



# AEROSPACE MATERIAL SPECIFICATION

**AMS2631™****REV. G**

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Revised 2022-06

Superseding AMS2631F

Ultrasonic Inspection  
Titanium and Titanium Alloy Bar, Billet, and Plate

## RATIONALE

AMS2631G is the result of a limited scope ballot to update Tables 3 and 4.

### 1. SCOPE

#### 1.1 Purpose

This specification covers the procedure for ultrasonic inspection of wrought titanium and titanium alloy products 0.25 inch (6.4 mm) and over in cross-section (thickness) or diameter.

1.1.1 When specifically requested by purchaser, this specification may be used for metals other than titanium.

#### 1.2 Application

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

1.2.1 Testing will normally be accomplished by a procedure utilizing straight beam longitudinal wave inspection with acceptance criteria specified in the Ultrasonic Quality classes as in Table 8 of this specification, but angle beam inspections accomplished by a procedure utilizing either refracted longitudinal or shear wave inspection may be used when agreed upon by purchaser and inspection source.

1.2.2 Round bar and billet may use AMS2628 techniques and equipment for billet over 4.5 inches, using the acceptance criteria of Table 8 of this specification.

### 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.

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## 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](http://www.sae.org).

|          |                                                                                     |
|----------|-------------------------------------------------------------------------------------|
| AMS2380  | Approval and Control of Premium-Quality Titanium Alloys                             |
| AMS2628  | Enhanced Ultrasonic Immersion Inspection for Titanium and Other Metal Alloy Billets |
| AMS4928  | Titanium Alloy Bars, Wire, Forgings, Rings, and Drawn Shapes 6Al - 4V Annealed      |
| ARP1917  | Clarification of Terms Used in Aerospace Metals Specifications                      |
| SAE J300 | Engine Oil Viscosity Classification                                                 |

## 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](http://www.astm.org).

|           |                                                                                                                                       |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------|
| ASTM E127 | Fabrication and Control of Flat Bottomed Hole Ultrasonic Standard Reference Blocks                                                    |
| ASTM E317 | Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Systems Without the Use of Electronic Measurement Instruments |

## 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](http://www.aia-aerospace.org).

|        |                                                                    |
|--------|--------------------------------------------------------------------|
| NAS410 | NAS Certification & Qualification of Nondestructive Test Personnel |
|--------|--------------------------------------------------------------------|

## 2.4 ANSI Accredited Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

|            |                 |
|------------|-----------------|
| ANSI B46.1 | Surface Texture |
|------------|-----------------|

## 2.5 ASNT Publications

Available from American Society for Nondestructive Testing, P.O. Box 28518, 1711 Arlingate Lane, Columbus, OH 43228-0518, Tel: 800-222-2768 (inside U.S. and Canada) or 614-274-6003 (outside USA), [www.asnt.org](http://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), 1301 Pennsylvania Avenue, NW, Suite 1100, Washington, DC 20004, Tel: 202-626-4000, [www.airlines.org](http://www.airlines.org).

|         |                                                                            |
|---------|----------------------------------------------------------------------------|
| 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 NAS410. Alternate procedures, i.e., SNT-TC-1A or ATA-105, may be used if permitted on the purchase order. It is the inspection source'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 either the purchaser or a third party that is independent of the purchaser. Reference specifications, procedures, and documentation necessary to verify the qualification of equipment and test personnel shall be available to purchaser, when requested.

##### 3.1.3 Written Procedure

Ultrasonic inspections performed in accordance with this specification shall be detailed in written procedures. Procedures shall identify the type of ultrasonic equipment, method(s) of test, ultrasonic test reference standards, search unit type, style, corrected beam/type focusing and frequency, 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.

#### 3.2 Equipment

##### 3.2.1 Basic Ultrasonic Test Instrument

Shall be capable of producing, receiving, and displaying high-frequency electrical pulses at the required frequencies and energy levels. The ultrasonic instrument shall be of the pulse-echo type capable of operating at 2.25 through 10 MHz except as permitted in 3.2.2.2. Gates, distance-amplitude correction systems, and other electronic aids to ultrasonic testing and interpretation shall be used as required. An alarm system, a recorder, or an auto-stop device, or combination of these, may be used.

##### 3.2.1.1 Instrument Linearity

The instrument performance characteristics shall be evaluated in accordance with ASTM E317 or original manufacturer's requirements with acceptance in accordance with Table 1.

