AEROSPACE MATERIAL SPECIFICATION

AMS2303™	REV. G
Issued 1967-11 Reaffirmed 2016-05 Revised 2023-05 Superseding AMS2303F	

Steel Cleanliness, Aircraft Quality
Martensitic Corrosion-Resistant Steels
Magnetic Particle Inspection Procedure

RATIONALE

AMS2303G is the result of a Five-Year Review and update of the specification. The revision clarifies specimen location and preparation (3.1.3.1).

1. SCOPE

1.1 Purpose

This specification covers steel cleanliness requirements in inch/pound units for aircraft-quality, ferromagnetic, hardenable, corrosion-resistant steels as determined by magnetic particle inspection methods. This specification contains sampling, specimen preparation, and inspection procedures and cleanliness rating criteria (see 8.2).

1.2 Application

This procedure has been used typically for the cleanliness evaluation of blooms, billets, tube rounds, stock for forging or flash welded rings, slabs, bars, sheet, strip, plate, 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 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 International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AS7766 Terms Used in Aerospace Metals Specifications

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E10 Brinell Hardness of Metallic Materials

ASTM E1444 Magnetic Particle Testing

2.3 ASME Publications

Available from ASME, P.O. Box 2900, 22 Law Drive, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (U.S./Canada), 001-800-843-2763 (Mexico), 973-882-1170 (outside North America), www.asme.org.

ASME B46.1 Surface Texture

2.4 Definitions

Terms used in AMS are defined in AS7766 and as follows:

2.4.1 PRODUCT

The term “product” is used to represent all types of wrought forms of uniform cross section (except tubing) commonly known as blooms, billets, bars, round-cornered squares, tube rounds, pressed forged stock, extrusions, and stock for forgings and rings.

2.4.2 STRAND CASTING

See Figure 1.

A “strand cast heat” is that which casts the product of a single furnace load in a continuous cast fashion; ingots are not involved.

A “strand” is the resulting as-cast configuration formed during strand casting; there may be one or more strands associated with each heat.

A “bloom,” as used in the context of strand casting, is a section of the strand after it has been cut from the strand; it is as-cast material that is no longer part of the whole strand.

The “front” of a strand is that which is formed first.

The “back” of a strand is that which is formed last.

The “middle” of the strand is that which is formed at the approximate mid-length of the strand.

An “inside strand” is a strand of a multiple strand heat that flows from an inside location of the molten reservoir.

An “outside strand” is a strand of a multiple strand heat that flows from an outside location of the molten reservoir.

2.4.3 BOTTOM POURED INGOTS

See Figure 2.

A "plate" is that which is initially impinged upon by the teemed liquid metal and which then directs the liquid metal through feeder troughs to the bottom of the ingot molds; a bottom poured heat may consist of one or more plates. Each plate may feed one or more ingots.

An "ingot" is that which is solidified in the ingot mold. The unique features of an ingot associated with a bottom poured heat are: (1) it is filled from the bottom rather than from the top, and (2) it is filled simultaneously with the other ingots being fed from the same plate.

3. TECHNICAL REQUIREMENTS

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 (see 2.4) 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 Over 36 Square Inches (232 mm^2) Cross-Sectional Area Except Flat Bars, Slabs, and Plates

A quarter-section shall be cut from the sample sufficiently oversize that the center and the outside edge or OD 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 6 inches (152 mm) consistent with the machining allowance specified in 3.1.4.1. As an alternate method when acceptable to the purchaser, the full section may be rolled or forged to a 6-inches (152-mm) round or square and an oversize quarter obtained as in 3.1.3.2. The identity for specimen surface representing center of original stock shall be maintained throughout machining and testing.

3.1.3.2 Solid Product 16 to 36 Square Inches (103 to 232 mm^2), Inclusive, in Cross-Sectional Area Except Flat Bars, Slabs, and Plates

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.

3.1.3.3 Solid Product Under 16 Square Inches (103 mm^2) in Cross-Sectional Area 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 after generating to test size. The quarter-section shall be converted into a test specimen by machining to a "one-step" straight cylinder nominally 5 inches (127 mm) long. Minimum stock removal shall be consistent with the machining allowance specified in 3.1.4.

3.1.3.3.1 As an alternate method, a step-down specimen may be generated from the full cross section in equal length circumferential steps as shown in Table 1, consistent with the machining allowance specified in 3.1.4.

