Aluminum Electrolytic Capacitors – Failure Modes

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Capacitor Workshop

Short Introduction of Today‘s Presenter

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Background:

- More than 10 years of work experience in electronics industry
- Background in Global Sales & Marketing, Industrial Engineering and Quality Management
- In charge for strategic sales conception and global market penetration of capacitor division at WE

Agenda

- Definition of Failure
- End of Lifetime = Failure?
- E-Cap Failure Modes
- Failures & Root Causes
- Common Failures

Definition of Failure

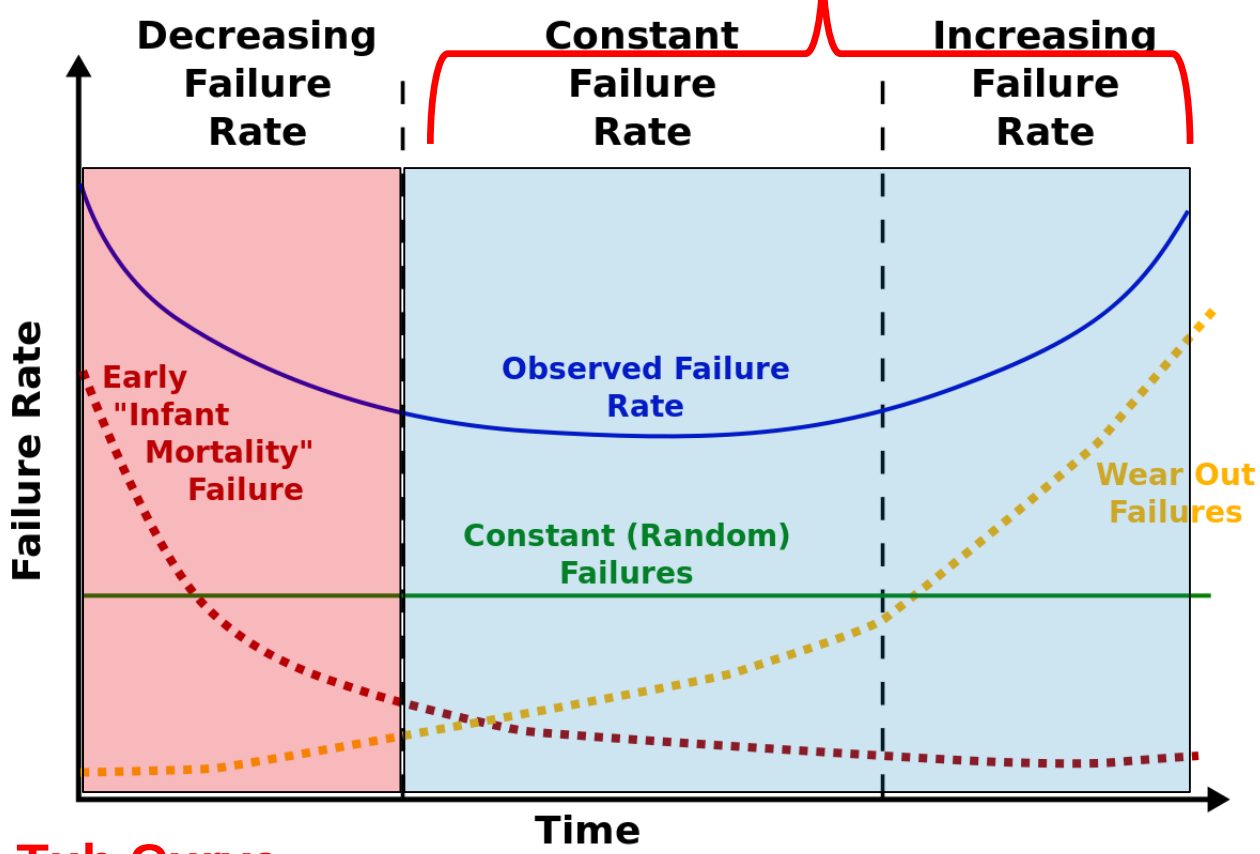
Definition of Failure

Manufacturers job at production to minimize such cases

Depending on dimensioning and mission profile

Product failures can happen at any time like:

- **Early Birds - occur at new devices**
  - **Early Failures**
- **Unexpected Failures**
  - **Random Failure**
- **At the End of Lifetime**
  - **Wear Out Failures**



>> overall observed failures result in Bath Tub Curve

End of Lifetime = Failure?

What means Endurance, Load Life and Useful Life?

End of Lifetime = Failure?

