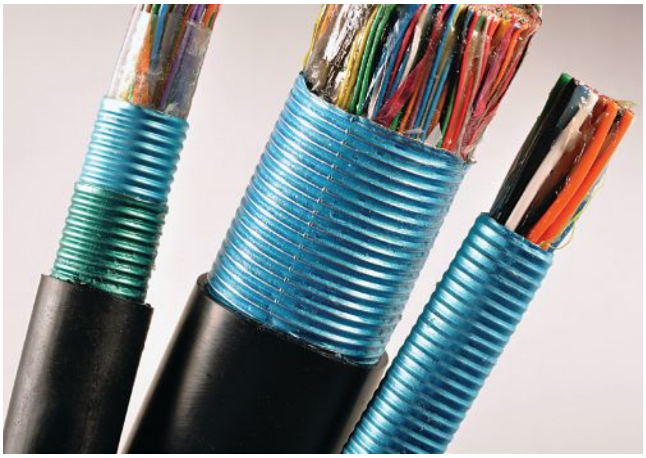
Effect of Jacket Bond Failure Mode on the Corrosion of Buried Telecom Cables

by:
Cheryl Craig, Mary Rolph & Jeff Zollinger
LLFlex
1225 West Burnett Avenue
Louisville, KY 40210 USA
www.llflex.com

Considering shielding-to-jacket failure mode during design helps protect the ECCS steel in plastic-coated metal shielding tapes against future corrosion and cable failure.

For decades, plastic-coated metal shielding tapes have been used in communication cables as barriers from moisture and chemicals as well as protection from rodents, lightning, corrosion and physical damage.

Utilizing sealed overlaps, shielding tapes greatly reduce the likelihood of moisture penetration into the core. Their bonding to the cable jacket during extrusion provides improved strength and mechanical integrity. Undoubtedly, plastic-coated metal shielding tapes increase the lifespans of modern cables across a wide variety of applications.



Yet all plastic-coated metal shielding tapes are not equal. Flaws in design can promote corrosion and possible failure under certain use and environmental conditions.

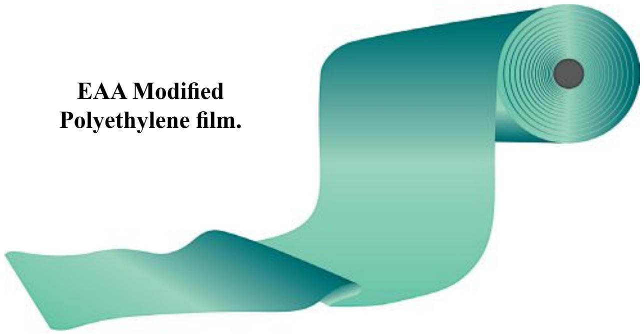
This article explains how enhanced film design can protect cables even more comprehensively.

Evolution of Plastic-Coated Metal Shielding Tapes

Before we look at optimizing shielding design, let's first explore the evolution of shielding tapes and their generally accepted structure.

For over 30 years, buried cables for filled telephone cables were required to meet *ASTM B736*, which specifies a 0.15 mm (0.006") electrolytic chromium-coated steel (ECCS) shield for protection. ECCS is a single, reduced tin mill plated steel with chromium and chromium oxide—a grade that has been specified and required for copper conductor and fiber optic cables by industry experts. This specification was designed to assist in preventing corrosion, protect against rodents and resist lightning strikes, among other useful applications.

Since maintaining the integrity of armored steel cable shielding throughout the lifespan of buried cables is essential,

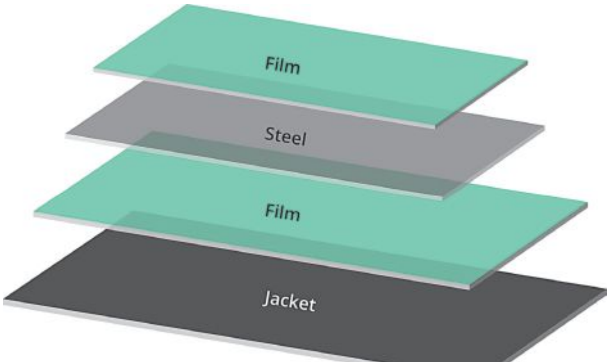


EAA Modified Polyethylene film.

the ECCS shield is laminated with film to further protect the steel. Copolymer ethylene and acrylic acid (EAA) film is used to protect the ECCS steel from moisture and chemical attack. The film not only protects the steel, but when sealed at the shielding overlap, prevents moisture penetration into the cable's core. The subsequent shield-to-jacket bond during the jacketing extrusion process creates a rigid sheath for added mechanical protection and prevents moisture ingress between the shielding and jacket. Considering this, cable wrap film must adhere to both ECCS steel and cable jacketing.

