The NASA Electronic Parts Assurance Group (NEPAG)

An Overview

NASA Electronics Technology Workshop

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Acronyms

Automotive Electronics Council (AEC)
The American Institute of Aeronautics and Astronautics (AIAA)
United States Army Aviation and Missile Research Development and Engineering Center (AMRDEC)
Ames Research Center (AMS)
The Johns Hopkins University Applied Physics Laboratory (APL)
Charged Device Model (CDM)
Commercial Off The Shelf (COTS)
Canadian Space Agency (CSA)
Defense Logistics Agency (DLA)
Electrical, Electronic, and Electromechanical (EEE)
Express Logistics Carriers (ELCs)
Engineering Practice (EP)
European Space Agency (ESA)
Electrostatic Discharge (ESD)
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Electrostatic Discharge Sensitivity [ESDS]
Field Programmable Gate Array (FPGA)
Government-Industry Data Exchange Program (GIDEP)
Glenn Research Center (GRC)
Goddard Space Flight Center (GSFC)
Human Body Model (HBM)
NASA Headquarters (HQ)
Integrated Circuits (ICs)
Japan Aerospace Exploration Agency (JAXA)
Joint Electron Device Engineering Council (JEDEC)
NASA Jet Propulsion Laboratory (JPL)
Johnson Space Center (JSC)
Kennedy Space Center (KSC)
Langley Research Center (LaRC)
Air Force Life Cycle Management Center (LCMC)
Missile Defense Agency (MDA)
Manufacturer (Mfr)
Military (MIL)
Multi-Layer Ceramic Chip Capacitors (MLCC)
Marshall Space Flight Center (MSFC)
Naval Sea Systems Command (NAVSEA)
The NASA Electronic Parts Assurance Group (NEPAG)
National Reconnaissance Office (NRO)
Office of Management and Budget (OMB)
Office of Safety and Mission Assurance (OSMA)
Package on Package (PoP)
Production Part Approval Process (PPAP)
Qualified Manufacturers List (QML)
Qualified Product List (QPL)
Society of Automotive Engineers (SAE)
Space and Missile Systems Center (SMC)
System on Chip (SOC)
Tantalum (Ta)
United States Air Force (USAF)

