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Improvements in Pulse Film Capacitor Technology

SBE's patented, novel approach to designing and manufacturing pulse film capacitors for extreme applications

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Introduction

- There are several differing philosophies and approaches to designing pulse capacitors
- When pressed to the limit many of these designs fail to perform, and fail catastrophically!

The SBE Solution

- SBE has developed a novel approach that overcomes the limitations of many designs available on the market today

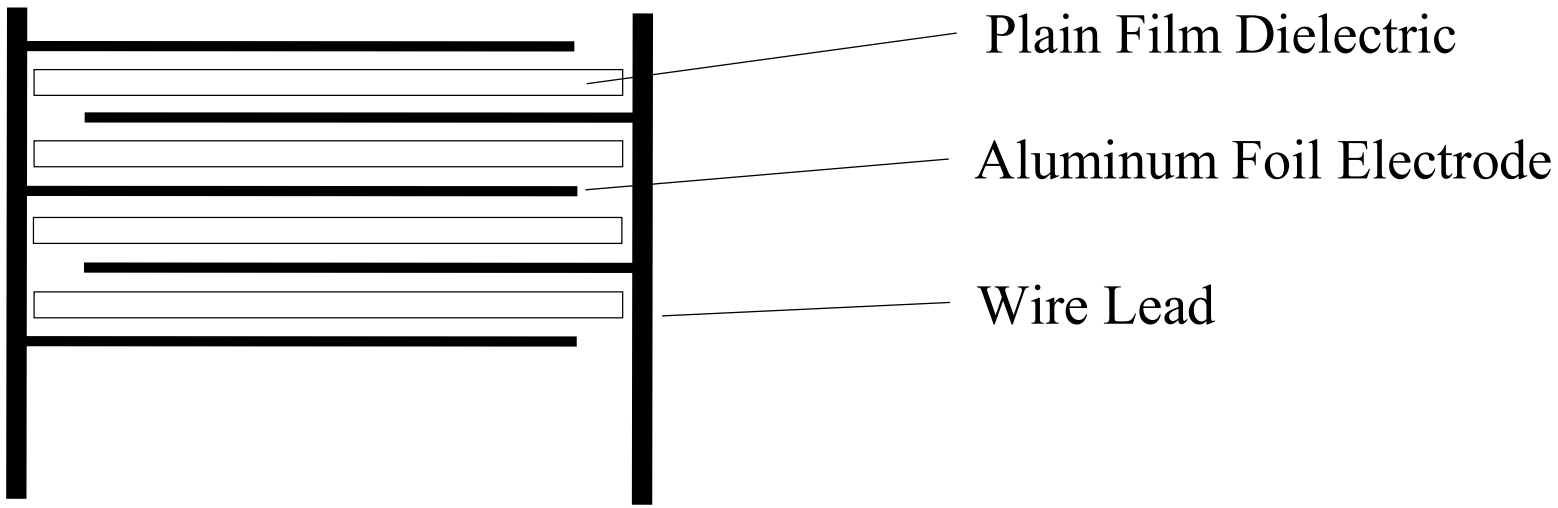
- SBE's patented film design provides extended pulse performance at levels far exceeding design ratings
  - U.S. Patent # 7,008,838

The SBE Solution

- To be presented:
  - Review of pulse film capacitors
  - Comparative designs will be discussed
  - Designs tested and data presented
  - Conclusion

