SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS-QQ-A-367 | REV. C

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Superseding AMS-QQ-A-367B

Aluminum Alloy Forgings

RATIONALE

AMS-QQ-A-367C corrects an error in Table 3.

NOTICE

The initial SAE publication of this document was taken directly from U.S. Military Specification QQ-A-367H, Notice 1, Amendment 2. This SAE Standard may retain the same part numbers established by the original military document. Any requirements associated with Qualified Products Lists (QPL) may continue to be mandatory for DoD contracts. Requirements relating to QPLs have not been adopted by the SAE for this standard and are not part of this SAE document.

1. SCOPE AND CLASSIFICATION

1.1 This specification has previously been widely used and may be required for production or processing of existing designs in the future. The Aerospace Materials Division, however, considers this specification non-current and does not recommend this specification for future use in new design.

1.2 Scope

This specification covers aluminum alloy die forgings and hand forgings.

1.3 Classification

1.3.1 Composition

Aluminum alloy forgings covered by this specification shall be the alloy number and compositions as specified in Table 1.

1.3.2 Form

Aluminum alloy forgings shall be furnished in the form of die forgings or hand forgings, as specified. If the method is not specified, manufacturers may use any method of forging most convenient.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
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SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMSQQA367C

1.3.3 Temper

Forgings shall be supplied in the temper specified in the order or contract. Forgings supplied in the T652 or T852 tempers shall be solution heat treated, stress relieved by compression to produce a permanent set of 1 to 5 percent, and artificially aged. Forgings in 7049 and 7075 alloy supplied in the T73 or T7352 temper shall be solution heat treated and aged in a manner to develop the mechanical properties shown in Tables 2, 3, and 5, and shall be capable of passing the test for resistance to stress-corrosion cracking 4.4.3.

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.

AMS2355 Quality Assurance, Sampling and Testing, Aluminum Alloys and Magnesium Alloy, Wrought Products (Except Forging Stock), and Rolled, Forged, or Flash Welded Rings

AMS2430 Shot Peening, Automatic

AMS2772 Heat Treatment of Aluminum Alloy Raw Materials

AMS-STD-2154 Inspection, Ultrasonic, Wrought Metals, Process for

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 B 557 Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products

ASTM B 660 Packaging/Packing of Aluminum and Magnesium Products

ASTM E 1282 Chemical Compositions and Selecting Sampling Practices and Quantitative Analysis Methods for Metals, Ores, and Related Materials

ASTM E 1417 Liquid Penetrant Testing

ASTM G 44 Exposure of Metals and Alloys by Alternate Immersion in Neutral 3.5% Sodium Chloride Solution

2.3 U.S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://assist.daps.dla.mil/quicksearch/.

FED-STD-123 Marking for Shipment (Civil Agencies)

MIL-STD-129 Military Marking for Shipment and Storage

2.4 Aluminum Association Publications

Available from the Aluminum Association Inc., 1525 Wilson Blvd., Suite 600, Arlington, VA 22209, Tel: (703) 358-2960, www.aluminum.org.

International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys (known as the “Teal Sheets”)

TABLE 1 - CHEMICAL COMPOSITION LIMITS (NOTE 1) PERCENT MAXIMUM, EXCEPT WHERE INDICATED AS RANGE

Alloy No.	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Zinc	Titanium	Nickel	Other Elements (Note 2)	Aluminum
2014	0.50-1.2	0.7	3.9-5.0	0.40-1.2	0.20-0.8	0.10	0.25	0.15	--	0.05	remainder
2018	0.9	1.0	3.5-4.5	0.20	0.45-0.9	0.10	0.25	--	1.7-2.3	0.05	remainder
2025	0.50-1.2	1.0	3.9-5.0	0.40-1.2	0.05	0.10	0.25	0.15	--	0.05	remainder
2218	0.9	1.0	3.5-4.5	0.20	1.2-1.8	0.10	0.25	--	1.7-2.3	0.05	remainder
2219	0.20	0.30	5.8-6.8	0.20-0.40	0.02	--	0.10	0.02-0.10	--	0.05 (Note 3)	remainder
2618	0.25	0.9-1.3	1.9-2.7	--	1.3-1.8	--	0.10	0.04-0.10	0.9-1.2	0.05	remainder
4032	11.0-13.5	1.0	0.50-1.3	--	0.8-1.3	0.10	0.25	--	0.50-1.3	0.05	remainder
5083	0.40	0.40	0.10	0.040-1.0	4.0-4.9	0.05-0.25	0.25	0.15	--	0.05	remainder
6061	0.40-0.8	0.7	0.15-0.40	0.15	0.8-1.2	0.04-0.35	0.25	0.15	--	0.05	remainder
6066	0.9-1.8	0.50	0.7-1.2	0.6-1.1	0.8-1.4	0.40	0.25	0.20	--	0.05	remainder
6151	0.6-1.2	1.0	0.35	0.20	0.45-0.8	0.15-0.35	0.25	0.15	--	0.05	remainder
7049	0.25	0.35	1.2-1.9	0.20	2.0-2.9	0.10-0.22	7.2-8.2	0.10	--	0.05	remainder
7075	0.40	0.5	1.2-2.0	0.30	2.1-2.9	0.18-0.28	5.1-6.1	0.20	--	0.05	remainder
7076	0.40	0.6	0.30-1.0	0.30-0.8	1.2-2.0	--	7.0-8.0	0.20	--	0.05	remainder
7079	0.30	0.40	0.40-0.8	0.10-0.30	2.9-3.7	0.10-0.25	3.8-4.8	0.10	--	0.05	remainder

