Capacitor Reliability Data

MIL-STD CDR Styles, RF & Microwave Systems

I. Reliability Data Monitoring

I.1. General Manufacturing Process

At each step of the manufacturing process, specific checks have been set-up to guarantee the quality level of our products. Statistical Process Controls – also known as SPC – are utilized to monitor key parameters within processes.

In addition to all these in-process controls, a sample of capacitors from each lot is micro-sectioned to check the internal structure and the absence of voids, delaminations, cracks or other defects.

When manufacturing is completed, the multilayer ceramic capacitors are fully screened for Capacitance, Dissipation Factor, Dielectric Withstanding Voltage, Insulation Resistance and Visual Defects.

I.2. Reliability Testing

During qualification of new capacitor series or at random intervals, Temex Ceramics performs life tests – 2,000 hours, +125°C, 2 x WVDC - and uses MIL-PRF-55681 as a guideline. The following parameters best describe our multilayer ceramic capacitors for military applications:

- data from MIL-PRF-55681 revision F;
- capacitor, chip, multiple layer, fixed, ceramic dielectric, established reliability;
- rated temperature: -55°C to +125°C;
- CDR11, CDR12, CDR13 and CDR14 case sizes;
- Failure Rate levels C, M, P, R and S.

The data obtained from our continuous life test monitoring are used to calculate an equivalent part failure rate and to compare it to the Failure Rate level as defined in MIL-PRF-55681F. The methods and formulae used are based on MIL-HDBK271F and MIL-STD-690D.

An acceleration factor of 8:1 is used to relate life test data obtained at 200% rated voltage at maximum rated temperature, to rated voltage at maximum rated temperature (125°C). The following formula is used:

$$AF = \left(\frac{V}{V_0}\right)^3 \times 2^{\frac{(T-T_0)}{10}}$$

where V_0 is the rated voltage, T_0 the rated temperature, V and T the life test parameters.

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II. Reliability Data Summary

As stated in MIL-STD-690D, data are accumulated from sample units selected from a production run and produced with equipment and procedures normally used in production. One of the prerequisites for valid data is that all lots produced during the production period be represented. The data are from the same product in current production, i.e. data from products of preceding designs are not acceptable.

II.1. Failure Rate Level

The summary of all collected data gives the following results:

- cumulative unit hours in millions: 8.57;
- cumulative unit hours in millions with acceleration factor: 68.56;
- number of defects: 1.

We consider a single sampling plan based on a 90 percent confidence level: FRSP-90. For this FR sampling plan, MIL-STD-690D gives the following criteria:

FR Level Symbol	*Qualified FR Level (% per 1,000 hours)*	*Number of Failures Permitted*
C	non-ER	N/A
M	1.0	1 over 0.389M hours
P	0.1	1 over 3.89M hours
R	0.01	1 over 38.9M hours
S	0.001	1 over 389M hours

Temex Ceramics therefore complies with the requirements of C, M,P and R failure rate levels.

S failure rate level according to European Space Agency specifications 3009/035 and 3009/036.

II.2. Mean Time To Failure

MTTF is the basic measure of reliability for non-repairable items. It is analogous to the more familiar MTBF (Mean Time Between Failures) used for systems which can be repaired and placed back in service after failure occurs. FR levels may be converted to mean time to failure (MTTF) as follows:

$$MTTF = \frac{100'000}{FR\_level}$$, in failures per 10^6 hours

II.3. Unit Hour Requirement

A complete Poisson distribution table is needed to compute unit hours. To calculate unit hours with a given number "C" of permitted failures – we are considering 1 permitted failure – we first have to determine the probability of acceptance P_a by subtracting the FRSP value (0.90 as we have selected a confidence level of 90%) from 1.

Example: $P_a = 1 - 0.90 = 0.10$

From Poisson's table and for a Failure Rate level M, we find for the parameters "C" and P_a equal respectively to 1 and 0.10 the corresponding "m" value of 3.89; this "m" value in the table is the total of failure rate λ multiplied by the time (test hours).

$M = \lambda \times t$

unit hours = m ÷ λ (1%/1,000hours as we are working with FR level M)

unit hours = 3.89 ÷ 0.00001 = 0.389 million hours (around 45 years)

Values for P, R and S levels are found by multiplying the previous level by 10.

III. Part Failure Rate

The Part Failure Rate as defined by MIL-HDBK-217F is given by the following formula:

$$\lambda_p = \lambda_b . \Pi_{CV} . \Pi_Q . \Pi_E$$

where:

- λ_b is the Base Failure Rate;
- π_{CV} is the Capacitance Factor;
- π_Q is Quality Factor;
- π_E is the Environment Factor.

The Part Failure Rate, considering the capacitor series meet the required FR level, gives the number of failures per 10^6 hours. In MIL-HDBK-217F, the values for all these parameters are given under Capacitors, Fixed, Ceramic, Temperature Compensating and Chip paragraph. The CDR style as described by MIL-PRF-55681F is taken into account and corresponds to Temex Ceramics CHA and CHB sizes.

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III.1. Quality Factor

The Quality Factor depends on the FR level. If we consider the three FR levels defined previously for Temex Ceramics multilayer capacitors, the given factors are:

Symbol	*Product Level*	π_Q
C	non-ER	3.0
M	1.0 % per 1,000 hours	1.0
P	0.1 % per 1,000 hours	0.3

III.2. Environment Factor

All part reliability models include the effects of environmental stresses through the Environmental Factor. The descriptions of these environments are shown below and encompass the major areas of equipment use:

Environment	*Description*	π_E
G_B : Ground, Benign	Non-mobile, temperature and humidity controlled environments readily accessed to maintenance; includes laboratory instruments and test equipment, medical electronic equipment, business and scientific computer complexes, and missiles and support equipment in ground silos.	1.0
G_F : Ground, Fixed	Moderately controlled environments such as installation in permanent racks with adequate cooling air and possible installation in unheated buildings; includes permanent installation of air traffic control radar and communications facilities.	2.0
G_M : Ground, Mobile	Equipment installed on wheeled or tracked vehicles and equipment manually transported; includes tactical missile ground support equipment, mobile communication equipment, tactical fire direction systems, handheld communications equipment, laser designations and range finders.	10.0

III.3. Part Failure Rate Calculation

The part failure rate calculated as specified in MIL-HDBK-217F provides a more accurate result than the standard failure rate given by a particular FR level. The two main parameters are the FR level achieved by the standard process – Quality Factor - and the application where the part will be used – Environment Factor. Specific study could be made on request based on customer's requirements and equipments.