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AEROSPACE MATERIAL SPECIFICATION

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Ultrasonic Inspection
Centrifugally-Cast, Corrosion-Resistant Steel Tubular Cylinders

RATIONALE

This document has been designated noncurrent because it is not being specified in new designs.

NONCURRENT NOTICE

This specification has been declared "NONCURRENT" by the Aerospace Materials Division, SAE, as of April, 2007. It is recommended, therefore, that this specification not be specified for new designs.

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Submitted for recognition as an American National Standard

SAE AMS 2633B

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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:

This procedure has been used typically for locating defects such as cracks, voids, spongy areas, and other discontinuities, but usage is not limited to such applications. 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 publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

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

SAE J300 Crankcase Oil Viscosity Classification

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM E 428 Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Inspection
ASTM E 1417 Liquid Penetrant Examination

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

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., 11 West 42nd Street, New York, NY 10036-8002.

ANSI B46.1 Surface Texture

2.5 ASNT Publications:

Available from American Society for Nondestructive Testing, Inc., 1711 Arlingate Plaza, P. O. Box #28518, Columbus, OH 43228-0518.

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

2.6 ATA Publications: Available from Air Transport Association, 1301 Pennsylvania Avenue, Suite 1100, Washington, DC 20004-1707.

ATA-105 Guidelines for Training and Qualifying Personnel in Nondestructive Testing

3. TECHNICAL REQUIREMENTS:

3.1 Qualification:

3.1.1 Personnel: Shall be qualified and certified in accordance with MIL-STD-410. Alternate procedures, such as ASNT-TC-1A or ATA-105, may be used if specified by the drawing or purchase order. It is the supplier's responsibility to ensure that personnel are certified and function within the limits of the applicable specification or procedure.

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), inclusive, 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 AE J300, or equivalent, 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 E 428 from centrifugally-cast, corrosion-resistant steel equivalent to the alloy to be tested; dimensions of reference standards shall conform to Table 1.

TABLE 1A - Metal Travel Distances, Longitudinal Wave, Inch/Pound Units

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

[1] See Table 2.

TABLE 1B - Metal Travel Distances, Longitudinal Wave, SI Units

Material Nominal Thickness (T) Millimeters	Near Depth Millimeters	Metal Travel Distance Millimeters
Up to 25, incl	[1]	T ± 1.6, T/2 ± 1.6
Over 25 to 76, incl	[1]	T ± 3.2, T/4 ± 3.2, T/2 ± 6.4
Over 76 to 152, incl	[1]	T ± 3.2, T/8 ± 3.2, T/4 ± 3.2, T/2 ± 6.4
Over 152	[1]	T ± 12.7, T/8 ± 3.2, T/4 ± 6.4, T/2 ± 12.7

[1] See Table 2

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 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.

3.2.5.3 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 2. Near depth resolution may be improved by using smaller diameter search units and short pulse length.

TABLE 2 - Near Depth Resolution

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

3.2.5.4 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), defined 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 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 or liquid penetrant examination in accordance with ASTM E 1417. Surfaces shall be free from loose scale, machining or grinding particles, oil, grease, cuffing 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 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 Procedure:

The product shall be inspected by the longitudinal 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 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 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 not be 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 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. Rotate the transducer 90 degrees and repeat the beam width measurement. This minimum distance is effective beam width.

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

3.8 Written Procedure:

Ultrasonic inspection performed in accordance with this specification shall be detailed in a written procedure. Unless otherwise specified, procedures shall be prepared by the vendor and approved by purchaser. Procedures shall identify the type of ultrasonic equipment, method(s) of test, ultrasonic test reference, search unit (type, style, frequency and qualification), fixturing, method of reporting indications, and all other instructions that pertain to the actual test. Procedures shall be detailed sufficiently that another qualified investigator could duplicate the test and obtain equivalent information.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Acceptance Grades:

Acceptance grades are defined in Table 3 for longitudinal wave inspection (L).

4.1.1 Acceptance standards for inspection by procedures other than specified and standards not covered in Table 3, shall be as agreed upon by purchaser and vendor.

TABLE 3 - 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 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.

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 referenced, the following cross references shall in Table 4 apply:

Table 4

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

4.1.4 Ultrasonic inspect in accordance with the requirements of Table 5, 4.1.4.1, and 4.1.4.2 for the specified class established in accordance with MIL-C-6021 or MIL-STD-2175.