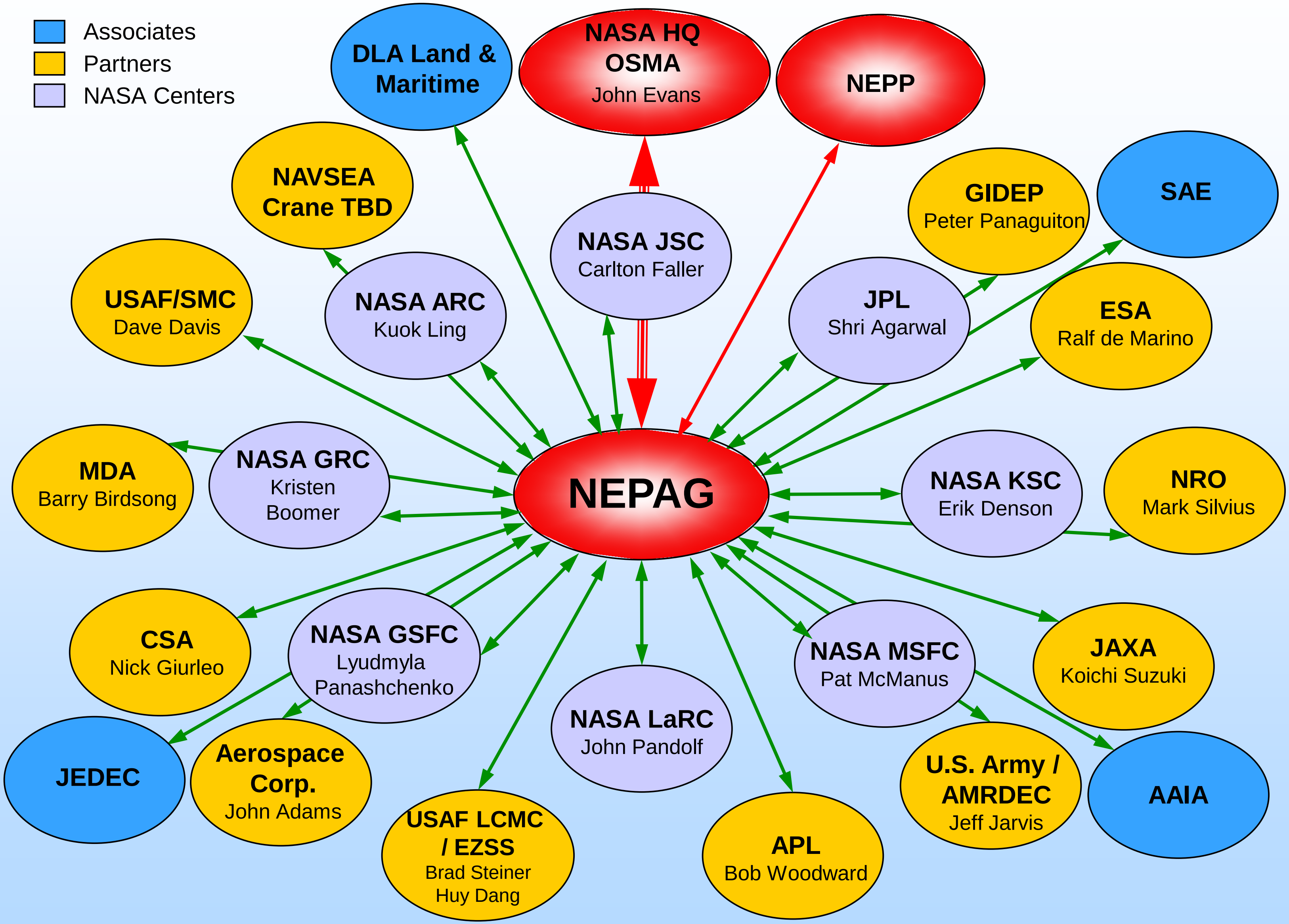
Outline

- NEPP Program Overview
- Highlights and “Concerns”
- Electrostatic Discharge (ESD)
- Automotive Parts
- Parts Issues
- GIDEP and Counterfeits
- A Look Forward
- Summary

NEPP and NEPAG

- **Chartered in the 1980's to ensure electronic commodities expertise supported the Agency.**
  - **The NASA Electronic Parts Assurance Group (NEPAG) was created in 2000, as a sub-element of NEPP for**
    - **Information sharing between NASA Centers and other agencies, and**
    - **Sufficient infrastructure to support Agency needs and leadership in EEE Parts Assurance**
- **NEPP evaluates new EEE parts technologies and develops insertion, test, screening, and qualification guidance.**
- **NEPAG supports audits, specification and standard reviews, failure investigations etc.**

NEPAG "Extended Family"



Program Highlights

- *NEPAG has celebrated 16 years of stimulating, weekly discussions and knowledge interchange that is/has been Educational, Influential, Collaborative, and Current*
  - *New multi-agency Working Group established for coordinated disposition of proposed changes to specifications and standards*
- **New NASA Standard, "Electrical, Electronic, and Electromechanical (EEE) Parts Management and Control Requirements for Space Flight Hardware & Critical Ground Support Equipment" NASA-STD-8739.10**
  - **Standardizes NASA traditional practices for the selection, acquisition, traceability, testing, handling, packaging, storage, and application of EEE parts**
  - **Includes radiation, prohibited materials and counterfeit avoidance**
- **Working with Aerospace to develop an agreement to share support of MIL QPL/QML audits led by the Defense Logistics Agency Land and Maritime**

NASA Concern - ESD

Electro Static Discharge (ESD)

- MIL-STD-883, Test Method 3015
  - Too old, long test times
  - Needs to be revisited for new technology
    - Smaller feature sizes, lots of contacts/pins, advanced packaging (2.5/3D)
  - 883 vs JEDEC (3 zaps/pin vs 1 zap/pin, for HBM test)
  - Equipment used to assemble /process parts/wafers need closer look – special talk at Space subcommittee meeting
  - Generic issue; applies to all parts military/space (and COTS)
- MIL-PRF-38535
  - Clarify requirements
    - No specific ESD requirements for wafer foundries
  - DLA is conducting their engineering practice (EP) study
- NASA EEE Parts Bulletin
  - Published a special edition on ESD, 2nd part published soon
- NASA ESD Surveys
  - Conducted to bring awareness

A Changing Landscape (Shipping/Handling/ESD Challenge)

A New Trend – Supply Chain Management
Ensuring gap-free alignment for each qualified product
(All entities in the supply chain must be certified/approved)

Performed By?	Production Step
Company A	Die Design and Fabrication
Company B	Fabrication
Company C	Wafer Bumping
Company D	Package Design and Package Manufacturing
Company E	Package Design
Company F	Assembly
Company G	Column Attach and Solderability
Company H	Screening, Electrical and Package Tests
Company I	Radiation Testing

NASA has adopted ANSI/ESD S20.20 as its controlling workmanship document

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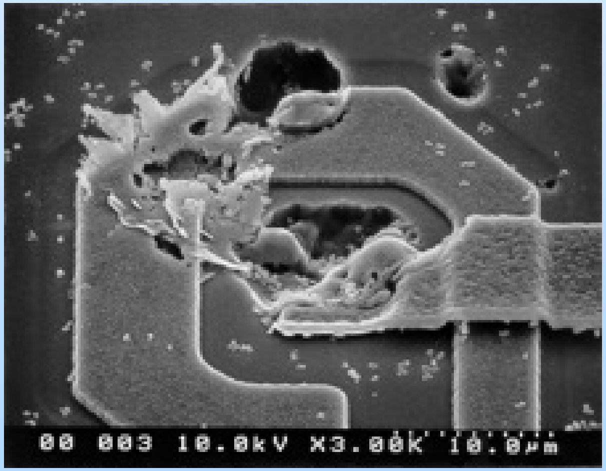
Some Standards for ESD Control

