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DEPARTMENT OF DEFENSE

TEST METHOD STANDARD

METHOD 220, ULTRASONIC INSPECTION

AMSC N/A

FSC 59GP

FOREWORD

1. This standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Comments, suggestions, or questions on this document should be emailed to std202@dla.mil or addressed to: Commander, Defense Logistics Agency, DLA Land and Maritime, ATTN: VAT, P.O. Box 3990, Columbus, OH 43218–3990. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil .

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METHOD 220
ULTRASONIC INSPECTION

1 SCOPE

1.1 Purpose. Ultrasonic imaging is a nondestructive method for detecting internal physical defects in components which are not otherwise visible. Ultrasonic imaging techniques are intended to reveal such flaws as delamination, voids and cracks.

2 APPLICABLE DOCUMENTS

This section not applicable to this standard.

3 DEFINTIONS

3.1 Bulk scanning. Bulk scanning is the process of using a single c-scan to image the entire thickness of the component. Typically, the transducer is focused 50 percent into the component.

3.2 C-scan. C-scan is a scan in an x-y plane with the z-axis location fixed.

3.3 Double-sided scanning. Double-sided scanning is the process of using 2 c-scans to image a component, where both scans have the components oriented with the electrodes perpendicular to the sound wave. After the first scan, the components are flipped over 180° and scanned a second time. Typically, the transducer is focused 25 percent into the component.

3.4 False responses. When performing ultrasonic imaging, a response typically indicates the presence of air trapped in the component body. The air is due to voids, delaminations, or cracks. When the response does not indicate the presence of air, it is a false response. False responses are typically seen when imaging non-flat surfaces such as the edges of a component or terminated surfaces.

3.5 Field of view. Field of view is the x-y area scanned. Optimal field of view is determined by multiplying the spot size by pixel density.

3.6 Reflection mode. Reflection mode uses one transducer to both send and receive ultrasound (often called pulse/echo).

3.7 Resolution. Resolution is the ability of a particular ultrasound system to discriminate closely spaced features. For a system using a focused transducer, the resolution is dependent on the material of the component under test, the characteristics of the transducer, the characteristics of the pulser and receiver, the coupling fluid used, and the software capability.

4 GENERAL REQUIREMENTS

4.1 Apparatus.

4.1.1 Ultrasonic Inspection Equipment. The ultrasonic equipment shall be capable of performing c-scans in the reflection mode. The frequency shall be such that the acoustic wave can penetrate the component and image the back surface. If this is not possible, double-sided scanning should be considered, but the depth that the sound wave will penetrate should be well understood. The resolution of the scan shall be adequate to detect defects as specified in the acquisition document, relative to the size of the component.

4.1.2 Output device. When specified in the acquisition document, a hard or soft copy, grey (or color) scale image, shall be recorded for each component scanned. The image or hard copy shall have sufficient resolution to meet the requirements of the acquisition document. Maximum contrast shall be used to highlight rejects.

4.1.3 Holding tank. The holding tank shall be level and designed to hold the coupling fluid and locating fixtures without corroding or contaminating the components under test.

4.1.4 Ultrasonic detector. Focused transducers capable of reflection mode imaging shall be used for inspection.

4.2 Procedure.

4.2.1 Mounting and handling. If offline inspection is used, components shall be set-up in fixtures in order to identify and locate accept/reject pieces. Components shall be fixtured so that the electrodes are perpendicular to the sound wave pulse from the transducer. If this is not possible, a second scan shall be performed with the components rotated 90° from the original scan. If adhesive is used to fixture the components, it shall be easily removed and not contaminate the components. The coupling fluid is typically water or any other suitable fluid that will not contaminate the components under test. Components shall only be immersed in water for the time necessary to complete the imaging. Components shall be cleaned and dried after imaging. Care should be taken to ensure that no moisture remains trapped in the components after drying.

4.2.2 Views. Unless otherwise specified in the acquisition document, bulk scanning shall be used. Each component shall be imaged at least once or as specified in the acquisition document.

4.2.3 Recording and marking. Images used for accept/reject determination shall be of sufficient resolution to meet the acquisition document requirements. Reject or unclassified components shall be clearly noted on the records. Information stored with the records shall clearly indicate the original identification of the image.

4.2.4 Identification. All components shall be identified prior to imaging. A detailed tally shall be kept of the number of components inspected, number of components accepted, and number of components failed.

4.2.5 Set-up verification. Verification of the test set-up shall be carried out on periodic basis. Unless otherwise specified in the acquisition document, the supplier shall determine the verification method to be used. The verification method used shall demonstrate that the set-up will find known defects.

4.2.6 Tests. The frequency of the transducer used shall be sufficient to resolve defects equal to or larger than the requirements specified in the acquisition document, while still penetrating at least 50% (double-sided imaging) or 100% (single sided imaging) of the component. Gate settings, receiver attenuation and other equipment settings shall be selected to achieve the resolution specified in the acquisition document.

