The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS-A-22771

Issued JUN 1999

Aluminum Alloy Forgings, Heat Treated

AREA FORG

NOTICE

This document has been taken directly from U.S. Military Specification MIL-A-22771D 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-A-22771D. 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.

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-7121 FAX: (724) 776-0243
TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS: http://www.sae.org

1. SCOPE:

1.1 Scope:

This specification covers the requirements for heat treated aluminum alloy die forgings, hand forgings, and ring forgings, produced under additional mechanical property control to ensure known mechanical properties for parts used in aerospace critical applications. This specification also covers the requirements for forgings furnished in the F or 01 conditions which will ultimately be used in the heat treated condition.

1.2 Classification:

The aluminum alloy forgings shall be furnished in the following alloys, tempers and forms, as specified (see 6.2.1):

1.2.1 Alloys and tempers:

2014-F, 01, T6, T652	6061-F, 01, T6, T652	7049-F, 01, T73, T7352
2219-F, 01, T6, T852	6151-F, 01, T6, T652	7050-F, 01, T74, T7452
2618-F, 01, T61		7075-F, 01, T6, T652, T73, T7352, T74, T7452
		7175-F, 01, T74, T7452, T7454

1.2.2 Form: Forgings shall be furnished in the form of die forgings, hand forgings or ring forgings. If the form is not specified, manufacturers may use any form of forging most convenient.

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-6088	Heat Treatment of Aluminum Alloys
MIL-I-6866	Inspection, Penetrant Method of
MIL-S-13165	Shot Peening of Metal Parts
MIL-I-25135	Inspection Materials, Penetrant
FED-STD-151	Metal, Test Methods
MIL-STD-410	Nondestructive Testing Personnel Qualification and Certification (Eddy Current, Liquid Penetrant, Magnetic Particle, Radiographic and Ultrasonic)
MIL-STD-649	Aluminum and Magnesium Products, Preparation for Shipment and Storage

2.1 (Continued):

MIL-STD-1537 Electrical Conductivity Test for Measurement of Heat Treatment of Aluminum Alloys, Eddy Current Method
MIL-STD-2154 Inspection, Ultrasonic, Wrought Metals, Process for

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM B 557 Tension Testing Wrought and Cast Aluminum-and Magnesium-Alloy Products
ASTM G 47 Determining Susceptibility to Stress-Corrosion Cracking of High Strength Aluminum Alloy Products

2.3 Order of precedence:

In the event of a conflict between the text of the specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENT:

3.1 Chemical composition:

The chemical composition of the forgings shall be as specified in Table I (see 4.4.1).

3.2 Heat treatment:

Unless otherwise specified, forgings shall be heat treated in accordance with MIL-H-6088. Forgings of alloy 7175 shall be heat treated in a manner that the heat treated forgings shall conform to all the requirements of this specification (see 6.1.10). Discoloration due to heat treatment shall not be cause for rejection.

3.3 Mechanical properties:

3.3.1 Die forgings: Mechanical properties of die forgings as determined in accordance with 4.4.2 shall conform to the applicable properties specified in Tables II and III. When die forgings are machined before heat treatment to sizes within the maximum section thickness specified in Tables II and III, the mechanical properties in these tables are applicable, provided the as-forged thickness shall be not more than twice the heat treated thickness. For as-forged thickness greater than twice the heat treated thickness, the properties shall be as agreed between the contractor and the forging supplier or between the acquiring activity and the forging supplier or contractor (see 6.2.1).

3.3.1.1 Mechanical property control of first production parts: After forging techniques have been established, a forging representative of the first production parts shall be tested. Tensile test specimens shall be taken from location both in the direction parallel to, within ± 15° of flow lines, and not parallel to the forging flow lines. The specimen location should be indicated on the forging enginering drawing. If the specimen locations are not indicated on the forging engineering drawing, they shall be taken from areas representative of thick and thin sections. The flow lines shall be determined as specified in 4.4.7. The mechanical properties shall be as specified in Table II and III. For forgings too small to yield suitable test specimens, the tension test shall be waived or negotiated between the contractor and the forging supplier or between the acquiring activity and the forging supplier or contractor (see 6.2.1). This mechanical property control shall be repeated after any major change in the forging process, forging stock size or forging stock.

3.3.1.2 Mechanical property control of production parts: Samples for mechanical properties of production lots subsequent to the first production lot shall be taken as specified in 4.3.2.2.2 and shall conform to the requirements of Table II and III.

