MIL-STD-1875(AT)
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MILITARY STANDARD

ULTRASONIC INSPECTION, REQUIREMENTS FOR

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DEPARTMENT OF DEFENSE
WASHINGTON, D.C. 20301

Ultrasonic Inspection, Requirements for

MIL-STD-1875(AT)

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FOREWORD

This Military Standard establishes the requirements for the ultrasonic inspection of materials and parts performed by either the contact or immersion methods.

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1. SCOPE

1.1 Scope. This standard governs the process for ultrasonic inspection of materials and parts, performed by either the contact or immersion methods.

1.2 Purpose. This process is used principally for the detection of internal discontinuities which may impair the quality or function of the material or part.

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

SPECIFICATIONS
MILITARY

MIL-I-8950	- Inspection, Ultrasonic, Wrought Metals Process for.
MIL-T-17128	- Transducer Fluid, Sonar.

STANDARDS
MILITARY

MIL-STD-410	- Non-destructive Testing Personnel Qualification and Certification.

(Copies of specifications, standards, drawings and publications required by suppliers in connection with specific acquisition functions should be obtained from the acquisition activity or as directed by the contracting officer).

2.2 Other publications. The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

SPECIFICATIONS

Society of Automotive Engineers, Inc. (SAE) SAE Standards and Recommended Practices

AMS 2630	- Ultrasonic Inspection.

(Copies may be obtained from the Society of Automotive Engineers, Inc., 400 Commonwealth Avenue, Warrendale, PA 15096).

STANDARDS

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E114	- Ultrasonic Pulse-Echo Straight-Beam Testing by the Contact Method.
ASTM E127	- Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks.
ASTM E164	- Ultrasonic Contact Examination of Weldments.
ASTM E214	- Immersed Ultrasonic Testing by the Reflection Method Using Pulsed Longitudinal Waves.

ASTM E317	- Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Systems Without the Use of Electronic Measurement Instruments.
ASTM E428	- Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Inspection.
ASTM E500	- Standard Definitions of Terms Relating to Ultrasonic Testing.
ASTM B594	- Ultrasonic Inspection of Aluminum-Alloy Wrought Products for Aerospace Applications.

(Copies of the above publications may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103).

American Society for Nondestructive Testing

Nondestructive Testing Handbook, Volume 2, 1959 Edition

(Copies of the above publication may be obtained from the American Society for Nondestructive Testing, 3200 Riverside Drive, P.O. Box 5642, Columbus, OH 43221).

American Society for Metals

Nondestructive Inspection and Quality Control, Volume 11, Eighth Edition

(Copies of the above publication may be obtained from the American Society for Metals, Metals Park, Ohio 44073).

"Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies."

3. DEFINITIONS

3.1 Definitions. For the purpose of this standard, all definitions of ultrasonic terms not shown, shall be as defined in ASTM E500.

3.1.1 Amplitude. The vertical pulse height of signal, usually base to peak, when indicated by an A-scan presentation.

3.1.2 Back reflection. Indication of the echo from the far boundary of the material under test.

3.1.3 Contact inspection. The method in which the search unit makes direct contact with the material with a minimum couplant film.

3.1.4 Couplant. A substance used between the search unit and the test surface to permit or improve transmission of ultrasonic energy.

3.1.5 C-scan. A means of data presentation which provides a plan of view of the material and discontinuities therein.

3.1.6 Frequency (inspection). Effective ultrasonic wave frequency of the system used to inspect the material.

3.1.7 Gate. An electronic means to monitor a selected segment of the distance trace.

3.1.8 Immersion inspection. An examination method where the search unit and the material are submerged in water.

3.1.9 Reference block. A block used to establish a measurement scale and a means of producing a reflection of known characteristics.

