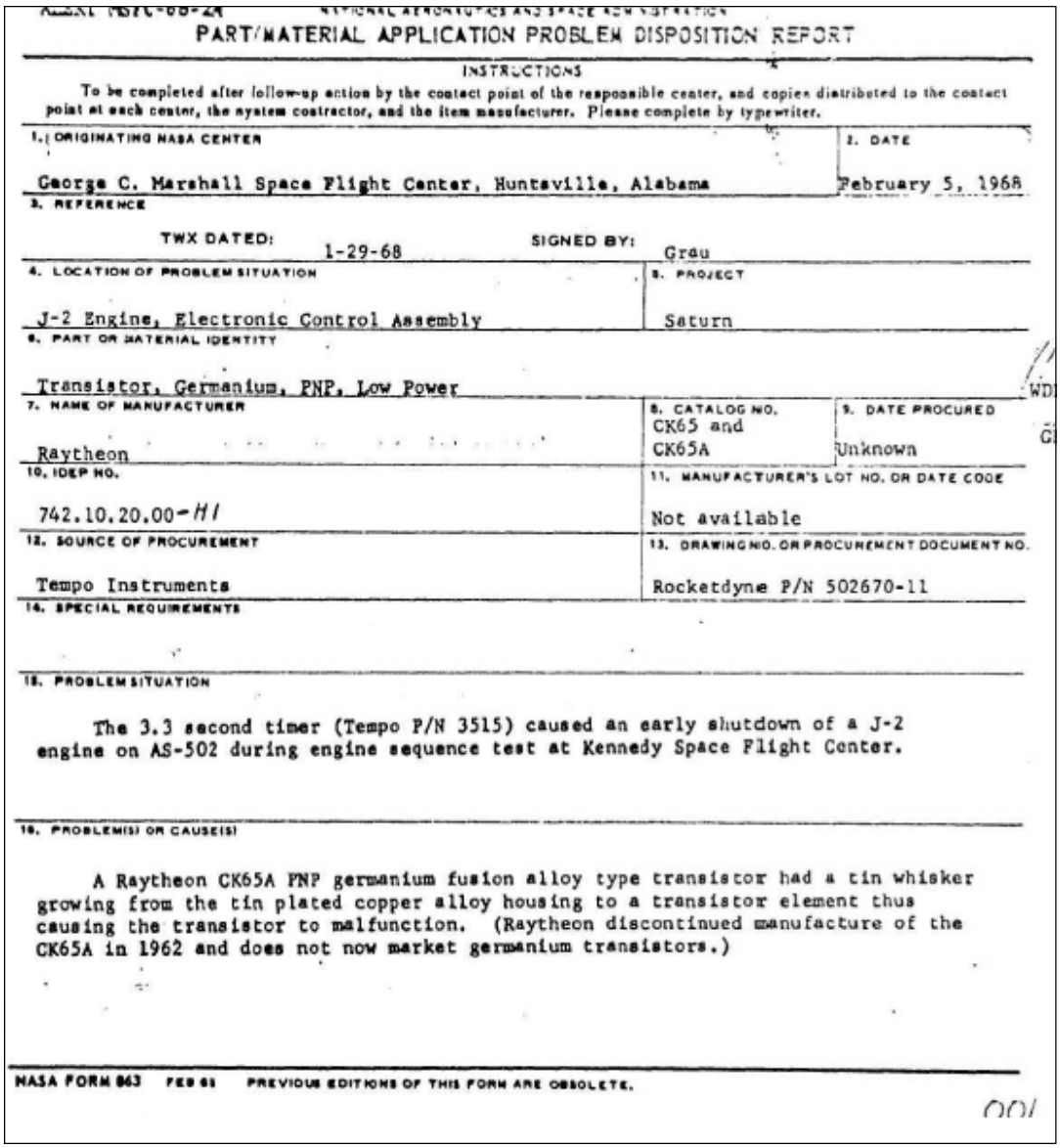
52 Years Later – Tin Whiskers Still Elude Comprehensive Solution

LDF Coatings metal cap process eliminates tin whiskers in printed circuit board assemblies.

