SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2630B

Issued 1960-06
Revised 1995-03
Reaffirmed 2008-10

Superseding AMS 2630A

Inspection, Ultrasonic
Product Over 0.5 Inch (12.7 mm) Thick

1. SCOPE:

1.1 Purpose:

This specification covers procedures for ultrasonic inspection, by pulse-echo procedures, of flat, rectangular, round, cylindrical, and contoured products having a thickness or cross-sectional dimension greater than 0.50 inch (12.7 mm), using either contact or immersion methods, and using the longitudinal-wave or shear-wave modes or combinations of the two, as necessary. This specification may apply to testing finished machined parts provided the parts can meet the basic testability requirements, such as size, contour, metallurgical structure, and thickness.

1.2 Parts with section thickness both over 0.50 inch (12.7 mm) and 0.5 inch (12.7 mm) and under may be tested using this procedure and AMS 2632, as applicable.

1.3 Application:

This procedure 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 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.

AMS 2632	Inspection, Ultrasonic, of Thin Materials, 0.5 Inch (12.7 mm) and Under Cross-Sectional Thickness
SAE J300	Crankcase Oil Viscosity Classification

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS2630B

2.2 ASTM Publications:

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

ASTM E 127 Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks
ASTM E 317 Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Systems Without the Use of Electronic Measurement Instruments
ASTM E 428 Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Inspection
ASTM E 1065 Evaluating Characteristics of Ultrasonic Search Units

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

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 on 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 of the inspected product. Ultrasonic test facility equipment shall include, but not be limited to, the basic ultrasonic test instrument, search units (transducers), appropriate ultrasonic references, couplant materials, fixtures, reference specifications, and immersion tanks where applicable. Reference specifications and documentation necessary to verify the qualification of equipment and test personnel shall be available upon request.

3.2 Ultrasonic Test System:

3.2.1 Basic Ultrasonic Test Instrument: Shall be capable of producing, receiving, amplifying, and displaying on a cathode ray tube (CRT) high frequency signals at specific frequencies as required by the test and shall be of a pulse-reflection (echo), pulse-transmission type. The instrument, if required by the test, shall be capable of being adapted with electronic circuitry, such as flaw gates and distance amplitude corrections. A minimum of a 21 signal-to-noise ratio is required unless otherwise agreed upon by purchaser and vendor.

3.2.1.1 Instrument Linearity: The instrument performance characteristics shall be evaluated in accordance with ASTM E 317 except as follows

3.2.1.1.1 The calibration block used for evaluating vertical linearity shall be as shown in Figure 1.

3.2.1.1.2 The vertical linearity plot and the tolerance limits shall be as shown in either Figure 2 or Figure 2A.

3.2.1.1.3 The horizontal linearity check shall be made by plotting signal displacement against known thickness in the range of 1.0 to 5 inches (25.4 to 127 mm) in 1.0 inch (25.4 mm) increments; the allowable difference in thickness between that indicated by the signal displacement and the actual measured thickness shall be within ±3% of the measured thickness of the respective block. Substitute performance checks are permissible when acceptable to purchaser.

3.2.1.2 Instrument Sensitivity: Instrument sensitivity or gain controls shall function so that a given amount or degree of sensitivity can be repeated or returned to with an accuracy of ±10% of the original pip height. If signal attenuators are used, they shall be accurate over the attenuation range and test frequency used so that the attenuation measurement will represent an amplitude ratio within ±10% of the correct value. The decibel (dB) attenuation value may be converted to an amplitude ratio by use of tables with dB versus voltage ratios. Alternately, it may be calculated from the relationship in Equation 1.

$$\text{Amplitude Ratio} = \text{Log}\,\frac{-1}{10}\,\frac{\text{dB}}{20} \qquad \text{(Eq. 1)}$$

3.2.1.3 Voltage Regulation: If fluctuations in line voltage cause variations in the displayed signal amplitude or sweep length of ±5% or greater, a power source voltage regulator shall be used. If fluctuations persist, proper adjustments to instrument or power source shall be made so that the system will operate within the ±5% limits. Battery powered systems are exempt from this requirement but such systems shall not be operated when the power source is below the level to achieve full vertical and horizontal display as viewed on the CRT graticule.

3.2.1.4 Alarm: Test criteria and part configuration determine alarm use feasibility, and must be agreed upon by purchaser and vendor. Audible and/or visual alarms 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 of the CRT and shall be automatically triggered within ±10% of the set level. The sound level produced by the alarm during operation shall be sufficiently above ambient to ensure being heard by the operator.

3.2.2 Ultrasonic Search Units: Ultrasonic search units shall be of a piezoelectric type capable of both transmitting and receiving ultrasonic signals at the specific frequencies required by the test. When used with the ultrasonic test instrument, the search unit shall be capable of transmitting and receiving ultrasonic energy with a spectral distribution that includes the central frequency required for the test. The peak radiated frequency shall be within ±0.5 MHz or ±10%, whichever is greater, of the required frequency. This history of each search unit shall be maintained in an appropriate log and shall include type, style, frequency, serial number, and size. Beam profile checks, both axial and cross section, for immersion units may also be kept if required by purchaser.

