

AEROSPACE MATERIAL SPECIFICATION

SAE

AMS 2370E

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Submitted for recognition as an American National Standard

QUALITY ASSURANCE SAMPLING AND TESTING Carbon and Low-Alloy Steel Wrought Products and Forging Stock

1. **SCOPE:** This specification covers quality assurance sampling and testing procedures used to determine conformance to applicable specification requirements of wrought carbon and low-alloy steel products and of forging stock.
 - 1.1 Attributes included in detail herein are: Composition, tensile properties, macrostructure and micro-inclusion rating. Other requirements are included in Table I.
 - 1.2 Quality assurance sampling and testing procedures for forgings are covered in AMS 2372.
2. **APPLICABLE DOCUMENTS:** The following publications form a part of this specification to the extent specified herein. The applicable issue of referenced publications shall be the issue in effect on the date of the purchase order.

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- 2.1 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM E 8 - Tension Testing of Metallic Materials
ASTM E 8M - Tension Testing of Metallic Materials (Metric)

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 material specification 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 requirements specified herein and requirements of a particular material specification, requirements of the material specification shall take precedence.

- 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. Results of such tests shall be reported to the purchaser as required by the applicable material specification.

3.3 Detail Requirements:

- 3.3.1 Lot: A lot shall be as defined in 3.3.1.1 or 3.3.1.2; the applicable definition being as specified in Table I for the type of test and type of product being tested.

- 3.3.1.1 A lot shall be all product identifiable to a single heat.

- 3.3.1.1.1 A heat shall be all steel melted in a single furnace charge. For consumable electrode remelted steel, a heat shall be all consumable electrode remelted ingots processed from steel originally melted as a single furnace charge.

- 3.3.1.2 A lot shall be a mill form of one shape, condition, and nominal cross-sectional dimensions from a single heat, processed by either of the following methods (See 3.3.1.2.1 and 3.3.1.2.2):

- 3.3.1.2.1 Sequentially heat treated during a 24-hour period in a continuous furnace with no interruption in operations and no change in furnace temperature, charge rate, or racking pattern.

- 3.3.1.2.1.1 The nominal dimension restriction may be disregarded when multiple sizes are heat treated in a single batch or during an eight-hour period in a continuous furnace operating at a constant speed. In such cases, tensile and macrostructure testing shall be performed on the size having the greatest equivalent round cross-section. The equivalent round cross-section shall be determined by multiplying wall thickness of tubing and thickness or diameter of solids by the following shape factors:

Product	Shape Factor
Tubing	2.0
Rounds	1.0
Hexagons	1.1
Squares	1.25
Flats	1.50

- 3.3.1.2.2 Sequentially heat treated during a 48-hour period in one or a series of batch-type furnace loads provided the loads are processed in the same furnace or same series of furnaces, and there is no change in power, set temperature, soak time, quench parameters, or racking pattern.

3.3.2 Sampling and Testing: Shall be as follows:

3.3.2.1 Composition:

- 3.3.2.1.1 The reported chemical composition of the steel subjected to a single melting operation shall be that of a sample taken immediately before or during the pouring of a heat. Analysis results of the sample shall be within the composition limits established by the material specification, excluding any consideration of product check analysis.

- 3.3.2.1.1.1 If the sample of 3.3.2.1.1 is lost, a new sample shall be taken from the semi-finished or finished product.

- 3.3.2.1.2 For remelted steels, analyses shall be obtained from the remelted ingot or product thereof in accordance with a sampling plan that will allow the reported chemical composition of the steel to conform to one of the following options:

- The average of all ingots in the remelted heat.
- The average of the ingots directly involved with the order.
- The average of samples representing the first and last usable metal poured from the master heat.
- The analysis of each ingot involved with the order.

- 3.3.2.1.2.1 If an average is reported, the analysis of each element shall fall within the compositional limits established by the material specification; the individual analysis may include the applicable product check analysis allowances but no average shall include analyses which are both above and below the compositional limits.

