



AEROSPACE MATERIAL SPECIFICATION

AMS2632™**REV. C**

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Revised 2022-06

Superseding AMS2632B

Inspection, Ultrasonic, of Thin Materials
0.50 Inch (12.7 mm) and Under in Cross-Sectional Thickness

RATIONALE

AMS2632C is the result of a Five-Year Review and update of the specification. The revision updates reference specifications (3.2.4.3.1, 3.3, 8.6), updates Figure 7 to be consistent with other AMS-UT specifications, adds Figure 8 as an example and adds reference to it (3.2.4.7.1, 3.2.4.7.2), and deletes recording of UT references (4.3.5) to standardize between other AMS-UT specifications.

1. SCOPE

1.1 Purpose

This specification covers the procedure for ultrasonic inspection of flat, contoured, round, and hollow cylindrical products having a cross-sectional thickness of 0.02 to 0.50 inch (0.5 to 12.7 mm). This specification does not apply to inspection of composite materials.

1.2 Application

This process has been used typically for locating and defining internal defects, such as cracks, voids, laminations, and other structural discontinuities, which may or may not be exposed to the surface, but usage is not limited to such applications.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order form 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.

AMS2631 Ultrasonic Inspection, Titanium and Titanium Alloy Bar, Billet, and Plates

AMS5070 Steel, Bars and Forgings, 0.18 - 0.23C (SAE 1022)

AS7766 Terms Used in Aerospace Metals Specifications

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Documents
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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 E127 Fabrication and Control of Flat Bottomed Hole Ultrasonic Standard Reference Blocks
- ASTM E213 Ultrasonic Inspection Testing of Metal Pipe and Tubing
- ASTM E317 Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Systems Without the Use of Electronic Measurement Instruments
- ASTM E1065 Evaluating Characteristics of Ultrasonic Transducers
- ASTM E1316 Standard Terminology for Nondestructive Examinations

2.3 AIA Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

- NAS410 Certification and Qualification of Nondestructive Test Personnel

2.4 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

2.5 ASNT Publications

Available from American Society for Nondestructive Testing, Inc., 1711 Arlingate Plaza, Caller #28518, Columbus, OH 43228-0518, <https://www.asnt.org/>.

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

2.6 Airlines for America (A4A) Publications

Available from Airlines for America (A4A), 1275 Pennsylvania Avenue, NW, Suite 1300, Washington, DC 20004, Tel: 202-626-4062, www.airlines.org.

- Spec 105 Guidelines for Training and Qualifying Personnel in Nondestructive Testing Methods

3. TECHNICAL REQUIREMENTS

3.1 Qualification

3.1.1 Personnel

Shall be qualified and certified in accordance with NAS410. Alternate procedures, such as SNT-TC-1A or Spec 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. The ultrasonic test facility equipment shall include, but not be limited to, the basic ultrasonic test instrument, transducers, appropriate ultrasonic references, couplant materials, fixtures, reference specifications, immersion tanks where applicable, and documentation necessary to verify the qualification of equipment and test personnel.

3.2 Ultrasonic Test System

3.2.1 Basic Ultrasonic Test Instrument

Shall be capable of producing, receiving, amplifying, and displaying high-frequency signals at specific frequencies as required by the ultrasonic test. The ultrasonic instrument shall be of a pulse-reflection (echo), pulse-transmission type capable of operation at frequencies from 2.0 to 10.0 MHz. The instrument shall be capable of being adapted with electronic circuitry, such as flaw gates, distance amplitude corrections, and alarms, that can aid in testing and interpretation of flaw signals. The instrument shall have a minimum dynamic range of 30 dB and shall have a transmit/receive crosstalk separation of at least 40 dB.

