Rescon

Aluminium Electrolytic Capacitors

SELECTION GUIDE

RWTÜV

PROFESSIONAL GRADE : SCREW TERMINAL TYPE

Type (series)	Rated Capacitance (μf)	Rated Voltage (DC)	Dimension (ØD X L) mm	Climatic Category	Endurance Test, T°C	100Hz Hrs.	Application
PG - 2 I	1000 -300,000	16 - 450	35x85 - 89x150	-40°C to +85°C	85°C	2000	General purpose, computer and industrial systems. Smoothing and Filtering. Motor control devices. Uninterruptible power supplies (UPS). Standard power supplies. Audio power supplies.
PG - 5 S	1000 -300,000	16 - 450	50x85 - 89x150	-40°C to +85°C	85°C	5000	As PG - 2I but 5000 hrs and higher ripple rating
PG - 105	470 -220,000	16 - 450	50x85 - 89x150	-40°C to +105°C	105°C	2000	As PG - 2I but 105°C
PG - WL	470 -5,000	150 - 450	50x85 - 89x150	-40°C to +85°C	85°C	2000	Welding and very high ripple current application. (Available on request)

INDUSTRIAL GRADE : LUG TERMINAL TYPE

Type (series)	Rated Capacitance (μf)	Rated Voltage (DC)	Dimension (ØD X L) mm	Climatic Category	Endurance Test, T°C	100Hz Hrs.	Application
RCST-1 Can Type	250 - 22,000	25 - 450	25X48 - 45X78	-40°C to +85°C	85°C	2000	General purpose, computer and industrial systems, Smoothing and filtering, Telecommunications, Audio, video systems. SMPS. Standard power supplies
RCSP-2 Can Type	250 - 22,000	100 - 450	35x58 - 45x78	-40°C to +85°C	85°C	2000	As above but with heavy duty luge
RCBPT-2 Can Type Snap-in	250 - 22,000	16 - 450	25x48 - 35x78	-40°C to +85°C	85°C	2000	As above
AXL	10 - 200	100 - 450	20X48	-40°C to +85°C	85°C	2000	As above

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TEST STANDARDS

ROUTINE TESTS :

Name of the Tests	IEC 603 48 - 4 IS 4317 Subclause	Procedure	Requirement
Visual Examination	4.2		No visible damage Legible marking and as specified in the detailed specification.
Leakage current	4.3.1	Protective resistance. ≈ 100 Ω for rated voltage upto and including 100 V. ≈ 1000 Ω for rated voltage above 100 V.	Within limit as per specified in the detail specification.
Capacitance	4.3.2	1 V, 100 Hz	Within specified tolerance.
Tangent of loss angle (tan δ)	4.3.3	1 V, 100 Hz	Within limit as per specified in the detail specification.
Impedance	4.3.4	1 V, 100 Hz	Within limit as per specified in the detail specification.
Voltage proof of the external insulation.	4.3.6	2kV for 1 min.	There shall be no break - down or flash over during the test.
Sealing	4.11.6	1 minute in water at 90°C.	No continuous chain of bubbles.

PERIODIC TYPE TESTS :

Name of the Tests	IEC 603 48 - 4/ IS 4317 Subclause	Procedure	Requirement
Solderability	4.6	Solder bath : 235°C; 2s, immersed up to 2mm from the body,	No visible damage. Legible marking.
Endurance (Accelerated)	8.8 (IS 4317)	168 hrs, at upper category temperature, at rated dc voltage and ripple current specified in the detail specification.	No visible damage. Legible marking. Leakage current within limit. ΔC/C ±15% of initial measurement. tan δ≤1.3 times the stated limit.
Pressure relief (only for safety vent type)	4.16	DC voltage applied in reverse direction producing a current of 1 to 10 A.	Pressure relief opens prior to explosion or fire.
Surge test	4.14	No. of cycles : 1000, at **Applied Voltage for PG - 2I** 1.15 x rated voltage for ≤ 250 V. 1.10 x rated voltage for ≥ 350 V. **Applied Voltage for PG - 5S** 1.25 x rated voltage for ≤ 250 V. 1.15 x rated voltage for ≥ 350 V. duration of charge 30s, duration of discharge 5 min 30s.	No visible damage and leakage of electrolyte. Leakage current within limit. Δ C/C ± 15% of initial measurement. tan δ≤ 1.3 times the stated limit.
Damp heat cyclic	4.11.2	1 cycle (55°C to 25°C) of 24 hrs, RH -95 to 100%, no voltage applied.	No visible damage. Legible marking. Leakage current within limit. Δ C/C ± 15% of initial measurement.

