Edif ERA

When it's critical, count on us

Capacitors – Lessons from Industry

Edif ERA

Reduce risk, enhance capability, optimise performance

Recently acquired by RINA S.p.A.

Engineering and consultancy

Asset integrity

Asset management | Condition assessment | Failure investigation | Cable consultancy and testing
ASME and API certified inspection training | Environmental and regulatory compliance

Capability assessment

Management services | Systems engineering | Modelling and simulation | Through-life support
Training and human capability | Safety assurance

Investment support

Due diligence | Feasibility | Independent technology reviews | Environmental impact
Owners/lenders engineer | Performance optimisation |Planning | Project management

Power engineering

Power systems studies | Design and analysis | Modelling | Power quality
EMC | Earthing | Lightning protection

Edif ERA

Transport

	Rail	Aerospace
Asset Integrity		
Condition assessment	●	●
Failure investigation	●	●
Cable consultancy and testing	●	●
ASME and API certified inspection training	●	
Environmental and regulatory compliance	●	●
Capability Assurance		
Management Services	●	
Systems Engineering	●	
Modelling & Simulation	●	
Through-Life Support	●	
Training & Human Capability	●	
Safety Assurance	●	●
Power Engineering		
Power Systems	●	
Electromagnetic Compatibility (EMC)	●	●
Earthing	●	
Lightning Protection	●	

Service and sector matrix

Transport

Large range of rail and aerospace clients

Operators, suppliers, consultancies and manufacturers

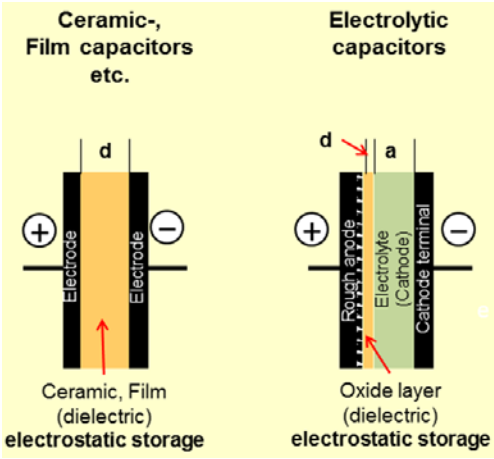
Over-ground, underground, metro systems

UK, Europe, Middle East, Far East

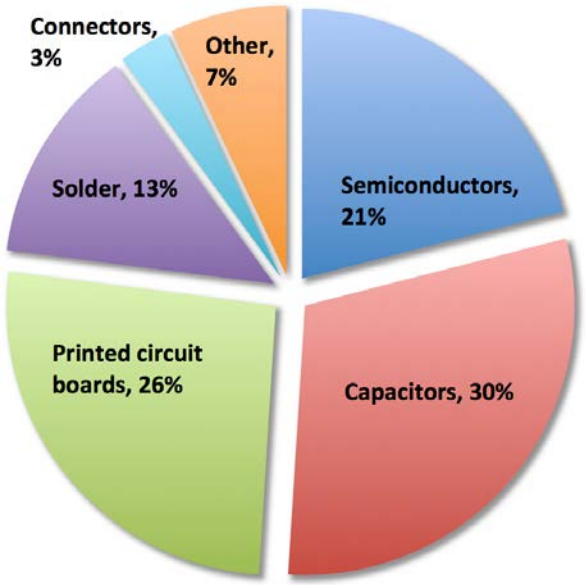
Network Rail
London Underground
Transport for London
THALES
Hitachi Rail Europe
Mors Smitt
A Wabtec Company
SIEMENS
ALSTOM
ABB
invensys
WESTINGHOUSE
rail systems
Balfour Beatty
Engineering Services
CH2MHILL
AgustaWestland
A Finmeccanica Company
EMBRAER
BOMBARDIER
AEROSPACE
BOMBARDIER
Rolls-Royce
Buro Happold
Interfleet
Technology
RSSB

