Precautions in using Tantalum Capacitors

The major conditions to be considered in relation to the use of the tantalum capacitors are as follows:
1) Electrical terms
2) Climatic terms
3) Conditions for mounting on equipment and circuit boards
4) Mechanical vibration, shock, and storage conditions
If the tantalum capacitors are used without satisfying any one of these conditions, the probability of short-circuiting, current leakage or other problems occurring increases. To avoid such problems, observe the following precautions when using tantalum capacitors.

1. Operating Voltage

(1) The voltage derating factor should be as great as possible. Under normal conditions, the operating voltage should be reduced to 50% or less of the rating. It is recommended that the operating voltage be 30% or less of the rating, particularly when the tantalum capacitors are used in a low-impedance circuit. (See Figs. 1, 2, and 3.)

(2) For circuits in which a switching, charging, discharging or other momentary current flows, it is recommended that the operating voltage be 30-% or less of the rating, with a resistor connected in series tolimit the current to 300 mA or less. (See section 4 for details.)

(3) When the tantalum capacitors are to be used at an ambient temperature higher than 85°C, the recommended operating range shown in Fig. 3 should not be exceeded.

•Low-impedance circuits

Power supply filter

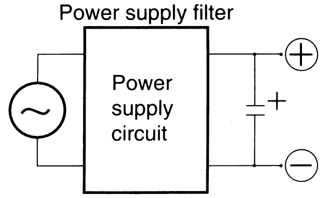

Fig. 1

Power supply bypass

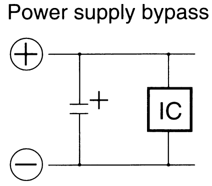

Fig. 2

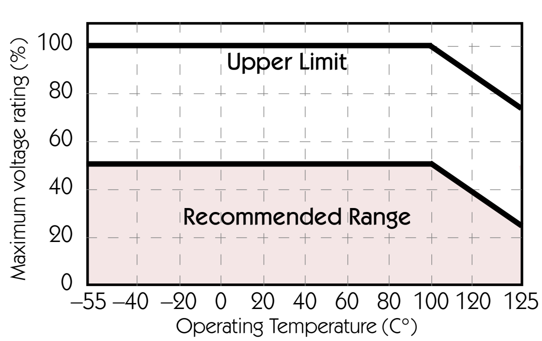

Fig.3

2. Ripple

If an excessive ripple voltage is applied to a tantalum capacitor, it's internal temperature rises due to Joule heat, resulting in the detriment of it's reliability. The maximum permissible ripple voltage and current are related to the ratings case size. Please consult Hitachi AIC for detail information.

2.1 Ripple Current

The maximum permissible current, $\mathbf{I_{MAX}}$, is calculated as follows:

$$I_{MAX} = \sqrt{\frac{P_{MAX}}{ESR\ (D)}}$$

where:
I_{MAX}: Maximum permissible capacitor ripple current (Arms).
P_{MAX}: Maximum permissible capacitor power loss (W). Varies with the ambient temperature and case size. Calculated according to Table 1.
ESR (D): Capacitor equivalent series resistance (Ω).

Since the ESR(D) value varies with the ripple frequency. the following correction must be made in accordance with the operating frequency. (See Table 2 and Fig. 4.)

$$ESR\ (D) = K \cdot ESR\ (120)$$

K: Coefficient for the operating frequency (Table 2 and Fig. 4).

$$ESR\ (120) = \tan\delta \cdot Xc = \frac{\tan\delta}{2\pi fC}$$

where:
ESR (120): Equivalent series resistance at 120 Hz (Ω).
Xc: Capacitive reactance at 120 Hz (Ω).
C: Electrostatic capacitance at 120 Hz (μF).
f: Operating frequency (Hz).

Table 1. Maximum permissible power loss values (P_{MAX}) by case size.

Ambient Temp. °C	P_{MAX} (W)					
	P	UA, A	UB, B	UC, C	UE, E	F
25	0.015	0.030	0.030	0.030	0.050	0.050
55	0.010	0.019	0.019	0.019	0.032	0.032
85	0.005	0.010	0.010	0.010	0.018	0.018

Table 2.