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GENERAL INFORMATION

General Information :

Basic Construction : The capacitance of a capacitor is a factor of proportionality defined as the ratio of the charges acquired to the voltage applied, or where 'Q' is the charge in coulombs, 'V' is the voltage in volts and 'C' is the capacitance in farads. C = Q/V

The fundamental formula for the capacitance of two parallel plates is C = εA/d

C - Capacitance in farad

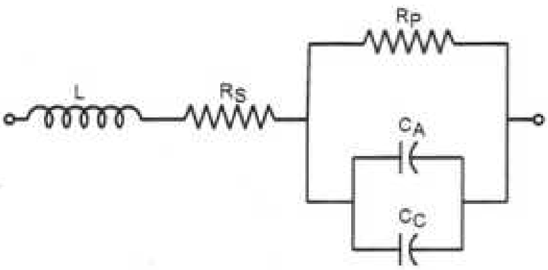
A - Area of one plate in Sq. mtrs.

ε - Permittivity of the dielectric

d - distance between the two plates in meters

Typical equivalent circuit of a capacitor :

FIG (1)



C_A = Capacitance of Anode

C_C = Capacitance of Cathode

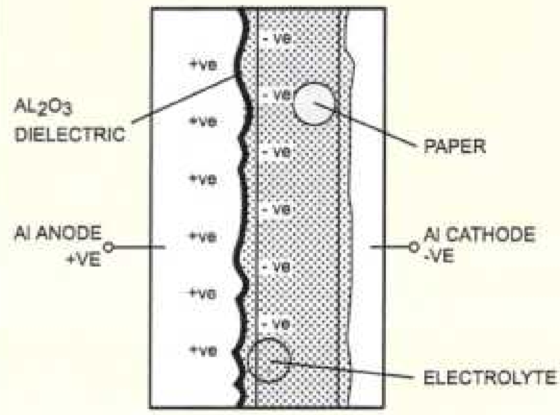
R_S = Series Resistances (int. & Ext. Connections)

L = Inductance of Capacitor Wound Element

R_P = parallel resistance (anode, cathode foil and electrolyte)

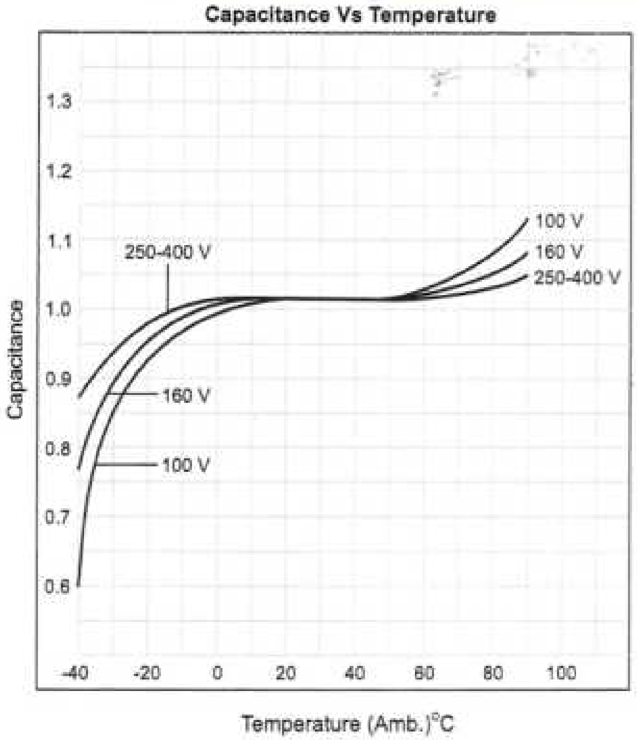
FIG (2)