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, 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 3/4 inch (9.5 mm through 19.0 mm) are acceptable. Contact units with a maximum area of 1 square inch (6.5 cm^2) with 1/2 inch (12.7 mm) minimum to 1-1/8 inches (28.6 mm) maximum dimensions are acceptable for longitudinal testing, while 1.0 inch x 1.0 inch (25.4 mm x 25.4 mm) or 1.0 inch x 1/2 inch (25.4 mm x 12.7 mm) transducers are acceptable for shear testing. Use of a focused, paint brush, liquid delay, special size, or other special transducer is acceptable when agreed upon by purchaser and vendor.

3.2.2.2 Test Frequencies: The frequency used shall be the highest practical frequency which will provide the penetration and resolution required; frequencies lower than 2.25 MHz when using the longitudinal mode or 1.0 MHz when using a shear mode shall not be used unless acceptable to purchaser.

3.2.2.3 Ultrasonic Beam Profiles for Immersion Units: The following are recommended, simplified (no special equipment required except a 3 mm ball) methods of finding Y_{+0} and distance amplitude curves and beam profiles. Complete performance parameters of ultrasonic transducers using special equipment are presented in ASTM E 1065. 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: A distance amplitude curve of a transducer shall be plotted from measured energy reflected from a flat reflector having dimensions greater than twice the sound beam diameter. The curve shall be plotted through at least the following locations, the near field (Y_{-1}) location, at the far field peak (Y_{+0}) location, and at the 3 and 6 dB locations referenced from the Y_{+0} point in both the near and far field directions. A distance amplitude curve shall be available before the transducer is put into service. The curve may be supplied by the manufacturer or the purchaser may make the curve. Subsequent periodic checks, at least annually, of the transducer shall include a distance amplitude curve which shall agree with the original curve within ±20% for the transducer to be acceptable.

3.2.2.3.2 Cross Section Profile (Beam Symmetry): 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 0.118 inch (3.0 mm) diameter steel ball. Larger diameter balls than those specified in ASTM E 1065 may be used when agreed upon by purchaser and vendor.

3.2.2.4 Contact Test Angle-Beam Search Units: The exit point and exit angle of ultrasonic energy and depth profile of the sound beam shall be established for angle-beam search units. Search units 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 reidentifying the unit to the correct new beam angle. The International Institute of Welding (IIW) ultrasonic reference block or an appropriate substitute may be used to test the exit angle of angle-beam search units.

3.2.3 Couplants: Shall be used for all tests.

3.2.3.1 Immersion Method: Couplants for testing by the immersion method may include any appropriate fluid such as tap water, light oils, ethylene glycol, or alcohol. Such fluids may contain wetting agents to improve couplant properties or rust inhibitors to reduce influence of the fluid on the product under test. No fluid may be used which stains, etches, or otherwise affects the surface of the product 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 bubblers, collimators, squirters, ultrasonic wheels, and immersion tanks.

3.2.3.2 Contact Method: Couplants for testing by the contact method shall not be injurious to the product being tested. Couplant materials include any appropriate fluid such as water, light oils, low-viscosity greases, and penetrant emulsifiers. Rubber-like wear membranes may be used between the search unit and the test part to prevent excessive search unit wear provided such use is approved by purchaser. As surface roughness influences the sound energy, couplant viscosity may be varied as a function of surface roughness. Table 1 provides a guide for selection of direct contact couplant materials; other couplants of similar viscosity may be used. The contact technique is defined to include direct contact of a search unit with the test surface, use of contour surface wearshoes, and thin-film couplant techniques such as the pressurized fluid (water gap) system.

TABLE 1 - Couplant Materials

Approximate Surface Roughness (ANSI B46.1)	Couplant (SAE J300)
5 to 100 RHR (0.1 to 2.5 mm)	SAE 10 Motor Oil
50 to 125 RHR (1.2 to 3.2 mm)	SAE 20 Motor Oil
100 to 200 RHR (2.5 to 5.1 mm)	SAE 30 Motor Oil

3.2.4 Ultrasonic Standards: Ultrasonic standards are required for all inspections. Calibration standards establish the performance of the inspection system. Reference standards interrelate the test results with reference reflectors. It is mandatory that the materials used for fabrication of ultrasonic references have ultrasonic properties similar to those of 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 ±25% from those of the product or part to be tested.

3.2.4.2 Entry Surfaces: The configuration (surface roughness, flatness, or of the ultrasonic reference should approximate that of the product or part to be tested. Requirements for a curved reference depend on type of test, direction of test, and size of search unit.