Frequency f	K
120	1.0
400	0.8
1k	0.65
10k	0.50
20k	0.45
40k	0.43
100k	0.40
1M	0.35

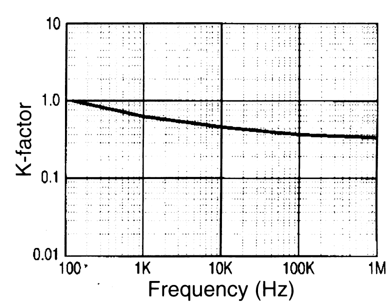

Fig. 4 Correction coefficient (K)

2.2 Ripple Voltage

(1) The tantalum capacitors must be used under such conditions that the sum of the working voltage and ripple voltage peak values does not exceed the rrated voltage.

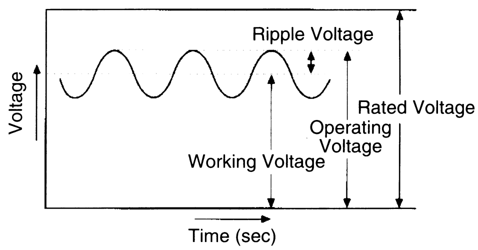

Fig. 5

(2) Ensure that a reverse voltage due to superimposed voltages is not applied to the capacitors.

(3) The maximum permissible ripple voltage varies with the rated voltage, Ensure that ripple voltage does not exceed the values shown in Figs. 6 and 7. If, however, the capacitors are used at a high temperature, the maximum permissible ripple voltage must be calculated as follows:

Vrms (at 55°C) = 0.8 X Vrms (at 25°C)
Vrms (at 85°C) = 0.6 X Vrms (at 25°C)
Vrms (at 125°C) = 0.4 X Vrms (at 25°C)

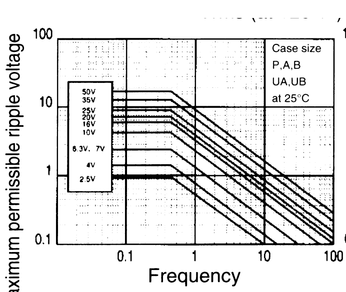

Fig. 6 Maximum permissible ripple voltage (P, UA, A, UB, B)

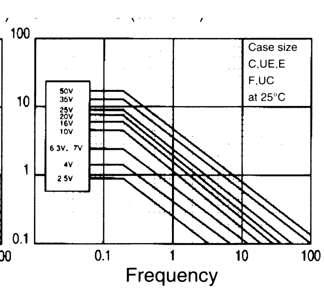

Fig. 7 Maximum permissible ripple voltage (UC, C, UE, E, F)

3. Reverse Voltage

(1) The tantalum capacitors must not be operated and changed in reverse mode. Also, the capacitors must not be used in an AC only circuit.

(2) The tantalum capacitor dielectric has a rectifying characteristics. Therefore, when a reverse voltage is applied to it, a large current flows even at a low reverse voltage. As a result, it may spontaneously generate heat and lead to shorting.

(3) Make sure that the polarity and voltage is correct when applying a multimeter or similar testing instrument to the capacitors because a reverse voltage or overvoltage can be accidentally applied.

(4) When using the capacitors in a circuit in which a reverse voltage is applied, consult Hitachi AIC. If the application of a reverse voltage is unavoidable, it must not esceed the following values:

At 25°C: 10% of the rated voltage or 1V, whichever is smaller.
At 85°C: 5% of the rated voltage or 0.5V, whichever is smaller.
Further, the reverse voltage application time must be no longer than 240 hours, with the power supply impedance maintained at 330Ω or more.
These limits are not specifications.

4. Reliability of Tantalum Capacitors

4.1 General

The failure rate of the tantalum capacitor varies with the derating ratio, ambient temperature, circuit resistance, circuit application, etc. Therefore, when proper selections are made so as to afford additional margins, higher reliability can be derived from the tantalum capacitors. Some examples of actual failure rates are presented below for reference.