Consumer Electronics
Transport
Lighting
Power

Thin Film
Ceramic
Tantalum
Aluminium electrolytic



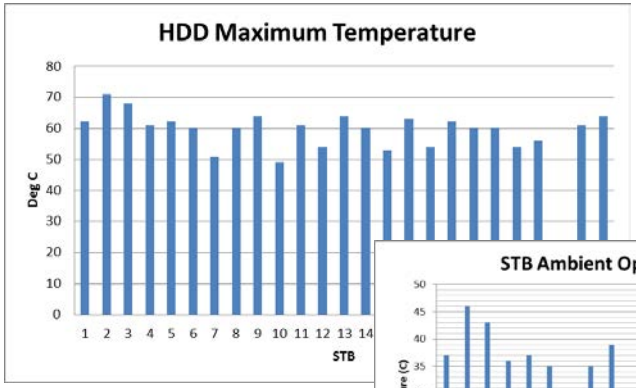
Utility meter failures
Luminaire fires
Rail breaking system safety
Marine propulsion failure
MW pulsed power supply reliability assurance
Television set top box failures
Unmanned aerial vehicle failure
Avionics warning system failure
Datacentre UPS Fire

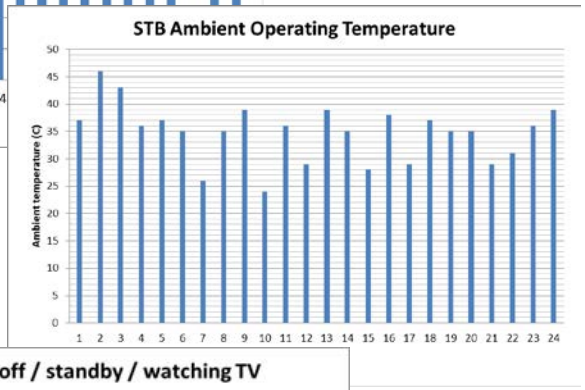



Windows
An error has occurred. To continue:
Press Enter to return to Windows, or
Press CTRL+ALT+DEL to restart your computer. If you do this,
you will lose any unsaved information in all open applications.
Error: 0E : 016F : BFF9B3D4
Press any key to continue _

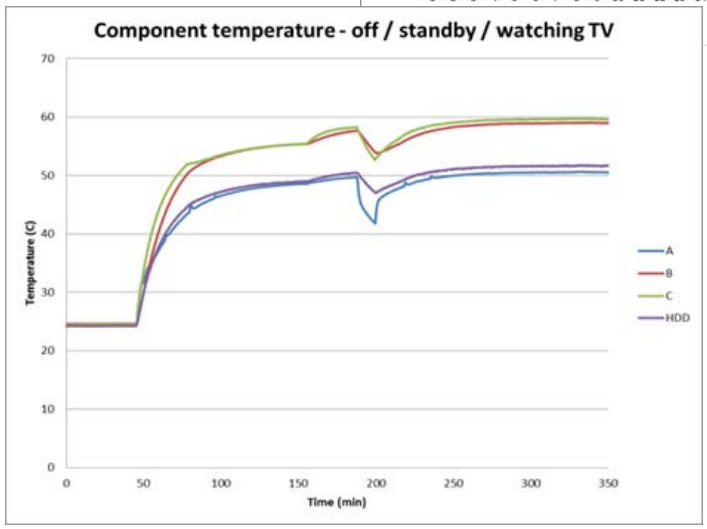
Set top box failures

- STB manufacturer being sued by TV supplier – £50M~£100M
- STB power supply failure due to premature aluminium electrolytic capacitor degradation





- Circa 1M STB's claimed to be defective due to capacitors
- ERA acquired random sample of 1000
- Analysed circuit / measured electrical stress
- Extracted peak temp from HDD
- Correlated HDD logged temp with ambient temp
- Checked boxes