- **Aluminum Electrolytic Capacitor**

Test Condition	Endurance / Evaluation Criterion
Life Time	1000h@105°C
Voltage	Full Rated Voltage
Current	Full Ripple Current
ΔC	Within +/- 20% of Initial Value
DF	< 200% of initial value
Leakage Current	Initial value

- **Aluminum Polymer Capacitor**

Test Condition	Endurance / Evaluation Criterion
Life Time	2000h@105°C
Voltage	Full Rated Voltage
Current	-
ΔC	Within +/- 20% of Initial Value
DF	< 150% of initial value
ESR	< 150% of initial value
Leakage Current	Initial value

Endurance and Useful Life as example with WCAP-AIG8 series

WE Matchcode	WCAP-AIG8	
Life	Endurance	Useful life
Time	2000 h	4000 h
Test condition	85°C, V_R, I_R	85°C, V_R, I_R
Requirements	1.ΔC/C≤±20%; 2.DF≤2 times of the specified value; 3.LC≤specified value; 4.Capacitor without visible damage.	1.ΔC/C≤±40%; 2.DF≤4 times of the specified value; 3.LC≤specified value; 4.Capacitor without visible damage.

- **It is necessary to check this for each manufacturer because it is not standardized!**

- **Not the specification of the manufacturer finally determines the lifetime, it will be the dimensioning and selection of the proper capacitor for your design**

>> How much capacitance drift is acceptable and still the application is running properly? <<

Major Factors for Aging of E-Caps

- The following factors mainly accelerate the aging behavior of an e-cap:
  - Temperature
    - electrolyte loss / dry out
    - leakage current >> oxide degradation

  - Ripple Current
    - self heating >> electrolyte loss / dry out

  - Voltage Level
    - leakage current >> oxide degradation

These effects result in:

>> capacitance decrease

>> increase of ESR

>> DF change

Failure Modes

Failure Modes

Leakage Current Increase

Capacitance Drop / ESR Change / DF Change

Short Circuit

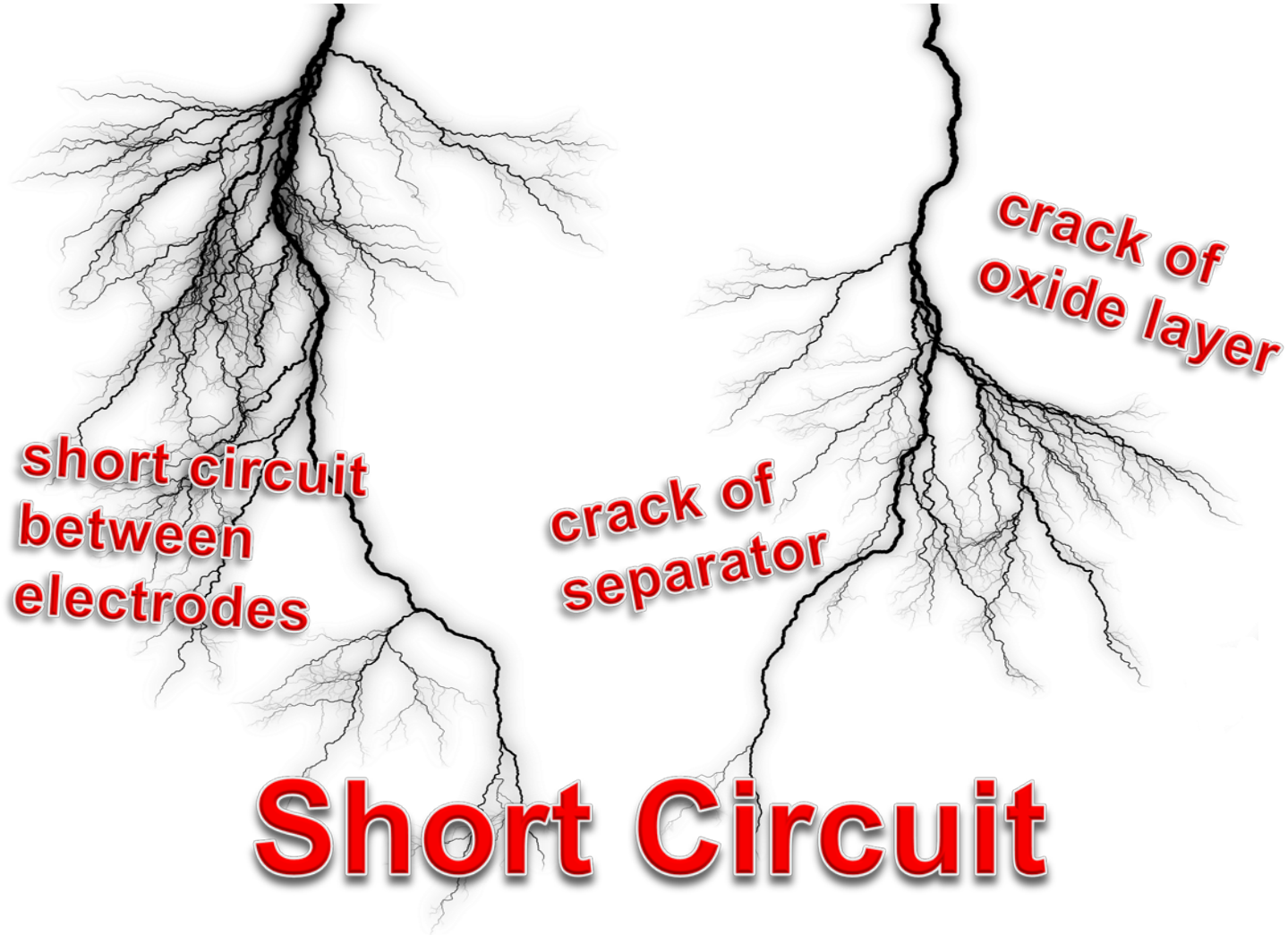
