CATHODIC DISBONDMENT or self-healing?

Nathan Muncaster, Polyguard Products, USA, and Luc Perrad, Expartech, Belgium, discuss cathodic disbondment testing and its importance within the industry.

By definition, cathodic disbondment is the loss of adhesion between a coating and its metal substrate, due to cathodic chemical reactions that take place in the interface of steel and coating. In cathodic protection systems, current passing through the metal frees hydrogen gas and oxidative molecules like chlorine and hypochlorite-ions, causing coating disbondment. This current passes only through metal exposed to the electrolyte where the coating is in default. The current flow amount depends on the size of the coating fault. If the size of the fault increases, the current increases, causing more cathodic disbondment. If there is no coating fault, then cathodic disbondment does not occur.

The purpose of the cathodic disbondment test is to quantitatively compare the resistance to excessive cathodic protection currents between different coating materials. Potential, temperature, duration, electrolyte, composition and diameter of the drill, are the main parameters of the cathodic disbondment test. Due to numerous variations of the test parameters, an extraordinary variety of test conditions and related acceptance criteria have been established. ASTM, CEN, or ISO publishes the major test methods used in the oil and gas and water industries. ISO21809-3 – the most recent published standard – gives different requirements, including maximum allowed disbondment radius for each type of coating.

Coatings

Coatings for anti-corrosion and electrical insulation are two different areas requiring diverse material selection. An electrical insulator based on current technology cannot be expected to provide the same anti-corrosion performance as a dedicated anti-corrosion coating, and vice versa. Thus, when someone applies a cathodic disbondment test to an anti-corrosion coating, one expects to capture a numerical value, which expresses the relative degradation of that material when attacked by excessive cathodic current.

Knowing this, and knowing that the functions of high strength electrical insulation and anti-corrosion control are not presently deliverable in the same product, one understands that the anti-corrosion coatings can never deliver a true zero in cathodic disbondment testing if the test were performed over a longer period. One expects to capture a certain degradation value and extrapolate the numerical result to analyse the anti-corrosion coating. Standardised accelerated test methodologies vary in duration and temperature, using an original artificial hole of typically 3 mm radius, but the purpose does not change. Engineers need to view this as a 'snapshot in time' – whether the test period is 30 days, 90 days or a modification, the accelerated testing is still just a glimpse, a parameter amongst many to consider an anti-corrosion coating's performance.

If an anti-corrosion coating cites a 0 mm disbondment result, it is important to understand this represents one of two possibilities. The first is that the anti-corrosion coating is understood to not have degraded during the observed time period, and this is deemed excellent. Yet, it is imperative to understand that anti-corrosion coatings are not full electrical insulations and that eventually degradation will occur. The second possible result is that the material cold flowed into the void (typically 3 mm radius) created for the purpose of the test. This is a completely different result and in no way captures the true value of the cathodic disbondment resistance of that coating system. In the real world, coating damage spots are highly unlikely to be perfectly formed circles with 3 mm radiuses. Rather, mechanical damage tends to be larger and exceed the self-healing capacity of coating systems. So, in any situation where the damage spot was larger than the cold flow capacity of the coating, bare metal would remain, and then cathodic disbondment would occur. If an engineer were only using a testing result that declared cathodic disbondment to be zero, or even a negative figure, the result they used would have absolutely no relationship to real world performance.

Figure 1. Cathodic disbondment on a pipeline.