- **ANSI/ESD S20.20-2014, ESD Association Standard for the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) -** *Adopted by NASA*
- **MIL-STD-750, Test Method 1020, *Electrostatic Discharge Sensitivity (ESD) Classification***
- **MIL-STD-883, Test Method 3015, *Electrostatic Discharge Sensitivity [ESDS] Classification***
- **MIL-STD-1686, *Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)*, Rev. C, Oct. 25, 1995.**
- **MIL-PRF-38535, *Integrated Circuits (Microcircuits) Manufacturing, General Specification for***
- **SEMI E78-0309, *Guide to Assess and Control Electrostatic Discharge (ESD) and Electrostatic Attraction (ESA) for Equipment***
- **JESD22-A114F, JEDEC Standard For *Electrostatic Discharge Sensitivity Testing Human Body Model (HBM) - Component Level***
- **ANSI/ESDA/JEDEC JS-001-2014, ESDA/JEDEC Joint Standard *Electrostatic Discharge Sensitivity Testing – Human Body Model (HBM) – Component Level***
- **ESDA/JEDEC JS-002 2014, Electrostatic Discharge *Sensitivity Testing - Charged Device Model (CDM) - Device Level*,**

Importance of ESD

- **Potentially affects everything, even mechanical parts, and there are major differences among the multiple ESD specs in use.**
- **There are ongoing efforts by various standards groups toward harmonizing the different standards.**
- **1686 is the original MIL document for ESD testing and control, and it could be built up into a major ESD spec. However, Office of Management and Budget (OMB) Circular A-119 favors Industry Standards over government ones.**

MIL-STD-750, MIL-STD-883, MIL-PRF-38535 and probably other MIL documents, call out MIL-STD-1686 Requirements



Alternate Grade Electronics: Automotive

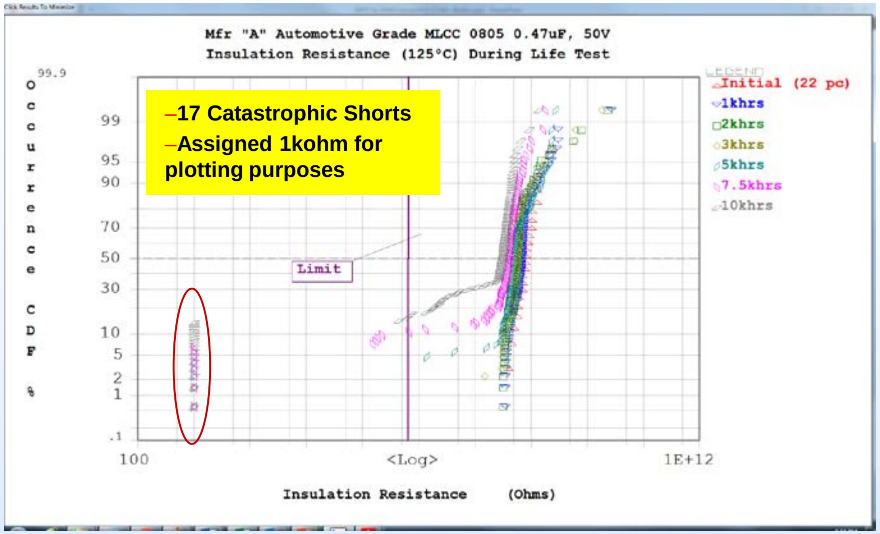
- **NEPP has three goals for automotive electronics efforts**
  - **Determine exactly what :"automotive grade" does or does not entail.**
    - **Includes understanding:**
      - **Automotive Electronics Council (AEC) documents, and,**
      - **Manufacturer Production Part Approval Process (PPAP).**
  - **Perform "snapshot" screening and testing on representative automotive grade electronics.**
  - **Explore adaption of resilient automotive electronics system concepts for use in space applications.**

