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400 Commonwealth Dr., Warrendale, PA 15096

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

MAM 2303

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AIRCRAFT QUALITY STEEL CLEANLINESS
Martensitic Corrosion-Resistant Steels
Magnetic Particle Inspection Procedure
Metric (SI) Measurement

1. SCOPE: This specification covers steel cleanliness requirements for aircraft-quality ferromagnetic, hardenable corrosion-resistant steels by magnetic particle inspection methods to determine the presence of nonmetallic inclusions, measured in metric (SI) units. Applicable primarily to blooms, billets, tube rounds, stock for forging or flash welded rings, slabs, bars, tubing, and extrusions used in fabricating parts subject to magnetic particle inspection, but may be used for qualification of a heat, melt, or lot of steel.

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
AMS 2640 - Magnetic Particle Inspection

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

ASTM E10 - Brinell Hardness of Metallic Materials

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:

REAFFIRMED
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3.1 Specimen Preparation:

3.1.1 Heat Qualification: Sampling shall be in accordance with 4.3.1. Samples shall be converted into test specimens in accordance with 3.1.3.

3.1.2 Product Qualification: Product from a heat not qualified based on sampling as in 4.3.1 shall be sampled in accordance with 4.3.2. Samples shall be converted into test specimens in accordance with 3.1.3.

3.1.3 Working and Rough Machining:

3.1.3.1 Solid Product Except Flat Bars and Slabs:

3.1.3.1.1 Product Over 150 mm in Nominal Diameter or Distance Between Parallel Sides: A quarter-section shall be cut from the sample sufficiently oversize that the center of the original specimen will be approximately on the surface of the specimen after generating to test size. The specimen shall be converted into test size by machining, or forging and machining, to a diameter not larger than 150 mm consistent with the machining allowance specified in 3.1.4.1. As an alternate method when agreed upon by purchaser and vendor, the full section may be rolled or forged to a 150 mm round or square and an oversize quarter obtained as in 3.1.3.1.2. The identity for specimen surface representing center of original stock shall be maintained throughout machining and testing.

3.1.3.1.2 Product 100 - 150 mm in Nominal Diameter or Distance Between Parallel Sides: A quarter-section shall be cut sufficiently oversize that the center of the original specimen will be approximately on the surface of the sample after generating to test size. The specimen shall be converted to test size by machining, or forging and machining, to the largest possible round consistent with the machining allowance specified in 3.1.4.1. The identity for specimen surface representing center of original stock shall be maintained throughout machining and testing.

3.1.3.1.3 Product Up to 100 mm in Nominal Diameter or Distance Between Parallel Sides: The specimens shall be machined, consistent with the machining allowance specified in 3.1.4.1, to straight cylindrical samples. As an alternate method when agreed upon by purchaser and vendor, a stepdown specimen shall be generated in equal length circumferential steps as in Table I, consistent with the machining allowance specified in 3.1.4.1.

3.1.3.1.3 (Continued):

TABLE I (SI)

Nominal Diameter or Distance Between Parallel Sides Millimetres	Step Length Millimetres	Step Diameter 1	2	3	4	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.

3.1.3.2 Flat Bars: The type of test and the location in the section shall be as agreed upon by purchaser and vendor.

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

3.1.3.3.1 Product Up to 100 mm, Incl, in Nominal Thickness: A straight cylindrical specimen shall represent the full thickness consistent with the machining allowance specified in 3.1.4.3.

3.1.3.3.2 Product Over 100 - 200 mm, Incl, in Nominal Thickness: A straight cylindrical specimen shall represent surface to mid-thickness consistent with the machining allowance specified in 3.1.4.3.

3.1.3.3.3 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.

3.1.3.4 Tubing:

3.1.3.4.1 Up to 250 mm, Incl, in Nominal OD: Specimens nominally 125 mm in length shall be machined to straight cylindrical sections in accordance with 3.1.4.2.1.

