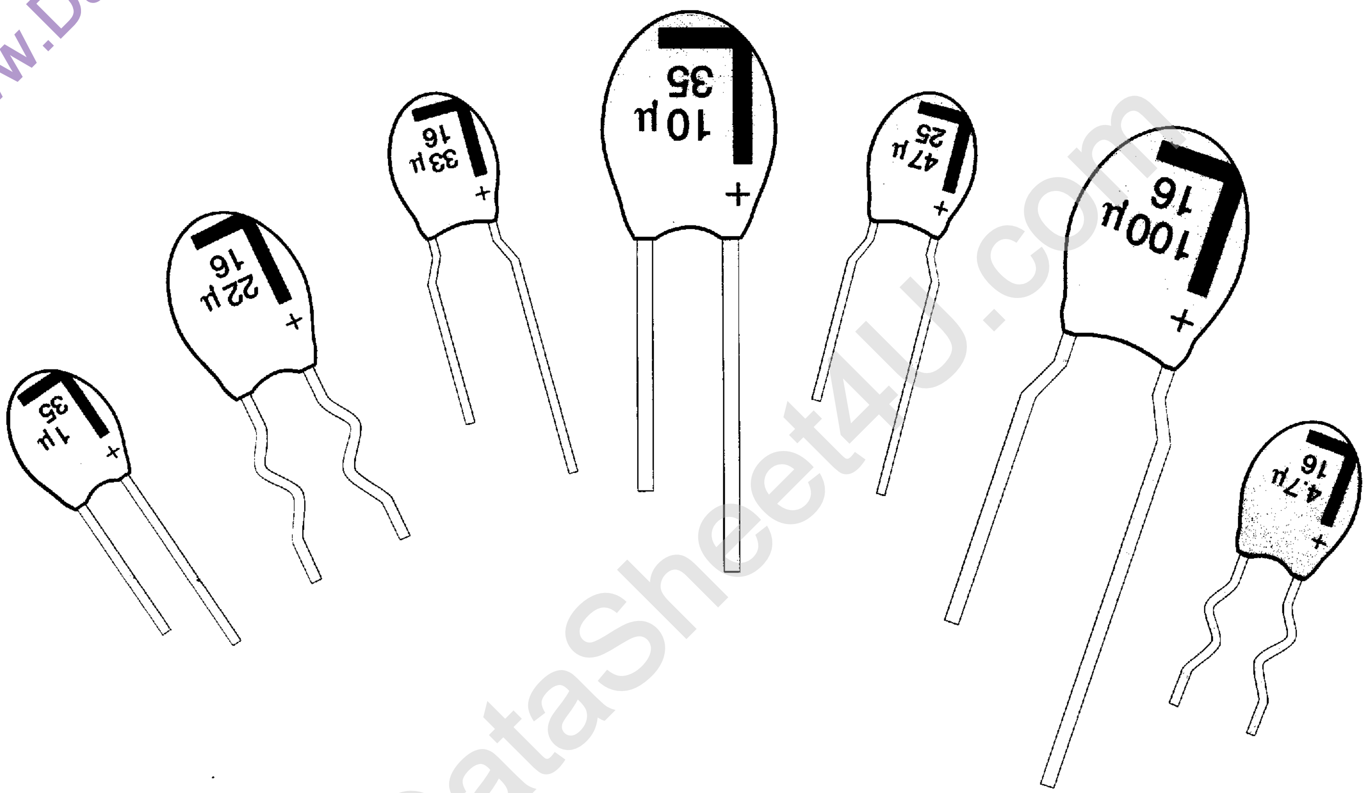
A-05-21-01

nemco RADIAL DIPPED TANTALUM CAPACITORS

Type TB



FEATURES

- Reliable, solid tantalum construction
- Small size per C.V. combination
- Capacitance range: 0.1 µf to 330 µf
- Surge tested for maximum robustness
- Operating temperature range -55°C to +125°C, 2/3 x Vr (linear derating) above +85°C
- Meniscus control-eliminates thru hole plugging for excellent top side solder joints
- Laser marking and bold polarity stripe
- Supplied bulk or available packaged for auto insertion
- Flame retardant, self extinguishing epoxy coating meets UL94 VO

nemco®
electronics corp.
THE TANTALUM COMPANY

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TB

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TB

PART NUMBERING SYSTEM

TB 10 / 16 M 1 ___

Series
TB

Capacitance Value
in microfarads

Voltage
6 (6.3)
10
16
20
25
35
50

Tolerance
M = 20%
K = 10%
J = 5%

Lead Spacing Code
1 = .1 inches
2 = .2 inches
250 = .250 inches
E1 = .1 snap in
E2 = .2 snap in

Additional Suffix Codes
TR = Tape & Reel Packaging
TA = Ammo Packaging

Standard packaging for dipped tantalum capacitors is bulk.
If tape and reeling or tape and ammo packaging is required please refer to the additional suffix codes in the above part numbering system.

When necessary a custom device (ie. cut leads) will be assigned a unique suffix code.

Table of Standard Products

Capacitance - Voltage Product Table by Case Size

Cap (µF) \ WVDC	6.3	10	16	20	25	35	50
0.1						A	A
0.15						A	A
0.22						A	A
0.33						A	A
0.47						A	A
0.68						A	B
1						A	C
1.5			A	A	A	A	D
2.2		A	A	A	A	B	E
3.3	A	A	A	B	B	C	F
4.7	A	A	B	C	C	E	G
6.8	A	B	C	D	D	F	J
10	B	C	D	E	E	F	J
15	C	D	E	F	F	H	K
22	D	E	F	H	H	K	
33	E	F	F	J	J		
47	F	G	H	K	M	N	
68	G	H	L	N	N		
100	H	K	M	N			
150	K	N	N				
220	M	O	O				
330	N	O					

Values outside this standard range may be available upon request.

HIGHER VOLTAGE RATINGS and/or tighter capacitance tolerance product may be substituted within the same case size at Nemco's option. Such substitutions will **IMPROVE OPERATING RELIABILITY.** Voltage substitutions will be marked with the higher voltage rating.