3.2.4.3 Longitudinal Wave Ultrasonic Reference (Straight Beam): The procedures established under ASTM E 127 and ASTM E 428 are recommended for manufacturing ultrasonic reference blocks for straight beam testing; these specifications describe the manufacture of flat-bottom holes (FBH) in aluminum alloys and steels, but the same procedures may be used to manufacture references from other materials. The entry surface may be square or round with minimum dimensions of 2 inches (50.8 mm) square or 2 inches (50.8 mm) diameter. For blocks over 6 inches (152.4 mm) metal travel, a minimum entry surface of 3 inches (76.2 mm) square or diameter is recommended. Step-type blocks may also be used provided the entry surface area for each step is in agreement with that recommended for individual blocks. The flat-bottom hole (FBH) opening shall be plugged either as recommended in ASTM E 127 and ASTM E 428 or with a water insoluble wax or similar material. Calibration standards shall be dimensioned and have surface finishes as recommended by ASTM E 127 or ASTM E 428.

3.2.4.4 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 calibration standards, the shear wave standard(s) to be used shall be acceptable to purchaser

3.2.4.4.1 Flat-bottom holes drilled at approximately 45 degrees to the entry surface shall be used to test flat surfaces (See Figure 3).

3.2.4.4.2 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 4 and 5 illustrate two types of construction.

3.2.4.4.3 Side-drilled holes shall be used for shear wave calibration for both flat and curved entry surfaces. A 0.020 inch (0.51 mm) side-drilled hole 0.25 inch (6.4 mm) long is approximately equivalent to a #3 (1.2 mm diameter) FBH, while the same diameter side-drilled hole 0.50 inch (12.7 mm) long is roughly equivalent to a #5 (2.0 mm diameter) FBH (See Figure 6).

3.2.4.4.4 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^2) 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^2); therefore the notch and FBH are approximately equal.

3.2.4.5 Ultrasonic References for Inspection of Curved Surfaces: Use of reference blocks with curved entry surfaces shall be required. Generally, curved entry surfaces with radii of 5 inches (127 mm) or greater may be tested using either flat entry surface standards, or curved standards with the curvature ±10% of that of the part being tested. For test surfaces with radii between 2 and 5 inches (50.8 and 127 mm), a reference standard with a 3-inch (76.2-mm) radius may be used. For test surfaces with radii up to 2 inches (50.8 mm), a reference standard with a 1 inch (25.4-mm) radius may be used.

3.2.4.6 Special Ultrasonic References: Where the part geometry dictates the need for using the actual part or part replica as an ultrasonic reference, all simulated defects shall be machined in accordance with the practices specified for longitudinal and shear wave inspection. Ultrasonic references made from actual parts or part replicas are recommended wherever practical.

3.3 Surface Preparation:

Visual examination shall be performed on each part to ensure that sound beam entry surfaces are free from loose scale, oxides, oil, grease, machining or grinding particles, excessive machining or grinding marks, and other surface conditions that could interfere with the sound beam and affect the test. Surface textures for machined parts shall be determined in accordance with ANSI B46.1. Surfaces to be inspected shall be not rougher than 63 microinches (1.6 µm) for Class AA. Classes A1 and A longitudinal wave tests and most shear wave tests require surfaces no rougher than 125 microinches (3.2 µm). A surface texture up to 250 microinches (6.35 µm) is acceptable for testing to Class B. Surface textures for testing to Class C become part of the Class "C" agreement. Unmachined part surfaces should have a texture approximately equivalent to that of machined surfaces as required for each class. When permitted by purchaser, inspections may be made on surfaces that are rougher than those specified herein, provided that the ultrasonic reference standards have a comparable surface finish. Sound beam exit surface (back face) requirements vary greatly, dependent on the tests performed. Some tests require back reflection surfaces to meet conditions similar to those required for the entry surfaces while on other types of parts, particularly fabrications and castings, it may be impractical to change the surface quality and in some cases it may even be impossible to examine the exit surface.

3.4 Testing Procedure:

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

3.4.2 Documentation: Shall provide for the complete inspection procedure for each product (size, shape, and alloy) or part to be inspected. Documentation format is flexible, but sketches, photographs, and graphics are recommended wherever practical. Because of the variety and complexity of tests that can be performed, the documentation of the inspection plan and the methods of recording and interpreting results become very important. This specification is not intended to restrict documentation beyond that which provides valid and reproducible quality control tests. As a minimum, the procedure shall specify

3.4.2.1 Specific product or specific part number (where applicable), stage of fabrication, surface condition, and configuration of the product to be tested.:

3.4.2.2 Manufacturer and model numbers of instrumentation modules, recording equipment if used, fixturing, tanks, manipulators, and coupling means used in the test.

3.4.2.3 The type of ultrasonic references used to calibrate equipment and the calibration procedure.

3.4.2.4 Testing plan, including the recording procedures, scanning plan, sensitivity, method of interpreting results, and relationship to ultrasonic references.

3.4.3 Testing System:

3.4.3.1 The product or part may be inspected by longitudinal or shear wave techniques or a combination of techniques as will most appropriately disclose material imperfections.