Structure Of Aluminium Electrolytic Capacitor



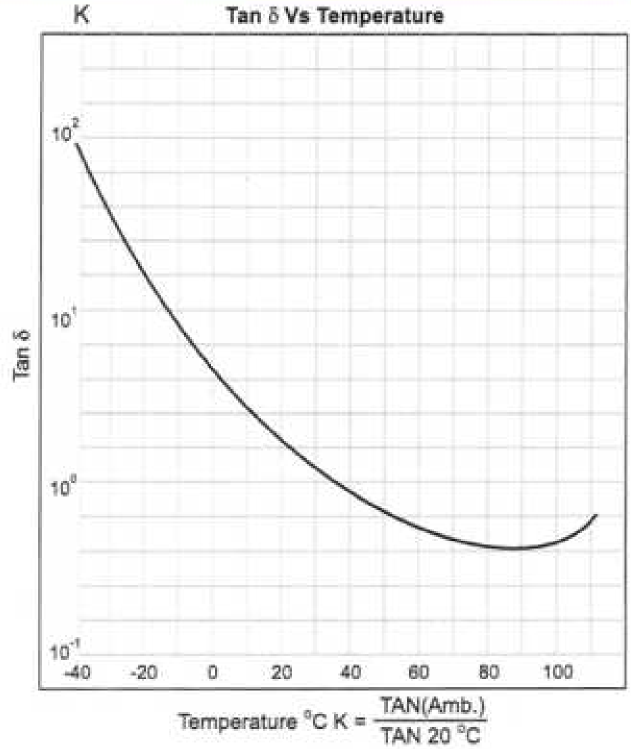
Capacitance & Tan δ Vs Temperature :

Capacitance Vs Temperature



Temperature (Amb.)°C

K **Tan δ Vs Temperature**



Temperature °C $K = \frac{TAN(Amb.)}{TAN\ 20\ ^{\circ}C}$

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GENERAL INFORMATION

Electrical characteristics :

1. Working Voltage (V_R) : maximum permitted DC voltage applied continuously with temperature.

2. Surge Voltage : The Surge Voltage of the capacitor is designed to take care of the transients while switching on etc. The maximum Surge voltage shall not exceed the specification. The capacitor shall withstand the following surge test as stated in IS : 4317. The capacitor shall be subjected to 1000 cycles each consisting of charge as described below followed by discharge period through a appropriate resistor of 1000 Ohm. The duration of charging shall not exceed 30 sec.

   Applied Voltage : PG-2I
   1.15 x rated voltage for rated voltage ≤ 250 V.
   1.10 x rated voltage for rated voltage ≥ 350 V.

   Applied Voltage : PG-5S
   1.25 x rated voltage for rated voltage ≤ 250 V.
   1.15 x rated voltage for rated voltage ≥ 350 V.

3. Capacitance : measured at 1Vrms, the frequency of the measuring voltage shall be 100 Hz

4. ESR : is a measure of the heat dissipation loss in the capacitor and is expressed as power factor or dissipation factor it is stated at 100 Hz and 25°C.

$$ESR = \frac{\tan\delta}{2 \pi f c}$$

5. Impedance (Z) : Determines output ripple voltage which is between the capacitor terminals

$$Z = \sqrt{ESR^2 + (2 \pi ESL - 1/2 \pi f c)}$$

6. Leakage current : The direct current that flows through the capacitor when voltage is applied. It is dependent on voltage, temperature and time. Measured at 25°C, and after 5 mins. of application of VR in accordance with international standards (IEC 60384-4).

   The leakage current of Rescon capacitors are lower than specified in (IEC - 60384-4), if after prolonged storage, the leakage current at the first measurement does not meet the requirements, preconditioning shall be carried out in accordance to the standard.

7. Ripple current (I_{RAC}) :The maximum ripple current defined as that which gives a steady temperature difference of 10°C between the outer surface and central core of capacitor.

8. Temperature Range : The temperature interval which gives the working temperature range.

9. Upper and Lower temperature range : Determines the temperature to which the capacitor may be continuously exposed in order to operate with specified life and reliability.

10. Case Temperature : The hottest part of the case which determines life reliability and maximum permitted ripple current. Forced air-cooling is recommended for better life and ripple current capability.

RESCON'S CAPACITOR CONSTRUCTION SCREW TERMINALS

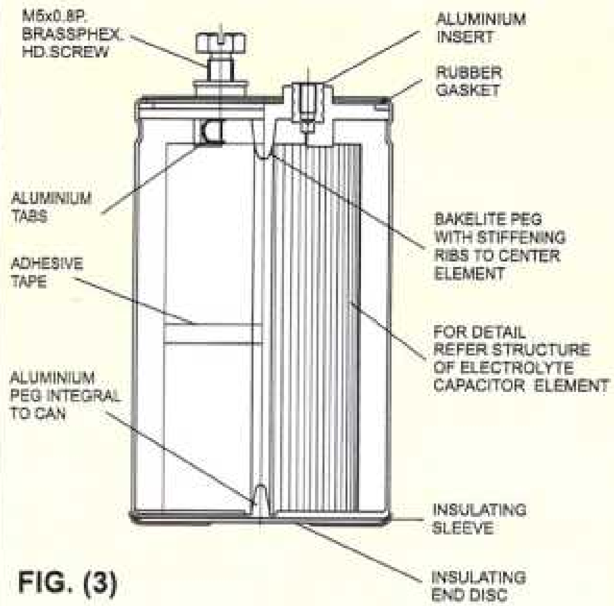


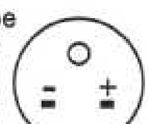
FIG. (3)