3.1.10 Scanning. Relative movement of the search unit over a test piece.

3.1.11 Search unit. A device incorporating one or more transducers.

3.1.12 Transducer. An electro-acoustical device for converting electrical energy into acoustical energy and vice versa.

3.1.13 Ultrasonic. Pertaining to mechanical vibrations having a frequency greater than approximately 20,000 Hertz (Hz).

4. GENERAL REQUIREMENTS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for performance of all inspection requirements as specified herein. The contractor shall specify more stringent requirements than the minimum specified in this standard when necessary to assure that a component meets its functional and reliability requirements. Except as otherwise specified in the contract or purchase order, the contractor may use any facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any inspections set forth in the standard where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Inspection facilities. Ultrasonic inspection facilities of the material producer, subcontractor, or commercial laboratory shall be suitable for the inspection of materials or parts.

4.3 Equipment. An ultrasonic inspection system shall include all electronic instrumentation, mechanical devices, calibration accessories and immersion tanks, where applicable.

4.3.1 Ultrasonic test instrument. The basic instrument shall be capable of transmitting, receiving, and displaying high frequency electrical impulses at the required frequencies and amplitude. When specified, adaptations may be incorporated to include distance amplitude correction systems, flow gates, display recorder, or alarm devices.

4.3.2 Transducers. Transducers shall be capable of converting electrical energy into acoustical energy and vice versa, as well as transmitting and receiving ultrasonic energy in the material being tested at the required frequency and energy levels.

4.3.3 Recorders. Devices capable of producing a "C" scan presentation or plotters (X-Y or polar) are required when the contract or purchase order requires permanent records of inspection results on critical parts or materials.

4.3.4 Alarm. When a facsimile recorder is not used, an audible electronic defect alarm or a stop-on-defect alarm is recommended.

4.3.5 Tank. The tank for immersion testing shall be of sufficient size to permit submersion of the part or portions of the part to be inspected as well as the search unit.

4.3.5.1 Turntable. The turntable shall be used to support the parts being inspected and shall be capable of being rotated at predetermined speeds.

4.3.5.2 Bridge. The bridge shall be mounted over the tank and should move smoothly over the working area. The bridge shall be capable of being accurately indexed manually or automatically over a predetermined distance.

4.3.5.3 Carriage. The carriage shall be mounted on the bridge and will support the manipulator. The carriage shall have uniform movement over its working range and shall be capable of traversing manually or automatically over a predetermined distance.

4.3.5.4 Manipulator. The manipulator shall be rigidly attached to the carriage and shall support the search unit and provide fine angular adjustment in two vertical planes that are normal to each other.

4.3.6 Reference standards. Reference standards shall be required for the inspection of all production parts and materials to establish the performance level of the inspection system. The reference standards shall be of similar material to the part under test and shall contain one or more simulated imperfections. The size of the imperfections shall be governed by the part usage and will be called out in the applicable specification. Reference standards containing flat bottom holes (FBH) shall conform to the requirements of ASTM E127 or ASTM E428 unless otherwise specified on the reference standard drawing. Surface roughness on both sides of the reference standard shall be equal to or better than the product being tested. Reference standards for brazed or bonded joints shall be made from the same material and configuration as the part under test, whenever practical. All reference standards will be supplied or approved by the acquisition activity.

4.3.7 Material.

4.3.7.1 Couplant. The couplant MIL-T-17128 or equivalent shall permit efficient transmission of ultrasonic energy from the transducer to the test surface. For immersion testing, rust inhibitors and wetting agents may be added to thoroughly wet the inspection surface and prevent corrosion. The couplant and any additives used shall not be detrimental to the inspection material.

4.3.8 Classification. Classification for the ultrasonic inspection of components shall be specified on the drawing. Complex components may be divided into zones and have separate classifications and quality grades assigned. Acceptance and rejection criteria for each zone or part shall be jointly established between the contractor and the Government agency.

5. DETAIL REQUIREMENTS

5.1 Requirements. Ultrasonic inspections shall meet the requirements of AMS 2630 and MIL-I-8950 to the extent specified herein.

