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INTERNATIONAL
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS-F-7190

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Submitted for recognition as an American National Standard

Forging, Steel, For Aircraft/Aerospace Equipment and Special Ordnance Applications

NOTICE

This document has been taken directly from U.S. Military Specification MIL-F-7190B, Amendment 1, and contains only minor editorial and format changes required to bring it into conformance with the publishing requirements of SAE technical standards. The initial release of this document is intended to replace MIL-F-7190B, Amendment 1. Any part numbers established by the original specification remain unchanged.

The original Military Specification was adopted as an SAE standard under the provisions of the SAE Technical Standards Board (TSB) Rules and Regulations (TSB 001) pertaining to accelerated adoption of government specifications and standards. TSB rules provide for (a) the publication of portions of unrevised government specifications and standards without consensus voting at the SAE Committee level, and (b) the use of the existing government specification or standard format.

Under Department of Defense policies and procedures, any qualification requirements and associated qualified products lists are mandatory for DOD contracts. Any requirement relating to qualified products lists (QPL's) has not been adopted by SAE and is not part of this SAE technical document.

1. SCOPE:

1.1 Scope:

This specification covers steel forgings suitable for use in the construction of aircraft/aerospace equipment, special ordnance, and related accessories.

1.2 Classification:

Steel forgings shall be furnished in the following grades. If grade is not specified, then Grade A is required (see Table I and 6.2.1).

Grade A - Testing and inspection
Grade B - Testing and inspection
Grade C - Testing and inspection

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2. APPLICABLE DOCUMENTS:

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

2.1 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-H-6875 Heat Treatment of steels (Aircraft Practice), Process for

FED-STD-151 Metals, Test Methods

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage
MIL-STD-183 Continuous Identification Marking of Iron and Steel Products
MIL-STD-1949 Inspection Process, Magnetic Particle
MIL-STD-6866 Inspection, Penetrant Method of

3. REQUIREMENTS:

3.1 Materials:

Forgings shall be produced from cast ingots or from a wrought stock conforming to the requirements of the applicable material specification and applicable drawing, as specified by the contract or purchase order. Materials shall be worked prior to and during the forging operation to produce a wrought metallurgical structure.

3.1.1 Cleanliness: Cleanliness rating requirements shall be as required by the material specification or as agreed upon between the purchaser and contractor.

3.1.2 Mill heat identification: Material to be used in all forgings shall be identified by mill heats within each ingot when required by the purchaser.

3.1.2.1 Alloy steel and corrosion resistant steel: For forgings of alloy steel and corrosion resistant steel, each bar, billet, bloom, or forging multiple received from the mill shall be marked with the mill heat number. Bar less than 0.500 inches in diameter or width shall be securely bundled and identified with a durable tag marked with the purchase order, specification number and/or grade, heat number, nominal size and manufacturer's identification. The tag shall be attached to each bundle. As an alternative, the manufacturer may box the bars and mark the box with the same identification as listed for bundles.

3.1.2.2 The mill heat number or an appropriate code, as agreed upon by purchaser, shall appear on individual forgings and all certification pertaining to these forgings.

3.1.3 Forging stock specification: Forge shop shall determine that the forging stock conforms to the requirements of the applicable material specification. Forging shop shall obtain complete test reports from the mill on each heat of forging stock.

3.2 Forging process:

Forgings shall be formed to the specified configuration and dimensions. Sufficient working shall be applied to the material to provide the specified grain size and a wrought structure throughout the forging.

3.2.1 Forging procedures: Forger shall establish forging sequence and other processing procedures, such as heat treating and cleaning, suitable for producing high quality forgings. These procedures shall be documented on operation sheets for the purpose of maintaining consistent practices and shall not be changed without the specific approval and consent of the purchaser.

3.2.2 Heat equipment control: Forging furnaces shall be properly instrumented to control heating of forging stock to ensure compliance with 3.5.

3.2.3 Forging flow pattern control: The forging techniques employed shall produce, except in the area of die forging parting plane which contains end grains, an internal grain flow pattern such that it shall essentially conform to the structural shape of the part and shall be free from both reentrant and sharply folded flow lines.

