SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2371G

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Superseding AMS 2371F

Quality Assurance Sampling and Testing Corrosion and Heat-Resistant Steels and Alloys 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 corrosion and heat-resistant steel and alloy 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 2.

1.2 Quality assurance sampling and testing procedures for forgings are covered in AMS 2374.

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, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2374 Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steel and Alloy Forgings

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: custsvc@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 or www.astm.org.

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 the performance of 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 2 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 or alloy 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 in accordance with 3.3.1.2.1 or 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 Time may be extended to 120 hours for austenitic, non-hardenable grades.

3.3.1.2.1.2 The nominal cross-sectional 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 shape factors shown in Table 1.

TABLE 1 - 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 at the same power setting, set temperature, soak time, quench parameters, and racking pattern.

3.3.1.2.2.1 Time may be extended to 120 hours for austenitic, non-hardenable grades.

3.3.2 Sampling and Testing: Shall be in accordance with Table 2 and as follows:

3.3.2.1 Composition:

3.3.2.1.1 The reported chemical composition of the steel or alloy 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 and alloys, 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 heat.
The analysis of each ingot involved with the order.

3.3.2.1.2.1 If an average for an element is reported, each analysis of the element shall fall within the composition limits established by the material specification; each individual analysis may include the applicable product check analysis allowance, 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 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 composition 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 specified 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 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 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 ½ 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, strip, and plate 0.625 inch (15.88 mm) and under in nominal thickness. For plate 0.625 to 0.750 inch (15.88 to 19.05 mm), inclusive, in nominal thickness, either the standard ½ inch (12.7 mm) wide rectangular specimen with 2-inch (50.8-mm) gage length or the standard ½ 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. For plate over 0.750 inch (19.05 mm) in nominal thickness, the standard ½ 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. The tensile specimen shall be located midway between the faces of product 1-½ inches (38.1 mm) and under in nominal thickness and midway from center to surface for product over 1-½ inches (38.1 mm) in nominal thickness.

3.3.2.2.1.2.2 Short-Transverse Specimens: For plate 2-½ 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 ½ inch (12.7 mm) round tensile specimens with 2-inch (50.8-mm) gage length. Short transverse testing is not applicable for plate under 2-½ inches (63.5-mm) in nominal thickness.

3.3.2.2.2 Bar, Rod, and Wire:

3.3.2.2.2.1 Orientation: Specimens shall be taken with 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 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 ½ 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 0.625 inch (15.88 mm) and under in nominal thickness, the standard ½ 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 1-½ inches (38.1 mm) and under in nominal diameter, thickness, or distance between flats and midway from center to surface for product over 1-½ inches (38.1 mm) in nominal thickness.

3.3.2.2.2.2.2 Short-Transverse Specimens: For bar 2½ 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 ½ inch (12.7 mm) round tensile specimens with 2-inch (50.8-mm) gage length. Short transverse testing is not applicable for bar under 2½ inches (63.5 mm) in nominal thickness.

3.3.2.2.3 Tubing:

3.3.2.2.3.1 Orientation: Specimens shall be taken with 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 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 ½ 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

3.3.2.2.3.2 (Continued):

are used, when the nominal wall thickness is under 1-½ inches (38.1 mm), specimens shall be taken midway between the inner and outer surface of the tubing; when the nominal wall thickness is 1-½ inches (38.1 mm) and over, specimens shall be taken at one-quarter wall thickness, referencing from either OD or ID.

3.3.2.2.3.3 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 wall 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 1-½ inches (38.1 mm); when the nominal wall thickness is 1-½ 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 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 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 ½ 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 ½ 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 1-½ inches (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 ¼ 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 ½ 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 1-½ inches (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 cross-sections 2-½ 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 ½ inch (12.7 mm) round tensile specimens with 2-inch (50.8-mm) gage length. Short-transverse testing is not applicable for cross-sections under 2½ inches (63.5 mm) in nominal thickness.

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 ½ 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 products 1-½ inches (38.1 mm) and under in nominal thickness, diameter, or distance between flats and midway from center to surface for products over 1-½ inches (38.1 mm) in nominal thickness.

3.3.2.2.6 Stock for Forging:

A sample of stock shall be forged to a test coupon (See 8.2) acceptable to purchaser and heat treated in accordance with the material specification. Specimens taken from the coupon shall conform to applicable requirements of the material specification. Forging stock from a heat meeting these requirements in a known forged-down size need not be retested to be acceptable data for qualifying a ship size that is smaller than the forged-down coupon.

