Suppress Static Sparks when Unwinding Release Liners and Laminated Webs

Kelly Robinson, PE, PhD

Electrostatic Answers
near Rochester NY
Eliminating injury and waste from static electricity
Suppress Static Sparks when Unwinding Release Liners and Laminated Webs

1. **Introduction** – Static sparks:
   a) ignite flammable solvents,
   b) shock people and machine control systems,
   c) cause sheets to stick and jam, and
   d) **damage products**.

2. **Tribocharging** causes charging at the unwinding nip

3. **Measure** static with 2 instruments
   1. Electrostatic Fieldmeter
   2. Non-contacting Electrostatic Voltmeter

4. **Unwinding Roll** charge control

5. **Suppress Sparks**

6. **Summary**
1. Eliminate ignitions.

2. Prevent shocks to operators.

3. Prevent static problems in customer applications (sheet sticking, process jams).
I. Introduction

Static sparks can damage the silicone release liner causing release failure (PSA label sticks to support).
2. Tribocharging

Charge is separated at the unwinding nip where the exiting web peels from the outside surface of the unwinding roll.
3. Measure Static - Fieldmeter

The electrostatic fieldmeter responds to the total amount of charge in the control volume.

\[ E \propto (\sigma_{\text{TOP}} + \sigma_{\text{BOTTOM}}) \]
3. Measure Static - Voltmeter

What is the charge density $\sigma_{\text{TOP}}$ on the top surface?

Measuring the surface potential $V_{\text{SURFACE}}$ with the sheet on a grounded surface removes the contribution from $\sigma_{\text{BOTTOM}}$. Here, the voltmeter responds only to the charge density $\sigma_{\text{TOP}}$ on the top surface.

$V_{\text{SURFACE}} \propto \sigma_{\text{TOP}}$
4. Unwinding Roll

$E_{ROLL} \approx +10 \text{ KV/cm}$

$E_{SPAN} \approx 0 \text{ KV/cm}$

$V_{TOP} \approx +200 \text{ V}$

$V_{BOTTOM} \approx -200 \text{ V}$

$E_{ROLL}$ responds to the static charges on the outside surface of the unwinding roll. $E_{SPAN}$ is nearly zero!
4. Winding Roll w/ balanced charge

\[ E_{\text{ROLL}} \approx +10 \text{ KV/cm} \]

\[ E_{\text{SPAN}} \approx 0 \text{ KV/cm} \]

\[ V_{\text{TOP}} \approx +200 \text{ V} \]

\[ V_{\text{BOTTOM}} \approx -200 \text{ V} \]

\( E_{\text{ROLL}} \) responds to the static charges on the outside surface of the unwinding roll. \( E_{\text{SPAN}} \) is nearly zero!
4. Unwinding Roll Charge Control

$E_{ROLL} \approx 0 \text{ KV/cm}$

$E_{SPAN} \approx -10 \text{ KV/cm}$

$V_{TOP} \approx 0 \text{ V}$

$V_{BOTTOM} \approx 0 \text{ V}$

$S_{BRoll}$ dissipates static on the outside surface of the unwinding roll.

$S_{BSpan}$ dissipates static on the inside surface of the exiting web.

However, sparking may still occur at the unwinding nip!
4. Suppress Sparks

**SB\textsubscript{ROLL}** dissipates static on the outside surface of the unwinding roll. The static curtain deposits + charges that suppress sparks. **SB\textsubscript{SPAN}** is inactive.
4. Suppress Sparks

SB\textsubscript{ROLL} dissipates static on the outside surface of the unwinding roll. SB\textsubscript{SPAN} dissipates static on the inside surface of the exiting web. The grounded lay-on roller suppresses sparking at the unwinding nip!
5. Summary

1. Release liners / laminates are prone to charge separation at the unwinding nip.
2. Balanced charge causes high static on the winding roll.
3. Use two static bars to neutralize on both surfaces of webs exiting unwinding rolls.
4. Suppressing sparks with brushes / blankets form balanced charge.
5. Use a conductive or static dissipative lay-on roller to suppress nip sparks.
THANK-YOU!

Questions? Comments?

Kelly Robinson, PE, PhD, IEEE Fellow
Owner, Electrostatic Answers
Tel: 585-425-8158
Kelly.Robinson@ElectrostaticAnswers.com
Kelly Robinson, PE, PhD
Owner, Electrostatic Answers, Rochester NY

• **Accomplished Engineer:**
  Institute of Electrical and Electronics Engineers (IEEE) Fellow
  US National Fire Protection Assoc. (NFPA) Static Electricity Committee
  Electrostatics Society of America (ESA) Distinguished Service Award
  Ph.D. in Electrical Engineering from Colorado State University
  Professional Engineer registered in New York.

• **Business Owner:** founded Electrostatic Answers, an engineering consulting company dedicated to eliminating injury and waste from static electricity.

• **Inventor:** 14 patents and 2 pending applications.

• **Active Technical Writer & Speaker:**
  Journal of Electrostatics (peer reviewed journal) Associate Editor
  Paper Film & Foil Converter Contributing Editor, writes “Static Beat” a regular column on static control
  Converting Quarterly, AIMCAL publication, contributes articles.
  AIMCAL John Matteucci Award
Around 585 BC, Thales of Greece rubbed amber with a piece of fur. The amber could then pick up light objects like straw or feathers.