3.4.3.2 All equipment used for the tests, such as ultrasonic test instrument, ultrasonic search units, ultrasonic references, recording system, and electronic gates, shall be assembled in one location and evaluated as a complete system. Once assembled, they shall remain together as part of the test equipment until the tests are completed. Any substitution of electronic gates, displays, search units, and other similar equipment for any reason shall require recalibration of the complete system.

3.4.4 Qualification Calibration of Test System: Before inspecting any product or part, the test system shall be qualified by adjusting the sensitivity, pulse duration, damping, or other external controls so that the signals reflected from known discontinuities in appropriate ultrasonic references can be clearly identified as separate and discrete indications. During initial calibration, signal amplitude (sensitivity) from a known reference discontinuity may be set within the range of 20 to 90% of the vertical height of the CRT screen. Sensitivity may be increased during test by a predetermined dB level to ensure an adequate test; however, when interpreting results, the sensitivity shall be returned to the original setting.

3.4.4.1 Calibration Record: When permanent records, such as wet or dry paper, x-y recorders, or digital computer, are established as part of the test plan, calibration of the test system shall include a record of the appropriate ultrasonic reference reflector.

3.4.4.2 Calibration Check: To ensure valid results, a calibration check shall be made prior to the test of each part configuration or start of each shift of operation and at the completion of each test or shift, as appropriate. Any change in equipment operation that requires a recalibration of the test system shall require retesting of all product or parts tested since the previous calibration.

3.4.5 Immersion Inspection:

3.4.5.1 Immersion Fluid: Shall be as specified in 3.2.3.1.

3.4.5.2 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 ±2 degrees. When contoured parts are being inspected, a surface or contour follower may be employed so that the surface entry angle is maintained perpendicular within ±2 degrees.

3.4.5.3 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 ±2 degrees.

3.4.5.4 Water Path: When practicable, the test shall be calibrated and run using water paths that result in inspection being performed in the far field. Valid tests may be performed in both the Fresnel (near) and Fraunhofer (far) field zones. A variety of sound beams, ranging from collimated to highly-focused, may be used. Special interpretation of test results may be necessary to characterize the discontinuity. A variety of test zones are possible but changing the test zone by varying the water path during test may present serious complications. During the test, the established water path (i.e, the distance from the face of the search unit to the entry surface) shall not vary more than ±0.25 inch (±6.4 mm) from that used for calibration.

3.4.6 Contact Testing:

3.4.6.1 Angle Beam Testing: The sound beam entry angle and the testing mode shall be established as part of the test procedure. The search unit qualification tests will establish the exit point and angle of exit. If wear of contact shoes or search unit results in a change in sound beam entry angle of more than ±3 degrees from the established angle, that search unit shall be replaced, repaired, or requalified to a new angle in accordance with 3.2.2.4. The wedge or contact shoes shall be examined visually for signs of poor contact between the transducer piezoelectric element and wedge or shoe. At any sign of insufficient coupling, the search unit assembly shall be taken apart, the contact surfaces cleaned, new couplant applied, and the unit reassembled.

3.4.6.2 Straight Beam Testing: Search unit qualification tests shall establish the sound beam character for the straight beam search unit. 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.

3.4.7 Special Testing:

3.4.7.1 Surface Wave: Special attention shall be given to ensuring surface cleanliness before and during a surface wave test. Every precaution shall be exercised to remove excess couplant, foreign material, and other matter that could influence the test.

3.4.7.2 Dual Search Units: For high-resolution, near-zone testing, dual search unit techniques may be used. The qualification for dual search unit shall be the same as for contact testing. If wear of the search unit results in a change in sound beam entry angle greater than ±3 degrees, the search unit shall be removed from service and replaced or repaired.

3.4.8 Distance Amplitude Correction (DAC): Electronic distance amplitude correction is recommended; however, distance amplitude curves plotted on the CRT screen face using distance amplitude calibration blocks may be used if the minimum pip height is not less than 20% and the maximum pip height is not greater than 80% of the vertical limit. For pip heights greater than 80%, the DAC curve is extended parallel to the baseline at a predetermined vertical limit level, usually 80%. Multiple curves shall be established for those areas above the predetermined level to properly evaluate discontinuities in the area. 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.

3.4.9 Electronic Alarm Gating and Recording: Wherever possible and practical, automatic signal alarm circuits shall be used. Automatic recording of test results is a special requirement that should be agreed upon by purchaser and vendor.

3.4.9.1 Electronic Gating:

3.4.9.1.1 Electronic gating may be used for depth and signal recording. Both interface gating and pulse synchronization are applicable. For automatic recording, the gates used shall maintain stable gate positions and gate widths throughout the test. Signal amplitude gates shall record a linear relationship, within ±5% of full scale deflection, between the signal displayed on the CRT and the recorded signal of the electronic gate over the range of 20 to 80% of the vertical amplitude displayed on the CRT.

3.4.9.1.2 At the start of each testing shift, the ultrasonic reference shall be recorded and compared with the acceptance recording. At the completion of the testing shift, a second recording shall be made and compared with the starting recording. Any deviation in excess of ±15% between start and ending recordings shall require the system to be requalified and all parts inspected since the last acceptance recording to be reinspected. For this requirement, testing shifts shall not exceed eight hours.

