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400 Commonwealth Dr., Warrendale, PA 15096

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

SAE AMS 2355E

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Superseding AMS 2355D

QUALITY ASSURANCE SAMPLING AND TESTING OF ALUMINUM ALLOYS AND MAGNESIUM ALLOYS
Wrought Products (Except Forging Stock) and Flash Welded Rings

1. SCOPE: This specification covers quality assurance sampling and testing procedures which shall be used to determine conformance to applicable specification requirements of wrought aluminum alloy and wrought magnesium alloy mill products (except forging stock) and flash welded rings, specified in inch/pound units. MAM 2355 is the equivalent, specified in metric (SI) units, of this AMS.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM B557 - Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products
ASTM B645 - Plane Strain Fracture Toughness Testing of Aluminum Alloys
ASTM E10 - Brinell Hardness of Metallic Materials
ASTM E34 - Chemical Analysis of Aluminum and Aluminum Alloys
ASTM E35 - Chemical Analysis of Magnesium and Magnesium Alloys
ASTM E55 - Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition

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2.2 (Continued):

ASTM E101 - Spectrographic Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique
ASTM E227 - Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique
ASTM E290 - Semi-Guided Bend Test for Ductility of Metallic Materials
ASTM E399 - Plane-Strain Fracture Toughness Testing of Metallic Materials
ASTM E561 - R-Curve Determination
ASTM E607 - Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by Point-to-Plane Technique, Nitrogen Atmosphere
ASTM E1004 - Electromagnetic (Eddy Currents) Measurements of Electrical Conductivity
ASTM G34 - Exfoliation Corrosion Susceptibility in 2XXX and 7XXX Series Aluminum Alloys (EXCO Test)
ASTM G47 - Determining Susceptibility to Stress-Corrosion Cracking of High-Strength Aluminum Alloy Products

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Standards:

MIL-STD-1537 - Electrical Conductivity Test for Measurement of Heat Treatment of Aluminum Alloys, Eddy Current Method

3. TECHNICAL REQUIREMENTS:

3.1 General:

3.1.1 Omission from this specification of confirmatory tests of certain material properties or attributes controlled by the applicable specification for a product does not relieve the vendor of responsibility for furnishing products which conform in all respects to the applicable material specification.

3.1.2 In event of conflict between the requirements specified herein and the requirements of a particular material specification, the following rules shall apply:

3.1.2.1 When the requirements of the material specification are more stringent, they shall take precedence.

3.1.2.2 When the requirements of this AMS are more stringent, they shall take precedence except as noted in 3.1.2.3.

3.1.2.3 If any tests mentioned in 3.3.2 are not required by the material specification, they shall not be considered a requirement.

3.1.2.4 When instructions are issued by purchaser regarding quality assurance sampling procedures, such instructions shall take precedence over the requirements of either this specification or the particular specification in which this specification is invoked.

3.2 Responsibility for Tests: The vendor of the product shall supply all samples for vendor's tests and shall be responsible for performing all required tests.

3.3 Detail Requirements:

3.3.1 Inspection Lot:

3.3.1.1 Wrought Alloy Products (Excluding Flash Welded Rings):

3.3.1.1.1 For heat-treated tempers, an inspection lot shall be an identifiable quantity of product of the same mill form, alloy, temper, section, and size traceable to a heat treat lot (See 8.3.3) or lots, and presented for vendor's inspection at one time. All sheet and plate of the same thickness is considered to be of the same size.

3.3.1.1.2 For non-heat-treated tempers, an inspection lot shall be an identifiable quantity of product of the same mill form, alloy, temper, section, and size presented for vendor's inspection at one time.

3.3.1.2 Flash Welded Rings: An inspection lot shall consist of all rings of the same alloy, cross-sectional configuration, and size heat treated in the same batch furnace load or in a continuous furnace during a period of eight consecutive hours and presented for vendor's inspection at one time.

3.3.2 Sampling:

3.3.2.1 Chemical Analysis:

3.3.2.1.1 Cast Unit: Producer shall take at least one control sample before and at least one additional sample during the casting of each cast unit (units, if cast simultaneously from the same molten metal source). Complete analysis records shall be available for review at the producer's plant (See 8.2).

3.3.2.1.2 Finished Product (Excluding Forgings and Flash Welded Rings): When compliance with 3.3.2.1.1 cannot be established, one sample shall be taken for each 4,000 lb, or fraction thereof, of each alloy in an inspection lot.

