

Selection (and precautions for use) of Aluminum Electrolytic Capacitors in LED Lighting Applications





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- or - requests to schedule technical seminars on this information should be directed to:

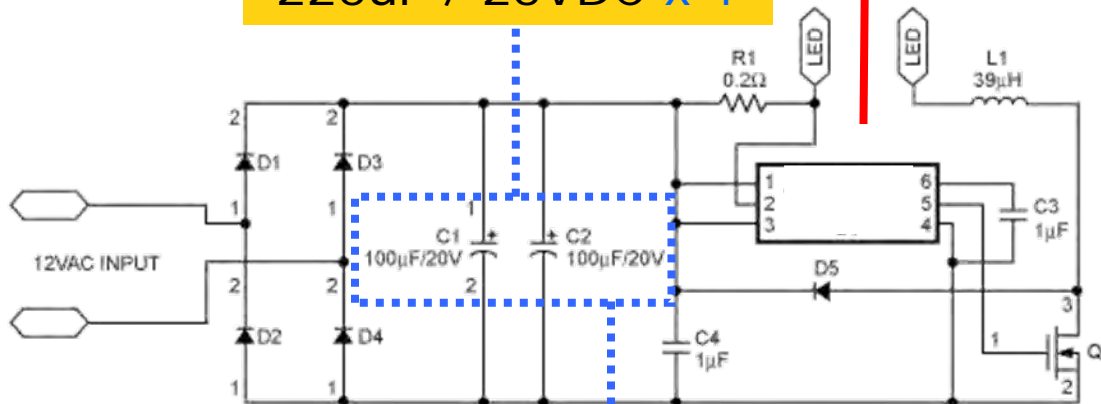
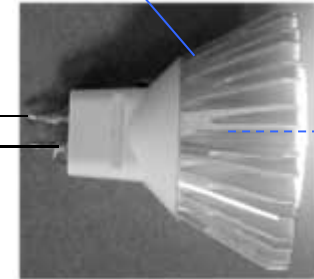
Jim Wight, VP Technology Jim.wright@niccomp.com 631-396-7500

▶ 5 Watt LED Driver Circuit

PCB Ambient Temperature +50 C ~ +65 C

100uF / 25VDC x 2
220uF / 25VDC x 1

Diffusion Temperature ~ +70 C
Junction Temperature ~ +95 C



INPUT CAPACITANCE

The total capacitance should be at least 200µF With 20VD (of higher VDC rating)

Electrolytic Capacitor with a 220µF/25VDC rating for low cost



- ▶ Establish life time (hours) goal for application
 - ▶ **Example: 80,000 hours** (9+ years @ 24/7 application)
- ▶ Establish ambient operating temperature
 - ▶ **Example: Multiple end-use applications**
 - **PCB operation over range of +50 C ~ +65 C**
- ▶ Capacitance value needed?
 - ▶ **Example: 220uF**
- ▶ Voltage rating needed?
 - ▶ **Example: 25VDC (minimum)**
- ▶ Selection of capacitor



Capacitor Requirement
CV: 220uF @ 25VDC
Life: 80,000 Hrs @ +65 C



Miniature Aluminum Electrolytic Capacitors

Part No.	Capacitance	Rated Voltage	Temperature Range	Life (Hours)	ESR (Ω)	Leakage Current (μA)	Dimensions (mm)
100M50	100μF	50V	-40 to +105	7,000	16~18	0.1	10.0 x 6.0 x 10.0
100M63	100μF	63V	-40 to +105	5,000	12.5	0.1	10.0 x 6.0 x 10.0
100M75	100μF	75V	-40 to +105	4,000	10	0.1	10.0 x 6.0 x 10.0
100M100	100μF	100V	-40 to +105	3,000	8	0.1	10.0 x 6.0 x 10.0
100M125	100μF	125V	-40 to +105	2,500	6.3	0.1	10.0 x 6.0 x 10.0
100M150	100μF	150V	-40 to +105	2,000	5	0.1	10.0 x 6.0 x 10.0
100M200	100μF	200V	-40 to +105	1,000	4	0.1	10.0 x 6.0 x 10.0

