



CATHODIC SHIELDING: ABSORBING THE DETAILS

Robert Buchanan,
Canusa-CPS, Canada,
analyses recent studies of
pipeline coatings and
their properties.

Perhaps guest articles in *World Pipelines* have recently become an open mic for various interested parties to talk about cathodic shielding of pipeline coatings. The author wrote an article entitled 'Let's talk shielding' for publication in *World Pipelines Coatings and Corrosion* (October 2012), while an article entitled 'Controversy contained' written by Professor Frank Cheng was published in *World Pipelines* September 2013. Other articles have been published and each of these has presented differing perspectives on the topic.

The two articles referenced above were essentially intended to address the question of what cathodic shielding is or isn't, since some manufacturers of pipeline coatings claim that they

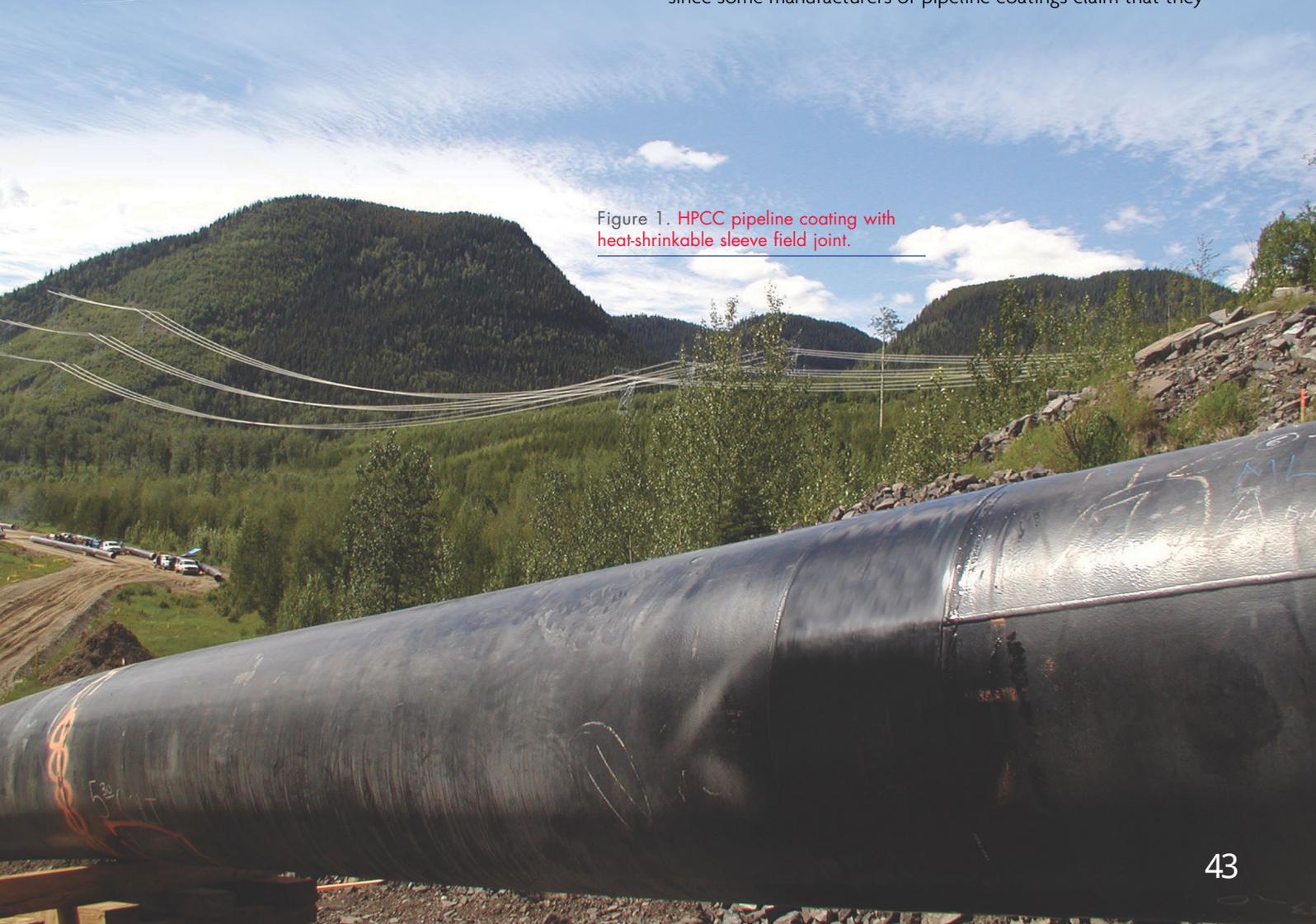


Figure 1. HPCP pipeline coating with
heat-shrinkable sleeve field joint.

