SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2632A

Issued 1974-03
Revised 1995-03
Reaffirmed 2008-10

Superseding AMS 2632

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

1. SCOPE:

1.1 Purpose:

This specification covers the procedure for ultrasonic inspection of flat, contoured, and cylindrical products having a cross-sectional thickness of 0.02 to 0.50 inches (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 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 5070 Steel Bars and Forgings, 0.18 - 0.23C (SAE 1022)

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/AMS2632A

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, Caller #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 2004-1707.

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

3. TECHNICAL REQUIREMENTS:

3.1 Qualification:

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

3.1.2 Facilities: Shall be subject to survey and approval by purchaser. The 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, 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 on a cathode ray tube (CRT) 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 megahertz (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 decibels (dB) and shall have a transmit/receive crosstalk separation of at least 40 dB.

3.2.1.1 Instrument Linearity: The instrument vertical and horizontal linearity shall meet or exceed ± 5% as defined in ASTM E 317. Where usable CRT dimensions differ from the 2.5 inches (63.5 mm) vertical dimension or 3.5 inches (88.9 mm) horizontal dimension, ASTM E 317 procedures still apply but in these cases, the graticule display on the CRT screen shall be used to establish the vertical and horizontal dimensions and the instrument shall be proportionately linear in accordance with ASTM E 317 procedures.

3.2.1.2 Instrument Sensitivity: Instrument sensitivity or gain shall be calibrated in decibels and shall be accurate within ±10% of the sensitivity setting, e.g., ±1 dB at 10 dB, or ±6 dB at 60 dB.

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 ±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: Whenever practical, an audible alarm 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 level-adjustable over the display range of the CRT and shall be automatically triggered within ±10% of the level of ultrasonic signal displayed on the CRT. 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 design, controlled as in ASTM E 1065, 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 specified for the test. The peak of the spectral distribution of ultrasonic energy emitted from the search unit shall fall within ±10% of the specified frequency established for the test.

3.2.2.1 Search Unit Dimension and Styles: 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, and pressurized-couplant search unit systems may be used.

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:

3.2.2.3.1 The transmission profile of the search unit shall not deviate more than ±15% of the calculated curve for a search unit of that frequency and dimension. See Figure 1A. The sound beam of the search unit shall be within ±2 degrees axial alignment with the outside housing. Both immersion and contact search units are subject to change with use and age. To ensure appropriate test capability, the history of each search unit shall be maintained in an appropriate log. The history on straight-beam search units shall include the type, style, frequency, serial number, size, and vendor or receiving acceptance ultrasonic profile of the ultrasonic beam transmitted from the search unit.

3.2.2.3.2 The history of a focused search unit shall include both an axial profile and a cross-sectional profile which establish the focal spot size (dimension of ultrasonic energy) at the peak of the focal zone. The cross-sectional dimension recorded for the focal spot shall be measured at the half amplitude level. See Figure 1B.

3.2.2.3.3 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 (See Figure 2) or an appropriate substitute may be used to test the exit angle of angle-beam search units. The history of an angle-beam search unit 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: Couplants for immersion 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 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 bubblers, columnators, squirters, ultrasonic wheels, and immersion tanks.

3.2.3.2 Contact: Couplant materials for testing by the contact method shall not be injurious to the material being tested. Couplant materials may include any appropriate fluid such as water, light oils, low-viscosity greases, or penetrant emulsifiers. Glycerin shall not be used. Thin 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. The couplant used shall be selected to ensure the best possible sound beam entry into the material under tests. 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 to the test surface, use of contour surface wear shoes, 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 µm)	SAE 10W Motor Oil
50 to 125 RHR (1.2 to 3.2 µm)	SAE 20W Motor Oil
100 to 200 RHR (2.5 to 5.1 µm)	SAE 30W Motor Oil

3.2.4 Ultrasonic References (Standards): Ultrasonic references are required for all inspection 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 ±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 search unit (See 3.2.4.5). The procedure used shall establish a minimum of a 2:1 signal-to-noise ratio with the minimum size reference discontinuity used.

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 E 127 and ASTM E 428 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 steels, but the same procedure may be used to manufacture references from other materials. Use of other materials is required where the ultrasonic transmission characteristics 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), 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 product or part thickness of 0.5 inch (12.7 mm) and under, ultrasonic references in accordance with Figure 3 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. Table 2 describes the applicable dimensions. Use of notches for angle beam ultrasonic reference blocks is preferred.

TABLE 2A - Angle Beam Inspection Parameters, Inch/Pound Units

Reference Thickness, T Inch	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

Notes:
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 2B - 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

Notes:
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 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 3 (See Figure 4). 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 5. Hole sizes shall be as shown in Table 3.

TABLE 3A - 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 3B - 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 3 shall apply (See Figure 6). 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 7). Flat-bottom holes shall be placed axially in the cylinder wall and shall be of the sizes specified in Table 3.

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 RHR (0.8 µm) 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 2 could be appropriate for flat materials and the notches specified in Table 3 could be appropriate for curved sections.