Load Life Rated at **maximum rated temperature** (i.e. +105°C) and WVDC

Load Life Test Limits

<p>Load Life Test at Rated W.V. & 105°C</p> <p>7,000 Hours: 16 ~ 18∅</p> <p>5,000 Hours: 12.5∅</p> <p>4,000 Hours: 10∅</p> <p>3,000 Hours: 8 ∅</p> <p>2,500 Hours: 6.3∅</p> <p>2,000 Hours: 5 ∅</p> <p>1,000 Hours: 4∅</p>	Capacitance Change	Within ±20% of initial measured value
	Tan δ	Less than 200% of specified maximum value
	Leakage Current	Less than specified maximum value

Load Life Rating by Component Diameter (∅ mm)
Based upon endurance test results performed by component manufacturer

NOTE: Possible variation in test limits between component manufacturers
Example: ±30% instead of ±20% limit for Δ Capacitance

Aluminium Electrolytic Capacitor Construction

X-Ray
Image

Aluminum
Can

End Seal

Safety Vent

Capacitor
Element

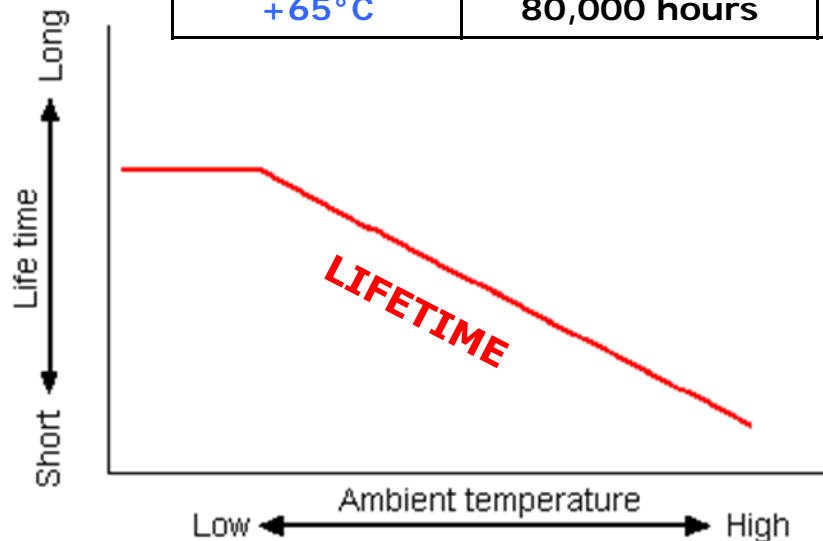
Mechanical
Seal

Lead Wire

Electrolyte dissipation follows the Arrhenius Rate

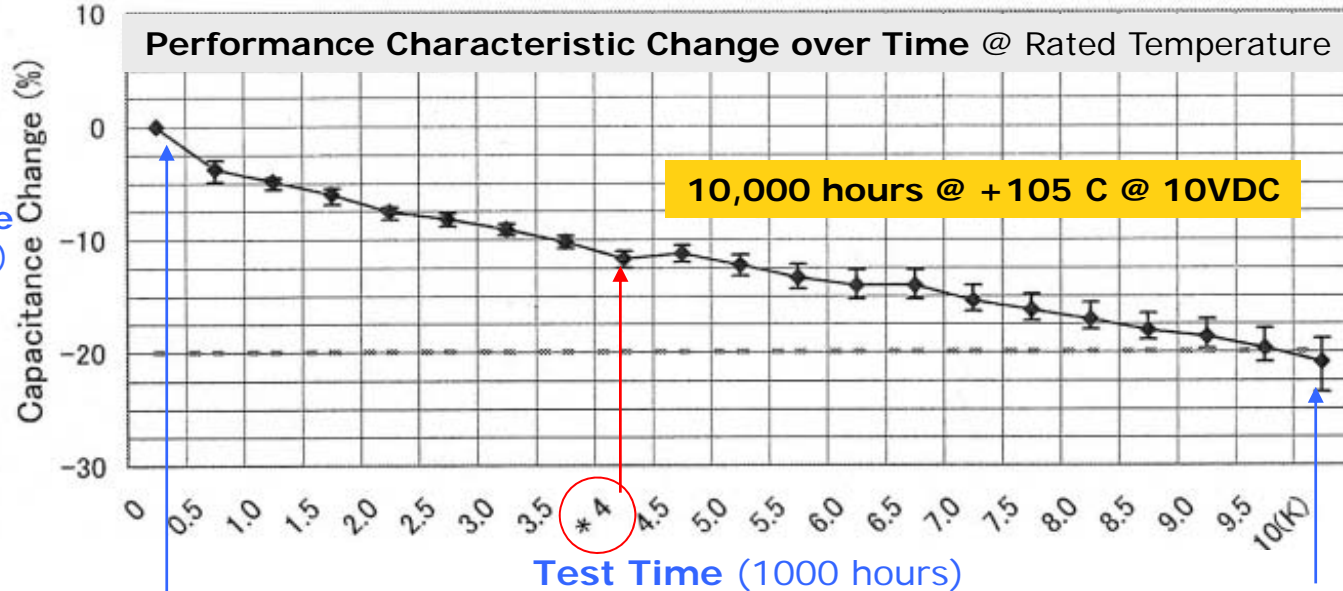
- ▶ Aluminum electrolytic capacitor life time is reduced at higher operating temperatures