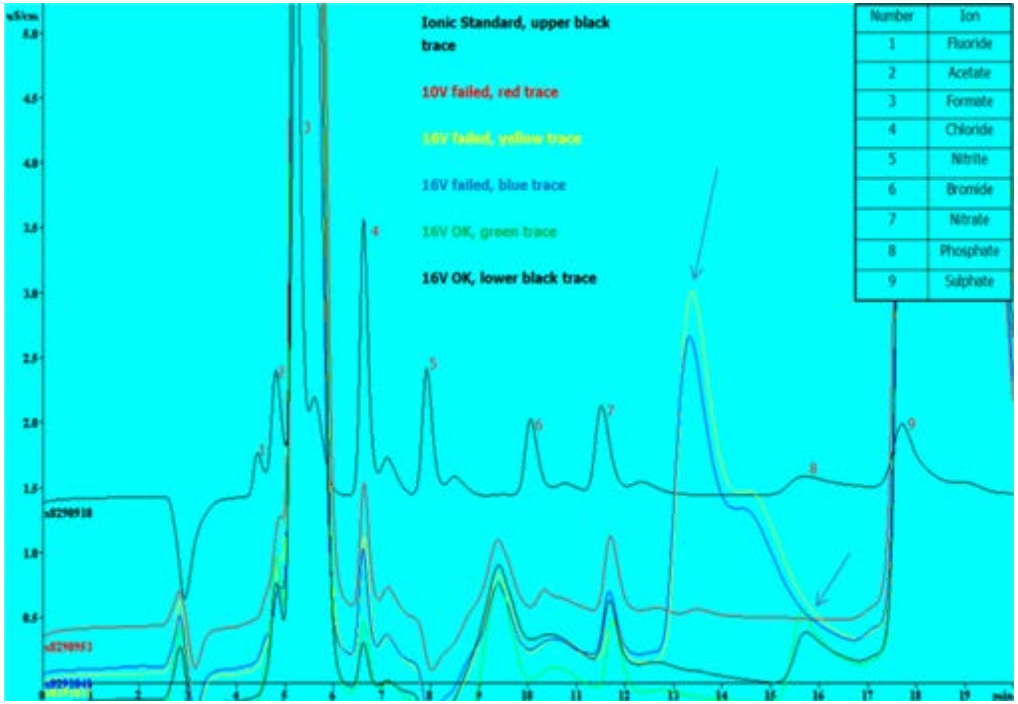


- Some capacitor batches were defective
- Overstated claim
- Majority of boxes operated outside manufacturers spec

Set top box failures

- Electrolyte analysis revealed differences in composition
- Unreliable batches – absence of phosphate

- SEM-EDX confirms aluma converted to aluminium hydroxide = ESR increase and venting

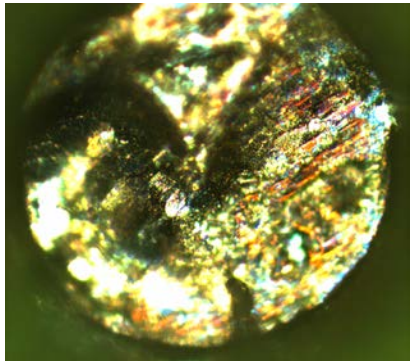


Wet tantalum capacitor failure

- Wet tantalum capacitors used in military application
- Failed after running in a high vibration environment

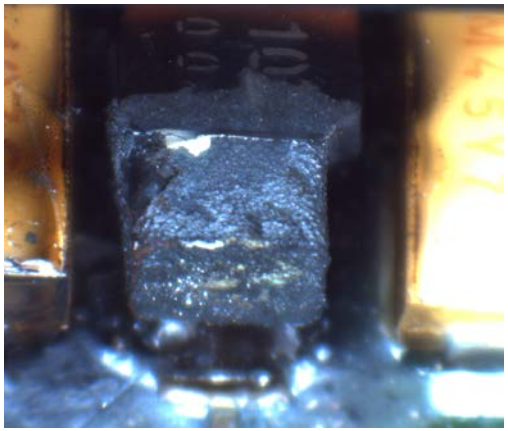
- Two failure modes
  - Abrasion against case contaminating electrolyte
  - Anode wire fracture

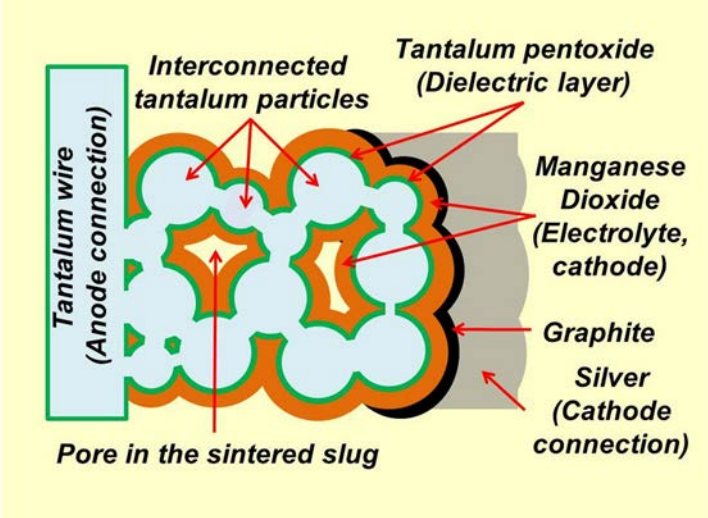
- Both failures related to mass of high density tantalum pellet / suspension on anode wire