- 3.3.2.1.2.2 When the remelting method is vacuum-arc remelting and the applicable material specification establishes minimum values for carbon and/or manganese, these elements shall be determined and reported for each remelted ingot.
- 3.3.2.1.2.3 The master heat analysis may be used for reporting the analyses of those elements governed only by a maximum in the material specification if the analysis is within the compositional limits and the element routinely decreases or remains constant during remelting.
- 3.3.2.1.2.4 Analyses of samples made prior to discard need not be reported.
- 3.3.2.2 Tensile Specimen Orientation, Location, and Size: Tensile specimens conforming to ASTM E 8 or ASTM E 8M shall be cut from the semi-finished or finished product in the direction indicated below, and shall be cut from the locations and to the sizes specified. The sample shall consist of one or more sections of the product selected to represent a specific location or locations with respect to the order of pouring of the selected ingot or ingots and with respect to the location within the ingot.
- 3.3.2.2.1 Sheet, Strip, and Plate:
- 3.3.2.2.1.1 Orientation: Specimens shall be taken with the axis of the specimen perpendicular to the direction of rolling from widths 9 inches (229 mm) and over and parallel to the direction of rolling from widths under 9 inches (229 mm). When short-transverse tensile properties are specified in the applicable material specification, specimens shall be taken with the axis of the specimen parallel to the thickness direction of the product.
- 3.3.2.2.1.2 Location and Size:
- 3.3.2.2.1.2.1 Longitudinal and Long-Transverse Specimens: The standard 1/2 inch (12.7 mm) wide rectangular specimen or pin-loaded tensile specimen with 2-inch (50.8 mm) gage length shall be used for sheet and plate under 0.750 inch (19.05 mm) in nominal thickness. For plate 0.750 inch (19.05 mm) and over in nominal thickness, the standard 1/2 inch (12.7 mm) round tensile specimen with 2-inch (50.8 mm) gage length or a smaller, round specimen proportional to the standard shall be used. The tensile specimen shall be located midway between the faces of product 1-1/2 inches (38.1 mm) and under in nominal thickness and midway from center to surface for product over 1-1/2 inches (38.1 mm) in nominal thickness.
- 3.3.2.2.1.2.2 Short-Transverse Specimens: For plate 2-1/2 inches (63.5 mm) and over in nominal thickness, subsize round tensile specimens, proportional to the standard, shall be used when thickness is insufficient to accommodate standard 1/2 inch (12.7 mm) round tensile specimens with 2-inch (50.8 mm) gage length.

3.3.2.2.2 Bar, Rod, and Wire:

3.3.2.2.2.1 Orientation: Specimens shall be taken with the axis of the specimen in the longitudinal direction, except that, when long-transverse tensile properties are specified in the applicable material specification, specimens shall be taken with the axis of the specimen perpendicular to the rolling or extruding direction. When short-transverse tensile properties are specified for rectangular bar in the applicable material specification, specimens shall be taken with the axis of the specimen parallel to the thickness direction of the bar.

3.3.2.2.2.2 Location and Size:

3.3.2.2.2.2.1 Longitudinal and Long-Transverse Specimens: If the product size or shape makes it impractical to use full-section specimens, the standard 1/2 inch (12.7 mm) round tensile specimen with 2-inch (50.8-mm) gage length or a smaller round specimen, proportional to the standard, shall be used, except that for rectangular bar under 0.750 inch (19.05 mm) in nominal thickness, the standard 1/2 inch (12.7 mm) wide rectangular specimen or pin-loaded tensile specimen with 2-inch (50.8-mm) gage length may be used. The tensile specimen shall be located at the center for product 1-1/2 inches (38.1 mm) and under in nominal diameter, thickness, or distance between flats and midway from center to surface for product over 1-1/2 inches (38.1 mm) in nominal thickness.

3.3.2.2.2.2.2 Short-Transverse Specimens: For bar 2-1/2 inches (63.5 mm) and over in nominal thickness, subsize round tensile specimens, proportional to the standard, shall be used when thickness is insufficient to accommodate standard 1/2 inch (12.7 mm) round tensile specimens with 2-inch (50.8-mm) gage length.

3.3.2.2.3 Tubing:

3.3.2.2.3.1 Orientation: Specimens shall be taken with the axis of the specimen in the longitudinal direction except that, when long-transverse tensile properties of square or rectangular tubing are required by the applicable material specification, specimens shall be taken with the axis of the specimen perpendicular to the drawing or extruding direction.

