AEROSPACE
MATERIAL SPECIFICATIONS

SOCIETY OF AUTOMOTIVE ENGINEERS, Inc. 485 Lexington Ave., New York, N.Y. 10017

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Revised

AIRCRAFT QUALITY STEEL CLEANLINESS
Martensitic Corrosion Resistant Steels
Magnetic Particle Inspection Procedure

1. ACKNOWLEDGMENT: A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

2. APPLICATION: Primarily for determining compliance with the cleanliness requirement for aircraft quality martensitic corrosion resistant steels by magnetic particle inspection methods. Applicable primarily to bars, forging stock, slabs, plate, and heavy wall tubing but may be used for qualification of heat, melt, or lot of steel.

3. PROCEDURE:

3.1 Sampling: The sampling procedures described in 3.1.1 shall be performed by the producer for heat release; procedures on the product shall be as described in 3.1.2.1, 3.1.2.2, 3.1.2.3, or 3.1.2.4, as applicable.

3.1.1 Heat Qualification: Unless otherwise agreed upon, a sample shall be taken from semi-finished product or finished rolled plate product representing the top and bottom of the first ingot and last usable ingot from heats having not over 10 ingots or not over 30 tons 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 30 tons. No further magnetic particle testing will be required to be performed by the producer on product from a qualified heat except as necessary to assure product quality.

3.1.1.1 Heats which have been qualified as semi-finished product will be considered qualified for flat products.

3.1.2 Product Qualification:

3.1.2.1 Blooms, Billets, and Product Over 6 In. in Diameter or Distance Between Parallel Sides: Unless otherwise agreed upon, stock to provide specimens shall be taken from not less than 10% of the pieces of each size of material from each heat in each shipment. Not less than 3 nor more than 10 specimens shall be selected, except that if the quantity is 3 pieces or less, 1 specimen shall be selected from each piece.

3.1.2.2 Bars Other Than Flat, Tubing, and Forging Stock 6 In. and Under in Diameter or Distance Between Parallel Sides: Unless otherwise agreed upon, specimens shall be taken from not less than 10% of the pieces of each size from each heat in each shipment. Not less than 3 nor more than 10 specimens shall be selected, except that if the quantity is 3 pieces or less, 1 specimen shall be selected from each piece.

3.1.2.3 Flat Bars and Slabs: Unless otherwise agreed upon, specimens shall be taken parallel to the direction of rolling from not less than 10% of the pieces from each heat in each shipment. Stock 6 in. and over in width shall cut longitudinally through the center and only a half section used for quality evaluation. Not less than 3 nor more than 10 specimens shall be selected, except that if the quantity is 3 pieces or less, 1 specimen shall be selected from each piece.

3.1.2.4 Flat product produced from a heat not previously qualified as in 3.1.1 or 3.1.2.3 shall be sampled as agreed upon by purchaser and vendor.

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3.2 Specimen Preparation:

3.2.1 Blooms, Billets, and Product Over 36 Sq In. in Cross Sectional Area: 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 6 in. consistent with the machining allowance specified in 3.2.5. As an alternate method, when agreed upon by purchaser and vendor, the full section may be rolled or forged to a 6 in. round or square and an oversize quarter obtained as in 3.2.2. The identity for specimen surface representing center of original stock shall be maintained throughout machining and testing.

3.2.2 Product 16 - 36 Sq In. in Cross Sectional Area: 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 into test size by machining, or forging and machining, to the largest possible round consistent with the machining allowance specified in 3.2.5. The identity for specimen surface representing center of original stock shall be maintained throughout machining and testing.

3.2.3 Product Less Than 16 Sq In. in Cross Sectional Area: The specimens shall be machined, consistent with the machining allowance specified in 3.2.5, to straight cylindrical samples. As an alternate method, when agreed upon by purchaser and vendor, a step-down specimen shall be generated in equal length circumferential steps as follows, allowing for the machining allowance specified in 3.2.5.