3.2.1.1 Instrument Requirements

The instrument performance characteristics shall be evaluated in accordance with ASTM E317 as follows:

Table 1 - Instrument performance requirements

Characteristic	Requirement
Signal to noise ⁽¹⁾	2:1
Vertical linearity	±5%
Horizontal linearity	±3%
Gain or attenuator accuracy	±2 dB per 20 dB of control range
Voltage regulation—Voltage fluctuations shall not cause amplitude variations exceeding:	±5%

⁽¹⁾ ASTM E127 reference block 1-0300.

3.2.1.2 Alarm

3.2.1.2.1 Alarms and visual monitoring of the A-scan are not required when C-scan data collection is used.

3.2.1.2.2 For unrecorded stop on defect inspections, test criteria and part configuration determine alarm use feasibility. When alarms cannot be used, this must be agreed upon by purchaser and vendor. Audible and/or visual alarms and/or stop on defect systems shall be used in conjunction with visual monitoring to identify signals which exceed the level established for the test. Alarm systems used for this purpose shall be capable of being adjusted to alarm at any point in the display range and shall be automatically triggered by indications exceeding the set level. The sound level produced by an audible alarm during operation shall be sufficiently above ambient to ensure being heard by the operator.

3.2.2 Ultrasonic Transducers

Ultrasonic transducers shall have the sensitivity and resolution required to detect the required reference reflectors.

3.2.2.1 Transducer Dimension and Styles

3.2.2.1.1 For testing thin materials, a variety of contact and immersion styles may be used. The choice is dependent on the test and the approved test procedure. Immersion flat and focused, contact, angle beam, liquid delay, phased array, and pressurized-couplant transducer systems may be used.

3.2.2.1.2 Phased Array Transducers

Linear phased array, annular phased array, and 2D array probes may be used for scanning and evaluation of wrought metals.

The written procedures shall include at least the following additional controls for phased array usage:

Virtual probes within the array shall meet the requirements for minimum effective beam diameter in both the scan and index directions.

Each virtual probe in the array shall meet the applicable requirements of a conventional probe.

There shall be no more than one dead element in a virtual probe and the array shall not have two adjacent dead elements.

All virtual probes in the array shall exhibit an amplitude response within 1 dB of the mean amplitude.

A virtual probe is defined as a group of individual array elements, pulsed simultaneously or at phasing intervals to generate a larger acoustic aperture.

3.2.2.1.3 Rectangular "Paintbrush" Transducers

Rectangular "paintbrush" transducers shall be allowed for straight beam, immersion initial scanning inspection of plate if it is demonstrated that the transducer provides the required inspection results. The written procedures shall include at least the additional items specified in this section.

A method shall be established for providing a uniform entry surface for the full extent of the sound beam when using test blocks for equipment standardization and adjustments.

A method shall be established for determining a sensitivity profile across the major dimension of the beam to locate the least sensitive area. The scan sensitivity must be established using the least active portion of the transducer at each position of the DAC curve to be used.

A method could be established for masking the ends of the transducer to eliminate over sensitive responses.

A procedure for evaluation of indications detected during scan shall be made using transducers that meet the requirements of 3.2.2.1.1.

A procedure for determining effective beam width (major dimensions of the transducer). The scan index shall be based on the beam width so determined.

3.2.2.2 Test Frequencies

No specific restrictions are imposed; however, use of frequencies below 5 MHz for longitudinal wave inspection shall be approved by purchaser prior to testing.

3.2.2.3 Ultrasonic Beam Profiles

For immersion testing, the waterpath used shall assure that testing is performed in the far field, past the Y_0 point. The following are recommended, simplified (no special equipment required except a 2.5 to 3 mm ball) methods of finding Y_{+0} (focal length or F_1 per ASTM E1065) and beam profiles. Complete performance parameters of ultrasonic transducers using special equipment are presented in ASTM E1065. Other methods or techniques for obtaining the same or similar data may be used if acceptable to purchaser.

