AIMCAL R2R Conference USA 2018
Phoenix, AZ, October 28 - 31, 2018

Static Control for Metallized Webs

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Electrostatic Answers

ABSTRACT

Metallized films, foil laminates, and films with conductive traces present several static control challenges especially on web conveyance lines that run a job mix with some jobs using insulating, polymer webs and others using metallized webs. With volumes growing for printed electronics and high security products such as currencies, applications using insulating webs having conducting traces are becoming more common. Especially challenging are webs having internal or buried conductive layers. This presentation reviews several important static problems with metallized webs and explains why commercially available static dissipators are ineffective on webs having conductive layers. To prevent static problems, four best practices are described.

(1) Design products with continuous conductive layers (metalized webs) to have an exposed conductive edge or "safe edge" especially when solvent coating.
(2) For webs having conductive traces, design products to have "bus bars" along the edges.
(3) Mechanically guard static bars located below the web to prevent the web from touching the static bar should web tension be lost.
(4) Also discussed are "static splices" that should be used on metallized webs prior to lamination.

1. INTRODUCTION

Table 1.1: Static problems with webs having a conductive layer

1.	Static sparks ignite fires when splices pass through solvent coaters.
2.	Sparks ignite fires when a tension loss allows a metallized web to drape across the pins of an active static bar.
3.	Sparks at the slit edges of films with buried metallized layer ignited fires
4.	Cascading sparks occur between isolated metal traces running across the film.

Films with metallized layers or conductive traces are important because, metallized layers provide excellent barrier properties. Conductive traces on insulating films enable electronic functionality. Some high value products such as currencies and financial certificates contain metallized security ribbons. The static problems on films with conductive layers in Table 1 are challenging because static control devices are ineffective in dissipating static on films with metallized layers or conductive traces.

Historically, conductive layers have been designed into products to provide static protection. In 2004, the Academy of Motion Picture Arts and Sciences presented a Scientific and Engineering Award (Academy Plaque or "Technical" Oscar Award) to my former colleagues Kenneth L. Tingler, Charles C. Anderson, Diane E. Kestner, and Brian A. Schell of the Eastman Kodak Company for the successful development of process-surviving antistatic layers for motion picture films [1]. "Process-surviving" means that the conductive, antistatic layer is buried beneath an insulating, polymeric coating that protects the antistatic layer from photographic processing solutions. The antistatic layer successfully controls the static charges that otherwise accumulate on films during high-speed, motion picture printing operations. While the buried, conductive layers in motion picture films provide excellent static protection, in most other applications, films with metallized layers or conductive traces are prone to the static problems in Table 1.

Suppressing static sparks on webs with conductive layers is difficult because static dissipators such as powered static bars are ineffective. To understand why, let's review how static bars dissipate static on insulating, polymer webs.

