ALUMINUM ELECTROLYTIC CAPACITORS

■ TECHNICAL NOTE

$$L=L_0 \times 2^{\left(\frac{T_0-T}{10}\right)} \text{---------(1)}$$

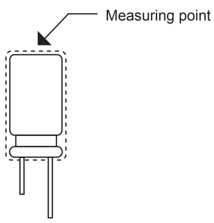
Where L: Life at temperature T
L_0: Life at temperature T_0
The effects to the life by derating of applied voltage etc. are neglected because they are small compared to that by the temperature.

2-2 Estimation of life considering the ripple current.
The ripple current affects the life of a capacitor because the internal loss (ESR) generates heat. The generated heat will be:
$P=I^2R$··················(2)
Where I: Ripple current (Arms)
R: ESR (Ω)
With increase in the temperature of the capacitor:

$$\triangle T=\frac{I^2R}{A \cdot H} \text{---------(3)}$$

Where △T: Temperature increase in the capacitor core (deg.)
I: Ripple current (Arms)
R: ESR (Ω)
A: Surface area of the capacitor (cm^2)
H: Radiation coefficient (Approx. 1.5~$2.0\times10^{-3}W/cm^2\times$℃)

The above equation (3) shows that the temperature of a capacitor increase in proportion to the square of the applied ripple current and ESR, and in inverse proportion to the surface area. Therefore, the amount of the ripple current determines the heat generation, which affects the life. The value of △T varies depending on the capacitor types and operating conditions. The usage is generally desirable if △T remains less than 5℃. The measuring point for temperature increase due to ripple current is shown below;



Test results:
(1) The life equation considering the ambient temperature and the ripple current will be:

$$L=L_0 \times 2^{\left(\frac{T_0-T}{10}\right)} \times K^{\left(\frac{-\triangle T}{10}\right)} \text{---------(4)}$$

Where L_0: Life at DC operation (h)
K: Ripple acceleration factor
(K=2, if with in allowable ripple current)
(K=4, if exceeding allowable ripple current)
T_0: Maximum guaranteed temperature (℃)
T: Operating temperature (℃)
△T: Temperature increase at capacitor core (deg.)
(2) The life equation based on the life with the rated ripple current applied under the maximum guaranteed temperature will be a conversion of the above equation (4), as below:

$$L=L_0 \times 2^{\left(\frac{T_0-T}{10}\right)} \times K^{\left(\frac{\triangle T_0-\triangle T}{10}\right)} \text{---------(5)}$$

$$L=L_0 \times 2^{\left(\frac{T_0-T}{10}\right)} \text{---------(1)}$$

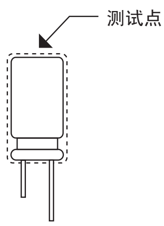
其中，L：温度T时的寿命
L_0：温度T_0时的寿命
与温度比较，降压使用对电容器的寿命影响很小，可忽略不计。

2-2. 考虑纹波电流时寿命的推算
叠加纹波电流，由于内部等效串连电阻（ESR）引起发热，从而影响电容器的使用寿命，产生的热量可由下式计算
$P=I^2R$··················(2)
I：纹波电流（Arms）
R：等效串联电阻（Ω）
由于发热引起的温升

$$\triangle T=\frac{I^2R}{A \cdot H} \text{---------(3)}$$

其中，△T：电容器中心的温升（℃）
I：纹波电流（Arms）
R: ESR (Ω)
A：电容器的表面积(cm^2)
H：散热系数(1.5~$2.0\times10^{-3}W/cm^2\times$℃)

上面公式（3）显示电容器的温度上升与纹波电流的平方以及等效串联电阻ESR成正比，与电容器的表面积成反比，因此，纹波电流的大小决定着产生热量的大小，且影响其使用寿命，电容器的类型以及使用条件影响着△T值的大小，一般情况下，△T<5℃。下图表示纹波电流引起的温升的测量点



测试结果：
（1）. 考虑到环境温度和纹波电流时的寿命公式

$$L=L_0 \times 2^{\left(\frac{T_0-T}{10}\right)} \times K^{\left(\frac{-\triangle T}{10}\right)} \text{---------(4)}$$

其中，L_0：直流工作电压下的使用寿命
（K=2，纹波电流允许的范围内）
（K=4，超过纹波电流范围时）
T_0：最高使用温度
T：工作温度
△T：中心温升
（2）电容器工作在额定的纹波电流和上限温度时，电容器的寿命可通过转化（4）式得到，如下：

$$L=L_0 \times 2^{\left(\frac{T_0-T}{10}\right)} \times K^{\left(\frac{\triangle T_0-\triangle T}{10}\right)} \text{---------(5)}$$