**PREFERRED
RELIABILITY
PRACTICES**

PART JUNCTION TEMPERATURE

Practice:

Maintain part junction temperatures during flight below 60^0C. (Short-term mission excursions associated with transient mission events are permissible.)

Benefit:

Reliability is greatly increased because the failure rate is directly related to the long-term flight temperature.

Programs That Certified Usage:

Voyager, Viking, Mariner series, Galileo

Center to Contact for Information:

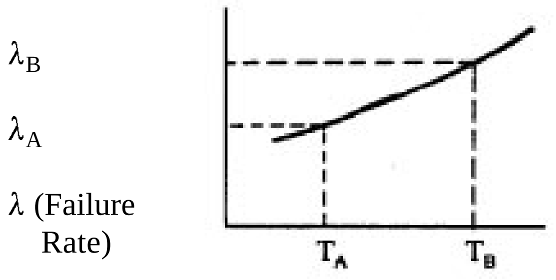
Jet Propulsion Laboratory (JPL)

Implementation Method:

Establish in-specification design (and test) temperatures $\geq 75^0$C and limit part junction temperatures (J_T) to $\leq 110^0$C[1] which constrains permissible part junction temperature rise (ΔJ_T) to $\leq 35^0$C.

Technical Rationale:

Basic reliability is directly related to temperature and time, i.e., $\lambda = f(T,t)$. The following relationship is obtained either theoretically from the Arrhenius relationship ($\lambda = A\exp[-E_a/k\ (1/T - 1/T_0)]$) or empirically from the data in MIL-HDBK-217E.



Given:
- Specific part
- Specific derating factor
- Specific chemical activation energy

**JET
PROPULSION
LABORATORY**

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[1] This practice has been verified on programs in place before the release of MIL-STD-975H. If the MIL-STD-975H junction temperature of 100^OC is used, junction temperature rise should be changed to assure that long-term flight junctions stay below 60^OC.

The curve shape is representative of all electronic parts (and most mechanical processes) in the range of temperature typified by space exposure. Simply stated, the higher the long-term flight temperatures, the lower the reliability:

$$\frac{B\ failures}{A\ failures} = \frac{\lambda_B}{\lambda_A}$$

Assume that a design and test temperature of 75^0C is chosen. In the figure from MIL-STD-883B reproduced on page 4, observe that a 25^0C ΔT corresponds to a failure rate increase of more than an order of magnitude-- i.e., >1000% difference. MIL-HDBK-217E has different values, but the factor is up to approximately 3X on some parts (depends on derating criteria and parts qualification). The following example illustrates the effect of this relationship on design and test temperatures.

Assume the following conditions as an example:

Case A: T = 75^0C in-specification design temperature for baseplate

Case B: T = 50^0C in-specification design temperature for baseplate

Case A and Case B:

T = 25^0C long-duration flight temperature for baseplate

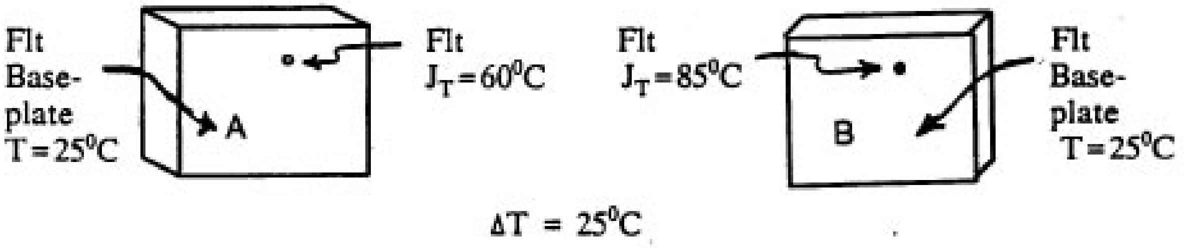
J_T = 110^0C limit for any exposure or analysis

Then:

Design/Test Parameters

	Case A	Case B
Design Baseplate	75^0C	50^0C
J_T limit	110^0C	110^0C
Permitted ΔJ_T rise	35^0C	60^0C

Flight Conditions



PART JUNCTION TEMPERATURE

from Arrhenius

$$\frac{Reliability\ (Case\ A)}{Reliability\ (Case\ B)} \geq \frac{10}{1}$$

NOTE: In the example given, short-term ground test exposure on the order of 1-2 weeks will use an insignificant amount of life in hardware designed for long-life and high reliability. For example, a 1-week thermal vacuum test at 75^0C provides a short-term high temperature screen in the actual circuit usage configuration to provide confidence for a long-term exposure under flight conditions ($J_T < 60^0$C), and uses only 0.018% of the parts capability. This demonstration is an important element in establishing pre-launch confidence in design adequacy.

Impact of Non-Practice:

Reliability of electronic parts will be reduced significantly.