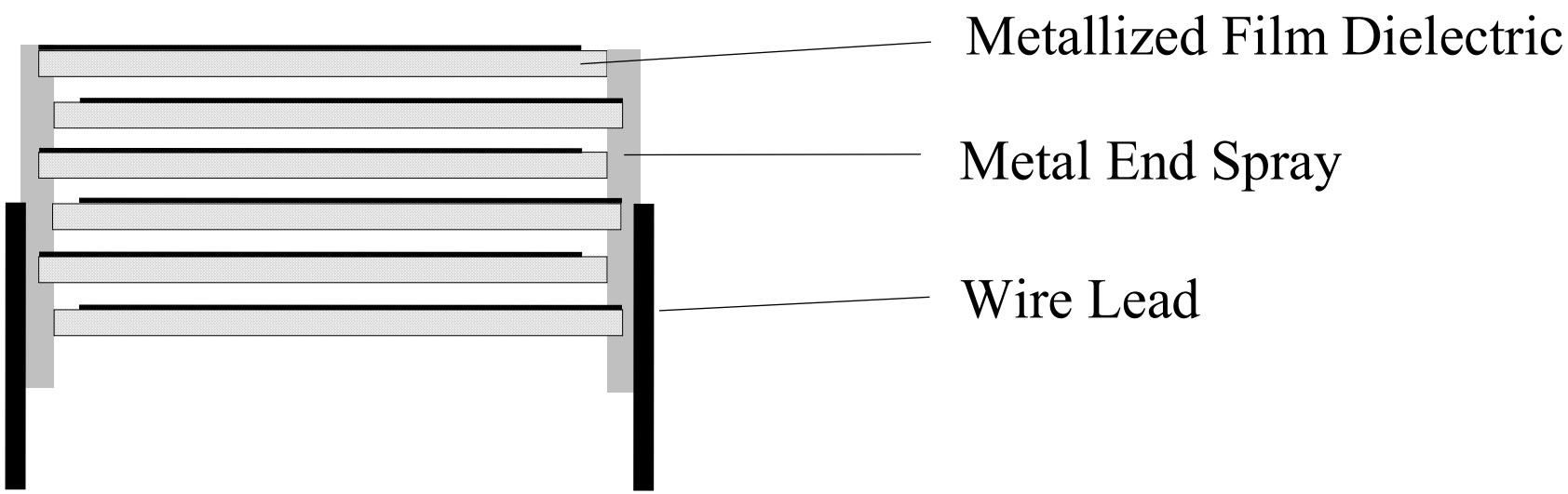
Pulse Capacitor Review

- Film/Foil construction: The gold standard for pulse film capacitors



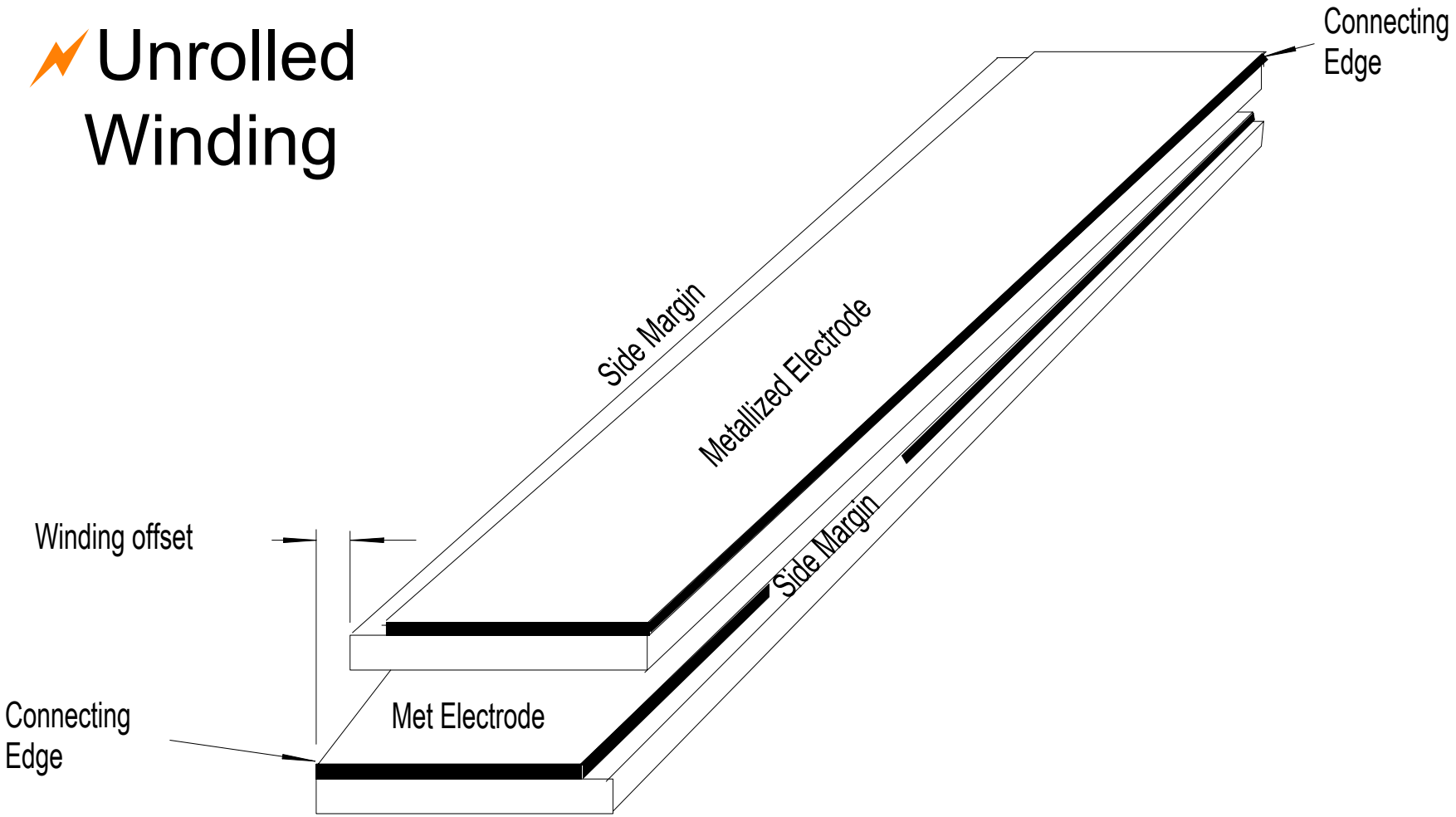
Pulse Capacitor Review

- Metallized Film construction



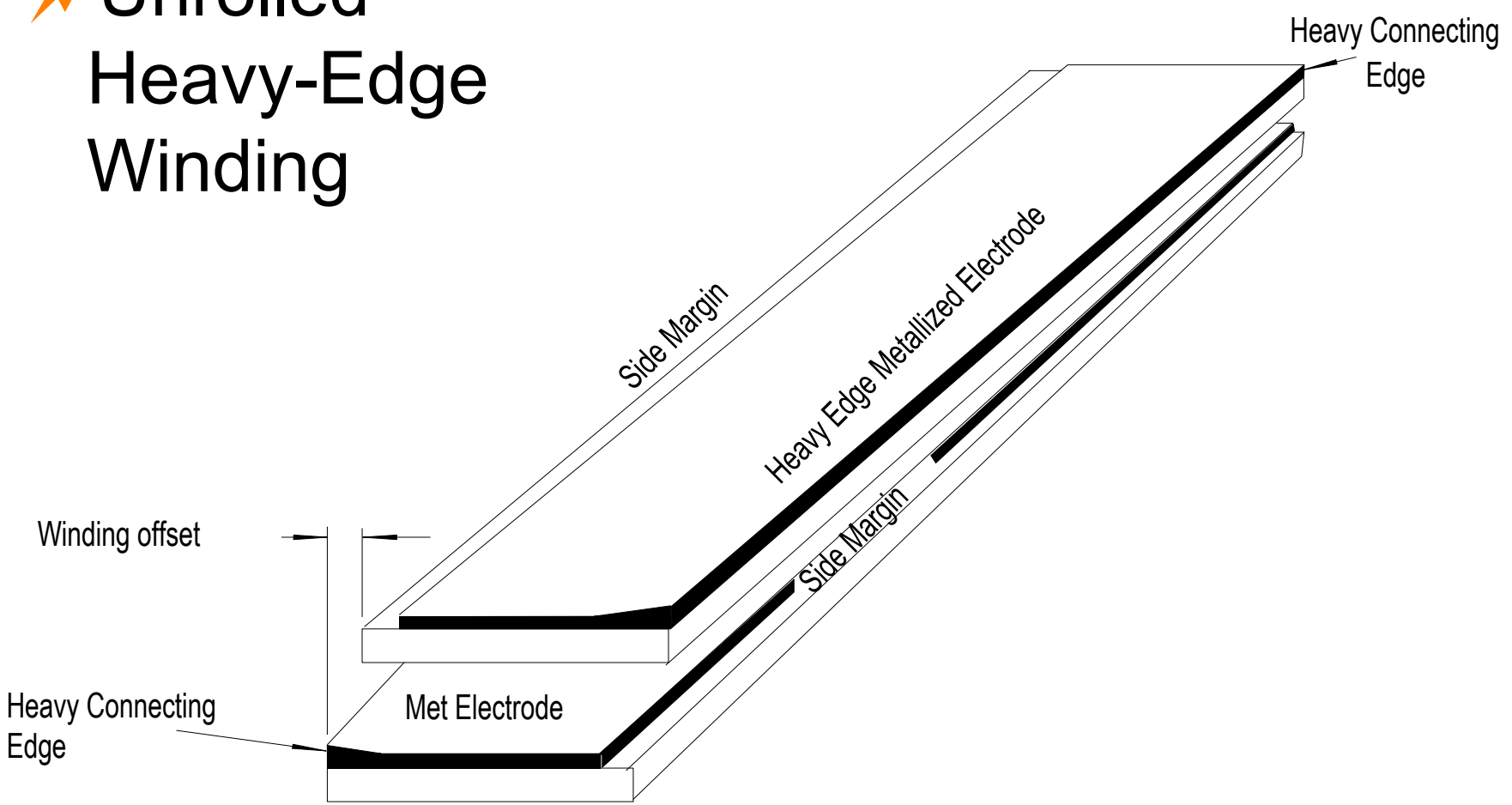
Conventional Metallized Film

- Unrolled Winding



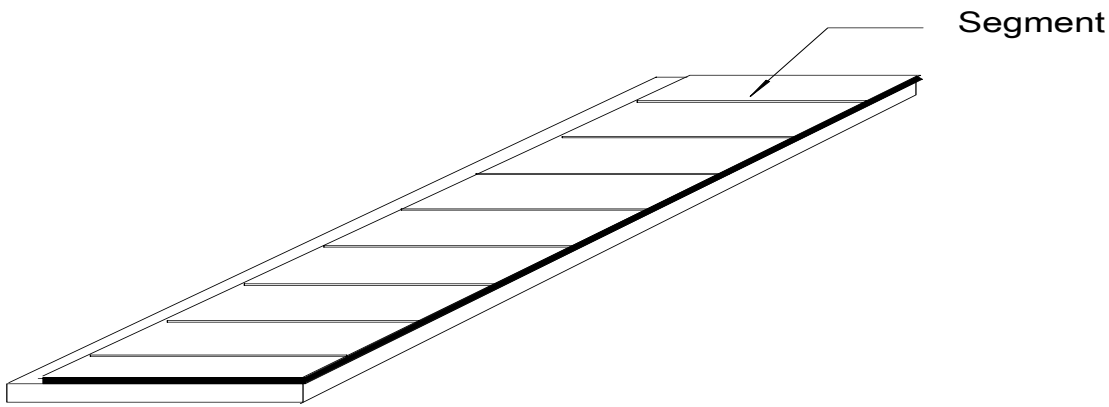
Heavy-Edge Metallized Film

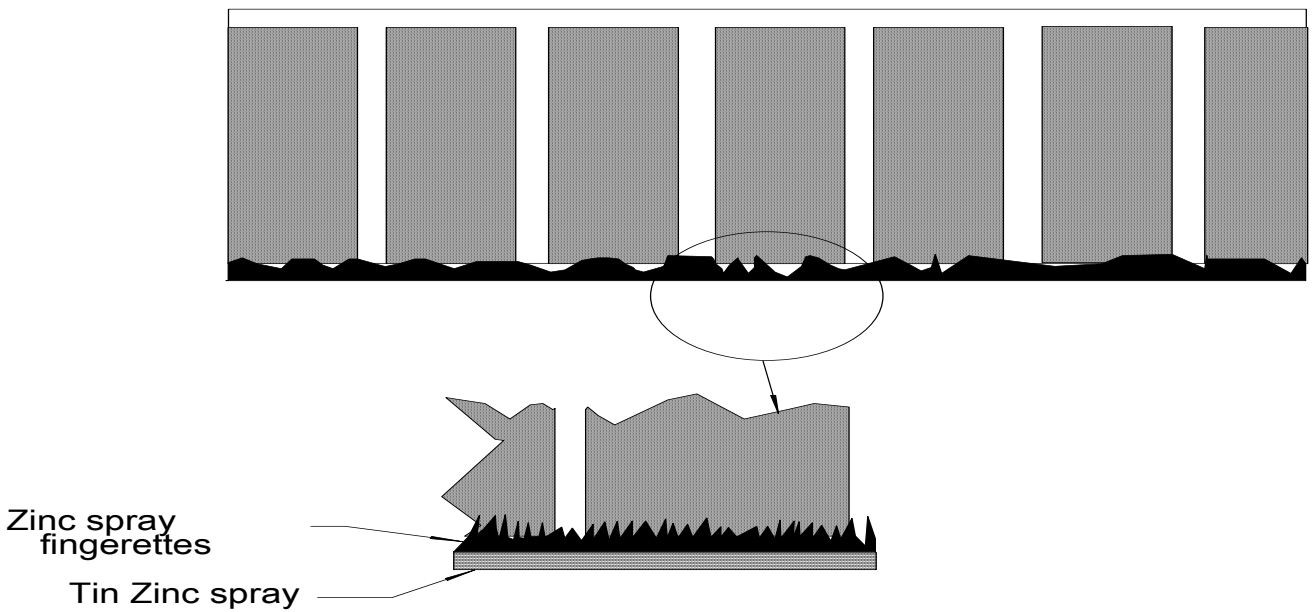
- Unrolled Heavy-Edge Winding



Segmented Film

- Unrolled Segmented Winding





Pulse Capacitor Parameter

- dV/dt is the prime Pulse Cap parameter
- Peak current in the capacitor is given by:
