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AEROSPACE MATERIAL SPECIFICATION

SAE MAM 2300A

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Superseding MAM 2300

Submitted for recognition as an American National Standard

PREMIUM AIRCRAFT-QUALITY STEEL CLEANLINESS
Magnetic Particle Inspection Procedure
Metric (SI) Measurement

1. SCOPE:

This specification covers steel cleanliness requirements for premium aircraft-quality ferromagnetic steels by magnetic particle inspection methods, measured in metric (SI) units. Primarily applicable to blooms, billets, tube rounds, stock for forging or flash welded rings, slabs, bars, plate, tubing, and extrusions used in fabricating highly-stressed parts where very strict magnetic particle inspection standards are used in final inspection of such parts.

1.1 AMS 2300 is the inch/pound version of this MAM.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2640 Magnetic Particle Inspection

2.2 ASTM Publications:

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

ASTM A 604 Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets
ASTM E 10 Brinell Hardness of Metallic Materials

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2.3 ANSI Publications:

Available from American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

ANSI B46.1 Surface Texture

3. TECHNICAL REQUIREMENTS:

3.1 Melting Practice:

If the material specification does not require a specific method or methods of consumable electrode remelting and the purchaser has not authorized an alternate method, steel supplied to this specification shall be produced using only the vacuum arc consumable electrode process in the remelt cycle except that steel cast as rectangular ingots for slab and plate may be produced by electroslag remelting.

3.2 Specimen Preparation:

3.2.1 (R) Heat Qualification: Sampling shall be in accordance with 4.3.1, 4.3.2, or 4.3.3. Samples shall be converted into test specimens in accordance with 3.2.3.

3.2.2 Product Qualification: Product from a heat not qualified based on sampling as in 4.3.1, 4.3.2, or 4.3.3, shall be sampled in accordance with 4.3.4. Samples shall be converted into test specimens in accordance with 3.2.3.

3.2.3 Working and Rough Machining:

3.2.3.1 Solid Product 300 mm and Over in Nominal Diameter or Distance Between Parallel Sides: A quarter section shall be cut from each sample sufficiently oversize that the center of the original sample will be approximately on the surface of the specimen after generating to test size. The quartered section shall then be forged to a 75 to 150 mm round or square, maintaining the axis of the forging approximately parallel to original direction of rolling. As an alternate method, the full section may be rolled or forged to a 150 mm round or square and an oversize quarter obtained as in 3.2.3.3. Specimens shall be rough machined to a "one-step" straight cylinder nominally 125 mm long. Minimum stock removal shall be consistent with the machining allowance specified in 3.2.4.1.

3.2.3.2 Solid Product Over 150 to 300 mm, Exclusive, in Nominal Diameter or Distance Between Parallel Sides Except Slabs and Plates: A quarter section shall be cut from each sample sufficiently oversize that the center of the original sample will be approximately on the surface of the specimen after generating to test size. The quarter section shall be converted into a test specimen by machining, or forging and machining, to a 75 to 150 mm round or square. Specimens shall be rough machined to a "one-step" straight cylinder nominally 125 mm long. Minimum stock removal shall be consistent with the machining allowance specified in 3.2.4.1.

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3.2.3.3 Solid Product 150 mm and Under in Nominal Diameter or Distance Between Parallel Sides Except Flat Bars, Slabs, and Plates: A quarter section shall be cut from each sample sufficiently oversize that the center of the original sample will be approximately on the surface of the specimen after generating to test size. The quarter section shall be converted into a test specimen by machining to a "one-step" straight cylinder nominally 125 mm long. Minimum stock removal shall be consistent with the machining allowance specified in 3.2.4.1.

3.2.3.3.1 As an alternate method, a stepdown specimen may be generated from the full cross-section in equal length, circumferential steps shown in Table 1.

TABLE 1 - Stepdown Procedure, Solid Product

Nominal Diameter or Distance Between Parallel Sides Millimeters	Step Lengths Millimeters	Step Diameter 1	Step Diameter 2	Step Diameter 3	Step Diameter 4	Step Diameter 5
6.25 to 12.50, incl	125.00	D	--	--	--	--
Over 12.50 to 18.75, incl	62.50	D	2/3D	--	--	--
Over 18.75 to 25.00, incl	41.62	D	3/4D	1/2D	--	--
Over 25.00 to 37.50, incl	31.25	D	4/5D	3/5D	2/5D	--
Over 37.50 to 100.00, incl	25.00	D	4/5D	3/5D	2/5D	1/5D

D = Original diameter or distance between parallel sides minus machining stock removed.

3.2.3.4 Flat Bars: Specimens, nominally 125 mm long, shall be rough machined to equal-length steps across the width of the specimen in accordance with Table 2, allowing 20% of the thickness or 2.50 mm, whichever is less, for minimum stock removal. Allowance of 0.25 mm shall be made for finish machining.