3.3.2 Hand forgings: The mechanical properties of hand forgings as determined in accordance with 4.4.2 shall conform to the applicable properties specified in Table IV. The properties specified in Table IV apply to hand forgings that are essentially rectangular in cross section. The requirement of long transverse and short transverse properties applies also to squares, even though transverse dimensions are equal. The forging process shall be controlled such that, the long transverse direction shall be perpendicular to the original stock axis, or both short transverse or long transverse properties shall meet the long transverse properties requirements. The direction of the long transverse properties shall be identified as specified in 3.8. For forgings too small to yield suitable test specimens, the method of tensile test shall be waived or negotiated between the contractor and forging supplier or between the acquiring activity and the forging supplier or contractor (see 6.2.1).

3.3.2.1 Large hand forgings: For hand forgings (1) of greater thickness or (2) heat treated in section thickness greater than covered by this specification, or (3) when the purpose of conditions under which the forging is to be used so dictates, the requirements shall be as specified in the contract, order or drawing. In such cases, the mechanical properties of test specimens taken from locations indicated on the drawing shall be as specified in the contract, order or drawing (see 6.2.1).

3.3.2.2 Machined hand forgings: When hand forgings are machined before heat treatment, the section thickness at time of heat treatment shall determine the minimum mechanical properties as long as the original (as forged) thickness does not exceed the maximum thickness for the alloy as shown in Table IV. When the maximum thickness in Table IV is exceeded by not more than 3 inches, the applicable thickness to establish properties shall be not less than half the original forged thickness.

3.3.3 Special purpose forgings: Biscuits, octagons, mandrel rings and contour hand forgings shall be classified as special purpose forgings. Mechanical properties of special purpose forgings shall be as negotiated between the contractor and the forging supplier or between the acquiring activity and the forging supplier or contractor (see 6.2.1). Testing to confirm mechanical properties shall be in accordancee with 4.4.2.

3.3.4 Rolled ring forgings: The mechanical properties of rolled ring forgings shall be determined in accordance with 4.4.2 and shall conform to applicable properties specified in Table V. For forgings too small to yield suitable test specimens, the method of tensile test shall be waived or negotiated between the contractor and the forging supplier or between the acquiring activity and the forging supplier or contractor (see 6.2.1).

3.3.5 Forging supplied in “F” or “01” conditions: The mechanical properties of forgings supplied in “F” or “01” conditions shall meet the requirements of Tables II, III, IV and V, or as required by drawing or contract order when heat treated to specified tempers in accordance with MIL-H-6088.

3.4 Stress-corrosion cracking:

3.4.1 Resistance to stress-corrosion cracking: Forgings of alloys 7049, 7050, 7075 and 7175 supplied in the T73, T7352, T74, T7452 and T7454 tempers shall meet the following acceptance criteria, as applicable, and shall exhibit no evidence of stress-corrosion cracking when subjected to test specified in 4.4.8.

3.4.2 Acceptance criteria for stress-corrosion cracking by conductivity test: The capability of individual lots (see 4.3.1) to resist stress-corrosion cracking shall be determined by testing as specified in 4.4.9, and using the acceptance criteria specified as follows for the applicable aluminum alloy and temper.

3.4.2.1 7049-T73 and 7049-T7352: The acceptance criteria for the 7049-T73 and 7049-T7352 aluminum alloy forgings shall be as follows:

a. If the electrical conductivity is 40.0 percent International Annealed Copper Standards (IACS) or greater and the tensile properties meet the minimum specified value, the lot is acceptable.

b. If the electrical conductivity is 38.0 to 39.9 percent IACS, inclusive, and the longitudinal yield strength does not exceed the specified minimum by more than 9.9 ksi, the lot is acceptable.

c. If the electrical conductivity is 38.0 to 39.9 percent IACS, inclusive, and the longitudinal yield strength exceeds the specified minimum by 10.0 ksi or more, the lot is acceptable provided it passes the stress-corrosion test specified in 4.4.8.

d. If the electrical conductivity is less than 38.0 percent IACS, the lot is unacceptable.

3.4.2.2 7050-T74 and 7050-T7452: The acceptance criteria for the 7050-T74 and 7050-T7452 aluminum alloy forgings shall be as follows:

a. If the electrical conductivity is 38.0 percent IACS or greater and the longitudinal yield strength (XX.X ksi) minus the electrical conductivity (XX.X percent IACS) is equal to or less than 32.0, the lot is acceptable. For die forgings only, the maximum yield strength shall also be 72 ksi.

b. If the electrical conductivity is 38.0 percent IACS or greater and the longitudinal yield strength (XX.X ksi) minus the electrical conductivity (XX.X percent IACS) is greater than 32.0, the lot is acceptable provided it passes the stress-corrosion test specified in 4.4.8.

c. If the electrical conductivity is less than 38.0 percent IACS, the lot is unacceptable.