Capacitance (μF)	Case Size	Nemco Part No.	D.C. Leakage current (μA) max.	tan δ (DF) max. (%)	ESR max (Ω) @ 100 KHz
6.3V DC					
3.3	A	TB3.3 / 6M1	0.5	0.06	13.0
4.7	A	TB4.7 / 6M1	0.5	0.06	10.0
6.8	A	TB6.8 / 6M1	0.5	0.06	8.0
10	B	TB10 / 6M1	0.5	0.08	6.0
15	C	TB15 / 6M1	0.8	0.08	5.0
22	D	TB22 / 6M1	1.1	0.08	3.7
33	E	TB33 / 6M1	1.7	0.08	3.0
47	F	TB47 / 6M1	2.4	0.08	2.0
68	G	TB68 / 6M1	3.4	0.08	1.8
100	H	TB100 / 6M1	5.0	0.10	1.6
150	K	TB150 / 6M2	7.6	0.10	0.9
220	M	TB220 / 6M2	11.0	0.10	0.9
330	N	TB330 / 6M2	16.6	0.10	0.7
10V DC					
2.2	A	TB2.2 / 10M1	0.5	0.06	13.0
3.3	A	TB3.3 / 10M1	0.5	0.06	10.0
4.7	A	TB4.7 / 10M1	0.5	0.06	8.0
6.8	B	TB6.8 / 10M1	0.5	0.06	6.0
10	C	TB10 / 10M1	0.8	0.08	5.0
15	D	TB15 / 10M1	1.2	0.08	3.7
22	E	TB22 / 10M1	1.7	0.08	2.7
33	F	TB33 / 10M1	2.6	0.08	2.1
47	G	TB47 / 10M1	3.7	0.08	1.7
68	H	TB68 / 10M1	5.4	0.08	1.3
100	K	TB100 / 10M2	8.0	0.10	1.0
150	N	TB150 / 10M2	12.0	0.10	0.8
220	O	TB220 / 10M2	17.6	0.10	0.6
330	O	TB330 / 10M2	20.0	0.10	0.5
15V DC					
1.5	A	TB1.5 / 16M1	0.5	0.04	10.0
2.2	A	TB2.2 / 16M1	0.5	0.06	8.0
3.3	A	TB3.3 / 16M1	0.5	0.06	6.0
4.7	B	TB4.7 / 16M1	0.6	0.06	5.0
6.8	C	TB6.8 / 16M1	0.8	0.06	4.0
10	D	TB10 / 16M1	1.2	0.08	3.2
15	E	TB15 / 16M1	1.9	0.08	2.5
22	F	TB22 / 16M1	2.8	0.08	2.0
33	F	TB33 / 16M1	4.2	0.08	1.6
47	H	TB47 / 16M1	6.0	0.08	1.3
68	L	TB68 / 16M2	8.7	0.08	1.0
100	M	TB100 / 16M2	12.8	0.10	0.8
150	N	TB150 / 16M2	19.2	0.10	0.6
220	O	TB220 / 16M2	20.0	0.10	0.5
20V DC					
1.5	A	TB1.5 / 20M1	0.5	0.04	9.0
2.2	A	TB2.2 / 20M1	0.5	0.06	7.0
3.3	B	TB3.3 / 20M1	0.5	0.06	5.5
4.7	C	TB4.7 / 20M1	0.7	0.06	4.5
6.8	D	TB6.8 / 20M1	1.0	0.06	3.6
10	E	TB10 / 20M1	1.6	0.08	2.9
15	F	TB15 / 20M1	2.4	0.08	2.3
22	H	TB22 / 20M1	3.5	0.08	1.8
33	J	TB33 / 20M2	5.2	0.08	1.4

Part numbers shown are for ± 20% (M) capacitance tolerance with standard lead spacings. Refer to part numbering system on page 1 to change tolerances and spacings/styles.

Capacitance (µF)	Case Size	Nemco Part No.	D.C. Leakage current (µA) max.	tan δ (DF) max. (%)	ESR max (Ω) @ 100 KHz
20V DC cont.					
47	K	TB47 / 20M2	7.5	0.08	1.2
68	N	TB68 / 20M2	10.8	0.08	0.9
100	N	TB100 / 20M2	16.0	0.10	0.6
25V DC					
1.5	A	TB1.5 / 25M1	0.5	0.04	8.0
2.2	A	TB2.2 / 25M1	0.5	0.06	6.0
3.3	B	TB3.3 / 25M1	0.6	0.06	5.0
4.7	C	TB4.7 / 25M1	0.9	0.06	4.0
6.8	D	TB6.8 / 25M1	1.3	0.06	3.1
10	E	TB10 / 25M1	2.0	0.08	2.5
15	F	TB15 / 25M1	3.0	0.08	2.0
22	H	TB22 / 25M1	4.4	0.08	1.5
33	J	TB33 / 25M2	6.6	0.08	1.2
47	M	TB47 / 25M2	9.4	0.08	1.0
68	N	TB68 / 25M2	13.6	0.08	0.8
35V DC					
0.1	A	TB.1 / 35M1	0.5	0.04	26.0
0.15	A	TB.15 / 35M1	0.5	0.04	21.0
0.22	A	TB.22 / 35M1	0.5	0.04	17.0
0.33	A	TB.33 / 35M1	0.5	0.04	15.0
0.47	A	TB.47 / 35M1	0.5	0.04	13.0
0.68	A	TB.68 / 35M1	0.5	0.04	10.0
1	A	TB1 / 35M1	0.5	0.04	8.0
1.5	A	TB1.5 / 35M1	0.5	0.04	6.0
2.2	B	TB2.2 / 35M1	0.6	0.06	5.0
3.3	C	TB3.3 / 35M1	0.9	0.06	4.0
4.7	E	TB4.7 / 35M1	1.3	0.06	3.0
6.8	F	TB6.8 / 35M1	1.9	0.06	2.5
10	F	TB10 / 35M1	2.8	0.08	2.0
15	H	TB15 / 35M1	4.2	0.08	1.6
22	K	TB22 / 35M2	6.1	0.08	1.3
33	M	TB33 / 35M2	9.2	0.08	1.0
47	N	TB47 / 35M2	10.0	0.08	0.8
50V DC					
0.1	A	TB.1 / 50M1	0.5	0.04	26.0
0.15	A	TB.15 / 50M1	0.5	0.04	21.0
0.22	A	TB.22 / 50M1	0.5	0.04	17.0
0.33	A	TB.33 / 50M1	0.5	0.04	15.0
0.47	A	TB.47 / 50M1	0.5	0.04	13.0
0.68	B	TB.68 / 50M1	0.5	0.04	10.0
1	C	TB1 / 50M1	0.5	0.04	8.0
1.5	D	TB1.5 / 50M1	0.6	0.04	5.0
2.2	E	TB2.2 / 50M1	0.8	0.06	3.5
3.3	F	TB3.3 / 50M1	1.3	0.06	3.0
4.7	G	TB4.7 / 50M1	1.8	0.06	2.5
6.8	J	TB6.8 / 50M2	2.7	0.06	2.0
10	J	TB10 / 50M2	4.0	0.08	1.6
15	K	TB15 / 50M2	6.0	0.08	1.2

Part numbers shown are for ± 20% (M) capacitance tolerance with standard lead spacings. Refer to part numbering system on page 1 to change tolerances and spacings/styles.

