2 Packing. All forgings shall be packed for shipment in a manner to ensure carrier acceptance and safe delivery at destination.

5.2.1 Large forgings. Large forgings having projections which may be damaged in handling shall be crated.

5.2.2 Small forgings. Small rough forgings shall be packed rigidly in boxes, or shall be shipped in burlap bags.

5.3 Marking. Marking shall be in accordance with MIL-STD-129 in addition to any special marking required in the contract or order.

6. NOTES

6.1 Intended use.

a. Grades A, A1 and B cover steel forgings for critical applications and highly stressed applications formerly covered by MIL-S-45203, now cancelled, and superseded by this specification.

b. Grades A, A1 and B shall not be used for forgings for gun tubes, breech rings, bomb bodies, recoil and recuperator pistons and cylinders, and some shells.

c. Grades C and D cover steel forgings for general purpose applications such, for example, as gear blanks and yokes, formerly covered by MIL-S-13048, now cancelled, and superseded by this specification.

d. Gun tube forgings should be procured under MIL-S-46119. Breech ring forgings should be procured under MIL-R-10185.

e. This specification is not intended to be used in the

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procurement of bars and billets for reforging.

6.2 Ordering data. Procurement documents should specify the following:

- a. Title, number and date of the specification.
- b. Grade of forging required (see 1.2.1).
- c. Applicable drawing number(s), if required.
- d. A first article and instructions for submission, if required (see 3.1).
- e. Chemical composition, if specified (see 3.2.1).
- f. Requirement for certificate of chemical analysis (see 3.2.3).
- g. Cleanliness of material, if required (see 3.6.3).
- h. Yield strength, if required (see 3.4.5.1).
- i. Reduction of area, if required (see 3.4.5.2).
- j. Charpy V-notch impact resistance, if required (see 3.4.5.3).
- k. Hardness, if required (see 3.4.5.4).
- l. Macroetching requirements, if required (see 3.6.2).
- m. Metallographic requirements, if required (see 3.7).
- n. Magnetic particle inspection, if required (see 3.8).
- o. Heat treat condition, if other than annealed or normalized (see 3.5.1).

6.3 When warranted, the contract should specify the application of MIL-Q-9858 or MIL-I-45208, as appropriate.

6.4 Data requirements. When this specification is used in

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an acquisition which incorporates a DD Form 1423, Contract Data Requirements List (CDRL), 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 CDRL incorporated into the contract.

When the provisions of DOD-FAR Supplement 52.227-7031 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 the purchase order requirements. Deliverable data required by this specification is cited in the following paragraphs:

<u>Paragraph No.</u>	<u>Data Requirement Title</u>	<u>Applicable DID No.</u>
3.1	First Article Inspection	DI-T-4902
3.2.3	Certification Data Report	UDI-T-23264
3.5.2	Request For Repair Welding Approval For Forgings Or Castings	DI-P-1637
3.5.2.1, 3.12	Chemical and Physical Properties for Forging Or Casting Analysis Report	DI-P-1638

(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).

6.5 Test metal from forgings not sampled should be removed from the forging and identified with the forging number.

#### 6.6 Definitions.

6.6.1 Forging. Forging for the purpose of this specification shall consist of a mass of metal of sufficient dimensional size

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and volume to provide both the required body of the forging from which a finished component is to be manufactured and the required integral test metal or prolongation.

6.6.2 Heat treat lot. A heat treat lot consists of two or more production forgings made from the same heat of steel and either simultaneously heat treated in a batch type furnace or consecutively heat treated in a continuous belt fed heat treatment furnace.

6.6.3 Prolongation. A prolongation, for purposes of inspection and testing, is the same as test metal (see 6.6.7) and is defined as an integral extension beyond the body of the forging from which test specimens are to be taken for mechanical property tests. The diameter and mass distribution of the prolongation shall not be less than those of the forging at a point coincident with the end of the forging from which it extends.

6.6.4 Retest. A retest is any test made after the results of the original test are known.

6.6.5 Supplies. Supplies includes one or more forgings.

6.6.6 Test coupon. Test coupon is a mass of metal taken from the body of a forging and includes at least a portion of the critical areas for which required mechanical properties shall be met. The test coupon is of sufficient dimensional size to provide the necessary chemical and mechanical property test specimens.

6.6.7 Test metal. Test metal is additional metal which is

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integrally forged and integrally heat treated material external to the body of the forging. The test metal shall be of sufficient size and volume to provide all necessary test specimens for chemical and mechanical property tests as required.

The diameter and mass distribution of the test metal shall not be less than those of the forging at a point coincident with the end of the forging from which it extends.

6.6.8 Value difference. Value difference is that difference between the average value of the test for each mechanical property attribute except hardness of the material test coupon and the average value of the test for the same mechanical property attribute except hardness of the respective test metal. The value difference may be plus or minus. Example: Value difference = (First article test coupon average value) - (First article test metal average value).

6.6.9 Adjusted value. An adjusted value is a value calculated by algebraically adding the particular value difference to the particular mechanical property attribute value of the test metal. Example: Adjusted value = (Production article test metal value) + (value difference).

6.6.10 Wake bar. A wake bar is a test specimen which is substituted for another test specimen which has been discarded because of the presence of local defects caused by or overlooked in the preparation of the specimen. The wake bar should be taken as close as possible to the site of the original test specimen.



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6.7 Finish-machine contour. The contour of the finish-machined component including important fillets should be indicated on the forging drawing or on a separate drawing furnished by the Contracting Officer.

6.8 International interest. Certain provisions of this specification (3.4.5.3 and 4.6.7.4), are the subject of international standardization agreement NATO STANAG NO. 4020: QSTAG-129.

When amendment, revision or cancellation of this specification is proposed, which affects or violates the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels, including departmental standardization offices, if required.

6.9 Metric units. When metric units are required, units for degree Fahrenheit, pounds per square inch, square inch and inch 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 SI Unit</u>
degree Fahrenheit	$t^{\circ}\text{C} = t^{\circ}\text{F} - 32 / 1.8$	=	degree Celsius ( $^{\circ}\text{C}$ )
pounds per square inch	6.894	=	Pascal (Pa)
square inch	6.452	=	(Cm) <sup>2</sup>
inch	2.54	=	Centimeter (cm)

Note: Conversion factors can be associated with ASTM E 380 entitled "Metric Practice Guide".

6.10 Changes from previous issue. Asterisks are not used in this

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revision to identify changes with respect to the previous issue,  
due to the extensiveness of the changes.

Custodian:

Army-MR

Review activities:

Army-AR

User activities:

Army-ME, AT

Preparing activity:

Army-MR

Project No. FORG-A054

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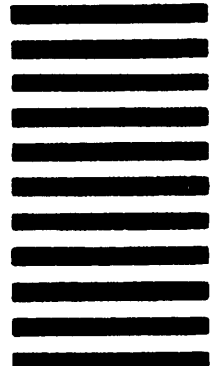
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