However, since access to the cable's core is occasionally needed, the strongest bond may not always be the most advisable. During installation or repairs, installers prefer bonds that permit access to the core without excessive manipulation to strip the jacket from the shielding. This need for accessibility led to the introduction of a product called controlled jacket bond (CJB), which entered the market in the last decade. This controlled level of bond strength between the shielding and the jacketing material provides bonds strong enough to provide cable protection, yet giving enough to allow installers easy access to the inside of the cable.

Once the jacketing has been removed, the exposed ECCS steel obviously brings potential for corrosion from damaged



Schematic of typical structure.

shielding, particularly as an initiation point for moisture and chemicals. For cables with CJB shielding, the design of the film now becomes a critical factor. Superior film designs allow the film to split or "fail", leaving a layer of film to remain on the steel for protection and a layer of film to remain on the removed jacketing material. This places a premium on the precise mode of failure of the shielding-to-jacket bond. This interlayer film failure, caused by the multilayer film design, creates the superiority of the CJB film.

Identifying the Modes of Failure

When peeled bonds of shielding-to-jacketing material are analyzed, the following modes of failure are possible: Jacket Failure, Metal Failure, Cohesive Film Failure and Interlayer Film Failure.

- Jacket Failure occurs when the film delaminates from the jacket and remains bonded to the metal.
- Metal Failure occurs when the film delaminates from the metal and remains bonded to the jacket.
- Cohesive Film Failure occurs when the film tears and leaves a portion bonded to both the metal and the jacket.
- Interlayer Film Failure occurs when the film layers separate, leaving one layer bonded to the metal and one layer bonded to the jacket.

Effects of Failure Mode on Cable Performance

If the mode of failure between shielding and jacketing material is a Jacket Failure, the film separates from the jacket and the ECCS steel remains protected. Conversely, if the mode of failure is Metal Failure and the film separates from the metal, the ECCS steel is exposed and may then be subjected to adverse environmental conditions.

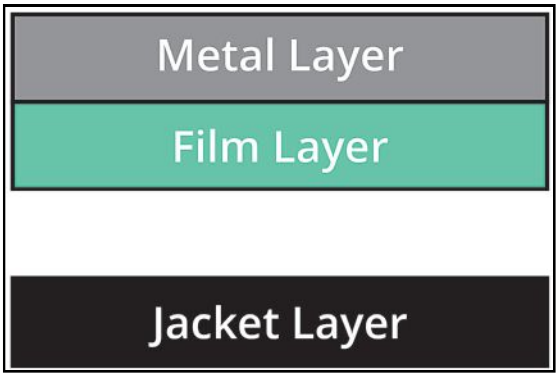
The result can be the same if the failure mode is Cohesive Film Failure, in which portions of the ECCS steel become exposed. Like Jacket Failure, Interlayer Film Failure also is seen as less critical since the ECCS steel remains protected by the film.

Commercial Product Comparisons

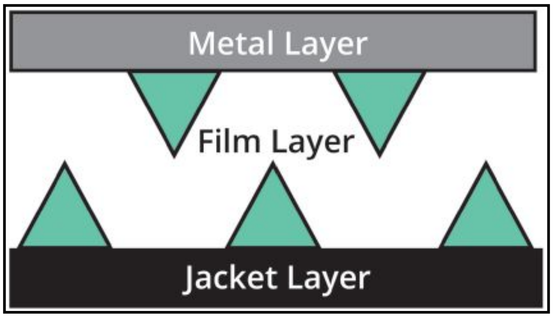
Samples of four different ECCS shielding tapes currently available in the marketplace were collected and analyzed to determine the shielding and jacket failure mode, and the effect on corrosion resistance. Each sample was sealed to polyethylene jacket material and peeled to evaluate the failure mode. Results indicate that most shielding and jacket failure modes are Cohesive or Metal Failure, with the exception of the LLFlex sample, which exhibits the intentional Interlayer Film Failure[1], due to the multilayer design, as shown in Appendix A.