  - $I_{PEAK} = C * dV/dt$
    - Where: I = instantaneous (peak) current
    - C = Capacitance in Microfarads
    - dV/dt = in volts per microsecond

Evaluating Pulse Capacitors

- Testing for Adequacy vs. Ultimate Performance
- Adequacy: Normal spec verification
- Ultimate: Rugged step stress testing
- Discharges to dead short (Copper bar across terminals) provides jarring test of termination

Step Stress Testing Method

- Charge to initial Voltage - Dump to dead short - Measure Cap and loss factor
- Increment voltage - Repeat Dump & repeat measurements
- When certain limit of Capacitance change is reached then start pulsing at that voltage to total cap loss or some other limit is reached

Designs Evaluated

- Group 1 consisted of 2 sets of units - Quality conventional Design by competitor & SBE Patented Design
  - 30 µF – 1400 VDC
- Group 2 consisted of 2 sets of units - Quality conventional Design by competitor & SBE Patented Design
  - 40 µF – 1000 VDC

Comparison Test Details

- Initial Charge Voltage = 100 VDC
- Increment step = 50 VDC
- First Cap change limit = -1%
- Voltage held and pulsed 10 more cycles
- If Δ Cap Less than 10% & DF less than 1% - then 90 more pulses & repeat measurement
- If Δ Cap still less than 10% & DF less than 1% then increment voltage 50 VDC & repeat 10 & 90 pulse sequence

Comparison Test Details

- Continued sequence until Cap loss limit or DF limit was exceeded
- Terminate Test

Test Results Set #1
30 µF – 1400 VDC

Pulse Cap #1 vs. Pulses & Pulse Count
30 Mfd 1400 VDC

Charge voltage VDC and Pulse count

Cap MFD

Data Point

# of Pulses @ voltage

Charge Voltage

SBE Cap Mfd

Conventional Unit #1

Test Results Set #1
30 µF – 1400 VDC

- Observations:
  - **Brown Line = Charge voltage per test point**
  - **Green Line = # of pulses at that voltage**
  - **Blue Line = Conventional unit Cap value**
  - **Orange Line = SBE Patented Pulse Cap value**

