

# Failure Modes of High Voltage Film Capacitors



ENERGIZING IDEAS

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# Failure Modes of High Voltage Film Capacitors

Everything you wanted to know about failure modes in high voltage film caps but were afraid to ask.

- What are some common causes for failure in HVFCs?
- What is a typical process for analyzing failure modes of HVFCs?
- What are the visual indications and causes of specific failure modes in HVFCs?

# Failure Modes of High Voltage Film Capacitors

What are some common causes for failure in HVFCs?

# Failure Modes of High Voltage Film Capacitors

## Misapplication and Environmental Causes

- $V_a > V_r$ : Overvoltage
- $T_a > T_r$ : Ambient temperature too high
- AC voltage applied to DC rated part
- $I_{RMS}$ : Ripple current exceeds capability
- $dV/dt$ : Too high pulse current
- Moisture

# Failure Modes of High Voltage Film Capacitors

## Poor Design for Intended Application

- Too thin dielectric for  $V_r$
- Wrong metallization type for application
  - Zinc, aluminum, alloy?
  - Too high or low ohms per square metallization
  - Wrong metallization pattern for application
- For AC application, part not designed to prevent or inhibit corona
- Design not proven with life test

# Failure Modes of High Voltage Film Capacitors

## Poor Processing

- Loose winding
- No burn-off
- Poor endspray penetration
- Thin endspray
- Poor end connection
  - Poor solder or weld
- Not cleared properly
- Assembled incorrectly

# Failure Modes of High Voltage Film Capacitors

## Inferior Materials

- Inferior base film
  - Degree of crystallinity
  - Defects per unit area
  - Substitute quality source for low cost without proving design or control of supply.
- Inferior metallization
  - Poor adhesion
  - Defects in metallized layer

# Failure Modes of High Voltage Film Capacitors

## Typical Process for Analyzing Failure Modes in HVFCs



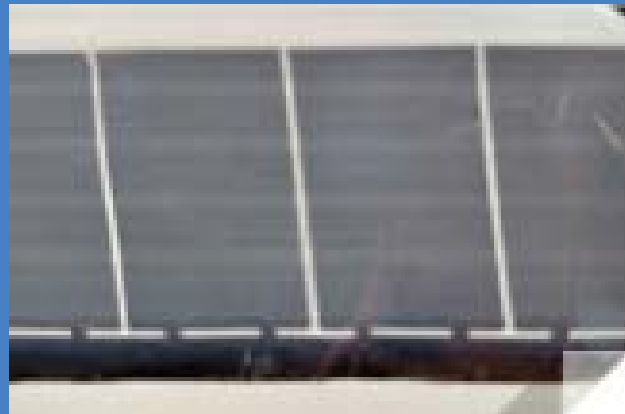


# Failure Modes of High Voltage Film Capacitors

What are the visual indications and causes of specific failure modes in HVFCs?

# Failure Modes of High Voltage Film Capacitors

First: This is what a good metallized polypropylene cap winding looks like.



Segmented Film



Non-Segmented Film

# Failure Modes of High Voltage Film Capacitors

## Corona

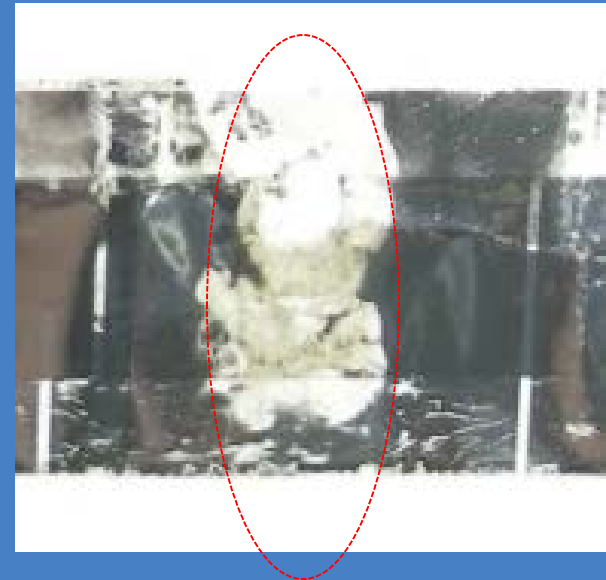
- Typical visual indications
  - Loss of metallization (pitting) at metal edge boundaries where field strength is highest and where air gaps may exist.
- Typical causes
  - Vac applied exceeds rated.
  - Loose winding, air gaps



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## Excessive clearing

- Typical visual indications
  - Loss of metal in cleared areas where dielectric has been compromised.
- Typical causes
  - Vdc or Vac applied exceeds rating
  - Application temperature exceeds rated temperature
  - End of life (dielectric aging)



# Failure Modes of High Voltage Film Capacitors

## Moisture

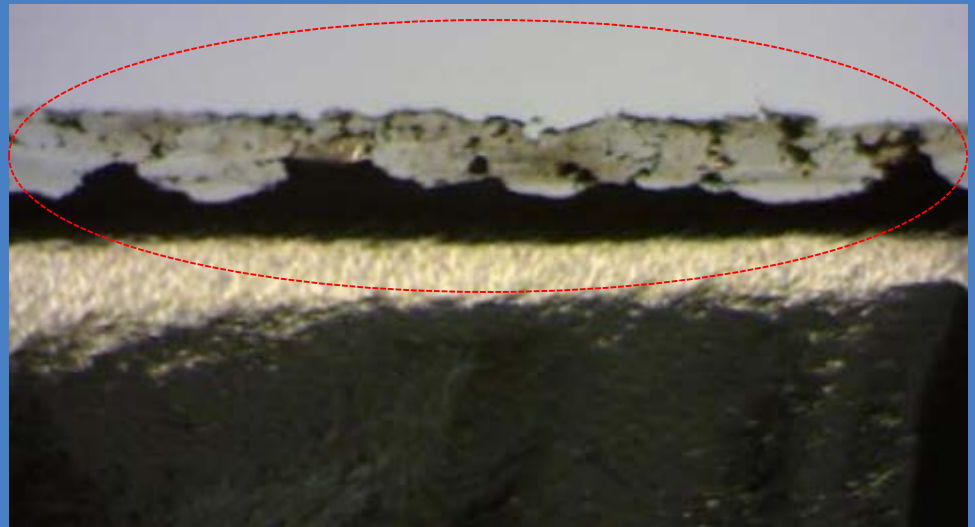
- Typical visual indications
  - Large areas of metal corrosion, discoloration without dielectric failure.
  - Typical causes
    - Excessive humidity



# Failure Modes of High Voltage Film Capacitors

## Peak Current Failure

- Typical visual indications
  - Metallization at end connection deteriorates due to pulsed current
  - Typical causes
    - $dV/dt$  exceeds rating



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## Thermal Runaway

- Typical visual indications
  - Massive charring and melting of plastic film
- Typical causes
  - Capacitor voltage or temperature ratings exceeded for extended periods
  - Cascading failure modes



Thank You!



# High Voltage Film Capacitors



Scott Franco

Director of Market Development at Cornell Dubilier Electronics

## Bio for Scott Franco

- Bachelor of Science Degree in Physics from UMass, 1989.
- Began working at Cornell Dubilier in 1989 as AC and DC Film Capacitor Applications and Design Engineer
- Received MBA in 1997 from Bryant College.
- Transitioned from engineering to product management and sales management roles.
- Currently serves the company as Director of Market Development