Application Precaution :

1. **Shelf Life :** Sudden application of rated voltage to the capacitor stored for more than six months may cause dielectric break-down due to thinness of the oxide film and heat generated from excessive current leakage. It is recommended that electrolytic capacitors are preconditioned as specified by IS 4317 category (2A)

2. **Pre conditioning :** In view of large value of capacitance of PG capacitor it is recommended that before starting the test sequence these capacitors should be preconditioned by applying the rated working voltage across the capacitors. Here again the power source must be a regulated DC power supply and suitable current limiting resistor must be connected in series, the value of which shall be approximately 100 Ohm for rated voltage upto and including 100V and approximately 1000 Ohm for rated voltage above 100V. The voltage shall be maintained for one hour after its value across the capacitor has been equal to the rated voltage. Thereafter the capacitor may be stored idle for 24 hrs. after this period the capacitor may be tested for any of the parameters specified.

3. **Mounting :** The capacitor may be mounted vertically or horizontally with or without clamp. Capacitors with safety valve can be used vertically (terminals on top) or horizontally. When used horizontally, following position -



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4. ESR : is a measure of the heat dissipation loss in the capacitor and is expressed as power factor or dissipation factor it is stated at 100 Hz and 25°C.

   ESR =

5. Impedance (Z) : Determines output ripple voltage which is between the capacitor terminals

   $Z = ESR^2 + (2\pi ESL - 1/2\pi f c)$

6. Leakage current : The direct current that flows through the capacitor when voltage is applied. It is dependent on voltage, temperature and time. Measured at 25°C, and after 5 mins. of application of

Series connection for aluminum electrolytic capacitors : In series circuit, it has to be ensured that the load on the individual capacitor does not exceed the rated voltage of the capacitor, It is common knowledge that the total V dc voltage applied is distributed proportional to the insulation resistance which is inversely proportional to the leakage current of each capacitor. Refer fig. 4.

And since the insulation resistance of the individual capacitors will differ, non-uniform voltage distribution will occur. We have therefore to ensure that this non-uniform distribution is not greater than the rated voltage of the capacitor. For this reason forced balancing of the voltage distribution may be necessary.

The most reliable method is to use electrically isolated voltage sources for the individual capacitors are shown in fig. no. 5 below :

If this is not possible, balancing (R_{symm}, fig. 6) can be externally connected to the individual capacitors. The balancing resistance must be lower than the insulation resistance of the capacitor.

A proven method is to design the balancing resistors so that a current approximately amounting 8 to 10 times the leakage current of capacitor flows through them. The method of resistance calculation is :

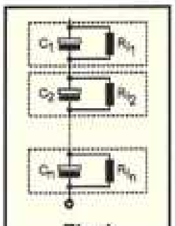

Fig 4

1. The rated leakage current of screw terminal capacitor is given by I_L = 0.005 CV and where I is in ampere and C is in farad.

2. Assume normal leakage to be 60% of this value.

3. Assume we want 8 times more current to pass through the balancing resistor route.

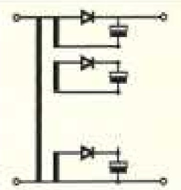
Fig 5

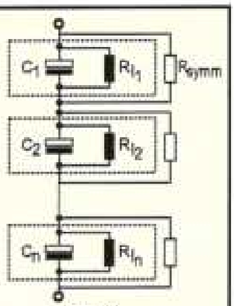

Fig 6

4. Therefore the current through resistance route = 8 x 0.60 x 0.005 CV.

5. Therefore resistance $R = \dfrac{V}{8 \times 0.60 \times 0.005\ CV.}$

6. And its wattage will be $V \times I = 8 \times 0.60 \times 0.005\ CV^2$

Let us consider that we want to connect 3 nos. capacitors of 3000 mfd/250 volts in series, to achieve 1000 mfd/600 volts then the balancing resistor will be 13.9 k ohms and its wattage 4.5 watts.

Theoretically, the above is a good solution, but practically it is not so good, for the simple reason that you will be using a less reliable component i.e. the resistor to protect a more reliable component, i.e. the capacitor. Fortunately, when only 2 or 3 capacitors are to be connected in series the balancing resistance can be avoided.