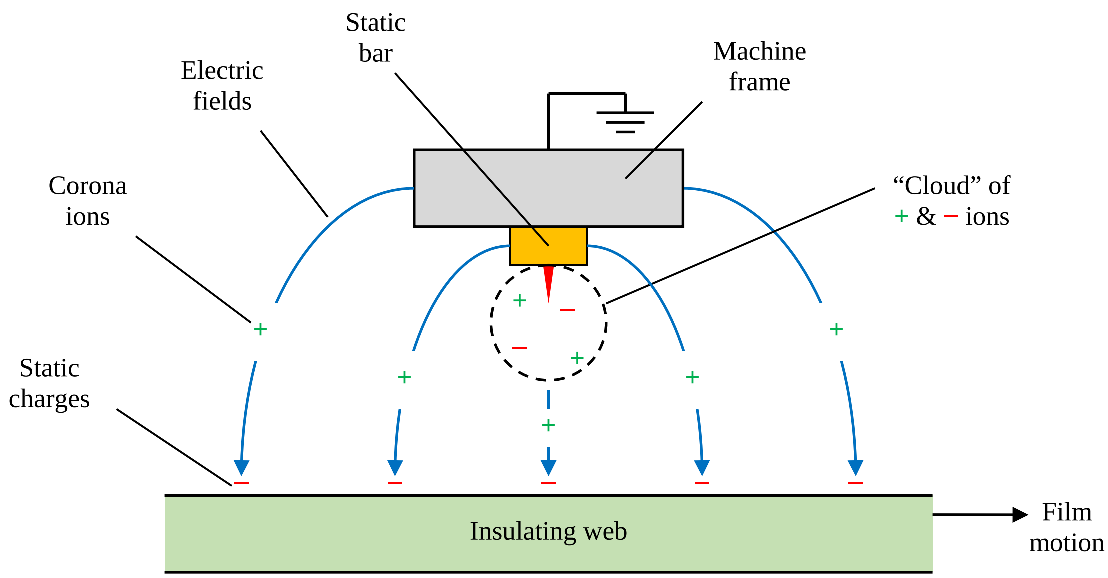

Figure 1.2: + ions flow along the electric field lines and deposit on the film to neutralize the – static.

The static bar in Figure 2 generates equal numbers of positive and negative ions near the tips of the pins. The electric field from the negative static on the web extends to the nearest, grounded object, which is the machine frame and the powered static bar. Positive ions from the static bar move along the electric field lines and deposit on the web neutralizing the negative charges. The negative ions generated by the static bar move either to the pins or to the grounded machine frame.

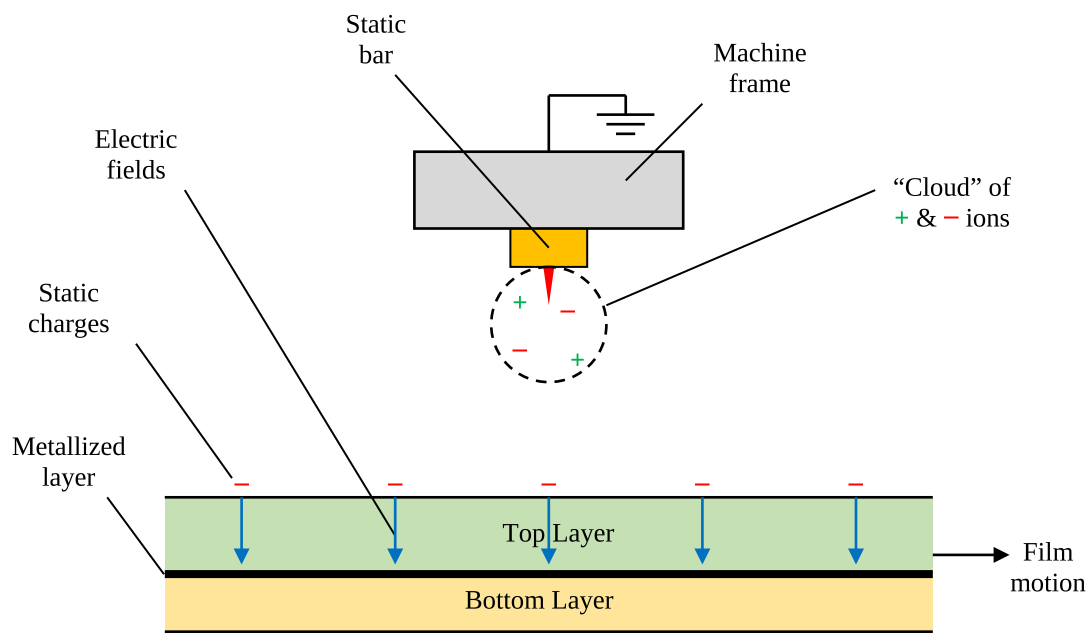

Figure 1.3: The electric fields from the static extend to the metallized layer rather than to the static bar.

Now let's look at the operation of the static bar in Figure 3 when the web has a metallized layer. The negative static on the film induces an electric field to the nearest conductor. For films with metallized layers, the nearest conductor is the metallized layer. No electric fields extend from the static on the film to the static bar. Even though the static bar generates positive and negative ions, these ions remain near the pins. The static charges on the film remain unchanged as the metallized film passes beneath the static bar. The static bar cannot “see” the static on the film because the pins are farther from the static than the metallized layer.

2. BEST PRACTICE STATIC CONTROL

Table 2.1: Static Control for Webs with Conductive Layers or Traces

1. Exposed or Buried?	Exposed			Buried (laminated)		
2. Continuous or Patterned	Continuous		Patterned	Continuous		Patterned
3. Edge-to-Edge or Center only	E-to-E	Center		E-to-E	Center	
	Grounded by idler rollers	Grounded by idler Rollers Static dissipators needed for insulating edges	Grounded by idler rollers May need static dissipators for insulating areas	Use Safe Edges	Use Safe Edges Static dissipators needed for insulating edges	Ground with traces to Safe Edges May need static dissipators for insulating areas

Static control for webs with conductive layers summarized in Table 2.1 depends on 3 key parameters.

