Sensitivity to Frequency and Temperature:

Ripple current ratings are specified at an ambient temperature of 85ºC in circulating air, using the 25ºC values of E.S.R.

The maximum allowable ripple current may be adjusted for frequencies other than 120 Hz and temperatures other than 85ºC using the tables below.

RIPPLE CURRENT *FREQUENCY* MULTIPLIERS

Series	100 Hz	120 Hz	400 Hz	4 KHz	10 KHz	20 KHz
23A	0.95	1.00	1.15	1.20	1.35	1.40
23B	0.97	1.00	1.10	1.15	1.25	1.25
23C	0.95	1.00	1.15	1.20	1.35	1.40
23D	0.92	1.00	1.04	1.08	1.25	1.25
23F	0.95	1.00	1.04	1.06	1.10	1.15
23H	0.95	1.00	1.10	1.15	1.25	1.25
23J	0.95	1.00	1.10	1.12	1.15	1.18
23M	0.97	1.00	1.10	1.15	1.25	1.25

Table-AP1

RIPPLE CURRENT *TEMPERATURE* MULTIPLIERS

Series	105ºC	95ºC	85ºC	75ºC	65ºC	55ºC	45ºC	35ºC
23A	-----	-----	1.0	1.4	1.7	2.0	2.3	2.5
23B	-----	-----	1.0	1.4	1.7	2.0	2.3	2.5
23C	-----	1.0	1.4	1.7	2.0	2.3	2.5	2.7
23D	-----	-----	1.0	1.4	1.7	2.0	2.3	2.5
23F	0.0	0.7	1.0	1.2	1.4	1.6	1.7	1.9
23H	-----	-----	1.0	1.4	2.0	2.3	2.5	2.7
23J	-----	-----	1.0	1.4	2.0	2.3	2.5	2.7
23M	0.0	0.7	1.0	1.2	1.4	1.6	1.7	1.9

Table-AP2

RIPPLE CURRENT *AIR-FLOW* MULTIPLIERS

AIR FLOW (Linear Feet / Minute)							
LFM	0	50	100	150	200	250	300
All Series	1	1.15	1.25	1.4	1.5	1.6	1.7

Note: Air-Flow Multiplier is in addition to other applied multipliers.