During charging it is reported that the voltage on each capacitor connected in series is proportional to the inverse of the capacitance, but upon reaching its final voltage it is proportional to the inverse of the capacitors leakage current.

Now in a series string, the leakage current passing through all the capacitors is the same, Therefore, the capacitor with a propensity of higher leakage current (i.e. lower insulation resistance) will get less voltage. Since leakage current increases with applied voltage, less voltage results in higher leakage resistance, and the voltages tend to equalize. It is for this reason; we can do away with balancing resistors when only two or three capacitors are used in the series.

The following four simple precautions however need to be taken :

1. Select capacitors from same manufacture, same type and same batch.

2. At least under Indian conditions it is possible to request the capacitor manufacture to label each capacitor and give its test reports as regards leakage current and Impedance or tan d. Use those capacitors in a bank which are nearest in value.

3. The total voltage applied across bank should not exceed 0.85 n x V where n = 2 or 3 capacitors in series. The factor of 0.85 will be further reduced for temperature and ripple current derating.

4. Ensure that the capacitors is series have the same thermal environment.

Parallel connection for aluminium electrolytic capacitors :

If one of the capacitors in a parallel circuit fails as a result of short circuit, the entire bank is discharged through the defective capacitor. In case of large banks with high energy content this may lead to extremely abrupt and severe discharge phenomena. It is therefore advisable to take measures to prevent or limit the discharge current. In smoothing capacitors banks, for example, this is achieved by individual fusing : the principle is shown in fig. 7. The fuse rating could be fixed at twice the maximum expected ripple current through the capacitor. In such a configuration, it is also necessary to have slow-start circuit at equipment turn-on. The slow-start circuit can be a resistor in series with the capacitors that is shorted after initial charging.

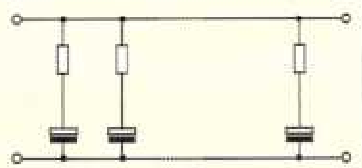
Fig 7

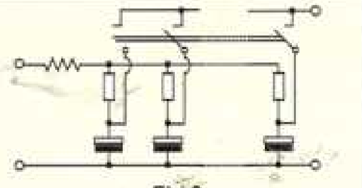
Fig 8

The above arrangement is however, not suitable for capacitor banks designed for pulse discharges. The parallel connection is then provided directly before the discharge as shown in fig. 8.

Combined parallel and series connection : The recommendations given above apply analogously to combined parallel/series connection. When using balancing resistors, it is advisable to assign each capacitor its own resistor. (fig. 9)

Other solution is the use of parallel connection within the series circuit and group balancing resistors.(fig. 10)

This solution is admittedly less complex yet it is characterized by a crucial disadvantage :

If a capacitor in the series circuit fails as a result of short circuit, the applied voltage is distributed among the remaining capacitors of the series circuit. This results in voltage overload and possibly in destruction of the remaining capacitors.

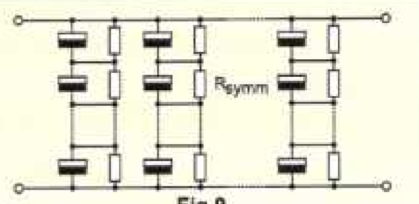

Fig 9

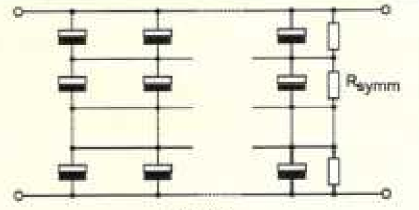

Fig 10

In the balancing arrangement shown in fig. 9 only one series branch is subject to the risk, whereas with the more simple configuration shown in fig. 10 the voltage overload affects all series branches due to the internal parallel connections and causes more severe damage. For this reason, internal parallel connections as shown in fig. 10 are to be avoided.

Bus structure

When connecting capacitors in parallel, design the connecting bus with these features in mind. Minimum series inductance requires a laminated bus or strip-line structure. For example, have one plane of the circuit board as the +ve connection and another plane as the -ve connection to all capacitors. Path resistance to each capacitor should be equal to assure equal current sharing. While ripple current divides among the capacitors in proportion to capacitance values for low-frequency ripple, high-frequency ripple current divides in proportion to ESR values and path resistance.

Note : We are not liable for any damages a rising out of implementation of any of our suggestions given above. We are essentially capacitor manufacturer and not circuit designers, and therefore it will be prudent to get our suggestions whetted by an expert circuit designer before incorporating the same in your design.

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