1/ Analysis shall be made only for the elements specifically mentioned in the above table. If, however, the presence of other elements is 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/ Total of all elements not specified shall not exceed 0.15 percent.
3/ Vanadium 0.05-0.15 and zirconium 0.10-0.25.
4/ In the case of a discrepancy in the values listed in Table 1 with those listed in the International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys (known as the “Teal Sheets”), the composition limits registered with the Aluminum Association and published in the “Teal Sheets” shall apply.

3. REQUIREMENTS

3.1 Forgings shall produced by hammering or pressing from a cast ingot or from as-fabricated (rolled, hand forged, or extruded) stock of suitable quality and of composition as specified in Table 1. Whether the forgings are produced from cast ingot or wrought stock, the material shall be sufficiently worked upon completion of forging operations to produce a thoroughly wrought structure.

3.2 Chemical Composition

3.2.1 The chemical composition of the forgings shall be as specified in Table 1.

3.3 Mechanical Properties

3.3.1 Die Forgings

The mechanical properties of test specimens taken as specified in 4.2.3.1 shall be as specified in Tables 2 and 3.

TABLE 2 - MECHANICAL PROPERTIES OF DIE FORGINGS AND SEPARATELY FORGED TEST BARS - TEST SPECIMEN PARALLEL TO FORGING FLOW (GRAIN) LINES

Alloy No.	Temper (Note 3)	Maximum Heat Treat Section Thickness Inches	Tensile Strength (Note 2) Minimum ksi	Yield Strength (Note 2) at 0.2 percent Offset Minimum ksi	Elongation in 2 inches or 4D (Note 1), Minimum Forging Percent	Elongation in 2 inches or 4D (Note 1), Minimum Test Coupon (Forged) Percent
2014	T4	4	55.0	30.0	11	16
2014	T6	Up thru 1	65.0	56.0	6	8
		Over 1 thru 2	65.0	56.0	6	(Note 4)
		Over 2 thru 3	65.0	55.0	6	(Note 4)
		Over 3 thru 4	63.0	55.0	6	(Note 4)
2018	T61	4	55.0	40.0	7	10
2025	T6	4	52.0	33.0	11	16
2218	T61	4	55.0	40.0	7	10
2219	T6	4	58.0	38.0	8	10
2618	T61	4	58.0	45.0	4	6
4032	T6	4	52.0	42.0	3	5
5083	H111 (Note 6)	4	42.0	22.0	14	16
5083	H112 (Note 6)	4	40.0	18.0	16	16
6061	T6	4	38.0	35.0	7	10
6066	T6	4	50.0	45.0	8	12
6151	T6	4	44.0	37.0	10	14
7049	T73	Up thru 2	72.0	62.0	7	10
		Over 2 thru 4	71.0	61.0	7	10
		Over 4 thru 5	70.0	60.0	7	10
7075	T6	Up thru 1	75.0	64.0	7	10
		Over 1 thru 2	74.0	63.0	7	(Note 4)
		Over 2 thru 3	74.0	63.0	7	(Note 4)
		Over 3 thru 4	73.0	62.0	7	(Note 4)
7075	T73	Up thru 3	66.0	56.0	7	10
		Over 3 thru 4	64.0	55.0	7	10
7075	T7352	Up thru 3	66.0	56.0	7	10
		Over 3 thru 4	64.0	53.0	7	10
7076	T61	4	70.0	60.0	10	14
7079	T6	Up thru 1	72.0	62.0	7	10
		Over 1 thru 2	72.0	62.0	7	(Note 4)
		Over 2 thru 3	71.0	61.0	7	(Note 4)
		Over 3 thru 4	71.0	61.0	7	(Note 4)
		Over 4 thru 5	70.0	60.0	7	(Note 4)
		Over 5 thru 6	70.0	59.0	7	(Note 4)

1/ D is diameter of test specimen.

2/ Tensile and yield strength test requirements may be waived 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.