Table-AP3

AIR-FLOW MULTIPLIERS

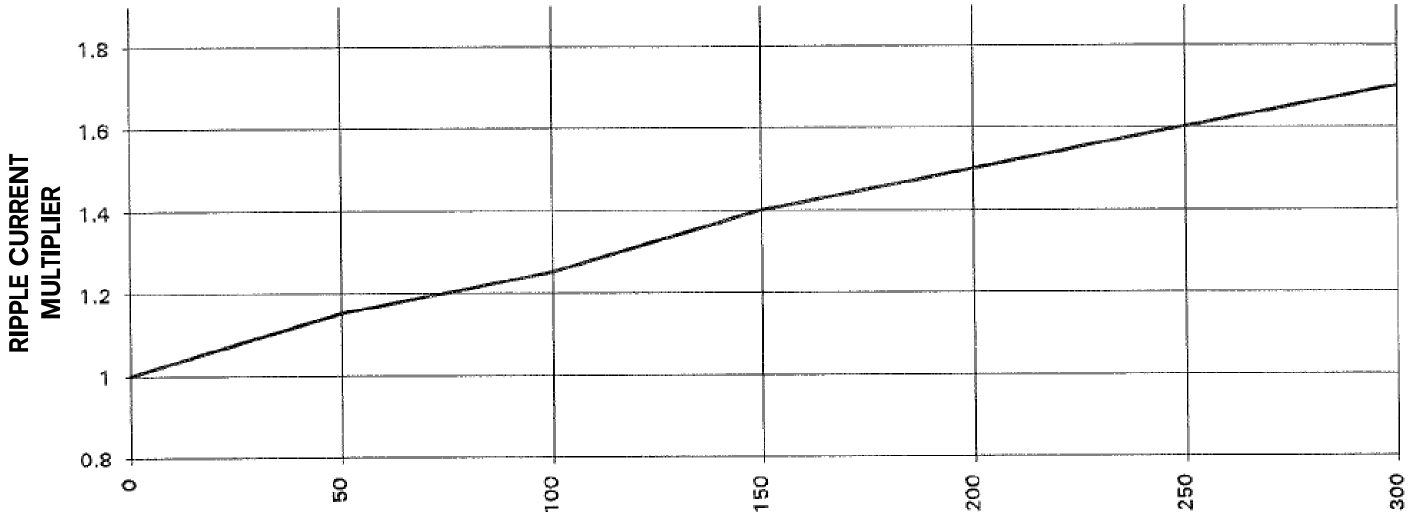

Chart-APC1

APPLIED VOLTAGE

The combined Peak AC Voltage and DC Voltage shall not exceed the DC Voltage Rating of the capacitor, or the reverse DC Voltage Rating of the capacitor.

REVERSE VOLTAGE

Unless otherwise specified, the maximum permissible reverse voltage rating for all aluminum Electrolytic Capacitors is 1.5 volts.

RMS CURRENT LIMITS FOR TERMINAL TYPES *

Terminal Type	Case Diameter				
	1.375	1.750	2.000	2.500	3.000
P	25	25	25	N/A	N/A
L	30	30	30	30	30
H	30	30	30	40	40
D	N/A	N/A	N/A	50	50
N	N/A	N/A	N/A	50	50
M	30	30	30	40	40
K	N/A	N/A	N/A	50	50

Table-AP4

*** NOTE:** The maximum values shown in the above table are expressed in Amps RMS, and based on the minimum specified torque in Table AP4A, and assuming a minimum of 4 threads are fully engaged.

SHELF LIFE

Aluminum Electrolytic Capacitors which have been stored for extended periods or in elevated temperatures undergo dielectric deterioration causing DC Leakage currents to increase beyond allowable levels. Sustained elevated Leakage currents cause decreased service life due to higher device operating temperatures. Use of capacitors exhibiting excessive leakage currents may cause premature activation of the pressure sensitive safety vent, or total dielectric failure.

The normal shelf life expectancy for these capacitors is described by Charts APC2 & APC3 on page 70. Units suspected of exceeding the “maximum Shelf Life” line in this chart, should be discarded and replaced. It is recommended that units be reformed only once to reduce the DC Leakage current to specification levels.