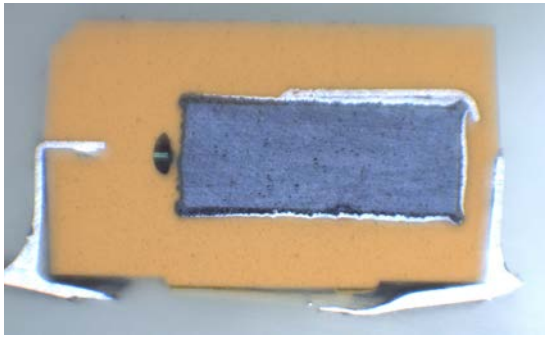


Dry tantalum capacitor failures

- Surge current damage
- Reverse bias damage
- Damage during assembly
- De-rating rules
- Benefits of re-forming after soldering
- Performance under mechanical shock
- Overvoltage damage? ESD?
- Circuit protection

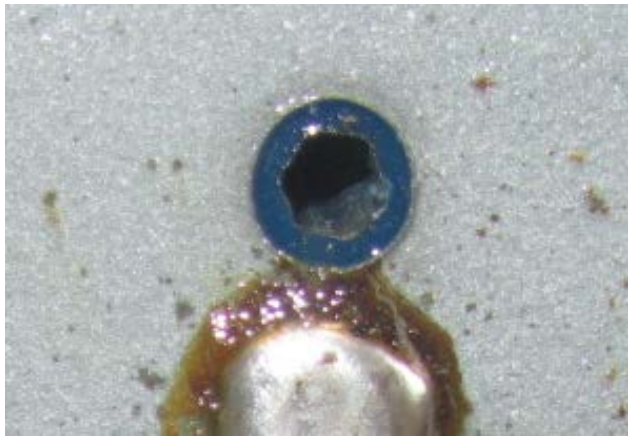


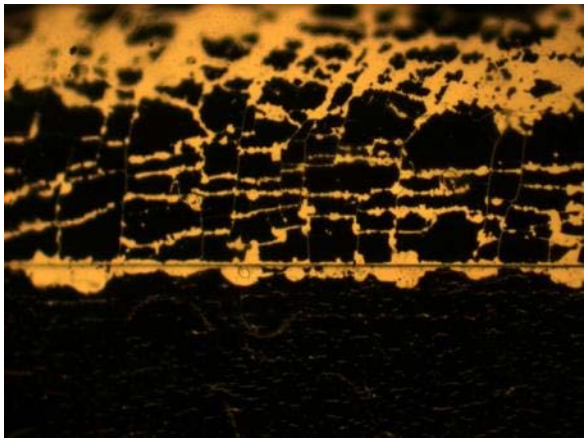


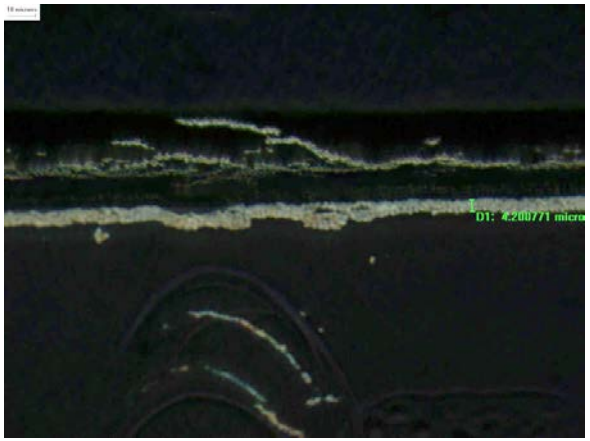


Marine propulsion failures

- 3KV capacitors used in propulsion system
- Failing to low capacitance / high ESR
- Array of 10's of thin film rolls – oil and paper insulated – soldered in parallel.
    - Paper insulation source of moisture
    - Solder connections using halogen based flux
    - Seasonal pattern to failures