1. Is the conductive layer exposed or buried?
2. Is the conductive layer continuous or patterned (traces)?
3. Does the conductive layer extend edge-to-edge or center only (having insulating edges)?

2.1 <u>Exposed Conductive Layer</u>

Exposed conductive layers are grounded by touching metal idler rollers. If the conductive layer or coating is continuous and extends across the web edge to edge, static is well controlled by having the conductive layer touch metal idler rollers. No additional effort is required to control static.

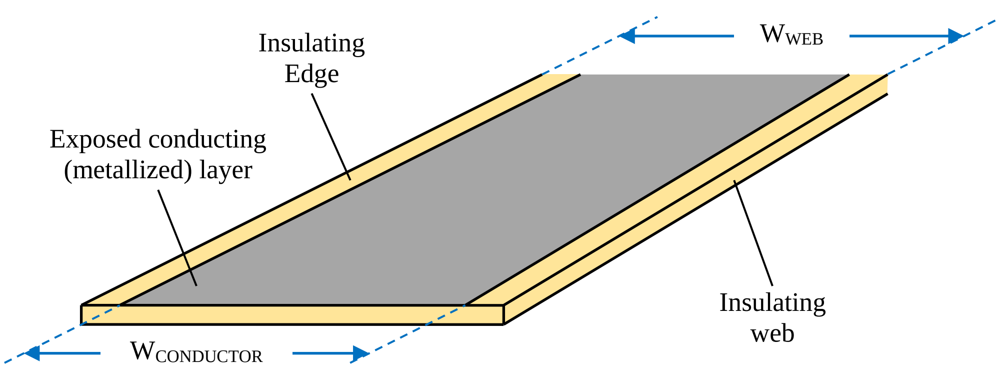

Figure 2.2: Insulating area near the edges can accumulate static.

When the web width W_{WEB} is bigger than the width of the conducting layer $W_{CONDUCTOR}$, the insulating edges in Figure 2.2 can accumulate static. If the insulating areas are wider than ~ 0.25 inches (5 mm), static problems can occur. Static dissipators should be used to neutralize static on the insulating areas of the web. Install the static dissipators as if the web were entirely insulating [2].

2.2 Buried Conductive Layer

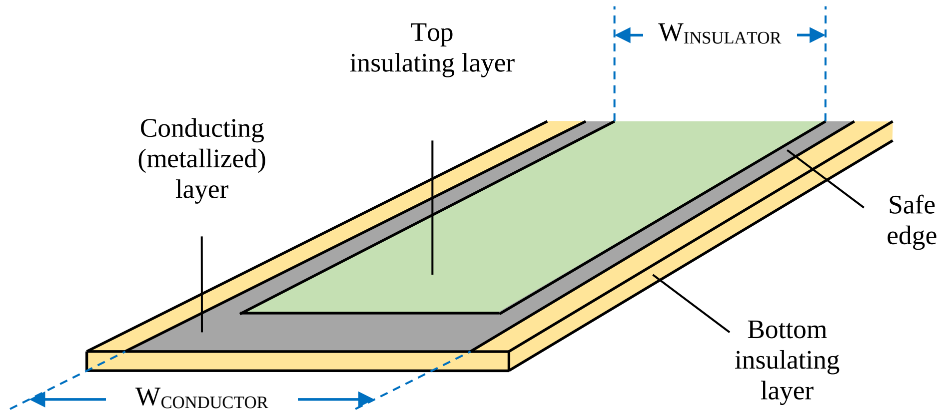

Figure 2.3: The total Safe Edge width $W_{CONDUCTOR}$ - $W_{LAMINATE}$ should exceed 10 mm.

