AEROSPACE MATERIAL SPECIFICATION

AMS6400™	REV. A

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Stabilized 2019-12

Superseding AMS6400

Forgings, Steel
For Aircraft/Aerospace Equipment

RATIONALE

This specification is only referenced by AMS-F-7190 that has been Stabilized. It has not been specified by any metal specifications.

STABILIZED NOTICE

AMS6400A has been declared "STABILIZED" by SAE AMS Committee E Carbon and Low Alloy Steels and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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1. SCOPE

This specification establishes requirements for steel forgings of any shape or form from which finished parts are to be made (See 8.2, 8.3, & 8.4). This specification covers steel forgings suitable for use in the construction of aircraft/aerospace equipment

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS 2750	Pyrometry
AMS 2808	Identification, Forgings
AMS-H-6875	Heat Treatment of Steel Raw Materials

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM A 370	Mechanical Testing of Steel Products
ASTM A 604	Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets
ASTM E 384	Microindentation Hardness of Materials
ASTM E 1417	Liquid Penetrant Examination
ASTM E 1444	Magnetic Particle Examination

3. TECHNICAL REQUIRMENTS

3.1 Materials

Forgings shall be produced from forging stock which conforms to the requirements specified in the applicable material specification (See 8.4). It shall be certified by the producing mill to meet all requirements specified for it by the purchaser of the forgings. The forging stock shall be identified with its mill heat number or with a code whose traceability to the mill heat number is documented and is publicly disclosed. Heat identification shall appear on all forging stock certifications. Reports of the results of all inspections and tests performed on the forging stock shall be available for examination by the forger and by the purchaser of the forgings.

3.2 Condition

3.2.1 Physical

Forgings shall not be welded except as allowed by the forging drawing. They shall be supplied descaled. Forgings with appended acceptance-test material (such as prolongations) shall be supplied with any acceptance-test material in place that is not consumed in predelivery testing.

3.2.2 Heat Treatment

Forgings shall be furnished in the heat treat condition specified by the purchaser. When heat treatment is not specified by the purchaser, 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 Properties

3.3.1 Mechanical Properties

3.3.1.1 Room Temperature Tensile

Required only for forgings furnished in the state of heat treatment of the finished part (See 8.2.4).

Room-temperature tensile properties, in the state of heat treatment of the finished part, shall conform to requirements specified by the purchaser (See 8.2.5). Tensile properties shall be determined in accordance with ASTM A 370 on material from a destructively inspected forging or from a prolongation.

3.3.1.2 Room Temperature Hardness

Room-temperature hardness, in the as-supplied state of heat treatment, shall conform to the requirements specified by the purchaser (See 8.2.5). Hardness shall be determined in accordance with ASTM A 370 on a forging or on a prolongation.

3.4 Subsurface Chemical Uniformity

Partial plus total decarburization, carburization, nitriding, and intergranular attack at as-supplied surfaces shall be absent except where the Engineering Drawing permits the use of an “as-forged” surface. When required, metal removal from raw forgings shall be as specified on the Engineering Drawing. Partial plus total decarburization, carburization, nitriding, and intergranular attack shall be determined as specified in AMS-H-6875. Decarburization, carburization, nitriding, and intergranular attack shall be evaluated on metallographic specimens taken from a destructively inspected forging, or from a prolongation, in the as-supplied state of heat treatment.

3.5 Quality

3.5.1 Grain Flow

The internal grain flow pattern shall conform to the requirements of the forging drawing. When not specified by the drawing, the grain flow of die forgings in regions within 0.25 inch (6.4 mm) or 25% of the section thickness, whichever is smaller, of the forged surface shall follow the general contour of the forging. This requirement shall not apply to areas of prolongation attachment, or of flash extrusion (“flash line” or “parting plane”). Unless locations are specified by the purchaser, the forging manufacturer shall select suitable locations for sectioning sufficient to fully document compliance with these requirements. As a minimum, cross-sections shall be taken normal to all die closures. For vacuum-melted alloys wherein the grain flow pattern is too faintly revealed to record photographically, an air-melted steel with similar hot-working characteristics may be used as a test medium. These sections shall be suitably etched in accordance with ASTM A 604, using hot hydrochloric acid, so as to develop the grain-flow pattern which shall be photographed for reporting purposes (See 4.7).

3.5.2 Surface Condition

Forgings shall be free of visually-verified tears, cracks, seams, laps, and imbedded scale. Surfaces shall be inspected in accordance with ASTM E 1417 for non-magnetic steels or in accordance with ASTM E 1444 for magnetic steels. The nature of any indication shall be established by visual examination. Forging surfaces shall be cleaned free of foreign material prior to such inspection. Inspection in accordance with ASTM E 1417 shall include etching as part of the cleaning operation. Imperfections may be removed and surfaces reinspected using ASTM E 1417 or ASTM E 1444, as applicable, to identify the areas to be visually evaluated.

3.5.3 Forging Control

Forgings shall be produced in accordance with a documented process which has been approved by the purchaser. The forging process shall assure that the forging stock is reduced 3 to 1, or more (See 4.4).

3.5.4 Heat Treating Control

Pyrometry shall conform to the requirements of AMS 2750. Carbon restoration treatment to rectify excessive decarburization is not permitted. Forgings and test material shall be heat treated in accordance with AMS-H-6875 or, for alloys not listed in AMS-H-6875, with instructions from the purchaser (See 8.2.4).