Related Practices:

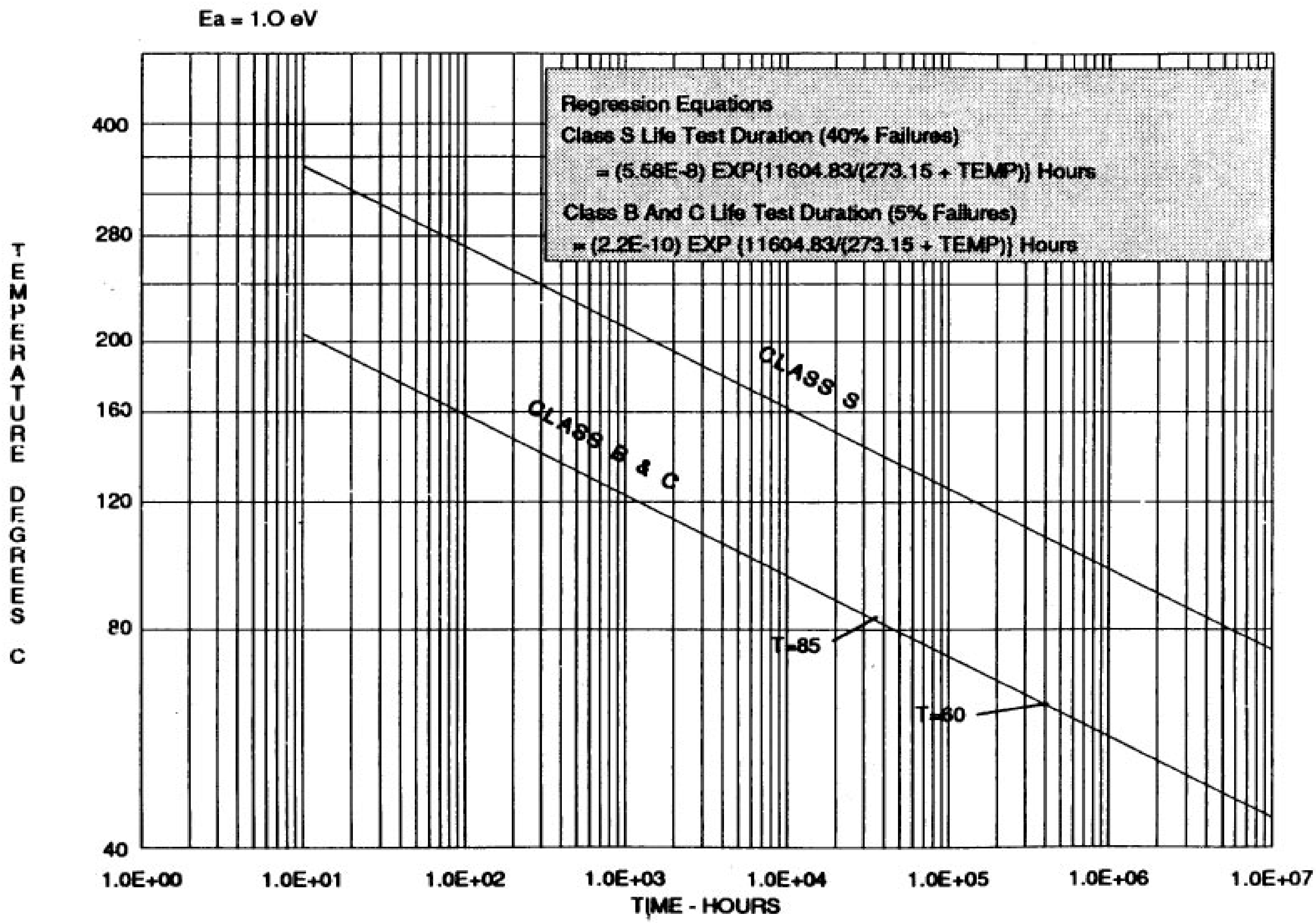
1. *Thermal Design Practices for Electronic Assemblies*, Practice No. PD-ED-1226

References:

1. Gibbel, M. and Clawson, J.F., “Electronic Assembly Thermal Testing Dwell/Duration/ Cycling,” Proceeding of the 12th Aerospace Testing Seminar, March 13-15, 1990.

2. Gibbel, M. And Cornford, S.L., “Surface Mount Technology Qualification Methodology (Testing and Verification),” Proceeding of the NASA Surface Mount Technology Workshop, NASA Lyndon B. Johnson Space Center, Houston, Texas, July 28-29, 1992.

PART JUNCTION TEMPERATURE



Regression Equations

Class S Life Test Duration (40% Failures)

= (5.58E-8) EXP{11604.83/(273.15 + TEMP)} Hours

Class B And C Life Test Duration (5% Failures)

= (2.2E-10) EXP {11604.83/(273.15 + TEMP)} Hours