Test Results Set #1
30 µF – 1400 VDC

Observations of part performance:

- Performance the same for first 20 data points then **conventional** cap change exceeded 1% so it was pulsed 10 times at that voltage – it **died** at data point 22

- **SBE patented pulse part** continued to data point 29 when cap dropped 1% - After 10 & 90 pulse step sequence it was still viable – After voltage increment and 10 & 90 sequence, cap loss exceeded 10% but bulk of cap was still available for duty

- Second Set of 30 µF/1400 VDC units behaved similarly

Test Results Set #2
30 µF – 1400 VDC

Pulse Cap #2 vs. Pulses & pulse count
30 Mfd 1400VDC

Charge voltage VDC and Pulse count

Cap MFD

Data Point

# of Pulses @ voltage

Charge Voltage

SBE Cap Mfd

Conventional Unit #2

Test Results, Group 2
40 µF – 1000 VDC

- Second Group of units rated at 40 µF/1000 VDC was tested following the same program

Test Results Set #1
40 µF – 1000 VDC

Pulse Cap #1 vs. Pulses & pulse count
40 Mfd 1000 VDC

Charge voltage VDC and Pulse count

Cap MFD

Data Point

Total Pulse # @ voltage

Charge Voltage

SBE Cap Mfd

Conventional Unit #1

Test Results Set #1
40 µF – 1000 VDC

- Observations:
  - **Brown Line = Charge voltage per test point**
  - **Green Line = # of pulses at that voltage**
  - **Blue Line = Conventional unit Cap value**
  - **Orange Line = SBE Patented Pulse Cap value**

Test Results
40 µF – 1000 VDC

Observations of part performance:

- Performance the same for first 20 data points then **conventional** cap loss exceeded 1% loss at data point 21 so it was pulsed 10 times at that voltage – it **died** at data point 22

- **SBE patented pulse part** also exceeded 1% cap loss at data point 20 - After 10 & 90 pulse step sequence it was still viable – After cap loss exceeded 10% the bulk of cap was still available for duty