3.1.3.4.2 Over 250 mm in Nominal OD with Nominal Wall Thickness Up to 50 mm, Incl: Specimens nominally 125 mm in length shall be machined to straight cylindrical sections in accordance with 3.1.4.2.2.

3.1.3.4.3 Over 250 mm in Nominal OD with Nominal Wall Thickness Over 50 - 100 mm, Incl: Specimens nominally 125 mm in length representing the full cross section less the machining allowance specified in 3.1.4.2.2, shall be machined to straight cylindrical sections.

3.1.3.4.4 Over 250 mm in Nominal OD with Nominal Wall Thickness Over 100 mm: Specimens nominally 125 mm in length, representing the inside surface to the mid-thickness of the wall, less the machining allowance specified in 3.1.4.2.2, shall be machined to straight cylindrical sections.

3.1.4 Machining:

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

TABLE II

Nominal Diameter or Distance Between Parallel Sides Millimetres	Minimum Stock Removal Millimetres per Side
6.25 to 12.50, incl	0.75
Over 12.50 to 18.75, incl	1.12
Over 18.75 to 25.00, incl	1.50
Over 25.00 to 37.50, incl	1.88
Over 37.50 to 50.00, incl	2.25
Over 50.00 to 62.50, incl	3.12
Over 62.50 to 87.50, incl	3.90
Over 87.50 to 112.50, incl	4.68
Over 112.50 to 150.00, incl	6.25

3.1.4.2 Tubing:

3.1.4.2.1 Up to 250 mm, Incl, in Nominal OD: Tubing under 6.25 mm in nominal wall thickness shall have 10% of the wall thickness or 0.38 mm, whichever is less, removed from the OD after heat treatment. Samples from tubing with nominal wall thickness of 6.25 mm and over shall be machined to conform to the stock removal requirement of Table III.

3.1.4.2.1 (Continued):

TABLE III

Machined Diameter Millimetres	Minimum Stock Removal Millimetres per Side
Up to 62.5, incl	1.10
Over 62.5 to 87.5, incl	1.15
Over 87.5 to 112.5, incl	1.30
Over 112.5 to 137.5, incl	1.45
Over 137.5 to 162.5, incl	1.60
Over 162.5 to 200.0, incl	1.85
Over 200.0 to 250.0, incl	2.20

3.1.4.2.2 Tubing Over 250 mm in Nominal OD: Tubing with nominal wall thickness up to 100 mm, incl, shall be turned to straight cylindrical sections representing the full cross section of the wall, less allowance of 3.75 mm stock removal on the OD and ID and allowing 0.25 mm per side for finish machining after heat treatment. Samples from tubing with nominal wall thickness over 100 mm shall be turned to cylindrical sections representing the cross section from the OD to mid-thickness of the wall less allowance of 3.75 mm stock removal on the OD and allowing 0.25 mm per side for finish machining after heat treatment.

3.1.4.3 Flat Bars and Slabs: Allowance of 20% of the nominal thickness or 2.50 mm, whichever is less, shall be made for minimum stock removal and allowing 0.25 mm per side for finish machining after heat treatment.

3.1.5 Heat Treatment: Rough machined specimens shall be hardened by suitably austenitizing, quenching, and tempering to produce hardness not lower than 200 HB, determined in accordance with ASTM E10.

3.1.6 Finish Machining: The heat treated specimens shall be finish machined to surface texture not rougher 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.

3.2 Inspection: Magnetic particle inspection shall be performed in accordance with AMS 2640 by the circular, wet, continuous method using 32 - 48 A/mm of diameter. If the stepdown bar (3.1.3.1.3) 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 as in 3.1.3.3 is used, only the longitudinal surfaces perpendicular to the two faces of the slab shall be inspected.

3.2.1 Cleanliness standards presented herein govern nonmetallic inclusions only. 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.