3.4.2.3 7075-T73, 7075-T7352, 7075-T74, 7075-T7452, 7175-T74, 7175-T7452 and 7175-T7454: The acceptance criteria for the 7075-T73, 7075-T7352, 7075-T74, 7075-T7452, 7175-T74, 7175-T7452 and 7175-T7454 aluminum alloy forgings shall be as follows:

a. If the conductivity is 40.0 percent IACS or higher and tensile properties meet the minimum values specified herein, the forgings shall be considered satisfactory.

b. If the electrical conductivity is 38.0 to 39.9 percent IACS, inclusive, if tensile properties meet the minimum limits specified herein, and the longitudinal yield strength does not exceed the specified minimum by more than 11.9 ksi, the forgings shall be considered satisfactory.

c. If conductivity is below 40.0 percent IACS and the longitudinal yield strength exceeds the specified minimum value by 12.00 ksi or more, the lot is unacceptable.

d. If the conductivity is below 38.0 percent IACS, the material shall be considered unsatisfactory and must be reprocessed, regardless of property level.

3.5 Defects:

3.5.1 Surface defects: Forgings shall be free of surface defects such as seams, laps, bursts and quench cracks, when inspected as specified in 4.4.4 and 4.4.5.

3.5.2 Internal defects: Limits of acceptability for ultrasonic inspection shall be in accordance with MIL-STD-2154, Class A for hand and ring forgings and Class B for die forgings, unless limits for acceptability of finished forgings are otherwise specified. Where forging thickness or configuration will not permit ultrasonic inspection, the forging stock shall be ultrasonically inspected to Class A limits as agreed upon by the contractor and the forging supplier. When die forgings are to be used in applications requiring a quality level higher than Class B limits, or for alloys not covered herein, the requirements shall be negotiated among the contractor, forging supplier and acquisition authority (see 4.4.6 and 6.2.1).

3.6 Grain-flow characteristics:

The grain-flow pattern shall conform to specified forging drawing approved by the acquiring activity (see 6.2.1). Precaution should be taken to avoid simultaneous occurrence of sharply re-entrant flow lines and high tensile stresses in the region of the parting line (see 4.4.7 and 6.2.1).

3.7 Tolerances:

The forgings shall conform to the shape and dimensions specified in the contract or purchase order within such variations as may be shown on the drawings (see 6.2.1).

3.8 Marking of forgings:

Forgings shall be marked with the commercial alloy designation and temper, ultrasonic symbol and the basic specification number in characters that are clearly legible and that shall not be obliterated by ordinary handling. For squares, the marking shall be on the face that is parallel to the direction of the long transverse properties but perpendicular to the direction of short transverse properties. The marking shall not be applied by the impression method, or by an electroetch or engraving method, unless it can be determined that all detrimental effects will be removed by subsequent machining. When specified (see 6.2.1), the marking of the commercial alloy designation, temper and basic specification number shall be continuous along the forging length (see 4.4.3).

3.9 Workmanship:

The forgings shall be of uniform forging quality and condition, free from blisters, fins, folds, seams, laps, cracks, segregations, spongy areas or other defects which would adversely affect their serviceability. Apparent surface defects may be removed as required, provided section thicknesses, as defined by the drawing, can be maintained. Forgings shall not be repaired by plugging or welding.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for inspection:

Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements 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 the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of inspections:

The inspection requirements specified herein are classified as quality conformance inspections (see 4.3 through 4.3.3.5).

4.3 Sampling:

Sampling for each inspection shall be in accordance with 4.3.2.1 through 4.3.3.5, as applicable. Unless otherwise specified, the sample unit shall be one finished forging and for Section 5 inspection, one container ready for shipment.

4.3.1 Lot: A lot shall consist of forgings of the same shape, same size, same alloy, and heat treated and aged in the same furnace charge. If forgings are heat treated in a continuous furnace, forgings charged consecutively during continuous operation of the furnace shall be considered a furnace charge; for such forgings weighing five pounds or less, the maximum weight of a lot shall be 2,000 pounds, and for larger forgings, it shall be 6,000 pounds.

4.3.2 Tests:

4.3.2.1 Chemical composition: The sampling for chemical analysis shall be in accordance with 4.3.2.1.1 and 4.3.2.1.2.

4.3.2.1.1 Ingot analysis: At least one sample shall be taken from each lot of ingots of the same alloy poured simultaneously from the same source of molten metal by the producer and analyzed to determine conformance to 3.1. Ingots not conforming to this specification shall be rejected. Complete ingot analysis records shall be maintained by the manufacturer and shall be available for review by the acquiring activity at the producing plant.

4.3.2.1.2 Finished product analysis: Unless compliance with 4.3.2.1.1 is established, one sample shall be taken for chemical analysis from each 2,000 pounds or fraction thereof in a lot for forgings having nominal weight of five pounds or less; or one for each 6,000 pounds or fraction thereof in a lot for forgings having nominal weight over five pounds.