Table 1A - Stepdown specimens. cylindrical, inch/pound units

Nominal Diameter or Distance Between Parallel Sides Inches	Step Length Inches	Step 1 Diameter	Step 2 Diameter	Step 3 Diameter	Step 4 Diameter	Step 5 Diameter
0.250 to 0.500, incl	5.000	D	--	--	--	--
Over 0.500 to 0.750, incl	2.500	D	2/3D	--	--	--
Over 0.750 to 1.000, incl	1.665	D	3/4D	1/2D	--	--
Over 1.000 to 1.500, incl	1.250	D	4/5D	3/5D	2/5D	--
Over 1.500	1.000	D	4/5D	3/5D	2/5D	1/5D

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

Table 1B - Stepdown specimens, cylindrical, SI units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Step Length Millimeters	Step 1 Diameter	Step 2 Diameter	Step 3 Diameter	Step 4 Diameter	Step 5 Diameter
6.35 to 12.70, incl	127.00	D	--	--	--	--
Over 12.70 to 19.05, incl	63.50	D	2/3D	--	--	--
Over 19.05 to 25.40, incl	42.29	D	3/4D	1/2D	--	--
Over 25.40 to 38.10, incl	31.75	D	4/5D	3/5D	2/5D	--
Over 38.10	25.40	D	4/5D	3/5D	2/5D	1/5D

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

3.1.3.4 Flat Bars

The type of test and the location in the section shall be as agreed upon by the purchaser and vendor. A step-down specimen may be generated from the full cross section in equal length steps as shown in Table 2.

Table 2A - Stepdown specimens, flat bar, inch/pound units

Nominal Thickness Inches	Step Length Inches	Step 1 Thickness	Step 2 Thickness	Step 3 Thickness	Step 4 Thickness	Step 5 Thickness
Up to 0.250, incl	5.000	T	--	--	--	--
Over 0.250 to 0.500, incl	2.500	T	2/3T	--	--	--
Over 0.500 to 1.000, incl	1.250	T	3/4T	1/2T	1/4T	--
Over 1.000	1.000	T	4/5T	3/5T	2/5T	1/5T

T = Original nominal thickness minus machining stock removed.

Table 2B - Stepdown specimens, flat bar, SI units

Nominal Thickness Millimeters	Step Length Millimeters	Step 1 Thickness	Step 2 Thickness	Step 3 Thickness	Step 4 Thickness	Step 5 Thickness
Up to 6.35, incl	127.00	T	--	--	--	--
Over 6.35 to 12.70, incl	63.50	T	2/3T	--	--	--
Over 12.70 to 25.40, incl	31.75	T	3/4T	1/2T	1/4T	--
Over 25.40	25.40	T	4/5T	3/5T	2/5T	1/5T

T = Original nominal thickness minus machining stock removed.

3.1.3.5 Slabs or Plates

A straight cylindrical or rectangular specimen shall be machined, or forged and machined, from each slab or plate tested. The specimen shall be taken essentially parallel to the direction of rolling, midway between edge and center of the slab or plate width, shall be nominally 5 inches (127 mm) in length, and not more than 4 inches (102 mm) in final diameter or thickness.

3.1.3.5.1 Product Up to 4 Inches (102 mm), Inclusive, in Nominal Thickness

A straight cylindrical specimen shall represent the full thickness consistent with the machining allowance specified in 3.1.4.3.

3.1.3.5.2 Product Over 4 to 8 Inches (102 to 203 mm), Inclusive, in Nominal Thickness

A straight cylindrical specimen shall represent surface to mid-thickness consistent with the machining allowance specified in 3.1.4.3.

3.1.3.5.3 Product Over 8 Inches (203 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, allowing 0.010 inch per side for finish machining after heat treatment.

3.1.3.6 Tubing

3.1.3.6.1 Up to 10 Inches (254 mm), Inclusive, in Nominal OD

Specimens nominally 5 inches (127 mm) in length shall be machined to straight cylindrical sections in accordance with 3.1.4.2.1.

3.1.3.6.2 Over 10 Inches (254 mm) in Nominal OD with Nominal Wall Thickness Up to 2 Inches (51 mm), Inclusive

Specimens nominally 5 inches (127 mm) in length shall be machined to straight cylindrical sections in accordance with 3.1.4.2.2.

3.1.3.6.3 Over 10 Inches (254 mm) in Nominal OD with Nominal Wall Thickness Over 2 to 4 Inches (51 to 102 mm), Inclusive

Specimens nominally 5 inches (127 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.

3.1.3.6.4 Over 10 Inches (254 mm) in Nominal OD with Nominal Wall Thickness Over 4 Inches (102 mm)

Specimens nominally 5 inches (127 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, Slab, and Plate

The converted sample shall be machined to conform to the allowance shown in Table 3 for surface removal, allowing 0.010 inch (0.25 mm) per side for finish machining after heat treatment.

