CONNECTORS

FAILURE MECHANISMS AND ANOMALIES

Connector Life

Connector life is affected by cyclic wear-out failure mechanisms. As the connector contacts are repetitively engaged and disengaged, plating surfaces are eroded and exposed to corrosive elements of the surrounding atmosphere. Repeated mating and un-mating also results in physical wear of the contact material, affecting the integrity of the connecting interfaces, the connector shell engagement interfaces, and the mounting/cable attachment hardware. Surface contact points become worn, making unsymmetrical contacts and corrosion results in non-conducting films on the contact surface. The result can be a significantly increased interface resistance, and in power connection applications, an increase in temperature at the interface that can accelerate further contact interface deterioration.

Relative Failure Modes

Relative failure modes of connectors are illustrated in Table 1. Most failures are open contact points or intermittent connections. Heat may cause these failures, but heat rise in a connector is normally very small, because the conductor resistance is in the order of miliohms. Failures from overheating normally occur only if excessive current is applied or if there is a defect in the contact, that causes a localized hot spot.

Table 1. Normalized Failure Mode Distributions[1]

Failure Mode	Relative Failure Mode Probability
Open	61%
Poor Contact or Intermittent	23%
Short	16%

Failure Mechanisms

Misapplication and inadequate mounting can contribute to connector and system failures. Because connectors do not contribute to, or enhance the circuit function, ideally it should only minimally affect the circuit function. The following are examples that can effect a circuit malfunction and may result in system failure as well:

a. Using a smaller connector with underrated contacts to save on space in a power connection application can result in reduced circuit efficiency and shortened connector life.

[1] Failure mode data was taken from a combination of MIL-HDBK-978, “NASA Parts Application Handbook,” 1991; MIL-HDBK-338, “electronic Reliability Design Handbook,” 1994; “Reliability Toolkit: Commercial Practices Edition, “Reliability Analysis Center (RAC), 1998, and “Failure Mode, Effects, and Criticality Analysis (FMECA),” RAC,. 1993.

b. Using a connector with a standard insert, instead of a moisture proof or hermetic seal design in a severe environmental application can result in connector failure and possible damage to the system.

c. Choosing an inappropriate plating or inadequate dielectric insert material can reduce the effectiveness of a connection in high frequency applications by causing excessive insertion losses.

d. Inadequate mounting in severe shock or vibration applications can result in damage to the connector insert, contacts, and shell, as well as potential cable damage. Inadequate keying can result in miss-mating and subsequent circuit damage.

e. Threaded shells that are subject to repeated mating and un-mating can wear and gall, resulting in loose connections or jamming.

f. Inadequate floating can result in physical damage to the contacts and insert when mating.

g. High sustained tensile, torsion, and bending stresses placed on the connector by inadequate strain relief, and poorly routed, bundled and dressed cable and wiring harnesses can shorten connector life.

Excessive temperature causes connectors to fail by breaking down the insulation or the conductivity of the connector material. Failures usually occur in an avalanche-type style, described as follows: as operating temperature increases, insulation tends to become more conductive. Simultaneously, conductor resistance increases, further increasing temperature. This avalanching effect raises the temperature beyond the maximum designed operating temperature, resulting in damage to the insert (insulation) material and the conductor. The resulting failure can be either partial or complete. Complete failures occur if the operating temperature reaches the point where the conductor begins to melt, breaks down electrical conductivity, or where the insulation fails. A graph of service life verses operating temperature is shown in Figure 1. As shown, service life is directly proportional to how close operating temperature is to the maximum rated insert temperature of the device.

Prolonged operation, at elevated temperatures and humidity, within rated values, can result in overall degradation of connector performance, e.g. increases in contact resistance, corrosion of the shell, deterioration of the insert material, lessening of locking spring effectiveness (resilience aging is accelerated), jamming of corroded threaded coupling mechanisms, etc. Frequent inspections and preventative maintenance may be in order.

Low temperatures can also cause conductors to fail, but such failure mechanisms are relatively rare. Low temperatures actually tend to slow the detrimental chemical effects, increase conductivity, and result in a longer life. However, extremely low temperatures can cause damage to the nonmetallic portions of the connector. The thermal coefficient of expansion of such materials is lower than the metals and will contract enough.

Improper assembly of the connector to the cable or wiring can lead to failure. As conductor density and signaling frequency increase, it becomes increasingly important that manufacturer specified stripping dimensions, alignment tolerances, and assembly procedures are strictly adhered to. Special tools and fixtures may be required and obtained from the manufacturer.

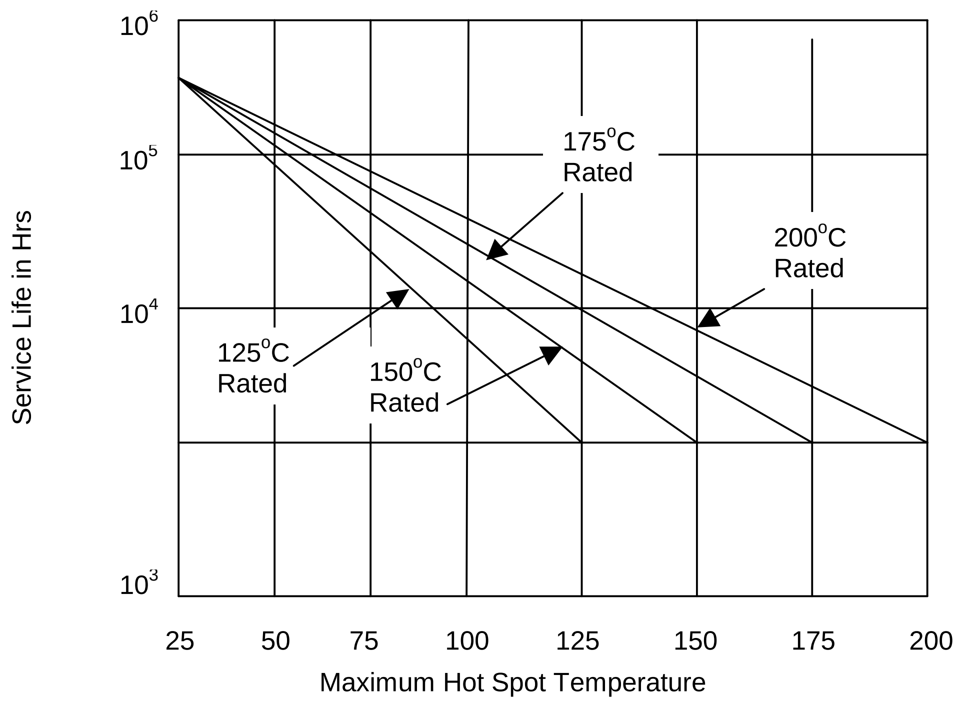

Figure 1**.** Service Life vs. Hot Spot Temperature