In order to evaluate the susceptibility of shielding to environmental conditions and chemical exposure after removal of the jacketing material, as shown in Appendix C, samples of each were immersed in water and various 0.1 Normal solutions for 20 days and rated from 0 to 10 based on the amount of surface attack on the bare metals.[1] The rating system is shown in Appendix B on the next page.

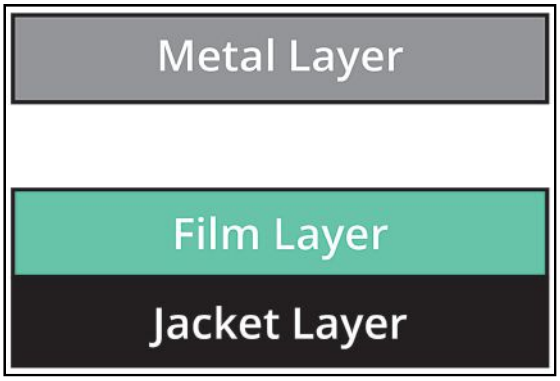
Continued...



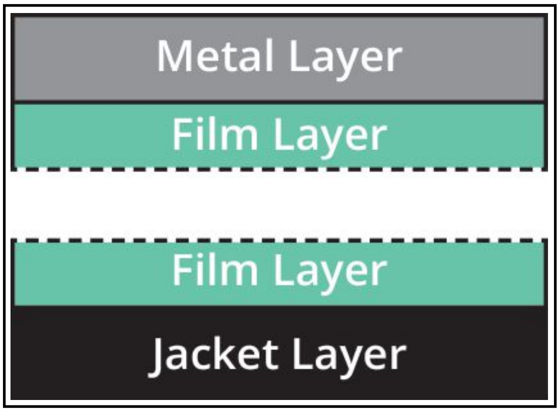
Jacket failure layers.



Cohesive film failure layers.



Metal failure layers.



Interlayer film failure layers.

The results shown above and in Appendices D and E confirm that shielding with bare ECCS exposed is significantly more prone to corrosion than shielding designed with multilayers that exhibits intentional Interlayer Film Failure, like the LLFlex samples.

Summary

While special materials and procedures exist to help ensure that at-risk, exposed shielding is protected during installation, service, repair and other potentially damaging activities, it is clear that consideration of the shielding-to-jacket failure mode during design is critical. Failing to protect the ECCS steel in plastic-coated metal shielding tapes can result in future corrosion, and under certain conditions, cable failure.

www.llflex.com

References:

[1] *Corrosion Performance of Cable Armoring Materials In Direct Burial Applications", Kenneth E. Bow.*

[2] *ASTM Standard D1654, 2008 (2016), "Evaluation of Painted or Coated Specimens Subjected to Corrosive Elements," ASTM International, West Conshohocken, PA, 2008, DOI: 10.1520/D1654-08R16E01, www.astm.org.*

Continued...

APPENDICES

Appendix A

Modes of Failure

Figure 4 - LLFlex Sample Exhibiting Interlayer Failure

Figure 5 - Sample A Exhibiting Metal Failure

Figure 6 - Sample B Exhibiting Cohesive Failure

Figure 7 - Sample C Exhibiting Metal Failure

Appendix B

Rating of Corrosion for Coated Samples

Table 2 - Rating of Undercutting for Coated samples per ASTM D-1654

Average Measurement From Edge (mm)	Rating by Number	Area Corroded (%)
0.0	10	0
0.4	9	0 to 1
0.8	8	2 to 3
1.6	7	4 to 6
3.2	6	7 to 10
4.8	5	11 to 20
6.4	4	21 to 30
9.5	3	31 to 40
12.7	2	41 to 55
15.9	1	56 to 75
25 or More	0	Over 75

Appendix C

Coated Samples Prior to Immersion

Figure 8 - LLFlex Sample Prior to Immersion

Figure 9 - Sample A Prior to Immersion

Figure 10 - Sample B Prior to Immersion

Figure 11 - Sample C Prior to Immersion

Continued...

