Figure 1. Lowering in of pipeline on right-of-way.

LET'S TALK SHIELDING

ROBERT BUCHANAN, CANUSA-CPS, CANADA, EXPLAINS THE OFTEN MISUNDERSTOOD PHENOMENON OF SHIELDING.

Shielding of cathodic protection (CP) current with respect to pipeline coatings is probably the most misunderstood yet talked about phenomenon in the pipe coatings marketplace. Whilst it is not clearly defined in real terms, certain industry codes and standards define characteristics of pipeline coatings that are desirable attributes. However, those attributes may result in a coating that could be interpreted as a coating that 'shields'. Generally, all coatings are electrically resistive; however, resistivity levels vary depending on the coating technology employed and the conditions of service. Electrically resistive coatings, otherwise referred to as high dielectric strength coatings, have a unique place in the industry but should not be misrepresented as being a negative because of their ability to resist the flow of cathodic current. In fact most, if not all, effective coatings are designed to resist the flow of cathodic current. Why is this?

The lesson starts with basic principles of corrosion protection design. In order for corrosion to occur, there are four required elements; an anode, a cathode, an electrolyte and an external circuit. By removing any one of these, the corrosion process will stop. A statement made by Alan Kehr is a fundamental in the pipeline corrosion protection industry. Mr Kehr, a leading American expert on pipeline coatings, 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."[1]

Coatings are passive systems that prevent corrosion from occurring by blocking corrosive elements from getting to the steel, comparable to the paint on your car, and are intended to be the primary provider of corrosion protection on a pipeline. If Kehr's definition is considered, these are coatings that are defined as cathodically shielding.

CP systems are active systems that are designed as a back-up to coatings in the case of damage or holidays. A typical passive/active system analogy is in fire protection on commercial buildings. Firewalls or fire proofing of structural members are passive systems, whereas sprinklers and fire extinguishers are active systems. The passive system is the primary protection and the active system works in conjunction. The question with active or passive systems in protecting pipelines is, do they always work? That largely depends on how well they are installed and maintained.

That question is partially answered by looking at trends. In the North American market, the predominant type of pipeline coating is fusion-bonded epoxy, or FBE, while in many other parts of the world, the predominant coating type is three-layer polyolefin (3LPO be it polyethylene or polypropylene). Why is that? There are various theories but the choice is probably a function of one or more of the following factors:

- Cost – FBE is economical and is the most 'friendly' to CP due to the fact that it is a thin film coating, although it is still electrically resistive.
- Availability of transportation and construction infrastructure – it is important to move the coated pipe to the right-of-way and into the ground without significant damage. This is typically easier in North America than in a Middle Eastern desert or on an offshore laybarge.
- The CP system – cathodic protection is complex and, in many situations, engineering an effective system is difficult with all the variables that must be considered. Also, in many instances, once the system is installed it may not be properly maintained.

Going back to the question of whether the coatings always work, the answer is probably yes, no or maybe. If the transportation and construction infrastructure is good and the CP can be well-engineered and maintained, then a thin film, CP-friendly coating works well. In North America, there is more focus on CP engineering than anywhere else in the world and they tend to gravitate to lower cost coatings. Outside of North America, corrosion engineers prefer to apply focus to a good coating and engineer the CP as a true back-up system. It is true that good coatings cost more than thin film coatings but the higher CAPEX cost is balanced by reduced construction (coating repair) costs, higher construction productivity and lower OPEX costs of maintaining a more complex CP system. Figure 2 is a snapshot of global coatings use by region that highlights these points.

Three-layer systems are thicker and insulate the substrate from the electrolyte, thus minimising future CP requirements. On a worldwide basis, there have been a 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 are various national and international codes and standards that make comments about coating attributes and, when testing is specified, either a method is included or otherwise referenced. Specifically, there are test methods that are used to measure electrical resistivity of coatings and resistance to water absorption. Most codes and standards do not specifically comment on shielding of cathodic current, rather they make comments on desirable levels of electrical resistance. However, the US Department of Transportation has regulations relating to pipelines, which are called the Code of Federal Regulations (CFR) 192 and 195.