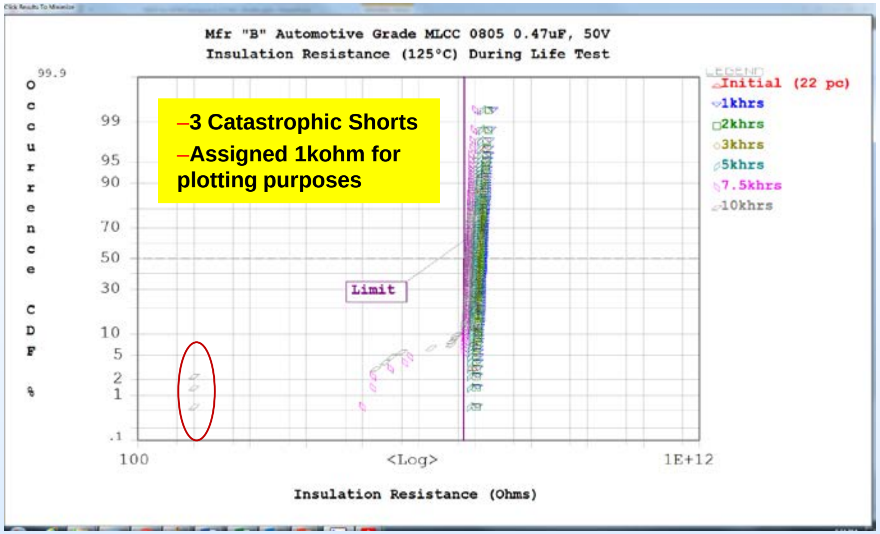
NEPP Evaluation of Automotive Grade EEE Parts

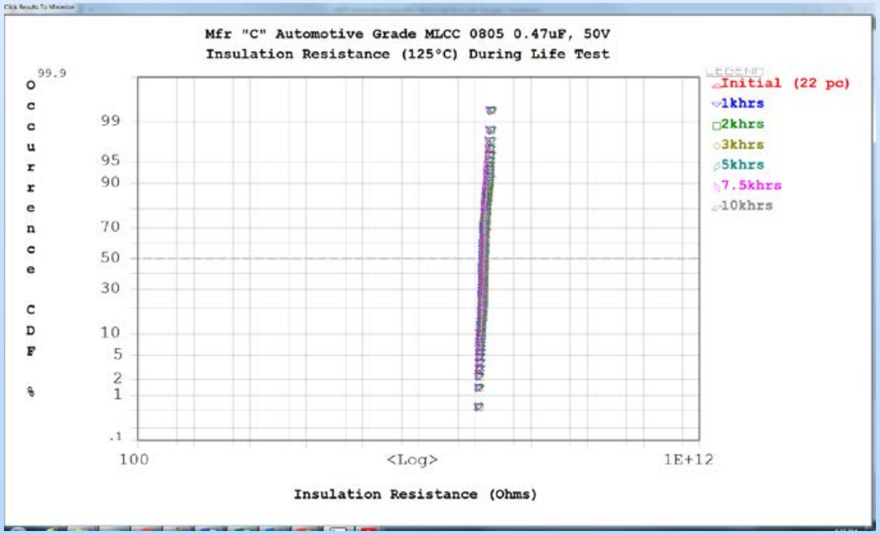
20-Mar-17

Manufacturer	Lot Code	Description	Quantity on Test	Life Testing Status	Comments
A	1302	Ceramic Chip Capacitor, 0805, 0.47uF, 50V	120	10khrs	120 pcs on test. 17 catastophic life test failures with first occurring ~3.1khrs
B	1304		120	10khrs	120 pcs on test. IR degradation noticed @7.5khrs; 3 catastrophic failures beyond 8khrs of test
C	1131		120	10khrs	120 pcs on test. No Catastrophic Life Test Failures
D	201028	Ceramic Chip Capacitor, 0402, 0.01uF, 16V	78	8k Hrs	few devices exhibit reduced IR (non-catastrophic)
E	TBD		80	8k Hrs	few devices exhibit reduced IR (non-catastrophic)
F	1247		79	8k Hrs	Stable IR Note: Precious Metal Electrode
AA	N/A	Tantalum Chip Capacitor, 22uF, 35V	80	2k Hrs	No Catastrophic Failures; ~10% show hot DCL above spec limit
AA	1301	Tantalum Chip Capacitor, 220uF, 10V	80	2k Hrs	No Catastrophic Failures;
G	TBD	Microcircuit, Transceiver	50	Not yet started	sent boards for fabrication
H	1152	Microcircuit, Comparator	90	2k hrs	Two setups, 45 units each. No failures.
I	1341	Microcircuit, comparator	50	Not yet started	Test Program in Development
J	unknown	Dual small signal NPN Bipolar transistor (similar to 2N2919 and 2N2920 MIL-PRF-19500/355)	20	>5k Hrs	No failures to Date Second batch of 20 devices in process to start life
K	1339	Switching diode (similar to 1N4148, MIL-PRF-19500/116)	20	100 hrs life test	No Failures to Date Parametric Degradation Observed beginning TA ~ 40°C behaves like short circuit >105°C
*L	unknown	Transient Voltage Suppressor, 36V minimum breakdown voltage, 400 watt peak pulse power	20	Not yet started	Test plan and test boards being validated Testing to commence 3rd or 4th QFY17