4.2 Failure Rate Calculation Formula

The tantalum capacitors are designed to work at their basic failure rates shown in Table 3 that prevail when the rated voltage is applied for 1000 hours at 85°C.

Table 3. Basic failure rate

Type	Classification	Basic failure rate
TMCR	Low ESR type	1%/1000h
TMCP	Miniature type (0805)	
TMCU	Low profile type	
TMCM	Small type	
TMCS	Standard type	
TMCTX	Fuse incorporated type	
TMCH	High reliability type	0.5%/1000h
TMCN	High performance polymer type	1%/1000h

A capacitor failure rate can be calculated from the formula shown below. Note that a capacitor failure rate can be lowered by giving margins to the circuit temperature, applied voltage ratio (derating factor), and circuit resistance selected for the basic failure rate.

• Failure rate calculation formula

λ use = λ 85 $\times K_V \times K_R$

λ use: Estimated capacitor failure rate under the operating conditions.
λ 85: Basic failure rate (Table 3)
K_V: Failure rate correction coefficient by the ambient temperature and derating factor.
K_R: Failure rate correction coefficient by the circuit resistance, which is the series-connected resistance divided by the voltage applied to the capacitor. This resistance is connected in series when the power supply side is viewed from the capacitor side. The K_V and K_R values must be determined according to Figs. 8 and 9.
K (derating factor)=operating voltage/rated voltage

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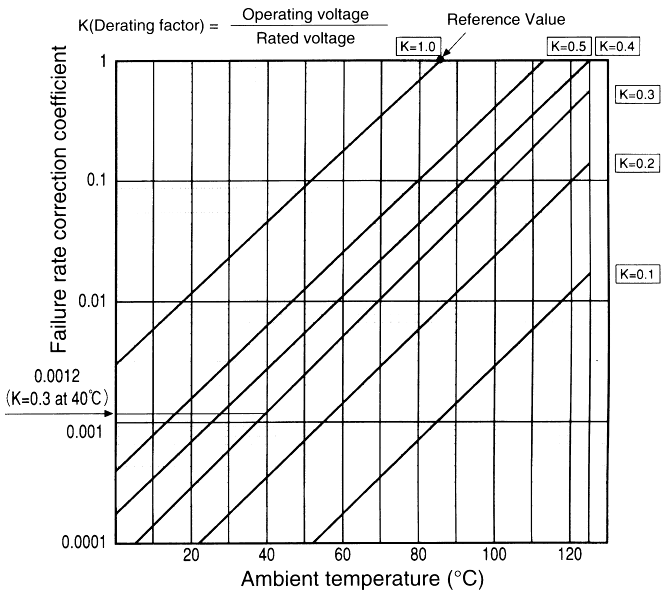
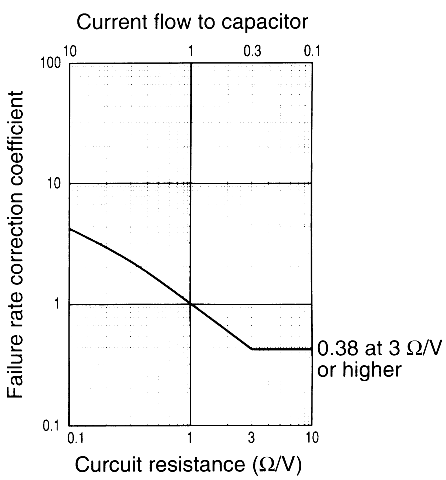


Fig. 8 Ambient temperature and derating-dependent failure rate correction coefficient



Fig, 9 Circuit resistance-dependent failure rate correction coefficient

4.3 Example of Capacitor Failure Rate Calculation

• Operating conditions

Type:	TMCM type
Rating:	10 V, 10 µF (B case)
Operating temperature:	40°C
Derating factor:	0.3 [K=operating voltage / rated voltage=3 V/10 V=0.3]
Circuit resistance:	3Ω / V
λ85:	1%/1000 hours (from Table 3)
K_V:	0.0012 (from Fig. 8)
K_R:	0.38 (from Fig. 9)