Open Circuit

Open Vent

Electrolyte Leakage

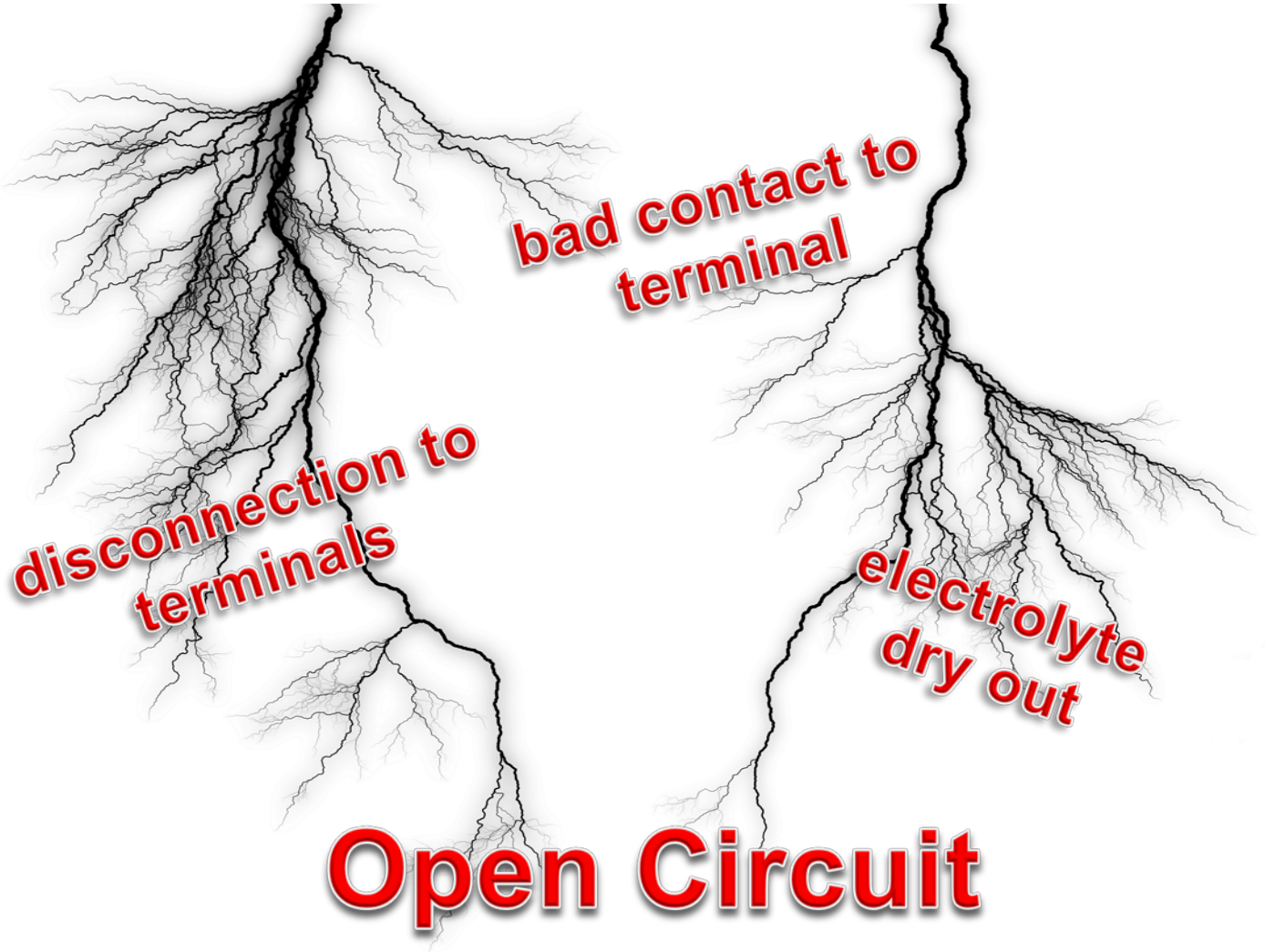
Failures & Root Causes

Failure Modes

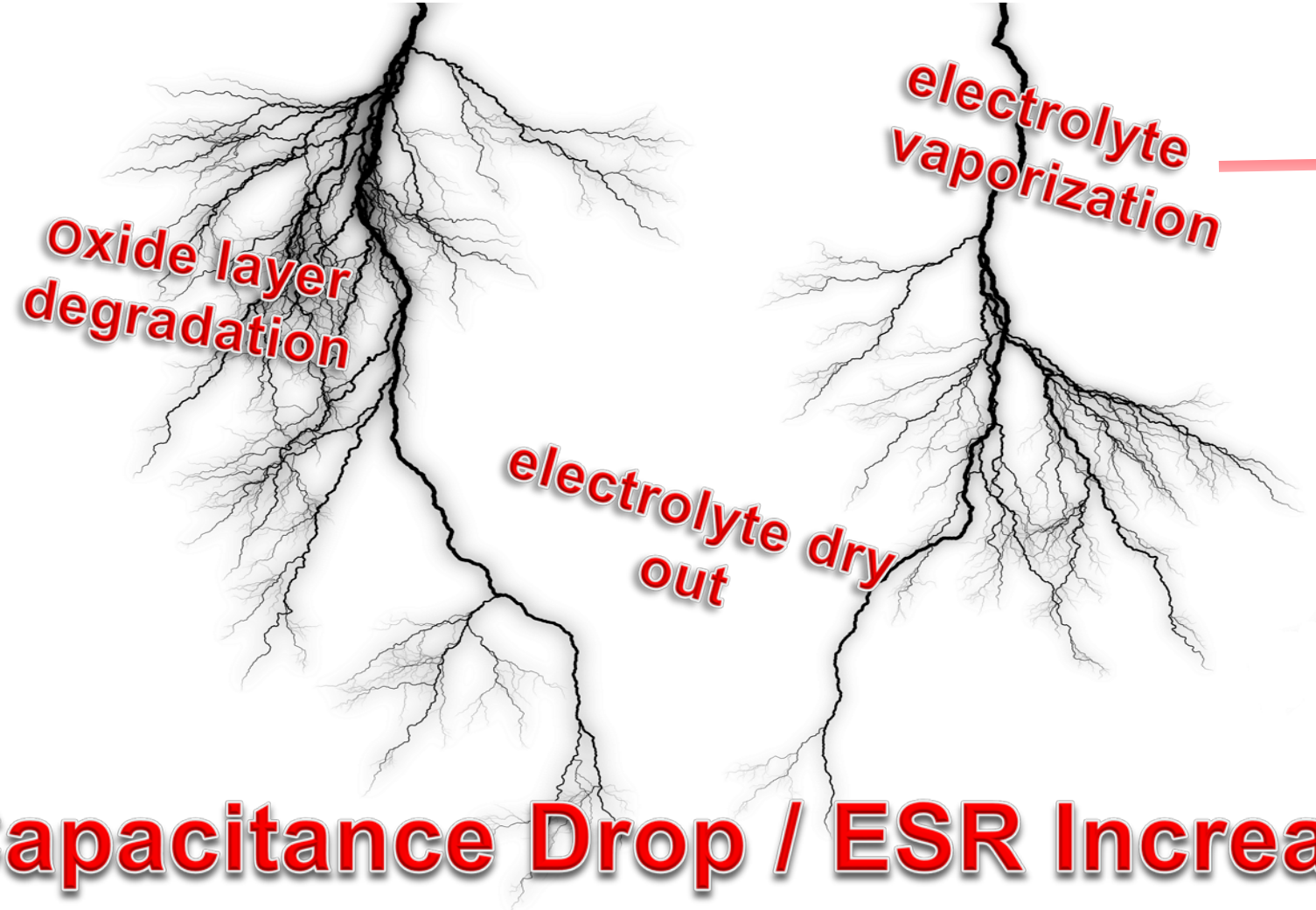


All effects result in an increase of internal pressure:

Failure Modes



Failure Modes



results in a rise of the internal pressure

Capacitance Drop / ESR Increase / DF Change

Failure Modes

poor sealing

internal pressure rise

Electrolyte Leakage

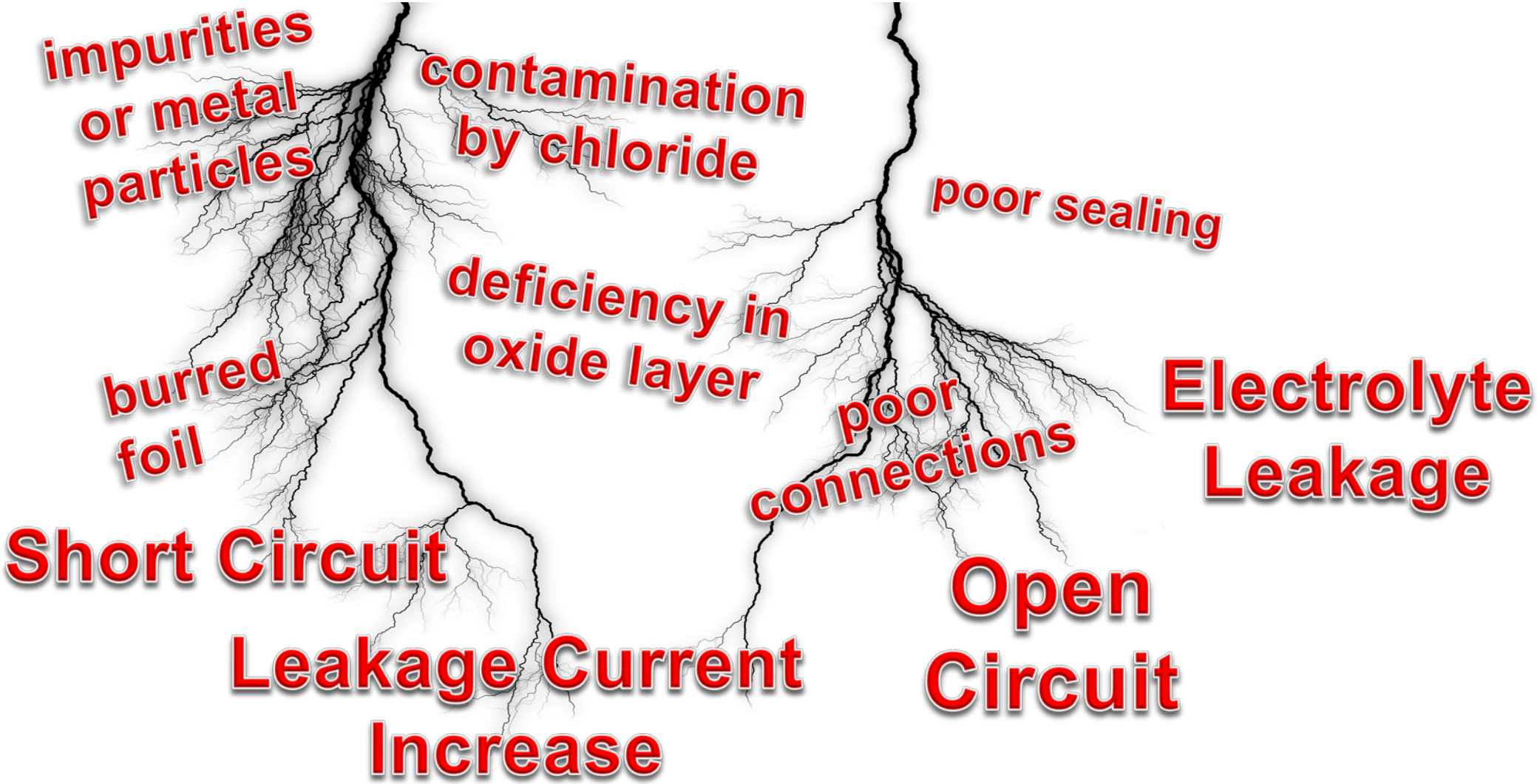
internal corrosion → leeds to open and short circuit