**Table 1 - Acceptance for instrument characteristics**

| Instrument Characteristics                   | Acceptance                                                                                      |
|----------------------------------------------|-------------------------------------------------------------------------------------------------|
| Upper linearity limit, percent of full scale | ≥95                                                                                             |
| Lower linearity limit, percent of full scale | ≤10                                                                                             |
| Vertical linearity, percent of full scale    | ≤5                                                                                              |
| Horizontal linearity, percent of full scale  | ≤2                                                                                              |
| Gain or attenuator (sensitivity) accuracy    | ±2 dB per 20 dB of control range and within ±10% of the reference amplitude for each increment. |

##### 3.2.2 Ultrasonic Search Units

Shall be capable of transmitting and receiving ultrasonic vibrations at the frequency and energy levels specified below. The frequency used shall be the highest practical ultrasonic frequency which will provide the required penetration, resolution, and signal to noise.

### 3.2.2.1 Search Unit Dimensions and Styles

For both contact and immersion tests with either longitudinal or shear mode, the choice of transducer dimension, style, focusing characteristics, type, etc., is dependent on the test and the approved test procedure. In general, for immersion testing, flat-faced or corrected-beam transducers with diameters 3/8 through 1 inch (9.5 through 25.4 mm) or rectangular units with a maximum area of 1 square inch (6.5 cm<sup>2</sup>) are acceptable. Contact units with a maximum area of 1 square inch (6.5 cm<sup>2</sup>) with 1/2 inch (12.7 mm) minimum to 1-1/8 inch (28.5 mm) maximum dimensions are acceptable for longitudinal testing, while 1 square inch (6.5 cm<sup>2</sup>) or 1 by 1/2 inch (25.4 by 12.7 mm) transducers are acceptable for shear testing. Use of a paint brush, liquid delay, special size, or other special transducer is acceptable when agreed upon by purchaser and inspection source.

3.2.2.2 Shall be the highest practical frequency which will provide the penetration and resolution required. Frequencies lower than 2.25 MHz for longitudinal inspections or 1.0 MHz for shear inspections shall not be used unless agreed upon by purchaser and inspection source.

### 3.2.3 Phased Array Search Units

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

3.2.3.1 The virtual probe dimensions (sum length of elements pulsed to form a single beam) shall meet the dimensions defined in 3.2.2.1.

3.2.3.2 Virtual probes within a linear array shall meet the requirements for minimum index in both the scan and index directions.

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

3.2.3.4 All virtual probes in the array shall exhibit an amplitude response within 10% of the mean amplitude.

### 3.2.4 Voltage Regulator

If fluctuations in line voltage cause variations exceeding  $\pm 5\%$  in a signal with an amplitude equal to the upper linearity limit of the instrument, a voltage regulator shall be used on the power source; this requirement does not apply to battery-powered units.

### 3.2.5 Couplant

#### 3.2.5.1 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 visible air bubbles which could interfere with the ultrasonic test.

#### 3.2.5.2 Contact Method

For inspection by the contact method, couplants that may be used include SAE 30 motor oil in accordance with SAE J300, cellulose gum, or other couplant materials, as long as they do not damage the material under inspection. Neoprene or urethane rubber sheet or similar material may be used between the transducer and the product being tested to prevent excessive transducer wear provided adequate compensation for its use is made.

### 3.2.6 Longitudinal Reference Standards

Shall be fabricated from AMS4928 titanium alloy or from other titanium alloy acoustically similar to the alloy to be tested. The procedures established in ASTM E127 are recommended for manufacturing ultrasonic reference blocks with flat bottom holes (FBH) for straight beam testing.

- 3.2.6.1 Acoustic compatibility between the reference standard material and the material to be tested shall be within 12 dB. If the acoustic compatibility is within 2.5 dB, no gain compensation is required for inspection. If the acoustic compatibility differences are greater than 2.5 dB but less than 12 dB, the instrument sensitivity shall be increased to compensate for the differences in acoustic compatibility. If the acoustic compatibility differences are greater than 12 dB, a different reference standard shall be used. Variations in acoustic response in the material to be tested may exist due to the nature of titanium structure, particularly in large diameter bars and relatively high thickness rectangles. Due to this variation, measurement of acoustic compatibility may be performed as necessary on individual pieces within a lot of material, or sections of those pieces, and instrument sensitivity increased in accordance with those measurements.
- 3.2.6.1.1 Compare acoustic compatibility by comparing the first unsaturated back reflection from the reference standard and the part being tested. The dB per inch (25.4 mm) comparison using back reflections is also frequently used. Other acoustic compatibility comparison measurements may be used when permitted by purchaser.
- 3.2.6.1.2 Instrument sensitivity increases may be applied in dB per inch (25.4 mm) for instruments with that capability using the formula: dB correction divided by the sound path to the reflector. Negative attenuation shall only be applied using the dB per inch (25.4 mm) technique.
- 3.2.6.2 For testing flat surfaces, flat test blocks shall be used. For testing curved surfaces, the reference standards shall have similar contour within approximately  $\pm 25\%$  of the radius of curvature of the dimensions being tested. Surface finish of the reference standard shall be similar to that of the material being tested.
- 3.2.6.2.1 In the event the hole diameter for the applicable class is not available, adjustments may be made to the sensitivity settings in decibels in accordance with Figure 1.
- 3.2.6.3 For longitudinal wave standardization, the reference standard reflectors shall be flat-bottom holes. The distance from the entry face of the ultrasonic beam to the bottoms of the reference standard FBHs (test metal distance) are recommended as follows in Tables 2, 3, and 4, based on the material contour and section thickness "T." Alternate reference standard FBHs may be used as long as alternate FBHs for the shortest test metal distance FBH are not longer than specified herein and alternate FBHs for the longest test metal distance FBH are not shorter than specified herein.