3.3.2.1.3 Forgings: When compliance with 3.3.2.1.1 cannot be established, sampling shall be as follows: one sample shall be taken for each 2,000 lb, or fraction thereof, in a lot of forgings having a nominal weight of 5 lb and under; one sample shall be taken for each 6,000 lb, or fraction thereof, in a lot of forgings having a nominal weight greater than 5 pounds.

3.3.2.1.4 Flash Welded Rings: Unless a report showing conformance of chemical composition to the applicable material specification is available on the stock used for flash welded rings, one sample shall be taken for each 6,000 lb, or fraction thereof, in a lot; however, not more than one sample is required from a piece.

3.3.2.2 Ø Tensile Properties: The location from which the sample is taken shall be as specified in 3.3.3 for the type of test and type of product being tested. The orientation with respect to direction of predominant grain flow shall be as specified in the applicable material specification or, if not specified therein, shall be as specified in 3.3.3. The samples shall be taken from randomly selected pieces of the product. Only one tensile specimen shall be taken in any one direction from any one piece when more than one piece is available. The number of samples shall be as specified herein for the type of product being tested. Product in the annealed (-O) temper of heat-treatable alloys shall have additional samples taken, equal in number to those specified for the product herein, for subsequent heat treatment and testing to demonstrate response to heat treatment, when specified in the applicable material specification.

3.3.2.2.1 Sheet: One sample shall be taken from each end of each parent coil but not more than one sample for each 2,000 lb, or fraction thereof, in a lot shall be required.

3.3.2.2.2 Plate: One sample shall be taken from each end of each parent plate but not more than one sample for each 4,000 lb, or fraction thereof, in a lot shall be required.

3.3.2.2.3 Wire, Rod, Bar, Shapes, Tubing, and Pipe: For products having a nominal weight under 1 lb per linear ft, one sample shall be taken for each 1,000 lb, or fraction thereof, in a lot. For products having a nominal weight of 1 lb or greater per linear ft, one sample shall be taken for each 1,000 ft, or fraction thereof, in a lot.

3.3.2.2.4 Ø Die Forgings: For die forgings having a nominal weight of 5 lb and under, one sample shall be taken in each specimen orientation specified for each 2,000 lb, or fraction thereof, in a lot. For die forgings having a nominal weight over 5 lb, one sample shall be taken similarly for each 6,000 lb, or fraction thereof, in a lot.

3.3.2.2.5 Ø Hand Forgings: One sample shall be taken for each 6,000 lb, or fraction thereof, in a lot in each grain direction for which properties are specified.

3.3.2.2.6 Flash Welded Rings: One sample shall be taken from parent metal, not including the weld-heat-affected zone, of a flash welded ring representing the lot.

3.3.2.3 Examination:

3.3.2.3.1 Dimensional and Workmanship Inspection: Each piece shall be inspected to determine conformance to the applicable material specification with respect to workmanship and identification marking. Inspection for dimensions shall be made to ensure conformance to specified tolerances. The vendor may use a system of statistical quality control for dimensional, marking, and workmanship inspection.

3.3.2.4 Conductivity Testing: When specified, conductivity testing for corrosion acceptance criteria purposes shall be performed on the same samples from which tensile property specimens are obtained.

3.3.2.5 Stress-Corrosion and Exfoliation-Corrosion Testing: Sampling for stress-corrosion and exfoliation-corrosion testing shall initially consist of two samples for each 4,000 lb or fraction thereof from each of the first three production lots for each size range listed in the table of tensile properties in the applicable material specification. Thereafter, periodic testing shall be performed in accordance with the applicable material specification.

3.3.2.6 Ø Fracture Toughness Testing: Unless specified in the applicable material specification, sampling for fracture toughness testing shall be in the location(s) and at the frequency agreed upon by purchaser and vendor; direction(s) of test shall be as specified in the material specification and as defined in ASTM E399..

3.3.3 Tensile Specimen Orientation, Location, and Size: Tensile specimens shall be cut from the product in the direction shown below and shall be cut from the locations and to the sizes specified.

3.3.3.1 Sheet and Plate:

3.3.3.1.1 Orientation:

3.3.3.1.1.1 Aluminum: For non-heat-treatable aluminum alloys, tensile specimens shall be taken parallel to the direction of rolling. For heat-treatable aluminum alloys, tensile specimens shall be taken perpendicular to the direction of rolling from widths 9 in. and over and parallel to the direction of rolling from widths under 9 inches. When short-transverse tensile properties are specified and are to be determined, short-transverse tensile specimens shall be taken with axis of specimen parallel to the thickness direction of the product.

