

## 1 General Specifications

### Capacitance

Nominal capacitance is specified at a frequency of 120Hz and a temperature of 20°C. Unless specified otherwise, standard capacitance tolerance is  $\pm 20\%$  of the nominal value.

### Working Voltage

The maximum allowable sum of continuous DC voltage plus peak ripple voltage, which can be applied to the capacitor.

### Surge Voltage

The maximum transient voltage level allowed for short periods of time without sustaining permanent damage to the capacitor. Values are listed in the standard product ratings.

### Leakage Current

Imperfections in the capacitor dielectric allow a small current to flow. This resultant leakage current is specified as a maximum after 5 minutes application of rated voltage at 20°C. See individual series listings for leakage current equations.

### ESR (Equivalent Series Resistance)

Equivalent series resistance causes heat generation within the capacitor when AC ripple current flows through the capacitor. Maximum ESR is normally specified at 120Hz, 20°C.

### Ripple Current

Ripple current is the rms value of alternating current flowing through a capacitor. This current causes an internal temperature rise due to power losses within the capacitor.

The standard product tables list allowable ripple current limits at specified maximum operating temperatures.

Ripple current multipliers for other temperatures and frequencies are listed in the introductory page for each series.

### Endurance Life Test

Endurance life is the minimum time a capacitor can operate under worst-case conditions.

Duration: Specified hours of life

Ambient Temp.: Maximum specified operating temperature

Ripple Current: Maximum specified value

Applied voltage: Rated DC voltage (the sum of the applied DC voltage plus the peak ripple voltage should not exceed rated working voltage).

*Post test requirements at +20°C:*

Leakage Current: < Initial specified value

Cap. change:  $< \pm 20\%$  of initial measured value

D.F./E.S.R.: <200% of initial specified value

### Shelf Life Test

Duration: 1000 hours

Ambient Temp.: Maximum specified operating temperature

Applied Voltage: None

*Post test requirements at +20°C:*

Same as the preceding Endurance Test requirements.

Measurements are to be performed after applying DC working voltage for 30 minutes.

## 2 Storage Life

Leakage current will increase during extended storage.

Capacitors should be stored in temperatures not to exceed +40°C and protected from direct exposure to sunlight.

Under normal conditions, storage life can exceed 10 years.

It is recommended that the leakage current be checked for conformance to the specified limit if the capacitor has been stored for four years or more.

Storage may require reforming of the capacitor to reduce leakage current below the specified limit. This can be accomplished by applying rated voltage in series with a 1000 resistor for a time period of 30 ~ 60 minutes.

The capacitor is acceptable for use if the capacitor leakage current is within the original specified limit or the capacitor is reformed to within the original specified limit.

Storage in high humidity conditions could cause oxidation of the terminal plating, which could adversely affect solderability.

### 3 Operation Life Expectancy

Aluminum electrolytic capacitors have a specified life at a maximum temperature and ripple current.

#### Operation Life Expectancy (continued)

Capacitor life at lower temperatures follows "The Doubling 10°C Rule" where life is doubled for each 10°C reduction in operating temperature. Voltage derating can also improve life expectancy and reliability. The following equations are useful for determining the life of the capacitor in the application;

For  $WV = 10\sim 100VDC$ ;

$$L_2 = L_1 \times 2^{(T_1 - (T_2 - \Delta T))/10}$$

For  $WV = 160\sim 500VDC$ ;

$$L_2 = L_1 \times 2^{(T_1 - (T_2 - \Delta T))/10} \times (V/WV)^{-6.5}$$

Where;

$L_1$  = Specified life (hours) at maximum operating temperature.

$L_2$  = Maximum specified operating temperature.

$T_1$  = Maximum specified operating temperature.

$T_2$  = Actual ambient temperature (°C)

$\Delta T$  = Ripple current temperature rise (°C).

$WV$  = Rated Capacitor voltage (160~500VDC).

$V$  = Applied voltage

*NOTE:  $WV \geq V \geq 0.9xWV$*

Use of the ripple current temperature multipliers listed for each product series may limit life to the value originally specified for maximum operating temperature.

It is recommended that the ripple current heat rise be limited to 15°C at lower ambient temperatures to accomplish the maximum operating life in the application.

End of life is defined by the occurrence of one of the following:

- Capacitance change exceeds 20% of the initial measured value.
- Dissipation factor exceeds 200% of the initial specified value.

- Leakage current exceeds the initial specified value.

