SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS2301 REV. K

Issued 1960-01
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Superseding AMS2301J

Steel Cleanliness, Aircraft Quality Magnetic Particle Inspection Procedure

RATIONALE

AMS2301K results from a Five Year Review and update of this document.

1. SCOPE

1.1 Purpose

This specification covers steel cleanliness requirements in inch/pound units for aircraft-quality ferro-magnetic steels, other than hardenable corrosion resistant steels (See AMS2303), by magnetic particle inspection methods. This specification contains sampling, specimen preparation, inspection procedures and cleanliness rating criteria (See 8.5).

1.1.1 The metric version, MAM2301, has been cancelled. The SI units have been included in this specification, but the inch/pound units are primary (See 8.5).

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 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 E 10 Brinell Hardness of Metallic Materials

ASTM E 1444 Magnetic Particle Testing

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS2301K

2.2 ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ANSI B46.1 Surface Texture

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 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 12 Inches (305 mm) and Over in Nominal Diameter or Distance Between Parallel Sides

A quarter-section shall be cut from each sample sufficiently oversized 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 then be forged to a 3 to 6 inch (76 to 152 mm) round or square, maintaining the axis of the forging approximately parallel to the original direction of rolling. As an alternate method, the full section may be rolled or forged to a 6-inch (152-mm) round or square and an oversize quarter obtained as in 3.1.3.3. Specimens shall be rough machined 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.

3.1.3.2 Solid Product Over 6 to 12 Inches (152 to 305 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 3 to 6 (76 to 152 mm) inch round or square. Specimens shall be rough machined 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 Solid Product 6 Inches (152 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 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 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 shall be 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 (0.25mm) per side for finish machining after heat treatment.

3.1.3.6 Tubing

3.1.3.6.1 10 inches (254 mm) and Under 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, and Slab and Plates Over 8 Inches (203 mm) Thick

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) on each side for finish machining after heat treatment.

TABLE 3 - STOCK REMOVAL

Nominal Diameter or Distance Between Parallel Sides Inches (Millimeters)		Minimum Stock Removal Inch (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 10 Inches and Under 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 and over shall be machined to conform to the stock removal requirement shown in Table 4.

TABLE 4 - STOCK REMOVAL

Machined Diameter Inches(Millimeters)		Minimum Stock Removal Inch (Millimeters) per Side
Up to 2-1/2	(63.5), incl	0.044 (1.12)
Over 2-1/2to 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 4 inches (102 mm) and under in nominal wall thickness 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) on each 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) on each 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) on each side for finish machining after heat treatment.

3.1.5 Heat Treatment

Rough machined specimens shall, if necessary, be heat treated by suitable 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 another acceptable method.

3.1.6 Finish Machining

The heat treated specimens shall be finished machined to surface texture not rougher than 40 microinches 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 E 1444 by the circular, wet, continuous method (See 8.3) using 800 to 1200 amperes per inch (32 to 48 amperes/mm) of diameter, or another magnetic particle procedure acceptable to purchser. If the stepdown bar (3.1.3.3.1 or 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). Product that, 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 the 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 1/16 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 of each specimen is determined by dividing the total number of indications for each specimen by the test surface area of the 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).

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

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

3.3.3 Severity (S)

3.3.3.1 The length of each indication is recorded.

3.3.3.2 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 (25.40 to 38.10), incl	16 (103)

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

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

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

3.3.3.5 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 Slab, Sheet, Strip, and Plate

3.4.1.1.1 Individual Test Bar

Shall be as shown in Table 6.

TABLE 6 - MAXIMUM FREQUENCY AND SEVERITY RATINGS

Carbon Content Percent	Frequency Rating	Severity Rating
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

Shall be as shown in Table 7.

TABLE 7 - MAXIMUM FREQUENCY AND SEVERITY RATINGS

Carbon Content Percent	Frequency Rating	Severity Rating
Up to 0.25, excl	0.37	0.28
0.25 and over	0.34	0.25

3.4.1.2 Slab and Plate

Shall be 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 Product Qualification (Reference 4.3.2)

3.4.2.1 Product Other Than Sheet, Strip, and Plate

3.4.2.1.1 Individual Test Bar

Shall be as shown in Table 9.

TABLE 9 - MAXIMUM FREQUENCY AND SEVERITY RATINGS

Product Nominal Diameter Inches (Millimeters)	Carbon Content Percent	Frequency Rating	Severity Rating
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

Shall be as shown in Table 10.

TABLE 10 - MAXIMUM FREQUENCY AND SEVERITY RATINGS

Product Nominal Diameter Inches	Carbon Content Percent	Frequency Rating	Severity Rating
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 to 4.000 (63.50 to 101.6), incl	Up to 0.25, excl	0.60	0.55
	0.25 and over	0.55	0.50
Over 4.000 (101.6)	Up to 0.25, excl	0.37	0.28
	0.25 and over	0.34	0.25

3.4.2.1.2.1 Product under 1.000 inch (25.4) in nominal diameter or distance between parallel sides, inspected using the straight cylindrical test bars or product under 16 square inches (103.2 square centimeters) in cross-sectional area, inspected by the alternate step-down specimen (3.1.3.3.1) shall have maximum average frequency and severity ratings agreed upon by purchaser and vendor.