- Second Set of 40 µF/1000 VDC units behaved similarly

Test Results Set #2
40 µF – 1000 VDC

Pulse Cap #2 vs. Pulses & pulse count
40 Mfd 1000 VDC

Charge voltage VDC and Pulse count

Cap MFD

Data Point

Total Pulse # @ voltage

Charge Voltage

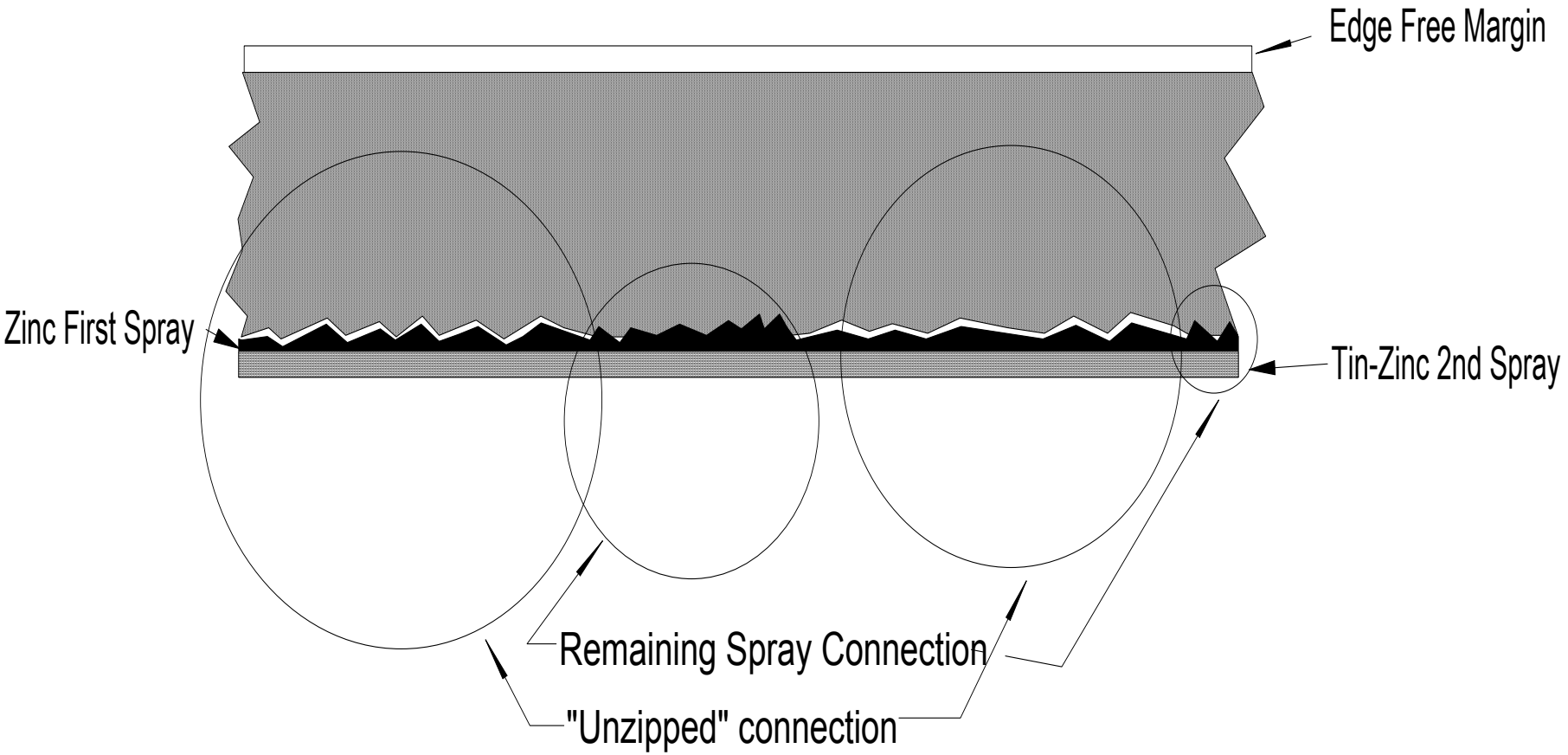
SBE Cap Mfd

Conventional Unit #2

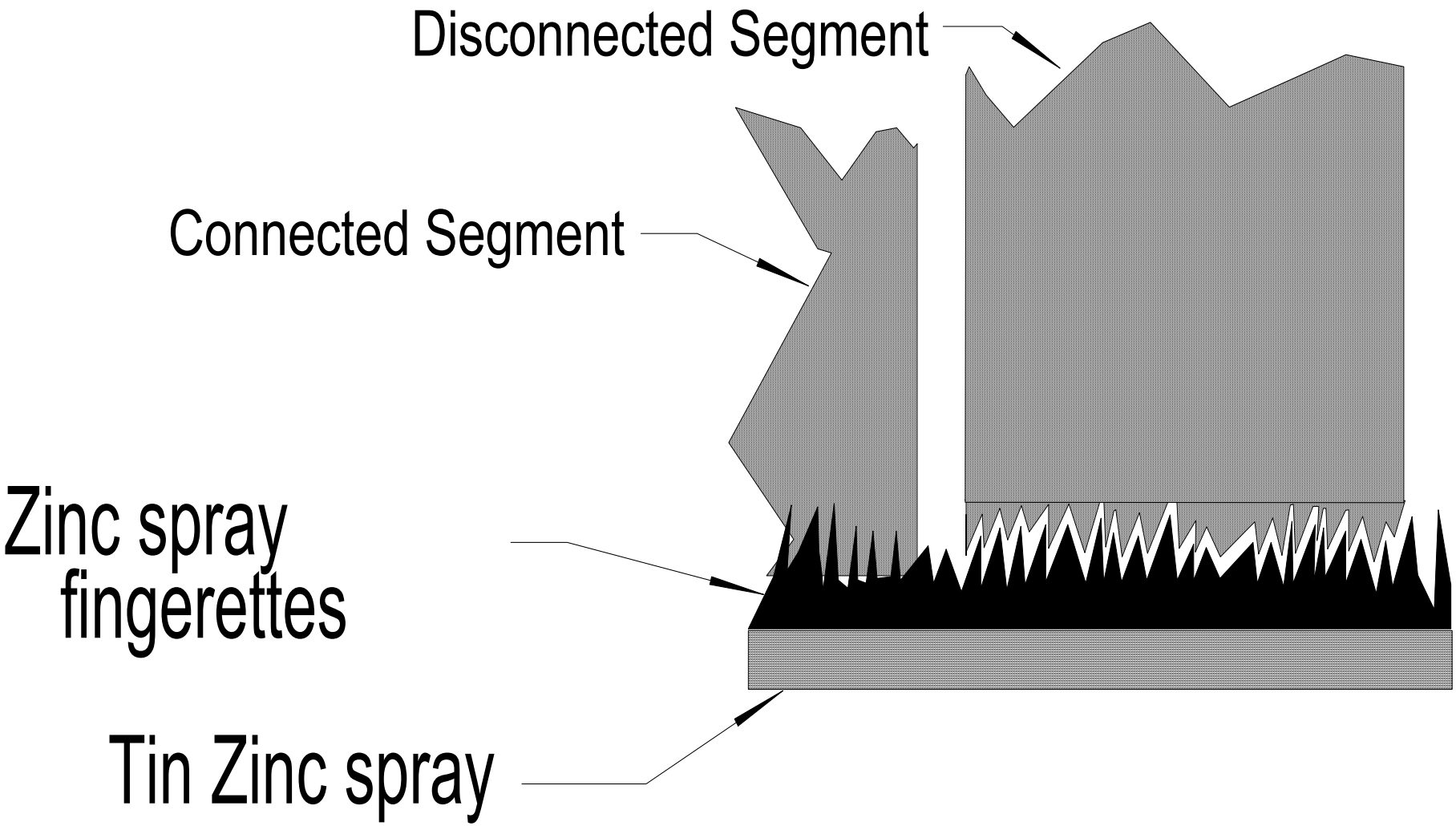
Overall Test Results

- **What happened** to fail the conventional part vs. the SBE part?
- **Conventional** part “Unzipped” and went open due to current concentrations
- **SBE patented pulse** part lost a few segments but remained useful

Unzipped Conventional Metallized Unit