In February of 1968, the Kennedy Space Flight Center issued a disposition report that cited a single transistor failure at the root of a J2 engine shutdown during a test sequence. What was unusual about the the failure is that it was due to a single tin whisker that shorted the metal housing of the transistor to one of it's internal elements. Here's an excerpt from the report describing analysis of the failure. [1]



PART/MATERIAL APPLICATION PROBLEM DISPOSITION REPORT

INSTRUCTIONS

To be completed after follow-up action by the contact point of the responsible center, and copies distributed to the contact point at each center, the system contractor, and the item manufacturer. Please complete by typewriter.

1. ORIGINATING NASA CENTER: George C. Marshall Space Flight Center, Huntsville, Alabama
2. DATE: February 5, 1968
3. REFERENCE: TWX DATED: 1-29-68 SIGNED BY: Grau
4. LOCATION OF PROBLEM SITUATION: J-2 Engine, Electronic Control Assembly
5. PROJECT: Saturn
6. PART OR MATERIAL IDENTITY: Transistor, Germanium, PNP, Low Power
7. NAME OF MANUFACTURER: Raytheon
8. CATALOG NO.: CK65 and CK65A
9. DATE PROCURED: Unknown
10. IDEP NO.: 742.10.20.00-HI
11. MANUFACTURER'S LOT NO. OR DATE CODE: Not available
12. SOURCE OF PROCUREMENT: Tempo Instruments
13. DRAWING NO. OR PROCUREMENT DOCUMENT NO.: Rocketdyne P/N 502670-11
14. SPECIAL REQUIREMENTS:
15. PROBLEM SITUATION: The 3.3 second timer (Tempo P/N 3515) caused an early shutdown of a J-2 engine on AS-502 during engine sequence test at Kennedy Space Flight Center.
16. PROBLEM(S) OR CAUSE(S): A Raytheon CK65A PNP germanium fusion alloy type transistor had a tin whisker growing from the tin plated copper alloy housing to a transistor element thus causing the transistor to malfunction. (Raytheon discontinued manufacture of the CK65A in 1962 and does not now market germanium transistors.)

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More than 50 years later, NASA continues to study the effects of whisker growth on reliability of electronic components and assemblies (see Tin Whisker Growth on Sn77.2In20Ag2.8 Solder), and the agency continues to analyze failures in components and printed circuit board assemblies due to whisker growth. The problems are exacerbated by widespread adoption of the European Union 2003 RoHS restrictions, which eliminate use of lead in consumer electronics.

The RoHS restrictions do not apply to military and aerospace electronics, which is a tacit acknowledgement of a downside to the RoHS policy. The downside is that whisker growth is significantly increased when lead is eliminated from the PCB component and assembly process.

While the EU's underlying mission to reduce harmful effects of toxic substances in the environment is a worthy pursuit, consideration of other resulting effects on the reliability and safety in electronic systems and assemblies also deserve consideration.

An earlier NASA study (Lead-Free Electroncs Reliabilty—An Update) observed that

- There is no evidence that lead (Pb) used in electronics manufacturing does any harm to humans or the environment
- The electronics industry represents approximately 0.5% of world Pb consumption
- No mechanism exists for transfer of Pb to blood through direct contact or proximity to Pb in electronics
- No evidence exists of elevated Pb levels in the blood of Sn/Pb soldering personnel
- Elimination of lead from 1 billion integrated circuits is equivalent to removing 100 automobile batteries from landfills worldwide.
- Inorganic lead is mainly particulate bound with relatively low mobility and bioavailability
- Natural weathering processes usually turn metallic lead into compounds, which are relatively stable and insoluble

The elimination of potential harmful effects in humans and the environment has merit, but lead-free components and manufacturing processes leave the electronics produced by those processes with reduced reliability and increased probabilities for failures.

The LDF Coatings process is not a mitigation solution–the LDF Coatings process completely eliminates whisker growth between component terminals on a printed circuit board (PCB) assembly. An introduction to LDF Coatings electroless nickel plating process simply explains how PCB assemblies are 100% protected from whisker growth. An in-depth presentation from a 2010 Reliability Society Annual Report provides a detailed technical examination of the process.

[1] *Part/Material/Application Problem Disposition Report,* Jay A. Brusse, GSFC-562.0 SCIENCE SYSTEMS AND APPLICATIONS INC.