3.4.9.2 Recording: Recording may be performed by the operator in accordance with good engineering practices. Automatic permanent records may utilize line storage display oscilloscopes, photographs of CRT recordings, chart recorders, facsimile recorders, e.g., dry or wet paper, or other equivalent recording devices. No restriction is placed on the type of recorder used except as limited by the instrument characteristics. Such test parameters as scanning speed, amplifier frequency response, electronic gate response, and recorder response may limit the selection of the permanent recorder to be used. During the selection and qualification of the testing system, the vendor shall provide the purchaser with evidence that the recording system is not the limiting component of the system and that reflections from known discontinuities are reliably and repeatedly portrayed. If the recorder is established as the limiting system component, the scanning and recording speeds shall be reduced to fall within the limitations of the recorder.

3.4.9.3 Scanning Index: In determining the index for 100% coverage, the effective beam diameter (EBD) shall first be measured. Using the assigned calibration standards, proper calibration gains, and water travel, measure the total traversing distance across the calibration blocks through which no less than 50% of the reference response is obtained. This distance will vary for each calibration block, dependent on the metal travel to the test hole. The least of the distances determined is the EBD and determines the maximum scanning index increment. Index increments based on a percentage of the EBD may be used when agreed upon by purchaser and vendor.

3.4.9.4 Scan Speed: Maximum scanning speed shall be determined by readability or recordability of the applicable ultrasonic reference. At the maximum speed used, the reference discontinuities shall be clearly discernible. If distortion related to scanning speed is observed, the scan speed shall be reduced until distortion is eliminated. As a general rule, the maximum scanning speed for automatic scanning with automatic gates, alarms, etc is 20 inches (508 mm) per second and for manual scanning and visual reading of the CRT is 6 inches (1524 mm) per second. Higher scanning speeds may be possible and, when suitably demonstrated, may be used when agreed upon by purchaser and vendor.

3.4.9.5 Gain Settings for Scanning: For automatic scanning inspection, the gain setting as established from the ultrasonic reference shall be used. The alarm shall be set to activate at a signal level equal to 50% of the distance amplitude curve for the material zone being inspected. If electronic distance amplitude correction (DAC) is employed, alarm activation level shall be set at 50% of the displayed signal. For manual scanning which monitors the amplitude of reflections from internal discontinuities, the gain level from the ultrasonic reference shall be established and 6 dB added, provided the added sensitivity does not increase the noise level more than 50% of the recordable indication height; when alarm systems are used with manual scanning, the alarm trigger level is normally set as for automatic scanning and it is not necessary to add extra sensitivity.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Acceptance Classes:

4.1.1 Longitudinal Wave Inspection Using Flat-Bottom Holes (FBH): Five classes of ultrasonic quality are established for longitudinal wave inspection. Table 2 defines these classes for inspections involving flat-bottom hole reflectors in ultrasonic references.

TABLE 2A - Longitudinal Wave Inspection Parameters, Inch/Pound Units

Quality Class	Single Discontinuity FBH Size (1)	Multiple Discontinuities FBH Size (1)	Linear Discontinuity inch, max	Loss of Back Reflection %, max
AA	#3	#1 (2)	#1 response for 0.12	50
A1	#3	#2 (3)	#2 response for 1.00	50
A	#5	#3	#3 response for 1.00	50
B	#8	#5	#5 response for 1.00	50
C	As established by purchaser and vendor for specific part.			

Notes:

1. FBH numbers indicate diameter in multiples of 1/64 inch of FBH in ultrasonic reference.
2. 11% of a #3 FBH is equivalent to a #1 FBH and may be used in place of the response from the #1 FBH.
3. 44% of a #3 FBH is equivalent to a #2 FBH and may be used in place of the response from the #2 FBH.

TABLE 2B - Longitudinal Wave Inspection Parameters, SI Units

Quality Class	Single Discontinuity FBH Size (1)	Multiple Discontinuities FBH Size (1)	Linear Discontinuity mm, max	Loss of Back Reflection %, max
AA	1.2	0.4 (2)	0.4 response for 3.0	50
A1	1.2	0.8 (2)	0.8 response for 25	50
A	2.0	1.2	1.2 response for 25	50
B	3.2	2.0	2.0 response for 25	50
C	As established by purchaser and vendor for specific part.			

Notes:

1. Diameter of flat-bottom hole in millimeters.
2. Percentage equivalents of the 1.2 mm FBH may be used. See Notes 2 and 3 in Table 2A.

4.1.1.1 Any discontinuity with a signal indication greater than allowed for the specific class shall disqualify the part for that class.

4.1.1.2 Multiple discontinuities are defined as two or more indications above the level established for the class that occur within 1 cubic inch (16.4 cm^3).

4.1.1.3 Loss of back surface reflection caused by an internal metallurgical condition showing a signal loss more than 50% of the distance amplitude curve established for the material is not acceptable.