### Triboelectric Series

<table>
<thead>
<tr>
<th>Less human processing</th>
<th>Positive</th>
<th>Nearly Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td>inorganics &amp; biological materials</td>
<td>human skin, asbestos, glass, human hair, mica</td>
<td>steel, poly(methyl methacrylate) (Elvacite®)</td>
</tr>
<tr>
<td>exception</td>
<td>nylon</td>
<td>wax, amber, latex</td>
</tr>
<tr>
<td>inorganics &amp; biological materials</td>
<td>wool, cat fur, silk, alumina</td>
<td>natural resins</td>
</tr>
<tr>
<td>natural fibers</td>
<td>paper, cotton, wood</td>
<td>metals</td>
</tr>
<tr>
<td>exceptions</td>
<td></td>
<td>copper, brass, gold, platinum</td>
</tr>
</tbody>
</table>
### Triboelectric Series

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearly metals</td>
<td>copper, brass, gold, platinum</td>
</tr>
<tr>
<td>exceptions</td>
<td>synthetic rubber (neoprene), sulfur</td>
</tr>
<tr>
<td>biopolymers</td>
<td>acetate (Rayon®), acrylic (Orlon®), cellophane</td>
</tr>
<tr>
<td>Negative</td>
<td>synthetic polymers</td>
</tr>
<tr>
<td>polyurethane</td>
<td></td>
</tr>
<tr>
<td>polycarbonate</td>
<td></td>
</tr>
<tr>
<td>polyvinylidene chloride (Saran®)</td>
<td></td>
</tr>
<tr>
<td>polystyrene</td>
<td></td>
</tr>
<tr>
<td>polyethylene</td>
<td></td>
</tr>
<tr>
<td>polypropylene</td>
<td></td>
</tr>
<tr>
<td>polyimide</td>
<td></td>
</tr>
<tr>
<td>polyethylene terephthalate (PET, Mylar®, Estar®)</td>
<td></td>
</tr>
<tr>
<td>chloropolymers</td>
<td>polyvinyl chloride (PVC)</td>
</tr>
<tr>
<td>fluoropolymers</td>
<td>polychloro trifluoro ethylene (PCTFE) Kel-F®</td>
</tr>
<tr>
<td></td>
<td>polyvinylidene fluoride (Kynar®)</td>
</tr>
<tr>
<td></td>
<td>polytetrafluoroethylene (PTFE) (Teflon®)</td>
</tr>
<tr>
<td>exception</td>
<td>silicone rubber</td>
</tr>
</tbody>
</table>
Chemical structure of poly dimethyl siloxane (PDMS), the repeat unit of silicone rubber

By Sei This vector image was created with Inkscape. - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=5505464
Release liners and laminated web are prone to tribocharging because the inside surface of the incoming web touches the outside surface of the winding roll.
Measure Static - Fieldmeter

\[\begin{align*}
\sigma_{\text{TOP}} & \text{ Coulombs} \\
\frac{\text{m}^2}{\text{m}^2} \\
\sigma_{\text{BOTTOM}} & \text{ Coulombs} \\
\frac{\text{m}^2}{\text{m}^2}
\end{align*}\]

Surface Area \(A\)

Electric Field \(E\)

Control Volume

\[\int\int_{\text{CV}} \varepsilon_0 E \cdot d\mathbf{s} = q_{\text{Enclosed}}\]

\[\begin{align*}
\varepsilon_0 E A &= (\sigma_{\text{Top}} + \sigma_{\text{Bottom}}) A \\
\left(\sigma_{\text{Top}} + \sigma_{\text{Bottom}}\right) &= \varepsilon_0 E
\end{align*}\]

\[\begin{align*}
\left(\sigma_{\text{Top}} + \sigma_{\text{Bottom}}\right)\left[\frac{\mu\text{C}}{\text{m}^2}\right] &\approx E\left[\frac{\text{KV}}{\text{cm}^2}\right]
\end{align*}\]

Suppress Static Sparks when Unwinding
3. Measure Static - Fieldmeter

Common industry standard for acceptably low static:

\[ E < \pm 2 \text{ (KV/cm)} = \pm 5 \text{ (KV/in)} = \pm 20 \text{ KV/(10 cm)} \]
Measure Static - Voltmeter

How much charge is on the surface of this sheet?

Plastic or insulating paper sheet

non-contacting electrostatic voltmeter probe

\[ Q = CV_{\text{SURFACE}} \]

\[ \left( \frac{Q}{A} \right) = \sigma_S = \left( \frac{C}{A} \right)V_{\text{SURFACE}} \]

\[ \sigma_S = \left( \frac{\varepsilon}{d} \right)V_{\text{SURFACE}} \]

permittivity \( \varepsilon \) material property
3. Measure Static - Voltmeter

V (Volts)
Range: ± 3,000 V
Response time: 50 μS

V (Volts)
Range: ± 3,000 V
Response time: 3 mS

Surface voltage are typically in the range ±200 V = ±0.2 KV.
Static Dissipators

A static dissipater is located to neutralize a charged web.

Ions generated by static dissipater

Static dissipater

Charged surface

Electric field

Static charge

Neutral surface

Web
Neutralization is complete after the motion of the ions stops.

Ions generated by static dissipater

Previously charged surface

Neutral surface

Static Dissipators
Static Dissipators

A static dissipater is located to neutralize a charged web.

Machine frame

Static dissipater

Ions generated by static dissipater

Neutral surface

Electric field

Web

Charged surface

Static charges
Neutralization is incomplete because the web is electrically insulating.

Ions generated by static dissipater

Machine frame

Static dissipater

Neutral surface

Electric field

Web

Charged surface

Static charges