3.3.3.1.1.2 Magnesium: For magnesium alloys, tensile specimens shall be taken parallel to the direction of rolling. When short-transverse tensile properties are specified and are to be determined, short-transverse tensile specimens shall be taken with axis of specimen parallel to the thickness direction of the product.

3.3.3.1.2 Location and Size of Tensile Specimen:

3.3.3.1.2.1 Longitudinal and Long-Transverse Specimens: The standard 1/2 in. wide rectangular tensile specimen or pin-loaded tensile specimen with 2 in. gage length of ASTM B557 shall be used for sheet and plate under 0.500 in. in thickness. For plate 0.500 in. and over in thickness the standard 1/2 in. round tensile specimen with 2 in. gage length of ASTM B557 or a smaller round specimen proportional to it shall be used. The tensile specimen shall be taken midway between the two surfaces of plate 0.500 to 1.500 in., incl, in thickness and midway between the center and surface of plate over 1.500 in. in thickness. Product under 3/4 in. in width shall be tested in full-section when the standard 1/2 in. round tensile specimen or a smaller round specimen proportional to it cannot be obtained, in which case elongation requirements shall not apply.

3.3.3.1.2.2 Short-Transverse Specimens: For plate 1.500 in. and over in thickness, sub-size specimens as specified in 3.3.4.3 shall be used. The tensile specimens shall be centered midway between the two surfaces of the plate.

3.3.3.2 Wire, Rod, and Bar:

3.3.3.2.1 Orientation:

3.3.3.2.1.1 Aluminum and Magnesium: Tensile specimens shall be taken in the longitudinal direction, except that when long-transverse tensile properties are specified and are to be determined, the tensile specimens shall be taken perpendicular to the rolling or extruding direction. When short-transverse tensile properties are specified for rectangular bar and are to be determined, short-transverse tensile specimens shall be taken with axis of specimen parallel to the thickness direction of the bar.

3.3.3.2.2 Location and Size of Tensile Specimens:

3.3.3.2.2.1 Longitudinal Specimens: If size or shape of product makes it impractical to use full-section tensile specimens, the standard 1/2 in. round tensile specimen with 2 in. gage length of ASTM B557 or a smaller round specimen proportional to it shall be used, except that for rectangular bar under 1/2 in. in thickness, the standard 1/2 in. wide rectangular tensile specimen or pin-loaded tensile specimen with 2 in. gage length of ASTM B557 may be used. For product not tested in full-section, the tensile specimen shall be taken from the locations specified in Table I. Elongation and yield strength requirements of material specifications do not apply to wire under 0.125 in. in diameter or thickness.

3.3.3.2.2.1 (Continued):

TABLE I

Location of Axis of Longitudinal Tensile Specimen in Rod and Bar

Section Thickness or Width, Inches	Location of Axis of Specimen with Respect to Thickness (T) and Width (W) of Section	
	Thickness	Width
Up to 1.500, incl	T/2	W/2
Over 1.500	T/4	W/4

3.3.3.2.2.2 Long-Transverse Specimens: The standard 1/2 in. wide rectangular tensile specimen or pin-loaded tensile specimen with 2 in. gage length of ASTM B557 shall be used for bar under 0.500 in. in thickness and 8 in. and over in width. For bar 0.500 in. and over in thickness, the standard 1/2 in. round tensile specimen with 2 in. gage length of ASTM B557 or a smaller round specimen proportional to it shall be used. The axis of the tensile specimen shall fall in the plane midway between the two surfaces of bar 0.500 to 1.500 in., incl, in nominal thickness and midway between the center and surface of bar over 1.500 in. in thickness.

3.3.3.2.2.3 Short-Transverse Specimens: For rectangular bar 1.500 in. and over in thickness, sub-size specimens as specified in 3.3.4.3 shall be used. The tensile specimens shall be taken at the center of the bar with respect to both thickness and width.

3.3.3.3 Tubing:

3.3.3.3.1 Orientation:

3.3.3.3.1.1 Drawn Aluminum and Extruded Aluminum and Magnesium: Tensile specimens shall be taken in the longitudinal direction, except that when long-transverse tensile properties are specified for square or rectangular tubing and are to be determined, the tensile specimens shall be taken perpendicular to the direction of drawing or extrusion.