4.1.2 Angle Beam Tests Using Flat-Bottom Holes (FBH): Five classes of ultrasonic quality are established for angle beam inspection, in either shear or longitudinal modes, which involves flat-bottom holes for ultrasonic reference reflectors. Table 3 defines these classes.

TABLE 3A - Angle Beam Ultrasonic Inspection Parameters, Inch/Pound Units

Quality Class	Single Discontinuity FBH Size (1)	Multiple Discontinuities FBH Size	Linear Discontinuity Inch, max
AA	#2	50% of #2 response	50% of #2 response for 0.12
A1	#3	#2	#2 response for 0.25
A	#5	#3	#3 response for 0.50
B	#8	#5	#5 response for 1.00
C	As established by purchaser and vendor for specific part.		

Notes:

1. FBH numbers indicate diameter in multiples of 1/64 inch of FBH in ultrasonic reference.

TABLE 3B - Angle Beam Ultrasonic Inspection Parameters, SI Units

Quality Class	Single Discontinuity FBH Size (1)	Multiple Discontinuities FBH Size	Linear Discontinuity mm, max
AA	0.8	50% of 0.8 FBH response	50% of 0.8 FBH response for 3.0
A1	1.2	0.8 FBH	0.8 FBH response for 6.4
A	2.0	1.2 FBH	1.2 FBH response for 12.7
B	3.2	2.0 FBH	2.0 FBH response for 25.4
C	As established by purchaser and vendor for specific part.		

Notes:

1. Diameter of flat bottom hole in millimeters.

4.1.2.1 Any discontinuity with a signal indication greater than allowed for the specific class shall disqualify the part for that class.

4.1.2.2 Multiple discontinuities are defined as two or more indications above the level established for the class that occur with 1 cubic inch (16.4 cm^3) of inspected surface.

4.1.3 Angle Beam Testing Using Reference Notches: The acceptance classes used to determine quality levels using various types of notches or side-drilled holes shall be as agreed upon by purchaser and vendor.

4.2 Disposition:

4.2.1 Product exhibiting evaluated indications not in excess of limits for its specified quality class may be accepted without remedial operations.

4.2.2 Product exhibiting evaluated indications in excess of limits for its specified quality class, but in a location which will be removed during manufacturing operations, may be approved by the cognizant quality assurance activity for acceptance.

4.2.3 Product containing discontinuities in excess of limits for its specified quality class and not covered by 4.2.2 shall be rejected.

4.3 Records:

4.3.1 General: The testing source shall prepare and maintain on file, for the time specified by purchaser, records of the requirements and techniques for either each size and configuration of product and of each part number or general records covering families of products. These records shall be made available for inspection by purchaser upon request.

4.3.2 Personnel Qualifications: It shall be verified that all inspections are performed by personnel qualified as in 3.1.1. A list of qualified personnel shall be maintained for purchaser's review upon request.

4.3.3 Instrument and System Qualification: It shall be verified that the instrument and system used in the inspection meet the requirements set forth herein.

4.3.4 Search Unit Qualification: Documentation regarding the qualification of search unit performance shall be maintained. Qualification tests shall be related to the time of actual test.

4.3.5 Procedure Verification: Copies of the written testing procedure shall include the type and response of the ultrasonic reference to be used and shall be maintained as part of the documentation. The procedure shall be reviewed periodically by vendor's cognizant supervisor to ensure that inspection is in compliance with this specification.

5. PREPARATION FOR DELIVERY:

Not applicable.

6. ACKNOWLEDGMENT:

A vendor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

7. REJECTIONS:

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

8. NOTES:

8.1 The 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 specification. An (R) symbol to the left of the document title indicates a complete revision of the specification.

8.2 Test Conditions:

It is essential that thorough understanding be developed between purchaser and vendor regarding interpretation of the results of inspection and how they shall be recorded and reported. Ultrasonic indications may appear which do not reflect conditions detrimental to use of the product. Purchaser and vendor should establish agreement on the following parameters prior to acceptance testing

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

8.3 Distance Amplitude Correction:

The following discussion relates to and defines terms and procedures recommended in 3.4.8.

8.3.1 Distance Amplitude (DA) Curve: The ultrasonic sound beam propagated from the search unit will vary in accordance with physical laws. Specific size holes at different depths within the material will reflect proportionately different energies and the display will record a corresponding progression of signal amplitudes. The curve plotted on the CRT is referred to as the distance amplitude (DA) curve.

8.3.2 Distance Amplitude Correction (DAC) Circuitry: To normalize the inherent influence resulting from the distance amplitude curves, electronic circuits known as distance amplitude corrections (DAC) are employed. These electronic circuits provide a variable gain versus depth function which normalizes the distance amplitude curve signals displayed on the CRT to a preselected amplitude.