3/ Die forgings in some configurations of these alloys can be purchased in the heat treated and mechanically stress relieved T652 temper conforming to the mechanical properties requirements specified for the T6 temper.

4/ When separately forged coupons are used to verify acceptability of forgings in the indicated thicknesses, the properties shown for thicknesses "Up thru 1 inch", including the test coupon elongation, apply.

5/ As-forged thickness. When forgings are machined prior to heat treatment the properties will also apply to the machined heat treat thickness provided the machined thickness is not less than one-half the original (as-forged) thickness.

6/ Maximum section thickness to which mechanical properties apply (non-heat-treatable-alloys).

TABLE 3 - MECHANICAL PROPERTIES OF DIE FORGINGS - SPECIMENS NOT PARALLEL TO FORGING FLOW LINES

Alloy No.	Temper (Note 3)	Maximum Heat Treat Section Thickness Inches	Tensile Strength (Note 2) Minimum ksi	Yield Strength at 0.2 percent Offset Minimum ksi	Elongation in 2 inches or 4D (Note 1), Minimum
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	4	56.0	36.0	4
2618	T61	4	55.0	42.0	4
5083 (Note 4)	H111	4	39.0	20.0	12
5083 (Note 4)	H112	4	39.0	16.0	14
6061	T6	4	38.0	35.0	5
6151	T6	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
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
7076	T61	4	67.0	58.0	3
7079	T6	Up thru 1	71.0	61.0	5
		Over 1 thru 2	70.0	60.0	5
		Over 2 thru 3	70.0	60.0	4
		Over 3 thru 4	70.0	60.0	4
		Over 4 thru 5	68.0	58.0	3
		Over 5 thru 6	68.0	58.0	3

1/ D is diameter of test specimen.
2/ Tensile and yield strength test requirements may be waived 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.
3/ Die forgings in some configurations of these alloys can be purchased in the heat treated and mechanically stress relieved T652 temper conforming to the mechanical properties requirements specified for the T6 temper.
4/ Maximum section thickness to which mechanical properties apply (non-heat-treatable-alloys).

3.3.1.1 A forging representing the first production lot of forgings produced from new or significantly reworked dies, significantly changed forging production procedures, or from significantly changed stock (See 3.1), shall be tested in accordance with 4.2.3.1.

3.3.1.2 If test specimens are taken from forgings of the alloys listed in Table 3 so that the axis is not substantially parallel (within plus or minus 15 degrees) to the metal flow lines in the specimen, the mechanical properties shall conform to the requirements of Table 3 except that the elongation requirements shall be as specified by the procuring activity for test specimens taken so that the reduced section (1) is in immediate proximity to an abrupt change in section thickness; or (2) intersects the parting plane within 1/4 inch of the flash line.

3.3.2 Hand Forgings

The mechanical properties of hand forgings of 2014-T6, T652; 7049-T73; 7075-T6, T652, T73; 7079-T6, T652; 6061-T6 or T652; 2618-T61; 2219-T6, T852; and 5083-H111, H112 determined from specimens taken in accordance with 4.2.3.2 shall conform to the applicable properties specified in Tables 4 through 11.

3.3.2.1 The properties in Tables 4, 5, 6, 7, 8, and 9 apply to hand forgings that are essentially rectangular in cross section. The requirements of long-transverse and short-transverse properties apply also to the squares even though both transverse dimensions are equal length. The cross-sectional grain direction, perpendicular to the longitudinal direction, of hexagons and rounds shall be considered the long transverse grain direction. The direction of the long transverse properties shall be identified as required in 3.7. Biscuits, octagons, rings, and contour hand forgings are considered to be special purpose forgings (See 3.3.3).

TABLE 4 - MECHANICAL PROPERTIES OF ALLOY 2014 HAND FORGINGS (NOTE 1)