**Table 2 - Round bar and billet**

| Diameter (T)                                 | Test Metal Distance (TMD) Required                      |
|----------------------------------------------|---------------------------------------------------------|
| 0.25 to less than 0.5 inch (6.35 to 12.7 mm) | 1/8 inch (3.2 mm) and T minus 1/8 inch (T minus 3.2 mm) |
| 0.5 to 2 inches (12.7 to 51 mm)              | 1/4 inch (6.4 mm) and 1/2T                              |
| Over 2 to 5 inches (51 to 127 mm)            | 1/4 inch (6.4 mm), 1/4T, and 1/2T                       |
| Over 5 inches (127 mm)                       | 1/2 inch (12.7 mm), 1/8T, 1/4T, and 1/2T                |

**Table 3 - Flat faced material**

| Thickness                                    | Test Metal Distance (TMD) Required                                                                      |
|----------------------------------------------|---------------------------------------------------------------------------------------------------------|
| 0.25 to less than 0.5 inch (6.35 to 12.7 mm) | 1/8 inch (3.2 mm) and T minus 1/8 inch (T minus 3.2 mm)                                                 |
| 0.5 to 2 inches (12.7 to 51 mm)              | 1/8 inch (3.2 mm), 1/2T, and T minus 1/8 inch (T minus 3.2 mm)                                          |
| Over 2 to 5 inches (51 to 127 mm)            | 1/4 inch (6.4 mm), 1/4T, 1/2T. Include T minus 1/4 inch (T minus 6.4 mm) if material noise permits.     |
| Over 5 to 9 inches (127 to 229 mm)           | 1/2 inch (12.7 mm), 1/8T, 1/4T, and 1/2T. Include T minus 1/2 inch (12.7 mm) if material noise permits. |
| Over 9 inches (229 mm)                       | 3/4 inch (19.1 mm), 1/8T, 1/4T, and 1/2T. Include T minus 3/4 inch (19.1 mm) if material noise permits. |

**Table 4 - Plate material**

| Thickness (T)                                | Test Metal Distance (TMD) Required                                                                  |
|----------------------------------------------|-----------------------------------------------------------------------------------------------------|
| 0.25 to less than 0.5 inch (6.35 to 12.7 mm) | 1/8 inch (3.2 mm) and T minus 1/8 inch (T minus 3.2 mm)                                             |
| 0.5 to 2 inches (12.7 to 51 mm)              | 1/8 inch (3.2 mm), 1/2T, and T minus 1/8 inch (T minus 3.2 mm)                                      |
| Over 2 to 5 inches (51 to 127 mm)            | 1/4 inch (6.4 mm), 1/4T, 1/2T. Include T minus 1/4 inch (T minus 6.4 mm) if material noise permits. |

### 3.2.7 Angle Beam Reference Standards

Angle beam testing may use the longitudinal mode with the beam refracted at a predetermined angle (usually 45 degrees) or the true shear (transverse) wave may be used with the refracted angle between 30 degrees and 60 degrees, usually 45 degrees. The same acoustical compatibility requirements between reference standard material and test material as is required for longitudinal wave standards shall apply to angle beam reference standards.

3.2.7.1 In immersion testing to establish an approximate 45 degree refracted longitudinal angle in titanium, a 10 degree incident angle shall be used.

3.2.7.2 In immersion testing to establish an approximate 45 degree refracted shear angle in titanium, a 20 degree incident angle shall be used.

3.2.7.3 For contact testing, the refracted angle in the part is determined by the angle of the wedge or shoe that is used between the transducer and the part being tested.

#### 3.2.7.4 Shear Wave Ultrasonic References (Angle Beam)

May be of several distinct types as follows; because of the variety of types and sizes of acceptable shear wave reference standards, the shear wave standard(s) to be used shall be acceptable to purchaser:

3.2.7.4.1 Flat-bottom holes drilled at approximately 45 degrees to the entry surface may be used to test flat surfaces when performing 45 degree angle inspection (see Figures 2A and 2B). For any angle beam inspection, flat bottom holes shall be drilled such that the hole axis is parallel to the resulting ultrasonic sound beam shear angle and the flat bottom reflector is perpendicular to the sound beam.