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

3.3 Evaluation of Steel Cleanliness: After inspection, each indication 1.5 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 three years after shipment of the product. The frequency (F) (number) and the severity (S) (length) of the indications shall be calculated as follows:

3.3.1 Frequency (F):

3.3.1.1 The number of indications per test specimen is totaled.

3.3.1.2 The frequency per specimen is determined by dividing the total number of indications from each specimen by the area of the test specimen in square millimetres.

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

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

3.3.2 Severity (S):

3.3.2.1 The length of each indication is recorded.

3.3.2.2 The product for each specimen is computed by totaling the product of the number of indications times the appropriate progression factor listed in the following table:

Length of Indication Millimetres	Progression Factor for Severity Rating
1.5 to 3.0, incl	0.5
Over 3.0 to 6.0, incl	1
Over 6.0 to 12.5, incl	2
Over 12.5 to 19.0, incl	4
Over 19.0 to 25.0, incl	8
Over 25.0 to 37.5, incl	16

3.3.2.2.1 Specimens which contain indications representing non-metallic inclusions over 37.5 mm in length shall be subject to rejection.

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

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

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

3.4 Disposition: Product inspected in accordance with this specification shall conform to the following maximum frequency and severity ratings:

3.4.1 Heat Qualification (Reference 4.3.1):

3.4.1.1 Product Other Than Slabs:

3.4.1.1.1 Individual Test Bar:

Carbon Content Percent	Ratings	
	Frequency	Severity
Up to 0.25, excl	0.75	0.75
0.25 and over	0.67	0.55

3.4.1.1.2 Average of All Test Bars From A Heat:

Carbon Content Percent	Ratings	
	Frequency	Severity
Up to 0.25, excl	0.40	0.35
0.25 and over	0.37	0.32

3.4.1.2 Slabs: Shall have maximum individual and average frequency and severity ratings as agreed upon by purchaser and vendor.

3.4.2 Product Qualification (Reference 4.3.2):

3.4.2.1 Individual Test Bar:

Product Nominal Diameter Millimetres	Carbon Content Percent	Ratings	
		Frequency	Severity
Up to 62.50, excl	Up to 0.25, excl	1.10	1.05
	0.25 and over	1.00	0.95
62.50 and over	Up to 0.25, excl	0.80	0.80
	0.25 and over	0.80	0.67

3.4.2.2 Average of All Test Bars From a Heat:

Product Nominal Diameter Millimetres	Carbon Content Percent	Ratings	
		Frequency	Severity
62.50 and over	Up to 0.25, excl	0.40	0.35
	0.25 and over	0.37	0.32

3.4.2.2.1 Product under 62.50 mm in nominal diameter or distance between parallel sides inspected using the straight cylindrical test bars or product less than 100 cm^2 in cross-sectional area inspected by the alternate step-down specimen (3.1.3.1.3) shall have maximum average frequency and severity ratings as agreed upon by purchaser and vendor.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of the product shall supply all samples for vendor's test and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.4. 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 to determine conformance to all applicable requirements of this specification are classified as acceptance tests and shall be performed as specified in 4.2.1 and 4.2.2.

4.2.1 Heat Qualification: Tests of samples taken as in 4.3.1 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.

4.2.2 Product Qualification: Tests to determine conformance to the requirements of this specification 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: The sampling procedure described in 4.3.1 shall be performed by the producer for heat qualification; no further sampling by the producer shall be required from a heat which meets the requirements of 3.4.1. Sampling procedures for product not heat qualified as in 4.3.1 shall be as described in 4.3.2.

4.3.1 Heat Qualification: 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 27,000 kg or from portions of heats within these limits; and from the top and bottom of the first ingot, middle ingot, and last usable ingot of heats having more than 10 ingots or over 27,000 kilograms.

4.3.2 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 3 nor more than 10 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.

4.4 Reports: The vendor of the product shall include the frequency-severity cleanliness rating for each lot in the shipment in addition to other information required by the applicable material specification.