3.4.2.2 Plate

Shall conform to the ratings specified in 3.4.1.2.

3.4.2.3 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 or severity, or both, ratings exceeding the specified limits may be reevaluated for specific applications when permitted by 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 vendor's tests and shall be responsible for the performance of all required tests. 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 technical requirements are acceptance tests.

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 on each heat.

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

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

The sampling procedure for heat qualification as described in 4.3.1 shall be performed by the producer. No further sampling by the producer shall be required from a heat that meets the requirements of 3.4.1. Sampling procedure on product not “heat qualified” 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 10 ingots, or not over 60 000 pounds (27 216 kilograms), 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 60 000 pounds (27 216 kilograms).

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 a heat consists of 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.

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 AMS2301K frequency-severity rating for each lot in the shipment in addition to other information required by the applicable material specification.

4.5 Resampling and Retesting

4.5.1 Product Other Than Slabs, Plates, Sheet, and Strip

If any specimen used in the above tests fails to meet the specified requirements, disposition of the heat or lot may be based on the results of testing three additional specimens for each original nonconforming specimen; additional specimens shall be as follows:

4.5.1.1 Heats of Top-Poured Ingots

One of the additional specimens shall be taken from the same position from product from each of the two available ingots most immediately adjacent in pouring sequence to where the originally nonconforming specimen was taken. The third specimen shall be taken from product of 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 acceptable results. Should any of the adjacent ingot tests fail to meet specified requirements, resampling and retesting of these ingots will be permitted using the procedure specified for the original nonconforming ingot.

4.5.1.2 Heats of Bottom-Poured Ingots

One of the additional specimens shall be taken from the same position from product from each of the two available ingots most immediately adjacent to where the originally nonconforming specimen was taken. The third specimen shall be taken from product of 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 acceptable results. Should any of the adjacent ingot tests fail to meet specified requirements, resampling and retesting of those ingots will be permitted using the procedure specified for the original nonconforming ingot.

4.5.1.2.1 If there are less than three ingots in the heat, all test locations that fail shall be retested after discard is taken.

4.5.1.3 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 specified requirements, resampling and retesting of those locations will be permitted using the procedure specified for the original nonconforming location.

4.5.2 Slab, Plate, Sheet, and Strip

4.5.2.1 For Heat Qualification of Slab and Plate

If the average of the specimens from a heat fails to meet the requirements of 3.4.1.2 for the average of all original specimens, disposition of the heat may be based on the results of testing three additional specimens for each original specimen to be retested. Two of the additional specimens shall be taken so as to be representative of the heat. The third specimen shall be taken from the original nonconforming slab or plate after additional discard. Should the average of the results on the original specimens not requiring retesting plus those on the additional specimens fail to meet the requirements of 3.4.1.2, resampling and retesting may be repeated after as many discards as necessary to obtain acceptable results.

4.5.2.2 For Product Qualification of Sheet, Strip, and Plate

If the average of all specimens from slabs or plates from a heat fails to meet the requirements of 3.4.1.2, but the slabs or plates have been rolled to under 0.1875 inch before being resampled for retesting, or if any specimen from sheet and strip fails to meet the maximum individual or average frequency or severity ratings agreed upon by purchaser and vendor (See 3.4.2.3), or if the average of all specimens from a lot of plate not qualified as a heat fails to meet the requirements of 3.4.1.2, disposition of the product may be based on the results of testing three specimens for each original specimen that exceeds the average frequency or severity limit, or both, of 3.4.1.2 in the case of plate or that exceeds the agreed-upon individual or average limits (See 3.4.2.4) in the case of sheet and strip. The retest specimens shall be taken so as to be representative of the heat or lot. Should the average of the results on the original specimens not requiring retesting plus those on the retest specimens fail to meet the requirements of 3.4.1.2 or 3.4.2.3, as applicable, resampling and retesting may be repeated after as many discards as necessary to obtain acceptable results.

5. PREPARATION FOR DELIVERY

5.1 Identification

Product, accepted for use in accordance with specified requirements, shall be identified with AMS2301K in addition to information required by the applicable material specification.

6. ACKNOWLEDGMENT

A vendor shall include this specification number and its revision letter in all quotations and when acknowledging purchase orders.

7. REJECTIONS

Product not conforming to this specification, or to modifications authorized by purchaser, will be subject to rejection.

8. NOTES

8.1 A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

8.2 It is to be appreciated that this document is not intended to describe a 100% magnetic particle surface inspection of individual bars, billets, or other product forms. Instead, it involves sampling plans that identify specific test locations, and at those locations inspeciton of both surface and interior. The results thereby qualify a heat or portion thereof to the quality level of the document.

8.3 It should be recognized that use of the continuous method of magnetic particle testing as specified in 3.2 may result in nonrelevant indications relating to alloy or carbide bands rather than nonmetallic inclusions. Such nonrelevant indications are more likely to appear in testing the more highly-alloyed steels. The residual method of magnetic particle inspection may be used to investigate areas of question. Frequently, alloy and/or carbide streaking will not appear as indications in tests by the residual method. When the residual method is inconclusive, metallographic examination of the specimen surface (magnetic particle examined surface) may be used to identify inclusions versus magnetic particle indications.