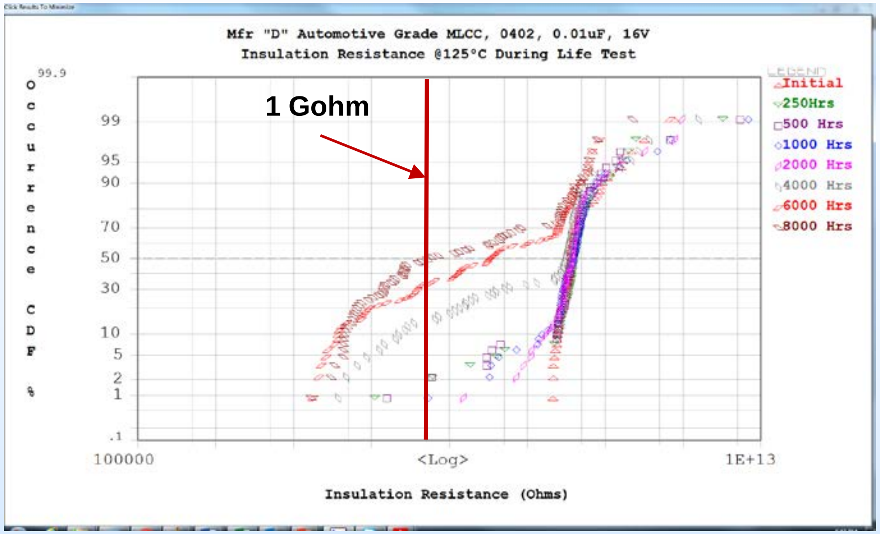
AEC-Q200: 0805 Ceramic Chip Capacitors, Insulation Resistance at 125^{0}C During Life Test

