Long Term Storage of EEE-Components for space applications

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I. Introduction

Degradation of electronic components during storage or in a non-operating state is often regarded as uncritical in current literature [1]. Studies covering long term storage (LTS) of components often conclude that reliability issues occur. Nevertheless it is difficult to find a significant amount of publications covering this topic, especially for parts meant to be used in space applications. The vast amount of reports on storage or non-operating reliability of EEE-components comes from the military sector, where storage up to 20 years is common. In average such equipment is in a non-operating state for 75% - 99% of the time [2].

An example for degradation during storage in the space sector happened in 1988 during the pre-flight testing of the space shuttle "Discovery". Due to the space shuttle Challenger disaster in 1986 the remaining shuttles remained in storage for an unusually long time. Pre-flight tests found that components and subsystems failed, due to deterioration in the non-operating state [3]. Another motivation for studying the effects of LTS on components for space industry is the obsolescence management. As space qualified parts tend to be based on mature technologies, LTS could be a solution to ensure the supply of qualified space components, even after they become obsolete [4], [5], [6].

II. Extend of the Study and Performed Tests

The study is based on components procured for ESA for Meteosat (first and second generation) weather-satellites. Most of the parts were space qualified (ESCC or US MIL QML). Procurement and storage were performed by two well-established European companies with a broad experience in component handling. The date codes of the components are in the range from 1991 to 2003. The body of the study contains also analysis of the condition of the storage containers.

The tests performed on the components were chosen by using the standard ECSS-Q-ST-60-14, which covers relifing of EEE-components, as a baseline. External visual inspection (EVI), electrical measurements, hermetic seal tests and solderability tests were performed. The results of electrical and fine leak tests are compared to the pre-storage results.

III. Results and discussion

The components were delivered and stored in several layers of packaging materials. As it is common practice in space industry, components are often packed individually (e.g. in plastic tubes) and wrapped in at least two antistatic or metallized film bags. In some cases bags were found to be open because of degradation of adhesives. Similarly labels glued on the bags were found to be detached. Rubber bands, which were used to hold some bags together were brittle after LTS, so their use should be dismissed. In some cases, metallised film bags appeared to be non-homogenous in the sense that some areas of the bag were more transparent than others. This is a potential hazard, ESD protection may be insufficient.

The most important test results concerning the components are summarised in Table 1. The highest amount of failures appeared during EVI. Below said table some images of reliability issues found during EVI are shown. Most failures were due to external discolouration (Fig. 1) or corrosion (Fig. 2 and Fig. 4). Frequently the condition of the lead finish was the reason for rejection (Fig. 3). A few failures due to physical damaging were found. These damages may have been caused by improper handling of the components. It is important to note that all components of the same type and lot were found to be in a similar condition, if corrosion or discolouration appeared. In most cases all components of a batch failed EVI, because the same reject-criterion was observed. Only physical damages are a failure mode affecting single components out of a batch, while the remaining components remained acceptable. A common issue identified is the degradation of lead finishes. In many cases evidence of corrosion on the leads or the body-lead connection was found. Additionally a brittle and dull appearance of the lead finish was often observed. Lead finish degradation is a well-known and common issue during LTS and relifing. It is reported in Ref. [5] that antistatic material used for storage may be the cause for this issue. GEIA-STD-0003 also forbids the use of "pink film" for LTS in certain cases.

Based on the findings during EVI, solderability testing was performed, preferably on components with non-conformant lead finish. Out of the 12 different component types submitted to testing, samples of two types showed poor wetting.

Electrical testing resulted in significantly less failures than EVI (see Table 1). Components failing EVI were tested electrically, too. A clear correlation between EVI and electrical failures could not be seen. All electrical non-conformances are limit failures and the basic functionality of each component was still given. There are components where most or even all components were rejected because of the same parameter being out of its specified limit (carbon composition resistors, metallised film capacitors and some transistors). These components may not be suited for LTS under the given conditions. Two batches were found, were only one of the components submitted to testing failed, which may point towards a failure caused by improper handling or ESD.

