U.S. ARMY RDECOM

Presented to:

Parts Standardization & Management Committee

Automotive Electronic Parts and Standards for Military Applications

AMRDEC

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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Outline

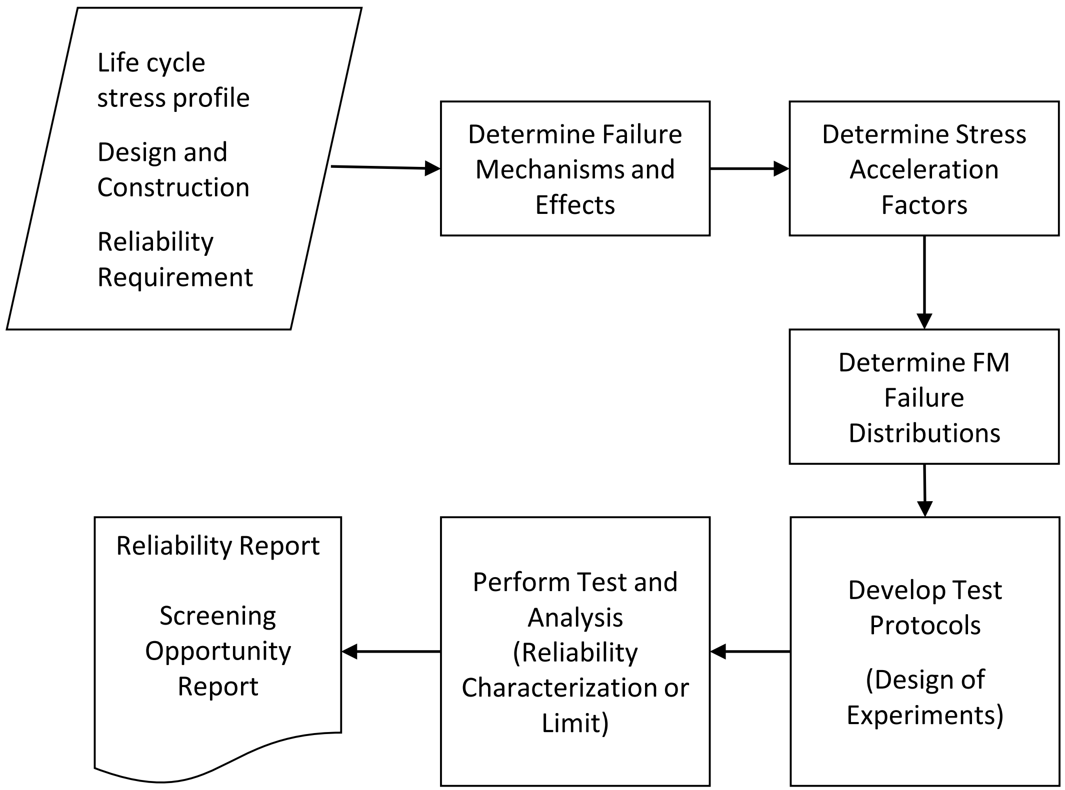
- Application compatibility
- Leverage supply chain discipline and requirements
- Automotive parts application details

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
  - G24: GEIA-STD-0005-1, -2, GEIA-STD-0006, GEIA-STD-0003
  - 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

Application Assessment General Procedure



- **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.

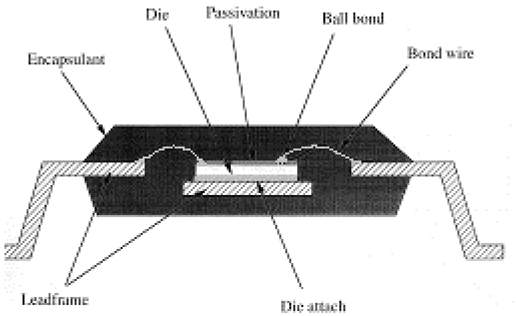
→ **Transportation**
-46/+71°C, 10-30% RH
ΔT=20°C, 30 cy.