When the conductive coating is buried beneath an insulating layer perhaps by lamination or by overcoating with an insulator, static charges trapped in the buried conductive layer can cause problems. The best practice is to design the product with "safe edges" [3] where the width of the conducting layer $W_{CONDUCTOR}$ in Figure 2.3 is larger than the width of the insulating layer $W_{INSULATOR}$ by at least 10 mm. The buried conducting layer is grounded when the exposed conducting "safe edges" touch grounded metal idler rollers. The safe edges are needed only for static sensitive operations where sparks would pose risks such as solvent coating operations. Once the web exits all sensitive operations, the safe edges may be trimmed.

Designing products with safe edges adds some "structural waste" to the value stream. However, safe edges are needed because they suppress static sparks.

2.3 Conductive Traces

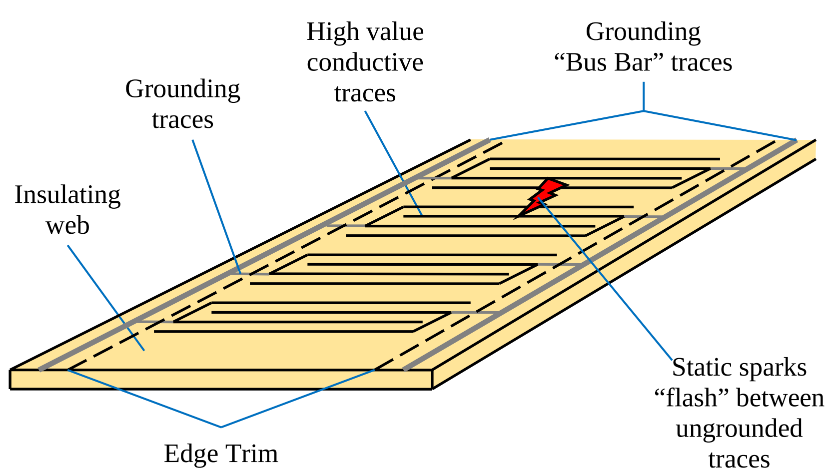

Figure 2.4: Conductive traces are connected to "grounding traces" that are later trimmed.

Static sparks can flash between isolated conductive traces. These sparks can be quite energetic because large amounts of static charges in the areas adjacent to the conductive trace participate in the spark. I have observed these energetic sparks flash on web spans exiting idler rollers.

The best practice is to design the pattern with the conductive traces connected to "bus bars" along the edges. With the traces connected to a common conductor, the traces are all at the same electrical potential, which suppresses sparks. And, the "bus bars" run along the machine direction so they will be in constant contact with idler rollers. Touching the idler rollers grounds the "bus bars." The "bus bars" may be trimmed once the web has exited the last, static sensitive process.

2.4 Mechanically Guard Powered Static Bars

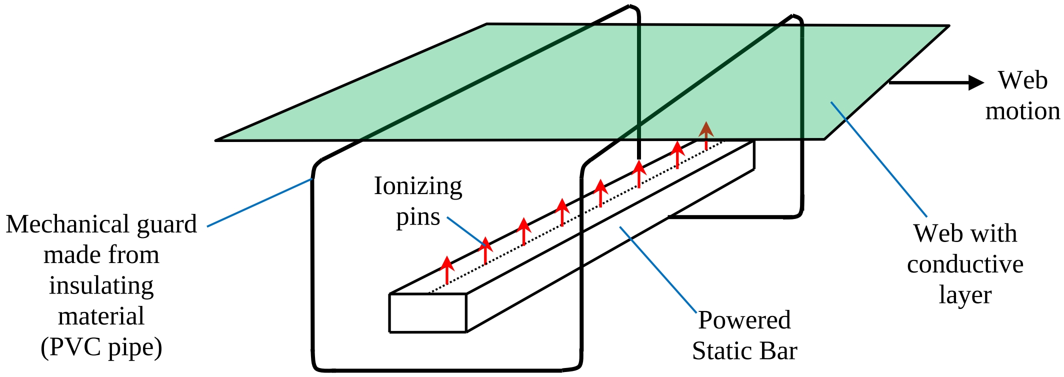

Figure 2.5: When web tension is lost, the mechanical guard prevents the web from touching the ionizing pins.

When web tension is lost from a web break or other failure, the web may drape across a powered static bar. Should the web have a conductive layer (metalized web), the conductive layer may touch most or all of the pins. While static bars are design to prevent sparks when a pin is shorted to ground, static fires have been ignited when many of the pins are simultaneously shorted.