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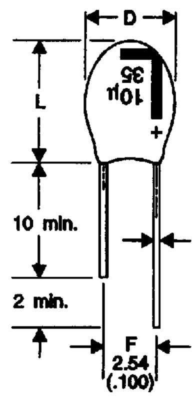
STANDARD

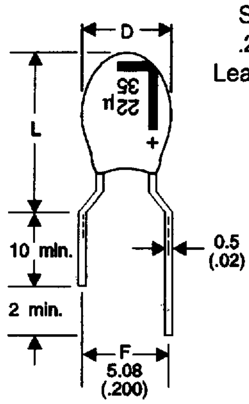
Dimensions and Lead Spacings

Standard .100 inch Lead Spacing



CASE SIZE	D max mm (inches)	L max mm (inches)	F ± 0.5 mm (.02 inches) mm (inches)
A	4.5 (.177)	7.0 (.276)	2.5 (.100)
B	4.5 (.177)	7.5 (.295)	2.5 (.100)
C	5.0 (.197)	8.5 (.335)	2.5 (.100)
D	5.0 (.197)	9.0 (.354)	2.5 (.100)
E	5.5 (.217)	9.0 (.354)	2.5 (.100)
F	6.0 (.236)	10.0 (.394)	2.5 (.100)
G	6.5 (.256)	10.0 (.394)	2.5 (.100)
H	7.0 (.276)	10.5 (.413)	2.5 (.100)

Standard .200 inch Lead Spacing



CASE SIZE	D max mm (inches)	L max mm (inches)	F ± 0.5 mm (.02 inches) mm (inches)
J	8.0 (.315)	13.0 (.512)	5.0 (.200)
K	8.5 (.335)	14.0 (.550)	5.0 (.200)
L	9.0 (.354)	14.0 (.550)	5.0 (.200)
M	9.0 (.354)	14.5 (.570)	5.0 (.200)
N	9.0 (.354)	16.0 (.630)	5.0 (.200)
O	10.0 (.394)	17.0 (.670)	5.0 (.200)

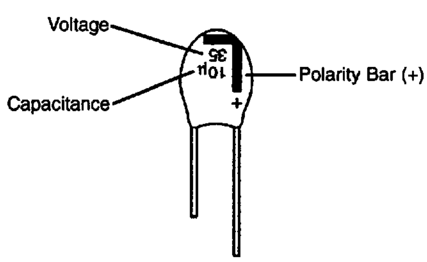
NOTE: Industry standard lead spacings and lead styles shown above are a function of physical case size. Physical case sizes are shown in the table of standard products, page 3. Case sizes are determined by the capacitance value and voltage combination.

MARKING

Radial dipped tantalum capacitors are marked by laser on the capacitor body. The positive (+) lead of the capacitor has a polarity stripe for improved recognition.

Minimum Marking shall consist of

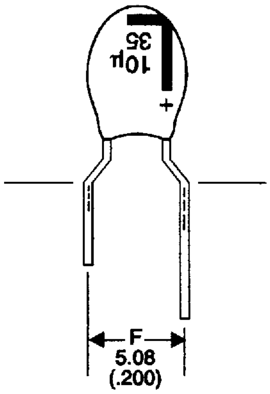
- Capacitance in µf
- Voltage (+85°C Vr)
- Polarity Bar (+)



OPTIONAL

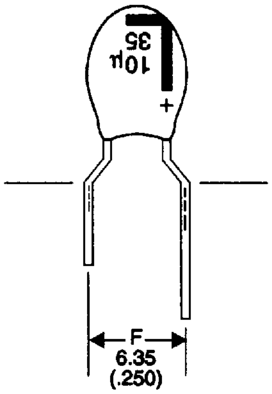
Lead Styles

.200 inch Lead Spacing



Case Sizes A - H
P/N Suffix Code 2

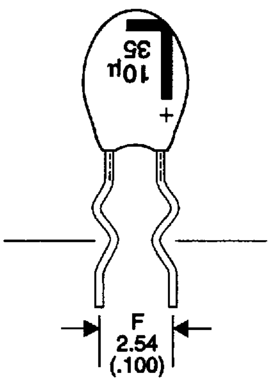
.250 inch Lead Spacing



Case Sizes A - O
P/N Suffix Code 250

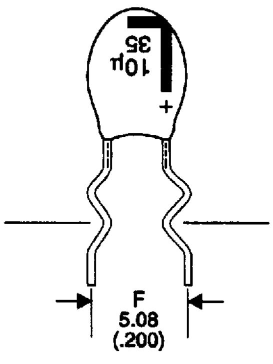
NOTE: Seated component heights for optional lead styles will vary based on case size. Contact your Nemco sales representative for samples of optional lead styles.

.100 inch Lead Spacing Snap-In



Case Sizes A - H
P/N Suffix Code E1

.200 inch Lead Spacing Snap-In



Case Sizes A - H
P/N Suffix Code E2

Available Services

- Sorting for special dimensions.
- Custom lead forming
- Lead length cutting.

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Introduction

Tantalum capacitors are manufactured from a powder of pure tantalum metal. The powder is compressed under high pressure around a tantalum wire to form a 'pellet'. The riser wire is the anode connection to the capacitor. This is subsequently vacuum sintered at high temperature (typically 1500 - 2000°C). This helps to drive off any impurities within the powder by migration to the surface. During sintering the powder becomes a sponge like structure with all the particles interconnected in a huge lattice. This structure is of high mechanical strength and density, but is also highly porous giving a large internal surface area. The larger the surface area the larger the capacitance. By choosing the powder used to produce each capacitance/voltage rating, the surface area can be controlled. The next stage is the production of the cathode plate. This is achieved by pyrolysis of manganese nitrate into manganese dioxide. The 'pellet' is dipped into an aqueous solution of nitrate and then baked in an oven at approximately 250°C to produce a dioxide coat. This process is repeated several times, varying specific densities of nitrate to build up a thick coat over all internal and external surfaces of the 'pellet'. The 'pellet' is then dipped into graphite and silver to provide a good connection to the manganese dioxide cathode plate. Electrical contact is established by deposition of carbon onto the surface of the cathode. The carbon is then coated with a conductive material to facilitate connection to the cathode termination. Packaging is carried out to meet specifications and customer requirements.

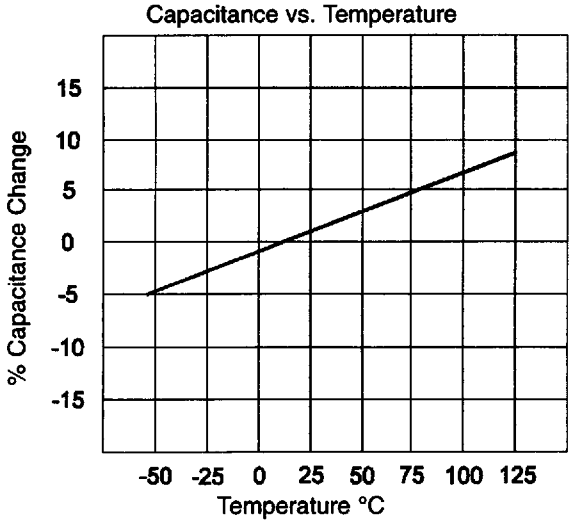
Specifications

Data relates to an ambient temperature of +25° C

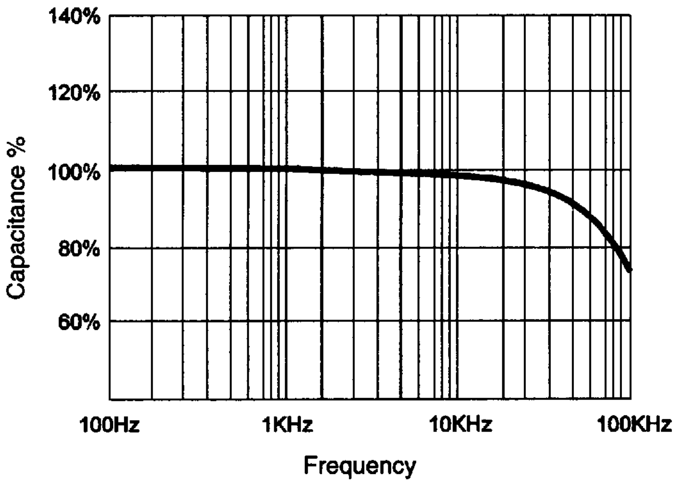
- **Operating temperature range** -55°C to +125°C
  2/3 x Vr (linear derating) required for operation above +85°C.

