DEFENSE LOGISTICS AGENCY
LAND AND MARITIME
P.O. BOX 3990
COLUMBUS, OHIO 43218-3990

October 23, 2013

MEMORANDUM FOR MILITARY/INDUSTRY DISTRIBUTION

SUBJECT: Engineering Practices Study: Ultrasonic Inspection of Ceramic Capacitors.

Project number: 59GP-2014-001.

An engineering practices study is being conducted to gather information and comments regarding a proposed test method for the ultrasonic inspection of ceramic capacitors.

BACKGROUND

The G-11 Component Parts Committee has assigned a task (11-303) to develop a standard test method for the ultrasonic inspection of ceramic chip capacitors, including transducer frequencies and accept/reject criteria. The intention is to include this test method in MIL-PRF-123, MIL-PRF-49470, the thin-layer ceramic capacitor specification that is currently under development, and eventually MIL-STD-202.

A task group was formed and has developed a test method proposal (see attachment). The group has requested that DLA Land and Maritime conduct an engineering practices study to survey manufacturers and users of ceramic capacitors for specifics and details related to their current ultrasonic imaging techniques. These details will be used to define the requirements in the individual specifications.

REQUEST FOR COMMENTS

Please assist the task group by providing information related to your current ultrasonic imaging methodology with the following topics in mind:

- Transducer frequencies.
- Resolution obtained.
- Scan mode and view.
- Accept/reject criteria.
- Do you use double sided imaging?
- Are the parts terminated or un-terminated?
- Are different techniques used for different part sizes?
- Verification method.
- Comments regarding the proposed test method.
- Comments regarding the addition of ultrasonic inspection to group A, subgroup 1 of MIL-PRF-123 and the thin-layer ceramic capacitor specification that is currently under development.

Please provide information and comments to this Center no later than **10 December 2013**. The point of contact for this study is Mr. John Bonitatibus, DLA Land and Maritime - VAT, Post Office Box 3990, Columbus, OH 43218-3990. The preferred method of contact is via email. John can be reached at john.bonitatibus@dla.mil or 614-692-4709/DSN 850-4709.

//Signed//

Michael A. Radecki
Chief
Electronic Components Branch

Attachment

This page intentionally left blank

NOTE: This draft, dated 24 October 2013, prepared by DLA-CC, has not been approved and is subject to modification.

DO NOT USE PRIOR TO APPROVAL.

MIL-STD-202_
DRAFT DATED 24 October 2013

METHOD XXX

ULTRASONIC INSPECTION OF CERAMIC CAPACITORS

1. PURPOSE. Ultrasonic imaging is a nondestructive method for detecting internal physical defects in ceramic capacitors which are not otherwise visible. Ultrasonic imaging techniques are intended to reveal such flaws as delaminations, voids and cracks.

1.1. Definitions.

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

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

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

d. 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.

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

f. 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 device under test, the characteristics of the transducer, the characteristics of the pulser and receiver, the coupling fluid used, and the software capability.

2. APPARATUS.

2.1 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 ceramic capacitor 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 defined in the acquisition document, relative to the size of the device.

2.2 Output device. When specified in the acquisition document, a hard or soft copy, grey (or color) scale image, shall be recorded for each device 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.

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

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

3. PROCEDURE.

3.1 Mounting and handling. If offline inspection is used, devices shall be set-up in fixtures in order to identify and locate accept/reject pieces. Devices 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 devices flipped 90° from the original scan. If adhesive is used to fixture the devices, it shall be easily removed and not contaminate the devices. The coupling fluid is typically water or any other suitable fluid that will not contaminate the devices under test. Devices shall only be immersed in water for the time necessary to complete the imaging. Devices shall be cleaned and dried after imaging. Care should be taken to ensure that no moisture remains trapped in the devices after drying.

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

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

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

3.5 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.

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

3.7 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.

3.8 Interpretation of ultrasonic images. Ultrasonic images shall be inspected to determine that each device 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.

3.9 Examination and acceptance criteria. Devices 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. REPORT.

5.1 Inspection report. Unless otherwise specified in the acquisition document, the following items shall be reported, at a minimum:

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 devices are terminated or unterminated.

f. Typical thickness of the devices imaged.

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

h. Date

i. Name of operator.

j. Device type or part number.

k. Device manufacturer.

l. Ultrasonic laboratory, if other than device manufacturer.

m. Typical scanned images for accept devices.

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

6. CALCULATIONS.

6.1 Fundamental resolution of transducer (λ):

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

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

6.2 F number ($F\#$):

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

6.3 Spot size (ΔX):

$$\Delta X = 1.22 \times F\#\lambda$$

6.4 Resolution of focused transducer in reflection mode (R):

$$R = .707\Delta X$$

6.5 Depth of field (ΔZ):

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

TABLE 1. Typical transducer resolution and depth of focus for barium titanate based ceramic capacitors.

Tranducer frequency	Fundamental resolution		Focal length	Diameter	F#	Spot size	Theoretical resolution	Optimal FOV	Optimal FOV	Depth of focus
(MHz)	(μm)	(inches)	(inches)	(inches)		(inches)	(inches)	(@512, in)	(@1024, in)	(inches)
10	275	0.0100	2.000	0.500	4	0.0488	0.03450	24.9856	49.9712	2.2720
10	275	0.0100	0.750	0.375	2	0.0183	0.01294	9.3696	18.7392	0.5680
15	180	0.0070	0.750	0.500	1.5	0.0128	0.00906	6.5587	13.1174	0.2237
20	137	0.0050	1.250	0.250	5	0.0153	0.01078	7.8080	15.6160	1.7750
20	137	0.0050	0.500	0.250	2	0.0061	0.00431	3.1232	6.2464	0.2840
30	92	0.0036	1.250	0.250	5	0.0110	0.00776	5.6218	11.2435	1.2780
30	92	0.0036	0.750	0.250	3	0.0066	0.00466	3.3731	6.7461	0.4601
30	92	0.0036	0.500	0.250	2	0.0044	0.00311	2.2487	4.4974	0.2045
50	75	0.0030	1.000	0.250	4	0.0073	0.00518	3.7478	7.4957	0.6816
50	75	0.0030	0.500	0.250	2	0.0037	0.00259	1.8739	3.7478	0.1704
75	38	0.0015	0.500	0.250	2	0.0018	0.00129	0.9370	1.8739	0.0852
100	25	0.0010	0.500	0.250	2	0.0012	0.00086	0.6246	1.2493	0.0568
100	25	0.0010	0.200	0.250	0.8	0.0005	0.00035	0.2499	0.4997	0.0091

7. SUMMARY. The following details shall be specified in the acquisition document:

a. Scan resolution.

b. Type and number of views.

c. Defect criteria.