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AEROSPACE MATERIAL SPECIFICATION

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ULTRASONIC INSPECTION
Centrifugally-Cast, Corrosion-Resistant Steel Tubular Cylinders

1. SCOPE:

1.1 Purpose: This procedure covers ultrasonic inspection of tubular, centrifugally-cast, corrosion-resistant steel cylinders.

1.2 Application: Primarily for locating defects such as cracks, voids, spongy areas, and other discontinuities. This procedure is not applicable to austenitic steels where grain boundaries mask results.

1.2.1 Immersion inspection is applicable to tubular products whose wall thickness is 0.5 to 9.0 inches (13 to 229 mm). Contact inspection is applicable to tubular product whose wall thickness is 3.0 to 9.0 inches (76 to 229 mm).

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 documents shall be as specified in AMS 2350.

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

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods

2.1.2 Standards and Recommended Practices:

SAE J300 - Crankcase Oil Viscosity Classification

2.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103.

ASTM E428 - Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Inspection

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Standards:

MIL-STD-410 - Nondestructive Testing Personnel Qualification and Certification
MIL-STD-1949 - Inspection, Magnetic Particle
MIL-STD-2175 - Castings, Classification and Inspection of
MIL-STD-6021 - Castings, Classification and Inspection of

2.4 ANSI Publications: Available from American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

ANSI B46.1 - Surface Texture

2.5 ASNT Publications: Available from American Society for Nondestructive Testing, Inc., 4153 Arlingate Plaza, Caller #28518, Columbus, OH 43228-0518.

SNT-TC-1A - Recommended Practice - Personnel Qualification and Certification in Nondestructive Testing

3. TECHNICAL REQUIREMENTS:

3.1 Qualification:

3.1.1 Personnel: Personnel shall be certified to SNT-TC-1A. Personnel who read Ø and interpret indications and evaluate them with reference to applicable codes and specifications shall be certified to either a Level II in accordance with SNT-TC-1A or to a Level I special in accordance with MIL-STD-410, as a minimum.

3.1.2 Facilities: Shall be subject to survey and approval by purchaser.

3.2 Equipment:

3.2.1 Electronic Apparatus: The ultrasonic instrument shall be of the pulse-echo type capable of operating at 2.25 through 10 megahertz. Gates, distance-amplitude correction systems, and other electronic aids to ultrasonic testing and interpretation shall be used as required. An alarm system and/or a recorder shall be used.

3.2.2 Transducers: The frequency used shall be the highest practical ultrasonic frequency which will provide the penetration and resolution required. The use of frequencies below 2.25 MHz or above 10 MHz is not permitted unless special permission is obtained from purchaser. The pulser/receiver shall be operated at the same test frequency as the transducer element being used for inspection. Transducers shall be 0.5 to 1.0 inch (13 to 25 mm), incl, in diameter except that rectangular search units with a length-to-width ratio of 2:1 may be used provided the length does not exceed 1.5 inches (38 mm).

3.2.3 Other equipment: Tanks, bridges, rotators, manipulators, and other equipment shall be adequate to perform the required tests.

3.2.3.1 Voltage Regulator: A voltage regulator shall be used on the power source when fluctuations in line voltage cause variations exceeding ±10% in a signal with an amplitude equal to the upper linearity limit of the instrument.

3.2.4 Couplant:

3.2.4.1 Immersion Method: For inspection by the immersion method, clean tap water shall be used as the couplant material; rust inhibitors, wetting agents, or both, may be added. The water shall be free of air bubbles which could interfere with the ultrasonic test.

3.2.4.2 Contact Method: For inspection by the contact method, SAE 30 motor oil conforming to SAE J300 or penetrant emulsifier shall be used as the couplant. Chloroprene rubber sheet or other similar materials may be used between the transducer and the part under inspection to prevent transducer wear providing adequate compensation for its use is made.

3.2.5 Reference Standards: Shall be fabricated in accordance with ASTM E428 from centrifugally-cast, corrosion-resistant steel equivalent to the alloy to be tested; dimensions of reference standards shall conform to Table I.

TABLE I

Metal Travel Distances, Longitudinal Wave

Material Nominal Thickness (T) Inches	Near Depth Inches	Metal Travel Distance Inches
Up to 1, incl	*	T ± 1/16, T/2 ± 1/16
Over 1 to 3, incl	*	T ± 1/4, T/4 ± 1/8, T/2 ± 1/4
Over 3 to 6, incl	*	T ± 1/4, T/8 ± 1/8, T/4 ± 1/8, T/2 ± 1/4
Over 6	*	T ± 1/2, T/8 ± 1/8, T/4 ± 1/4, T/2 ± 1/2

*See Table II.