3.2.7.4.2 For testing cylinders, flat-bottom holes drilled in the center of the wall and perpendicular to the radius of the cylinder may be used. Figures 3 and 4 illustrate two types of construction.

3.2.7.4.3 Side-drilled holes (SDH) may be used for shear wave standardization for both flat and curved entry surfaces. See Figure 5 that provides suggested side-drilled holes based on equivalency to FBH sizes associated with Table 8 Ultrasonic Quality classes for Grade 1 or non-premium material. Comparisons of SDH to FBH sensitivity should include consideration of the actual beam diameter intercepting the SDH. For example, if the beam diameter is only 0.25 inch (6.4 mm), then the sensitivity would be approximately equivalent to a #3 FBH even if the SDH is 0.5 inch (12.7 mm) long.

3.2.7.4.4 Various styles of notches may be used; these include V-notches, usually with a 60 degree included angle, square, or "U" bottomed notches, and slots. The sizes of the notches are generally equated to the test area thickness (typically, 1 inch (25.4 mm) maximum length x 3% of the part thickness) or the notch area is equated to a flat-bottom hole area; as an example, a 5/64 inch (2.0 mm) FBH has an area of 0.0047 square inch (3.03 mm<sup>2</sup>) and a slot with a depth of 0.050 inch (1.27 mm) and a length of 0.10 inch (2.5 mm) has an area of 0.005 square inch (3.2 mm<sup>2</sup>); therefore, the notch and FBH are approximately equal.

### 3.3 Surface Preparation

3.3.1 The surfaces to be inspected shall be common geometrical sections such as round, square, and octagonal. Flat-face product shall be prepared to ensure flatness of the various faces.

3.3.2 Texture of surfaces to be inspected shall be not rougher than 250 microinches (6 µm). For longitudinal mode tests to Class AA or A1 requirements and for shear mode tests, surface texture of approximately 125 microinches (3 µm) is desirable. Surface texture is defined in ANSI B46.1.

3.3.3 Surface discontinuities remaining after surface preparation shall not be removed before ultrasonic inspection because local grinding depressions will cause sonic wave attenuation, loss of back reflection, and inability to locally meet standards. Surfaces shall be free from loose scale, machining or grinding particles, oil, grease, cutting compounds, and other foreign material.

### 3.4 Standardization of Apparatus

Before inspecting the product, the apparatus shall be adjusted, using appropriate reference blocks, to produce, from the simulated imperfections, 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 signal height shall be not less than 20%, the maximum signal height shall be not greater than 80% of the vertical limit or the upper linearity limit, whichever is less.

3.4.1 Instruments using solid state electronic components shall be warmed up for not less than 10 minutes before being used. Sufficient time shall also be allowed for temperature of water, reference blocks, and product to stabilize before standardization and testing.

### 3.4.2 System Performance Check

In order to check test system performance characteristics, verification of systems with respect to sensitivity shall be performed prior to and immediately after each inspection and after any changes in instrument settings, or instrument modules, and at 2 hour intervals during continuous operation. The 2 hour interval may be extended up to 8 hours with documented stability of the system performance. If a system performance check is found to be unacceptably low, the test items examined since the previous acceptable system performance check shall be re-examined. If sensitivity has been found to increase, indications found during the interim may be re-examined. During the system performance checks, sensitivity shall be adjusted to reference level when found to be lower than the reference level.

### 3.5 General Scanning Procedure

3.5.1 Standardization for determination of loss in the back reflection pattern shall be performed on parallel surfaces of the product being inspected. For round product, parallel sides consist of the entry surface and 180 degrees from the entry surface. The back reflection pattern from the full material thickness section of the test block at the scanning sensitivity shall be observed. If the back reflection pattern from the product being tested averages a variation of more than -50% from that recorded from the test block, testing shall be stopped until corrective action is taken.

3.5.2 Permissible background noise for angle beam testing shall not exceed 50% of the response height from the reference standard made as in 3.2.7.

3.5.3 Permissible background noise for longitudinal beam testing is dependent on the method used for measurement of the effective beam width and cannot exceed 75% of the response height from the reference standard made as in 3.2.6. When background noise levels are greater than 50% of the response height from the reference standard made as in 3.2.6 an alarm system or recorder shall be used. Alarm level shall be set to ensure noise levels do not exceed the value recorded by the inspection source.