manufacture a 'non-shielding coating'. Bear in mind that this would suggest that the coating has the ability to conduct electrical current from the cathodic protection (CP) system but still act as a coating should do in terms of being an electrical insulator and a barrier to the penetration of water or electrolyte. It is definitely a fine balance and one that fusion bonded epoxy (FBE) seems to be able to attain under certain conditions. However, it is not proven and highly unlikely for coatings that are considered as having high dielectric strength and, as such, are highly electrically resistive, to be non-shielding.

Analysing coatings

As a quick synopsis of 'Let's talk shielding', the article looked at different technologies of coatings and how they are viewed by various codes and standards. The key focus was in the USA, where FBE is a favoured coating due to its low cost and perceived friendliness to cathodic protection. The article also highlighted the fact that multi-layer polyolefin coatings are favoured outside of the USA due to their robustness and less reliance on CP as an active corrosion protection system.

Professor Cheng's 'Controversy contained' article seemed to take on a balanced approach by looking at how an FBE coating compared with HPCC. HPCC is a thin polyolefin coating but, by design, is still one that is highly electrically resistive. The author reviewed the article in fair detail with Dr. Dennis Wong of ShawCor Ltd., who has spent a career studying pipeline coatings and their electrical interaction.

The bottom line on the conclusions reached by Professor Cheng was that FBE can be considered "leaky" to CP current where the HPCC polyolefin coating was not. However, the method to evaluate this did not indicate at what temperature or duration the testing was performed, or the porosity or presence of microdefects in the free film of FBE that was evaluated. Each of these parameters will vastly affect the resistivity of a coating and hence its ability to allow passage of CP current. A proper treatise on the impact of water absorption, electrolyte permeability with their attendant decrease in coating resistivity or the long term adhesion stability was not presented.

Adhesion

Professor Cheng's article did comment on adhesion, which is an absolutely fundamental attribute for quality pipeline coatings, and the effects of disbondment at surface defects.

The conclusions that he came to on the ability of CP current to travel under a disbonded coating differ to the works by W. Schwenk,¹ or R. R. Fessler et al.² One consideration is the timescale of the experiment referred to by Professor Cheng, as compared to the works by Fessler et al with a similar set up. Protection potentials were achieved at different time intervals depending on the steel surface condition, potential applied and the conductivity of the electrolyte. Moreover, in the presence of a holiday, the CP current requirement to achieve protection under a crevice depends on the current penetration under the coating and the diffusion rate of corroding species such as oxygen into the crevice. This is a complex situation that warrants a more detailed treatment.

Electrical resistivity

In consideration of electrical resistivity, a simple study was commissioned to look at various coatings and their resistivity under dry and wet conditions of service and was published in a paper that was presented at NACE Corrosion 2013. The paper summarised some of the arguments written about in the 'Let's talk shielding' article as an introduction to the topic, but also looked at the study that included independent testing and manufacturer- and user-sponsored research into coatings and their electrical interaction.³

Testing for resistivity and water absorption

A fundamental attribute of pipeline coatings as defined in some of the codes and standards is electrical resistivity and, as such, a basic test to determine how a coating performs entails measuring how resistant a coating is to the passage of electrical current. If a coating has high electrical resistivity, or is not very conductive, then it essentially shields cathodic current which is, as defined by the referenced codes and standards, a positive attribute.

To understand this, testing was carried out with three types of thick film coatings and compared to FBE. Resistivity is the inverse of conductivity and was measured in ohm-cm using ASTM D257 as a test method. Volume resistivity is the resistance to current leakage through the body of an insulating material. The higher the surface/volume resistivity, the lower the current leakage and the less conductive the material is.