4.3.2.2 Mechanical properties:

4.3.2.2.1 Hand, rolled ring and special purpose forgings: Unless otherwise specified, one tension test specimen shall be taken from each lot in each grain direction for determining the mechanical properties. Specimen type and location shall be in accordance with ASTM B 557. If a prolongation is used, its minimum dimension must not be less than the maximum heat treat section thickness of the forging. Unless otherwise specified, rolled ring forging sections shall be taken from an area representative of the center of mass where size permits.

4.3.2.2.2 Die forgings: Unless otherwise specified, tension test specimens shall be taken from a forging or an integral test coupon chosen to represent the lot. One test specimen shall be taken so that the axis of the specimen is substantially parallel to, within ± 15°, the direction of forging flow lines in the forging. One additional test specimens shall be taken so that the axis of the specimen is not parallel to the direction of the forging flow lines in the forging, being as close to the short transverse direction as possible.

4.3.3 Examination:

4.3.3.1 Surface defects:

4.3.3.1.1 Visual inspection: Unless otherwise specified, each forging shall be 100 percent visually inspected for surface defects (see 4.4.4).

4.3.3.1.2 Penetrant inspection: Unless otherwise specified, each forging shall be 100 percent penetrant inspected (see 4.4.5 and 6.2.1).

4.3.3.2 Internal defects: Unless otherwise specified, all forgings shall be ultrasonically examined for internal defects (see 4.4.6 and 6.2.1).

4.3.3.3 Grain flow: After the forging technique is established for a required size and shape, one sample from first production lot shall be selected for the grain flow structure examination. This examination shall be repeated after any major change in forging technique (see 4.4.7 and 6.2.1).

4.3.3.4 Stress-corrosion: Sampling for stress-corrosion cracking and electrical conductivity is applicable when testing forgings of alloy temper combinations 7049-T73, 7049-T7352, 7050-T74, 7050-T7452, 7075-T73, 7075-T7352, 7075-T74, 7075-T7452, 7175-T74, 7175-T7452 and 7175-T7454 for conformance to 3.4.1.

4.3.3.4.1 Stress-corrosion surveillance test: Unless otherwise specified, each month, at least one forging from each shape and thickness range, 0.750 inch and greater, produced during that month from forgings of alloys and tempers noted in 4.3.3.4, shall be sampled for stress-corrosion testing. The samples shall be taken from the forgings determined to be acceptable in accordance with the lot acceptance criteria specified in 3.4.2.

4.3.3.4.2 Electrical conductivity: Unless otherwise specified, one forging from each lot shall be selected for electrical conductivity test.

4.3.3.5 Heat treat capability: Unless otherwise specified, forgings in “F” and “01” conditions shall be sampled and tested in the same manner as comparable to heat treated forgings. The sample shall be heat treated to the -T6 or -T61 temper, unless otherwise specified, or to the final temper as specified in the part drawing or other acquisition documents.

4.4 Methods of tests and examination:

4.4.1 Chemical analysis: Sampling for chemical analysis shall in accordance with 4.3.2.1.1 and 4.3.2.1.2. The chemical analysis of the samples shall be wet chemical method or spectro chemical method in accordance with Method 111 or 112 of FED-STD-151. In case of dispute, chemical analysis by wet chemical method shall be the basis for acceptance (see 3.1).

4.4.2 Mechanical properties: The mechanical properties of the samples selected in accordance with 4.3.2.2 through 4.3.2.2.2 shall be determined as specified in ASTM B 557.

4.4.3 Examination for marking: Unless otherwise specified, each forging shall be inspected for markings as specified in 3.8.

4.4.4 Visual inspection of surface defects: Prior to visual inspection, each die or ring forging (see 4.3.3.1.1) shall be etched in an aqueous solution of sodium hydroxide containing an inhibitor to prevent intergranular attack of copper bearing alloys. A suitable solution consists of 50 grams of sodium hydroxide and 2.5 grams of sodium sulphide disolved in one liter of water. Etching time for this solution maintained at 155°F(±5°F) should be one minute. Other inhibited solutions may be used provided, they produce the same etching effect. Subsequently, the parts shall be thoroughly rinsed in water followed by a wash in nitric acid or in chromic-sulphuric acid solution or other solution that shall produce a surface of equivalent suitability for visual or penetrant inspection. After etching, each forging shall be inspected visually for surface defects such as seams, laps, bursts and quench cracks (see 3.5.1). Parts should be thoroughly dried after each etch and rinse operation to prevent fluid entrapment.

4.4.5 Penetrant inspection: Prior to penetrant inspection, each forging shall be etched (see 4.4.4), dried (see 4.4.4), and penetrant inspected (see 4.3.3.1.2) in accordance with MIL-I-6866, using Group V post-emulsified penetrant or Group IV water washable penetrant of equivalent senesitivity conforming to MIL-I-25135 to determine conformance to 3.5.1. Penetrant inspection personnel shall be certified to NDT Level II in accordance with MIL-STD-410.