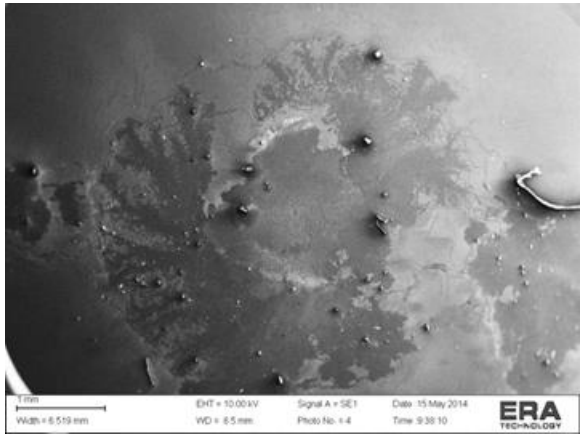
Large power supply degradation

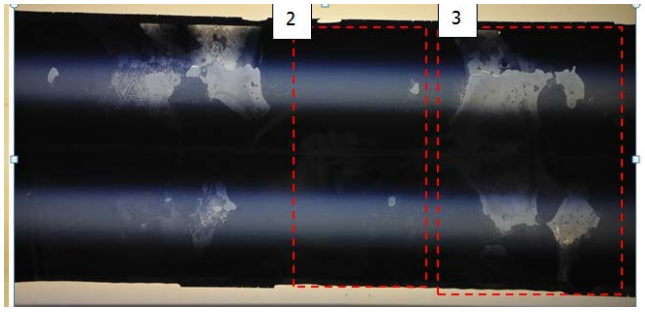
- 5KV capacitors used in high power application
- Routine inspection revealed metal damage
- ERA asked to conduct independent investigation

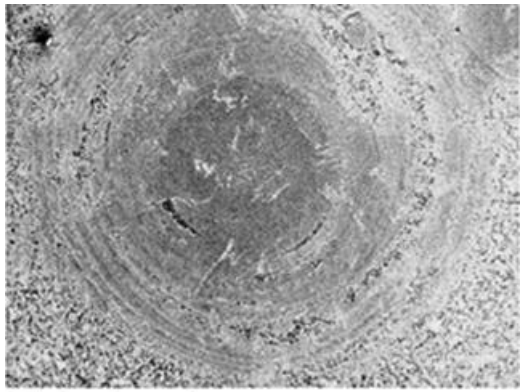
- Application assessment
- Electrical testing
- Disassembly
- Materials analysis
- Trace contamination analysis

Large power supply degradation

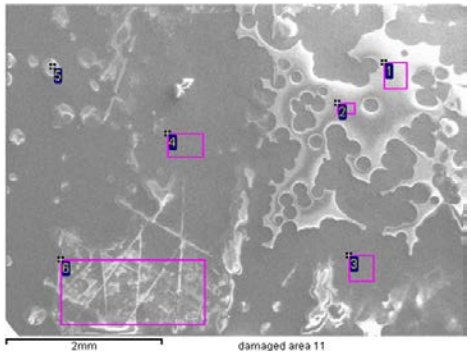
- Found a range of effects
- Primary concern - corrosion linked to fluorine, with spacing varying with diameter, linked to flux and lamination issue
- Recommended ongoing monitoring over life of asset.
- Recommended on site measure of electrical stress

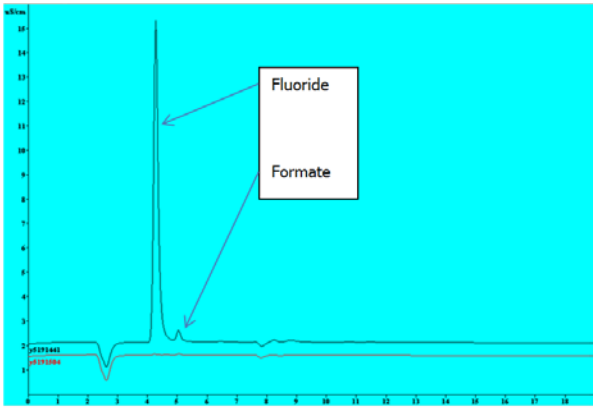


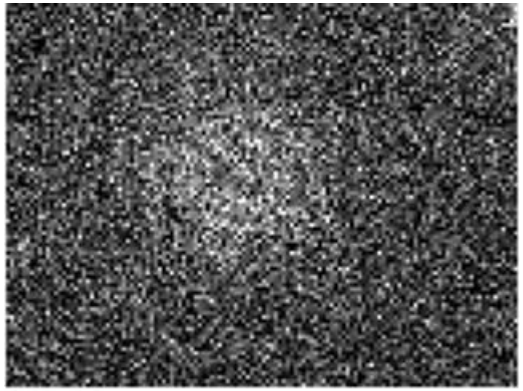




Electron Image 1







F Ka1_2

Spectrum	C	O	F	Al	Zn
1	88.3	3.6	1.5	2.6	3.9
2	83.5	5.5	2.2	3.2	5.7
3	70.5	14.9	3.4	3.6	7.6
4	92.5	2.2	1.5	1.6	2.2
5	86.5	7.8	3.4	2.4	0.0
6	84.4	5.9	3.6	2.1	3.9