Temper	Thickness (Notes 4,5) Inches	Axis of Test Specimen	Tensile Strength (Note 2) Minimum ksi	Yield Strength (Note 2) Minimum ksi	Elongation (Note 2) in 2 inches or 4D (Note 3) Minimum Percent
T6	Up thru 2	Longitudinal	65.0	56.0	8
		Long Transverse	65.0	56.0	3
	Over 2 thru 3	Longitudinal	64.0	56.0	8
		Long Transverse	64.0	55.0	3
		Short Transverse	62.0	55.0	2
	Over 3 thru 4	Longitudinal	63.0	55.0	8
		Long Transverse	63.0	55.0	3
		Short Transverse	61.0	54.0	2
	Over 4 thru 5	Longitudinal	62.0	54.0	7
		Long Transverse	62.0	54.0	2
		Short Transverse	60.0	53.0	1
	Over 5 thru 6	Longitudinal	61.0	53.0	7
		Long Transverse	61.0	53.0	2
		Short Transverse	59.0	53.0	1
	Over 6 thru 7	Longitudinal	60.0	52.0	6
		Long Transverse	60.0	52.0	2
		Short Transverse	58.0	52.0	1
	Over 7 thru 8	Longitudinal	59.0	51.0	6
		Long Transverse	59.0	51.0	2
		Short Transverse	57.0	51.0	1
T652	Up thru 2	Longitudinal	65.0	56.0	8
		Long Transverse	65.0	56.0	3
	Over 2 thru 3	Longitudinal	64.0	56.0	8
		Long Transverse	64.0	55.0	3
		Short Transverse	62.0	52.0	2
	Over 3 thru 4	Longitudinal	63.0	55.0	8
		Long Transverse	63.0	55.0	3
		Short Transverse	61.0	51.0	2
	Over 4 thru 5	Longitudinal	62.0	54.0	7
		Long Transverse	62.0	54.0	2
		Short Transverse	60.0	50.0	1
	Over 5 thru 6	Longitudinal	61.0	53.0	7
		Long Transverse	61.0	53.0	2
		Short Transverse	59.0	50.0	1
	Over 6 thru 7	Longitudinal	60.0	52.0	6
		Long Transverse	60.0	52.0	2
		Short Transverse	58.0	49.0	1
	Over 7 thru 8	Longitudinal	59.0	51.0	6
		Long Transverse	59.0	51.0	2
		Short Transverse	57.0	48.0	1

1/ Maximum cross-sectional area is 256 square inches.
2/ Tensile property requirements may be waived 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.
3/ D is diameter of test specimen.
4/ Thickness is measured in the short transverse direction and applies to the dimension as forged and before any machining operation.
5/ When the as-forged dimension is 8 inches or less, the guaranteed properties shall be based on the machined thickness at the time of heat treatment.

TABLE 5 - MECHANICAL PROPERTIES OF ALLOY 7049 HAND FORGINGS (NOTE 1)

Temper	Thickness (Notes 4, 5) Inches	Axis of Test Specimen	Tensile Strength (Note 2) Minimum ksi	Yield Strength (Note 2) Minimum ksi	Elongation (Note 2) in 2 inches or 4D (Note 3) Minimum Percent
T73	Over 2 thru 3	Longitudinal	71.0	61.0	9
		Long Transverse	71.0	59.0	4
		Short Transverse	69.0	58.0	3
	Over 3 thru 4	Longitudinal	69.0	59.0	8
		Long Transverse	69.0	57.0	3
		Short Transverse	67.0	56.0	2
	Over 4 thru 5	Longitudinal	67.0	56.0	7
		Long Transverse	67.0	56.0	3
		Short Transverse	66.0	55.0	2

1/ Maximum cross-sectional area is 256 square inches.
2/ Tensile property requirements may be waived 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.
3/ D is diameter of test specimen.
4/ Thickness is measured in the short transverse direction and applies to the dimension as forged and before any machining operation.
5/ When the as-forged dimension is 8 inches or less, the guaranteed properties shall be based on the machined thickness at the time of heat treatment.

TABLE 6 - MECHANICAL PROPERTIES OF ALLOY 7075 HAND FORGINGS (NOTE 1)

Temper	Thickness (Notes 4, 5) Inches	Axis of Test Specimen	Tensile Strength (Note 2) Minimum ksi	Yield Strength (Note 2) Minimum ksi	Elongation (Note 2) in 2 inches or 4D (Note 3) Minimum Percent
T6	Up thru 2	Longitudinal	74.0	63.0	9
		Long Transverse	73.0	61.0	4
	Over 2 thru 3	Longitudinal	73.0	61.0	9
		Long Transverse	71.0	59.0	4
		Short Transverse	69.0	58.0	3
	Over 3 thru 4	Longitudinal	71.0	60.0	8
		Long Transverse	70.0	58.0	3
		Short Transverse	68.0	57.0	2
	Over 4 thru 5	Longitudinal	69.0	58.0	7
		Long Transverse	68.0	56.0	3
		Short Transverse	66.0	56.0	2
	Over 5 thru 6	Longitudinal	68.0	56.0	6
		Long Transverse	66.0	55.0	3
		Short Transverse	65.0	55.0	2
T652	Up thru 2	Longitudinal	74.0	63.0	9
		Long Transverse	73.0	61.0	4
	Over 2 thru 3	Longitudinal	73.0	61.0	9
		Long Transverse	71.0	59.0	4
		Short Transverse	69.0	57.0	2
	Over 3 thru 4	Longitudinal	71.0	60.0	8
		Long Transverse	70.0	58.0	3
		Short Transverse	68.0	56.0	1
	Over 4 thru 5	Longitudinal	69.0	58.0	7
		Long Transverse	68.0	56.0	3
		Short Transverse	66.0	55.0	1
	Over 5 thru 6	Longitudinal	68.0	56.0	6
		Long Transverse	66.0	55.0	3
		Short Transverse	65.0	54.0	1
T73	Up thru 3	Longitudinal	66.0	56.0	7
		Long Transverse	64.0	54.0	4
		Short Transverse	61.0	52.0	3
	Over 3 thru 4	Longitudinal	64.0	55.0	7
		Long Transverse	63.0	53.0	3
		Short Transverse	60.0	51.0	2
	Over 4 thru 5	Longitudinal	62.0	53.0	7
		Long Transverse	61.0	51.0	3
		Short Transverse	58.0	50.0	2
	Over 5 thru 6	Longitudinal	61.0	51.0	6
		Long Transverse	59.0	50.0	3
		Short Transverse	57.0	49.0	2
T7352	Up thru 3	Longitudinal	66.0	54.0	7
		Long Transverse	64.0	52.0	4
		Short Transverse	61.0	50.0	3
	Over 3 thru 4	Longitudinal	64.0	53.0	7
		Long Transverse	63.0	50.0	3
		Short Transverse	60.0	48.0	2
	Over 4 thru 5	Longitudinal	62.0	51.0	7
		Long Transverse	61.0	48.0	3
		Short Transverse	58.0	46.0	2
	Over 5 thru 6	Longitudinal	61.0	49.0	6
		Long Transverse	59.0	46.0	3
		Short Transverse	57.0	44.0	2

