# Pipeline Coatings – An Integrity Question?

## Setting the Record Straight on Pipeline Protection

By Bob Buchanan and Scott Smith

Pipeline integrity is a hot topic these days, and there are obviously a number of factors that impact integrity. There are also a number of viewpoints, with some being louder than others, so it's often difficult to make the distinction between fact and fiction. As the famous physics professor Dr. Feynman once said, "For a successful technology, reality must take precedence over public relations, for Nature cannot be fooled."

One aspect of the above is "cathodic shielding" of pipeline coatings and some misconceptions being propagated regarding the use of high dielectric strength coatings in relationship to cathodic shielding, NACE Standards and U.S. Department of Transportation (DOT) regulations.

The purpose of this article is to set the record straight on how pipeline coatings and cathodic protection work together, and what the industry truly requires for pipeline corrosion protective coatings.

Coatings are passive systems providing primary corrosion protection while cathodic protection is an active system providing supplemental protection. An analogy is a firewall in a structure providing a barrier to fire (a passive system) teamed with a fire sprinkler providing suppression. If the electricity fails and the pumps won't work, the barrier still stands if it is designed properly.

The combination of coatings and cathodic protection (CP) is a good team toward protecting a pipeline against corrosion, but be careful when CP is designed such that failure of the coating is assumed, thus requiring the active component to be absolute for the corrosion protective system to perform. CP systems require maintenance and continuous power, along with proper distribution and levels of cathodic protection current. This is often a challenge, especially for remote pipelines.

A statement made by Alan Kehr is a fundamental in the pipeline corrosion protection industry. Kehr is a leading American expert on pipeline coatings and stated that external pipe coatings are "intended to form a continuous film of electrical insulating material over the metallic surface to be protected. The function of such a coating is to isolate the metal from direct contact with the electrolyte, interposing a high electrical resistance so that electrochemical reactions cannot occur."

There are industry standards that clearly define how coatings are intended to perform and what the role of CP is in the corrosion protection system. The bottom line is that coatings provide primary corrosion protection and CP provides supplementary corrosion protection.

*Coatings and Cathodic Protection Facts:*

- Industry standards stipulate that coatings are to provide primary corrosion protection.
- The standards are specific about what attributes are desirable in coatings.
- CP is used to protect against damage (holidays) in coatings.

If a pipeline corrosion protection design is considering CP as being active in the equation, then the life cycle cost can become prohibitive, but, more importantly, a failure in the CP system can result in catastrophic failure of the corrosion protection system.

In pipeline system design, the standard NACE SP0169 clearly states that coatings are the primary corrosion protective system and that cathodic protection is used as supplemental protection. Furthermore, the standard states that desirable attributes of a good coating are high electrical resistance and low moisture absorption. This is what Kehr referred to in his statement.

The standard also addresses coating adhesion and makes the comment that "unbonded coating could shield electrical current," thus making the case that coatings with good adhesion quality should be used.

By definition, shielding is caused by some external material that prevents current from getting to the steel. It is not the intent to bring highly electrically resistive and properly applied coatings into this list. Various materials can result in shielding. These can be plastic sheets with no adhesive, tree roots, rocks, soil, improper backfill or compaction, casings and any other high resistance materials.

Although disbonded coatings are often blamed, any dielectric barrier can have the same result. All materials have electrical resistance, thus no pipeline coatings can claim 100 percent effectiveness against shielding, nor can they be "non-shielding" under all conditions.

In comparing a high electrically resistive coating like polyethylene with some "fiber-backed coatings" that market themselves as non-shielding coatings, it is interesting to see how the coatings stack up against the requirements of SP0169.

| Property NACE SP0169 | Polyethylene-backed coatings | Fiber-backed coatings |
|---|---|---|
| Effective electrical insulator | Yes | Yes |
| Effective moisture barrier | Yes | No |
| Reduces CP current requirements | Yes | No |
| Improves current distribution | Yes | No |
| Damage resistant | Yes | Only with added protection |
| Good adhesion | Yes | Yes |

The U.S. DOT has regulations relating to pipelines. Code of Federal Regulations (CFR) 192 relates to natural or other gas pipelines and CFR 195 relates to hazardous liquids pipelines. Both make statements relative to corrosion protection and coatings.

Relative to these codes, it is clear that CFR 192 views attributes such as good adhesion, resistance to migration of moisture, low moisture absorption and high electrical resistance as stringent requirements. Likewise, CFR 195 views adhesion, moisture resistance and electrical resistance as principal to an effective anti-corrosion coating.