$\lambda_{use} = \lambda_{85} \times K_V \times K_R = 1\%/1000h \times 0.0012 \times 0.38$

$= 1 \times 10^{-5} \times 0.0012 \times 0.38$

$= 4.56 \times 10^{-9}$ } Estimated failure rate

$= 0.000456\%/1000h$

$= 4.56 Fit$

5. Mounting Precautions

5.1 Limit Pressure on Capacitor Installation with Mounter

Pressure must not exceed 4.9N with a tool end diameter of 1.5mm when applied to the capacitors using an absorber, centering tweezers, or the like. (Maximum permitted pressurization time: 5 seconds.) An excessively low absorber setting position would result in not only the application of undue force to the capacitors, but also capacitor and other component scattering, as well as circuit board wiring breakage and/or cracking, particularly when the capacitors are mounted together with other chips having a height of 1mm or less.

5.2 Flux Selection

(1) Select a flux that contains a minimum of chlorine and amine.
(2) After flux use, the chlorine and amine in the flux remain and must therefore be removed.

5.3 Recommended Soldering Pattern Dimensions

The recommended chip soldering pattern dimensions are as shown in Table 4 and Fig. 10. Note, however, that they are affected by such factors as reflow conditions, solder type, and circuit board size.
If the pattern area is significantly larger than the capacitor terminal area, the capacitor in place may be displaced with the solder melts.

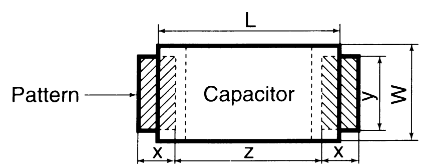


Fig. 10

Table 4. Recommended soldering pattern dimensions

Dimensions / Case	Capacitor Size		Pattern Dimensions		
	L	W	x	y	z
P	2.0	1.25	1.2	1.1	0.8
UA, A	3.2	1.6	1.6	1.2	1.2
UB	3.5	2.8	1.6	2.2	1.4
B	3.5	2.8	1.6	2.2	1.4
UC, C	5.8	3.2	2.3	2.4	2.4
D	5.8	4.5	2.3	3.3	2.4
UE, E	7.3	4.3	2.3	2.6	3.8
F	7.3	5.8	2.3	3.8	3.8
G	7.3	4.3	2.3	2.6	3.8

5.4 Chip Soldering Temperature and Time

For the capacitor body, the chip soldering temperature and time must be as shown here.

(1) Reflow soldering (infrred, hot air, hot plate)

Capacitor body temperature:	260°C or lower
Time:	10 sec. max.
Permitted temperature/time range:	See Fig. 11

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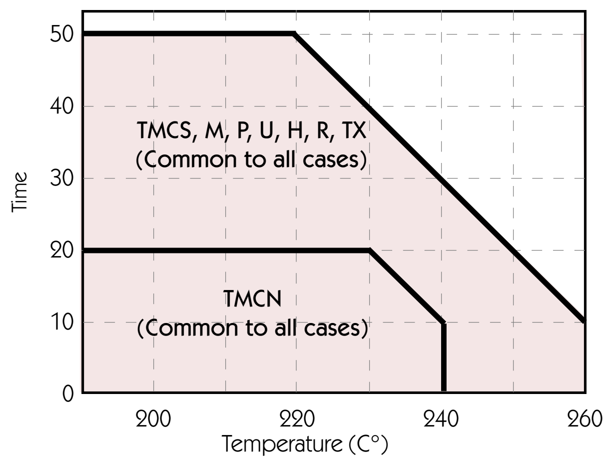

Fig.11. Reflow soldering permitted temperature/time range

NOTE 1: When upward heating is provided by infrared, the capacitor body temperature rises above the circuit board surface temperature.

When a high power hot blast stove or the like is used, a sudden temperature rise occurs.

Therefore, a 130-160°C, 1-minute preheating zone should be provided to ensure that the difference from the reflow maximum temperature in not greater than 100°C. (See Fig. 12.)