3.5.3.1 When background noise is less than or equal to 50% of the response height from the reference standard made as in 3.2.6, measure the effective beam width transverse to the direction of scanning by determining the total traverse distance at the appropriate gain settings across all FBHs in the test block(s) used for setup through which not less than 50% signal amplitude is displayed.

3.5.3.2 When background noise levels exceed 50% but are less than or equal to 75% of the response height from the reference standard made as in 3.2.6, measure the effective beam width by determining the total traverse distance at the appropriate gain settings across all FBHs in the test block(s) used for setup through which not less than a signal amplitude equal to the alarm level is displayed.

3.5.4 Whenever an alarm system is used the gated region of the screen shall include the depth range equal to at least the minimum and maximum FBH test metal distances.

3.5.5 Whenever possible, a dynamic alarm check shall be made to determine the operational scanning speeds, pulse repetition rates, and index increments, and to ensure that the alarm system or recording system is capable of detecting all rejectable defects at these operating conditions. A successful dynamic alarm check is achieved when the reference standard reflector with the smallest effective beam width is detected a minimum of two times on consecutive indexes during scanning of the reference standard at the operating scanning speed.

- 3.5.6 If a dynamic alarm check cannot be made or if alarms cannot be used scan speed and pulse repetition rate shall be controlled for automated scanning. Actual scan speed shall not exceed the scan speed as determined in both 3.5.6.2.1 and 3.5.6.2.2.
- 3.5.6.1 For manual scanning without alarm systems, a scanning speed not greater than 5.0 inches (127 mm) per second is recommended.
- 3.5.6.2 Determine the maximum scanning speed (S), using Equations 1 and 2, based on smallest effective beam width (EBW) as determined in 3.5.3.1 or 3.5.3.2, the pulse repetition rate (PRR), the number of times the reference standard FBH with the smallest effective beam width is to be detected (N), and the monitor count function (C). Note (N) is equal to a minimum of 2.
- 3.5.6.2.1 The monitor count function is a control available in some instruments that allows the user to set up the number of alarm pulses that must be present before an alarm circuit provides a positive alarm output. For instruments that do not have this control, C = 1.

$$S = \frac{(EBW \times PRR)}{(N \times C)} \quad (\text{Eq. 1})$$

Equation 1: Determination of Maximum Scanning Speed based on effective beam width measured transverse to the direction of scanning.

- 3.5.6.2.2 Measure the EBW in the scan direction on all FBHs used for setup. Determine the maximum scanning speed (S) based on the pulse repetition rate (PRR) and EBW as measured in the scan direction (EBWS).

$$S = EBWS \times PRR \quad (\text{Eq. 2})$$

Equation 2: Determination of Maximum Scanning Speed based on EBW as measured in the scan direction.

- 3.5.7 When an alarm system is used without a recording system, the alarm system shall be set at the equivalent of "Hold" or "Manual Reset" or "Stop on Defect." Special situations exist, such as when bar ends are being inspected in a stuffing box tank that require the equipment to be run without the alarm set at "Hold" or "Manual Reset" or "Stop on Defect." In these situations, a manual override may be used. In any situation where the alarm level is not set at the equivalent of "Hold" or "Manual Reset" or "Stop on Defect" it is required that the operator be aware of and react properly to all alarm conditions.
- 3.5.8 The instrument control settings and test parameters established during standardization shall not be changed during testing of the product. The pulse length and reject control shall be set at the minimum that will afford the proper resolution without affecting acceptable linearity.

### 3.5.9 Distance Amplitude Correction

Electronic distance amplitude correction is recommended; however, distance amplitude curves plotted on the instrument display using distance amplitude blocks may be used if the minimum signal height complies with 3.4. Testing using the highest sensitivity from the distance amplitude blocks and evaluating to the proper metal travels is also permitted provided noise levels do not obscure required information.

- 3.5.10 Zone testing may be used with separate standardizations and/or transducers for each zone. When performing zone testing there must be one common FBH that is used in the setup for both zones and gates must extend a minimum of 1/4 inch into the other zone.

### 3.6 Immersion Testing

#### 3.6.1 Longitudinal (Straight) Beam Testing

The sound beam entry angle shall be adjusted until the sound beam is perpendicular to the test surface. Where appropriate, the maximum signal amplitude from the entry surface may be used to determine this condition. Where not appropriate (e.g., a highly-focused search unit), an alternate procedure such as multiple reflections may be used. During testing, the angle established shall not vary more than  $\pm 2$  degrees.

#### 3.6.2 Angle Beam Testing

Products may be inspected with both longitudinal and shear wave motions at preselected angles. Once established, the surface entry angle shall not vary more than  $\pm 2$  degrees.

#### 3.6.3 Water Travel

The water travel distance shall be the optimum for the transducer and the metal travels encountered during testing. The water travel distance for testing shall be within  $\pm 0.25$  inch ( $\pm 6.4$  mm) of that used for standardization.