Fine and gross leak tests were performed on 14 different component types on a sample basis of at least 5 parts. None of the tested samples failed the test.

IV. Conclusions

No fundamental obstacle for LTS of EEE-components was found, but proper screening according to ECSS-Q-ST-60-14 is recommended. Appropriate storage conditions and containers have to be used. Containers used by manufacturers and during procurement are not suited for LTS due to outgassing. EVI and electrical tests need to be performed on a 100% basis, as single components out of a batch can be damaged for example by mishandling. Most failures are superficial degradation or corrosion, which is also the result of similar studies (e.g. [5]) and reports of relifing based on ECSS-Q-ST-60-14.

V. References

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	EVI		Electrical Tests		Fine & Gross leak tests	
Family	Types tested	At least 1 failure	Types tested	At least 1 failure	Types tested	At least 1 failure
Connectors	4	0	-	-		
Resistors	11	2	11	1		
Capacitors	12	5	15	4		
Inductors	2	1	3	0		
Diodes	4	1	5	1		
Transistors	6	5	7	2	5	-
ICs	8	3	-	-	3	-
Relays	6	1	7	1	6	-

Table 1 *Summary of the test results. For each component type 5 – 10 samples were tested.*

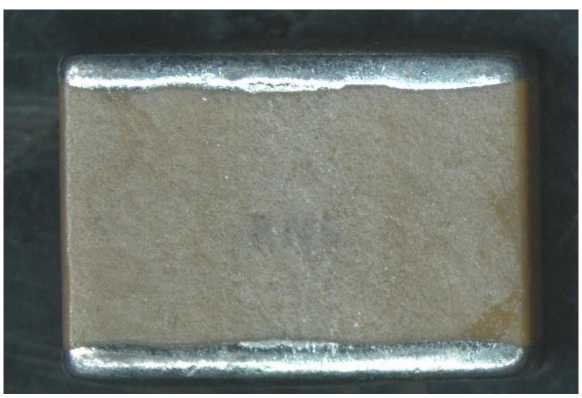

Fig. 1 *SMD-capacitor produced in 2004 with a discolourated package and illegible marking.*

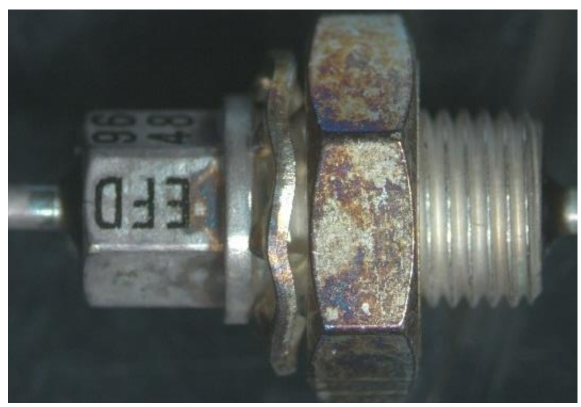

Fig. 2 *Corroded filter produced in 1996.*

Fig. 3 *Dull lead finish of a component produced in 1996.*

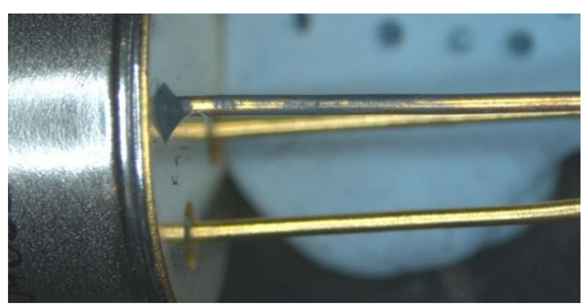

Fig. 4 *Transistor produced in 1991, with corrosion on th lead and the body.*