3.3.3.3.2 Location and Size of Tensile Specimens:

3.3.3.3.2.1 Longitudinal Specimens: Tensile specimens from round tubing 2.000 in. and under in nominal OD and from square tubing 1.500 in. and under on a side shall be the full-section of the tubing unless limitations of the testing machine preclude the use of such a specimen. For tubing of larger size, or when it is not possible to test the full-section, the standard 1/2 in. wide rectangular tensile specimen or pin-loaded tensile specimen with 2 in. gage length; or

3.3.3.3.2.1 (Continued):

standard 1/2 in. round tensile specimens with 2 in. gage length; or standard 1/2 in. longitudinal tensile specimen of ASTM B557 may be used for large-diameter tubular products. When the size of the product makes it impractical to use any of these specimens, round specimens proportional to the standard 1/2 in. round tensile specimen of ASTM B557 shall be used. For tubing having a wall thickness of 1.500 in. and under not tested in full-section, the tensile specimen shall be taken from the center of the wall. For tubing having a wall thickness over 1.500 in. the specimen shall be taken midway between the center of the wall thickness and the inner or outer surface of the tubing.

3.3.3.3.2.2 Long-Transverse Specimens: The standard 1/2 in. round tensile specimen with 2 in. gage length of ASTM B557 or a smaller round specimen proportional to it shall be used for thicknesses of 3/8 in. and over and having widths of 2-3/8 in. and over, except that for square or rectangular tubing under 0.500 in. in thickness, the standard 1/2 in. wide rectangular tensile specimen or pin-loaded tensile specimen with 2 in. gage length of ASTM B557 may be used. For tubing from which these machined specimens cannot be obtained, a round or rectangular specimen of the largest possible dimensions shall be used. For tubing having a wall thickness of 1.500 in. and under, the tensile specimen shall be taken from the center of the wall. For tubing having a wall thickness over 1.500 in., the specimen shall be taken midway between the center of the wall thickness and the inner or outer surface of the tubing.

3.3.3.4 Shapes:

3.3.3.4.1 Orientation:

3.3.3.4.1.1 Aluminum and Magnesium: Tensile specimens shall be taken in the longitudinal direction, except that when long-transverse tensile properties are specified and are to be determined, tensile specimens shall be taken perpendicular to the extruding direction. When short-transverse tensile properties are specified for shapes and are to be determined, short-transverse tensile specimens shall be taken with axis of specimen parallel to the thickness direction of the shape.

3.3.3.4.2 Location and Size of Tensile Specimens: Shall be as in 3.3.3.4.2.1 through 3.3.3.4.2.3 except that size, location, and orientation of tensile specimens from complicated shapes shall be as agreed upon by purchaser and vendor.

3.3.3.4.2.1 Longitudinal Specimens: If the size or shape of product makes it impractical to use full-section tensile specimens, the standard 1/2 in. round tensile specimen with 2 in. gage length of ASTM B557 or smaller round specimen proportional to it shall be used, except that for shapes under 0.500 in. in thickness having parallel surfaces, the standard 1/2 in. wide rectangular tensile specimen or pin-loaded tensile specimen with 2 in. gage length of ASTM B557 may be used. For shapes from which these machined specimens cannot be obtained and which cannot be tested in full-section, a round or rectangular specimen of the largest possible dimensions shall be used. The tensile specimen shall be taken from the predominant section of the shape and from the location which most nearly complies with Table II. Elongation requirements do not apply to specimens from shapes less than 0.062 in. in thickness or to round or rectangular specimens of non-standard proportions.

TABLE II

Location of Axis of Longitudinal Tensile Specimen in Extruded Shapes

Section Thickness or Width, Inches	Location of Axis of Specimen with Respect to Thickness (T) and Width (W) of Section	
	Thickness	Width
Up to 1.500, incl	T/2	W/2
Over 1.500	T/4	W/4

3.3.3.4.2.2 Long-Transverse Specimens: The standard 1/2 in. round tensile specimen with 2 in. gage length of ASTM B557 or a smaller round specimen proportional to it shall be used for thicknesses of 3/8 in. and over and having widths of 2-3/8 in. and over, except that for shapes under 0.500 in. in thickness having parallel surfaces, the standard 1/2 in. wide rectangular tensile specimen or pin-loaded tensile specimen with 2 in. gage length of ASTM B557 may be used. For shapes from which these machined specimens cannot be obtained, a round or rectangular specimen of the largest possible dimensions shall be used. The tensile specimens shall be taken from the center of the predominant section of the shape with respect to both thickness and width. Elongation requirements do not apply to specimens from shapes less than 0.062 in. in thickness or to round or rectangular specimens of non-standard proportions.