### 3.7 Contact Testing

#### 3.7.1 Straight Beam Testing

Visual inspection of the search unit shall be made to verify that the wear face surface is intact. Periodic visual inspections shall be made during tests to ensure that the search unit facing has not degraded. Any cracking, chipping, break-up, or uneven wear conditions shall disqualify the search unit and the test.

#### 3.7.2 Angle Beam Testing

Angle beam entry and testing mode shall be established as part of the test procedure.

#### 3.7.3 Indexing

Indexing increments used in scanning a product shall be not greater than 70% of the effective beam width, determined in accordance with 3.5.3.1 or 3.5.3.2. When practical, transducer indexing shall be controlled by a mechanical system.

### 3.8 Surface Area of Product to be Scanned

Surface area of product to be scanned is described as follows in Tables 5, 6, and 7 and accompanying notes.

**Table 5 - Round bar and billet**

| Diameter | Surface Area To Be Scanned |
|----------|----------------------------|
| All      | The entire circumference   |

**Table 6 - Flat-faced material <sup>(1)</sup>**

| Thickness                          | Surface Area To Be Scanned                                        |
|------------------------------------|-------------------------------------------------------------------|
| <2 inches (51 mm)                  | 100% of one wide side                                             |
| 2 to 5 inches (51 to 127 mm)       | Adjacent faces representing 50% of the periphery <sup>(2)</sup>   |
| Over 5 to 9 inches (127 to 229 mm) | All four sides, representing 100% of the periphery <sup>(3)</sup> |
| Over 9 inches (229 mm)             | All four sides, representing 100% of the periphery <sup>(4)</sup> |

<sup>(1)</sup> Alternate tests of rectangular product are allowed as follows. Single-face or opposite-face tests of all flat-faced rectangular product may be made by shear or refracted longitudinal wave testing in the transverse direction, with the transducer angled toward the edges substituted for the adjacent face test. If inspection half way through the width is not practical, such as in the case of a high ratio width to thickness rectangle, an alternate method of inspecting through both sides of the width, is permitted. The test through the width shall extend to a depth equal to or deeper than the test through the thickness.

<sup>(2)</sup> If material noise does not permit set up on the T minus 1/4 inch (T minus 6.4 mm) TMD FBH as in Table 3, then inspection through the opposite side is required.

<sup>(3)</sup> If material noise permits set up on the T minus 1/2 inch (T minus 12.7 mm) TMD FBH as in Table 3, then inspection through the opposite side is not required.

<sup>(4)</sup> If material noise permits set up on the T minus 3/4 inch (T minus 19 mm) TMD FBH as in Table 3, then inspection through the opposite side is not required.

**Table 7 - Plate material <sup>(1)</sup>**

| Thickness                         | Surface Area To Be Scanned           |
|-----------------------------------|--------------------------------------|
| 0.25 to 5 inches (6.35 to 127 mm) | 100% of one wide side <sup>(2)</sup> |

<sup>(1)</sup> The instructions above only apply to material that is certified as plate, in accordance with a plate material specification in the same contract specifying AMS2631.

<sup>(2)</sup> For sizes over 2 inches (51 mm) thick, if material noise does not permit set up on the T minus 1/4 inch (T minus 6.4 mm) TMD FBH as in Table 4, then inspection through the opposite side is required.

#### 4. QUALITY ASSURANCE PROVISIONS

##### 4.1 Acceptance Classes

4.1.1 Four classes of ultrasonic quality for longitudinal wave inspection are defined in Table 8. Drawings, quality control specifications, or purchase orders will specify the applicable class. Melting parameters and grade designations are defined in AMS2380. Material that is inspected and meets UT requirements of a class with a FBH size smaller than other classes also meets the requirements of those classes. For example, a material meeting requirements of Class AA also meets requirements of Class A1, A and B, a material meeting requirements of Class A1 also meets requirements of Class A and B, a material meeting requirements of Class B only meets requirements of Class B.

**Table 8 - Ultrasonic quality classes**

| Ultrasonic Classification | Single Discontinuity Hole Size No. <sup>(1)</sup> | Single Discontinuity Hole Size No. <sup>(1)</sup> |
|---------------------------|---------------------------------------------------|---------------------------------------------------|
|                           | Grade 1 or Non-Premium Material                   | Grades 2, 3, 4                                    |
| AA                        | 2                                                 | 2                                                 |
| A1                        | 3                                                 | 3                                                 |
| A                         | 5                                                 | 4                                                 |
| B                         | 8                                                 | 6                                                 |

<sup>(1)</sup> Diameter, in 64ths of an inch, of a flat-bottom hole (FBH) in the reference standard (1/64 inch = 0.4 mm).