The three types of thick film coatings that were evaluated included 3-layer polyethylene, a heat-shrinkable sleeve and a fibre backed tape coating, which is being promoted as a non-shielding coating. The test programme looked at electrical resistance and water absorption rates, which are two critical characteristics of a pipeline coating.

The electrical resistivity tests were performed on fresh, dry samples of the materials and also after water absorption tests were complete as defined by absorption stabilisation. This was to see if a wet coating could conduct electrical current better than a dry coating.

It was found that polyethylene-based coatings exhibited high electrical resistance and low water absorption and stabilised quite quickly. The fibre backed tape was

Table 1. Test data providing a practical comparison between FBE and thick film coatings

Property	Polyethylene	HSS	Fibre tape	FBE
Backing type	HDPE	HDPE	Fibre mesh	n/a
Adhesive type	n/a	PE hot melt	Butyl mastic	n/a
Dry volume resistivity (Ω-cm)	10 ¹⁷	10 ¹⁶	10 ¹⁵	10 ¹⁵
Time to absorption stabilisation (hrs)	24	24	672	~500
Water absorption (%)	0.02	0.05	5.8	0.75
Wet volume resistivity (Ω-cm)	10 ¹⁷	10 ¹⁶	10 ¹⁴	10 ⁹

also electrically resistive but had high water absorption and took many days to stabilise.

The study also looked at how typical FBEs perform but because FBE is a thin film coating, the methods of testing and reporting of results varies from thick film coatings. The data in Table 1 extrapolates available electrochemical impedance spectroscopy (EIS) test data and data from manufacturer supplied literature to provide a practical comparison to the thick film coatings.

In looking at the results, note that any coating with a resistivity greater than 10^9 ohm-cm is generally considered non-conductive and less than that would be semi-conductive or conductive.

The only coating where a significant change in resistivity was noted was FBE. When dry, the coating is a good electrical insulator and when wet, the epoxy became semi-conductive, which is viewed by some as a desirable attribute assuming that the CP system will be 100% effective all of the time. However, the electrolytic conductivity of the FBE coating is still very low and it is questionable if it is enough to polarise the underlying disbanded coating to the protection level required.

Passive and active corrosion protection

Coatings are passive systems that prevent corrosion from occurring by blocking corrosive elements from getting to the steel and are intended to be the primary provider of corrosion protection. Cathodic protection systems are active systems

that are designed as a back-up to coatings in the case of damage or holidays.

Cathodic protection is complex and, in many situations, engineering an effective system is difficult with all the variables that must be considered, especially the soil conditions. Also, in many instances, once the system is installed it may not be properly maintained. Professor Cheng came to a similar conclusion when he wrote about “other factors”. He commented on properties of soil being a factor in shielding, i.e., its conductivity and stray current such that the coating property is not the sole factor causing shielding.

Conclusions

The question of what cathodic shielding is or is not, is obviously a tough one. All good pipeline coating systems have the potential to shield the CP system, because 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). Coatings are designed to bond to the steel and, as such, shielding should not be a major consideration, adhesion and installation quality should be. 

References

1. 'Current Distribution during the Electrochemical Protection of Pipes', *Corrosion Science*, Vol 23, No. 8, pp 871 - 886, 1983.
2. 'Cathodic Protection Levels under Disbonded Coatings', *Corrosion* 82, paper 118.
3. NACE Corrosion 2013 Paper No. 2080, 'A Critical Review of Industry Codes and Standards as They Related to Electrically Resistive Coatings and What That Means to Shielding', Robert Buchanan, Canusa-CPS.

PROVEN

FIELD JOINT COATING QUALITY



Canusa's advanced technology GTS-PP and GTS-PE heat-shrinkable sleeves coupled with *IntelliCOAT™*, state-of-the-art equipment for automated field installation, provide field-joint coating systems that not only far exceed the requirements of the ISO 21809-3 standard for 3LPE and 3LPP joint coatings, but that also provide equivalent performance to the 3LPE and 3LPP mainline coatings as per the requirements of the ISO 21809-1 standard for these coating types.



SHAWCOR

ENERGY SERVICES • GLOBAL SOLUTIONS



CANUSA-CPS

A SHAWCOR COMPANY

canusa.com