1/ Maximum cross-sectional area is 256 square inches.
2/ Tensile property requirements may be waived 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.
3/ D is diameter of test specimen.
4/ Thickness is measured in the short transverse direction and applies to the dimension as forged and before any machining operation.
5/ When the as-forged dimension is 8 inches or less, the guaranteed properties shall be based on the machined thickness at the time of heat treatment.

TABLE 7 - MECHANICAL PROPERTIES OF ALLOY 7079 HAND FORGINGS (NOTE 1)

Temper	Thickness (Notes 4, 5) Inches	Axis of Test Specimen	Tensile Strength (Note 2) Minimum ksi.	Yield Strength (Note 2) Minimum ksi	Elongation (Note 2) in 2 inches or 4D (Note 3) Minimum Percent
T6	Up thru 2	Longitudinal	72.0	63.0	9
		Long Transverse	71.0	61.0	5
	Over 2 thru 3	Longitudinal	72.0	62.0	9
		Long Transverse	70.0	60.0	5
		Short Transverse	67.0	56.0	4
	Over 3 thru 4	Longitudinal	71.0	61.0	9
		Long Transverse	70.0	59.0	5
		Short Transverse	67.0	56.0	4
	Over 4 thru 5	Longitudinal	70.0	60.0	9
		Long Transverse	69.0	58.0	4
		Short Transverse	66.0	55.0	4
	Over 5 thru 6	Longitudinal	69.0	59.0	9
		Long Transverse	68.0	56.0	4
		Short Transverse	66.0	54.0	4
	Over 6 thru 7	Longitudinal	68.0	58.0	9
		Long Transverse	67.0	54.0	4
		Short Transverse	65.0	53.0	4
	Over 7 thru 8	Longitudinal	67.0	57.0	9
		Long Transverse	66.0	53.0	4
		Short Transverse	64.0	52.0	4
T652	Up thru 2	Longitudinal	72.0	63.0	9
		Long Transverse	71.0	61.0	5
	Over 2 thru 3	Longitudinal	72.0	62.0	9
		Long Transverse	70.0	60.0	5
		Short Transverse	67.0	55.0	3
	Over 3 thru 4	Longitudinal	71.0	61.0	9
		Long Transverse	70.0	59.0	5
		Short Transverse	67.0	55.0	3
	Over 4 thru 5	Longitudinal	70.0	60.0	9
		Long Transverse	69.0	58.0	4
		Short Transverse	66.0	54.0	3
	Over 5 thru 6	Longitudinal	69.0	59.0	9
		Long Transverse	68.0	56.0	4
		Short Transverse	66.0	53.0	3
	Over 6 thru 7	Longitudinal	68.0	58.0	9
		Long Transverse	67.0	54.0	4
		Short Transverse	65.0	51.0	3
	Over 7 thru 8	Longitudinal	67.0	57.0	9
		Long Transverse	66.0	52.0	4
		Short Transverse	64.0	50.0	3

1/ Maximum cross-sectional area is 256 square inches.
2/ Tensile and yield strength test requirements may be waived 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.
3/ D is diameter of test specimen.
4/ Thickness is measured in the short transverse direction and applies to the dimension as forged and before any machining operation.
5/ When the as-forged dimension is 8 inches or less, the guaranteed properties shall be based on the machined thickness at the time of heat treatment.

