1 General Specifications

The following specifications apply to all TS and T type products listed in this catalog.

■ **Capacitance**

Nominal capacitance is specified at 120Hz frequency and 20°C temperature. Unless specified otherwise, standard capacitance tolerance is ±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**

$I = 3\sqrt{CV}$ (μA) maximum after 5 minutes of applying rated voltage. Capacitance is the nominal value in μF, voltage in VDC.

■ **Ripple Current**

The standard product tables list ripple current allowable limits at specified maximum operating temperatures. Both 120Hz and 10k through 50kHz frequencies are listed. Correction factors for other temperatures and frequencies are as follows:

TS and T Type Frequency Correction Factors

Frequency (Hz)	50	60	100–120	500	1k	10k–50k
16–100WV	0.93	0.95	1.0	1.05	1.08	1.15
160 ~ 450WV	0.75	0.8	1.0	1.2	1.25	1.4

TS and T Type Temperature Correction Factors

Max. Temp.	105°C	85°C	70°C	60°C	≤45°C
+105°C	1.0	1.55	2.0	2.2	2.35
+85°C	—	1.0	1.3	1.4	1.5

Note: Use of temperature correction factors can limit load life to the hours specified for the maximum operating temperature of the series.

■ **Endurance (Life) Test**

- Duration: Specified hours of life
- Ambient temperature: Maximum specified operating temperature
- Applied voltage: DC voltage with maximum specified ripple current applied (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
- Capacitance change: ≤ ± 20% of initial measured value
- Dissipation factor: ≤200% of initial specified value

■ **Shelf Life**

- Duration: 1000 hours
- Ambient temperature: Maximum specified operating temperature
- Applied voltage: None

Post test requirements at +20°C:

Same as endurance test requirements above.

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

2 Life Expectancy

TS type capacitors have a specified life at a maximum temperature and ripple current. Typical life can be considerably longer based on actual life test results performed by the factory. This data can be provided to help the designer estimate expected life. This information is given with a 60% confidence level.

Capacitor life at lower temperature follows “The Doubling 10°C Rule,” where life is doubled for each 10°C reduction in operating temperature. The following equation is useful for determining the life of a capacitor in the application:

$$L_2 = L_1 \times 2^{\frac{T1 - (T2 + \Delta T)}{10}}$$

where:

L_1 = Specified life (hours) at maximum operating temperature. Typical life may be substituted (at a 60% confidence level).

L_2 = Expected life (hours) at actual operating temperature.

T1 = Maximum operating temperature

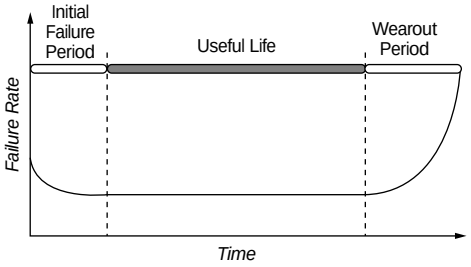
T2 = Ambient temperature (°C)

ΔT = Ripple current temperature rise (°C)

It is recommended that the ripple current heat rise be limited to 15°C at lower ambient temperature as higher temperature rises may reduce operating life.

End of life is defined by the occurrence of one of the following when stabilized at 20°C:

- 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



Life Cycle of an Aluminum Electrolytic Capacitor

3 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 temperatures, 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 low DC bias voltages do no cause reverse voltage conditions.

■ **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.

■ **Electrical Precautions**

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

■ **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.

■ **Electrical Precautions**

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

The aluminum case of the capacitor has an indeterminate resistance to the cathode terminal. The vinyl 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, combustive, electrolyte liquid or vapor escaping from the safety vent should also be considered.

4 Capacitor Mounting Considerations

■ **Circuit Board Design**

Avoid wiring pattern runs which pass between the mounting 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 vinyl sleeve of the capacitor can be damaged if solder passes through a lead hole for subsequently processed parts.

Electrically isolate the extra terminals on T type products from the anode terminal, cathode terminal, and other circuit paths.

■ **Clearance Requirements**

Case-mounted pressure relief vents require sufficient clearance to operate properly. The minimum clearance is diameter dependent as follows: 20–35mm diameters: 3mm minimum; 40mm diameters or greater: 5mm minimum.

■ **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 may remove vinyl sleeve ink printing.

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

■ **Mounting Adhesives and Coating Agents**

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

A thorough drying process after application is required to p prevent solvent entrapment between the capacitor and the circuit board.

Mounting adhesives or reinforcement clamps are recommended on 2 terminal, TS types with case sizes of ¯ 35 x 45mm or larger.

5 Storage

Leakage current will increase with long storage times.

Storage times in ambient temperatures of 40¢ or less can be four years or more before leakage current should be checked for conformance to the specified limit. Longer storage times may require reforming of the capacitor to reduce leakage below the specified limit. This can be accomplished by applying rated voltage in series with a 1000 resistor for a time period of 30 to 60 minutes.

Under normal conditions, shelf life can exceed 10 years, providing that leakage current is checked before use.

Long-term storage in high humidity conditions could cause oxidation of the terminal plating which could adversely affect solderability.

6 Safety Precautions

If the pressure relief vent of the capacitor should operate, immediately turn off the equipment and disconnect from the power source. This will minimize additional damage caused by vaporizing electrolyte.

Avoid contact with the escaping electrolyte which can exceed 100¢ temperatu res.

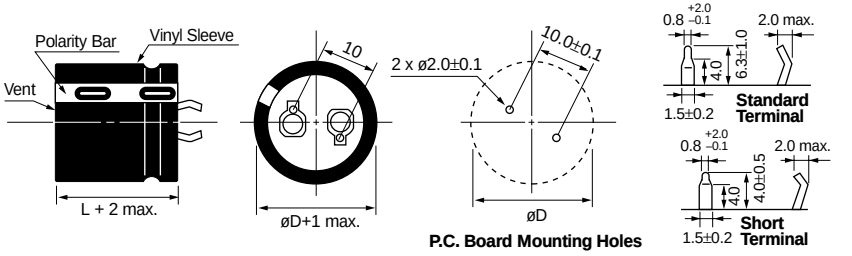
If electrolyte or vapors enter the eye, immediately flush the eye with large amounts of water and seek medical attention.

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

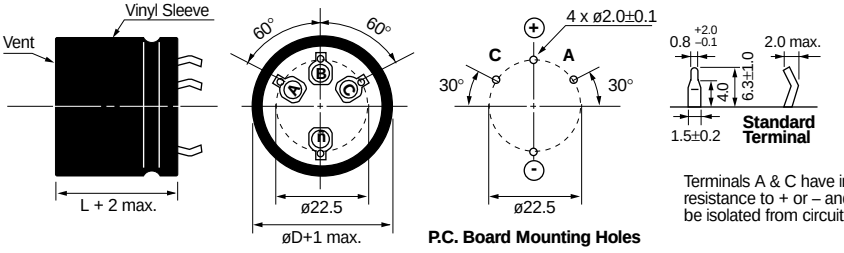
If electrolyte contacts the skin, wash with soap and water.

■ **Dimensions in mm** (not to scale)

TS Type



T Type



Terminals A & C have indeterminate resistance to + or – and must be isolated from circuit wiring.