3.2.4.7 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 practices specified for longitudinal, shear, and surface 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 and exit 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. Surfaces to be inspected shall not be rougher than 125 microinches (3.2 µm), defined in accordance with ANSI B46.1.

3.4 Testing Procedure:

3.4.1 Written Procedure: Ultrasonic inspections shall be detailed in a written procedure. Procedures shall be prepared by the vendor and accepted by purchaser. Procedures shall identify the type of ultrasonic equipment, method(s) of test, ultrasonic test reference, search unit serial number, type, style, and frequency, search unit qualification, fixturing, method of reporting indications, and all other instructions that pertain to the actual test. Procedures shall be detailed sufficiently that another qualified investigator could duplicate the test and obtain equivalent information.

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 on thin materials, documentation of the inspection plan and the methods of recording and interpreting results becomes 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 and serial numbers, where applicable, stage of fabrication, surface condition, and configuration of the material to be tested.

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

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

3.4.2.4 Search unit qualification tests.

3.4.2.5 Testing plan, including the recording procedure, scanning plan, recording sensitivity, anticipated results, method of interpreting recorded results, and relationship to ultrasonic references.

3.4.3 Testing Systems:

3.4.3.1 The product or part may be inspected by longitudinal, shear, or surface wave techniques or a combination of techniques as will most appropriately disclose material imperfections. The pulse-reflection (echo) pulse-transmission procedures may involve one or more search units as required for the evaluation.

3.4.3.2 All equipment used for the tests, such as ultrasonic test instruments, 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 the like, for any reason shall require requalification 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 each design configuration test 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 material 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 shall 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 various preselected angles. Once established, the surface entry angle shall not vary more than ±2 degrees.

3.4.5.4 Water Path: Valid tests may be performed in both the Fresnel (near) and Fraunhofer (far) field zones. A variety of sound beams ranging from columnated 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 ±0.2 inch (5 mm).

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 or repaired.

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 the 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 than could influence the test.

3.4.7.2 Dual Search Units: For thin materials, dual search unit test techniques may be used. Search unit qualification for dual search units shall be as for contact testing. If wear of the search unit facing results in a change in sound beam entry angle in excess of ±3 degrees, the search unit shall be removed from service and replaced or repaired.

3.4.7.3 Lamb Wave: Lamb wave testing shall be as agreed upon by purchaser and vendor.

3.4.8 Distance Amplitude Correction: Electronic distance amplitude correction is recommended; however, distance amplitude curves plotted on the screen face (Cathode Ray Tube) using distance amplitude calibration blocks may be used if the minimum pip height is not less than 1.0inch (25.4 mm) and the maximum pip height is not greater than 90% of the screen height. 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 Gating and Recording: Wherever possible and practical, automatic signal alarm and recording circuits shall be used, e.g., alarms which alert the inspector, identify depth, or record signal information.

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 analog voltage output 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 shall be reinspected. For this requirement, the testing shift shall not exceed 8 hours.

3.4.9.2 Recording: Recording may be performed manually 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 purchaser with evidence that the recording system is not the limiting component of the system and that reflections from known discontinuities are reliably and repeatably 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 beam diameter shall first be measured at the near-field-far field transition $Y_o = r^2/\lambda$, where Y_o = transition, r = radius of search unit, and λ = wavelength at operating frequency in two perpendicular directions. The minimum beam diameter value shall be used. The scan index shall not exceed the diameter of the sound beam as measured at the half amplitude level (See 3.2.2.3). When focused search units are used, the index shall not exceed the beam diameter as measured at the half amplitude level profiled at the focal point. A closer index is recommended to ensure adequate inspection overlap (See Figure 1B).

3.4.9.4 Scan Speed: Maximum scanning speed is determined by the recordability of the applicable ultrasonic reference. At the maximum recording speed used, the reference discontinuities shall be clearly recorded, If distortion related to scanning speed is observed, the scan speed shall be reduced until distortion is eliminated.

3.4.9.5 Gain Settings for Inspection: 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. In 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 before proceeding with inspection.

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 4 defines these classes for inspections involving flat-bottom hole reflectors in ultrasonic references.

TABLE 4A - Ultrasonic Reference Inspection Classes, 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	#1 response for 0.12	50
A1	#3	#2	#2 response for 0.25	50
A	#5	#3	#3 response for 0.50	50
B	#8	#5	#5 response for 1.00	50
C	As established by purchaser and vendor for specific part.			

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

TABLE 4B - Ultrasonic Reference Inspection Classes, SI Units

Quality Class	Single Discontinuity FBH (1)	Multiple Discontinuities FBH (1)	Linear Discontinuity mm, max	Loss of Back Reflection % max
AA	1.2	0.4	0.4 FBH response for 3.0	50
A1	1.2	0.8	0.8 FBH response for 6.4	50
A	2.0	1.2	1.2 FBH response for 12.7	50
B	3.2	2.0	2.0 FBH response for 25.4	50
C	As established by purchaser and vendor for specific part.			

Note: 1. Diameter of flat bottom hole in millimeters.