3.3.2.2.3.2 Longitudinal Specimens: Specimens from round and square tubing shall be the full section of the tubular product unless limitations of the testing machine preclude the use of such specimens. Snug-fitting metal plugs shall be inserted into the ends of tubular specimens to a sufficient depth to permit the jaws of the testing machine to grip the specimen properly without crushing. The plugs shall not extend into that portion of the specimen to be tested. Care shall be exercised to ensure that the load is applied axially. The length of full-section specimens shall be determined by the gage length specified for measuring elongation. For large-size tubing, or when it is not possible to test in full section, longitudinal specimens shall be obtained from strips cut from the tube. Either 1/2 inch (12.7 mm) wide rectangular or subsize round tensile specimens, proportional to the standard (for thick-wall tube) shall be machined from these strips. Longitudinal strip-type tensile specimens from welded tubing shall not include weld bead. For thick-wall tubing for which subsize round tensile specimens are used, when the nominal wall thickness is under 1-1/2 inch (38.1 mm), specimens shall be taken midway between the inner and outer surface of the tubing; when the nominal wall thickness is 1-1/2 inch (38.1 mm) and over, specimens shall be taken at one-quarter wall thickness referencing from either OD or ID.

3.3.2.2.3.3 Long-Transverse Specimens: Rectangular specimens or subsize round specimens, proportional to the standard, shall be used for square or rectangular tubing. Rectangular or round tensile specimens of the largest possible dimensions, proportional to the standard, shall be used when standard size specimens cannot be obtained. For thick walled tubing, a round tensile specimen shall be taken midway between the inner and outer surface of the tubing when the nominal wall thickness is under 1-1/2 inches (38.1 mm); when the nominal wall thickness is 1-1/2 inches (38.1 mm) and over, specimens shall be taken at one-quarter wall thickness referencing from either OD or ID.

3.3.2.2.4 Shapes:

3.3.2.2.4.1 Orientation: Specimens shall be taken with the axis of the specimen in the longitudinal direction, except that, when long-transverse tensile properties are specified in the applicable material specification, specimens shall be taken with the axis of the specimen perpendicular to the rolling or extruding direction. When short-transverse tensile properties of shapes are specified in the applicable material specification, specimens shall be taken with the axis of the specimen parallel to the thickness direction of the shape.

3.3.2.2.4.2 Location and Size:

3.3.2.2.4.2.1 Longitudinal Specimens: If the product size or shape makes it impractical to use full-section specimens, the standard 1/2-inch (12.7-mm) round tensile specimen with 2-inch (50.8-mm) gage length or smaller round specimen, proportional to the standard, shall be used except that for shapes under 0.500 inch (12.70 mm) in nominal thickness having parallel surfaces, the standard 1/2 inch (12.7 mm) wide rectangular specimen or pin-loaded tensile specimen with 2-inch (50.8 mm) gage length 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. For shapes not tested in full section, specimens shall be taken from the center of the predominant or thickest part of the shape when that predominant nominal dimension is under 1-1/2 inch (38.1 mm); for thicker cross-sections, the specimens shall be taken from a one-quarter thickness location.

3.3.2.2.4.2.2 Long-Transverse Specimens: The standard 1/4 inch (6.35 mm) round tensile specimen with 1-inch (25.4 mm) gage length or a smaller round specimen, proportional to the standard, shall be used for nominal thicknesses of 3/8 inch (9.5 mm) and over. For shapes under 3/8 inch (9.5 mm) in nominal thickness having parallel surfaces, the standard 1/2 inch (12.7 mm) wide rectangular specimen or pin-loaded tensile specimen with 2-inch (50.8-mm) gage length shall 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. For shapes not tested in full section, specimens shall be taken from the center of the predominant or thickest part of the shape when that predominant nominal dimension is under 1-1/2 inch (38.1 mm); for thicker cross-sections, specimens shall be taken from a one-quarter thickness location.

3.3.2.2.4.2.3 Short-Transverse Specimens: For bar 2-1/2 inches (63.5 mm) and over in nominal thickness, subsize round specimens, proportional to the standard, shall be used when thickness is insufficient to accommodate standard 1/2-inch (12.7 mm) round tensile specimens with 2-inch (50.8 mm) gage length.

3.3.2.2.4.2.4 Complicated Shapes: Size, location, and direction of tensile specimens shall be as agreed upon by purchaser and vendor.

3.3.2.2.5 Flash Welded Rings: Specimens shall be taken from parent metal, not including the weld-heat-affected zone, with the axis of the specimen in the circumferential direction. Standard 1/2 inch (12.7 mm) round tensile specimens with 2-inch (50.8-mm) gage length or subsize round specimens, proportional to the standard, shall be used. The tensile specimen shall be located at the center for product 1-1/2 inches (38.1 mm) and under in nominal thickness, diameter, or distance between flats and midway from center to surface for product over 1-1/2 inches (38.1 mm).