TABLE 8 - MECHANICAL PROPERTIES OF ALLOY 6061 HAND FORGINGS (NOTE 1)

Temper	Thickness (Notes 4, 5, 6) Inches	Axis of Test Specimen	Tensile Strength (Note 2) maximum ksi	Yield Strength (Note 2) Minimum ksi	Elongation (Note 2) in 2 inches or 4D (Note 3) Minimum Percent
T6 or T652	Up thru 4	Longitudinal	38.0	35.0	10
		Long Transverse	38.0	35.0	8
		Short Transverse	37.0	33.0	5
	Over 4 thru 8	Longitudinal	37.0	34.0	8
		Long Transverse	37.0	34.0	6
		Short Transverse	35.0	32.0	4

1/ Maximum cross-sectional area is 256 square inches.
2/ Tensile and yield strength test requirements may be waived 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.
3/ D is diameter of test specimen.
4/ Thickness is measured in the short transverse direction and applies to the dimension as forged and before any machining operation.
5/ For T652 forging thicknesses greater than 8 inches at the time of heat treatment, the properties shall be as specified in the contract or purchase order.
6/ When the as-forged dimension is 8 inches or less, the guaranteed properties shall be based on the machined thickness at the time of heat treatment.

TABLE 9 - MECHANICAL PROPERTIES OF HAND FORGINGS (MAXIMUM THICKNESS - 4 INCHES) (NOTE 3) - ALLOY 2618

Temper	Thickness (Note 4) Inches	Axis of Test Specimen	Tensile Strength (Note 2) Minimum ksi	Yield Strength (Note 2) Minimum ksi	Elongation (Note 2) in 2 inches or 4D (Note 1) Minimum Percent
T6	Up thru 2	Longitudinal	58.0	47.0	7
		Long Transverse	55.0	42.0	5
		Short Transverse	52.0	42.0	4
	Over 2 thru 3	Longitudinal	57.0	46.0	7
		Long Transverse	55.0	42.0	5
		Short Transverse	52.0	42.0	4
	Over 3 thru 4	Longitudinal	56.0	45.0	7
		Long Transverse	53.0	40.0	5
		Short Transverse	51.0	39.0	4

1/ D is diameter of test specimen.
2/ Tensile and yield strength test requirements may be waived 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.
3/ Maximum cross-sectional area is 144 square inches.
4/ When the as-forged dimension is 4 inches or less, the guaranteed properties shall be based on the machined thickness at the time of heat treatment.

TABLE 10 - MECHANICAL PROPERTIES OF HAND FORGINGS (MAXIMUM THICKNESS - 4 INCHES) (NOTE 3) - ALLOY 2219-T6, 2219-T852

Temper	Direction	Tensile Strength (Note 2) Minimum ksi	Yield Strength (Note 2) Minimum ksi	Elongation (Note 2) in 2 inches or 4D (Note 3) Minimum Percent
T6	Longitudinal	58.0	40.0	6
	Long Transverse	55.0	37.0	4
	Short Transverse	53.0	35.0	2
T852	Longitudinal	62.0	50.0	6
	Long Transverse	62.0	49.0	4
	Short Transverse	60.0	46.0	3

1/ D is diameter of test specimen.
2/ Tensile and yield strength test requirements may be waived 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.
3/ For cross-sectional areas greater than 144 square inches, or thickness greater than 4 inches at the time of heat treatment, the properties shall be as specified in the contract or purchase order.

TABLE 11 - MECHANICAL PROPERTIES OF HAND FORGINGS (MAXIMUM SECTION THICKNESS - 4 INCHES) (NOTE 1) - ALLOY 5083

Temper	Direction	Tensile Strength (Note 2) Minimum ksi	Yield Strength (Note 2) Minimum ksi	Elongation (Note 2) in 2 inches or 4D (Note 3) Minimum Percent
H111	Longitudinal	42.0	22.0	14
	Long Transverse	39.0	20.0	12
H112	Longitudinal	40.0	18.0	16
	Long Transverse	39.0	16.0	14

1/ For thickness greater than 4 inches, the properties shall be as specified in the contract or purchase order.
2/ Tensile and yield strength test requirements may be waived 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.
3/ D is diameter of test specimen.

3.3.3 Special Purpose and Large Forgings

For die forgings and hand forgings (1) of greater cross-sectional area or (2) heat treated in section thickness greater than covered by this specification or (3) when the purpose or 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.

3.3.4 When die forgings, other than 2014, 7075 and 7079 and as covered in 3.3.3, are machined before heat treatment, the properties of the as-forged thickness will apply unless the forgings are machined to less than half the original (as-forged) section thickness. Properties of material machined to less than half of original thickness shall be as agreed upon between the contractor and the vendor for properties required greater than covered by the specification.