deterioration of oxide layer

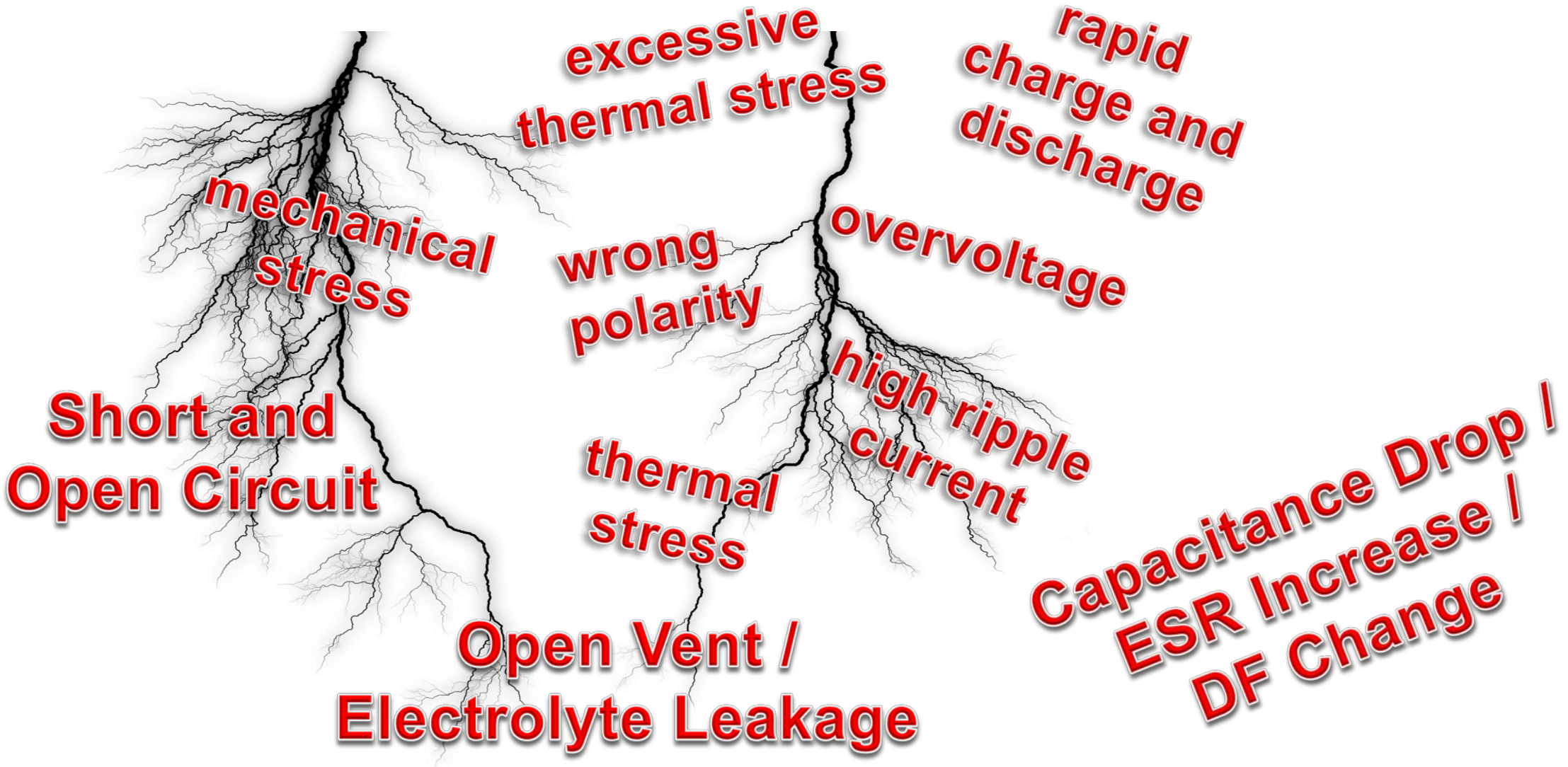
Leakage Current Increase

Open Vent

Root Causes during Production