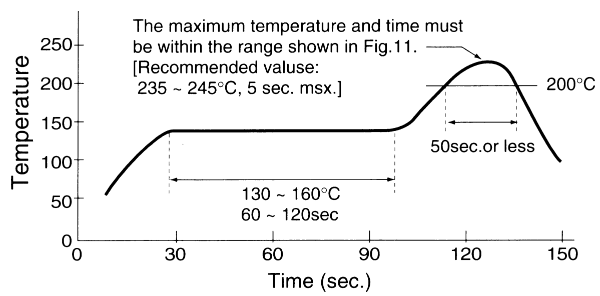

Fig. 12 Recommended temperature profile

(2) Flow soldering

Solder bath temperature: 260°C or lower

Time: P, UA, A UB, or B case, 10 sec max.
UC, C, UE, E, F or G case, 5 sec max.

Permitted temperature and time range: See Fig. 13

NOTE 1: To avoid sudden heating, conduct preheating. 130-160°C, 1-minute preheating zone should be provided. (See Fig. 14.)

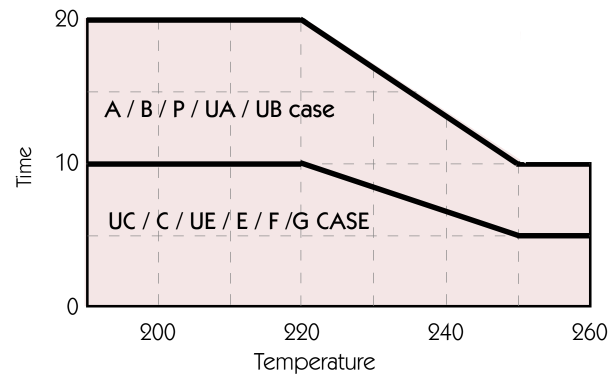

Fig. 13. Flow soldering permitted temperature/time range

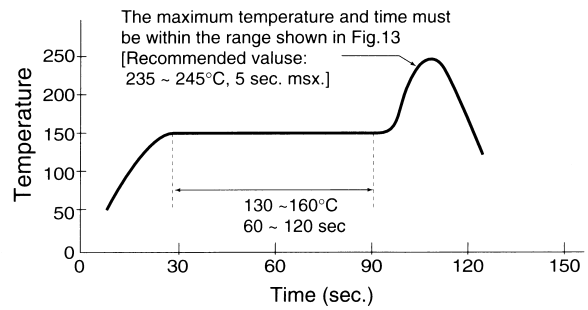

Fig. 14. Recommended temperature profile

(3) Soldering with an iron

The use of a soldering iron should be avoided wherever possible. If it is unavoidable, follow the instructions set forth in Table 5.

Table 5.

Type	TMCR, TMCS, TMCM, TMCU, TMCH	
Soldering iron tip temp	350°C MAX	290°C MAX
Time	3 sec MAX	3 sec MAX
85	30 W MAX	30 W MAX

NOTE 1: If a soldering iron is used at a high temperature for the TMCTX type which incorporates a thermal fuse, the fuse opens. Due care must be used to avoid this adverse situation.

(4) Repetition of soldering

The soldering conditions for soldering operations (1) through (3) above are established on the presumption that only one type of soldering operation is conducted.

When repeating a reflow soldering or a combined flow-and-reflow soldering operation, comply with the following conditions:

i) Once the capacitor is mounted, it must not be removed for reuse.

ii) Any type of soldering operation may be performed to the capacitor only twice.

iii) The second performance of a type of soldering operation must not be initiated until after a 2-hour or longer heat dissipation period.

iv) Cleaning must be conducted upon completion of the second soldering operation.

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5.5 Cleaning after Mounting

The following solvents are usable when cleaning the capacitors after mounting. NEVER use a highly active solvert.

- Halogen organic solvent (HCFC225, etc.)
- Alcohol solvent (IPA. ethanol, etc.)
- Petroleum solvent, alkali saponifying agent, water, etc.