5.1.1 Test procedure. It shall be the responsibility of the contractor test facility to develop a satisfactory test procedure which is capable of consistently producing the desired results and quality level.

5.1.2 Inspection and coverage. The number of parts inspected and the coverage of each part shall be as specified by the drawing or other specifications, as applicable. If the amount of inspection is not specified, all parts and material requiring ultrasonic inspection shall receive 100 percent ultrasonic coverage. Welded parts requiring ultrasonic inspection shall be inspected for 100 percent of the length of the weld zone, including the weld heat affected zone.

5.2 Part preparation.

5.2.1 Identification. All parts shall be identified prior to ultrasonic inspection in a manner that will allow traceability through the inspection process. The method of identification used shall not tend to create erroneous interpretations.

5.2.2 Sonic configuration. Unless otherwise agreed upon or specified by the acquisition activity, all critical components requiring ultrasonic inspection shall be machined to a sonic shape (configuration drawing) to permit maximum ultrasonic inspectability. Machining shall be as follows:

a. On all surfaces that can be inspected from both sides, stock allowance shall be 0.100 inch minimum.
b. On all entry surfaces that can be inspected from one side only, stock allowance shall be 0.150 inch minimum.
c. All surfaces are to be flat, cylindrical, or conical.

5.2.3 Surface condition.

5.2.3.1 Cleanliness. Surface of parts or material to be inspected shall be free from forging or heat treat scale, oil, grease or other foreign material which may interfere with proper interpretation.

5.2.3.2 Texture. Surface texture of 125 microinches or better is required unless specified otherwise by the acquisitioning Government agency.

5.2.4 Ultrasonic frequency. The ultrasonic frequency (Hertz) used shall be the highest practical frequency which will provide the required penetration and resolution.

5.2.5 Inspection method. The product shall be inspected by the method or methods which will most appropriately disclose any imperfections in accordance with product requirements. When welds are examined by ultrasonic inspection (see ASTM E164), specific reference shall be made by the contractor as to the desired method of inspection, contact or immersion, and have concurrence from the acquisitioning Government agency.

5.2.5.1 Contact method. The search unit shall be moved across the surface under test, each pass slightly overlapping the previous pass, until the entire surface being scanned has been covered. The speed of scanning shall permit detection of any imperfections equivalent to or larger than the response from the reference standard.

5.2.5.2 Immersion method. The part to be inspected shall be immersed in the tank and shall be scanned in a manner that there is relative motion between the part and search unit until the entire part or area of interest has been inspected:

a. The search unit shall be indexed for not more than 50 percent of the effective beam diameter.
b. Scan rate - The scan rate shall not exceed the speed at which the simulated defects in the applicable reference standard can be detected.

5.2.6 Personnel. Ultrasonic inspectors shall be qualified and certified in accordance with the requirements of MIL-STD-410.

5.2.7 Standardization of equipment. Ultrasonic system shall be allowed to warm up before calibration is attempted and the inspection of parts or products commences. When reproducibility has been established using the appropriate reference standard i.e., response from the simulated imperfection in the standard produces a clearly defined indication of sufficient amplitude. Parts or products may then be inspected as required to locate any discontinuities of a detrimental size in nature. The frequency of recalibration shall be at least every 4 hours to provide the quality level requirements desired.

5.2.8 Reports of inspection. Unless otherwise specified, the ultrasonic facility shall furnish inspection documentation giving the complete results of the ultrasonic inspection and signed by NDT Level II or III ultrasonic inspector authorized to do so by the testing facility. All reports required herein shall be available to the Government representative at all times. The reports shall list the purchase order number or equivalent identification, the number of parts, and the date of test. Each part shall be listed by the part number, serial number (when applicable), serial number of the test, and rated condition of the product (accepted or rejected).