Summarizing the two codes' requirements vs. the various coating types, it is clear that a coating that is designed to absorb or wick water, such as fiber-backed tape-type coatings, lack in key areas such as migration of moisture and low moisture absorption.

Heat-shrinkable sleeves comply with the intent of NACE SP0169 relative to the use of electrically resistive coatings. They also meet the requirements of the DOT's CFR 192 (Section 192.461) and CFR 195 (Section 195.559) for external protective coatings.

Properly selected and applied heat-shrinkable sleeves provide the following requirements as outlined in these standards and codes:

- Sufficient adhesion to the metal surface to effectively resist under-film migration of moisture.
- Be sufficiently ductile to resist cracking.
- Have sufficient strength to resist damage due to handling and soil stress.
- Have properties compatible with supplemental cathodic protection.
- Have low moisture absorption and high electrical resistance.

Based on the above facts, the general pipeline industry does not believe that cathodic shielding due to disbondment of properly installed, high dielectric strength coatings is becoming an increasing problem as suggested by some coating manufacturers. Evidence of this position is supported by the Michael Baker Jr. Inc. report "Pipeline Corrosion — Final Report" submitted to the DOT Pipeline and Hazardous Materials Safety Administration (PHMSA) in November 2008.

According to the report:

- The average number of pipeline related corrosion leaks was 52 per year over a 20-year study period. In 2007 this average would amount to only one corrosion leak per every 31,903 miles of pipelines based on approximately 1,659,000 miles of pipelines in service. Also, most of the leaks did not occur at the field joint.
- The corrosion rate has been relatively consistent over time, has not been influenced by the aging of the infrastructure, and the fact the rate had not increased significantly attests to the effectiveness of the industry efforts at corrosion control.
- Some of these corrosion failures can be attributable to the fact that DOT regulations requiring cathodic protection and dielectric coatings were not implemented until the early 1970s.
- Corrosion failures can be attributable to a number of factors such as inadequate levels or lack of cathodic protection, cathodic interference, MIC corrosion and stress corrosion cracking. As such, most of the incidents are not related to disbonded pipeline coatings at all.
- High dielectric strength and low water permeability or absorption are favorable traits of pipeline coatings for buried and submerged use because coatings are considered to be the first line of defense in preventing oxygen and water migration to the substrate. They insulate the substrate from the electrolyte, and reduce future unpredictable cathodic protection requirements.

On a worldwide basis, there have been a significant number of technological advancements over the last 40 years to provide better long term performance of plant applied and field joint coatings. These newer coatings provide for reduced water permeability, increased electrical resistance, improved adhesion-to-steel and better mechanical protection.

There is no such thing as a perfect coating. Coatings that have disbonded from the substrate may allow some degree of cathodic polarization beneath the coating and/or provide some degree of protection due to an increase in pH, but there are no pipeline coatings that can guarantee either of these conditions will be met in all cases. Factors such as soil and electrolyte conductivity, presence of a continuous electrolyte beneath the disbonded coating, structure potential at the crevice opening of the disbonded coating and conductivity of the trapped electrolyte beneath the disbonded coating all have an impact on the level of protection. Rocks and debris, expansive and contractive soils and improper bedding/backfilling of the pipe during construction can also cause cathodic shielding.

In 2002, the Gas Technology Institute embarked upon a major study of pipeline field joint coatings applied to cathodically protected fusion-bonded Epoxy (FBE) coated pipe and three-layer polyethylene (3LPE) coated pipe. The study was sponsored by the industry members and recently the full confidential report after five- and seven-year studies was released to the sponsors. Abbreviated reports were issued to the participating companies who applied their field joint systems on the test pipe such that they could see the performance of their specific systems. A public report is expected in the near future but an interim report was issued in 2005 "GRI-05/0180."

As a participating company, Canusa-CPS was able to see the results of their proprietary heat-shrinkable sleeve products and were not surprised that "heat-shrink sleeves" were consistently ranked first (best performing) or tied for first with FBE coatings. Tapes and composites (in which fiber-backed tapes are grouped) were consistently ranked fourth or fifth (last). Performance was measured relative to holidays, rust and wrinkling.

Heat-shrinkable sleeves that have been properly selected and applied will provide a sufficient bond to the substrate to resist disbonding due to soil stress, pipe movement and cathodic protection, thus they will not cause cathodic shielding problems.

At a basic level, the fundamentals of pipeline corrosion protection design is simple common sense; these being adhesion, fit-for-purpose performance, electrical resistance and low water absorption all providing a quality corrosion coating with minimal reliance on CP for overall performance.

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