→ **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



PEM Application Example Q100 vs JESD47

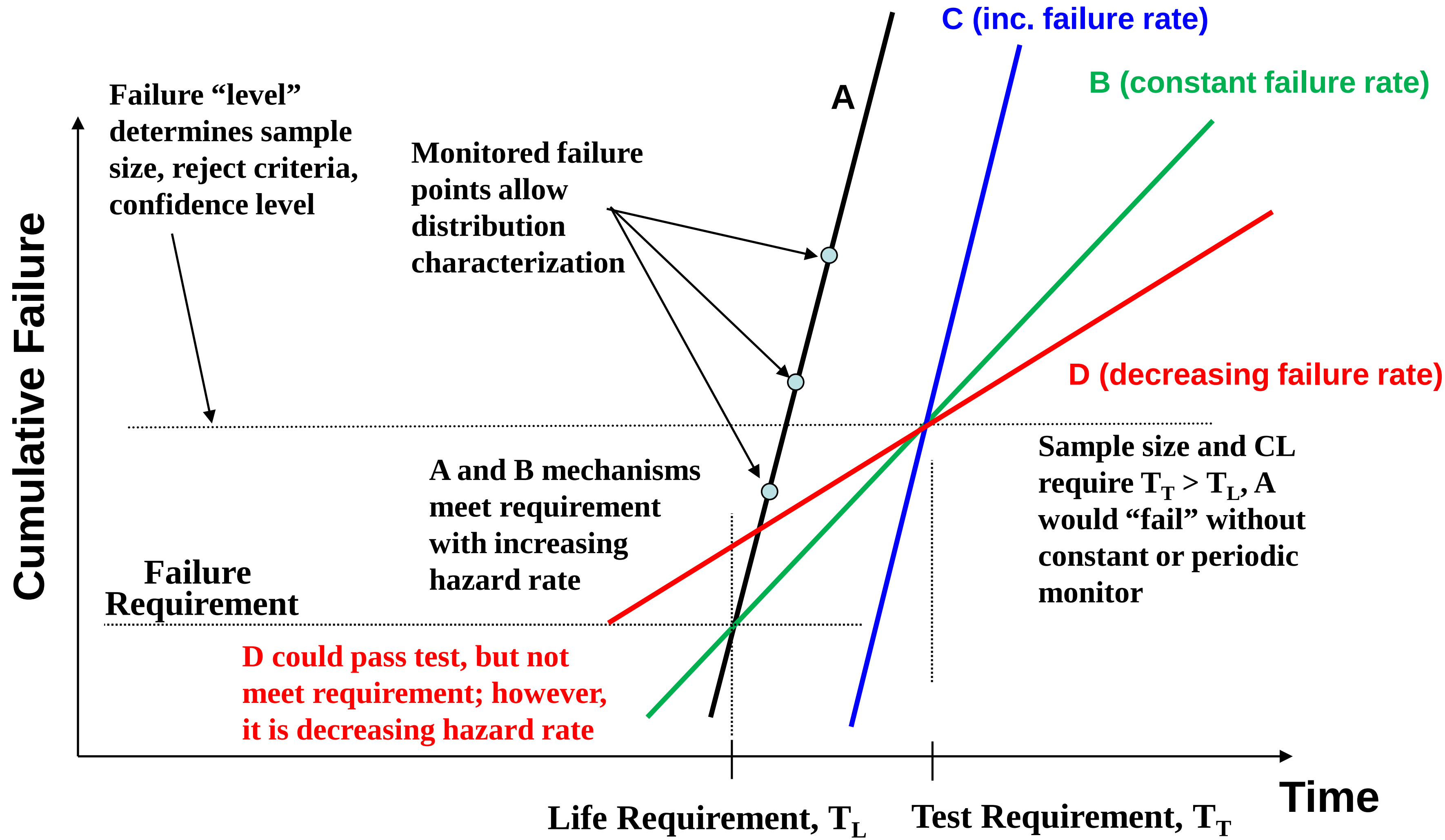
- Reliability verification (Q100), 3 lots of 77 devices in 96 hours HAST Notional use: 20°C, 50% RH, 10 years
  - Peck Model (nominal, 0.7 eV, n=3)
    - Assuming Exponential distribution, F = 383 ppm (0.99962)
    - Weibull, β = 2, more representative, F = 37 ppm (0.99996)
  - JESD47, 1 lot of 77 devices: β = 1, F = 1150 ppm; β = 2, F = 111 ppm
- Extended HAST testing for risk mitigation
  - Some suppliers test to ~192 hrs or more
    - Automotive and Texas Instruments Enhanced Plastic
    - β = 2, F = 9 ppm (0.99999)
- Common Military application life cycles
  - Ave 14-28°C, 30-50% RH, 5-30 years
  - Diurnal ΔT 10-15°C, 5-30 years; Power cycling ΔT 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



PEM Application Example
Copper Wire Bonds

- **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

Auto Grade Application Detail

- **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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