Temperature	Period	24 / 7	8 Hours/Day
+105°C	5000 hours	0.6 years	1.7 years
+85°C	20,000 hours	2.3 years	6.8 years
+65°C	80,000 hours	9.1 years	27.4 years



Aluminium Electrolytic Capacitor Life Time

1200uF @ 10VDC, 10x20mm Size: **4000 Hour** Load Life Rating @ +105 C @ WVDC



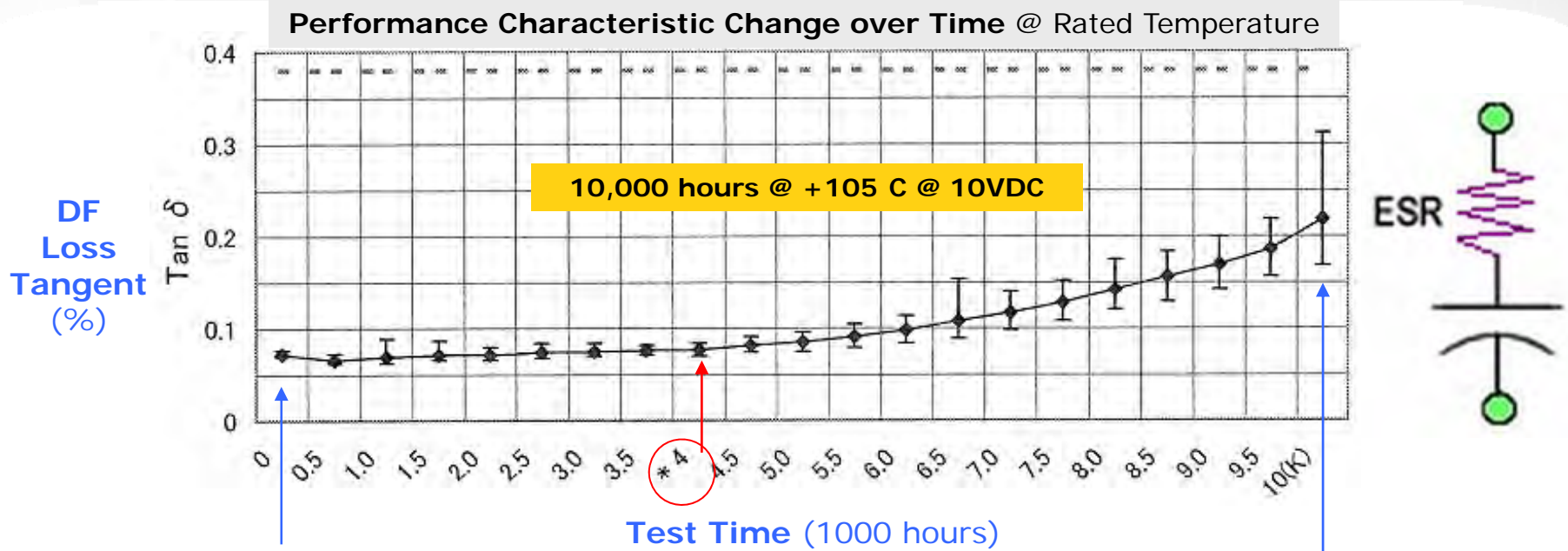
Capacitance Change (%)