8.4 Terms used in AMS are clarified in ARP1917, and as follows:

8.4.1 The term “product” as mentioned herein 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 forging and rings.

8.4.2 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; see sketch, Figure 1.

An outside strand is a strand of a multiple strand heat that flows from an outside location of the molten reservoir; see sketch, Figure 1.

8.4.3 Bottom-Poured Ingots

See Figure 2.

A “plate” is that which is initially impinged upon by the teemed liquid metal and that 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.

8.5 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as the approximate equivalents of the primary units and are presented only for information.

PREPARED BY AMS COMMITTEE "E"

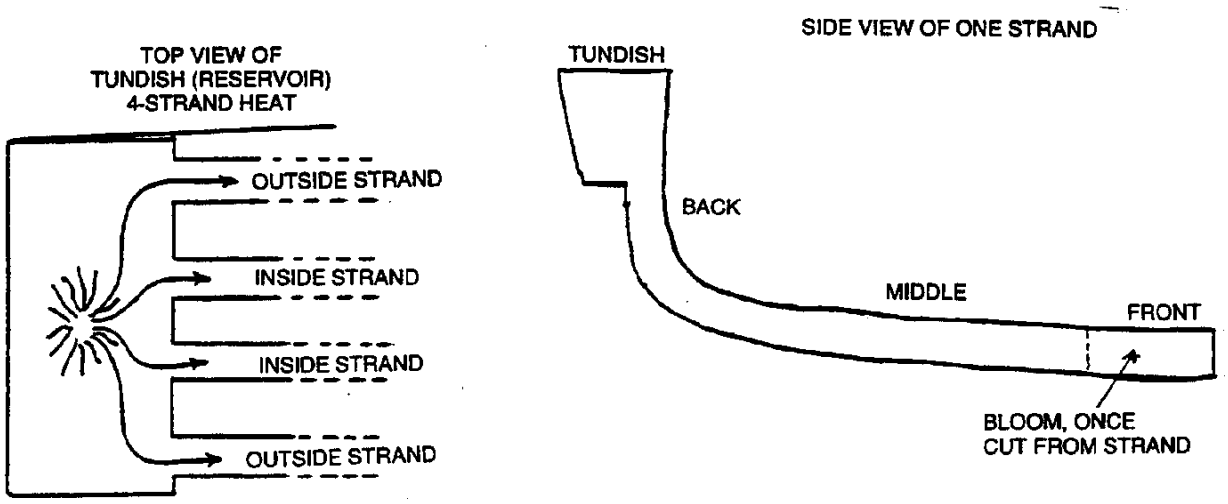
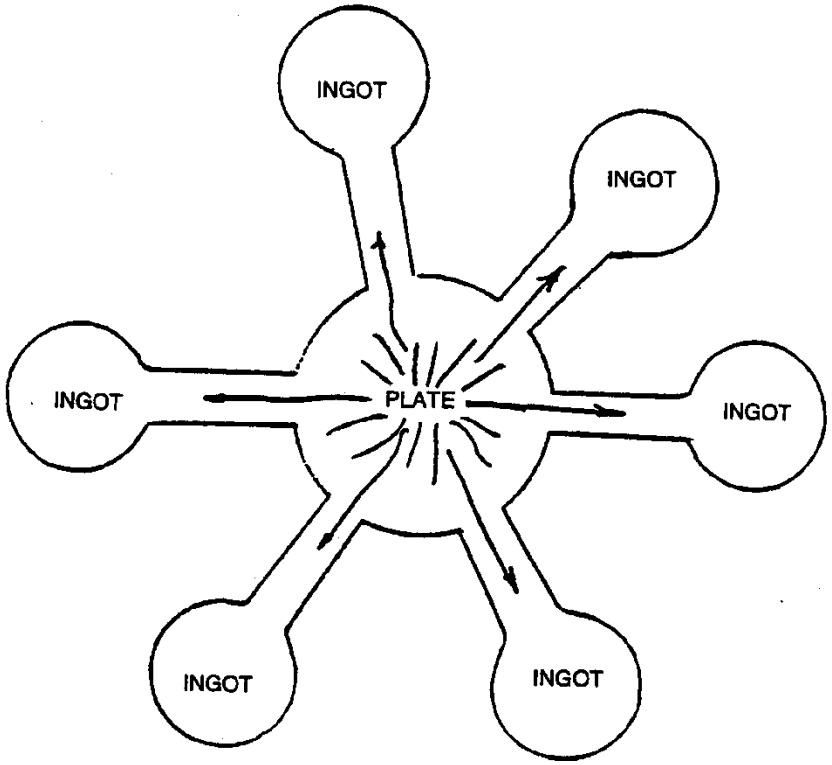


FIGURE 1 - STRAND-CAST HEAT



Top view of one plate and associated ingots, six in this example. A heat can have more than one plate.

FIGURE 2 - BOTTOM-POURED HEAT

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