The best practice is to mechanically guard all static bars below the web in Figure 2.5 so that the web drapes across the guard and does not touch the static bar. The mechanical guard should be made from an insulating material such as a PVC pipe.

3. STATIC SPLICES

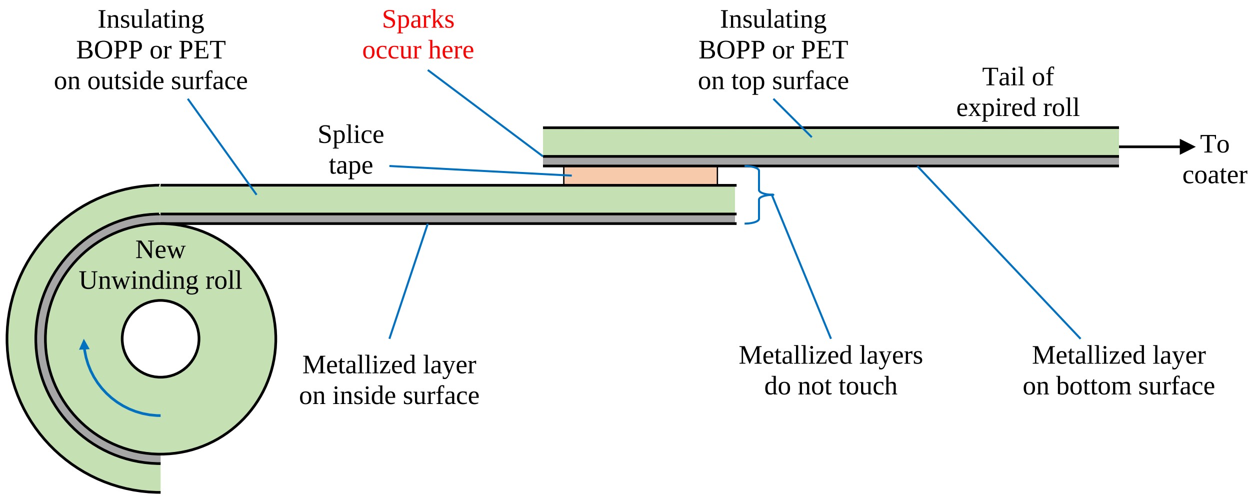

Figure 3.1: Sparks can occur when splices pass over rollers because the metal layers do not touch.

The splice on metallized web in Figure 3.1 can cause a spark when the splice passes over an idler roller because the metallized layer in the tail of the expired roll does not touch the metallized layer in the new roll. Such sparks have ignited fires in solvent coaters.

The conductive layers must be grounded to suppress sparks. When metallized layers are exposed, touching metal idler rollers grounds the conductive layers. Problems occur when the metalized layer is covered by a laminated layer. As mentioned in Section 2.2, designing products to have “Safe Edges” [3] is the best, most reliable way to suppress sparks.

In operations where a metallized film is laminated and subsequently coated or printed, we can use “Static Splices” to suppress sparks when splices pass over conductive rollers [4]. When the metallized layer in Figure 3.1 is to be covered by an insulating layer wider than the metallized layer, the metallized layer is fully encapsulated. Once the splice passes over the last metal idler that touches the metallized layer prior to coating, the metallized layer in the expired roll becomes ungrounded and it is prone to static sparking.