4.2.7 Operating personnel. Personnel engaged in ultrasonic inspection shall have training in ultrasonic imaging procedures and techniques. They shall be certified by their employer to be capable of setting up and operating the equipment to meet the requirements of the acquisition documents and ensuring that accept/reject determinations are valid.

5. DETAILED REQUIREMENTS

5.1 Evaluation.

5.1.1 Interpretation of ultrasonic images. Ultrasonic images shall be inspected to determine that each component meets the specified criteria. Hard copy or electronic images shall be of high enough resolution, and lighting shall be adequate, to make valid accept/reject determinations.

5.1.2 Examination and acceptance criteria. Components shall be rejected when they have ultrasonic responses that indicate the presence of voids, cracks, or delaminations that exceed the allowances of the acquisition document.

5.2 Inspection report. The manufacturer or test facility shall maintain adequate verification of the results of the ultrasonic inspection. A complete record of the details of the inspection shall be kept by the manufacturer or test facility. If the components are scanned at a location other than that of the manufacturer, the items listed below shall be included in the summary report provided to the manufacturer. The record or manufacturer's procedures shall include the following information:

a. Equipment used, including the transducer frequency, focal length, diameter and serial number, if applicable.

b. Scan resolution.

c. Field of view / pixel density.

d. Fixturing method and adhesive used, if applicable.

e. Whether components are terminated or unterminated.

f. Typical thickness of the components imaged.

g. Number of components scanned and the accept/reject quantities.

h. Date

i. Name of operator.

j. Component type or part number.

k. Component manufacturer.

l. Ultrasonic laboratory, if other than component manufacturer.

m. Typical scanned images for accept components.

5.3 Retention. All ultrasonic images and reports shall be maintained for the period specified in the acquisition document.

5.4 Calculations.

5.4.1 Fundamental resolution of transducer (λ).

$$\lambda = {}^{c}/_{f}$$

Where: λ = wavelength
c = material sound velocity
f = frequency

5.4.2 F number ($F\#$).

$$F\# = {}^{Focal\ length}/_{Diameter}$$

5.4.3 Spot size (ΔX).

$$\Delta X = 1.22 \times F\#({}^{\lambda}/_{2})$$

5.4.4 Resolution of focused transducer in reflection mode (R).

$$R = .707\Delta X$$

5.4.5 Depth of field (ΔZ).

$$\Delta Z = 7.1(F\#)^2(\lambda/2)$$

5.4.6 Example.

For a 50 MHz transducer with a focal length of .5 inch, a diameter of .250 inch, and using 5.53×10^3 m/s as the velocity of sound in barium titanate:

$$\lambda = 5.53x10^3/50x10^6 = .00011\ m = .0044\ inch$$

$$\lambda/2 = 55\ \mu m = .0022\ inch$$

$$F\# = .5/.25 = 2$$

$$\Delta X = 1.22 \times 2(.0022) = .0054\ inch$$

$$R = .707(.0054) = .0038\ inch$$

$$\Delta Z = 7.1(2)^2(.0022) = .0625\ inch$$

TABLE I. Typical transducer resolution and depth of focus for barium titanate based components.

Transducer frequency (MHz)	Fundamental resolution (µm)	Fundamental resolution (inches)	Focal length (inches)	Diameter (inches)	F#	Spot size (inches)	Theoretical resolution (inches)	Optimal FOV (@512, in)	Optimal FOV (@1024, in)	Depth of focus (inches)
10	275	.0108	2.000	.500	4	.0488	.03450	24.9856	49.9712	2.2720
10	275	.0108	.750	.375	2	.0183	.01294	9.3696	18.7392	.5680
15	180	.0071	.750	.500	1.5	.0128	.00906	6.5587	13.1174	.2237
20	137	.0054	1.250	.250	5	.0153	.01078	7.8080	15.6160	1.7750
20	137	.0054	.500	.250	2	.0061	.00431	3.1232	6.2464	.2840
30	92	.0036	1.250	.250	5	.0110	.00776	5.6218	11.2435	1.2780
30	92	.0036	.750	.250	3	.0066	.00466	3.3731	6.7461	.4601
30	92	.0036	.500	.250	2	.0044	.00311	2.2487	4.4974	.2045
50	55	.0022	1.000	.250	4	.0107	.00759	3.7478	7.4957	.2499
50	55	.0022	.500	.250	2	.0054	.00381	1.8739	3.7478	.0625
75	38	.0015	.500	.250	2	.0018	.00129	.9370	1.8739	.0852
100	25	.0010	.500	.250	2	.0012	.00086	.6246	1.2493	.0568
100	25	.0010	.200	.250	0.8	.0005	.00035	.2499	.4997	.0091

5.5 Summary. The following details shall be specified in the acquisition document:

a. Scan resolution.

b. Type and number of views.

c. Defect criteria.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

Custodians:
Army - CR
Navy - EC
Air Force - 85
DLA - CC

Preparing activity:
DLA - CC

(Project 59GP-2017-005)

Review activities:
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Navy - AS, OS, SH
Air Force - 19
NSA - NS

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