Appendix D

Coated Samples after Immersion in Water and Various 0.1 Normal Solutions

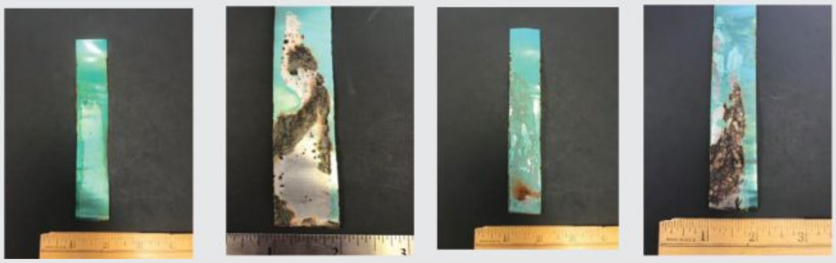


Figure 12 - LLFlex, Sample A, Sample B, and Sample C after Water Immersion

Figure 13 - LLFlex, Sample A, Sample B, and Sample C After Immersion in Acetic Acid

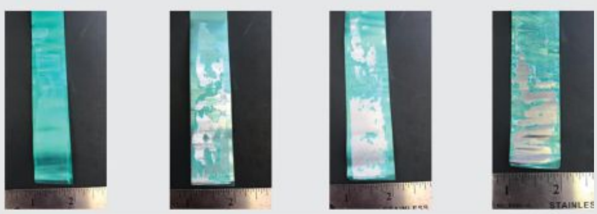


Figure 14 - LLFlex, Sample A, Sample B, and Sample C After Immersion in Ammonia

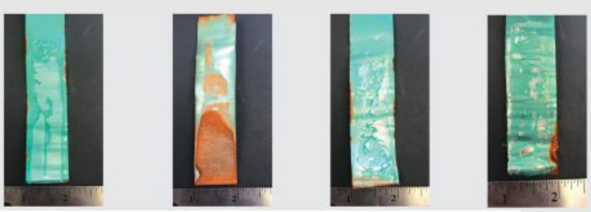


Figure 15 - LLFlex, Sample A, Sample B, and Sample C After Immersion in Sodium Chloride

Figure 16 - LLFlex, Sample A, Sample B, and Sample C After Immersion in Sodium Hydroxide

Appendix E

Chemical Results

Table 3 - Corrosion Resistance After 20 Days Immersion in Water and Various 0.1 Normal Solutions with Sample Averages

	LLFlex	A	B	C
H_2O	10	6	4	1
CH_3COOH	10	1	3	1
NH_4OH	10	8	8	8
NaCl	9	1	8	5
NaOH	10	10	10	10
Average	9.8	5.2	6.6	5

*Rating Scale per ASTM D-1654 in Appendix B

Table 4 - Corrosion Resistance After 20 Days Immersion in Water and Various 0.1 Normal Solutions with Chemical Averages

	H_2O	CH_3COOH	NH_4OH	NaCl	NaOH
LLFlex	10	10	10	9	10
A	6	1	8	1	10
B	4	3	8	8	10
C	1	1	8	5	10
Average	5.25	3.75	8.5	5.75	10

*Rating Scale per ASTM D-1654 in Appendix B

Company Profile:

*For 30 years, **LLFlex** has led the industry with high-quality armoring and shielding tapes. Its mono layer film formulations use the same uniform, high-quality resins across 100% of the structure for consistent, reliable long-term performance. LLFlex is a pioneer in the development of wire & cable products, offering a robust global supply chain, excellent quality and manufacturing, in addition to collaborative product development. **www.llflex.com***

Author Profiles:

***Cheryl Craig** is Business Segment Director of Industrial Laminates at **LLFlex**. She has years of industry experience and has contributed to patents for the wire and cable industry. She holds a bachelor's degree in business from the **University of Louisville**.*

***Mary Rolph** is employed as a Special Projects Engineer with LLFlex. In this special projects role, she works to develop and engineer design solutions for cable shielding products. She holds a bachelor's degree in chemical engineering from the University of Louisville.*

***Jeff Zollinger** maintains the position of Technical Director at LLFlex in Louisville, KY, USA. His work primarily involves the engineering and development of new materials and products designed for industrial markets. He holds a bachelor's degree in materials science engineering from the **University of Kentucky**.*