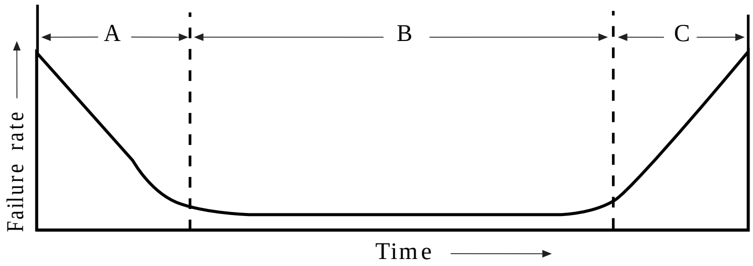
RELIABILITY

With the advancements in aluminium electrolytic capacitor technology, the capacitors used in equipments must have a very long life characteristics and must operate even under severe conditions. A careful choice of a capacitor for a particular application and an adequate installation in the circuit will assure a good service life. In any case any component will eventually fail, usually this occurs due to a slow, steady drift of parameters called wear-out; sometimes there is a sharp change in capacitor properties also called catastrophic failure. In general terms the failure rate of aluminium electrolytic capacitors follows a bathtub curve with time as shown here.



THE BATHTUB CURVE
Three different areas are defined where capacitor life could be observed: A, B, C.

(A) Initial Failure Period

This is the period during which failures are caused by deficiencies in design, structure, manufacturing processes or severe applications. Such failures occur soon after the components are exposed to circuit conditions. In aluminium electrolytic capacitors, these failures are either corrected through aging or found during the 100% inspection processes and do not reach the field.
Initial failures due to a bad application of the capacitor such as inappropriate ambient conditions, over voltage, reverse voltage or excessive ripple current can be avoided with an adequate circuit design and careful installation.

(B) Random Failure Period (USEFUL LIFE)

Here the failure rate is low. During this period a constant failure rate is shown.
These failures are not related to operating time but to application conditions.
This period of useful life is normally calculated with a confidence level of 60%.

(C) Wear-Out Failure Period

In this period the properties of a component gradually deteriorate and the failure rate increases with time. Aluminium electrolytic capacitors end their useful life during this period.
Criteria for judging failures varies with application design factors.

Reliability represents this measure of the expected failure rate during the useful life of the capacitor.
Failure rate is defined as the number of components failing during a unit working time.
It is expressed by following formula:

1 fit = 1 10^{-9}/hours (failure in time) also indicated as percentage of failures in 1000 hours.

$$\lambda = \text{number of failures} \ / \ (\text{number of components tested x working time})$$

MTBF (Mean Time Before Failure) could be calculated according to failure rate following the relashionship:

$$MTBF = 1/\lambda$$

This value defines the failure frequency occurring on a large number of components inside an equipment, therefore is not suitable to predict failure on one single capacitor. Statistical calculations should be used instead. It is helpful as a design tool to determinate reliability features for components and complex systems.

EXAMPLE

A batch of 10000 capacitor tested, for 40000 operating hours, finding 4 failures.
λ= 4/10000 x 1/40000 h = 10 fit = 0.001% /1000 hours

The failure rate calculation is derived from endurance tests at specified temperatures, taking into account all measurable and non-measurable defects arised. Kind of measurable defects are meant for each type of capacitor endurance test point. While non-measurable defects are meant to be open and short circuit, safety valve break or electrolyte leakage. Ripple current and ambient temperature contribute to the internal temperature rise of the capacitor, so affecting its useful life. In general, every 10°C reduction in temperature carries a multiplier factor of two times the life value.