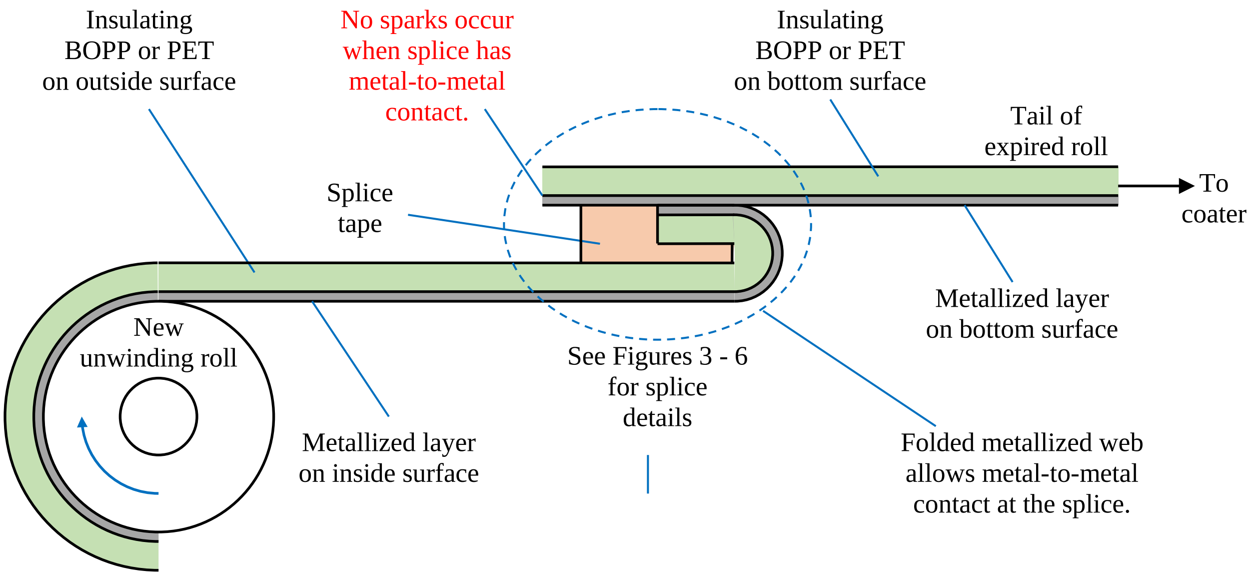

Figure 3.2: Fold the metallized web so that the Static Splice has metal-to-metal contact

The leading edge of the web on the new roll is folded to make the “Static Splice” in Figure 3.2 that allows metal-to-metal contact. The challenge is to make this spice strong and so that it allows metal-to-metal contact.

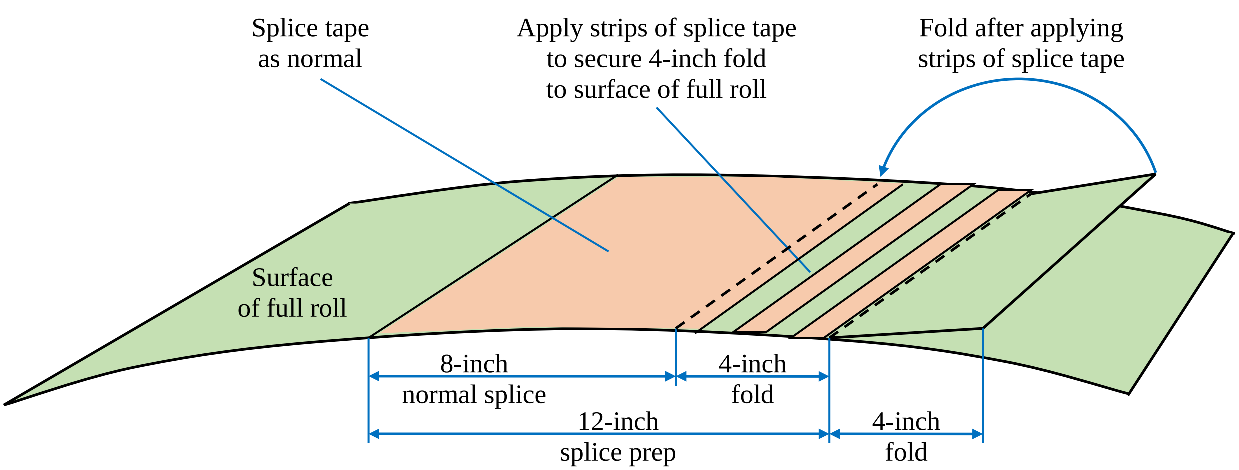

Figure 3.3: Space the strips of spice tape securing the folded metallized web apart by 1 tape width plus ~1/4 inch.

To prepare the 12-inch Static Splice in Figure 3.3, apply splice tape as usual to the 8-inch splice. Extend the splice tape about a half tape width into the 4-inch fold area. Next, apply two more strips of splice tape that will secure the folded web. The first on the leading edge of the 4-inch fold area. The second strip is half way between the leading strip and the large, 8-inch splice area. The gaps on either side of the second strip should be about a tape width plus ¼ inch.