- **Capacitance** 0.1 - 330µf
  Nominal rated capacitance is measured at +25°C, 120 Hz source, free of harmonics with a maximum bias of 2.2V d.c. Capacitance decreases with increasing frequency and increases with increasing temperature.

Typical Component
Capacitance vs. Temperature



Typical Component
Capacitance vs. Frequency



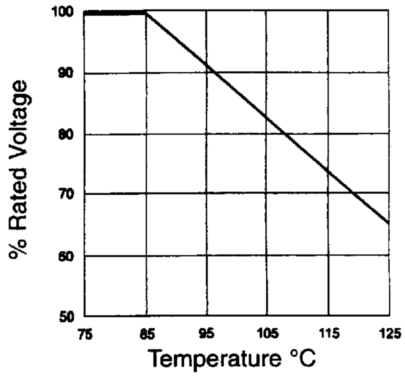
- **Capacitance tolerances** E.I.A. standard ±20% and ±10%. (±5% is available upon request)
  Tolerance is the permissible variation of the actual value of capacitance from the rated value.

- **Stability** $\frac{\Delta C}{C}$ ≤ 12% over the operating temperature range

- **Environmental Classification** 55/125/56 (IEC 68-2)

- **Working DC voltage range** - 6.3 to 50 WVDC
  Rated voltages are the maximum recommended peak DC operating voltages for continuous use from -55°C to +85°C. Operation above +85°C requires linear derating to 2/3 rated voltage at +125°C.

  To improve operating liability select higher voltage ratings (30% to 70% recommended) than the maximum line voltage. This is known as voltage derating. The effects of voltage derating can be seen by referring to the section on reliability, failure rate.



- **Surge Voltage VDC** Surge voltage includes the sum of peak AC ripple, DC bias and any transients. This is the highest voltage that may be applied to a capacitor for a short period of time. The surge voltage may be applied up to ten times in an hour for periods up to 30 sec. at a time. These values are not intended to apply to continuous operation. The surge voltage must not be used as a parameter in the design of circuits in which, in the normal course of operation, the capacitor is periodically charged and discharged.
  The solid tantalum capacitor has a limited ability to withstand surges due to the fact that they operate at very high electrical stress within the oxide layer. It is important to insure that the voltage across the terminals of the capacitor does not exceed the surge voltage rating at any time. This is particularly so in low impedance circuits where the capacitor is likely to be subjected to the full impact of surges. Even an extremely short duration spike is likely to cause damage. In such situations it may be necessary to use a higher voltage rating such as an extended range value.

Rated Working Volts +85°C	Surge Voltage +85°C	Derated DC Volts +125°C	Surge Voltage +125°C
6.3	8	4	5
10	13	7	8
16	20	10	12
20	26	13	16
25	32	16	20
35	46	23	28
50	65	33	40

Solid tantalum capacitors have a self healing ability due to the manganese dioxide semiconducting layer used as the negative plate. In the case of low impedance circuits, the capacitor is likely to be stressed by current surges. Derating the capacitor voltage by 50% or more increases the reliability of the component. In circuits which undergo rapid charge or discharge a protective resistor of 1Ω/V is recommended. If this is impossible, a derating factor of up to 70% is recommended. In such situations a higher voltage may be needed than is available as a single capacitor. A series combination can be used to increase the working voltage of the equivalent capacitor: For example two 22μF 25V parts in series is equivalent to a 11μF 50V part. 1 ohm per volt series resistance is recommended for dynamic conditions which include current in-rush applications such as inputs to power supply circuits. In many power supply topologies where the di / dt through the capacitor(s) is limited, (such as most implementations of buck (current mode), forward converter, and flyback), the requirement for series resistance is decreased. 0.1 ohm per volt series resistance is recommended for steady state conditions. This level of resistance is used as a basis for the series resistance variable in a 1% /1000 hours 60% confidence level reference. This is what steady state life tests are based on.

NOTE: Certain test circuits (i.e. ICT) are likely to subject the capacitors to large voltage and current transients, which will not be seen in normal use. These conditions should be taken into account when considering the capacitor's rated voltage for use. This can be controlled by ensuring a correct test resistance is used.

- **Reverse voltage** A small degree of reverse voltage is permissible for short periods. Limiting reverse voltage excursion to the maximum limits shown will avoid a reduction in the components life expectancy. The maximum allowable reverse voltage is summarized as follows:

25°C	10% of rated voltage not exceeding 1.0 volt
85°C	3% of rated voltage not exceeding 0.5 volt
125°C	1% of rated voltage not exceeding 0.1 volt

The values quoted are not intended to cover continuous reverse operation.
They are designed to cover exceptional conditions of small levels into reverse polarity.

Non-Polar operation If higher reverse voltages are unavoidable, then two capacitors, each of twice the required capacitance and of equal tolerance and rated voltage, should be connected in a back-to-back configuration, i.e. both cathodes joined together.

- **DC Leakage Current** The DC leakage current is the current that, after a three to five minute charging period, flows through a capacitor when voltage is applied. The leakage current increases with increasing temperature. The leakage current decreases when reduced voltages are applied. The DC leakage current is measured at +25°C with rated voltage applied, through a 1000 ohm resistor connected in series in the measuring circuit. Reforming of solid tantalum capacitors is unnecessary even after prolonged periods without the application of voltage.