8.3.3 Applications:

8.3.3.1 DA curves and DAC circuitry may be utilized for straight-beam, angle-beam, and surface-wave tests. A minimum of three points are required to establish a DA curve. When the DA curve is used, the maximum amplitude point on the curve should not exceed 80% and the minimum point should be not less than 20% of the maximum vertical deflection displayed on the CRT. If these limits cannot be maintained, multiple curves should be used to cover the range of material being inspected. Once the DA curve is established for an appropriate set of ultrasonic references, reflections may be recorded as percentages of this curve or the sensitivity may be adjusted to establish a ±dB relationship between the unknown discontinuity and the known reference.

8.3.3.2 For automatic recording systems, use of DAC circuitry is recommended. Care should be exercised to ensure that the DA curve falls within the linear sensitive range of the electronic recording gate; 50% vertical amplitude display is recommended.

8.3.3.3 DA curves are applicable to focused and non-focused search units but are not as accurate for testing in the near field of the search unit.

8.4 Reference Publications:

Nondestructive Testing Handbook, edited by Dr. R. C. McMasters, 1959; Ronald Press, 70 Madison Avenue, New York, NY 10016 (Available from ASNT).

Sonics, by T. F. Hueter and R. H. Bolt, 1955; John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10016.

Ultrasonic Testing of Materials, by J. Krautkramer and H. Krautkramer (Translation of 2nd revised German edition), 1969; Springer-Verlag New York, 175 Fifth Avenue, New York, NY 10010.

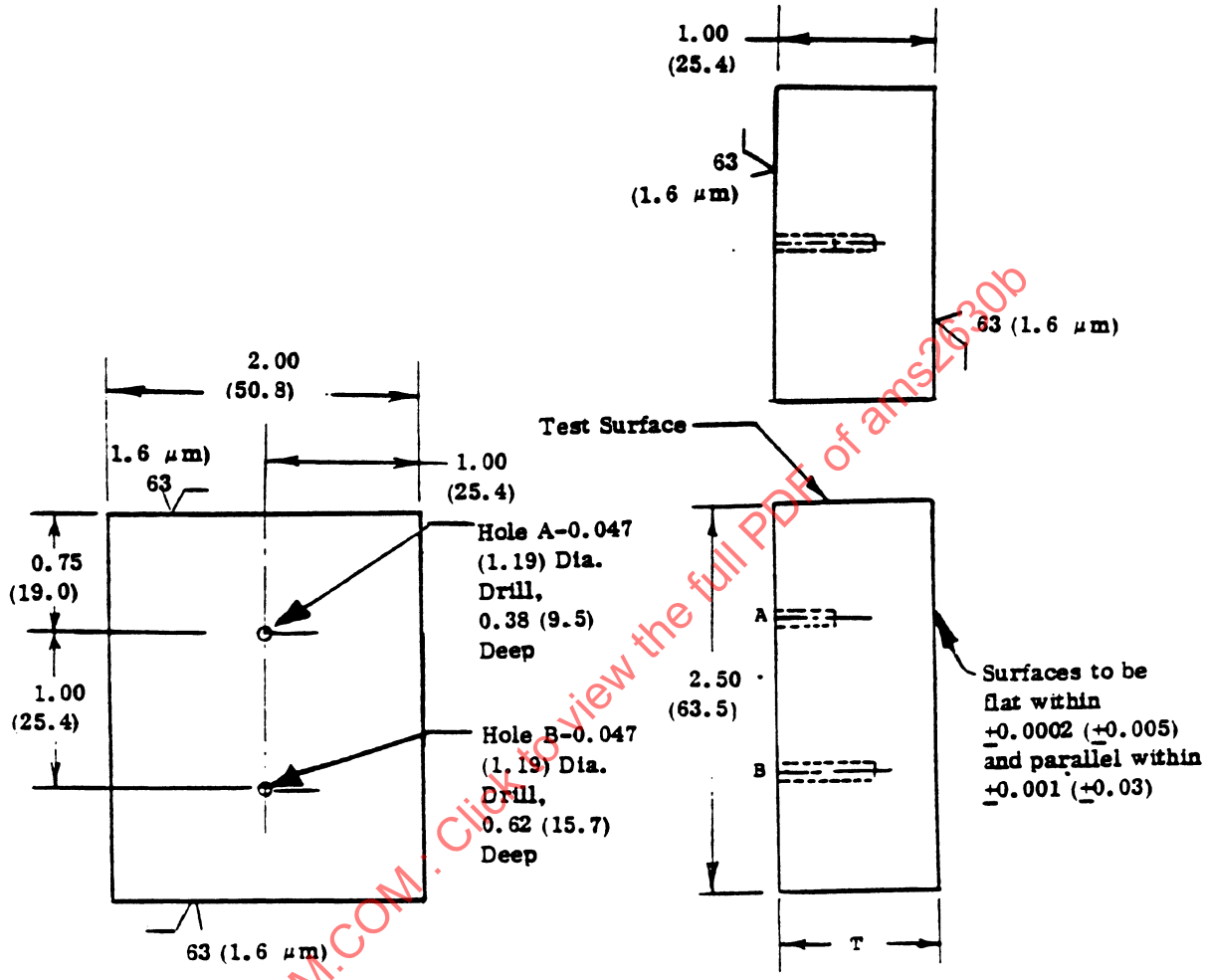
AMS 2631 Ultrasonic Inspection of Titanium Alloys

8.5 Definitions of terms used in AMS are presented in ARP1917.

8.6 Dimensions in inch/pound units are primary; dimensions in SI units are shown as the approximate equivalents of the primary units and are presented only for information.