3.3.4.1 When hand forgings, other than covered in 3.3.3 are machined before heat treatment, the properties of the as-forged thickness will apply regardless of machined section thickness.

3.3.5 The mechanical properties of any forging supplied in any temper (See 6.3) other than one shown for that alloy in Tables 2 through 11, inclusive, shall after suitable heat treatment conform to the applicable properties shown in Tables 2 through 11, inclusive. Specimens shall be taken in accordance with 4.2.3.1 and 4.2.3.2.

3.4 Resistance to stress-corrosion cracking (7049-T73, 7075-T73 and 7075-T7352).

3.4.1 Resistance

Susceptibility to stress-corrosion cracking shall be established by the criteria as covered in 4.9.

3.4.2 Capability

Forgings supplied shall be capable of exhibiting no evidence of stress-corrosion cracking when subjected to the test specified in 4.4.3. The supplier shall maintain records of all lots so tested.

3.5 Internal Defects

When so specified (See 6.3), forgings shall be inspected ultrasonically for internal defects. Test methods and limits of acceptability shall be as agreed upon by the vendor and purchasing activity.

3.5.1 Internal Defects (Air Force Only)

Forgings shall be ultrasonically inspected for internal defects in accordance with AMS-STD-2154.

3.6 Tolerances

The forgings shall conform to the shape and dimensions specified (See 6.3), within such variations as may be shown on the drawings.

3.7 Marking of Hand Forgings

Unless otherwise specified (See 6.3), hand forgings shall be marked continuously along their length with the alloy and temper designation, if applicable, in characters that are clearly legible and that will not be obliterated by ordinary handling. For squares, the marking shall be on the fact that is parallel to the direction of the long transverse properties.

3.8 Heat Treatment

Unless otherwise specified (See 6.3), applicable tempers of forgings shall be heat treated in accordance with the requirements of AMS2772.

3.9 Workmanship

The forgings shall be of uniform quality and condition, free from blisters, fins, folds, seams, laps, cracks, segregations, spongy areas, or other defects, which would adversely affect their serviceability. Surface defects may be explored and if they can be removed so they do not appear on re-etching (See 4.6) and the required section thickness can be maintained, they shall not be cause for rejection.

3.9.1 When specified (See 6.3), the grainflow pattern shall conform with that of a sample forging, photograph or drawing approved by the procuring activity.

3.9.2 The forgings shall not be repaired by plugging or welding.

3.10 Surface Conditioning (Air Force Only)

Unless otherwise specified, all heat treated and machined die forgings purchased for use on Air Force contracts shall be processed to produce surface compressive stresses in both internal and external parting line areas and areas where “end grains” have been exposed by machining. Surface working by means of shot peening or rolling to induce residual residual surface compressive stresses shall be applied.

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.

4.1.1 Certification of Quality Compliance

For the Naval Sea Systems Command, a certificate of quality compliance shall be prepared by the manufacturer or supplier for each lot of material offered for acceptance (See 6.3.1). It shall show the results of the required tests performed by the manufacturer and shall also state that each lot has been sampled, tested, and inspected in accordance with the specification and meets all specification requirements. The certificate shall be signed by a responsible representative of the contractor.

4.2 Sampling

4.2.1 Lot

4.2.1.1 Die Forgings

A lot shall consist of forgings of the same shape or group of forgings of similar size and shape of the same alloy and heat treated 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 forgings weighing 5 pounds or less, the maximum weight of a lot shall be 2000 pounds, and for larger forgings it shall be 6000 pounds.

4.2.1.2 Hand Forgings

A lot shall consist of not more than 6000 pounds of forgings of the same alloy, temper, heat treat furnace charge (when heat treated), and dimensions submitted for inspection at one time.

4.2.2 Sampling for Chemical Analysis

4.2.2.1 Ingot Analysis

At least one sample shall be taken from each group of ingots of the same alloy poured simultaneously from the same source of molten metal by the producer and analyzed to determine conformance to 3.2. Ingots not conforming to this specification shall be rejected. Complete ingot analysis records shall be available at the producer's plant to the procuring activity.

4.2.2.2 Finished Product Analysis

Unless compliance with 4.2.2.1 is established, an analysis shall be made as specified in ASTM E 1282, for each 4000 pounds or less of material comprising the lot, except that not more than one analysis shall be required per piece.

4.2.3 Mechanical Property and Stress-Corrosion Test

Unless otherwise specified (See 4.2.3.1.2, 6.3), at least two standard 0.500 inch round tensile test specimens in accordance with AMS2355 shall be taken to represent the lot. If the cross-sectional area of the forging is too small to permit use of the standard specimen, sub-size specimens shall be used. If the forging is too small to obtain any of these specimens, the test method shall be as directed by the procuring activity (See 6.3). The tensile test specimen used for testing in accordance with 4.4.2 may be utilized for the stress-corrosion acceptance test of 4.9.