TABLE I (SI)

Metal Travel Distances, Longitudinal Wave

Material Nominal Thickness (T) Millimetres	Near Depth Millimetres	Metal Travel Distance Millimetres
Up to 25, incl	*	T ± 1.6, T/2 ± 1.6
Over 25 to 76, incl	*	T ± 3.2, T/4 ± 3.2, T/2 ± 6.4
Over 76 to 152, incl	*	T ± 3.2, T/8 ± 3.2, T/4 ± 3.2, T/2 ± 6.4
Over 152	*	T ± 12.7, T/8 ± 3.2, T/4 ± 6.4, T/2 ± 12.7

*See Table II.

3.2.5.1 The test block material shall have ultrasonic sound transmission characteristics equal to those of the material to be tested within ±25%. If the sound transmission characteristics vary more than ±25%, compensation correction techniques shall be approved by purchaser.

3.2.5.2 Ø Except as permitted by 3.2.5.2.1, the reference standards shall have similar contour within ±25% of the radius of curvature of the dimensions being tested. Surface finish of the calibration standard, if made from an actual part, shall be similar to that of the material being tested.

3.2.5.2.1 Ø For testing curved surfaces having diameters greater than 10 inches (254 mm), flat test blocks may be used.

3.2.5.3 For longitudinal wave calibration, the calibration reflectors shall be flat-bottom holes 3/64, 5/64, and 8/64 inch (1.2, 2.0, and 3.2 mm) in diameter.

3.2.5.3.1 Near depth resolution is best obtained at higher frequencies as shown in Table II. Near depth resolution may be improved by using smaller diameter search units and short pulse length.

TABLE II

Ultrasonic Test Frequency (MHz)	2.25	5.0	10.0
Near Depth, Inch	0.70	0.50	0.30
Near Depth, millimetres	17.8	12.7	7.6

3.2.5.4 Ø Special reference standards to calibrate testing modes other than specified and any other reference standards necessary to aid in testing or evaluation may be used as agreed upon by purchaser and supplier.

3.3 Surface Preparation:

3.3.1 The OD and ID surfaces shall be uniformly machined prior to inspection.

3.3.2 Texture of surfaces shall be not rougher than 125 microinches (3.2 µm), determined in accordance with ANSI B46.1. Inspection surfaces not meeting the above requirements may be conditioned by machining, polishing, grinding, buffing, or other suitable method.

3.3.3 Ø Surface discontinuities remaining after surface preparation shall not be removed before ultrasonic inspection as local grinding depressions can cause sonic wave attenuation, loss of back reflection, and inability to locally meet standards. Surface discontinuities shall be evaluated by magnetic particle inspection in accordance with MIL-STD-1949. Surfaces shall be free from loose scale, machining or grinding particles, oil, grease, cutting compounds, and other foreign materials.

3.4 Equipment Preparation: Instruments of the vacuum tube type shall be warmed up for not less than 15 minutes before being used; instruments using solid state electronic components shall be warmed up for not less than 5 minutes before being used. Sufficient time shall also be allowed for temperature of water, reference blocks, and material to stabilize before calibration and testing.

3.5 Ø Calibration of Equipment: Before inspecting the product, the equipment shall be adjusted, using appropriate standards, to produce clearly defined indications of sufficient height to ensure that the product under test can be inspected as required to locate any imperfections of detrimental size, nature, and location. The minimum pip height shall be not less than 1.0 inch (25 mm); the maximum pip height shall be not greater than 90% of the screen height. The instrument standardization shall be rechecked at intervals not exceeding two hours of continuous inspection.

3.6 Ø Procedure: The product shall be inspected by the longtitudinal wave method. The sound beam entry angle for longitudinal wave (straight beam) testing shall be normalized by adjusting for maximum signal amplitude from the front (entry) surface. During testing, the angle established shall not vary more than ±2 degrees. The product shall be inspected by immersion or contact methods, as applicable (See 1.2.1).

3.7 General:

3.7.1 Calibration for determination of loss in amplitude of the back reflection pattern shall be performed on parallel surfaces of the product being tested. The back reflection pattern from the full material thickness section of the reference standard at the scanning sensitivity shall be recorded. If the back reflection pattern from the product being tested averages a variation of more than ±50% from that recorded from the reference standard, no testing shall be performed until necessary corrective action has been taken.

3.7.2 Ø The permissible background noise shall not exceed 10% of saturation or 25% of the response height from the reference standard of the same alloy as the product being tested. If the background noise exceeds this level, the section involved shall be re-examined to ensure that the product meets the specified requirements.