3.6 Tolerances

Flash extension, measured from the body of the forging to the trimmed edge of the flash, shall not exceed the dimensional limits shown in Table 1.

TABLE 1A - FLASH EXTENSION TOLERANCES, INCH/POUND UNITS

Weight of Forging After Trimming Pounds	Flash Extension Limits Inch
Up to 5, incl	0 to 0.03
Over 5 to 25, incl	0 to 0.06
Over 25 to 50, incl	0 to 0.09
Over 50 to 100, incl	0 to 0.13
Over 100 to 200, incl	0 to 0.19
Over 200 to 500, incl	0 to 0.25
Over 500 to 1000, incl	0 to 0.31
Over 1000	0 to 0.38

TABLE 1B - FLASH EXTENSION TOLERANCES, SI UNITS

Weight of Forging After Trimming Kilograms	Flash Extension Limits Millimeters
Up to 2.3, incl	0 to 0.8
Over 2.3 to 11.3, incl	0 to 1.5
Over 11.3 to 22.7, incl	0 to 2.3
Over 22.7 to 45, incl	0 to 3.3
Over 45 to 91, incl	0 to 4.8
Over 91 to 227, incl	0 to 6.4
Over 227 to 454, incl	0 to 7.9
Over 454	0 to 9.6

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of the forgings shall supply all samples for vendor's tests and shall be responsible for the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

The requirements shown in Table 2 are acceptance tests which shall be performed on the sample and at the frequency shown. "Lot" is defined in 4.3.

TABLE 2 - ACCEPTANCE TESTS

Para.	Requirement	Sample & Frequency
3.1	Material	Each lot
3.2	Condition	Each lot
3.3.1.1	Room Temperature Tensile (when applicable)	One specimen/lot
3.3.1.2	Room Temperature Hardness	IAW Table 3
3.4	Subsurface Chemical Uniformity (when applicable)	IAW Table 4
3.5.2	Surface Condition	Each forging
3.5.3	Forging Control	Each lot
3.5.4	Heat Treating Control	Each lot
3.6	Tolerances, Flash Extension	Each forging

TABLE 3 - SAMPLE SIZES FOR HARDNESS TESTING

No. of Forgings in the Lot	Sample Size/Lot
Heat treat condition of forgings is other than the final heat treatment of the finished part	
1 to 20	All
21 to 100	25% (20 pcs min)
Over 100	10% (25 pcs min)
Heat treat condition of forgings is the same as the final heat treatment of the finished part	
1 to 44	All
45 to 65	44 pcs
66 to 110	60 pcs
111 to 180	67 pcs
181 to 300	73 pcs
301 to 500	78 pcs
501 to 800	80 pcs

Over 800	10% (85 pcs min)

TABLE 4 - SAMPLE SIZES FOR SUBSURFACE CHEMICAL UNIFORMITY TESTING

No. of Forgings in the Lot	Sample Size/Lot
1 to 4	All
5 to 25	5 pcs
26 to 100	6 pcs
Over 100	7 pcs

4.2.2 Preproduction Tests

All technical requirements are Preproduction tests and shall be performed on the first-article. They shall be repeated after any change in the design or method of manufacture that affects grain flow or mechanical properties, and after a change of forging supplier.

4.3 Sampling and Testing

A forging lot consists of all forgings of the same alloy and design (opposite hands being considered one design), produced from the same heat of forging stock, forged to shape in one production forging run (normally in the same day), heat treated in the same furnace without interruption, and presented for inspection at the same time.

4.4 Approval

After successful Preproduction testing of a product produced in accordance with a documented forging plan the plan shall be submitted to the purchaser for approval. All of the preproduction inspection and testing results shall be submitted with the plan.

The forging plan shall outline the forging procedures used to obtain the desired raw forging configuration, the required mechanical properties, and the grain flow pattern. The forging plan shall describe the forging procedures from cutting of the forging stock to the final inspection stage. It shall include at least the following information:

The starting forge stock size and form (e.g., plate, bar, or other mill form).
Size and type of forging equipment used.
Forging die(s) for each stage.
Whether a blocker die is used.
Trim die, if used.
Sequence of forging operations that change size or shape of the material
Forging temperature(s) for each stage.
Heat treating cycles.
Inspections and tests performed.

4.4.1 If supplier proprietary information is involved, the supplier may certify that the information is proprietary and is on file. The information shall be available for review by personnel representing the purchaser or the cognizant quality control function. A copy of the purchaser-approved document shall be retained by the supplier.

4.5 Acceptance

Only forging lots which pass all preproduction tests and meet all acceptance requirements, as specified in 4.2, shall be accepted, except that failure of individual forgings to meet requirements for surface condition shall not be cause for rejection of the entire lot, but only of the individual nonconforming forgings. Rejected forging lots, or rejected individual forgings, shall not be resubmitted for inspection without a statement indicating how the nonconformity was resolved.

4.6 Resampling and Retesting

If the results from a valid test fail to meet the specified requirements, acceptance of the product may be based on the results of retesting three additional specimens for each nonconforming specimen. Specimens for retest, or for replacement of invalid tests, shall be taken from a location adjacent to the original specimen(s). If no adjacent material is available, material shall be taken from another forging in the same lot. Failure of the results of a valid retest to meet specified requirements shall prohibit acceptance. A test may be declared invalid only if the specimen is dimensionally