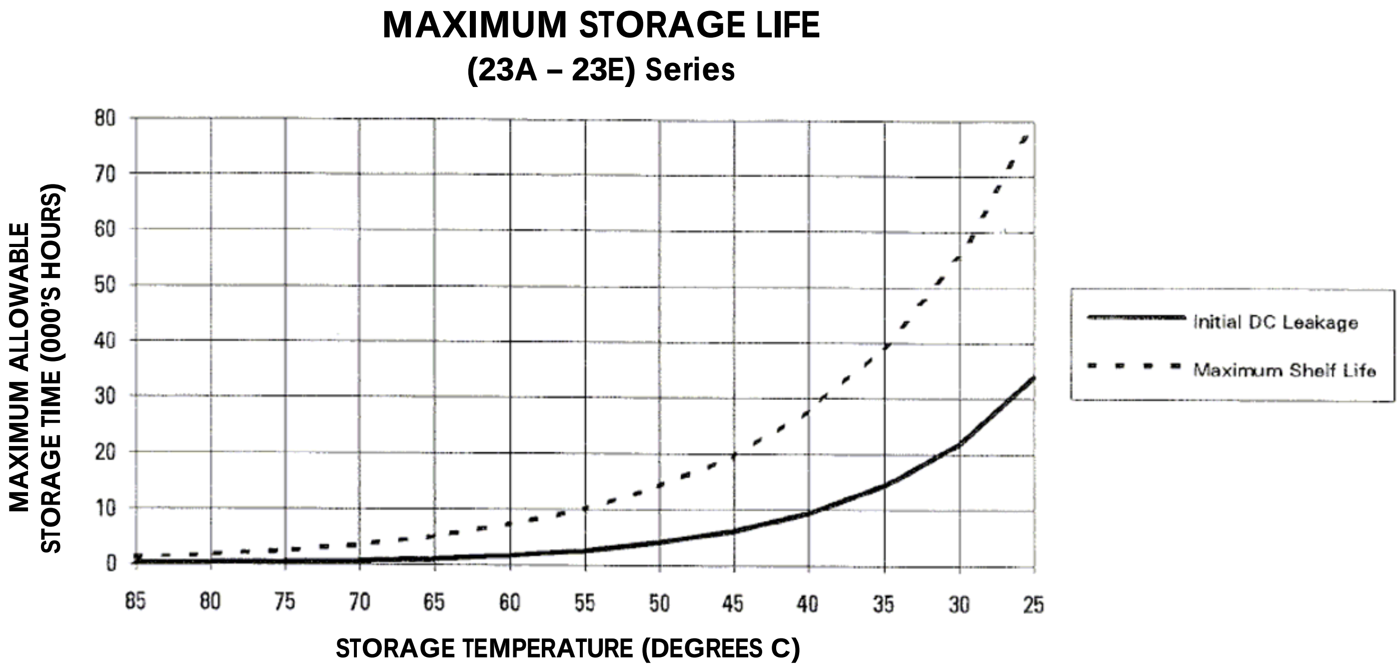

Chart-APC2

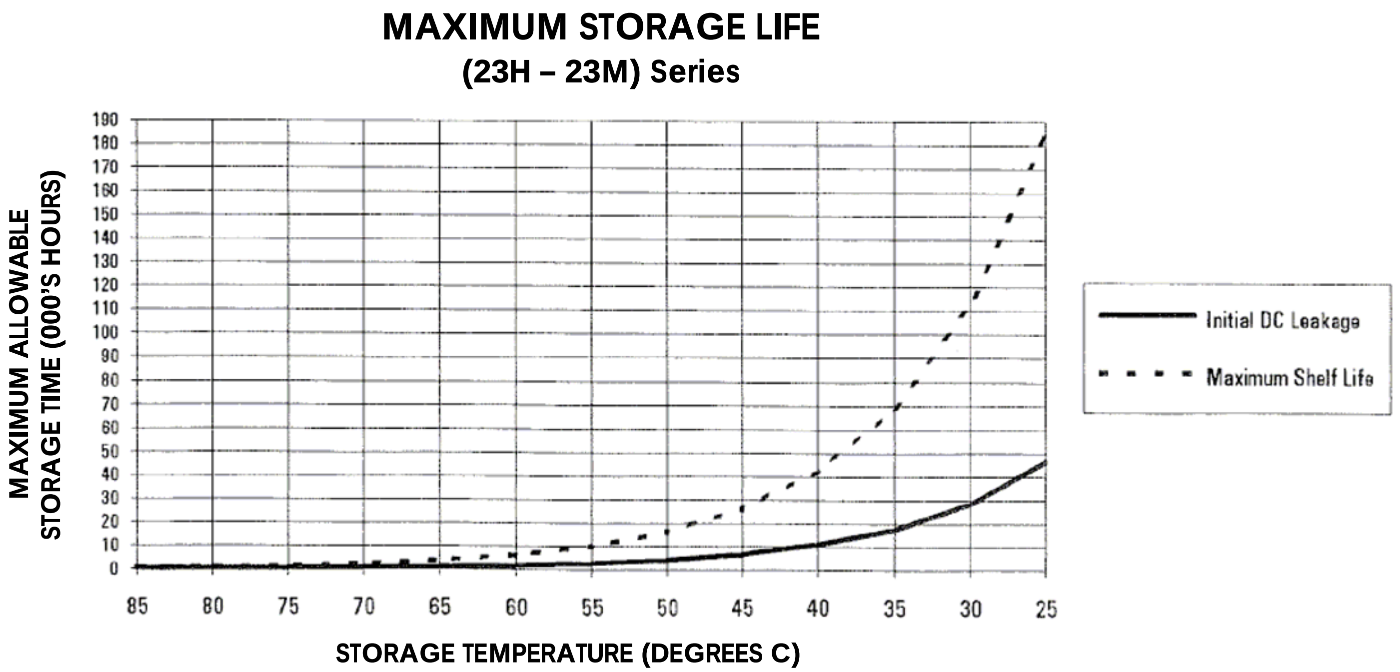

Chart-APC3

OPERATING LIFE

Operating life of capacitors is determined by operating temperature and applied voltage. Operating life can be extended by derating applied voltage, operating temperature, or applied RMS ripple current. Refer to the equations below for estimating capacitor life.

EXPECTED CAPACITOR OPERATING LIFE

Le = Lb x Lv x Lt

To calculate the predicted life expectancy at 100% DUTY CYCLE for a given Electrolytic capacitor, the following specification information and operating parameters must first be determined.

Le: Expected Capacitor Life
Lb: This is the base life for the capacitor being used, as shown in **Table-AP5** (BASE LIFE BY SERIES) on page 74 of this catalog.
Lv: Represents the extension of life of the capacitor due to voltage derating; determined by the following calculation:

$$Lv = 2\wedge\left[\frac{Vr - Va}{Vr} \times 6.66\right]$$

Va: Represents the applied DC working voltage (worst case) the capacitor will see during operation.
Vr: Represents the maximum rated DC working voltage (WVDC) of the capacitor selected; this value is shown on the capacitor specification sheet or listed by part number in this catalog.
Lt: Represents the extension of life of the capacitor due to the derating of the core temperature; determined by the following calculation:

$$Lt = 2\wedge\left[\frac{(Tm - Tc)}{10}\right]$$