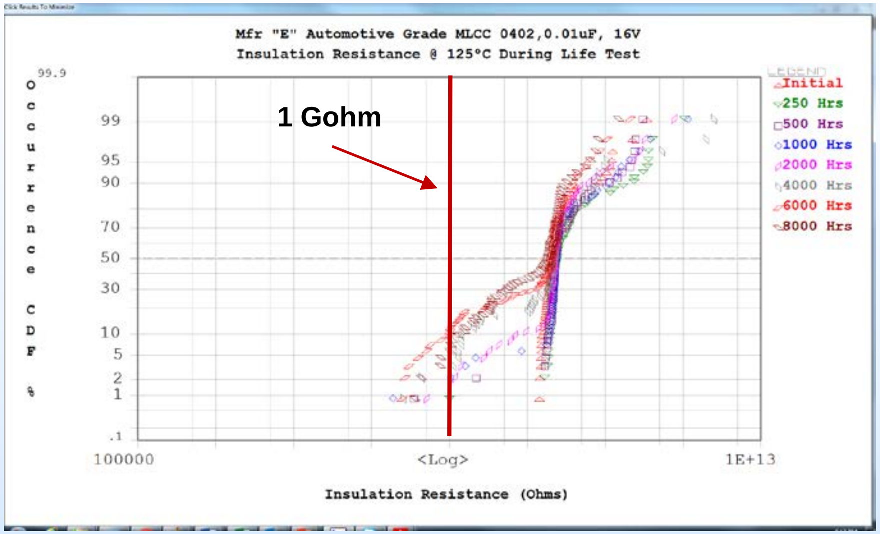


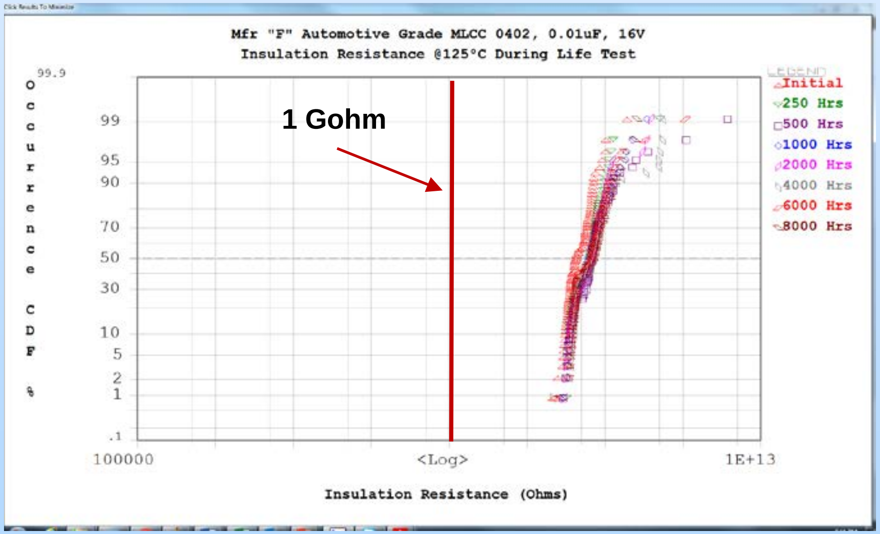




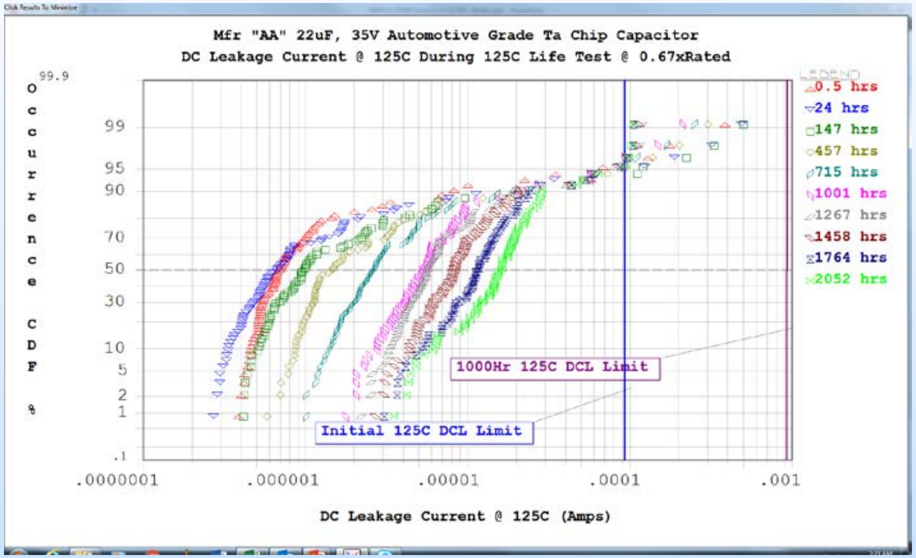
AEC-Q200: 0402 Ceramic Chip Capacitors, Insulation Resistance at 125^{0}C During Life Test