4.4.6 Internal defects: Unless otherwise specified, all forgings (see 4.3.3.2) shall be ultrasonically tested for internal defects in accordance with MIL-STD-2154.

4.4.7 Grain flow: After the forging technique is established for forging a required size and shape, a sample unit forging, selected as specified in 4.3.3.3, shall be sectioned and suitably etched to show the grain flow of structure. This sectioning shall be repeated after any change in the forging technique. Location of cross sectioning shall be such as to represent principal sections of the forging, or as agreed upon between the contractor and the forging supplier or between the acquiring activity and the forging supplier or contractor.

4.4.8 Resistance to stress-corrosion cracking: Specimens of alloys and tempers specified in 4.3.3.4, selected for stress-corrosion testing, shall be prepared and tested in accordance with ASTM G 47. The stress-corrosion test stress level for each alloy temper combination shall be in accordance with 4.4.8.1.

4.4.8.1 Stress-corrosion test stress level: Unless otherwise specified, the stress level shall be 75 percent of the longitudinal yield strength as specified in Tables II and IV for alloys 7049 and 7075. The stress level for 7050 alloy shall be 35 ksi. The stress level of alloy 7175 shall be 35 ksi, except for alloy 7175 hand forgings exceeding 3.000 inches, where the stress level shall be 50 percent of the longitudinal yield strength specified in Table IV.

4.4.9 Electrical conductivity: Forgings for alloys and tempers selected for conductivity testing (see 4.3.3.4.2) shall be prepared and tested in accordance with MIL-STD-1537 to the criteria specified in 3.4.2.1 through 3.4.2.3.

4.4.10 Special inspection procedures: When special purpose or large forgings are specified, the inspection procedure, as related to the number and location of test samples taken from the sample forgings, shall be as agreed upon between the contractor, forging supplier and the acquiring activity.

4.5 Rejection and retests:

4.5.1 Rejection: If any individual test specimen fails to conform to this specification, the lot represented by the specimen shall be rejected.

4.5.2 Retests: If a lot of material is rejected, retests of that lot shall be permitted in accordance with the provisions of FED-STD-151 by:

a. Taking twice the original number of test specimens from an area in the original sample forging adjacent to the area represented by the failure.

b. Taking the original number of test specimens from an area in each of two other forgings identical to the area in the original sample forgings represented by the failure.

c. Both failing initial test data and passing retest data shall be retained with the production records.

Should any of these specimens fail to conform to this specification, the entire lot shall be rejected.

5. PACKAGING:

5.1 Preservation, packing and marking:

Preservation, packing and marking shall be in accordance with MIL-STD-649. The level of preservation shall be Level A or Commercial and packing shall be Level A, B or Commercial as specified (see 6.2.1).

6. NOTES:

6.1 Intended use:

The aluminum alloy forgings of this specification have characteristics that are intended for use in critical aerospace applications, as follows:

6.1.1 2014: Alloy 2014 is most commonly used for general applications where high strength is essential, however, special care should be taken in the application of this alloy because of susceptibility to stress-corrosion cracking.

6.1.2 2219: Alloy 2219 is used for applications which require good weldability and uniformity of strength of welds, moderate strength at room temperature and high strength in the range of 500° to 600°F.

6.1.3 2618: Alloy 2618 is used for elevated temperature (approximately 575°F) applications.

6.1.4 6061: Alloy 6061 is most commonly used for structural applications where strength, weldability and corrosion resistance are needed.

6.1.5 6151: Alloy 6151 is used for applications requiring good forgeability, good strength and resistance to corrosion.

6.1.6 7049-T73: Alloy 7049-T73 is recommended for applications requiring high strength and high resistance to stress-corrosion cracking.

6.1.7 7050: Alloy 7050 is recommended for applications requiring high strength and resistance to stress-corrosion.

6.1.8 7075: Alloy 7075 is used for small and medium sized forgings where maximum weight saving is essential. Special care should be taken in the application of this alloy in temper other than T73 because of susceptibility to stress-corrosion cracking.

6.1.9 7075-T73: Alloy 7075-T73 is recommended for components which are subjected to assembly stresses in transverse direction because of its stress-corrosion resistance.

6.1.10 7175: Alloy 7175 is recommended for applications requiring high strength and resistance to stress-corrosion.

6.2 Ordering data:

6.2.1 Acquisition requirements: Acquisition documents should specify the following:

a. Title, number and date of this specification.

b. Alloy designation, temper, method of forging (see 1.2.1 and 1.2.2) and grain-flow pattern, if required (see 3.6).

c. Applicable drawings (see 3.3.2.1 and 3.6).

d. Applicable levels of preservation and packaging required (see 5.1).

e. The percent of parts to be inspected, when less than 100 percent ultrasonic inspection is required (see 4.3.3.2).

f. Ultrasonic inspection acceptance criteria, if other than required by 3.5.2.

g. The percent of parts to be inspected, when less than 100 percent penetrant inspection of die forgings is required (see 4.3.3.1.2).