Tm: Represents the maximum allowable core temperature, for the series, as shown in **Table-AP5**.
Tc: Is the operating core temperature determined by the following calculation:

$$Tc = Ta + \left[\frac{(I)^2\,(ESR) + (Va)\,(Idcl)}{(AREA)\,(Kt)}\right]$$

Ta: Represents the highest ambient temperature in the immediate vicinity of the capacitor (in Degrees C).
I: Represents the **applied** RMS ripple current.
ESR: Represents the equivalent series resistance of the capacitor as shown on the specification sheet, or listed for the capacitor in this catalog.

OPERATING LIFE (cont'd)

Idcl: Represents the rated DC leakage current. This value is found on the individual specification sheet for the capacitor intended for this application, or determined from the following calculation:

$$Idcl = (X)\sqrt{C \times V}$$

Where C = Capacitance in uF; V = Rated working voltage (WVDC) of the capacitors, and (X) = the value found in Table-AP8 on page 74.

AREA: Represents the area of the aluminum case of the capacitor as shown in **Table-AP6** (SURFACE AREA OF ALUMINUM CASE) on page 75.

Kt: Represents the thermal conductivity of the selected capacitor. This is found by using the case code of the capacitor part number, and selecting the appropriate **Kt value** shown in **Table-AP7** (THERMAL CONDUCTANCE) on page 75.

EXAMPLE: Part Number – 23J252F400FH1H1

THE FOLLOWING ARE SAMPLE APPLICATION PARAMETERS TO BE USED IN THE EXAMPLE FOR LIFE EXPECTANCY CALCULATION.