Capacitance = 1200uF ----- 1056uF -----> 948uF

- ▶ Dissipation of the liquid electrolyte from the capacitor reduces the cathode connection, resulting in Capacitance decrease & Dissipation Factor (ESR) increase
- ▶ The rate of dissipation follows the Arrhenius equation for chemical reactions
 - ▶ Reaction rate will double for each 10 C increase in temperature
- ▶ → Capacitor **life time expectation doubles for 10 C decrease** in operating temperature

Aluminium Electrolytic Capacitor Life Time

1200uF @ 10VDC, 10x20mm Size: **4000 Hour** Load Life Rating @ +105 C @ WVDC



Tan δ = 0.19 \rightarrow 0.38

120Hz ESR = 0.26 ohm \rightarrow 0.66 ohm

- ▣ Increasing resistive losses over time
- ▣ Capacitor becomes less efficient over time of operation
- ▣ ESR (series resistance) increases over time

Aluminium Electrolytic Capacitor Life Time

→ Capacitor Life time Expectation doubles for 10°C decrease in operating temperature ←

+45°C	+55°C	+65°C	+75°C	+85°C	+95°C	+105°C
64,000	32,000	16,000	8,000	4,000	2,000	1,000
128,000	64,000	32,000	16,000	8,000	4,000	2,000
> 15 Yrs	96,000	48,000	24,000	12,000	6,000	3,000
> 15 Yrs	128,000	64,000	32,000	16,000	8,000	4,000
> 15 Yrs	> 15 Yrs	80,000	40,000	20,000	10,000	5,000

Capacitor Requirement
 CV: 220uF @ 25VDC
 Life: 80,000 Hrs @ +65°C


5000 Hrs
 @ +105°C

Capacitor Requirement
CV: 220uF @ 25VDC
Life: 80,000 Hrs @ +65 C
Rating of 5000 Hrs @ +105 C

2 Times Reflow
 80 Sec > +200 C
 40 Sec > +230 C
 Peak = + 260 C

- ▶ **SMT V-Chip Type:**
- ▶ **5000 hours @ +105°C**
 - ▶ **220uF**
 - ▶ **25VDC (or greater)**

PN: NAZT221M25V8X10.5
 220 μF, 25VDC, 8X10.5mm
 -40C ~ +105 C
5000 hrs @ +105 C
 20,000 hrs @ +85 C
 80,000 hrs @ +65 C



- » **Radial Leaded Type:**
- » **5000 hours @ +105 C**
 - » **220uF**
 - » **25VDC (or greater)**

PN: NREHL221M25V8x11.5
 220 μF 25VDC, 8x11.5mm 3.5mm LS
 -40C ~ +105C
7000 hrs @ +105 C
 28,000 hrs @ +85 C
 112,000 hrs @ +65 C



**DOUBLE
LIFETIME**

Capacitor Requirement
CV: 220uF @ 25VDC
Life: 80,000 Hrs @ +75°C
Rating of 10,000 Hrs @ +105°C

2 Times Reflow
 60 Sec > +200°C
 20 Sec > +230°C
 Peak = + 250°C

- » **SMT V-Chip Type:**
- » **10,000 hours @ +105°C**
 - » **220uF**
 - » **25VDC (or greater)**

PN: NAZV NAZV221M25V8X10.5LBF
 220 μ F, 35VDC, 10X10.5mm
 -40C ~ +105C
 10,000 hrs @ +105°C
 40,000 hrs @ +85°C
80,000 hrs @ +75°C
 > 15 years @ +65°C



- » **Radial Leaded Type:**
- » **10,000 hours @ +105°C**
 - » **220uF**
 - » **25VDC (or greater)**

PN: NRSH221M50V10x16F
 220 μ F, 50VDC, 10x16mm 5mm LS
 -40C ~ +105C
 10,000 hrs @ +105°C
 40,000 hrs @ +85°C
80,000 hrs @ +75°C
 > 15 years @ +65°C