5.2.9 Technique approval. Ultrasonic inspections performed in accordance with this standard shall be detailed in a written procedure. Procedures shall identify the type of ultrasonic equipment, method(s) of test, reference standard, search unit (type, style, and frequency), fixturing, method of reporting indications, and all other instructions that pertain to the actual test. Approval by the acquisitioning activity shall be required prior to use.

5.2.10 Documentation. The ultrasonic facility shall prepare and maintain on file for a period of not less than 4 years, results of tests, recordings, records of the requirements, and techniques for each size and configuration of the product and each part number. This documentation shall be available to the contractor or Government agency upon reasonable notification.

5.2.10.1 Instrument and system. Records shall be maintained to verify that the instrument and system used in the inspection meets the requirements set forth herein.

5.2.10.2 Procedures. Copies of the written test procedure (ref 5.1.1) including the type and response of the reference standard shall be maintained as part of the documentation.

5.2.11 Acceptance criteria. Unless otherwise specified, the acceptance criteria shall be as specified in the applicable specification or on the drawing and jointly concurred by the acquisitioning Government agency.

5.2.12 Rejection. Parts containing discontinuities or defects exceeding the permissible limits of the applicable specification, drawing, standard, or directive shall be separated from acceptable material, appropriately identified as discrepant, and submitted for material review as provided in the contract.

5.3 Marking.

5.3.1 Acceptable parts. Parts which conform satisfactorily to applicable ultrasonic inspection requirements shall be marked in a manner and location harmless to the part and which will preclude removal, smearing, or obliteration by subsequent handling. When subsequent processing which would remove identification is planned, the applicable symbol shall be affixed to the records accompanying the parts.

5.3.2 Impression stamping. Impression stamping shall be used where permitted by the applicable specifications or drawings. Marking shall be located in areas adjacent to the part number or the Government inspector stamp.

5.3.3 Etching. When applicable parts shall be marked by etching, suitable etchants and application methods shall be employed. Etching methods other than fluid etching may be used.

5.3.4 Dyeing. Where etching or impression stamping is not appropriate, identification may be accomplished by dyeing.

5.3.5 Other identification. Other means of identification such as tagging may be applied to completely ground and polished parts for which construction, finish, or functional requirement preclude the use of etching, stamping, or dyeing.

6. NOTES

6.1 Ultrasonic applications. Ultrasonic inspection techniques are used in numerous applications involving the structural integrity of engineering materials. They are suitably adapted to the following:

1. Detection of discontinuities resulting from:

   a. Inherent processing of base product such as steel ingot defects appearing in subsequent bar or sheet product, internal casting defects, etc.

   b. Processing defects that may occur during heat treatment, welding, brazing, etc.

   c. Service defects that may occur as the result of fatigue, stress, corrosion, etc.

2. Measuring thickness.
3. Determination of elastic moduli.
4. Determination of microstructural differences in metals.

6.2 Ultrasonic limitations. Test conditions which may limit the application of ultrasonic methods usually relate to one of the following factors:

1. Unfavorable sample geometry: i.e. size, contour complexity and defect orientation.

2. Undesirable internal structure: i.e. grain size, structure porosity, inclusion content or fine dispersed precipitates.

6.3 Operator-controlled parameters. The major parameters controlled by the operator relate to:

1. Equipment selection

   a. Type instrument.
   b. Type and size of search unit.

2. Equipment operation

   a. Technique

      (1) Coupling method.
      (2) Scanning sequence.
      (3) Peaking procedure.

b. Control settings

(1) Frequency.
(2) Pulse length.
(3) Linearity.
(4) Distance/time-varied gain (TVG) or sensitivity-time gain (STG).

6.4 Parameters controlled by inspection problems. Those parameters determined by the specific inspection problem involve:

1. Specimen properties

a. Velocity.
b. Impedance.
c. Geometry.
d. Surface.
e. Attenuation.
f. Noise level.

2. Flaw conditions

a. Depth.
b. Size.
c. Shape.
d. Impedance.
e. Orientation.

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