3.2.2.3.1 Axial Beam Profile

The focal length of transducers shall be determined by the manufacturer or user before the transducer is put into service. When focal length measurements are used to determine water path distances without empirical verification during setup, focal length shall be verified on an annual basis. Focal length shall agree with the original value within a tolerance defined by the Level 3 for the transducer to be acceptable. This tolerance shall be based on the intended use of the transducer and shall not exceed 20%.

3.2.2.3.2 Cross Section Profile (Beam Symmetry)

Beam symmetry only applies to round transducers. The ratio of beam widths shall be not less than 0.75:1 when measured to the 6 dB points in two directions, 90 degrees apart, across the beam at the Y_{+0} location. The measurements shall be made from energy reflected from a 2.5 to 3.0 mm diameter ball target. Larger diameter balls may be used when agreed upon by purchaser and vendor.

3.2.2.3.3 For contact testing and immersion tests performed in the near zone, the exit point and exit angle of ultrasonic energy and depth profile of the sound beam shall be established for angle-beam transducers. Transducers with beam angles departing more than ± 3 degrees from manufacturer's indicated values shall not be used. Such units may be requalified to a new angle by verifying proper operation and by re-identifying the unit to the correct new beam angle. The International Institute of Welding (IIW) ultrasonic reference block (see Figure 1) or an appropriate substitute may be used to test the exit angle of angle-beam transducers. The history of an angle-beam transducer shall include the type, style, size, frequency, serial number, and vendor or receiving acceptance tests.

3.2.3 Couplants

Couplants shall be used for all tests.

3.2.3.1 Immersion

Couplant for immersion may be tap water. Other couplant fluids shall be specified in the procedure. Such fluids may contain wetting agents to improve couplant properties or rust inhibitors to reduce influence of the fluid on the material under test. No fluid may be used which stains, etches, or otherwise affects the surface of the material under test. Any fluid used for immersion testing shall be free of visible air bubbles and shall not exhibit excessive attenuation at the test frequency. The immersion technique is defined to include any liquid delay such as bubble, columnator, squirts, ultrasonic wheels, and immersion tanks.

3.2.3.2 Contact

Couplants for testing by the contact method shall not be injurious to the product being tested. Couplants shall be approved in the test procedure. Table 2 contains a guide for viscosities of commercial couplants or oils for various surface finishes. Rubber-like wear membranes may be used between the transducer and the test part to prevent excessive transducer wear provided such use is approved by purchaser. The contact technique is defined to include direct contact of a transducer with the test surface, use of contour surface wearshoes, and thin-film couplant techniques such as the pressurized fluid (water gap) system.

Table 2 - Couplant viscosity guidance

Approximate Surface Roughness	Couplant Viscosity
5 to 100 Ra (0.1 to 2.5 μm)	SAE 10
50 to 125 Ra (1.2 to 3.2 μm)	SAE 20
100 to 200 Ra (2.5 to 5.1 μm)	SAE 30

3.2.4 Ultrasonic References (Standards)

Ultrasonic reference standards are required for all inspections to establish the performance of the inspection system and to interrelate the test results with reference reflectors. Because thin material testing involves many special problems in various type of materials, it is mandatory that the materials used for fabrications of ultrasonic references have the same ultrasonic properties as the product or part under test. Whenever practical, the ultrasonic references shall be made from the same material and with the same configuration as the part under test.

3.2.4.1 Material

Prior to fabrication, the material used for the ultrasonic reference shall be ultrasonically tested and proven to be free of imperfections that would influence the test. At the frequency selected for the test, the ultrasonic transmission characteristics shall not vary more than $\pm 25\%$ from those of the product or part to be tested.

3.2.4.2 Entry Surfaces

The configuration, of surface roughness, flatness, or contour, of the ultrasonic reference should approximate that the product or part to be tested. When product or part radius of curvature is less than 5 inches (127 mm), it may be necessary to use a curved surface ultrasonic reference to establish the operating parameters of the test. Requirement for a curved reference depends on type of test, direction of test, and size of transducer (see 3.2.4). The procedure used shall resolve the near surface FBH to a level of 6 dB from the front reflection.