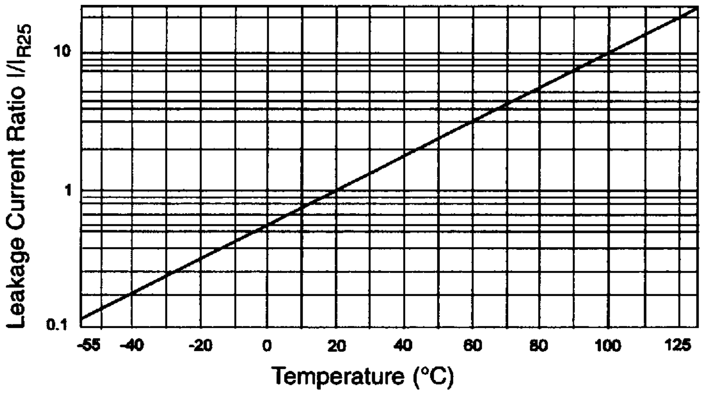
@	25°C	the DCL values are shown in part number tables
@	85°C	the DCL should not exceed 10 times the value
@	125°C	the DCL should not exceed 12 times the value

Temperature Dependance of the Leakage Current

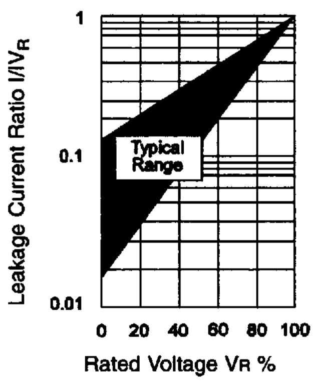
For operation between +85°C and +125°C, the maximum working voltage must be derated and can be found from the following formula.

$$V\,max = \left(1 - \frac{(T - 85)}{120}\right) \times V_R \text{ volts}$$

T is the required operating temperature.

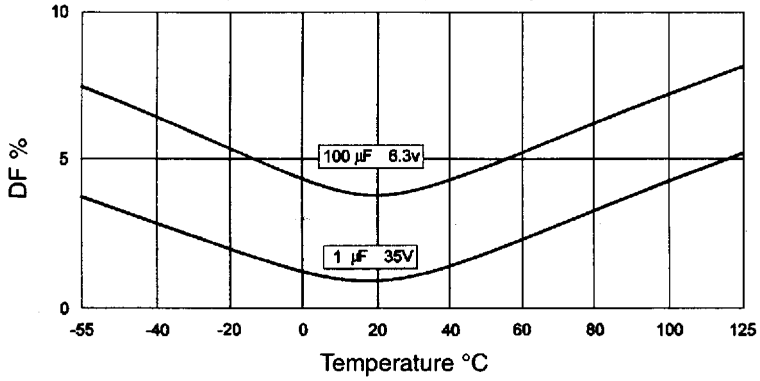


Voltage Dependence of the Leakage Current The leakage current drops rapidly when reduced voltages are applied. The effect of voltage derating on leakage current gives a significant increase in reliability for any application.

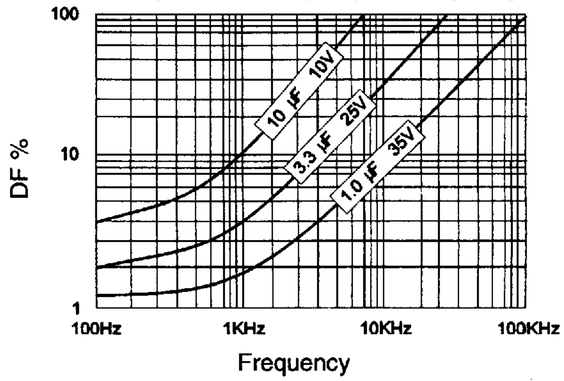


- **Tan δ** (at 120 Hz/25°C) **(DF)**
  Tangent of Loss Angle is a measurement of the energy loss in the capacitor. Terms also used are power factor, loss factor, quality factor, "Q" (the reciprocal of DF) and DF which is the measurement of Tan δ expressed as a percentage. Tan δ is the power loss of the capacitor divided by its reactive power at a sinusoidal voltage of a specified frequency. Measurement is carried out at +25°C and 120Hz with 2.2V DC bias max., with an a.c. voltage free of harmonics. The value of Tan δ is temperature and frequency dependent. DF increases with increasing frequency. DF loses its importance at higher frequencies where impedance and ESR are the normal parameters of concern.

Typical Curve
Dissipation Factor (D.F.) vs. Temperature



Typical Curve
Dissipation Factor (D.F.) vs. Frequency



Tan δ (DF) values are indicated in part number tables. The values shown in the part number tables are the limits met by the component after soldering onto the substrate.

$$\text{Tan } \delta \text{ (DF)} = \frac{R}{X_c} = 2\pi f CR$$

Tan δ (DF) = Dissipation factor
R = ESR (ohms)
X_c = Capacitive reactance (ohms)
f = Frequency (Hertz)
C = Series capacitance (Farads)

- **Impedance** Impedance is the ratio of voltage to current at a specified frequency. Three factors contribute to the impedance of a tantalum capacitor; the resistance of the semiconductor layer; the capacitance value and the inductance of the electrodes and terminations. At high frequencies the inductance of the terminations becomes a limiting factor. The temperature and frequency behavior of these three factors of impedance determine the behavior of the impedance. The impedance is measured at +25°C and 100KHz. There is unavoidable inductance as well as resistance in all capacitors. At some point in frequency, the reactance stops being capacitive and becomes inductive. This frequency is the self resonant point and typically falls in the area of 1 MHz depending on the rating. In solid tantalum capacitors, resonance is damped by the ESR and a smooth transition from capacitive to inductive reactance occurs. Total Impedance of the capacitor can be viewed as:

  Below resonance - The vector sum of capacitive reactance. $\left(X_c = \frac{1 \text{ ohm}}{2\pi f c}\right)$ and ESR

  Above resonance - The vector sum of inductive reactance. $(X_L = 2\pi f L)$ and ESR

  f = frequency, Hertz C = capacitance,farad L = inductance, Henries

- **ESR** Equivalent Series Resistance (ESR) is the preferred high frequency statement of the unavoidable resistance appearing in tantalum capacitors. Maximum limits for 100KHz ESR are listed in the part number tables. Resistance losses occur in all practical forms of capacitors. These are made up from several different mechanisms, including resistance in components and contacts, viscous forces within the dielectric and defects producing bypass current paths. To express the effect of these losses they are considered as the ESR of the capacitor. The ESR is measured at +25°C and 100KHz. The ESR is frequency dependent and can be found by using the relationship;

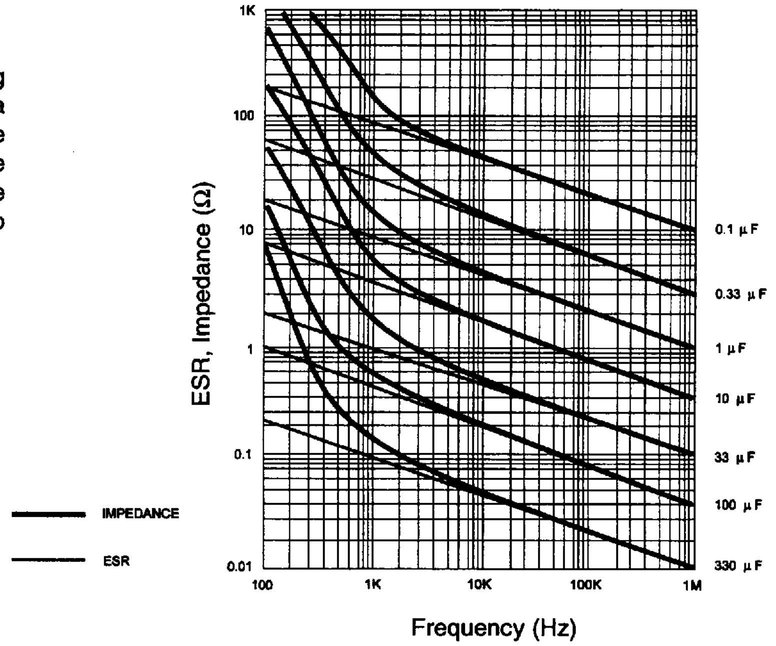
  $$\text{ESR} = \frac{\text{Tan } \delta}{2\pi f C}$$

  Where f is the frequency in Hertz, and C is the capacitance in farads.

