

The typical useful life represents a period of time until the end of life of the capacitor. The end is caused by different incidents (or different failure modes) such as the following:

### MECHANICAL FAILURES

operation of safety vent due to overpressure, splitting of PVC sleeve and damaged insulation, unusable terminals, external short circuiting of terminals due to spilling of electrolyte.

### OVER FAILURES

when a short or open circuit occurs.

### ELECTRICAL CHARACTERISTICS FAILURES

In a group of capacitors considered to have reached the end when 3% of them have failed, useful life is influenced by following failure criteria:

#### END OF LIFE CRITERIA (for $V \leq 100V$ DC and for capacitors with diameter $\leq 35$ mm)

- ESR > 3 times initial value
- impedance > 3 times initial value
- capacitance value change of greater than 30%
- leakage current over initial limit.

#### END OF LIFE CRITERIA (for $V \geq 160V$ DC and for capacitors with diameter $\geq 40$ mm)

- ESR > 1.75 times initial value
- impedance > 1.75 times initial value
- capacitance value change of greater than 15%
- leakage current over initial limit.

In some cases, it is possible that even larger values of the above indicated could be applied without leading to failure, but generally capacitors tested in the laboratory at Kendeil show standard behaviour around these limits.

Obviously, when operating at lower voltages together with moderate temperature as well as lower values of current, the final life expectation should be better.

When an adequate cooling system has been provided, the overall performance is substantially better and the life of the capacitor is improved.

In normal conditions, statistics are produced after extensive endurance tests compliant to standard specifications. Depending of the type of capacitor, endurance tests have been undertaken over different lengths of time using capacitors coming from production batches. Data is collected and results summarized, so we have generated wide information displayed graphically for each model, which can be seen on each product datasheet. The useful lifetime regarding the ambient temperature is given by following practical formula:

$$\text{USEFUL LIFETIME} = L_{\text{OPMAX}} \times 2^{(T_{\text{max}}+10-T_c) / 10}$$

Where:

USEFUL LIFETIME expressed in hours

$L_{\text{OPMAX}}$  = Lifetime at max rated operating temperature (eg.: 10000 hs at 85°C)

$T_{\text{max}}$  = Actual operating temperature of the capacitors (eg.: 85°C for K01 type)

$T_c$  = Temperature of the core = internal hot spot of the capacitor (°C)

Example:

For a capacitor that has an internal core temperature of 55,43 °C, at ambient temperature of 45 °C, the life, expected calculation gives the following:

$$\begin{aligned} \text{USERFUL LIFETIME} &= 10000 \times 2^{(85+10-55.43) / 10} \\ &= 10000 \times 2^{3.956} \\ &= 155194 \text{ hours} \end{aligned}$$

NOTE

Applicable temperature range is the temperature depending on the capacitor type characteristics, usually situated in the operating range of -40°C to +85°C or 105°C . Typically, each 10°C step carries a reduction factor of 2 times the lifetime value.

Useful life is also determined by ripple current.

It is advisable not to apply a ripple current exceeding the max ripple current allowed as this will shorten capacitor life and may result in opening of the vent or catastrophic failure.

It often happens that heating due to ripple current is even more severe than ambient temperature stress.