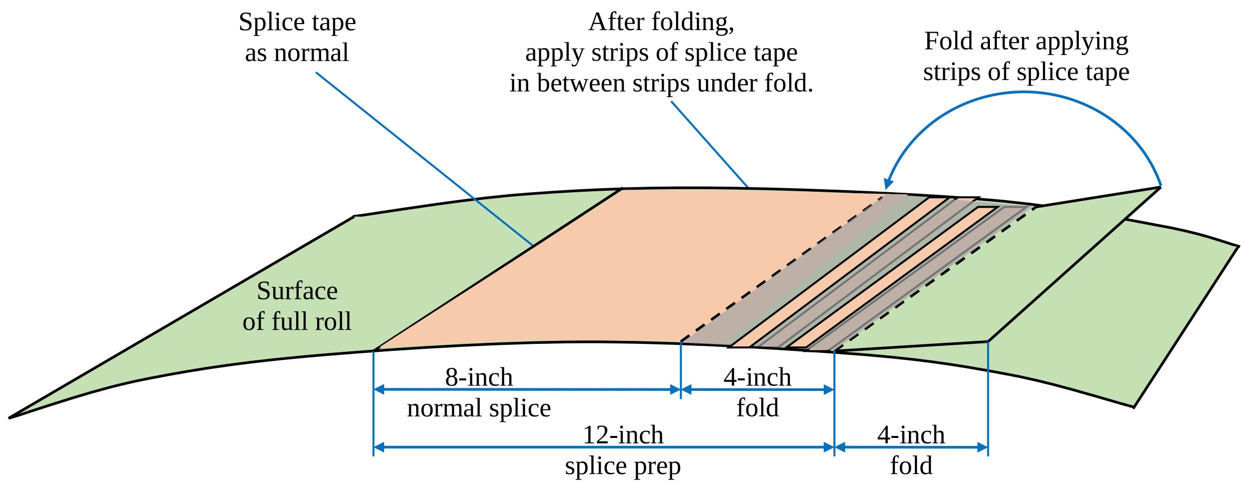

Figure 3.4: Apply strips of spice tape onto the metallized web between the strips below the folded web

Fold the 4-inch section of the leading edge of the web of the new roll in Figure 3.4 onto the strips of splice tape. The splice tape should secure the folded web.

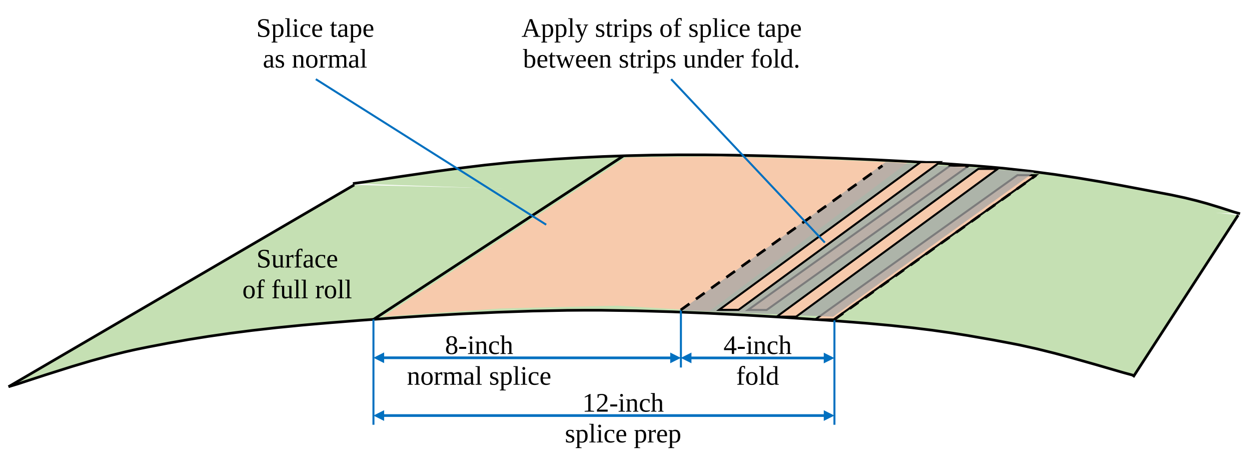

Figure 3.5: The metallized layer is exposed allowing metal-to-metal contact in a Static Splice.

Finish the Static Splice in Figure 3.5 by applying two more strips of splice tap on top of the folded web that exposes the metallized layer. Apply the two additional strips of splice tape we in the gaps between the strips under the web.

