Polymeric Mesh Backed Coatings: Interaction with Cathodic Protection

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Abstract:

The primary function of pipeline coatings is to insulate the steel surface physically and electrically from the environment. In other words, the coating must “shield” the steel from the electrolyte and thus from the cathodic protection. On the other hand, published regulatory and industry documents (NACE, ISO and others) are stating that the coating should not prevent cathodic protection current from its intended path. In other words, the coating should not “shield” the cathodic protection.

The presentation is clarifying the often misunderstood and misrepresented following topics: Cathodic protection interaction with coatings and cathodic protection “shielding or non-shielding”. It explains how the field applied Mesh Backed Coating system interferes at best with Cathodic Protection, supported by laboratory testing recently conducted in Europe.

Contents:

1. Pipeline Coating: Definition and basic properties such as Electrical Insulation and Mechanical Protection.
2. Cathodic Protection Shielding: Clarification and consequences.
3. NACE Task Group 523 clarifies Cathodic Protection Shielding.
4. Polymeric Mesh Backed Coating combines Electrical Insulation and Mechanical Protection with Non-Shielding Cathodic Protection.
1 Pipeline Coating: Definition and basic properties such as Electrical Insulation and Mechanical Protection.

It is not easy to find valid definitions of Pipeline Coating. Most of the coating engineers have their own perspective and vision. The following reputable and well-known Standards give a clear and precise definition on this subject:

ISO15589-1: Cathodic Protection of pipelines systems – On-land pipelines. Chapter 7.5 (Coating):
The coating provides the primary prevention against corrosion. It reduces protection current demand, improves current distribution, extends the protected area, and reduces interference to other foreign structures.

NACE SP0169: Control of External Corrosion on Underground or Submerged Metallic Piping Systems. Chapter 5.1.1
The function of external coatings is to control corrosion by isolating the external surface of the underground or submerged piping from the environment, to reduce CP current requirements, and to improve current distribution

These standards show that the primary functions of Pipeline Coatings are to insulate Physically (from Mechanical damage) and Electrically the steel pipe from the environment (electrolyte). In other words, one of the major primary functions of the coating is to shield the environment and the Cathodic Protection current.

Electrical Insulation is measurable with specific requirements from some field applied coatings standards under the name of “Specific Electrical Insulation Resistance”

- **EN12068 (Tapes & HSS)**: \( R_{S100} \geq 10^8 \ \Omega \cdot m^2 \) & \( R_{S100}/R_{S70} \geq 0,8 \)
- **EN10290 (PU) & EN10289 (Epoxy):**
  - \( R_{S100} \geq 10^7 \ \Omega \cdot m^2 \) (\( \geq 1500\mu m \)) & \( R_{S100}/R_{S70} \geq 0,8 \)
  - \( R_{S300} \geq 10^4 \ \Omega \cdot m^2 \) (\( \geq 1500\mu m \)) @ \( T_{max} \)
- **ISO21809-3:**
  - Hot Applied bituminous tape: \( R_{S100} \geq 10^6 \ \Omega \cdot m^2 \) & \( R_{S100}/R_{S70} \geq 0,8 \)
  - Petrolatum tape: \( R_{S100} \geq 10^6 \ \Omega \cdot m^2 \) & \( R_{S100}/R_{S70} \geq 0,8 \)
  - Viscoelastic: \( R_{S100} \geq 10^6 \ \Omega \cdot m^2 \) & \( R_{S100}/R_{S70} \geq 0,8 \)
  - Elastomeric coating: Electrical volume resistivity (for information)
  - Liquid coatings: \( R_{S100} \geq 10^6 \ \Omega \cdot m^2 \) & \( R_{S100}/R_{S70} \geq 0,8 \)

Specific Electrical Insulation Resistance is measured during a period of 100 days and can fluctuate between \( 10^4 \ \Omega \cdot m^2 \) and \( 10^8 \ \Omega \cdot m^2 \), in function of the coating material. This resistance typically decreases with time; maximum acceptable decrease is 20% between 100 test days and 70 test days.