- CFR 192 – Natural or Other Gasses.
- CFR 195 – Hazardous Liquids.

CFR 192 relates to gas pipelines and CFR 195 relates to liquids pipelines and both make statements relative to corrosion protection and coatings.

Relative to these codes, 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. The interesting point is that CFR 192 includes a section stating that, under certain conditions, the pipe must be protected against external corrosion by a non-shielding coating. This is contrary to the body of code but does specify that the 'non-shielding coating' type is considered to be FBE and in some cases liquid epoxy. No adhesive-based or thick film coatings are mentioned.

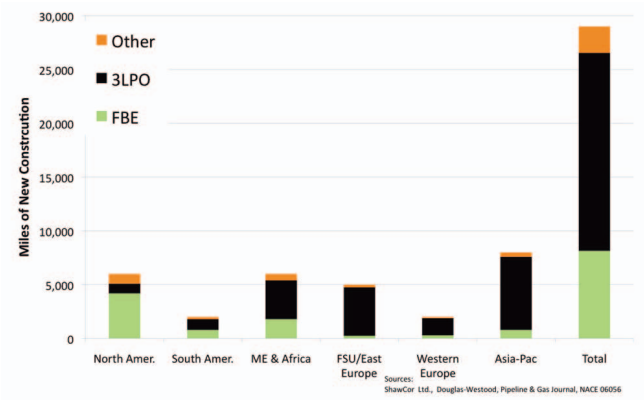

Figure 2. Global coatings market share by region.

Figure 3. Heat-shrinkable sleeve installation.

Some manufacturers promote what they call a 'non-shielding' coating but how is that defined when desirable attributes of a coating include high electrical resistivity? The reality is that all 'non-shielding coatings' actually have high electrical resistivity and will shield CP current, creating confusion in the industry. Some coating types state that shielding is a design principle but is not a problem. That also seems confusing but the reality is that a properly applied, high dielectric strength coating will perform its intended role of preventing corrosive elements from reaching the steel. It also minimises the long-term costs associated with CP.

Most codes and standards define a desirable attribute of a coating as high electrical resistivity and resistance to water absorption. That seems to be a given but does that describe a coating that shields? One of the coatings on the market that is described as non-shielding actually has high electrical resistivity but is also designed to absorb water. Why? The author believes that the cathodic path for CP current to reach the steel pipe is along the water (electrolyte) that is absorbed. This tends to defeat the purpose of a coating.

Moving from a discussion of Codes to a discussion about Standards, a key industry standard for field applied pipeline coatings is ISO 21809-3. In a recently published article, the standard was described in detail. One statement is that "Field joint coatings are an integral part of the continuous corrosion protection coating system and must be specified and applied as such."[2]

The standard addresses this and, as described in the article, the standard "contains a 'library' of field joint coating systems and materials. The standard is impartial and does not seek to directly contrast one system with another."[2]

However, the standard also "defines requirements for the following:

- Application procedure specifications.
- Pre-qualification trials.
- Pre-production trial.
- Inspection and testing plan.
- Quality assurance versus quality control."

The above elements ensure that a coating is properly installed rather than relying on CP to balance for expected deficiencies in installation quality. The question of shielding or non-shielding is never considered.

The question on some peoples' minds is: is shielding a real problem or a perceived issue? All good field joint coating systems have the potential to shield the CP system because good coatings must be good insulators with high dielectric strength and should not allow CP current to pass (through or along a path of absorbed electrolyte). Otherwise, the pipe could be left bare and protected with a very robust CP system.

References

1. KEHR, A., *Fusion-Bonded Epoxy (FBE): A Foundation for Pipeline Corrosion Protection.*
2. ROCHE, R., 'Understanding ISO 21809-3', *PCE* (July - September, 2012), pp. 33 - 39.

Figure 4. Induction heating of field joint on right-of-way.

Figure 5. Pipeline right-of way.