  ESR is one of the contributing factors to impedance. At high frequencies (100KHz and above) it becomes the dominant factor. ESR and impedance become almost identical, impedance being only marginally higher.

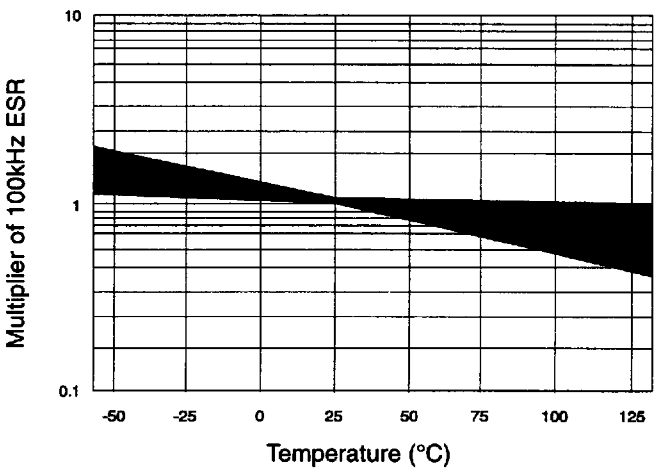
- **Frequency Dependence of Impedance and ESR**
  ESR and impedance decrease with increasing frequency. At lower frequencies the extra contribution to impedance due to the reactance of the capacitor becomes more significant. Beyond the resonant point of the capacitor, impedance again increases due to the inductance of the capacitor.

  Typical response curve to frequency.



- **Temperature Dependence of the Impedance and ESR**
  At 100KHz, impedance and ESR behave identically. Impedance and ESR decrease with increasing temperature. The amount of change is influenced by the size of the capacitor and is generally more pronounced on smaller ratings.

  Typical effect of temperature on 100KHz ESR can be seen by applying a multiplier to 100kHz ESR.



- **AC Operation** In an AC application heat is generated within the capacitor by both the AC component of the signal (which will depend upon the signal form, amplitude and frequency), and by the DC leakage. For practical purposes the DCL is insignificant. Permissible AC ripple voltage and current are related to ESR and power dissipation capability. Actual power dissipated can be calculated from the following formula: $P = I^2R = \frac{E^2R}{Z^2}$ (substituting $I = \frac{E}{Z}$)

I = rms ripple current (amperes)
R = equivalent series resistance at specified frequency (ohms)
E = rms ripple voltage (volts)
P = power dissipated (watts)
Z = impedance at frequency under consideration (ohms)

Using this formula it is possible to calculate the maximum a.c. ripple current and voltage permissible for a particular application.

Maximum allowable rms ripple voltage or ripple current may be determined taking into account three limiting factors.

1. The d.c. working voltage of the capacitor must not be exceeded by the sum of the positive peak of the applied a.c. voltage and the d.c. bias voltage.
2. The sum of the applied d.c. voltage and the negative peak of the a.c. voltage must not allow a voltage reversal in excess of that defined in "Reverse Voltage".
3. The power dissipated in the ESR of the capacitor must not exceed the power dissipation rating for the case size.

NOTE: Temperature derating factors to power dissipation ratings for case size must be considered in calculations.

RIPPLE CURRENT

$$I_{RMS} = \sqrt{\frac{P_{MAX}\,T_{DF}}{ESR}}$$

I_{RMS} = rms current (amps)
P_{MAX} = Power Dissipation rating (watts)
T_{DF} = Temperature derating factor

RIPPLE VOLTAGE

$$E_{RMS} = \sqrt{(X_L - X_C)^2 + (ESR)^2} \bullet I_{RMS}$$

E_{RMS} = rms ripple voltage
X_L = $2\pi f h$ f = Frequency (of interest), h = Inductance (Negligible at Low f)
X_C = $1/2\pi f c$ f = Frequency (of interest), c = Capacitance (Farad)
ESR = ESR (at f of interest)
I_{RMS} = rms ripple current

- **AC Power Dissipation** Power dissipation is a function of capacitor size and materials. Maximum power ratings have been established for all case sizes to prevent overheating. These ratings are shown as free air values with temperature derating factors up to +125°C. In application circuit layout, thermal management, available ventilation, and signal waveform may affect the values quoted. It is recommended that temperature measurements are made on devices during operating conditions ensuring that the temperature differential between the device and the ambient temperature is: < 10°C up to +85°C
  < 2°C above +85°C

Power Dissipation Ratings (in Free Air)

TB Series Dipped Radial

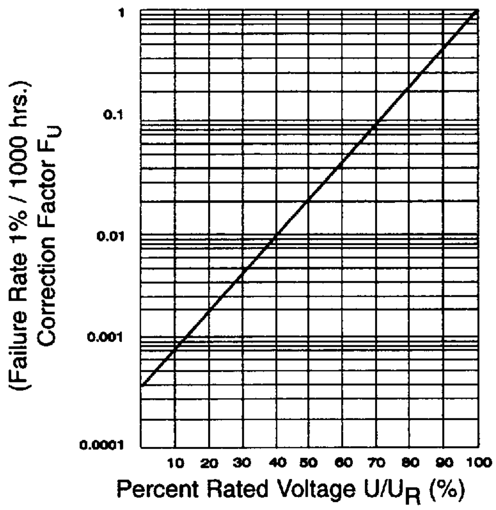
Case Size	Max. Power Dissipation (W)	Temperature Derating Factors	
		Temp °C	Factor
A	0.045	+25	1.00
B	0.050	+85	0.40
C	0.055	+100	0.15
D	0.060	+125	0.09
E	0.065		
F	0.075		
G	0.080		
H	0.085		
J	0.090		
K	0.100		
L	0.110		
M	0.120		
N	0.130		
O	0.140		

- **Reliability** Tantalum capacitors have no known wear-out mechanism and in certain circumstances are capable of limited self-healing. Random failures can still occur in operation. The failure rate will decrease with time and not increase as with other capacitor types and other electronic components. The reliability of solid tantalum capacitors is dependent upon three key factors which affect the working environment and operating conditions:
  Operating voltage / Voltage derating
  Operating temperature
  Circuit impedance
  Operational reliability generally increases with reduction of applied voltage and temperature and with an increase of series resistance.