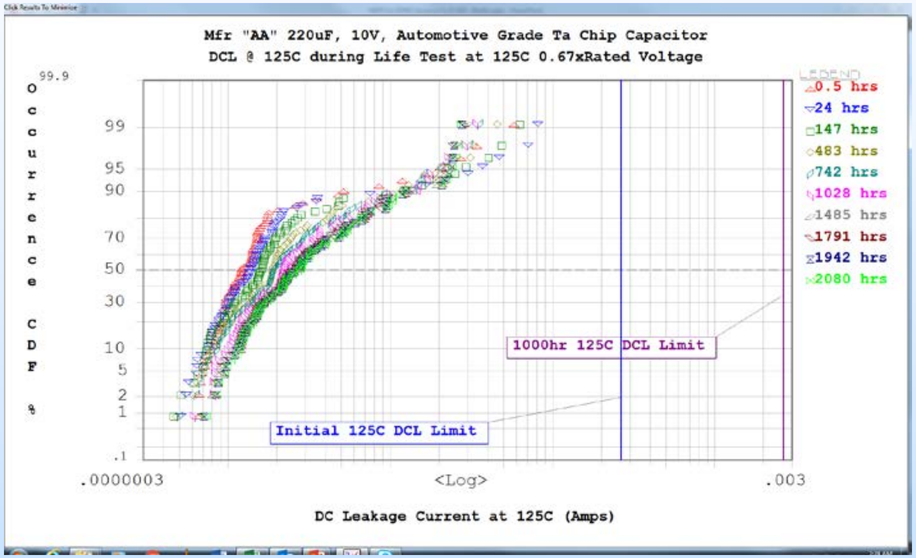




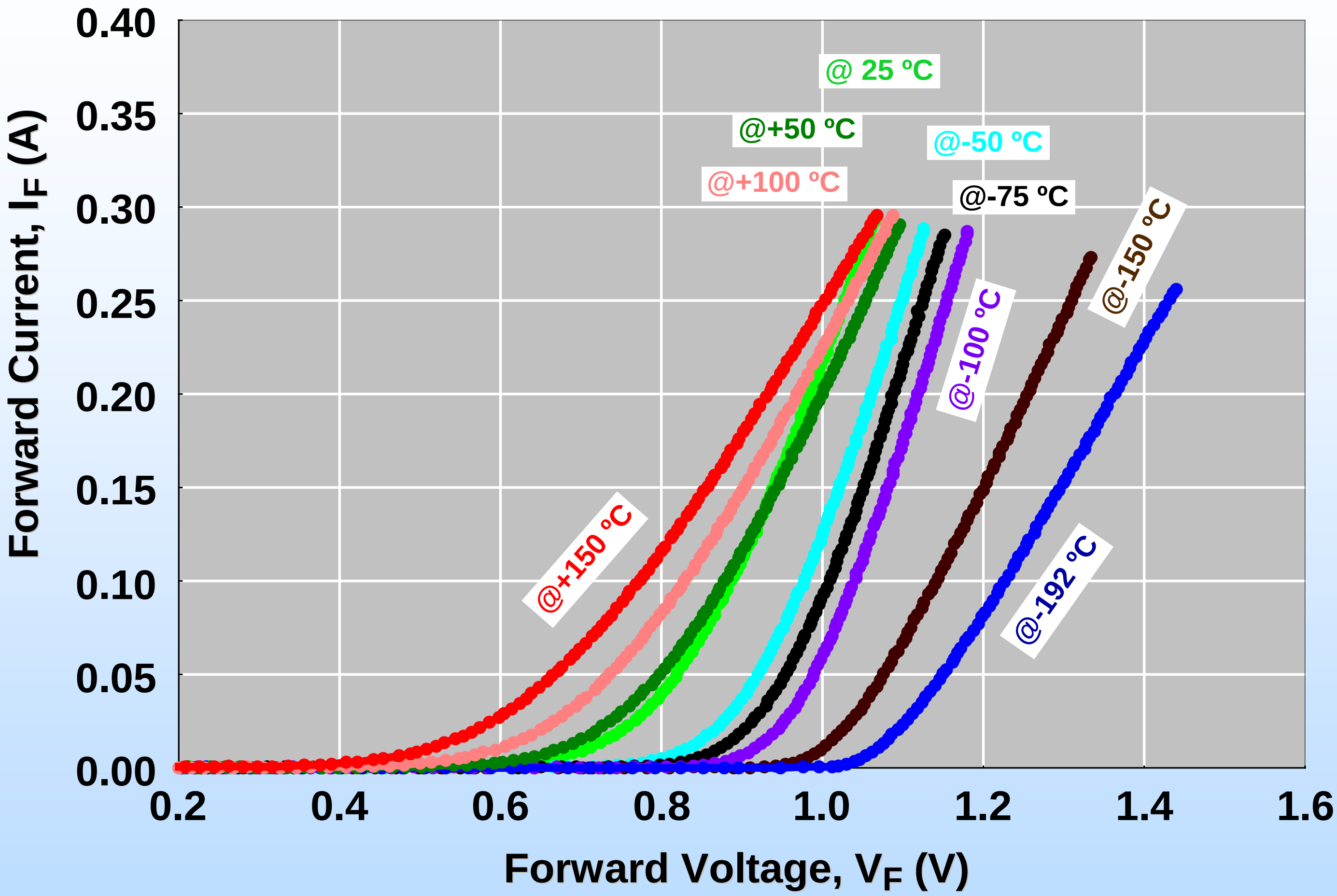


AEC-Q200: D-Case Tantalum Chip Capacitors, DC Leakage Current at 125^{0}C During Life Test





Switching Diode Testing



- **Forward V/I characteristics of switching diode versus temperature**

Switching Diode Temperature Testing Summary

- **Temperature cycling and short extreme temperature exposures caused no effect on the plastic packaging.**
- **Diodes maintained operation between -192C and +150C with minimal characteristic changes**
- **Temperature Changes observed:**
  - **Increase in leakage current at high temperature**
  - **Decrease in breakdown voltage at extremely high and low temperatures**
  - **Further investigation needed to determine whether switching diode function and packaging would function in extended temperature ranges (-192C) for long periods of time.**