3.3.2.3 Macrostructure: Shall be as follows:

3.3.2.3.1 Aircraft Quality (Static or Strand Cast):

3.3.2.3.1.1 Heat Qualification:

3.3.2.3.1.1.1 Heats of Top Poured Ingots: Samples shall be taken from semi-finished or finished product representing the top and bottom of the first ingot and last usable ingot from heats having not more than 10 ingots or not over 30 tons (27 215 kg) or from portions of heats within these limits, and from the top and bottom of the first, middle, and last usable ingot of heats having more than 10 ingots or over 30 tons (27 215 kg).

3.3.2.3.1.1.2 Heats of Bottom Poured Ingots: Samples shall be taken from semi-finished or finished product representing the top and bottom of three ingots. One ingot shall be taken at random from the first usable plate poured, one ingot at random from the usable plate poured nearest to the middle of the heat, and one ingot at random from the last usable plate poured. When a heat is constituted by two usable plates, two of the sample ingots shall be selected from the second usable plate poured. When a heat consists of a single usable plate, any three random ingots may be selected.

3.3.2.3.1.1.2.1 If there are less than three ingots in the heat, samples shall be taken representing the top and bottom of all ingots.

3.3.2.3.1.1.3 Strand Cast Heats: Samples shall be taken from semi-finished or finished product having at least a 3:1 reduction in cross-section from the cast strand (or samples of the as-cast strand similarly reduced) representing the front, middle, and back of both strands when two strands are cast, or of an inside strand and an outside strand when more than two strands are cast. When a single strand is cast, six samples having at least a 3:1 reduction from the cast strand (or samples of the cast strand similarly reduced), representing both ends of the first, middle, and last usable cuts (blooms) of the strand or product shall be taken.

3.3.2.3.1.2 Product Qualification: Samples shall be taken at random from not less than 10% of the pieces of each lot. A lot shall be all product of one size from one heat in one shipment. Not less than three nor more than ten samples shall be selected from a lot, except that if the quantity in the lot is three pieces or less, one sample shall be taken from each piece.

3.3.2.3.2 Premium Aircraft-Quality:

3.3.2.3.2.1 Heat Qualification: The samples shall be taken from semi-finished or finished product representing the top and bottom of each consumable remelted ingot.

3.3.2.3.2.2 Product Qualification: Samples shall be taken at random from not less than 10% of the pieces of each lot. A lot shall be all product of one size from one heat in one shipment. Not less than three nor more than ten samples shall be selected from a lot, except that if the quantity in the lot is three pieces or less, one sample shall be taken from each piece.

3.3.2.4 Micro-inclusion Rating:

3.3.2.4.1 Aircraft-Quality or Aircraft-Quality for Bearing Applications: Sample shall represent the product specified for macrostructure in 3.3.2.3.

3.3.2.4.2 Premium Aircraft-Quality: Samples shall represent the top and bottom of the first and last usable remelted ingot from a heat yielding less than 10 ingots. From a heat yielding 10 or more ingots, samples shall represent the top and bottom of the first, middle, and last usable, remelted ingot.

3.3.2.4.2.1 For product identified as premium aircraft-quality vacuum arc remelted or premium aircraft-quality not vacuum arc remelted from a heat yielding less than 10 ingots, samples shall represent the top and bottom of the first and last usable remelted ingot; if the master heat consists of ten or more ingots, the samples shall represent the top and the bottom of the first, middle, and last usable remelted ingot.

3.3.3 Sampling and Testing: Shall be in accordance with Table I.

3.3.3.1 Only one value need be reported for composition.

3.3.4 Testing Method: Shall be in accordance with requirements of the applicable material specification. If a test method is not specified, the method of test shall be as agreed upon by purchaser and vendor.

3.3.5 Resampling and Retesting: Depending on the attributes to be evaluated, proceed as follows:

3.3.5.1 If any test fails, the location may be considered a non-representative location; the material may be cut back and all properties from the new location redetermined.

3.3.5.2 For Composition: If an invalid specimen (3.3.5.2.1) is suspected, resample as in 3.3.2.1. If a non-representative sample (e.g. an end condition) is involved, cut back the test location as appropriate and resample as in 3.3.2.1.

3.3.5.2.1 A test for composition may be declared invalid if caused by a malfunction of the chemical analysis equipment or by use of an improper test procedure. Resampling and retesting results shall fulfill requirements of 3.3.2.1.