3.2.3.1 First article forging: Sections taken from a test forging at locations designated on the applicable drawing shall be suitably prepared and etched to reveal the grain flow developed in the forging. When the specified alloy is not conducive to good grain flow determination, a suitable alloy exhibiting good grain flow etch response and having equivalent forgeability may be substituted. The grain flow pattern shall be in essential agreement with the drawing or shall be as agreed upon by the purchaser and vendor and as provided in 3.2.3. This procedure shall be repeated following any major change in forging technique or die design. When the test forging is of the same alloy as specified, the sections may also be used for metallographic examination and hardness surveys. Photographs of each section of adequate quality and magnification to resolve detailed main flow-pattern shall be furnished to the purchaser and one set shall be retained by the forger.

3.2.4 Welding: Repair welding shall not be permitted, except as indicated on applicable drawings and approved by the procuring activity.

3.2.5 Cleaning: All forgings shall be thoroughly cleaned by tumbling, machining, shot, grit or sand blasting, pickling, or other process approved by the purchaser. Local surface imperfections may be removed by blending to the adjacent as-forged surface provided all drawing requirements are met. For parts which will be subjected to penetrant method of nondestructive testing, concurrence of the purchaser is required when the cleaning method does not include etching.

3.3 Heat treatment:

Forgings shall be heat treated in accordance with MIL-H-6875 to produce the condition and properties specified, unless the purchaser issues instructions modifying this requirement. When heat treatment is not specified, carbon and alloy steel forgings shall be furnished in the normalized or normalized and tempered condition and corrosion and heat resistant steel forgings shall be furnished in the solution heat treated or annealed condition.

3.3.1 Heat treatment shall be performed on the entire forging, not on a localized section.

3.3.2 All forgings shall be cleaned of contaminants before heat treatment.

3.4 Heat treatment records:

The forger shall keep records of all furnace charts for each heat treat batch or cycle. Unless otherwise specified, records shall be kept on file for a minimum of five years. Information retained shall include set temperature, time, and furnace loading instructions.

3.5 Metallographic structure:

The microstructure of the finished forging shall be essentially uniform and free from defects, and shall be free from indications of overheating or burning.

3.6 Quality:

Forgings shall be ordered to the grades specified in Table 1, and shall be subjected to the tests as indicated therein. Tests shall be conducted in accordance with the methods in 4.3.

TABLE 1. Required tests for forgings.

Grade	Tensile 1/	Hardness	Magnetic particle or fluorescent penetrant	Grain flow	Composition
A	X	X	X	X	X
B	X	X	---	---	X
C	---	X	X	---	X

1/ Tensile tests required only for forgings furnished in the final heat treated condition. The frequency of testing shall be as required by Table II.

3.7 Hardness:

Hardness of the forgings shall be specified by the purchaser (see 6.2).

3.8 Nondestructive inspection:

Unless otherwise specified, forgings shall be inspected by nondestructive methods as required in Table I based on specified forging grade (see 4.3.4). The purchaser shall specify the acceptance criteria.

3.9 Dimensions and tolerances:

Dimensions and tolerances shall be as specified on the applicable drawing or purchase documents.

3.10 Identification of product:

Forgings shall be individually marked in accordance with MIL-STD-183, including the serial number when required.

3.11 Workmanship:

Forgings shall be uniform in quality and condition, and shall be free from tears, cracks, seams, laps, internal ruptures, imbedded scale, segregation, or other defects which may detrimentally affect the suitability for the purpose intended.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

Unless otherwise specified in the contract or purchase order, the forger is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the forger may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the purchaser. The purchaser reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of inspections:

4.2.1 Results of all tests and location of test specimens shall be reported to the purchaser.

4.2.2 Instructions issued by the purchaser requiring more stringent quality conformance sampling procedures shall take precedence over the requirements of this specification.

4.2.3 Tests for properties of a given heat, as required by the applicable material specification, need not be repeated on forgings from the heat provided that these tests have been performed on the forging stock, heat identity of the forgings is maintained as required by 3.1.2, and reports of tests conducted are available.

4.3 Test methods and specimen preparation:

Test specimens shall be prepared and tested in accordance with the applicable methods of FED-STD-151. The frequency of sampling and testing shall be as specified in Table II, based on specified forging grade.