Table 3 - Stock removal

Nominal Diameter or Least Distance Between Parallel Sides Inches (Millimeters)	Minimum Stock Removal Inches (Millimeters) per Side
0.250 to 0.500 (6.35 to 12.70), incl	0.030 (0.76)
Over 0.500 to 0.750 (12.70 to 19.01), incl	0.045 (1.14)
Over 0.750 to 1.000 (19.01 to 25.40), incl	0.060 (1.52)
Over 1.000 to 1.500 (25.40 to 38.10), incl	0.075 (1.91)
Over 1.500 to 2.000 (38.10 to 50.80), incl	0.090 (2.29)
Over 2.000 to 2.500 (50.80 to 63.50), incl	0.125 (3.18)
Over 2.500 to 3.500 (63.50 to 88.90), incl	0.156 (3.96)
Over 3.500 to 4.500 (88.90 to 114.30), incl	0.187 (4.75)
Over 4.500 to 6.000 (114.30 to 152.40), incl	0.250 (6.35)

3.1.4.2 Tubing

3.1.4.2.1 Up to 10 Inches (254 mm), Inclusive, in Nominal OD

Tubing with nominal wall thickness under 0.250 inch (6.35 mm) shall have 10% of the wall thickness or 0.015 inch (0.38 mm), whichever is less, removed from the OD after heat treatment. Samples from tubing with nominal wall thickness of 0.250 inch (6.35 mm) and over shall be machined to conform to the stock removal requirement shown in Table 4.

Table 4 - Stock removal, tubing

Machined Diameter Inches (Millimeters)	Minimum Stock Removal Inches (Millimeters) per Side
Up to 2-1/2 (63.5), incl	0.044 (1.12)
Over 2-1/2 to 3-1/2 (63.5 to 88.9), incl	0.046 (1.17)
Over 3-1/2 to 4-1/2 (88.9 to 114.3), incl	0.052 (1.32)
Over 4-1/2 to 5-1/2 (114.3 to 139.7), incl	0.057 (1.45)
Over 5-1/2 to 6-1/2 (139.7 to 165.1), incl	0.064 (1.63)
Over 6-1/2 to 8 (165.1 to 203.2), incl	0.074 (1.88)
Over 8 to 10 (203.2 to 254.0), incl	0.087 (2.21)

3.1.4.2.2 Tubing Over 10 Inches (254 mm) in Nominal OD

Tubing with nominal wall thickness up to 4 inches (102 mm), inclusive, shall be turned to straight cylindrical sections representing the full cross section of the wall, less allowance of 0.150 inch (0.38 mm) stock removal on the OD and ID and allowing 0.010 inch (0.25 mm) per side for finish machining after heat treatment. Samples from tubing with nominal wall thickness over 4 inches (102 mm) shall be turned to cylindrical sections representing the cross section from the OD to mid-thickness of the wall less allowance of 0.150 inch (0.38 mm) stock removal on the OD, and allowing 0.010 inch (0.25 mm) per side for finish machining after heat treatment.

3.1.4.3 Flat Bars, Slabs, and Plates

Allowance of 20% of the nominal thickness or 0.100 inch (2.54 mm), whichever is less, shall be made for minimum stock removal, allowing 0.010 inch (0.25 mm) per side for finish machining after heat treatment.

3.1.5 Heat Treatment

Unless otherwise specified, rough machined specimens shall be hardened by suitably austenitizing, quenching, and tempering, or by solution and precipitation heat treating, to produce hardness not lower than 200 HB. Hardness testing shall be in accordance with ASTM E10. Following heat treatment, surface scale may be removed by grit blasting or another suitable method.

3.1.6 Finish Machining

The heat-treated specimens shall be finished machined to a surface texture not rougher than 32 µin AA, determined in accordance with ANSI B46.1. Rateable surface of specimens shall be nominally 5 inches (127 mm) in length. The ends of the specimen shall be finished to provide good electrical contact.

3.2 Inspection

Magnetic particle testing shall be performed in accordance with ASTM E1444 by the circular, wet, continuous method (see 8.3) using 800 to 1200 A/in (32 to 48 A/mm) of diameter, or using another magnetic particle procedure acceptable to the purchaser. If the stepdown bar (3.1.3.3, 3.1.3.4) 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 3.1.3.5 is used, only the longitudinal surfaces perpendicular to the two faces of the slab or plate shall be inspected.

3.2.1 Cleanliness standards presented herein govern nonmetallic inclusions only (see 8.3). 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. If such indications are the consequence of sample preparation, a replacement retest sample may be obtained from material adjacent to the original test location.