- **Base Failure Rate** Standard tantalum product conforms to Level M reliability (i.e. 1%/1000 hours) at rated voltage, rated temperature (+85°C) and 0.1Ω/volt circuit impedance. This is known as the base failure rate, F_B, which is used for calculating operating reliability. The effect of varying the operating conditions on failure rate are shown.

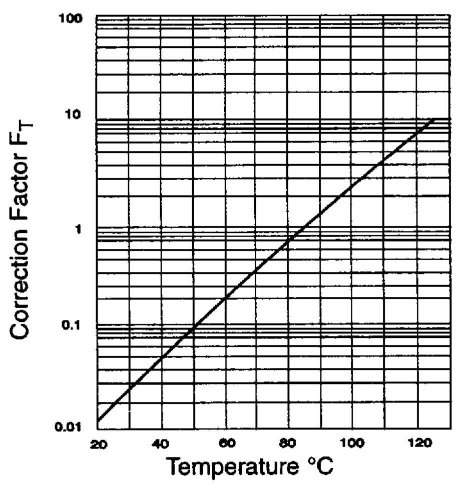
- **Operating Voltage/Voltage Derating** If a capacitor with a higher voltage rating than the maximum line voltage is used, then the operating reliability will be improved. This is known as voltage derating. The graph shows the relationship between voltage derating (the ratio between applied and rated voltage) and the failure rate. The graph gives the correction factor F_U for any operating voltage.

Effect of applied voltage on basic failure rate for typical component (60% confidence level).



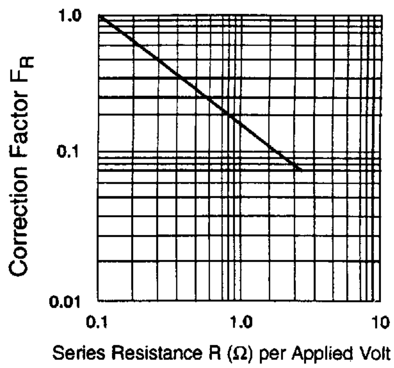
- **Operating Temperature** If the operating temperature is below the rated temperature for the capacitor then the operating reliability will be improved as shown. This graph gives a correction factor Ft for any temperature of operation.

Correction Factor to Failure Rate F for Ambient Temperature T for typical component



- **Circuit Impedance** All solid tantalum capacitors require current limiting to prevent burning of the device. A series resistor is recommended for this purpose. A lower circuit impedance may cause an increase in failure rate, especially at temperatures higher than 25°C. An inductive low impedance circuit may apply voltage surges to the capacitor and similarly a non-inductive low impedance circuit may apply current surges to the capacitor, causing localized over-heating and failure. The recommended circuit impedance is 1 ohm per volt. Where this is not feasible, equivalent voltage derating should be used. The graph shows the correction factor, F_R, for increasing series resistance.

  Correction Factor to Failure Rate for Series Resistance R on Basic Failure Rate F_B for typical component



- **Reliability Assessment**
  Operational reliability F in any circuit condition can be deduced from the three previous graphs by multiplying the base failure rate, F_B, for the series by the correction factors, F_U, F_T, and F_R.
  Worked example of reliability calculation. For a capacitor with a 16v rating, being operated on a 10v line with 0.8Ω per volt circuit impedance, at a temperature of 50°C, the correction factors given by the previous graphs are as follows:

  $F_U = 0.04$
  $F_T = 0.1$
  $F_R = 0.2$

  For a series with F_B = 1%/1000 hours, the failure rate F will be $F = F_U \times F_T \times F_R \times F_B$
  = (0.04 x 0.1 x 0.2 x 1)%/1000 hours
  = 0.0008% per 1000 hours at 60% confidence level

  It should be noted that the above analysis refers to steady state operating conditions. The failure rate will also be affected by the presence of surges.

- **Life test** Our regular quality assurance program requires capacitors be subjected to +85°C at rated voltage and +125°C at 2/3 x rated voltage for 2000 hours with 3 ohms circuit impedance. The capacitors shall meet the following limits after stabilizing for 1 - 2 hours at room temperature.

capacitance change	within +/-10% of the initial value
Tan δ (DF)	within the initial value
DC leakage current	within 125% of the initial value

- **Humidity life test** Capacitors shall be capable of withstanding 1000 hours at +55°C with 95% RH and rated voltage applied. The capacitors shall meet the following limits after stabilizing for 24 hours at 25°C.

capacitance change	within +/-10% of the initial value
Tan δ (DF)	less than 2X the initial limit
DC leakage current	less than 5X the initial limit

- **Thermal Shock Test** Capacitors are subjected to 5 cycles of 30 minute durations at -55°C followed by 30 minutes at +125°C. The capacitors shall meet the following limits after stabilizing at 25°C.

capacitance change	within +/-5% of the initial value
Tan δ (DF)	within the initial limit
DC leakage current	within 125% of the initial limit

- **Surge Current** Capacitors shall withstand 3 consecutive cycles. The capacitors are charged approximately 4 seconds at rated voltage thru a low circuit resistance of approximately 1 ohm @ +25°C followed by a discharge to below 1% of rated voltage. Post test readings must meet the following criteria:

capacitance change	less than +/-5% of the initial value
Tan δ (DF)	within the initial limit
DC leakage current	within the initial limit

- **Surge Voltage Test** Surge voltage tests are performed at +25°C, +85°C and +125°C. The capacitors shall be applied a surge voltage in series with a 33 Ω resistor at a cycle of .5 minutes "on" and 5.5 minutes "off" repeating 1000 times at +85°C. After stabilizing at room temperature the capacitor shall meet the following limits.

capacitance change	within +/-10% of the initial value
Tan δ (DF)	within the initial limit
DC leakage current	within the initial limit

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- **Mechanical properties**

Tantalum chip capacitors are mechanically robust, meeting requirements for high speed insertion machines and the needs of most automotive and aerospace applications. The performance specifications:

Acceleration 10 g (98.1 m/s^2)

Vibration severity 10 to 2000 Hz, 0.75mm of 10 g (98.1 m/s^2)

Shock Trapezoidal Pulse 10 g (98.1 m/s^2) for 6 ms

Tensile strength of connection 5 N.

Bending strength of connections 2 bends at 90° with 50% of the tensile strength loading.

Flammability Flame retardant epoxy resin with a limiting oxygen index of 30 (ASTM-D-2863). UL Rating 94 VO.

Resistance to solvents MIL-STD-202, Method 215. Brushing required after test. There shall be no visible damage to epoxy or marking.

Resistance to soldering heat MIL-STD-202, Method 210, Test condition B (+260°C for 10 seconds). Leads shall be immersed to within 1/4 inch of the capacitor body. Capacitance, DF, and DCL should be within original limits.

Solderability MIL-STD-202, Method 208. Depth of insertion into a solder bath at 235°C to within .125 inches of capacitor body. Greater than 90% of the dipped area shall exhibit good tinning.