4.1.1.1 All indications 75% or greater than the rejection level for each class shall be explored and evaluated.

4.1.1.2 Any discontinuity with an indication greater than the response from a reference flat-bottom hole at the estimated discontinuity depth of the size given is not acceptable.

4.1.1.3 Loss of unsaturated back reflection pattern greater than 50%, when compared with non-defective material in the same, similar, or like product, is not acceptable when this loss of back reflection pattern is accompanied by any increase in signal, at least double the normal background noise signal, between the front and back surfaces.

4.1.1.4 Noise levels exceeding the limits of 3.5.2 and 3.5.3 are not acceptable.

4.1.2 Acceptance standards for angle beam inspection shall be equal to 100% of the response height from the reference standard selected as in 3.2.7, or as agreed to by the purchaser.

#### 4.2 Disposition

4.2.1 Product exhibiting evaluated indications not in excess of established standards may be accepted without remedial operations.

4.2.2 Product exhibiting evaluated indications in excess of established standards but in a location which will be removed during manufacturing operations may be approved by authorized personnel for acceptance. Information on the evaluated indication shall be reported to the purchaser when the manufacturing source providing subsequent removal of the evaluated indication is not part of the same organization as the inspection source. Information on the evaluated indication shall be reported to the purchaser in all situations when a contract laboratory performs the inspection.

4.2.3 Product containing discontinuities in excess of established standards and not covered by 4.2.2 shall be rejected.

#### 4.3 Records

The testing source shall prepare and maintain on file, for the time specified by purchaser, records of the requirements and techniques for each size and configuration of product. When requested by purchaser, these records shall be made available for inspection.

#### 4.4 Reports

The inspection source shall document equipment used, set-up parameters, results of inspection, and personnel performing inspection on a report. The report shall provide enough detail such that a duplication of the original setup can be accomplished.

### 5. PREPARATION FOR DELIVERY

Not applicable.

### 6. ACKNOWLEDGMENT

An inspection source shall mention this specification number, its revision letter and the Ultrasonic Quality Class (see Table 8) in all quotations and when acknowledging purchase orders.

### 7. REJECTIONS

Product inspected in accordance with this specification and not meeting specified requirements, or modifications authorized by purchaser, will be subject to rejection.

### 8. NOTES

#### 8.1 Revision Indicator

A change bar (I) 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 Test Conditions

It is essential that thorough understanding be developed between purchaser and inspection source regarding interpretation of the results of inspection and how they shall be recorded and reported. Ultrasonic testing is so comprehensive that it is necessary that all interested parties fully recognize that indications may appear which do not reflect conditions detrimental to use of the product. Agreement between purchaser and inspection source should be established in advance on the following:

Surface finish  
Internal structure  
Location and extent of areas to be scanned  
Size of transducer and type of search unit  
Test frequency  
Type and grade of couplant  
Method of standardization of equipment

8.3 Local grinding depressions will cause sonic wave attenuation, loss of back reflection, and inability to locally meet standards.

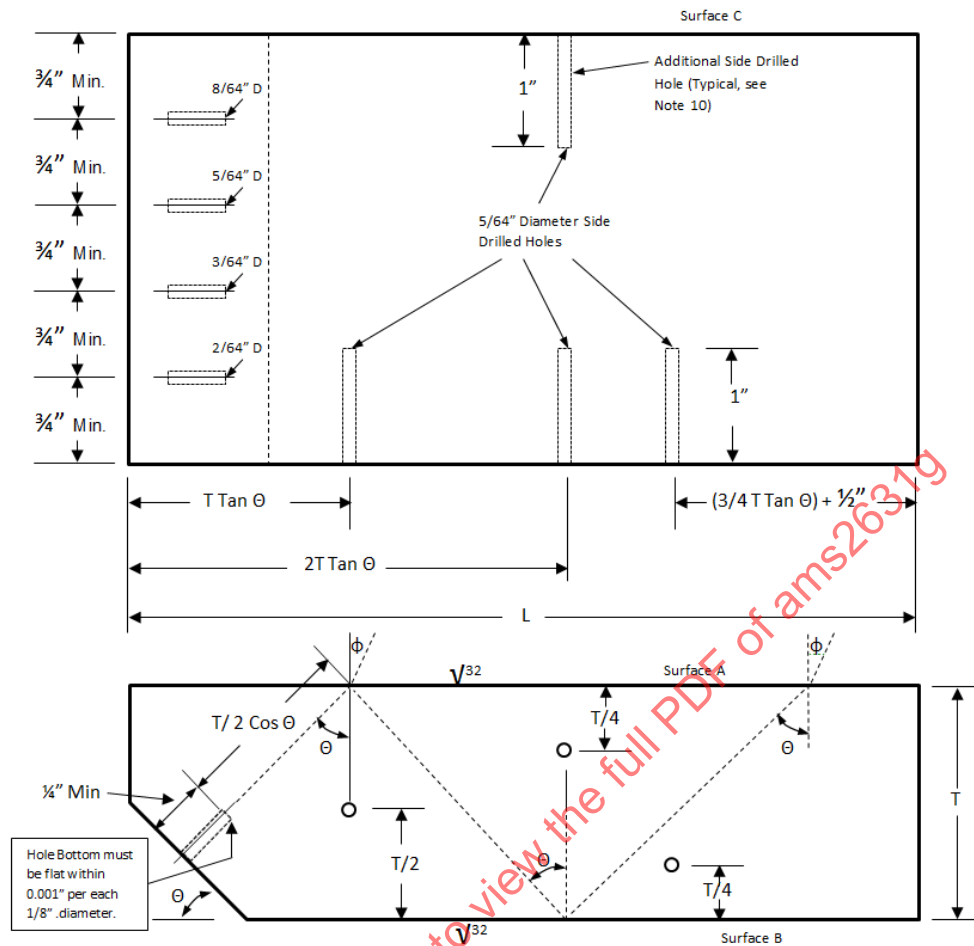
8.4 Terms used in AMS are clarified in ARP1917.