6.2.1 (Continued):

h. Special markings (see 3.8).

i. For special purposes and large forgings or any other options desired (see 3.3.3 and 6.3).

j. For as-forged thickness of die forgings greater than twice the heat treated thickness, the properties shall be waived or negotiated between the contractor and forging supplier or between the acquiring activity and the forgig supplier or contractor (see 3.3.1).

k. For forgings too small to yield suitable test specimens, the tension test shall be waived or negotiated between the contractor and forging supplier or between the acquiring activity and the forging supplier or contractor (see 3.3.1.1, 3.3.2, and 3.3.4).

6.3 Special purposes and large forgings:

Attention is called to the references herein to special purpose or large forgings, for which special mechanical properties and inspection procedures are necessary. Special attention should be given to including all special instructions on the drawings and orders so that tensile properties and grain flow will be determined at the desired areas, and to the determination of properties, particularly ductility and tensile yield strength in directions normal to the observed grain flow in critically stressed areas in the forging.

6.4 Hardness:

For information, the minimum Brinell hardness (500 Kgf load, 10 mm diameter ball) usually measured on the surface of the properly heat treated forgings is shown in Table VI.

6.5 Change in temper designation:

Tempers T736 and T73652 of alloys 7050, 7075 and 7175 have been designated as T74 and T7452, respectively. Temper T73654 of alloy 7175 has been designated as T7454.

6.6 This paragraph was deleted as it did not pertain to the converted SAE document.

PREPARED UNDER THE JURISDICTION OF AMS COMMITTEE “D”

TABLE I. Chemical composition. 1/ 2/

Alloy	Copper	Silicon	Iron	Manganese	Magnesium	Zinc	Chromium	Titanium	Zirconium	Vanadium	Nickel	Other elements each	Other elements total	Aluminum
2014	3.9-5.0	0.50-1.2	0.7	0.40-1.2	0.20-0.8	0.25	0.10	0.15	---	---	---	0.05	0.15	Remainder
2219	5.8-6.8	0.20	0.30	0.20-0.40	0.02	0.10	---	0.02-0.10	0.10-0.25	0.05-0.15	---	0.05	0.15	Remainder
2618	1.9-2.7	0.10-0.25	0.9-1.3	---	1.3-1.8	0.10	---	0.04-0.10	---	---	0.9-1.2	0.05	0.15	Remainder
6061	0.15-0.40	0.40-0.8	0.7	0.15	0.8-1.2	0.25	0.04-0.35	0.15	---	---	---	0.05	0.15	Remainder
6151	0.35	0.6-1.2	1.0	0.20	0.45-0.8	0.25	0.15-0.35	0.15	---	---	---	0.05	0.15	Remainder
7049	1.2-1.9	0.25	0.35	0.20	2.0-2.9	7.2-8.2	0.10-0.22	0.10	---	---	---	0.05	0.15	Remainder
7050	2.0-2.6	0.12	0.15	0.10	1.9-2.6	5.7-6.7	0.04	0.06	0.08-0.15	---	---	0.05	0.15	Remainder
7075	1.2-2.0	0.40	0.50	0.30	2.1-2.9	5.1-6.1	0.18-0.28	0.20	---	---	---	0.05	0.15	Remainder
7175	1.2-2.0	0.15	0.20	0.10	2.1-2.9	5.1-6.1	0.18-0.28	0.10	---	---	---	0.05	0.15	Remainder

1/ Analysis shall be made only for the elements specifically mentioned in the above table. If, however, the presence of other elements are indicated in the course of routine analysis, further analysis shall be made to determine that these other elements are not present in excess of the limits specified.

2/ Percentage figures are maximum allowed, except where a range is indicated.

TABLE II. Mechanical properties of die forgings, specimen axis parallel to direction of grain flow lines. 1/