1) **C** = 2,500 uF (Microfarads of example part)
2) **Vr** = 400 WVDC (Rated Voltage)
3) **Va** = 325 VDC (The applied voltage for application)
4) **ESR** = 0.026 Ohms (Rated E.S.R. of the capacitor as shown in the catalog or specification sheet)
5) **Ta** = 65°C (ambient temperature in application)
6) **I** = 9.2 Amps RMS @ 120 Hz (Applied RMS ripple current)

Le = Lb x Lv x Lt

7) **Lb** = 2,000 (Base life from **Table-AP5** on page 74)

8) $$Lv = 2^\wedge\left[\frac{400 - 325}{400} \times 6.66\right]$$

9) $$Idcl = (X)\sqrt{C \times V} = (0.75)\sqrt{2{,}500 \times 400} = (0.75)\,1{,}000 = 750\ uA$$

For purposes of calculating Tc, Idcl should be expressed in AMPS.

10) $$Tc = Ta + \left[\frac{(I)^2 (ESR) + (Va)(Idcl)}{(AREA)(Kt)}\right] = 65 + \left[\frac{(9.2)^2 (0.026) + (325)(0.00075)}{(55.37)(0.0044)}\right] = 75.05$$

11) $$Lt = 2^\wedge\left[\frac{105 - 75.05}{10}\right] = 8$$

12) **Le = Lb x Lv x Lt**

13) **Le = 2,000 x 2.38 x 8 = 38,080 Hrs.** (At 100% Duty Cycle)

OPERATING LIFE (cont'd)

In the foregoing example for estimating capacitor life, all calculations were made based on 120 Hz. Operation and convective air-flow condition. For additional considerations at other than 120 Hz. And where air-flow is available, see the additional calculations below.

EXAMPLE: Use the following to determine Life Expectancy, when the capacitor is exposed to 150 LFM (linear feet per minute) air-flow and operating at 400 Hz.

Where Tc = Core temperature and is used to determine derating or extension of life; the following should be used to determine life extension where above adjustments are to be considered.

$$Tc = Ta + \frac{(I)^2\,(ESR \times \sqrt{1 / \text{Ripple current mult.}}) + (Va)\,(Idcl)}{(AREA)\,(Kt \times \sqrt{\text{Airflow mult.}})}$$

The Ripple current multiplier = 1.10 (found in **Table-AP1** on page 67)
The Airflow multiplier = 1.40 (found in **Table-AP3** on page 68)

$$Tc = 65 + \frac{(9.2)^2\,(0.026 \times \sqrt{1 / 1.10}) + (325)\,(0.00075)}{(55.37)\,(0.0044 \times \sqrt{1.40})} = 73.12$$

Recalculating expected life under the additional operating conditions results in the following:

Le = 2,000 x 2.38 x Lt

$$Lt = 2\text{\^{}}\left[\frac{105 - 73.12}{10}\right] = 9$$

Le = 2,000 x 2.38 x 9 = 42,480 Hrs. (Operated at 400 Hz. And forced air at 150 LFM) (At 100% Duty Cycle)

TERMINAL TORQUE
(Expressed in Inch Pounds)
(Minimum of 4 threads engaged)

Terminal Style	CLASS 2B		CLASS 2C	
	Min.	Max.	Min.	Max.
L	14	20	8	10
H	20	30	10	15
D	32	50	16	25
N	32	50	20	30
M5	20	30	10	15
M6	32	50	16	25

Table-AP4A

BASE LIFE by SERIES

Series Type	Rated Ambient Temp (°C)	Max. Core Temp (°C)	Base Life (Hours)
23A	85	95	1,000
23B	85	105	3,000
23C	85	100	2,000
23D	85	95	1,000
23F	85	105	3,000
23H	85	95	2,000
23H (500V)	65	75	1,000
23J	105	105	2,000
23M	85	95	2,000

Table-AP5

Idcl value of X

Series Type	Value of X
23A	3.00
23B	1.50
23C	3.00
23D	1.50
23F	1.50
23H	1.00
23J	0.75
23M	2.00

Table-AP8

RoHS Compliant

SURFACE AREA of ALUMINUM CASE
(Square Inches)