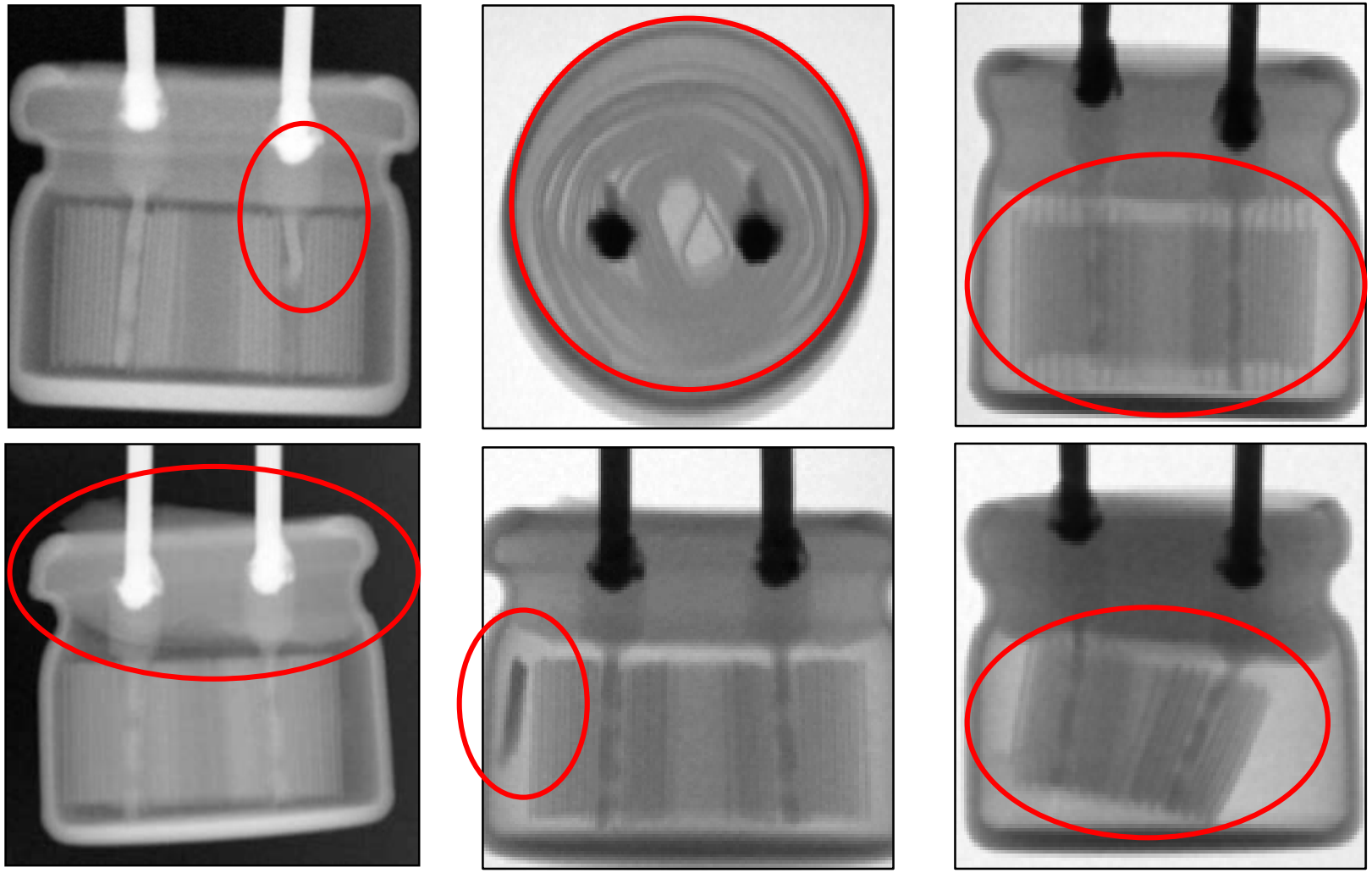


Root Causes within Application or by Aging

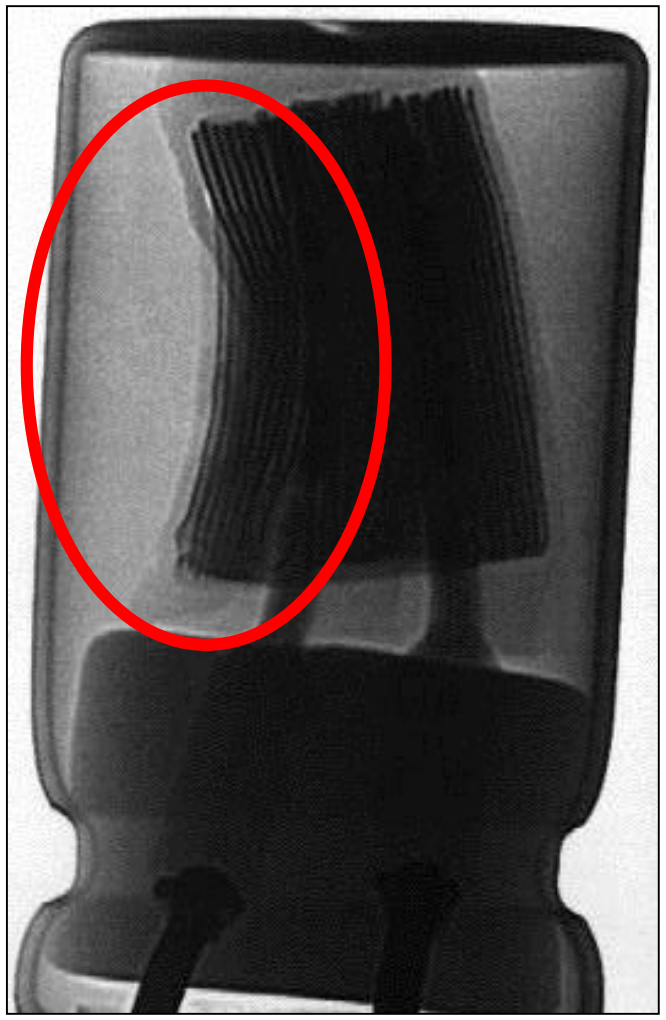


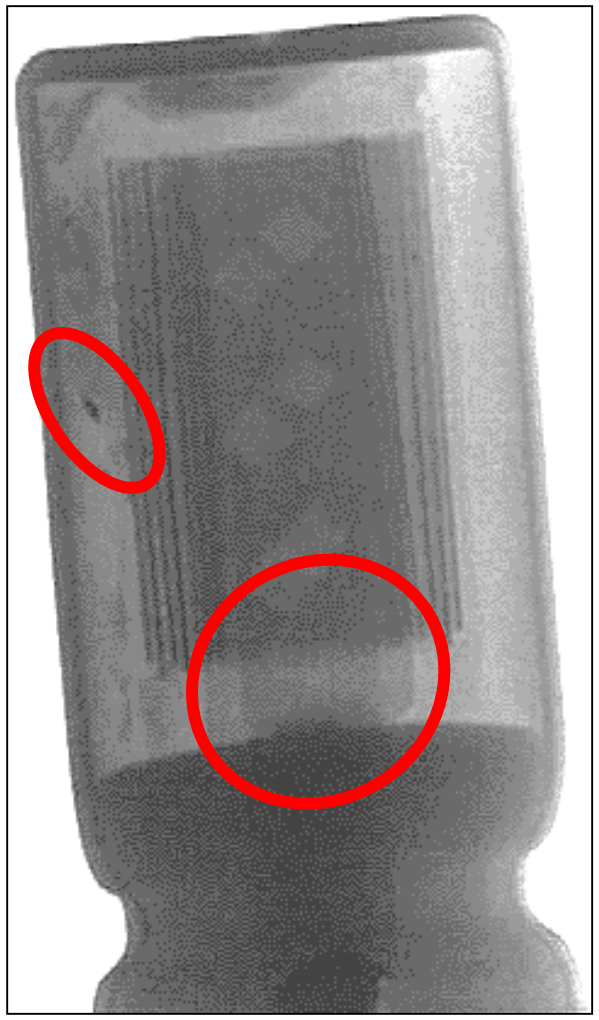
