Evaluation of MultiLayer Ceramic Capacitors for Low Voltage Type Failures

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October 20, 2000

Component Technologies and Radiation Effects (Code 562
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1.0 INTRODUCTION

In this evaluation, a series of tests were performed on CKR 06 style multi-layer ceramic capacitors that were procured from two manufacturers, with two capacitance/voltage ratings for each. The capacitors were subjected to: (a) Initial electricals consisting of capacitance, dissipation factor, and insulation resistance tests, (b) 85^0 C / 85% Relative Humidity (RH) test with a 1.3 volt bias, and (c) final electricals, which were repeat of initial electricals. In parallel with this evaluation plan, five capacitors from each of the four lots were subjected to Destructive Physical Analysis (DPA).

2.0 OBJECTIVES

The objective of this testing performed on 50 volt rated ceramic capacitors from two different manufacturers was to subject sample parts to 85^0 C / 85% RH testing, and determine if this environment in presence of dielectric cracks, delaminations and voids, or cracks in the capacitor encapsulation would contribute to low Insulation Resistance (IR), and cause low voltage failures during post-environmental electrical tests and measurements. In a high humidity environment, the humidity can ingress through the openings, or egress out of the openings and contact the flawed surface in the ceramic dielectric. A low voltage application will cause a shunt current to pass at the flaw site, which will be seen as an intermittent low insulation resistance (IR). Several reports exist that have documented the problem of low voltage failures observed in ceramic capacitors in the presence of high humidity environments [see References].

3.0 PARTS DESCRIPTION

The capacitors used for this evaluation were military grade parts screened and qualified to MIL-C-39014 specification. Each manufacturer provided two capacitor lots of different voltage ratings and date codes, with part numbers and quantities, as shown in Table 1 below:

TABLE 1

Manf.	Rating	Date Code	Generic P/N	Military P/N	Quantity
A_0	0.33uf/50V	9938-ONZ	MR065X334KSA	M39014/2-1358	75
A_1	1.0uf/50V	9936-PR	MR065X105KSA	M39014/2-1419	75
B_0	0.33uf/50V	9946-R	C066T334K5X5CS	M39014/2-1358	75
B_1	1.0uf/50V	9947-B	C062T105K5X5CS	M39014/2-1419	75

4.0 TEST PLAN

Title	Military Standard	Test Method	Test Conditions
Cleaning			Wash in deionized water, rinse with alcohol
Serialization			Identification of all parts with serial number
Visual Inspection			@ 10 X
Destructive Physical Analysis (DPA) on 5 Devices from each of the four lots.			Using in-house procedures
Initial Electricals @ 25^0 C:			
Capacitance	MIL-STD-202F	305	1KHz, 0.1 volt
Dissipation Factor	MIL-STD-202F	306	1KHz, 0.1 volt
Insulation Resistance	MIL-STD-202F	302	1.5 volts, 2 minutes
Low Voltage Humidity Test	MIL-C-123		Paragraph 4.6.16.1
Post Environmental Electricals @ 25^0 C			Repeat Initial Electricals

5.0 DISCUSSIONS AND TEST RESULTS

Discussions

All capacitors from the four different lots passed the low voltage initial electricals, 85^0C / 85% RH test, and post humidity electrical tests.

Three lots of 5 samples each, p/n MR065X334KSA, D/C 9938; p/n C066T334K5S5CS, D/C 9946 and p/n C0622T105K5X5CS, D/C 9947 met the DPA requirements of GSFC S-311-M-70 specification. However, the 4^{th} lot, p/n MR065X105KSA, D/C 9937, did not meet the requirement and was considered a rejectable lot.

This lot was considered rejectable, because: (1) During removal of the epoxy encapsulation from one sample, two leads fell off and in the second sample, one lead fell off, (2) Upon further examination of the leads, insufficient solder was detected on the lead bond, and (3) Close examination of additional samples detected insufficient solder on the lead bonds (Refer to GSFC Report summary # C08026). Rejection of the lot was based on EIA-469-B 4.1.1b document requirements for lead attachment defects.

Test Results

The test results, examinations, and analysis that were performed on the four capacitor lots are contained in the following additional documents:

1. Work Request # EV08026 for test and examination results

2. GSFC Test Report Summary # C08026 for DPA results

6.0 CONCLUSIONS

No failures were encountered in the 85^0C / 85% RH test. This was possibly because of the non-existence of cracks, delaminations, and voids in the dielectric or defects in the encapsulation that might have allowed moisture penetration.

DPA was performed on 5 devices from each of the four lots of capacitors. One lot was rejected, because of the inadequate lead soldering in the attachment area.

Further tests are planned on much larger lots of ceramic capacitors that would provide a larger defect occurrence base.

7.0 REFERENCES

[1] Eugene Loh from Hughes Aircraft Company, “A Model for Low-Voltage Instability in Ceramic Capacitors”.

[2] Gary Ewell from Hughes Aircraft Company, “Extended Electrical Characterization of Ceramic Capacitors Failing Under Low-voltage Conditions”.

[3] A. M. Holladay from Marshall Spaceflight Center, “Unstable Insulation Resistance In Ceramic Capacitors”.