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TABLE 2 - Stepdown Procedure - Flat Bar

Nominal Thickness Millimeters	Step Lengths Millimeters 1	Step Thickness 2	Step Thickness 3	Step Thickness 4	Step Thickness 5	Step Thickness 6
Up to 6.25, incl	125.00	T				
Over 6.25 to 12.50, incl	62.50	T	2/3T			
Over 12.50 to 25.00, incl	31.25	T	3/4T	1/2T	1/4T	
Over 25.00	25.00	T	4/5T	3/5T	2/5T	1/5T

T = Original nominal thickness minus machining stock removed.

3.2.3.5 Slabs or Plates: A straight cylindrical or rectangular specimen shall be machined, or forged and machined, from each slab or plate to be tested. The specimen shall be taken essentially parallel to the direction of rolling at the center of the slab or plate width and thickness and shall be nominally 125 mm in length and not more than 100 mm in final diameter or thickness.

3.2.3.5.1 Product Up to 100 mm, Inclusive, in Nominal Thickness: A straight cylindrical specimen shall represent the full thickness consistent with the machining allowance specified in 3.2.4.1.

3.2.3.5.2 Product Over 100 to 200 mm, Inclusive, in Nominal Thickness: A straight cylindrical specimen shall represent surface to mid-thickness consistent with the machining allowance specified in 3.2.4.1.

3.2.3.5.3 Product Over 200 mm in Nominal Thickness: A straight cylindrical specimen shall be taken so that the axis is approximately midway between the surface and mid-thickness and shall have a diameter equal to one-third the nominal thickness of the section.

3.2.3.6 Tubing:

3.2.3.6.1 Nominal Wall Thickness 6.25 mm and Over: Specimens, nominally 125 mm long, shall be rough machined to four equal circumferential steps, T, 3/4T, 1/2T, and 1/4T, allowing 2.50 mm on the diameter for stock removal. Allowance of 0.25 mm on the radii for finish machining shall be made. T = nominal wall thickness minus the machining allowance.

3.2.3.6.2 Nominal Wall Thickness Under 6.25 mm: Specimens, nominally 125 mm long, after heat treatment as in 3.2.5, shall have 10% of the wall thickness or 0.38 mm, whichever is less, removed from the outer diameter and be tested as a straight cylinder.

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3.2.4 Machining:

3.2.4.1 Product Other Than Tubing, Flat Bars, Slab, and Plate: The converted sample shall be machined to conform to the allowance of Table 3 for surface removal, allowing 0.25 mm per side for finish machining after heat treatment.

TABLE 3 - Minimum Stock Removal

Nominal Diameter or Distance Between Parallel Sides Millimeters	Minimum Stock Removal Millimeters per Side
6.25 to 12.50, incl	0.75
Over 12.50 to 18.75, incl	1.15
Over 18.75 to 25.00, incl	1.50
Over 25.00 to 37.50, incl	1.90
Over 37.50 to 50.00, incl	2.25
Over 50.00 to 62.50, incl	3.20
Over 62.50 to 87.50, incl	4.00
Over 87.50 to 112.50, incl	4.75
Over 112.50 to 150.00, incl	6.25

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3.2.5 Heat Treatment: Rough machined specimens shall, if necessary, be heat treated by suitably austenitizing, quenching, and tempering or by solution and precipitation heat treating to produce hardness of 248 to 352 HB or appropriate lower hardness for steel of low hardenability. Hardness testing shall be in accordance with ASTM E 10. Specimens shall be austenitized in a neutral or slightly reducing atmosphere. Following heat treatment, surface scale may be removed by grit blasting or other acceptable method.

3.2.6 Finish Machining: The heat treated specimens shall be finish machined to surface roughness not greater than 0.8 μm AA, determined in accordance with ANSI B46.1. The ends of the specimen shall be finished to provide good electrical contact.

3.3 Inspection:

(R) Magnetic particle inspection shall be performed in accordance with AMS 2640 by the circular, wet, continuous method (See 8.5) using 32 to 48 A/mm of diameter. If a stepdown bar is used, the smallest step shall be magnetized and inspected first; the larger steps shall be magnetized and inspected individually in succession of increasing size until all steps have been evaluated. If a longitudinal slice from slab or plate, as in 3.2.3.5, is used, only the longitudinal surfaces perpendicular to the two faces of the slab or plate shall be inspected.

3.3.1 Cleanliness standards presented herein govern nonmetallic inclusions only (See 8.5). Steel which, during inspection, reveals indications representing actual ruptures, such as cracks, seams, laminations, and laps, will be subject to rejection except where these defects result from sample preparation.

3.3.2 The results of the magnetic particle inspection shall be appropriately recorded. All recorded results shall be identified, filed, and made available to purchaser upon request.

3.4 Evaluation of Steel Cleanliness:

After inspection, each indication 0.4 mm and over shall be recorded on an inspection chart. All recorded results shall be identified, filed, and, upon request, made available to purchaser. Records shall be available for at least three years after shipment of the product. The frequency (F) (number) and the severity (S) (length) of the indications shall be calculated as follows:

3.4.1 Frequency (F):

3.4.1.1 The number of indications per test specimen is totaled.

3.4.1.2 The frequency per specimen is determined by dividing 6.45 times the total number of indications for each specimen by the test surface area of the specimen in square centimeters.