- **Soldering conditions**

The soldering temperature and time should be the minimum necessary for a good connection. A suitable combination for wave soldering is 230°C - 250°C for 3 - 5 secs. Small parametric shifts may be noted immediately after wave solder, components should be allowed to stabilize at room temperature prior to electrical testing.

DIP Soldering is permissible provided solder bath temperature ≤ 270°C, < 3 seconds, circuit board thickness ≥ 1 mm.

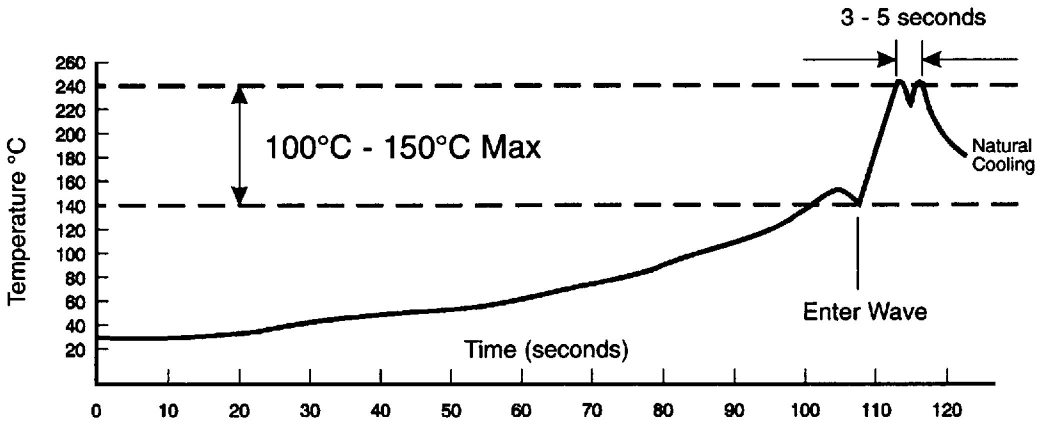
Fluxes containing acids must not be used.

Installation Position There are no restrictions on installation position, however, the upper temperature limit (maximum capacitor surface temperature) should not be exceeded. This must be considered when devices are positioned near components which radiate heat strongly.

- **Cooling**

After soldering, the assembly should preferably be allowed to cool naturally to room temperature. In the event that assisted cooling is used, the rate of change in temperature should not exceed that used in reflow.

- **Recommended Wave Soldering Profile**

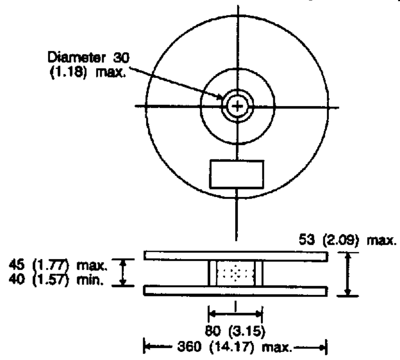


Packaging for Auto Insertion, In Accordance with EIA RS - 468

Dimensions mm (inches)

Description	Code	Dimension
Feed hole pitch	P	12.7 ± 0.3 (0.5 ± 0.01)
Hole center to lead	P_1	3.85 ± 0.7 (0.15 ± 0.03) to be measured at bottom of clinch (5 mm L.S.)
		5.05 ± 1.0 (0.2 ± 0.04) (2.5 mm L.S.)
Hole center to component center	P_2	6.35 ± 0.4 (0.25 ± 0.02)
Change in pitch	Dp	± 1.0 (± 0.04)
Lead diameter	d	0.5 ± 0.05 (0.02 ± 0.003)
Lead Spacing	S	5.0 (0.2) Tol. 0.8 (.031)
		2.5 (0.1) Tol. 0.8 (.031)
Component Alignment	Dh	0 ± 2.0 (0 ± 0.08)
Feed hole diameter	D	4.0 ± 0.2 (0.15 ± 0.008)
Tape width	W	18.0 + 1.0 (0.7 + 0.04) - 0.5 (- 0.02)
Hold down tape width	W_1	6.0 (0.24) min.
Hold down tape position	W_2	1.0 (0.04) max.
Lead wire clinch height	H	16 ± 0.5 (0.63 ± 0.02) 19 ± 1.0 (0.75 ± 0.04) on request
Hole position	H_1	9.0 ± 0.5 (0.35 ± 0.02)
Base of Component height	H_2	18 (0.7) min.
Component Height	H_3	32.25 (1.3) max.
Length of snipped lead	L	11.0 (0.43) max.
Total tape thickness	T	0.7 ± 0.2 (0.03 ± 0.001)
		Carrying card 0.5 ± 0.1 (0.02 ± 0.005)

Reel configuration mm (inches)

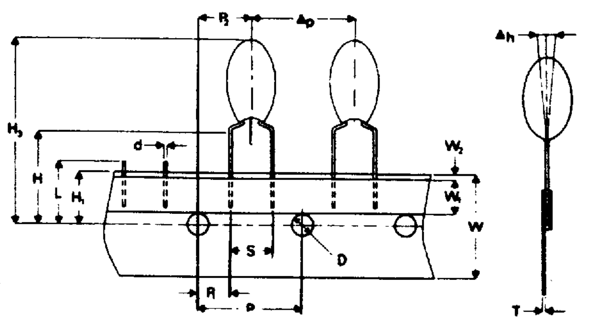


Manufactured from cardboard with plastic hub. Holding tape outside. Positive terminal leading (negative terminal by special request).

Reel Quantities

Style	Case Size	No. of pieces
TB	A	1500
	B, C, D	1250
	E, F	1000
	G, H, J	750
	K, L, M	500

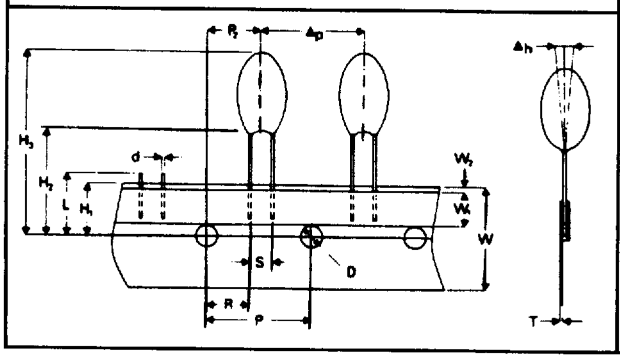
Size codes N and O are not available taped



STYLE TB

LEAD SPACING

5.0 (.200)



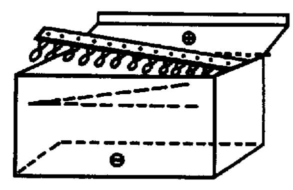
STYLE TB

LEAD SPACING

2.54 (.100)

Ammo pack dimensions mm (inches)

Height 360 (14.17, width 360 (14.17, thickness 60 (2.36)



Ammo Pack Quantities

Style	Case Size	No. of pieces
TB	A, B, C, D	3000
	E, F, G	2500
	H	2000
	J, K, L, M	1000

Size codes N and O are not available taped