Mechanical Insulation is defined and measurable in many factory and field applied coatings standards through specific properties like “Impact, Indentation, Lap Shear, Abrasion and Soil Stress Resistance.”
In addition to these basic properties; the mechanical protection should not shield Cathodic Protection current as clearly stated in different well-known relevant standards:

**ISO13623: 2017: Petroleum and natural gas industries — Pipeline transportation systems (Chapter 10.6.3)**
*Any bedding material or mechanical protection shall not act as a shield to the passage of the cathodic-protection current to the pipe surface*

**NACE SP0169: Control of External Corrosion on Underground or Submerged Metallic Piping Systems. Chapter 5.1.3.1**
*Mechanical damage protection such as rock shield, abrasive resistance overcoatings, etc, maybe installed if required by owner specifications, and should be designed to eliminate or minimize damage to the pipe and its coating without inhibiting or interfering with CP requirements (see Electrical shielding in section 2)*

In conclusion, there are some contradictory texts which lead to a misunderstanding in the pipeline industry between shielding and non-shielding coatings.

**2 Cathodic Protection Shielding: Clarification and consequences.**

If the pipeline coating fails (disbonds for example); water can penetrate under the coating with time (short or long time in function of the coating) which creates an electrolyte between disbonded coating and the steel. Because the coating is an electrical insulator, cathodic protection can’t reach the steel under the coating. As a result, crevice corrosion (corrosion in closed environment) and Stress Corrosion Cracking occur.
Some Examples

Below, you can find some examples which show the serious consequences of Cathodic Protection Shielding:

Pitting corrosions under PE tape (left) and PE heat Shrinkable sleeve (right) occur with the “Crevice Corrosion” phenomena.

*May 2009 - Florida: Rupture 18-inch pipeline:*
Section of pipe jumped out of the soil after explosion due to Cathodic Protection Shielding under disbonded PE tapes.

SCC (Stress Corrosion Cracking) occurred with mechanically failed coating in the absence of adequate cathodic protection (Shielding).

3 **NACE Task Group 523 clarifies Cathodic Protection Shielding.**

NACE Task Group 523, found in 2015, clarified the definition of cathodic shielding for international Pipelines Cathodic Protection and Coatings experts:

The Task Group concluded:

*The main “shielding” issue is not whether the stand-alone coating is electrically insulating, it is whether the coating has a tendency to disbond (to fail) in such a way that polarization of the exposed steel surface is not possible*

The Task Group studied 18 Coating Types such as FBE, Liquids coatings, Tapes, Wax systems, heat shrinkable sleeves, 2-3LPE.

In total, 21 Failure Modes have been identified like Wrinkling, Blisters, Penetration, Disbondment, Cathodic Disbondment.

The NACE Task Group 523 studied for each coating type and failure mode the tendency to result in Cathodic Protection shielding:

Examples:
- Wrinkling = High
- Disbondment = High
- Blisters = Medium
- Penetration = Low
The Group concluded that the failure mode is the most important factor which influences shielding behavior.

Surface preparation is critical for some coating systems:
Left: PE tapes do not adhere on poor surface preparation.
Right: Liquid Coatings are sensitive to salt contamination.

Left: Heat Shrinkable Sleeve Application is particularly critical at the 6 o'clock position.
Right: Poor soil stress resistance for PE tape.
The most vulnerable coatings to Cathodic Protection shielding issues are, by far, field applied. This statement is also reported in the relevant standards:

**ISO15589-1 Cathodic Protection of pipelines systems – On-land pipelines**

**Chapter 7.5.1:**
Field joints and fittings coated on site are applied under more demanding conditions and can be a weak point in the general corrosion protection system if not selected and applied correctly.

**ISO15589-1: Cathodic Protection of pipelines systems – On-land pipelines. Chapter 7.5.6:**
Disbondment can cause cathodic protection current shielding by preventing access of the cathodic current to the steel surface … Non-bonded polyethylene wraps should be avoided as they cause shielding of the cathodic protection current and can be detrimental to the protection.