3.4.1.3 The frequency ratings for all test specimens from a heat are totaled.

3.4.1.4 The average frequency (F) equals the total frequency rating for all test specimens from a heat divided by the number of specimens.

3.4.2 Severity (S):

3.4.2.1 The length of each indication is recorded.

3.4.2.2 The product for each specimen is computed by totaling the product of the number of indications times the appropriate progression factor listed in Table 4.

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TABLE 4 - Severity Rating Progression Factor

Length of Indication Millimeters	Progression Factor for Severity Rating
0.4 to 0.8, excl	13
0.8 to 1.6, excl	26
1.6 to 3.2, excl	103
3.2 and over	1650

3.4.2.3 The severity per specimen is determined by dividing the product for each specimen by the test surface area of the specimen in square centimeters.

3.4.2.4 The severity ratings for all test specimens from a heat are totaled.

3.4.2.5 The average severity (S) equals the total severity rating for all test specimens from a heat divided by the number of specimens.

3.5 Disposition:
(R)

Product inspected in accordance with this specification shall conform to one of the following requirements as applicable:

3.5.1 Product inspected for heat qualification as in 4.3.1, 4.3.2, or 4.3.3, and for product qualification as in 4.3.4 shall conform to a maximum average frequency rating (F) of 0.25 and a maximum average severity rating (S) of 0.50.

3.5.2 (R) Product inspected for heat qualification as in 4.3.1.2 shall conform to a maximum average frequency rating (F) of 0.10 and a maximum average severity rating (S) of 0.20 and, in addition, specimens as in 4.3.1.2.2, macroetched in accordance with ASTM A 604 shall meet the macrostructure requirements of the applicable material specification.

3.5.3 Product inspected in accordance with this specification and having a frequency-severity rating exceeding the specified limits may be re-evaluated for specific applications when permitted by purchaser. Evaluation of any one or two steps of stepdown specimens may be waived by purchaser when the area represented is not considered critical for the end product.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:
(R)

The vendor of the product shall supply all samples for vendor's tests and shall be responsible for performing all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

Tests for all applicable requirements are acceptance tests and shall be performed as specified in 4.2.1 and 4.2.2.

4.2.1 (R) Heat Qualification: Tests of samples taken as in 4.3.1, 4.3.2, or 4.3.3 to determine conformance to "heat qualification" requirements, if acceptable, need be conducted only once per heat.

4.2.1.1 Heats which have been qualified as semi-finished product shall be considered qualified for finished product.

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4.2.2 Product Qualification: Tests on product not "heat qualified" shall be conducted on product of each size and shape of each lot made from each heat.

4.3 Sampling and Testing:

(R) One of the sampling procedures described in 4.3.1, 4.3.2, or 4.3.3 shall be performed by the producer for heat qualification; the procedure used shall be at the producer's option. No further sampling by the producer shall be required from a heat which meets the requirements of 3.5. For product not heat qualified as in 4.3.1, 4.3.2, or 4.3.3, sampling procedures shall be as described in 4.3.4.

4.3.1 For Heat Qualification of Heats Produced from Top Poured Electrodes:

(R) Samples shall be taken from semi-finished or finished product in accordance with the sampling plan of either 4.3.1.1 or 4.3.1.2.

4.3.1.1 First Option:

4.3.1.1.1 For heats having four remelted ingots or less, or for portions of heats within this limit, samples shall be taken to represent remelted material that relates to the bottom of the first electrode and to the top of the last electrode of the heat.

4.3.1.1.2 For heats having five through nine remelted ingots, inclusive, or for portions of heats within these limits, samples shall be taken to represent the top and bottom of the first and last remelted ingots.

4.3.1.1.3 For heats having ten or more remelted ingots, samples shall be taken to represent the top and bottom of the first, middle, and last remelted ingots.

4.3.1.2 Second Option (See 3.5.2):

4.3.1.2.1 For all heats, regardless of the number of remelted ingots, samples shall be taken from remelted material representing the top of one electrode and the bottom of one electrode of the heat.

4.3.1.2.2 Samples for macrostructure testing shall be full cross-sectional specimens representing the top and bottom of each remelted ingot; samples shall be taken from equiaxed product not less than 100 mm in cross-section and from rectangular product not less than 75 mm in thickness.

4.3.2 For Heat Qualification of Heats Produced From Bottom Poured Electrodes:

(R) Samples shall be taken from semi-finished or finished product in accordance with the sampling plan of either 4.3.2.1, 4.3.2.2, or 4.3.2.3, as applicable, or 4.3.1.2.

4.3.2.1 For heats having four plates (clusters) or less for casting electrodes,

(R) samples shall be taken to represent remelted material that relates to a bottom of an electrode from the plate cast first and to a top of an electrode from the plate cast last.

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