**FURTHER
EXTENDED
LIFETIME**

Capacitor Requirement
CV: 220uF @ 25VDC
Life: >80,000 Hrs @ +75°C

» **SMT V-Chip Type:**

PN: NSPE-T271M25V10X10.8NBYP

270uF, 25VDC in 10X10.8mm

12,000Hrs @ 105°C

48,000Hrs @ +85°C

96,000Hrs @ **+75°C** (11 Yrs)

PN: NSPE-Y271M25V10X10.8NBYP

270uF, 25VDC in 10X10.8mm

2000Hrs @ 135°C

16,000Hrs @ 105°C

64,000Hrs @ **+85°C** (7.3 Yrs)

128,000Hrs @ **+75°C** (14.6 Yrs)

2 Times Reflow

80 Sec > +217°C

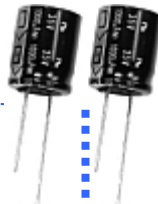
40 Sec > +230°C

Peak = + **260°C**

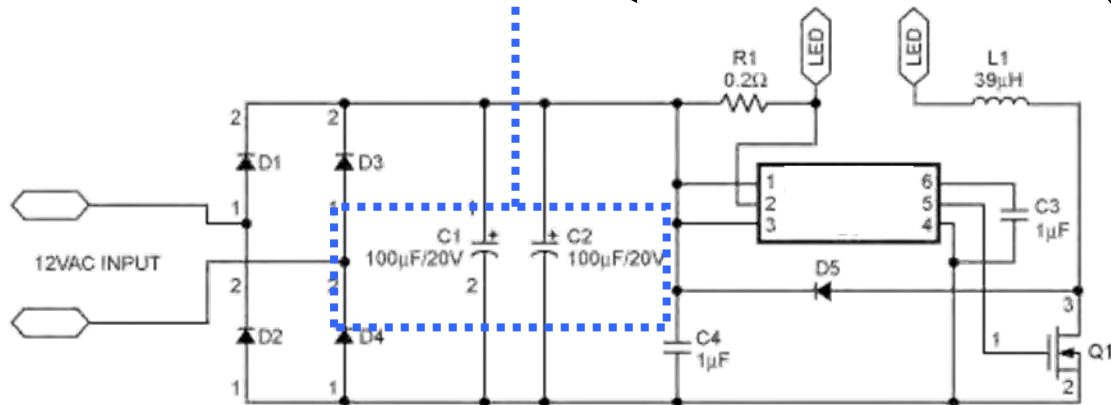


Capacitor Requirement
CV: 200uF @ 25VDC
Life: 80,000 Hrs @ +75°C
Rating of 10,000 Hrs @ +105°C

- » Radial Leaded Type:
- » 10,000 hours @ +105°C
 - » **2 X 100uF**
 - » **25VDC**



PN: **NRGB101M25V6.3X11F**
100 μF, 25VDC, 6.3x11mm 2.5mm LS
 -40C ~ +105C
 10,000 hrs @ +105°C
 40,000 hrs @ +85°C
80,000 hrs @ +75°C
 160,000 hrs @ +65°C



Low Cost & Smallest Size Solution

- ▶ For higher voltage requirements (> 16VDC) look to **aluminium electrolytic capacitors**
 - ▶ Lowest cost solution
 - Aluminium E-cap :
 - 100uF @ 25VDC \approx **\$0.08 each**
 - 220uF @ 25VDC \approx **\$0.12 each**
 - Tantalum E-cap:
 - 100uF @ 25VDC = **>\$0.80 each**
 - ▶ Wide range of offerings CVs – sizes: SMT & LDD
 - ▶ Voltages to 450VDC
 - ▶ Transient resistant:
 - Ability to handle transient events
 - Excellent inrush current characteristics
 - Reverse bias tolerant
 - ▶ Stable characteristic under voltage bias
 - ▶ Open mode wear-out (safe)