NOTE: Electrical measurements are taken after the capacitor is stabilized at 20°C.

### 4 Circuit Design Considerations

#### Operating Temperature and Frequency

Aluminum electrolytic capacitor electrical characteristics are normally specified at a temperature of 20°C and a frequency of 120Hz.

Electrical parameters are temperature and frequency dependent as follows:

#### (1) Effects of operating temperature

At higher temperatures capacitance and leakage current increase while ESR decreases.

At lower temperatures, capacitance and leakage current will decrease while ESR increases.

#### (2) Effects of frequency

Capacitance, impedance, and ESR will decrease as frequency increases.

At lower frequencies, ripple current generated temperature will rise due to increasing ESR.

#### Reverse Voltage

DC capacitors have polarity, which must be verified before insertion.

Avoid use in circuits with changing or uncertain polarity.

Ensure that allowable ripple currents super-imposed on DC voltage do not cause reverse voltage conditions.

#### Charge / Discharge applications

Standard capacitors are not suitable for use in strobe or photoflash applications.

Contact the factory for low duty cycle applications.

#### Capacitors Connected in Parallel

Circuit resistance can approximate the series resistance of the capacitor, resulting in ripple current load imbalances. Careful design of wiring methods can

minimize excessive ripple currents applied to a capacitor.

### Capacitors Connected in Series

Normal DC leakage current variations among capacitors can cause voltage differences. The use of voltage dividing sharing resistors with consideration to leakage currents can compensate for voltage imbalances.

### Circuit Design Considerations (continued)

#### Electrical Precautions

Transient recovery voltage may be generated in the capacitor due to dielectric absorption. Typical voltage levels are less than 10% of the rated capacitor voltage. If required, the voltage can be discharged with a resistor.

The aluminum case of the capacitor has an indeterminate resistance to the cathode terminal. The sleeve on the capacitor is for marking and identification purposes and is not meant to electrically isolate the capacitor.

When designing circuits, consider worst case capacitor failure modes such as open or short circuits.

The effects of hot, electrically conductive, combustible electrolyte liquid or vapor escaping from the safety vent should also be considered.

## 5 Capacitor Mounting Considerations

### Circuit Board Design

Avoid wiring pattern runs, which pass between the mounted capacitor and the circuit board. When dipping into a solder bath, excessive solder may collect under the capacitor by capillary action and short circuit the anode and cathode terminals.

The sleeve of the capacitor can be damaged if solder passes through a lead hole for subsequently processed parts.

Electrically isolate the extra terminal(s) on 4 and 5 pin products from the anode terminal, cathode terminal, and other circuit paths.

### Clearance Requirements

Case mounted pressure relief vents require a clearance of 3mm minimum above the top of the case to operate properly.

### Circuit Board Cleaning

Aluminum electrolytic capacitors can withstand immersion or ultrasonic cleaning with "safe" cleaning solvents for up to 5 minutes and 60°C maximum temperatures.

Most aqueous based cleaning solvents and detergents are acceptable. Some solvent groups could damage capacitors as follows

Halogenated cleaning solvents may permeate the capacitor seal, causing internal corrosion and failure.

Alkali solvents may attack and dissolve the aluminum case.

Petroleum based solvents may deteriorate the rubber seal.

Xylene may deteriorate the rubber seal.

Acetone and some alcohols may remove sleeve ink

A thorough rinsing and drying process will prevent entrapment of residual solvents between the capacitor and the circuit board and the capacitor case and the sleeve. Excessive drying temperatures and / or radiant heat drying sources may result in splitting or excessive shrinkage of the sleeve.

### Mounting Adhesives and Coating Agents

When using mounting adhesives or coating agents, avoid materials with halogenated solvents including chloroprene based polymers.

A thorough drying process for adhesives or coatings is required to prevent solvent entrapment between the capacitor and the circuit board.

Mounting adhesives or reinforcements clamps are recommended on 2 or 3 pin styles with case sizes of 35 x 45mm or larger. Additional mounting support is also recommended for 4 or 5 pin styles with lengths exceeding 63mm.

## 6 Safety Precautions

If the pressure relief vent of the capacitor should operate, immediately turn off the equipment and disconnect from the power source.

Avoid contact with the escaping electrolyte, which can exceed 100°C temperatures.

***If electrolyte or vapors enter the eye, immediately flush the eye with large amounts of water and seek medical attention.***

***If electrolytes or vapors are ingested by mouth, gargle with water.***

***If electrolyte contacts the skin, wash with soap and water.***