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.

| To FBH Diameter |      | 1/64 | 2/64 | 3/64 | 4/64 | 5/64 | 6/64 | 8/64 |
|-----------------|------|------|------|------|------|------|------|------|
|                 | 1/64 | 0    | +12  | +20  | +24  | +28  | +31  | +36  |
|                 | 2/64 | -12  | 0    | +7   | +12  | +16  | +19  | +24  |
|                 | 3/64 | -20  | -7   | 0    | +5   | +9   | +12  | +17  |
|                 | 4/64 | -24  | -12  | -5   | 0    | +4   | +7   | +12  |
|                 | 5/64 | -28  | -16  | -9   | -4   | 0    | +3   | +8   |
|                 | 6/64 | -31  | -19  | -12  | -7   | -3   | 0    | +5   |
|                 | 8/64 | -36  | -24  | -17  | -12  | -8   | -5   | 0    |

dB change -  $\text{dB} = 20 \cdot \log(A1/A2)$  where A1 and A2 are the areas of the respective FBHs.

**Figure 1 - dB conversion for FBH size**



NOTE: All dimensions are in inches unless otherwise stated.

| Thickness (t), of Part of Material to be Tested | T<br>t = Part Thickness | L<br>Minimum (inches) |
|-------------------------------------------------|-------------------------|-----------------------|
| Up to and including 1 inch                      | 3/4 inches or t         | (3 T Tan Θ + 1)       |
| Over 1 to 2 inches                              | 1 - 1/2 inches or t     |                       |
| Over 2 to 4 inches                              | 3 inches or t           |                       |
| Over 4 to 6 inches                              | 5 inches or t           |                       |
| Over 6 inches                                   | t + 1 inches            |                       |

- (1) A block fabricated with flat-bottom holes with diameters as shown will cover all classes in this practice. A narrower block with fewer holes may be used if the block is to be used for a fewer number of classes.
- (2) Side-drilled holes shall not be used for T less than 3/4 inch.
- (3) A shorter block than shown may be used for thicker materials when only 1/2 or 1 vee-path examining distance is to be used. For shorter reference blocks the side-drilled holes shall be relocated along L so that each hole lies at least 3/4 inch from all sound beam paths used for the other holes.
- (4) D = hole diameter for applicable class.
- (5) Θ is the nominal angle ±2 degrees of the sound beam in the part with respect to the normal to the sound entry surface.
- (6) φ is the angle of the entering sound beam with respect to the normal to the sound entry surface.
- (7) All dimensions are in inches.
- (8) All dimensions ±0.03 inch except for hole diameters which are ±3% of diameter specified.
- (9) Surface A and Surface B must be flat and within 0.001 inch per inch.
- (10) For blocks thicker than one inch, additional 5/64-inch diameter side-drilled holes shall be drilled from Surface C with the axes of these holes located 1/4 inch, 1/2 inch, 1 inch, 1-1/2 inch, 2 inches, etc., from surface A until the T/4 distance is reached. No specific location along L is required for these holes except that they shall be located at least 3/4 inch from the sound beam paths used for the flat bottom hole and at least 3/8 inch from sound beam paths used for other side-drilled holes.
- (11) All holes shall be permanently plugged in a manner to ensure that they are water-tight and that an air-metal interface is preserved.

**Figure 2A - Standard ultrasonic test block for angle beam examination, inch/pound units**