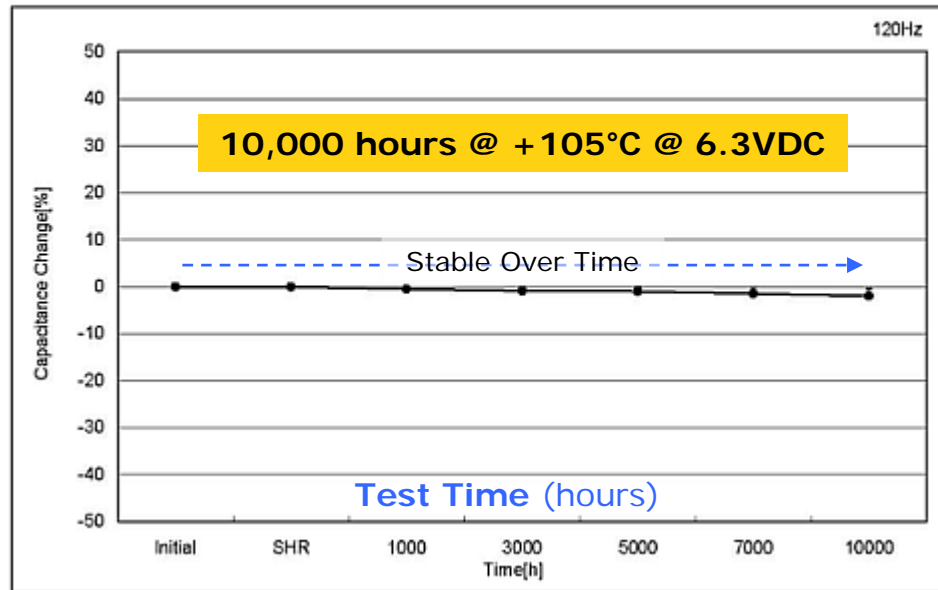
Solid Aluminium Electrolytic Capacitors

ENDURANCE- LIFE TEST
 n = 10 / +105degC @ Rated VDC

PN: NSP470M6.3D2TRF (47uF / 6.3VDC)

PARAMETERS:
 Capacitance Change [%]
 tanδ [%]
 LC [μA]
 ESR [100kHz]

Capacitance
 Change
 (%)



- Solid Aluminum (polymer electrolyte) has stable characteristics (no wear-out)
- Solid aluminum construction **limited to ≤16VDC** maximum rating

Product Type:

Aluminum Electrolytic Capacitors – Liquid Electrolyte Construction



Failure Modes:
Parametric Change
Open
Intermittent
Short

Causes:
Wear-out
Electrical
Thermal
Mechanical
Corrosion
Altitude



Product Type:

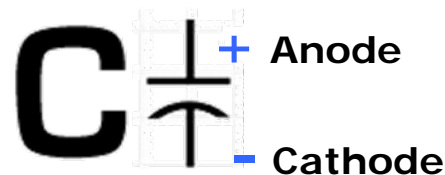
Aluminum Electrolytic Capacitors – Liquid Electrolyte Construction

Potential Failure Mode - Causes:

- » **Electrical Over-stress** failures ... rapid failure >> case opening - case rupture >> or accelerated wear-out, joule heating, decreased cap, increased DF & ESR >> open circuit (Short circuit, Arcing; under extreme overstress conditions)

Causes:

- ▾ Reverse Bias
- ▾ Over-voltage or Over-current
- ▾ Rapid charge - discharge



Remedies - Fixes:

- ▾ Assure polarity
- ▾ Use within specification limits
- ▾ Use alternate types:
 - ▾ Low ESR & High RCR, Strobe-Photoflash or Solid technology



Product Type:

Aluminum Electrolytic Capacitors – Liquid Electrolyte Construction

Potential Failure Mode - Causes:

- » **Thermal Stress** failures ... end-seal compromised >> accelerated wear-out
>> open circuit

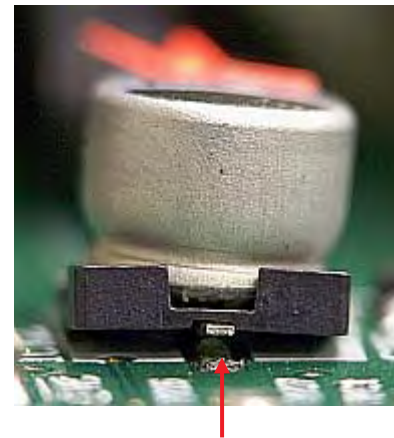
Causes:

- ▣ Excessive soldering (reflow) heat

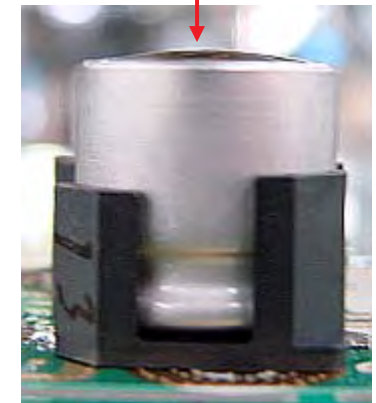
Remedies - Fixes:

- ▣ Use higher reflow rated component
- ▣ Revise reflow conditions
- ▣ Revert to radial LDD & wave soldering

Can Bulge - Deform

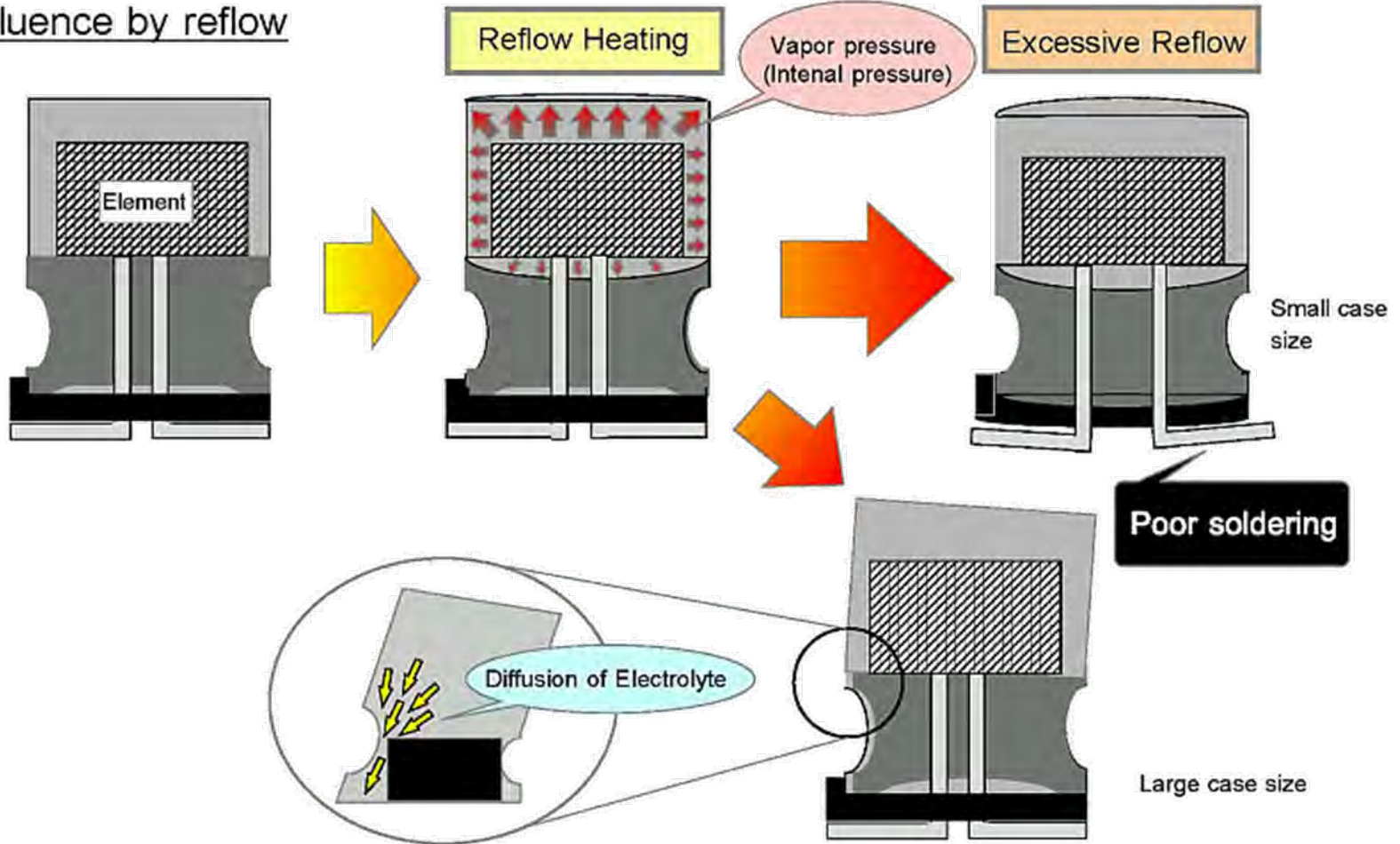


Terminal Lift, Base-plate Warp



Thermal Stress

Influence by reflow





Product Type:

Aluminum Electrolytic Capacitors – Liquid Electrolyte Construction

Potential Failure Mode - Causes:

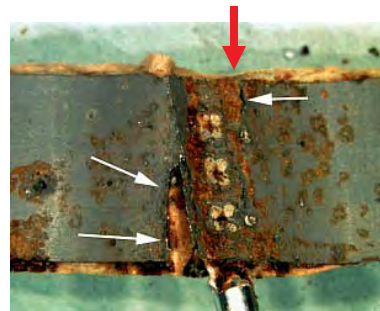
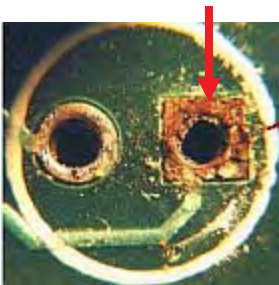
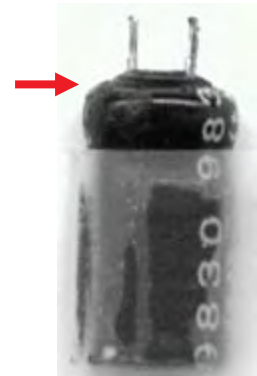
- » **Corrosion failures** ... Parametric changes, increased leakage current >> joule heating >> leading to short or disconnection; open circuit

Causes:

- ▣ Halogenated fluxes and cleaning solvents
- ▣ Harsh end use environments

Remedies - Fixes:

- ▣ Eliminate use of halogenated fluxes & solvents
- ▣ Sealer – coatings to protect components





Product Type:

Aluminum Electrolytic Capacitors – Liquid Electrolyte Construction

Potential Failure Mode - Causes:

- » **Mechanical stress** failures ... **stress to leads** >> **end-seal compromised** >> **accelerated wear-out** >> **open circuit**

Causes:

- ▣ Lead wire trimming
- ▣ Stress to component after mounting to PCB
 - ▣ Lifting PCB by component case



Remedies - Fixes:

- ▣ Review lead trimming
- ▣ Review PCB handling practices





Product Type:

Aluminum Electrolytic Capacitors – Liquid Electrolyte Construction

Potential Failure Mode - Causes:

- » **Mechanical stress** failures ... stress to case >> dielectric compromised >> increased leakage current or short circuit

Causes:

- ▣ Mishandling
 - ▣ Stacking PCBs
- ▣ Improper Bulk Storage



Remedies - Fixes:

- ▣ Review handling & storage practices



Product Type:

Aluminum Electrolytic Capacitors – Liquid Electrolyte Construction

Potential Failure Mode - Causes:

- » **Altitude** (reduced pressure) failures ... **accelerated wear-out decreased cap, increased DF & ESR >> open circuit**

Causes:

- ▣ Differential between internal pressure to outside pressure
- ▣ Exposure to high altitude or aviation

Remedies - Fixes:

- ▣ Use of alternate construction (solid)

Minimal Impact

Will Impact Lifetime



Altitude (m)	Air Pressure (hPa)
0	1013.3
2,000	795.0
4,000	616.4
6,000	471.8
8,000	356.0
10,000	264.4
20,000	54.7

Wear-Out Accelerators

- ▶ Electrical Overstress
 - ▶ Over-voltage
 - ▶ Rapid charge–discharge
 - ▶ Reverse operation
- ▶ Mechanical & Thermal Stress
- ▶ Corrosive Agents
 - ▶ Cleaning solvents & fluxes
 - ▶ Environment
- ▶ Reduced Pressure
 - ▶ High altitude [>20,000 Feet = >6100 Meters]

