Nathan Muncaster, Polyguard Products, USA, discusses the phenomenon of cathodic shielding.

SHIELDING FROM FAILURE

In 2015, NACE formed a new task group – TG 523 – the role of which was to clarify and define the mechanisms that cause pipeline coatings to shield cathodic protection (CP), and to enhance the industry's understanding of the topic.

Whether or not a pipeline coating shields CP is determined by the following: during the coating's failure mode, CP currents are unable to reach the substrate adequately. This is shielding the CP. Though this seems straight forward, the particulars of how this occurs can vary depending on materials. A common misunderstanding is to link the shielding of CP to proper electrical insulation, which is a different topic.

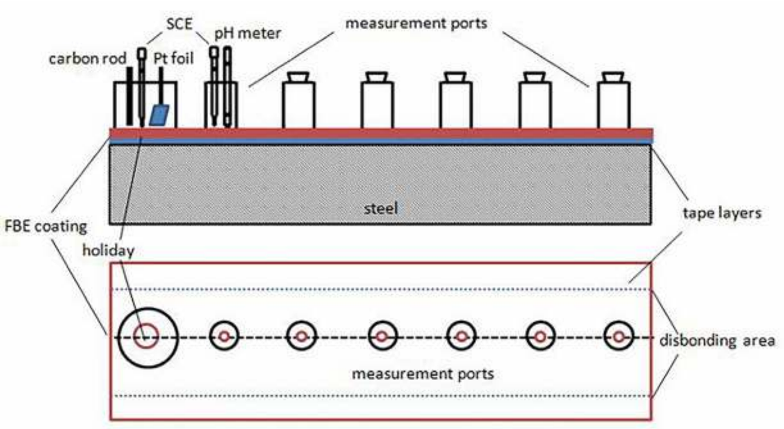

Figure 1. Experimental setup simulating a disbanding crevice under coating and the potential/solution pH measurements.

Figure 2. RD-6 application in the Middle East.

Coatings and CP

The foreword of most current working document of NACE TG523 states: 'Coatings and CP are designed to work as a complementary corrosion protection system for pipelines.

'As pipeline infrastructure ages, CP systems are expected to be maintained (per SP0169) but a protective coating system will tend to physically and chemically degrade over time. The manner in which these coatings can degrade is critical to maintaining the integrity of the pipeline, in particular the potential for CP shielding. CP shielding can result in corrosion, stress corrosion cracking, or both on an operating pipeline.

'Overall performance of coatings and CP, historically, has proven to be highly effective for a large majority of operating pipelines. CP shielding problems should be considered an outlier in terms of occurrences.

The purpose of this report is to provide basic information regarding the mechanisms involved with CP shielding and the manner in which the breakdown of a coating system may or may not contribute to CP shielding. It is intended to be a basic reference from which the tendency of a coating system to fail and shield CP may be understood on a conceptual basis'.[1]

Managing cathodic shielding

Discussions at recent presentations on the management of cathodic shielding in industry forums would suggest that confusion in definitions had been left behind in the prior decade. Nevertheless, NACE incorporated guidelines about shielding of CP in their SP 0169 (updated 2013). Additionally, in 2010 the US Department of Transportation, Pipeline and Hazardous Materials Safety Administration (PHMSA) issued the following statement: 'For the purpose of the alternative MAOP Rule, a 'non-shielding' coating is a coating that allows CP currents to pass through the coating and along the outside surface of pipe and which is an oxygen barrier, even if the coating has disbonded from the pipe surface.

'An example of such a coating is fusion bonded epoxy (FBE), which does allow CP currents to reach the external surface of the pipe, even if the coating disbonds from the pipe surface. The intent of the alternative MAOP Rule is for operators to use modern external coatings that do not impede CP. Also, PHMSA would consider a two part epoxy girth weld field joint coating or repair coating as a 'non-shielding' coating.

'Some examples of 'shielding' coatings are polyethylene tapes, shrink sleeves, coal tar mastics, asphalts etc. These coatings can prevent CP currents from reaching the pipe when they disbond from the pipe surface. The use of shielding coatings is not the intent of the alternative MAOP Rule'.[2]

From the Administrations' statement, it is clear that shielding is understood to be legitimate concern when selecting a coating and that certain coating types have been identified that shield CP. In both design and maintenance, then, the shielding or non-shielding properties of a coating need to be taken into consideration and discussion as to proper electrical insulation and other factors are independent. Pipeline owners and operators in the US are required by regulation to think beyond ideal field performance and think of the failure mechanism and behaviour of the selected coating system.

Affecting cathodic currents

In a study published in *Materials Performance*, May 2015, entitled, 'Probing Potential and Solution pH under Disbonded Coating on Pipelines', co-authors D. Kuang and Y.F. Cheng of the University of Calgary (Canada), discuss cathodic shielding/penetration as demonstrated with FBE and X65 pipeline steel.

The purpose of the study was to show factors that affect the ability of cathodic currents to protect substrates with coating (FBE) failures. The facts that were quantitatively analysed included solution resistivity, holiday size, temperature and disbond geometry, and particular focus was paid to equipment containing corrosive products. Their conclusions showed that coating disbondment geometry was a factor in keeping an otherwise non-shielding system from allowing current through. The study assumed that FBE was understood to be non-shielding and that a wide range of factors affected the performance of non-shielding capabilities during a failure. Figure 1 details their test set up.[3]

In North America, FBE occupies a dominant market position, and the topic of cathodic shielding is broadly understood throughout industry, but outside of North America opinions become much more diverse. Perhaps this lack of agreement on the particulars of cathodic shielding can be partially attributed to the complexity of the topic, especially regarding the failure mechanisms involved.

As mentioned earlier, the discussion of cathodic shielding is not a new one, with an increase in research concentrating on the topic dating back approximately 10 years. Citing part of the conclusion from *Materials Performance,* October 2006, 'Pipeline Coating Failure Modes', co-authors S. Papavinasam, M. Attard and R. W. Revie from CANMET of Ontario (Canada), write: 'Although any chemical, physical, or electrochemical changes may be considered as a coating failure, not all changes affect the ability of coatings to protect the pipeline.

'In an ideal situation, polymeric coating protects the pipeline and, when it fails, the CP acts as the backup. Only after both defence mechanisms fail would the pipeline become susceptible to corrosion. The worst case scenario of coating failure is the one in which the coating no longer protects the pipeline and, in addition, the coating prevents the CP from protecting the pipeline. This type of failure mode is primary in terms of the impact of the failure on the protection of the pipe.'[4]

Conclusion

When choosing a coating, it is clearly necessary to research the topic thoroughly to ensure the information used to inform purchasing decisions is founded upon correct fundamentals. As pipeline safety is, undoubtably, of tremendous consequence and importance.

References

1. NACE Task Group 2016 working document, April 2016, Foreword.
2. https://primis.phmsa.dot.gov/maop/faqs.htm, point 34.
3. KUANG, D., CHENG, Y.F., 'Probing Potential and Solution pH under Disbonded Coatings on Pipelines', *Materials Performance*, May 2015, p. 40 - 45.
4. PAPAVIASAM, S., ATTARD, M., REVIE, R. W., 'Pipeline Coating Failure Modes', *Materials Performance,* October 2006, p. 28 - 30.