3.3.3.4.2.3 Short-Transverse Specimens: For shapes 1.500 in. and over in thickness, sub-size specimens as specified in 3.3.4.3 shall be used. The tensile specimens shall be taken from the center of the predominant section with respect to both thickness and width.

3.3.3.5 Die Forgings:

3.3.3.5.1 Orientation:

3.3.3.5.1.1 Aluminum and Magnesium: Tensile specimens shall be taken parallel to the direction of grain flow, except that when tensile properties are required to be determined in other directions, the tensile specimens shall be taken in the specified direction. Unless prohibited by the material specification, tensile specimens may be taken from a prolongation on the forging or from coupons separately-forged from the same stock used to produce the forgings.

3.3.3.5.2 Location and Size of Tensile Specimens:

3.3.3.5.2.1 Specimens Parallel to Grain Flow: The standard 1/2 in. round tensile specimen with 2 in. gage length of ASTM B557 or a smaller round specimen proportional to it shall be used for section thicknesses 0.500 in. and over. Smaller round specimens proportional to the standard 1/2 in. tensile specimen or rectangular tensile specimens of ASTM B557 shall be used for section thicknesses 0.312 to 0.499 in., inclusive. Rectangular tensile specimens of ASTM B557 shall be used for section thicknesses under 0.312 inch. Tensile specimen shall be taken at the center of the predominant section with respect to both thickness and width.

3.3.3.5.2.2 Specimens Not Parallel to Grain Flow: Sub-size specimens as specified in 3.3.4.3 shall be used. Tensile specimens shall be taken from the location specified on the engineering drawing or otherwise specified by purchaser.

3.3.3.6 Hand Forgings:

3.3.3.6.1 Orientation:

3.3.3.6.1.1 Aluminum and Magnesium: Tensile specimens shall be taken in the long-transverse direction, except that when longitudinal tensile properties are specified and are to be determined, the tensile specimens shall be taken parallel to the forging direction. When short-transverse tensile properties are specified and are to be determined, short-transverse tensile specimens shall be taken with the axis of the specimen parallel to the thickness direction of the hand forging.

3.3.3.6.2 Location and Size of Tensile Specimens:

3.3.3.6.2.1 Longitudinal Specimens: The standard 1/2 in. round tensile specimen with 2 in. gage length of ASTM B557 or a smaller round specimen proportional to it shall be used. The tensile specimen shall be taken so that its axis coincides with the longitudinal center line of the hand forging and the distance from the midpoint of its axis to the end of the hand forging is at least one-half the thickness of the hand forging.

3.3.3.6.2.2 Long-Transverse Specimens: The standard 1/2 in. round tensile specimen with 2 in. gage length of ASTM B557 or a smaller round specimen proportional to it shall be used. The tensile specimen shall be taken so that the midpoint of its axis lies on the longitudinal center line of the hand forging at a distance from the end of the hand forging of at least one-half the thickness of the hand forging.

3.3.3.6.2.3 Short-Transverse Specimens: For hand forgings 2.000 in. and over in thickness, sub-size specimens as specified in 3.3.4.3 shall be used. The tensile specimens shall be taken so that the midpoint of specimen axis lies on the longitudinal center line of the hand forging at a distance from the end of the hand forging of at least one-half the thickness of the hand forging.

3.3.3.7 Flash Welded Rings: Tensile specimens shall be taken in the circumferential direction and from a location in respect to cross-section as applicable to the flash welded stock size as specified in 3.3.3.2.2.1.

3.3.4 Tensile Specimen Types: Tensile specimens may be substantially the full cross-section of the product being tested or they may be machined.

3.3.4.1 Full-Section Specimens: Tensile specimens of substantially the full cross-section of the product may be used for wire, rod, bar, tubing, and shapes. The section may be reduced slightly throughout the test section to ensure fracture within the gage marks. The gage length shall be four times the diameter for solid round specimens and 2 in. for all other specimens.

3.3.4.2 Machined Specimens: Standard machined specimens for tensile testing are of two types: round and rectangular, with a gage length of 2 in. and a width or diameter of 1/2 inch. These standard specimens are shown in ASTM B557.