Case Code	DIA.	LNG.	AREA
BB	1.375	2.125	10.66
BC	1.375	2.625	12.82
BD	1.375	3.125	14.98
BE	1.375	3.625	17.14
BF	1.375	4.125	19.30
BG	1.375	4.625	21.45
BH	1.375	5.125	23.62
BI	1.375	5.625	25.78
CB	1.750	2.125	14.09
CC	1.750	2.625	16.84
CD	1.750	3.125	19.59
CE	1.750	3.625	22.33
CF	1.750	4.125	25.08
CG	1.750	4.625	27.83
CH	1.750	5.125	30.58
CI	1.750	5.625	33.33
DB	2.000	2.125	16.49
DC	2.000	2.625	19.63
DD	2.000	3.125	22.78
DE	2.000	3.625	25.92
DF	2.000	4.125	29.06
DG	2.000	4.625	32.20
DH	2.000	5.125	35.34
DI	2.000	5.625	38.48
DJ	2.000	5.875	40.05
DL	2.000	8.625	57.33
EC	2.500	2.625	25.52
ED	2.500	3.125	29.45
EE	2.500	3.625	33.38
EF	2.500	4.125	37.31
EG	2.500	4.625	41.23
EH	2.500	5.125	45.16
EI	2.500	5.625	49.09
FD	3.000	3.125	36.52
FE	3.000	3.625	41.23
FF	3.000	4.125	45.95
FG	3.000	4.625	50.66
FH	3.000	5.125	55.37
FI	3.000	5.625	60.08
FJ	3.000	5.875	62.44
FK	3.000	7.625	78.93
FL	3.000	8.625	88.36
FM	3.000	6.625	69.51

Table-AP6

THERMAL CONDUCTANCE
(Watts per Square Inch Degrees C)

Case Code	DIA.	LNG.	Kt
BB	1.375	2.125	0.0130
BC	1.375	2.625	0.0101
BD	1.375	3.125	0.0083
BE	1.375	3.625	0.0071
BF	1.375	4.125	0.0062
BG	1.375	4.625	0.0054
BH	1.375	5.125	0.0049
BI	1.375	5.625	0.0044
CB	1.750	2.125	0.0139
CC	1.750	2.625	0.0102
CD	1.750	3.125	0.0081
CE	1.750	3.625	0.0068
CF	1.750	4.125	0.0058
CG	1.750	4.625	0.0051
CH	1.750	5.125	0.0045
CI	1.750	5.625	0.0041
DB	2.000	2.125	0.0140
DC	2.000	2.625	0.0107
DD	2.000	3.125	0.0083
DE	2.000	3.625	0.0068
DF	2.000	4.125	0.0057
DG	2.000	4.625	0.0050
DH	2.000	5.125	0.0044
DI	2.000	5.625	0.0040
DJ	2.000	5.875	0.0038
DL	2.000	8.625	0.0033
EC	2.500	2.625	0.0102
ED	2.500	3.125	0.0082
EE	2.500	3.625	0.0071
EF	2.500	4.125	0.0058
EG	2.500	4.625	0.0049
EH	2.500	5.125	0.0043
EI	2.500	5.625	0.0038
FD	3.000	3.125	0.0081
FE	3.000	3.625	0.0070
FF	3.000	4.125	0.0064
FG	3.000	4.625	0.0052
FH	3.000	5.125	0.0044
FI	3.000	5.625	0.0038
FJ	3.000	5.875	0.0035
FK	3.000	7.625	0.0026
FL	3.000	8.625	0.0022
FM	3.000	6.625	0.0030

Table-AP7

REPETITIVE DISCHARGE APPLICATIONS

Applications wherein the capacitor may experience repetitive discharges into inductive loads, should be protected using a free wheeling diode, or a blocking diode to prevent the capacitor from being exposed to excessive reverse voltage.

HIGH ALTITUDE APPLICATIONS

Regal-Beloit's Electrolytic Capacitors may be stored or operated at altitudes up to 100,000 feet with no adverse effects.