3.2.4.3 Straight Beam Ultrasonic References

3.2.4.3.1 Where the part thickness is greater than 0.125 inch (3.18 mm), the procedures established under ASTM E127, shall be used for manufacturing ultrasonic references for straight beam testing; these specifications describe the manufacture of flat-bottom holes (FBH) in aluminum alloys and other materials. Use of more compatible material is required where the ultrasonic transmission characteristic differs from that of the product to be tested by more than 25%.

3.2.4.3.2 Ultrasonic references may be made from thin materials, e.g., 0.125 inch (3.18 mm) or less, by drilling appropriate flat-bottom holes of appropriate sizes and depths. The specifications for the flat-bottom hole remain the same as described in the ASTM specifications; only the material thickness requirement is altered.

3.2.4.4 Angle Beam Ultrasonic References

For flat product with a part thickness of 0.5 inch (12.7 mm) and under, ultrasonic references in accordance with Figure 2 are required. The reference which most nearly approximates the product or part under test shall be used. Ultrasonic references may be made in a variety of thicknesses; however, a minimum of three are required to cover the range. Tables 3A and 3B describe the applicable dimensions. Use of notches for angle beam ultrasonic reference blocks is preferred.

Table 3A - Angle beam inspection parameters, inch/pound units

Reference Thickness, T Inches	FBH ⁽¹⁾ A	FBH ⁽¹⁾ B	FBH ⁽¹⁾ C	FBH ⁽¹⁾ D	Notches ⁽²⁾ E	Notches ⁽²⁾ F	Notches ⁽²⁾ G	Notches ⁽²⁾ H
0.50	#2	#3	#5	#8	0.02D ⁽⁴⁾ 0.04L	0.03D 0.05L	0.05D 0.10L	0.08D 0.16L
0.25	#2	#3	#5	#8	0.02D 0.04L	0.03D 0.05L	0.05D 0.10L	0.08D 0.16L
0.125	#2	#3	#5	NA ⁽³⁾	0.02D 0.04L	0.03D 0.05L	0.05D 0.10L	NA NA

⁽¹⁾ Flat-bottom hole (FBH) numbers are based on 1/64 inch diameter hole progression, i.e., #1 means 1/64 inch and #8 means 8/64 inch diameter flat-bottom holes.

⁽²⁾ Notches are to be generated by electrodischarge machining (EDM) techniques and shall have a maximum width of 0.01 inch. All other dimensions are to be ± 0.002 inch. Notches shall be perpendicular to part surface within ± 2 degrees.

⁽³⁾ NA = Not applicable.

⁽⁴⁾ D = depth of notch and L = length of notch in inches.

Table 3B - Angle beam inspection parameters, SI units

Reference Thickness, T Millimeters	FBH ⁽¹⁾ A	FBH ⁽¹⁾ B	FBH ⁽¹⁾ C	FBH ⁽¹⁾ D	Notches ⁽²⁾ E	Notches ⁽²⁾ F	Notches ⁽²⁾ G	Notches ⁽²⁾ H
12.7	0.8	1.2	2.0	3.2	0.51D ⁽⁴⁾ 1.02L	0.76D 1.27L	1.27D 2.54L	2.03D 4.06L
6.4	0.8	1.2	2.0	3.2	0.51D 1.02L	0.76D 1.27L	1.27D 2.54L	2.03D 4.06L
3.18	0.8	1.2	2.0	NA ⁽³⁾	0.51D 1.02L	0.76D 1.27L	1.27D 2.54L	NA NA

⁽¹⁾ Diameter of flat-bottom hole in millimeters.

⁽²⁾ Notches are to be generated by electrodischarge machining (EDM) techniques and shall have a maximum width of 0.25 mm. All other dimensions are to be ± 0.05 mm. Notches shall be perpendicular to part surface within ± 2 degrees.

⁽³⁾ NA = Not applicable.