4.1.1.1 Any discontinuity with a signal indiction 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 square inch (645 mm^2) of inspected surface.

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 5 defines these classes.

TABLE 5A - Ultrasonic Quality Classes, FBH, inch/Pound Units

Quality Class	Single Discontinuity FBH (1)	Multiple Discontinuities FBH (1)	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.		
Note 1: FBH numbers indicate diameter in multiples of 1/64 inch of FBH in ultrasonic reference.			

TABLE 5B - Ultrasonic Quality Classes, FBH, SI Units

Quality Class	Single Discontinuity FBH(1)	Multiple Discontinuities FBH(1)	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	0.8 FBH response for 6.4
A	2.0	1.2	1.2 FBH response for 12.7
B	3.2	2.0	2.0 FBH response for 25.4
C	As established by purchaser and vendor for specific part.		
Note 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 within 1 square inch (645 mm^2) of inspected surface.

4.1.3 Angle Beam Using Reference Notches: Five classes of ultrasonic quality are established for angle-beam inspection, in longitudinal, shear, or surface-wave modes, which involves notches as the ultrasonic reference reflectors. Table 6 defines these classes.

TABLE 6 - Ultrasonic Quality Classes, Notch

Class	Single Discontinuity Notch Size Inch	Single Discontinuity Notch Size mm	Multiple Discontinuities
AA	E - 0.02D x 0.04L	E - 0.5D x 1.0L	50 % of E response
A1	F - 0.03D x 0.05L	F - 0.8D x 1.3L	E response
A	G - 0.05D x 0.10L	G - 1.3D x 2.5L	F response
B	H - 0.08D x 0.16L	H - 2.0D x 4.1L	G response
C	As established between purchaser and vendor for specific part.		

4.1.3.1 Any discontinuity with a signal indication greater than allowed for the specific class shall be cause for rejecting the part for that class.

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 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 each size and configuration of product and of each part number. These records shall be made available for inspection by purchaser at any reasonable time.

4.3.2 Personnel Qualifications: It shall be verified that all inspections are performed by personnel qualified in accordance with 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 specified requirements.

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 Ultrasonic References: Signal indications from ultrasonic references shall be recorded at least once a year and results compared to a master record established at initial acceptance.

4.3.6 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 supervison to ensure 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:

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

8. NOTES:

8.1 A change bar (**l**) 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, including technical revisions. Change bars and (R) are not used in original publications, nor in specifications that contain editorial changes only.

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 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. 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 pre-selected 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 not be 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 ±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 applicable to 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, 79 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

ASTM E 213 Ultrasonic Inspection of Metal Pipe and Tubing for Longitudinal Discontinuities

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

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

8.7 Similar Specifications:

MIL-STD-1875 is listed for information only and shall not be construed as an acceptable alternate unless all requirements of this AMS are met.

8.8 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”

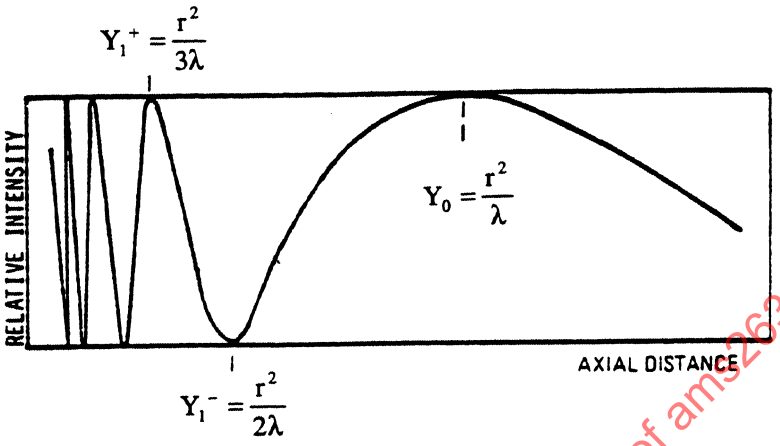

FIGURE 1A - Search Unit Axial Distance Amplitude Curve
(Profile for Flat Piston Radiator)

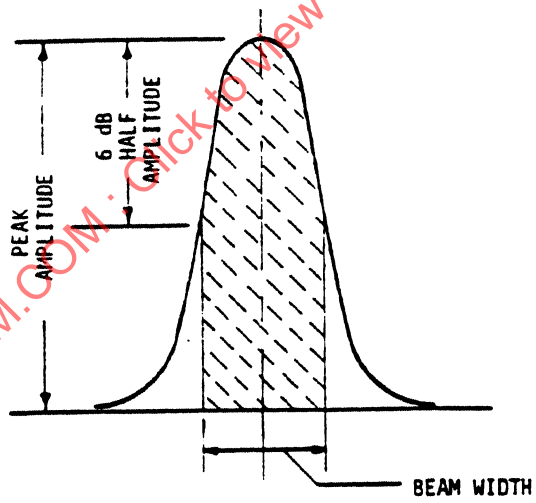

FIGURE 1B - Cross Section Profile of Sound Beam at Y_o or Focal Point