TABLE II - Quality conformance inspection

Tests and inspections	Requirement	Test method	Sampling and testing frequency
Composition	3.6	4.3	Each mill heat
Cleaning	3.2.5	Visual	Each forging
Metallographic structure	3.5	4.3.1	One forging from the first lot of each configuration: Grade A
Hardness	3.7	4.3	See 4.3.3
Grain flow	3.2.3, 3.2.3.1	4.3.1	One forging from the first lot of each configuration: Grade A
Heat identification	3.1.2.2	Visual	Each applicable forging
Nondestructive inspection	3.8	4.3.4	Each forging for Grades A & C
Tensile Properties	3.6	4.3	One sample per lot for Grades A & B

4.3.1 Metallographic structure: Grain size determinations, grain flow pattern, and other metallographic examinations shall be made in accordance with FED-STD-151.

4.3.2 Mechanical properties: Unless otherwise specified, when tensile testing of a forging is required the tensile test specimens shall be taken from the locations in the forgings as specified by the purchaser. When there is an agreement between forger and purchaser not to destroy a forging because of excessive cost or forging size, test specimens shall be taken from a full size prolongation of the forging in the area of maximum section reduction. The direction for testing shall be as specified by the purchaser. Variations from properties because the section size, or test specimen orientation, shall require the approval of the purchaser.

4.3.2.1 Varieties in properties prolongations shall not be parted from the forgings until all required thermal treatments required to be performed by the forger have been completed.

4.3.2.2 When it is not practicable to take a specimen from a forging or from a prolongation, a representative test bar may be used when agreed upon between purchaser and forge shop. The representative test bar shall be from the same heat of material as the forgings and shall have been heat treated with the parts. The percent reduction given the representative test bar shall not be greater than the minimum amount of reduction given the forging.

4.3.2.3 When parts are made in multiple from a single forging, i.e., forged in one piece and machined apart, tests on the large single forging shall govern the individual units.

4.3.3 Hardness: Forgings shall be sampled for hardness tests in accordance with Table III.

TABLE III - Hardness test sampling requirements.

Condition	Quantity 1/	Sample size
Thermal treatment other than final heat treatment.	1 - 20	All
	21 - 100	25% (20 pcs. min.)
	Over 100	10% (25 pcs. min.)
Final heat treatment	1 - 44	All
	45 - 65	44
	66 - 110	60
	111 - 180	67
	181 - 300	73
	301 - 500	78
	501 - 800	80
	Over 800	10% (85 pcs. min.)

1/ In each heat treat lot of same forging lot.

4.3.4 Nondestructive inspection: Each Grade A and C forging shall be magnetic particle inspected in accordance with MIL-STD-1949 to determine conformance with the workmanship requirement herein. When the magnetic characteristics of the material prevent satisfactory magnetic particle inspection, the forgings shall be fluorescent penetrant inspected in accordance with MIL-STD-6866. Standards for acceptance and rejection shall conform to the workmanship requirements herein, unless established by the purchaser, and are subject to the approval of the purchaser.

4.3.4.1 The forger shall maintain records of nondestructive testing of Grade A & C forgings for a period of time agreed upon by the purchaser and vendor.

4.4 Maintenance of facilities:

The forger shall keep records demonstrating that the facilities used for heat treatment to control, measure, and test the forgings during processing and inspection are properly maintained and are checked at stated intervals against acceptable standards for accuracy. Heat treatment controls shall be made in accordance with Specification MIL-H-6875.

4.5 Nonconforming items:

Failure of any valid specimen to conform to specified requirements shall cause the forgings represented by such specimens to be subject to rejection. When a failed specimen is judged to be invalid, either dimensionally or for equipment malfunction, replacement from a location adjacent to the original specimen shall be allowed. Forger, in an attempt to obtain a waiver for parts represented by a valid specimen failure, may retest two specimens removed from a location adjacent to the nonconforming specimen. If these specimens fail and are valid, then individual forgings in the lot may be tested (100 percent testing of the lot represented by the failed test).

4.5.1 Upon completion of the additional testing, forger shall submit for review by the purchaser all data pertaining to the nonconforming parts. Data shall be submitted in the format given by the purchaser and shall include:

a. identification of nonconforming items
b. number of pieces involved
c. all original test results
d. all results of retest
e. reason for nonconformance, if known
f. corrective action taken to prevent recurrence of nonconformance.

4.5.2 Forger shall not ship any nonconforming forgings until notified by the purchaser that the forgings in question are acceptable for the application intended.

4.5.3 Rejection: Forgings not conforming to this specification or to authorized modifications will be subject to rejection.