Segmented Metallized Film Disconnect



Conclusion

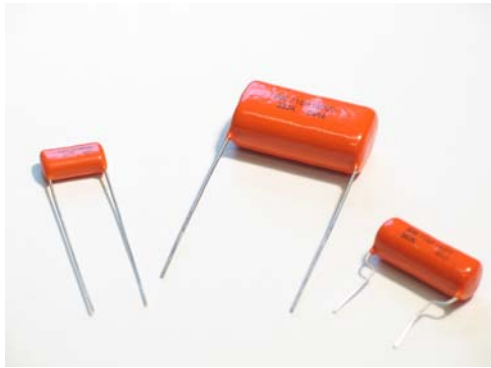
- Test series shows the value of SBE Patented pulse capacitor to prevent “Unzipping” found with conventional designs
- SBE Patented designs can be “Pushed” far beyond pulse ratings
- Conventional designs cannot withstand limit pushing

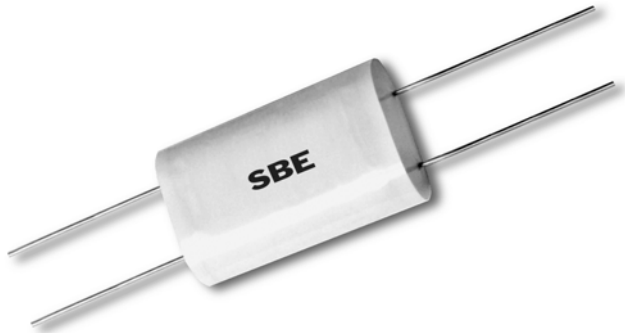
Product Range

- Radial-Lead Orange Drop® series
- Axial-Lead Wrap & Fill designs
- Power Ring Film Capacitor™ units

- The SBE patented pulse technology can be applied to all of these capacitor packaging technologies!

SBE, Inc.





Thank you!

Come see us at Booth 130