X2 Film Capacitor Failures

- Manufacturer of utility meters sued for large amount due to power supply failure
- X2 capacitors responsible

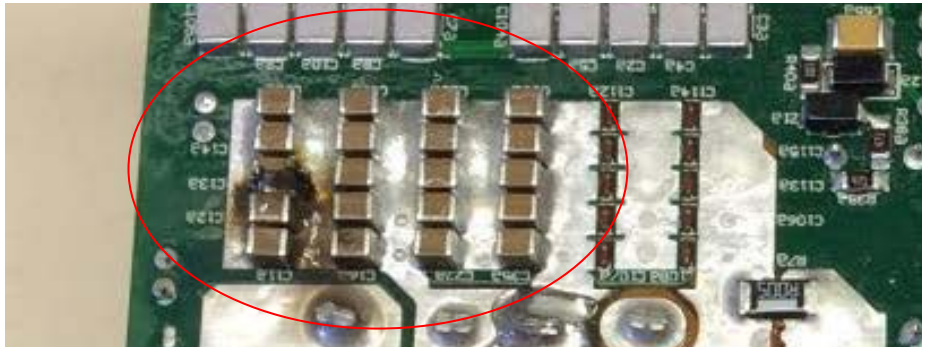
- Humidity affects the film
- Miniaturisation allows moisture into package
- Cost reduction of capacitors brings them into new applications
- Effect takes time to become evident
- Capacitor manufacturers didn't realise?

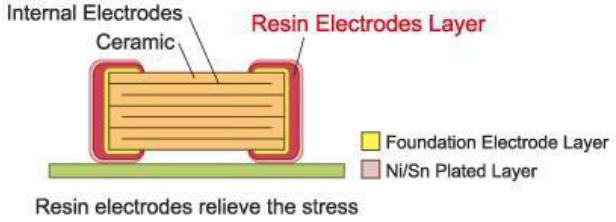
- ERA reported on manufacturers responsibility / due diligence / circuit design
- Responsibility directed towards capacitor manufacturers

Ceramic capacitor failure example

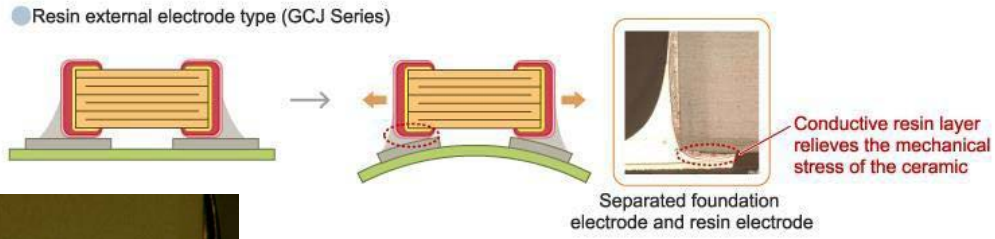
- Industrial electronics – capacitor short circuit failure
- Manufacturer had specified “automotive” MLCCs
- Sub contractor had fitted two different capacitors
- Assembled using wave solder process = specifically not allowed in capacitor datasheet.

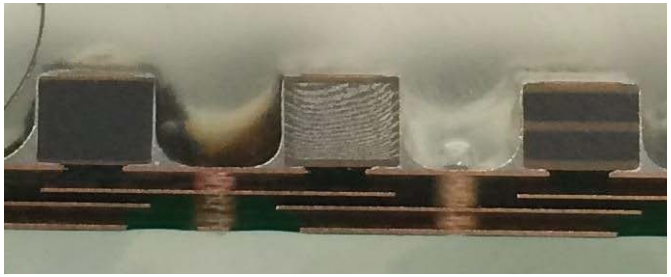
- Recommended solder process change and capacitor change

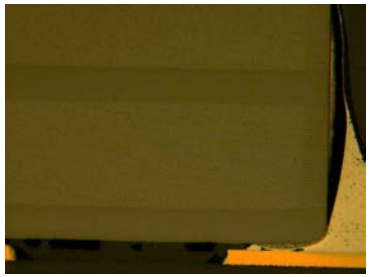




<Example of Structure>







- Failures seen in most capacitor types – from many manufacturers
  - **Thin film - mostly associated with contamination**
  - **Tantalum – electrical + mechanical stresses**
  - **Aluminium electrolytic – electrolyte balance / contamination**

- COTS concerns
  - **Latent defects**
  - **Subtle changes in process especially trace contamination**
  - **Production transparency / supply chain changes**

Thankyou

When it's critical, count on us

www.edifgroup.com