CAPACITOR MOUNTING APPLICATIONS

Regal-Beloit utilizes a pitchless construction for all case sizes. This allows capacitors to be mounted in any orientation; however, Regal-Beloit recommends that all electrolytic capacitors be mounted with the terminals in a vertical position. This provides the best possible protection against loss of electrolyte in the event of vent activation. (SEE ELECTROLYTE FLUIDS)

As with all Electrolytic Capacitor "Electrolyte Fluids," a precaution should be taken and appropriate action should be taken in the event of spill or exposure, as described in Regal-Beloit's Material Safety Data Sheets.

ELECTROLYTE FLUIDS

Regal-Beloit will upon request, provide Material Safety Data Sheets for the various fluids used in manufacture of any Regal-Beloit Electrolytic Capacitor. The Regal-Beloit part number must be advised so we may supply the correct Data Sheet.

USE OF CLEANING SOLVENTS or ELECTRICAL JOINT COMPOUNDS

Regal-Beloit recommends using only those cleaning solvents and electrical compounds which are free of halogens, or halogen groups. Further, Regal-Beloit recommends not using any petroleum or petroleum distillate products.

VIBRATION SPECIFICATIONS

Regal-Beloit Electrolytic Capacitors are capable of withstanding 10 G's of sinusoidal vibration with a frequency range of 10 to 500 Hz., provided mounting is accomplished using an approved clamp around the capacitor case.

(Reference MIL Std 202(F); Method 204D; Test condition A) Products are designed and produce commercially with the capability of meeting the vibration conditions referenced.

USE OF CAPACITORS IN SERIES

DC VOLTAGE SHARING

Capacitors can safely be used in series pairs to allow application at higher DC bus voltages, provided proper voltage sharing within the series group is maintained using balancing resistors. This will provide proper voltage sharing over the course of the useful life of the capacitor, if the resistors are sized such that the current through the resistor is roughly a factor of 10 greater than the initial specified DC Leakage current of the capacitor.

TRANSIENT VOLTAGE SHARING

Voltage sharing of series-connected capacitors under transient voltage conditions can be accomplished by matching the capacitance values of the series connected units. The degree of matching required is determined by the degree of derating on the unit. The greater the derating allowed, the less critical exact voltage sharing becomes. Generally, a 10 percent symmetrical tolerance is sufficient for most applications.

FUSING OF SERIES CAPACITORS

Fusing of individual series groups is recommended to minimize the risk of catastrophic failure in the event of a device fault. It is recommended that a common midpoint connection NOT be used due to the risk of cascaded failures.

SAFETY

ELECTROLYTIC CAPACITORS HAVE A HIGH WATT-SECOND CAPABILITY. IT IS IMPORTANT THAT SUITABLE PRECAUTIONS BE OBSERVED IN THE TESTING AND APPLICATION OF THESE CAPACITORS. BLEEDER RESISTORS AND OTHER DISCHARGE CIRCUITRY SHOULD BE USED FOR PROTECTION AGAINST ELECTRICAL SHOCK. MECHANICAL STRUCTURES MUST BE DESIGNED TO WITHSTAND CATASTROPHIC FAILURE DUE TO THE LARGE FAULT CURRENTS WHICH MAY OCCUR IN THE EVENT OF A CAPACITOR SHORT CIRCUIT. THE MECHANICAL STRUCTURE SHOULD BE CONSTRUCTED SUCH THAT IT WILL BE CAPABLE OF CONTAINING THE CAPACITOR(S) IF A CAPACITOR EXPLOSION SHOULD OCCUR. EXTREME CAUTION SHOULD BE TAKEN AT ALL TIMES WHEN WORKING WITH ENERGIZED SYSTEMS. **UNDER NO CIRCUMSTANCES SHOULD ANY ENERGIZED EQUIPMENT BE RENDERED UNSECURE AS TO CAUSE PERSONAL INJURY OF PROPERTY DAMAGE IN THE EVENT OF A CAPACITOR EXPLOSION.**

RoHS Compliant