**PHMSA (Pipeline and Hazardous Material Safety Administration) 2010:** Some examples of shielding coatings are polyethylene, tapes, shrink sleeves, coal tar mastics, asphalts, etc...

It should be noted that as PHMSA regulates 2.730.000 miles (+/- 4.370.000 km) of Gas and Hazardous liquids Pipelines in the USA, no doubt they have a lot of experience.

**4 Polymeric Mesh Backed Coating combines Electrical Insulation and Mechanical Protection with Non-Shielding Cathodic Protection**

Developed in the 80’s in North America, field applied Polymeric Mesh Backed Coating has been specifically designed to insure the fundamental basic properties listed above:

- A. Mechanical Resistance.
- B. Electrical Insulation.
- C. Interaction with Cathodic Protection: Secures cathodic protection current from its intended path if the coating fails.

**A. Mechanical Resistance:**

Polymeric Mesh Backed Coating meets all the requirements of relevant international and well-known standards. Any additional mechanical protection such as “Rock shield” can always reinforced the coating against mechanical stresses if it does not shield cathodic protection current.
Rock shield application in Spain to protect Polymeric Mesh Backed Coating from backfill stones.

B. Electrical Insulation:

Tested by Charter Coating in 2014 according to ISO21809-3 test method, Polymeric Mesh Backed Coating showed high electrical insulation resistance ($4.7 \times 10^8 \ \Omega \cdot m^2$); stable during the 100 test days.

![Specific Electrical Insulation Resistance](image)

Figure 1. The Plot of the Specific Electrical Insulation Resistance of the RD-6 Polymeric Tape Coating verse Time for Immersion in 0.1 mol/L NaCl Solution at 23±2°C
C. Interaction with Cathodic Protection: Secures cathodic protection current from its intended path if the coating fails

In the overlap area, the Mesh Backing allows Cathodic Protection current to reach the steel under disbonded coating.

This feature was firstly tested in the USA, it has been recently tested in Europe:

French Cathodic Protection Expert for Pipelines “INGECA” tested it between October 2015 and January 2016:

Steel coupons have been coated with intentionally disbonded Polymeric Mesh Backed Coating. Cathodic protection current was measured during a 3-month test period (Cfr Graph) and coupons were inspected after the test period which showed the following results:

- pH of 12
- No trace of corrosion.
French Gas Transmission Pipelines Operator “GRT gaz” tested this feature again between June 2017 and September 2018 (i.e. 15 months).

GRT gaz made a comparison of non-shielding properties between Polymeric Mesh Backed Coating and PE tape in different electrolytes.

The test was performed in parallel in the following 3 electrolytes:
- Sand + 20% tap water.
- Salt Water: tapwater + 18gr/L Salt (NaCl).
- Sweet Water: tap water.

In each electrolyte, 2 steel samples 300mm length were used. Each steel sample was installed in a PVC tube.

Two coating types were tested:
- Polymeric Mesh Backed coating: 50mm (2-inch) width applied with 25 mm (1-inch) overlap.
- PE Tapes coating: 50 mm (2-inch) width applied with 50% (1-inch in this case).

Cathodic Protection potential level was set at -1000mV (vs AgAgCl electrode). Off Potential (E Off) on non-coated 25cm² steel marker was monitored by NEUTEL Box.
The following Cathodic Protection currents were measured under disbonded coatings:

- Sand: 49 Ω.m, 30-60 μAmps (Pol. Mesh), 0 μAmps (PE T.)
- Sweet water: 18 Ω.m, 10-35 μAmps (Pol. Mesh), 0.2-0.6 μAmps (PE T.)
- Salt water: 0.38 Ω.m, 35-400 μAmps (Pol. Mesh), 10-85 μAmps (PE T.)

**Inspection after 15 months (Sand container):**

Polymeric Mesh Backed Coating: No Corrosion with pH >8.

**CONCLUSION:**

Polymeric Mesh Backed Coating shows ideal interaction with Cathodic Protection:

Although, this coating shows good Mechanical and Electrical Insulations; it does not shield Cathodic Protection Current only when the coating fails which protects the pipeline steel under all circumstances.