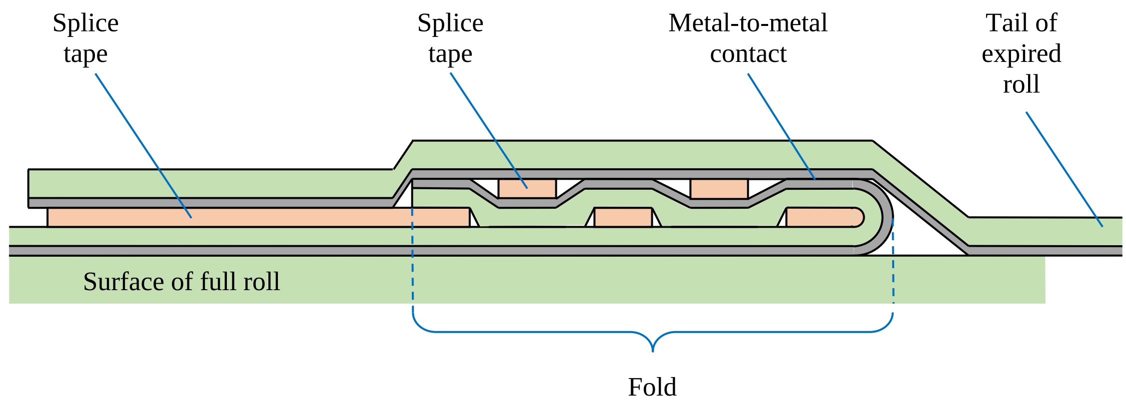

Figure 3.6: The metallized layer is exposed allowing metal-to-metal contact in a Static Splice.

The cross section of the Static Splice in Figure 3.6 shows metal-to-metal contact between the tail of the expired web and the leading edge of the new web is achieved by folding the leading edge of the web on the new roll. The metal-to-metal contact suppresses sparks as the Static Splice passes over metal rollers.

Metallized layers have many benefits including providing excellent barrier properties. Conducting traces on films enable electronic functionality and valuable security features. Using Static Splices ensures that sparks are suppressed as the splice passes through solvent coaters.

4. SUMMARY

Films with metallized layers or conductive traces are important because, metallized layers provide excellent barrier properties. Conductive traces on insulating films enable electronic functionality. Some high value products such as currencies and financial certificates contain metallized security ribbons. The static problems on films with conductive layers are challenging because static control devices are ineffective in dissipating static on films with metallized layers or conductive traces.

When the conductive layer is exposed, touching grounded, metal idler rollers prevents most static problems. If the conductive layer covers only a portion of the web, the insulating areas can accumulate enough static to cause problems. Use static dissipators to neutralize static on the insulating parts of the web. Mechanically guard static bars located below the web so that the web cannot touch the static bar if web tension is lost.

If the conductive layer is buried beneath an insulating layer perhaps by lamination or over-coating with an insulating layer, design the product so that the conductive layer is wider than the insulating layer leaving exposed, metal “safe edges” that can ground the conductive layer by touching metal idler rollers. Similarly, ground conductive traces to “bus bars” along the edges of the web.

Use “static splices” in operations where a conductive layer is fully encapsulated by lamination or by over-coating. With a “static splice,” the conductive layer on the expired roll touches the conductive layer in the new roll.

5. REFERENCES

[1] The 76th Scientific & Technical Awards 2003 | 2004, “To Kenneth L. Tingler, Charles C. Anderson, Diane E. Kestner, and Brian A. Schell of the Eastman Kodak Company, for the successful development of a process-surviving antistatic layer technology for motion picture film,” http://www.oscars.org/sci-tech/ceremonies/2004, 2/14/2004.

[2] K. Robinson, “Static Beat | Static Dissipator Locations,” http://www.pffc-online.com/static-beat/12384-static-beat-static-dissipator-locations, 9/18/2014.

[3] K. Robinson, “Static Beat | Static Control for Films with Conductive Layers,” http://www.pffc-online.com/surface-prep/15021-static-beat-static-control-for-films-with-conductive-layers, 2/27/2018.

[4] K. Robinson, “Static Beat | Use Static Splices with Metallized Films,” http://www.pffc-online.com/static-beat/15211-static-beat-use-static-splices-with-metallized-films, 5/22/2018.