Circuit board cleaning must be conducted at a temperature of not higher than 50°C and for an immersion time of not longer than 30 minutes. When an ultrasonic cleaning method is used, cleaning must be conducted at a frequency of 48kHz or lower, at a vibration output of 0.02 W/cm^3, at a temperature of not higher than 40°C, and for a time of 5 minutes or less.

NOTE 1: Care must be exercised in the cleaning process so that the mounted capacitor will not come into contact with any cleaned object or the like, or will not get rubbed by a stiff brush or similar object. If such precautions are not taken, particularly when the ultrasonic cleaning method is employed, terminal breakage may occur.

NOTE 2: When performing ultrasonic cleaning under conditions other than stated here, conduct adequate advance checkout.

6. Long-term Stock

Before using capacitors that have been stored for more than 2 years, please contact Hitachi AIC.

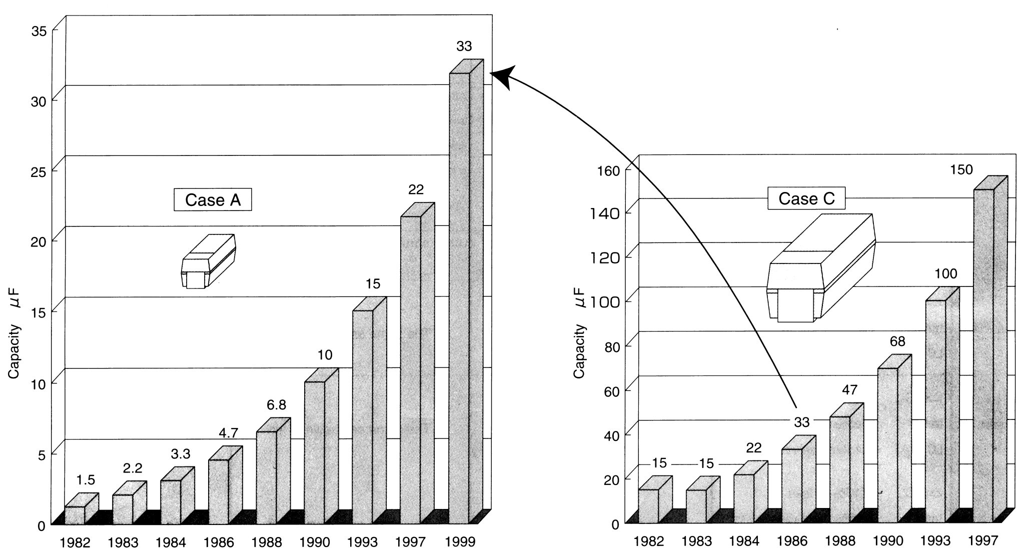
7. Other

(1) For further details refer to EIAJ RCR-2368, Precautions and Guidelines for Using Electronic Device Tantalum Capacitors.
(2) If you have any questions, feel free to contact you local Hitachi AIC representative. They can be located by visiting our web site at www.hitachiaic.com.

About downsizing (upgrading)

To meet the recent trends for electronic products smaller in size and lighter in weight, chip type tantalum capacitor manufacturers have downsized their products by various methods. Of these methods, the method of ensuring a required capacity by thinning the dielectric film greatly reduces the withstanding voltage characteristics. The most common and effective method therefore, is using fine tantalum powder to enlarge the surface area of the anode per unit area.
Hitachi AIC's TMC type tantalum capacitors have been enlarged in capacity and reduced in size by taking full advantage of fine powder known as "high-CV powder". In recent years downsizing and increased capacity of multilayer ceramic capacitors has been achieved. To keep the competitive advantage held by Hitachi AIC's TMC chip capacitors we use only the best high-CV powder to upgrade the TMC family of products.
Hitachi AIC is currently developing the following families of products:

1). Series with a larger capacity than the TMCM type
2). Series with a larger capacity than the TMCP type (2010mm)
3). Series with a larger capacity than the TMCU type (thin type, low-height version of the TMCM type)
4). Series TMCJ type (1608mm)



History of capacity expansion in 7-V models