Alloy and temper 2/	Maximum heat treat section thickness, inches	Minimum tensile strength, ksi 3/	Minimum yield strength at 0.2 percent offset, ksi 3/	Minimum elongation in 2 inches or 4D 4/, percent 3/
2014-T6	Up thru 2	65.0	56.0	6
	Over 2 thru 3	65.0	55.0	6
	Over 3 thru 4	63.0	55.0	6
2219-T6	Up thru 4	58.0	38.0	8
2618-T61	Up thru 4	58.0	45.0	4
6061-T6	Up thru 4	38.0	35.0	7
6151-T6	Up thru 4	44.0	37.0	10
7049-T73	Up thru 2	72.0	62.0	7
	Over 2 thru 4	71.0	61.0	7
	Over 4 thru 5	70.0	60.0	7
7050-T74 5/	Up thru 2	72.0	62.0	7
	Over 2 thru 4	71.0	61.0	7
	Over 4 thru 5	70.0	60.0	7
	Over 5 thru 6	70.0	59.0	7
7075-T6	Up thru 1	75.0	64.0	7
	Over 1 thru 2	74.0	63.0	7
	Over 2 thru 3	74.0	63.0	7
	Over 3 thru 4	73.0	62.0	7
7075-T73	Up thru 3	66.0	56.0	7
	Over 3 thru 4	64.0	55.0	7
7075-T7352	Up thru 3	66.0	56.0	7
	Over 3 thru 4	64.0	53.0	7
7075-T74 5/	Up thru 3	76.0	66.0	7
7175-T74 5/	Up thru 3	76.0	66.0	7
7175-T7452 6/	Up thru 3	73.0	63.0	7
71750T7454 7/	Up thru 3	75.0	65.0	7

1/ The parallel direction of specimens shall be ± 15 degrees.

2/ Die forgings in some configurations of these alloys can be purchased in the heat treated and compression stress relieved T652 temper conforming to the mechanical property requirements specified for T6 temper, respectively.

3/ Tensile property test requirements may be waived or negotiated between the contractor and the forging supplier or between the acquiring activity and the forging supplier or contractor for material in any direction in which the dimension is less than 2 inches because of the difficulty to obtain a tension test specimen suitable for routine control testing (see 6.2.1).

4/ D represents specimen diameter.

5/ Formerly designated as T736 temper.

6/ Formerly designated as T73652 temper.

7/ Formerly designated as T73654 temper.

TABLE III. Mechanical properties of die forgings, specimen axis not parallel to direction of grain flow lines. 1/

Alloy and temper 2/	Maximum heat treat section thickness, inches	Minimum tensile strength, ksi 3/	Minimum yield strength at 0.2 percent offset, ksi 3/	Minimum elongation in 2 inches or 4D 4/, percent 3/
2014-T6	Up thru 1	64.0	55.0	3
	Over 1 thru 2	64.0	55.0	2
	Over 2 thru 3	63.0	54.0	2
	Over 3 thru 4	63.0	54.0	2
2219-T6	Up thru 4	56.0	36.0	4
2618-T61	Up thru 4	55.0	42.0	4
6061-T6	Up thru 4	38.0	35.0	5
6151-T6	Up thru 4	44.0	37.0	6
7049-T73	Up thru 1	71.0	61.0	3
	Over 1 thru 3	70.0	60.0	3
	Over 3 thru 4	70.0	60.0	2
	Over 4 thru 5	68.0	58.0	2
7050-T74 5/	Up thru 2	68.0	56.0	5
	Over 2 thru 4	67.0	55.0	4
	Over 4 thru 6	66.0	54.0	3
7075-T6	Up thru 1	71.0	61.0	3
	Over 1 thru 2	71.0	61.0	3
	Over 2 thru 3	70.0	60.0	3
	Over 3 thru 4	70.0	60.0	2
7075-T73	Up thru 3	62.0	53.0	3
	Over 3 thru 4	61.0	52.0	2
7075-T7352	Up thru 3	62.0	51.0	3
	Over 3 thru 4	61.0	49.0	2
7075-T74 5/	Up thru 3	71.0	62.0	4
7175-T74 5/	Up thru 3	71.0	62.0	4
7175-T7452 5/	Up thru 3	68.0	55.0	4
7175-T7454 7/	Up thru 3	70.0	61.0	4

1/ The parallel direction of specimens shall be ± 15 degrees.

2/ Die forgings in some configurations of these alloys can be purchased in the heat treated and compression stress relieved T652 temper conforming to the mechanical property requirements specified for T6 temper, respectively.

3/ Tensile property test requirements may be waived or negotiated between the contractor and the forging supplier or between the acquiring activity and the forging supplier or contractor for material in any direction in which the dimension is less than 2 inches because of the difficulty to obtain a tension test specimen suitable for routine control testing (see 6.2.1).

4/ D represents specimen diameter.

5/ Formerly designated as T736 temper.

6/ Formerly designated as T73652 temper.

7/ Formerly designated as T73654 temper.