Nominal Diameter or Distance Between Parallel Sides Inches	Step Length Inches	Step Diameter				
		1	2	3	4	5
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 to 4.000, incl	1.000	D	4/5D	3/5D	2/5D	1/5D

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

3.2.3.1 For flat bars, the type of test and the location in the section shall be agreed upon by purchaser and vendor.

3.2.4 Slabs and Plates: Unless otherwise specified, a straight cylindrical section or full thickness longitudinal slice shall be machined, or forged and machined, from each slab or plate tested. The specimen shall be taken parallel to the direction of rolling and shall be approximately 5 in. in length and not more than 4 in. in final diameter. After generating to test size, each specimen shall be representative of both the center and original surface consistent with the machining allowance in 3.2.5.

3.2.5 Machining Allowance:

3.2.5.1 Product Other Than Tubing and Flat Bar: The converted sample shall be machined to conform to the following allowance for surface removal, allowing 0.010 in. per side for finish machining after heat treatment.

Nominal Diameter or Distance Between Parallel Sides Inches	Minimum Stock Removal Inch per Side
0.250 to 0.500, incl	0.030
Over 0.500 to 0.750, incl	0.045
Over 0.750 to 1.000, incl	0.060
Over 1.000 to 1.500, incl	0.075
Over 1.500 to 2.000, incl	0.090
Over 2.000 to 2.500, incl	0.125
Over 2.500 to 3.500, incl	0.156
Over 3.500 to 4.500, incl	0.187
Over 4.500 to 6.000, incl	0.250

3.2.5.2 Tubing: Tubing with nominal wall thickness less than 0.250 in. shall have 10% of the wall thickness or 0.015 in., whichever is less, removed from the OD after heat treatment. Samples from tubing with wall thickness of 0.250 in. and over shall be machined to conform to the following minimum stock removal per side after heat treatment.

Machined Diameter Inches	Minimum Stock Removal Inch per Side
Up to 2-1/2, incl	0.044
Over 2-1/2 to 3-1/2, incl	0.046
Over 3-1/2 to 4-1/2, incl	0.052
Over 4-1/2 to 5-1/2, incl	0.057
Over 5-1/2 to 6-1/2, incl	0.064
Over 6-1/2 to 8, incl	0.074
Over 8 to 10, incl	0.087

3.2.5.3 Flat Bar, Slab, and Plate: Allowance of 20% of the thickness or 0.100 in., whichever is less, shall be made for minimum stock removal, allowing 0.010 in. for finish machining after heat treatment.

3.2.6 Heat Treatment: Unless otherwise specified, rough machined specimens shall be hardened by suitably austenitizing, quenching, and tempering to produce hardness not lower than Brinell 200.

3.2.7 Finish Machining: The heat treated specimens shall be finish machined to surface roughness not greater than 40 microinches. Specimens shall be nominally 5 in. in length. The ends of the specimen shall be finished to provide good electrical contact.

3.3 Inspection: Magnetic particle inspection shall be performed in accordance with the latest issue of AMS 2640 by the circular, wet, continuous method using 800 - 1200 amp per in. of diameter. If the step-down bar is used (3.2.3), 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.

3.3.1 Cleanliness standards presented herein govern nonmetallic inclusions only. Material 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 the purchaser upon request.

3.4 Evaluation of Steel Cleanliness: After inspection, each indication 1/16 in. and over in length shall be recorded. The frequency (number) and severity (size) 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 total number of indications is divided by the area of the test specimen in square inches (frequency per specimen).

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 test 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 products of the number of indications times the appropriate progression factor listed in the following table.

Length of Indication Inches	Progression Factor for Severity Rating
1/16 to 1/8, incl	0.5
Over 1/8 to 1/4, incl	1
Over 1/4 to 1/2, incl	2
Over 1/2 to 3/4, incl	4
Over 3/4 to 1, incl	8
Over 1 to 1-1/2, incl	16

3.4.2.3 The product for each specimen is divided by the area of the specimen in square inches (severity per specimen).

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 test specimens.

4. DISPOSITION: Material inspected in accordance with this specification shall conform to the following maximum frequency and severity ratings:

4.1 Heat Qualification (Reference 3.1.1):

4.1.1 Material Other Than Slabs and Plates: Material inspected in accordance with this specification shall conform to the following maximum frequency and severity ratings.

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