⁽⁴⁾ D = depth of notch and L = length of notch in millimeters.

3.2.4.5 Ultrasonic References for Inspection of Hollow Cylinders

For cylinders of 5 inches (127 mm) radii and greater, the flat ultrasonic references outlined in 3.2.4.3 and 3.2.4.4 are suitable. Where radius of curvature is less than 5 inches (127 mm), the following procedures shall apply:

3.2.4.5.1 Circumferential Shear Inspection

For product and parts 0.125 inch (3.18 mm) and under in thickness, an EDM, or end mill notch or an equivalent reflecting surface shall be used as an ultrasonic reference. Notches shall be generated axially and be perpendicular to the part surface within ± 2 degrees. Replicating techniques or their equivalent shall be used to establish perpendicularity. Notch sizes shall be as shown in Table 4 (see Figure 3). Both ID and OD notches may be necessary to ensure full inspection of critical parts. The ultrasonic references for materials 0.125 to 0.50 inch (3.18 to 12.7 mm) thickness shall use flat-bottom holes as reference targets. Target holes shall be placed in the appropriate cylindrical references as shown in Figure 4. Hole sizes shall be as shown in Tables 4A and 4B.

Table 4A - Hole and notch sizes for circumferential shear ultrasonic references, inch/pound units

Material Thickness (T) Inch	FBH A	FBH B	FBH C	FBH D	Notches E	Notches F	Notches G
0.50	#2	#3	#5	#8	--	--	--
0.25	#2	#3	#5	--	--	--	--
0.125 and under ⁽¹⁾	--	--	--	--	0.02D 0.04L	0.03D 0.05L	0.05D 0.10L

⁽¹⁾ Notches for material 0.125 inch and under in thickness are rectangularly dimensioned. When end mill or saw cuts are used, make the reflectors equal in area for each specific size.

Table 4B - Hole and notch sizes for circumferential shear ultrasonic references, SI units

Material Thickness (T) Millimeters	FBH A	FBH B	FBH C	FBH D	Notches E	Notches F	Notches G
12.7	0.8	1.2	2.0	3.2	--	--	--
6.4	0.8	1.2	2.0	--	--	--	--
3.18 and under ⁽¹⁾	--	--	--	--	0.51D 1.02L	0.76D 1.27L	1.27D 2.54L

⁽¹⁾ Notches for material 3.18 mm and under in thickness are rectangularly dimensioned. When end mill or saw cuts are used, make the reflectors equal in area for each specific size.

3.2.4.5.2 Axial Shear Inspection

For product or parts 0.125 inch (3.18 mm) and under in thickness, EDM notches or equivalent reflecting surfaces shall be used. Notches shall be generated circumferentially and be perpendicular to the surface within ± 2 degrees. Notch sizes listed in Table 4 shall apply (see Figure 5). Both ID and OD notches may be necessary for full inspection of critical parts. For parts with thickness over 0.125 inch (3.18 mm), the flat-bottom hole shall be used as the target (see Figure 6). Flat-bottom holes shall be placed axially in the cylinder wall and shall be of the sizes specified in Table 4.

3.2.4.6 Surface Wave Inspection

Ultrasonic references for surface wave inspection shall use EDM notches as reference targets. Notches shall be made perpendicular to the inspection surface within ± 2 degrees and shall be placed to intersect the ultrasonic beam perpendicular to its projection axis. The sound entry surface shall have a surface roughness of 32 μ in (0.8 μ m) or smoother. No specific notch sizes are specified; the procedures agreed upon by purchaser and vendor for a particular inspection shall apply. However, the notches specified in Table 3 could be appropriate for flat materials and the notches specified in Table 4 could be appropriate for curved sections.

3.2.4.7 Ultrasonic References for Inspection of Round and Flat Bar

3.2.4.7.1 Straight beam inspection standards shall utilize FBH reflectors. A minimum of one reflector between 1/2 thickness and the back wall is required. An example standard is shown in Figure 3.