Automotive Electronic Parts and Standards for Military Applications

Presented by:
David Locker
Electronic Parts/Processes Technology Team
Engineering Directorate
U.S. Army Aviation and Missile Research, Development, and Engineering Center

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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Outline

- Application compatibility
- Leverage supply chain discipline and requirements
- Automotive parts application details
Industry Standards for Electronics

- **JEDEC (Companies)**
  - JESD22, JESD47
- **Automotive Electronics Council (Companies)**
  - AEC Q100 (Microcircuits), Q101 (Discrete Semis), Q200 (Passives)
- **Society of Automotive Engineers, Aerospace Council (Individuals)**
  - APMC: EIA-STD-4899, EIA-933, SAE STD-0016
  - G12: GEIA-STD-0008
  - G25: AS12500
- **International Electrotechnical Commission (Countries)**
  - TC107: Standards similar to APMC and G24

MIL-STD-11991 and MIL-STD-3018 can be used to effectively implement these industry standards.
• SAE ARP6379 framework (also part of MDA HALT Plus process)
• Characterize application requirements, characterize part capability, identify gaps between requirements and capability, fill gaps with test and analysis
Life Cycle Environments

- Factory Test/Environment: +10/+30°C, 40-60% RH (ΔT=100°C, 10 cy.)
- Transportation: -46/+71°C, 10-30% RH (ΔT=20°C, 30 cy.)
- Storage: -46/+71°C, 10-30% RH (ΔT=10°C, 3650 cy.)
- Transportation: -46/+71°C, 10-30% RH (ΔT=20°C, 30 cy.)
- Field Handling: -46/+71°C, 10-30% RH (ΔT=30°C, 30 cy.)
- Field/Tactical Use: -32/+71°C, 10-30% RH (ΔT=40°C, 30 cy.)

- Determine all environments to be experienced
- Understand degradation mechanisms for item
- Determine appropriate assembly level for verifying all requirements

✔ Example: System level testing cannot likely address solder joint durability and tin whisker risk due to considerations for test acceleration factors and competing failure mechanisms
• Primary degradation environments
  – Humidity
  – Temperature/power cycling
  – Operation
• Primary degradation mechanisms
  – Delamination of mold compound/underfills from die and substrate
    • Subsequent thermal expansion mismatch stresses
      – Wires, solder balls, die surface
    – Copper wire bond corrosion
    – Semiconductor operation wear-out
• Emerging issue: atmospheric radiation single event upsets
• Reliability verification (Q100), 3 lots of 77 devices in 96 hours HAST
  Notional use: 20°C, 50% RH, 10 years
  – Peck Model (nominal, 0.7 eV, n=3)
    • Assuming Exponential distribution, $F = 383$ ppm (0.99962)
    • Weibull, $\beta = 2$, more representative, $F = 37$ ppm (0.99996)
  – JESD47, 1 lot of 77 devices: $\beta = 1$, $F = 1150$ ppm; $\beta = 2$, $F = 111$ ppm

• Extended HAST testing for risk mitigation
  – Some suppliers test to ~192 hrs or more
    • Automotive and Texas Instruments Enhanced Plastic
      • $\beta = 2$, $F = 9$ ppm (0.99999)
  • Common Military application life cycles
    – Ave 14-28°C, 30-50% RH, 5-30 years
    – Diurnal $\Delta T$ 10-15°C, 5-30 years; Power cycling $\Delta T$ 20-60°C, 100-2000 cycles

\[ A_f = \left( \frac{RH_t}{RH_u} \right)^n \exp \left[ \frac{E_a}{k} \left( \frac{1}{T_u} - \frac{1}{T_t} \right) \right] \]

\[ R = 1 - F = e^{-\left( \frac{t}{\eta} \right)^\beta} \]

HAST: Highly Accelerated Stress Test, 130°C/85% RH, JESD22-A110
Failure Distribution Effects

Failure “level” determines sample size, reject criteria, confidence level.

Monitored failure points allow distribution characterization.

A and B mechanisms meet requirement with increasing hazard rate.

D could pass test, but not meet requirement; however, it is decreasing hazard rate.

Sample size and CL require $T_T > T_L$, A would “fail” without constant or periodic monitor.

A (constant failure rate)

B (constant failure rate)

C (increasing failure rate)

D (decreasing failure rate)

Life Requirement, $T_L$

Test Requirement, $T_T$

Cumulative Failure
Automotive AEC Q006 instituted June 2015 (rev A in July 2016)
  - Cu wire stress test qualification results required
  - Wire pull/ball shear – mean, min, max, standard deviation
    - Required after Q100 stress, suggested after 2X exposure
  - CSAM images before/after stressing
    - Delamination criteria for 2X standard exposure of Q100
  - Electrical/ATE functional/parametric test results before/after stress tests
  - Cross-sections of ball/wedge bonds
    - Required after Q100 stress, suggested after 2X exposure
  - Suggests Board Level Stress Test

JESD47 much less comprehensive Copper wire assurance
  - Ball shear standard, JESD22-B116, discusses copper issues
  - JESD47 does not require enhanced testing of copper wire compared to gold; only criteria is for pre-mold
Automotive Grade Capability

• End use requirements require very low quality defects (<1 ppm)
  – Assembly complexity drives quality requirement
  – Automotive applications now targeting 1 ppb defects

• Use application generally aims for 10-15 years in field
  – Automotive life cycle conditions correspond to many military applications

• Supply chain contractual requirements encourage meeting high reliability requirements

Military Applications can leverage Automotive supply chain discipline and infrastructure to obtain high reliability parts at reasonable cost
• Need to verify manufacturer Data backs up Marketing
• Data
  – Production Part Approval Process
  – Informal manufacturer queries (customer support)
  – Independent testing
• Marketing information is not sufficient data
  – “Meets automotive grade requirements”
  – “Suggested for Automotive application”
  – “Q100 capable”
• Upcoming SAE AS6294 leverages AEC Q100
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