8.7 Inspection procedures meeting the requirements of this specification have been classified under Federal Standardization Area Symbol “NDTI”.

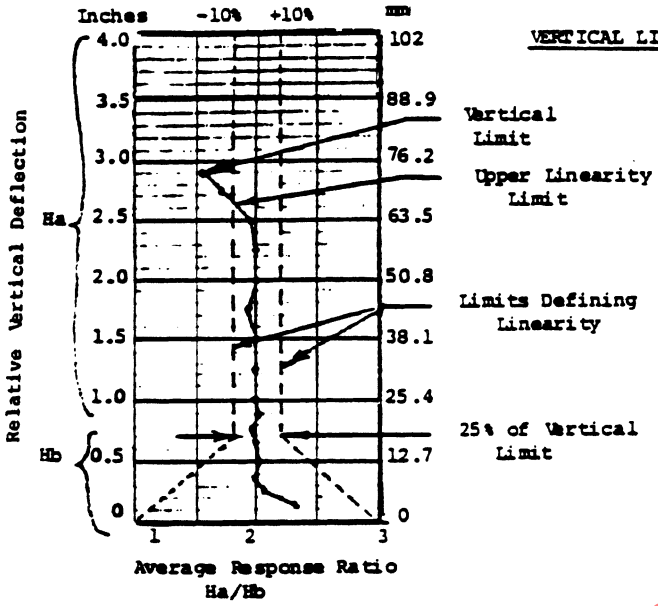
PREPARED UNDER THE JURISDICTION OF AMS COMMITTEE "K"



Note 1. Thickness T may be increased to accommodate larger search units provided the depth of hole A is T/2 and the depth of hole B is T/2 +0.123 (3.2).

Note 2. Dimensions are in inches (millimeters) except as noted.

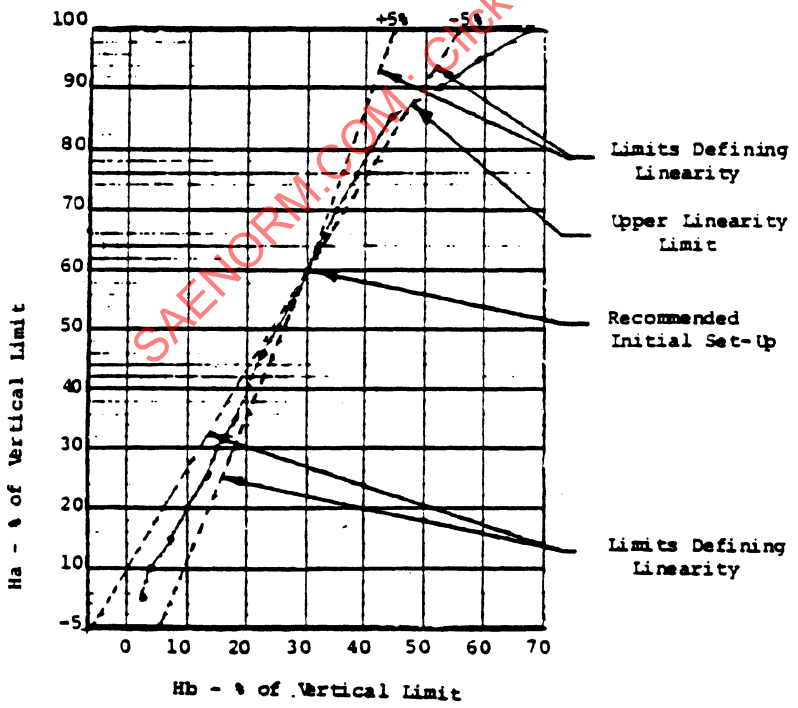
FIGURE 1 - Calibration Block Used for Evaluating Vertical Linearity



Typical plots of ultrasonic responses (Hole B Figure 1) as a function of varying vertical deflection (Hole A Figure 1). Initial set-up: Adjust the instrument sensitivity and position the transducer over the calibration block, Figure 1, so that (1) the signal height (Ha) from Hole A will be at a convenient height between 50 and 70% of the Vertical Limit and (2) the Response Height (Hb) from Hole B will be such that the Ratio of Ha/Hb equals 2.

Adjust controls in steps so that Ha is set at approximately 0.25 inch (6.4 mm) intervals and plot values for Ha against Ha/Hb.

FIGURE 2



Set-up and plotting same as in Figure 2 except all screen heights are converted to % of Vertical Limits and % Ha is plotted against % Hb rather than ratio of Ha/Hb.

Note that limit lines originate at the initial set-up point and will change if the set-up is changed.

The Vertical Limit equals 100%.

FIGURE 2A