4.2.3.1 Die Forgings

4.2.3.1.1 Initial Production Lot

At least two tensile specimens, one parallel to forging flow lines and one transverse to forging flow lines, shall be taken from a forging representative of the first production lot of forgings produced from each new die or significantly reworked die, and tested to determine conformance with the requirements of Tables 2 and 3. Results of such first item tests shall be made available to the procuring activity.

4.2.3.1.2 Subsequent Production Lots

For production, the tension test specimen shall be taken from a test coupon forged from the stock used in making the forgings and heat treated with the lot which is represents or from a prolongation of the forgings or from a forging chosen to represent the lot. The test specimen shall be taken so that the axis of the specimen is substantially parallel to the direction of forging flow lines in the test coupon or forging, except that, when specified, an additional test specimen shall be taken so that the axis of the specimen is transverse to the direction of forging flow lines in the test coupon or forging.

4.2.3.2 Hand Forgings

The tension test specimens shall be taken from a prolongation of the forgings or from a forging chosen to represent the lot. The specimen representing the longitudinal direction shall be taken so that its axis coincides with the longitudinal center line of the forgings, and the specimen representing a transverse direction shall be taken so that the midpoint of its axis shall lie on the longitudinal center line of the forging. For any specimen, the midpoint of its axis shall be at least one-half of the forging thickness from any surface of the forgings. Tests will regularly be made only in the long transverse direction, but when required by the procuring activity, tests shall also be made in the longitudinal direction or short transverse direction.

4.3 Visual Examination

4.3.1 Tolerances

At least three forgings from each lot shall be measured to determine compliance with 3.6.

4.3.2 Workmanship

Visual examination of at least three forgings shall be made to establish compliance with 3.7, 3.9, and 3.9.2.

4.3.3 Preparation for Delivery

The preservation, packing, and marking shall be examined for compliance with Section 5.

4.4 Tests

4.4.1 Chemical Analysis

Chemical analysis shall be made by wet chemical or spectrochemical methods in accordance with ASTM E 1282. In case of dispute, wet chemical analysis shall be the basis for acceptance.

4.4.1.1 (Air Force Only)

Forgings shall be penetrant inspected in accordance with ASTM E 1417. Penetrant materials shall be equal to or greater than sensitivity Level 2.

4.4.2 Tension Test

Tensile and yield strengths and elongation shall be determined in accordance with AMS2355. The yield strength shall be determined by the offset method.

4.4.3 Stress-Corrosion Cracking test

Specimens of 7049-T73, 7075-T73 and 7075-T7352 alloy shall be capable of passing the following stress-corrosion test:

a. Thirty days' exposure.

b. Stressed in the short transverse direction with respect to grain flow and held at a constant strain. The stress level shall be 75 percent of the longitudinal yield strength specified in Table 2 or 5, as applicable.

c. The stressed specimens shall be exposed to a solution of 3-1/2 percent NaCl conforming to ASTM G 44, by alternate immersion. The exposure cycle shall consist of 10 minutes immersion in the solution and 50 minutes out of solution. Specimens must be dried prior to each immersion.

4.5 Heat Treatment

4.5.1 Specimens of alloy 2014 material in the solution heat-treated temper (T4) shall not be required to be mechanically tested within 4 days after completion of the heat treatment. If the manufacturer elects, samples may be tested prior to 4 days' aging. If, however, the results fail to conform with the requirements of Table 2, these tests shall be made after the expiration of 4 days without prejudice.

4.5.2 Discoloration due to heat treatment shall not be cause for rejection:

4.6 Macroscopic Examination

4.6.1 Each die forging shall be etched by swabbing or immersing in an aqueous solution of sodium hydroxide after which it shall be thoroughly rinsed in water followed by a wash in nitric acid or in chromic sulfuric acid solution or other solution where will produce a surface of equivalent suitability for visual inspection. At the option of the procuring activity (See 6.3), a sampling plan may be used in lieu of etching each forging.

4.6.1.1 (Air Force Only)

Forgings shall be penetrant inspected in accordance with ASTM E 1417. Penetrant materials utilized shall be equal to or greater than sensitivity Level 2. At the option of the procuring activity, a sampling plan may be used in lieu of 100 percent penetrant inspection.

4.6.2 When a doubt exists as to the homogeneity of the material, the etched forgings shall be examined with a glass of approximately 10 diameter magnification. A representative forging shall require deep etching of the entire cross section.

4.7 Surface Conditioning (Air Force Only)

Shot peening shall be accomplished in accordance with AMS2430 except that corrosion resisting steel shots will be used in lieu of steel shots. For intensities of 0.010A and over, the shot size shall not be smaller than 0.028 inch diameter.