Common Failures

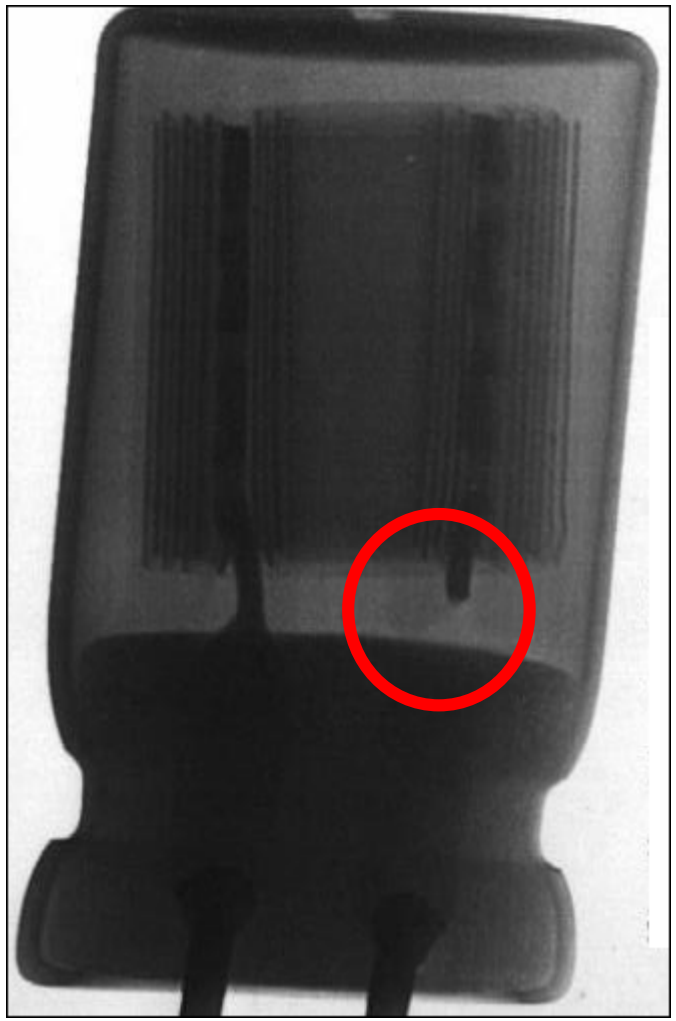
Common Failures



Common Failures







Common Failures

Thanks for your attention!