3.7.3 The pulse rate shall be not lower than 600 per second.

3.7.4 Scanning Speed:

3.7.4.1 The scanning speed for calibration shall be not greater than that at which the calibration holes in the reference standards are resolved.

3.7.4.2 The scanning speed for testing the product shall be not greater than that established in 3.7.4.1.

3.7.4.3 The scanning speed shall not exceed the response time of the audible alarm or of the recorder.

3.7.4.4 If a C-scan recording system is used, the scanning speed shall be the same for the reference standard as for the product.

3.7.4.5 For manual scanning without alarm systems, scanning speed shall not exceed 5.0 inches (127 mm) per second.

3.7.4.6 For manual or automatic scanning with alarm systems, scanning speed shall not exceed 20 inches (508 mm) per second.

3.7.5 When the alarm system is used during testing, it shall be set to Ø continuous response until deactivated by the operator.

3.7.6 The instrument control settings and test parameters established during calibration shall not be changed during testing of the product.

3.7.7 Distance Amplitude Correction (DAC): Electronic distance amplitude correction is recommended; however, distance amplitude curves plotted on the screen face (cathode ray tube) using distance amplitude calibration blocks may be used if the minimum pip height complies with 3.5. Testing using the highest sensitivity from the distance amplitude calibration blocks and evaluating to the proper metal travels is also permitted provided noise levels do not obscure required information.

3.7.8 Contact Method: Indexing increments used in scanning a product shall be not greater than one-half the effective beam diameter, determined in accordance with 3.7.10. Transducer indexing shall be controlled by a mechanical system.

3.7.9 Immersion Method:

3.7.9.1 Water Path: The distance from search unit to product surface shall be such that the second front reflection from the test material does not appear between the first front and first back reflection or shall be not less than 3 inches (76 mm). Water path distance shall be equal within 1/4 inch (6.4 mm) for calibration, scanning, and evaluation.

3.7.10 Scanning Index: The maximum scanning index used shall be determined as follows and shall be documented:

3.7.10.1 Use the same water path or coupling used for scanning.

3.7.10.2 Adjust sensitivity to obtain an 80% full scale response from the Ø reference giving the least response. At this setting, scan the references in the index direction. Move the transducer until a response of 40% full scale is obtained. Note position of transducer and move transducer in the opposite direction until signal peaks and returns to 40% of full scale. Note the distance the transducer was moved. This distance is effective beam width.

3.7.10.3 Scanning increments shall be no greater than one half the effective Ø beam diameter.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Acceptance Grades: Acceptance grades are defined in Table III for Ø longitudinal wave inspection (L).

4.1.1 Acceptance standards for inspection by procedures other than specified and standards not covered in Table III, shall be as agreed upon by purchaser and vendor.

4.1.2 If the product is zoned for different grades of quality, purchaser shall provide the vendor with a sketch showing the locations of the different zones.

4.1.3 For engineering drawings, where classes in accordance with MIL-C-6021 are Ø referenced, the following cross references shall apply:

MIL-C-6021	MIL-STD-2175
Class I A	Class 1
Class I B	Class 2
Class II A	Class 3
CLASS II B	Class 4

4.1.4 Ultrasonic inspect in accordance with the requirements of Table IV, Ø 4.1.4.1, and 4.1.4.2 for the specified class established in accordance with MIL-C-6021 or MIL-STD-2175.

TABLE III

ACCEPTANCE CRITERIA, LONGITUDINAL WAVE INSPECTION (L) (4)

Grade	Single Discontinuity Indications Max Size Equivalent Ref. Std.	Multiple Discontinuity Indications Max Size Equivalent Ref. Std.	Multiple Discontinuity Indications Min Spacing (2)	Linear Discontinuity Indications Max Size Equivalent Ref. Std.	Linear Discontinuity Indications Max Length (3)	Attenuation Max (1) % Normal Back Reflection
A Standard	#5	#3	1 inch (25 mm)	#3	1 inch (25 mm)	50
B	#8	#5	1 inch (25 mm)	#5	1 inch (25 mm)	50

NOTES: (1) A loss of back reflection greater than 50%, when compared to normal sound material in a similar location in the same or similar product, is not acceptable when associated with a twofold increase in ultrasonic noise within the product.

(2) Center-to-center distance.

(3) End points are defined as those points where the signal amplitude drops to one-half the maximum height of the equivalence Ø reference reflector response at the flaw depth or DAC height at the flaw depth.

(4) Any discontinuity with an indication greater than the response from the reference flat-bottom hole at the estimated discontinuity depth is not acceptable.