3.3.2.2.6.1 As an option, if specimens are taken from the stock after heat treatment conform to the requirements of the material specification, the tests shall be accepted as equivalent to tests of a forged coupon.

3.3.2.2.7 Stock for Flash Welded Rings:

Coupons shall be obtained as described in 3.3.2.2.5. Specimens taken from the coupon shall conform to applicable requirements of the material specification.

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: Full cross-sectional 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: Full cross-sectional 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 shall be selected.

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

3.3.2.3.1.1.3 Strand Cast Heats: Full cross-sectional 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: Full cross-sectional 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 10 samples shall be selected from a lot except that, if the quantity in the lot is less than three pieces, one sample shall be taken from each piece.

3.3.2.3.2 Premium Aircraft-Quality:

3.3.2.3.2.1 Heat Qualification: Full cross-sectional 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: Full cross-sectional 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 less than three pieces, 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 3.3.2.3.1.

3.3.2.4.2 Premium Aircraft-Quality: Sampling for heat qualification is described herein. If product qualification of steel which has not been heat qualified is to be involved, the sampling shall be agreed upon by purchaser and vendor.

3.3.2.4.2.1 Heats of Top Poured Electrodes/Ingots: Samples shall represent the top and bottom of the first and last usable remelted ingots from a heat yielding less than 10 ingots. From a heat yielding 10 or more ingots, samples shall represent the top and the bottom of the first, middle, and last usable, remelted ingot.

3.3.2.4.2.1.1 For product, identified as 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 ingot; if the heat consists of ten or more ingots, the samples shall represent the top and the bottom of the first, middle, and last usable ingot.

3.3.2.4.2.2 Heats of Bottom Poured Electrodes/Ingots: Samples shall represent the top and bottom of one electrode/ingot from each heat cluster (plate) of electrodes/ingots.

3.3.2.5 Flarability, Bending, and Pressure Testing of Tubing:

3.3.2.5.1 Flarability: Specimens shall be full tubes or sections cut from tubes. The end of the specimen to be flared shall be cut square, with the cut end smooth and free from burrs, but not rounded. One or more specimens from each lot shall be tested.

3.3.2.5.2 Bending: A section of tubing of sufficient length to conduct the bending test shall be tested from each lot.

3.3.2.5.3 Pressure Test: Specimens shall be full tubes or sections cut from tubes. The unsupported length shall be not less than 2 feet (0.6 m) or six times the nominal OD, whichever is greater. One or more specimens from each lot shall be tested.

3.3.3 Test Methods: Shall be in accordance with requirements of the applicable material specification. If a test method is not specified, the method of test shall be acceptable to the purchaser.

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

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

3.3.4.2 For Composition: If an invalid specimen (3.3.4.2.1) 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.

3.3.4.2.1 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.

3.3.4.3 For Mechanical Properties: If the sample is not invalid (3.3.4.3.1), disposition may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet specified requirements shall be cause for rejection of the product represented. All test data shall be reported.

3.3.4.3.1 Any mechanical property test may be declared invalid if the specimen was dimensionally discrepant and that discrepancy caused failure, or if the failure was caused by a malfunction of the test equipment or improper test procedure. When a test is declared invalid, the specimen may be replaced.

3.3.4.4 For Macrostructure, Cleanliness, and Micro-Inclusion Rating:

3.3.4.4.1 For single melted heats, additional specimens shall be taken from the product representing the same position in each of the two available ingots most immediately adjacent in pouring sequence to that from which the failed specimen was taken and one from the original nonconforming ingot after additional discard. Should the latter specimen be unacceptable, resampling and retesting of the nonconforming ingot may be repeated after as many consecutive discards as necessary to obtain sound material.

3.3.4.4.2 For strand cast heats, one of the additional samples shall be taken from the section adjacent to the original nonconforming specimen after sufficient discard, and the two adjacent cuts (blooms) shall be sampled at both ends and tested. Should any of the adjacent cut (bloom) test locations fail to meet the specified requirements, resampling and retesting of those locations will be permitted using the procedure specified for the original nonconforming location.

3.3.4.4.3 For multiple melted heats, additional specimens shall be taken from product representing the same remelt ingot after as many consecutive discards as necessary to obtain sound material.

4. QUALITY ASSURANCE PROVISIONS:

Not applicable.