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

3.3 Evaluation of Steel Cleanliness

After inspection, each indication 1/16 inch (1.58 mm) and over in length shall be recorded. The frequency (number) and severity (size) 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 rating per specimen is determined by dividing the total number of indications for each specimen by the area of the test specimen in square inches (by dividing 6.45 times the total number of indications for each specimen by the test surface area of the specimen in square centimeters).

3.3.1.3 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 shown in Table 5.

Table 5 - Progression factor for severity rating

Length of Indication Inches (Millimeters)	Progression Factor
1/16 to 1/8 (1.59 to 3.18), incl	0.5 (3.2)
Over 1/8 to 1/4 (3.18 to 6.35), incl	1 (6.5)
Over 1/4 to 1/2 (6.35 to 12.70), incl	2 (13)
Over 1/2 to 3/4 (12.70 to 19.05), incl	4 (26)
Over 3/4 to 1 (19.05 to 25.40), incl	8 (52)
Over 1 to 1-1/2 (25.4 to 38.1), incl	16 (103)

3.3.2.2.1 Specimens which contain indications representing nonmetallic inclusions over 1-1/2 inches (38.1 mm) in length shall be subject to rejection.

3.3.2.3 The severity rating per specimen is determined by dividing the product for each specimen by the area of the specimen in square inches (square centimeters).

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 (see 4.3.1)

3.4.1.1 Product Other Than Slab, Sheet, Strip, and Plate

3.4.1.1.1 Individual Test Bar

As shown in Table 6.

Table 6 - Maximum frequency and severity ratings

Carbon Content Percent	Ratings Frequency	Ratings 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

As shown in Table 7.

Table 7 - Maximum frequency and severity ratings

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

3.4.1.2 Slabs and Plate

As shown in Table 8.

Table 8 - Maximum frequency and severity ratings

Average of All Tests From a Heat Frequency	Average of All Tests From a Heat Severity
0.80	0.67

3.4.2 Production Qualification (see 4.3.2)

3.4.2.1 Product Other Than Sheet, Strip, and Plate

3.4.2.1.1 Individual Test Bar

As shown in Table 9.

Table 9 - Maximum frequency and severity ratings

Product Nominal Diameter Inches (Millimeters)	Carbon Content Percent	Ratings Frequency	Ratings Severity
Up to 2.500 (63.50), excl	Up to 0.25, excl	1.10	1.05
	0.25 and over	1.00	0.95
2.500 (63.50) and over	Up to 0.25, excl	0.80	0.80
	0.25 and over	0.80	0.67

3.4.2.1.2 Average of All Test Bars from a Heat

As shown in Table 10.

Table 10 - Maximum frequency and severity ratings

Product Nominal Diameter Inches (Millimeters)	Carbon Content Percent	Ratings Frequency	Ratings Severity
1.000 to 2.500 (25.40 to 63.50), incl	Up to 0.25, excl	0.90	0.85
	0.25 and over	0.85	0.80
Over 2.500 (63.50)	Up to 0.25, excl	0.40	0.35
	0.25 and over	0.37	0.32

3.4.2.1.2.1 Product under 1.000 inch (25.4 mm) in nominal diameter or least distance between parallel sides inspected using the straight cylindrical test bars or product under 16 square inches (103 cm^2) in cross-sectional area inspected by the alternate step-down specimen (see 3.1.3.3), shall have maximum average frequency and severity ratings agreed upon by purchaser and vendor.

3.4.2.2 Sheet and Strip

Shall have maximum individual and average frequency and severity ratings agreed upon by purchaser and vendor.

3.4.3 Product inspected in accordance with this specification and having frequency, severity, or both ratings exceeding the specified limits may be reevaluated for specific applications when permitted by the purchaser. Evaluation of any one or two steps of the alternate stepdown specimen 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

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

4.2 Classification of Tests

All applicable requirements are acceptance tests and shall be performed as specified in 4.2.1 or 4.2.2.

4.2.1 Heat Qualification

Tests in accordance with 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 requirements 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

The sampling procedure for heat qualification shall be as described in 4.3.1. No further sampling by the producer shall be required from a heat which meets the requirements of 3.4.1. The sampling procedure for product qualification shall be as described in 4.3.2.

4.3.1 Heat Qualification

4.3.1.1 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 ten ingots or not over 60000 pounds (27216 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 ten ingots or over 60000 pounds (27216 kg).

4.3.1.2 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 less than three plates per heat are produced, samples shall be taken from the top and bottom of one random ingot per plate.

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

4.3.1.3 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.

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 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.

4.4 Reports

The vendor of the product shall include the AMS2303G frequency-severity rating for each heat or lot in the shipment, in addition to other information required by the applicable material specification.