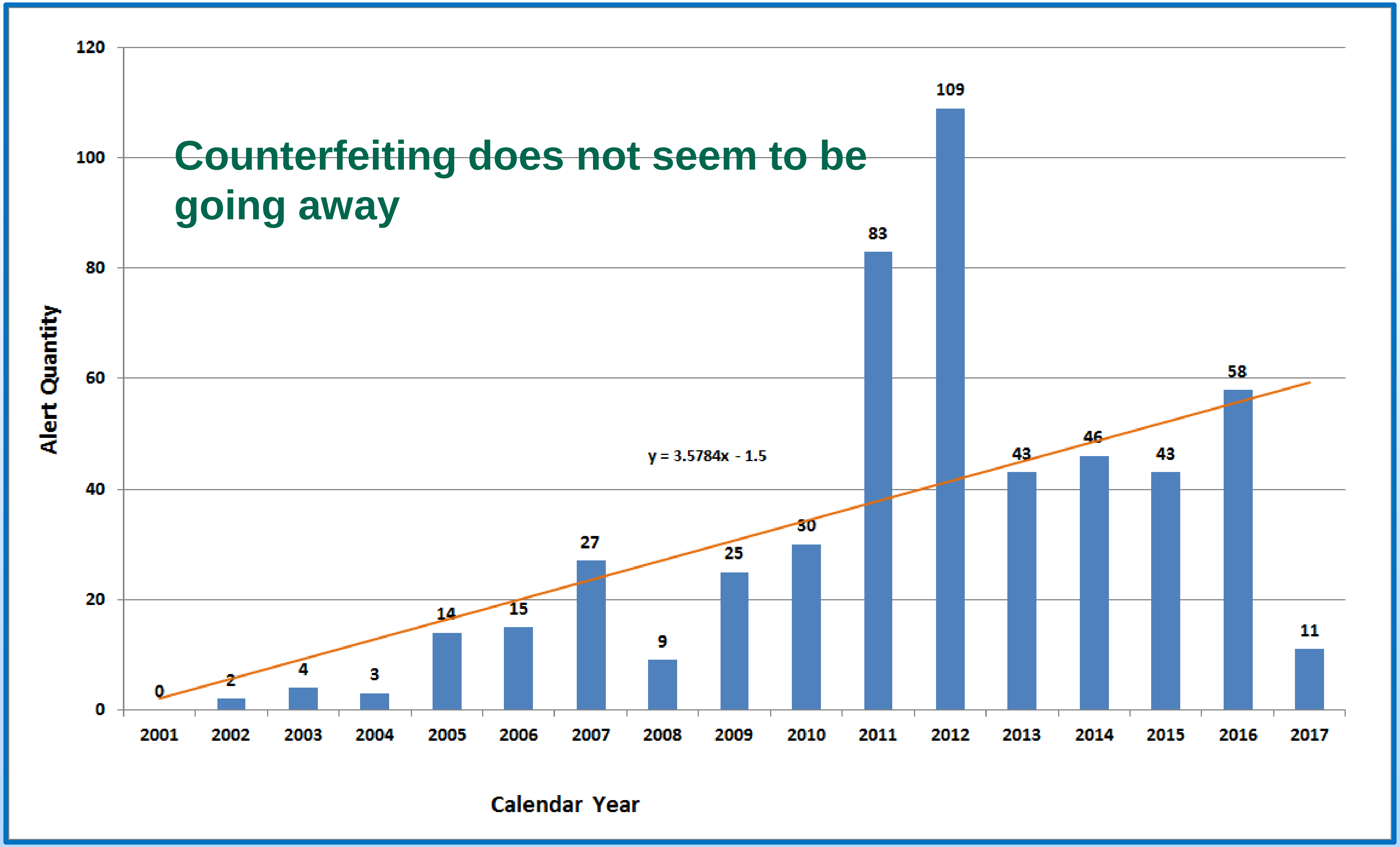
Reverse-bias Tantalum Chip Capacitors

- **Capacitors in International Space Station experiment pallets known as Express Logistics Carriers (ELCs) were found installed backwards**
- **They have so far functioned satisfactorily for 6 years on orbit**
- **The risk of failure needs to be understood to avoid a workaround including a space walk**
- **Why are the capacitors not failing and what performance envelope must they occupy to avoid failure for as long as possible?**
- **Experiments in progress to look at effects of voltage, temperature and humidity**

Multi-layer Ceramic Capacitors (MLCCs)

- **NASA has recently experienced 2 on-orbit MLCC anomalies on one project**
  - **Characteristics duplicated on engineering model**
- **Both came from same 2010 lot**
- **Investigation has found previous indications of similar anomalies going back to at least 2004 and a discovery of another NASA instrument failure in 2014 traceable to the same problem (2005 lot)**
- **Anomalies are a gradual, yet significant increase in leakage currents and are associated with internal delaminations and cross dielectric cracks**
- **Too early in our investigation to identify the problem as manufacturer or part type specific.**
- **Handling and soldering stresses may be causing a sub-population to develop new or exacerbate pre-existing delams and cracks. They passed all MIL specification tests**
  - **Exploratory experiments have begun**
- **Indications are this problem was recognized years ago but not communicated in a way NASA could hear**

Quantity of Counterfeit EEE Parts Alerts per Year



Upcoming Challenges

- **Complexity issues for inspection, screening, device preparation, and test**
  - **2.5/3D Packages/ICs**
  - **Package on Package (PoP) Commercial Devices**
  - **An FPGA combined with an SOC (MPSOC+ from Xilinx)**
  - **Cu Wirebonds**
- **Assurance**
  - **Automotive and catalog commercial EEE parts?**
  - **Increasing risk with a worldwide supplier base**
  - **Standardization**
  - **Source Consolidation.**
    - ***What if the only source left is in an inhospitable or unauditable part of the world?***

Summary and Comments

- **Roadmaps and Tasks are constantly evolving as technology and products become available.**
  - **Like all technology roadmaps, NEPP/NEPAG's are limited to funding and resource availability.**
  - **We should anticipate resource reductions**
  - **Partnering is the key:**
    - **Government,**
    - **Industry, and,**
    - **University.**
- **We look forward to further opportunities to partner.**

https://nepp.nasa.gov