TABLE IV. Mechanical properties of hand forgings. 1/

Alloy and temper	Maximum heat treat section thickness, inches 4/	Axis of test specimen	Minimum tensile strength, ksi 2/	Minimum yield strength at 0.2 percent offset, ksi 2/	Minimum elongation in 2 inches or 4D 3/, percent 2/
2014-T6	Up thru 2	Longitudinal	65.0	56.0	8
		Long trvs.	65.0	56.0	3
	Over 2 thru 3	Longitudinal	64.0	56.0	8
		Long trvs.	64.0	55.0	3
		Short trvs.	62.0	55.0	2
	Over 3 thru 4	Longitudinal	63.0	55.0	8
		Long trvs.	63.0	55.0	3
		Short trvs.	61.0	54.0	2
	Over 4 thru 5	Longitudinal	62.0	54.0	7
		Long trvs.	62.0	54.0	2
		Short trvs.	60.0	53.0	1
	Over 5 thru 6	Longitudinal	61.0	53.0	7
		Long trvs.	61.0	53.0	2
		Short trvs.	59.0	53.0	1
	Over 6 thru 7	Longitudinal	60.0	52.0	6
		Long trvs.	60.0	52.0	2
		Short trvs.	58.0	52.0	1
	Over 7 thru 8	Longitudinal	59.0	51.0	6
		Long trvs.	59.0	51.0	2
		Short trvs.	57.0	51.0	1
2014-T652	Up thru 2	Longitudinal	65.0	56.0	8
		Long trvs.	65.0	56.0	3
	Over 2 thru 3	Longitudinal	64.0	56.0	8
		Long trvs.	64.0	55.0	3
		Short trvs.	62.0	52.0	2
	Over 3 thru 4	Longitudinal	63.0	55.0	8
		Long trvs.	63.0	55.0	3
		Short trvs.	61.0	51.0	2
	Over 4 thru 5	Longitudinal	62.0	54.0	7
		Long trvs.	62.0	54.0	2
		Short trvs.	60.0	50.0	1
	Over 5 thru 6	Longitudinal	61.0	53.0	7
		Long trvs.	61.0	53.0	2
		Short trvs.	59.0	50.0	1
	Over 6 thru 7	Longitudinal	60.0	52.0	6
		Long trvs.	60.0	52.0	2
		Short trvs.	58.0	49.0	1
	Over 7 thru 8	Longitudinal	59.0	51.0	6
		Long trvs.	59.0	51.0	2
		Short trvs.	57.0	48.0	1
2219-T6	Up thru 4	Longitudinal	58.0	40.0	6
		Long trvs.	55.0	37.0	4
		Short trvs.	53.0	35.0	2

TABLE IV. Mechanical properties of hand forgings. 1/ - Continued

Alloy and temper	Maximum heat treat section thickness, inches 4/	Axis of test specimen	Minimum tensile strength, ksi 2/	Minimum yield strength at 0.2 percent offset, ksi 2/	Minimum elongation in 2 inches or 4D 3/, percent 2/
2219-T852	Up thru 4	Longitudinal	62.0	50.0	6
		Long trvs.	62.0	49.0	4
		Short trvs.	60.0	46.0	3
2618-T61	Up thru 2	Longitudinal	58.0	47.0	7
		Long trvs.	55.0	42.0	5
		Short trvs.	52.0	42.0	4
	Over 2 thru 3	Longitudinal	57.0	46.0	7
		Long trvs.	55.0	42.0	5
		Short trvs.	52.0	42.0	4
	Over 3 thru 4	Longitudinal	56.0	45.0	7
		Long trvs.	53.0	40.0	5
		Short trvs.	51.0	39.0	4
6061-T6	Up thru 4	Longitudinal	38.0	35.0	10
		Long trvs.	38.0	35.0	8
		Short trvs.	37.0	33.0	5
	Over 4 thru 8	Longitudinal	37.0	34.0	8
		Long trvs.	37.0	34.0	6
		Short trvs.	35.0	32.0	4
7049-T73	Over 2 thru 3	Longitudinal	71.0	61.0	9
		Long trvs.	71.0	59.0	4
		Short trvs.	69.0	58.0	3
	Over 3 thru 4	Longitudinal	69.0	59.0	8
		Long trvs.	69.0	57.0	3
		Short trvs.	67.0	56.0	2
	Over 4 thru 5	Longitudinal	67.0	56.0	7
		Long trvs.	67.0	56.0	3
		Short trvs.	66.0	55.0	2
7049-T7352	Over 1 thru 3	Longitudinal	71.0	59.0	9
		Long trvs.	71.0	57.0	4
		Short trvs.	69.0	56.0	3
	Over 3 thru 4	Longitudinal	69.0	57.0	8
		Long trvs.	69.0	54.0	3
		Short trvs.	67.0	53.0	2
	Over 4 thru 5	Longitudinal	67.0	54.0	7
		Long trvs.	67.0	53.0	3
		Short trvs.	66.0	51.0	2
7050-T452	Up thru 2	Longitudinal	72.0	63.0	9
		Long trvs.	71.0	61.0	5
	Over 2 thru 3	Longitudinal	72.0	62.0	9
		Long trvs.	70.0	60.0	5
		Short trvs.	67.0	55.0	4