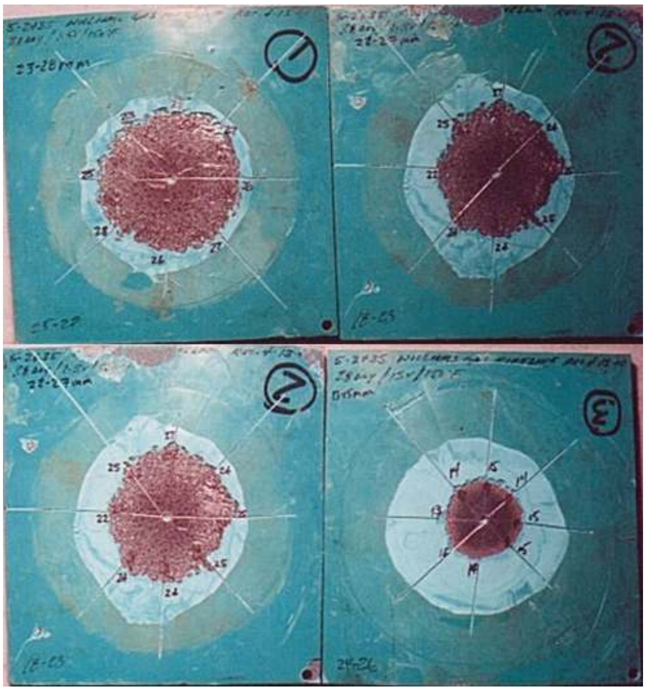

Figure 2. Cathodic disbondment testing.

Disbondment testing

In Polyguard, historically, if the RD-6 coating system cold flowed into the void during cathodic disbondment testing, the American customers would not accept a result of zero, since we were only demonstrating our self-healing/cold flow capabilities. Consequently, for the American market, we often had to redo testing and try to apply less tension or pressure on the sample so that the viscosity would be less.

On the other side, some markets in Europe for example, easily accept a 0 mm disbondment result and sometimes even a -3 mm result (self-healing over the 3 mm radius original hole). Amendment One of the international standard ISO21809-3, largely inspired by the European EN12068 standard, is requesting 0 mm disbondment for coating types 1E-a and 1E-b after 28 days cathodic disbondment test at 23°C and at maximum service temperature. Coatings 1E are based on non-crystalline low viscosity polyolefin tapes (simply called viscoelastic coatings). Their manufacturers recognise themselves that the result of cathodic disbondment test of such coating systems is 0 mm, due to the self-healing effect. Experts like the members of the committee for the new edition of the standard ISO21809-3 discussed this issue and agreed that self-healing is the main, and probably the only reason, for 0 mm disbondment for viscoelastic coatings.

It is interesting to note that ISO21809-3 is requesting 0 mm disbondment for coating type 1E (viscoelastic) only. All the other coating systems listed in ISO21809-3 do have cathodic disbondment requirements above 0 mm just because they don't measure self healing in that test (Table 1).

We feel it is important that engineers in the global market understand and appreciate what is being observed and captured. With cathodic disbondment testing your objective should be to obtain a quantitative value of the anti-corrosion coating's resistance or degradation when in contact with excessive cathodic currents. If this means that the radius used to analyse the cathodic disbondment value for some coating systems needs to be wider, then that could be an individual decision as current testing methodologies can fall short in capturing this property accurate in some cases.

Is too much viscosity a positive or a negative?

Knowing that pressure triggers flow, one could extrapolate the deleterious effect of soil movement and the pressure it exerts on a coating system and assume this pressure would trigger coating flow, typically towards the bottom of the pipeline. Amendment One of ISO21809-3 standard is requesting only 0.2 N/mm for peel strength at 23°C for coating types 1E-a and 1E-b (viscoelastic coatings). This value can be compared with the peel strength required for other coating systems: type 1D (polymeric tapes): 1 N/mm; type 2B (3LPE heat shrinkable material): 2.5 N/mm. Adhesion to steel is the most fundamental property for pipeline coatings; is self-healing more important than adhesion?

The lap shear resistance test is one method to capture a coating system's resistance against soil movements. For large diameter pipelines, this property is certainly as important as the adhesion to the substrate. ISO21809-3 is requesting 0.05 N/mm^2 for coatings type 1D, cold applied polymeric tapes (PE tapes) and only 0.02 N/mm^2 for coatings type 1E (viscoelastic coatings). From many years of field experience, the well-known weakest point for PE tape coatings is the soil stress resistance, causing many cases of delamination at the four and eight o'clock positions. With only 0.02 N/mm^2, viscoelastic coatings present even less resistance to soil stress.

The most important principle is that an engineer understands the testing parameters, what is being observed, and how methodologies can interact differently between materials. While a simple review of standards and methodologies is not very complicated and available for anybody with Internet access or a small budget to purchase copies, a comprehensive grasp of methodologies can be intimidating. Drawing an analogy, a civil engineer would not expect to use wood and concrete for the same application. Likewise, identical testing parameters cannot be applied for those materials. A healthy collaboration between industry and manufacturers is desired, but not all engineers know how to compare test methods on different materials, and not all manufacturers seek to truly assist them.

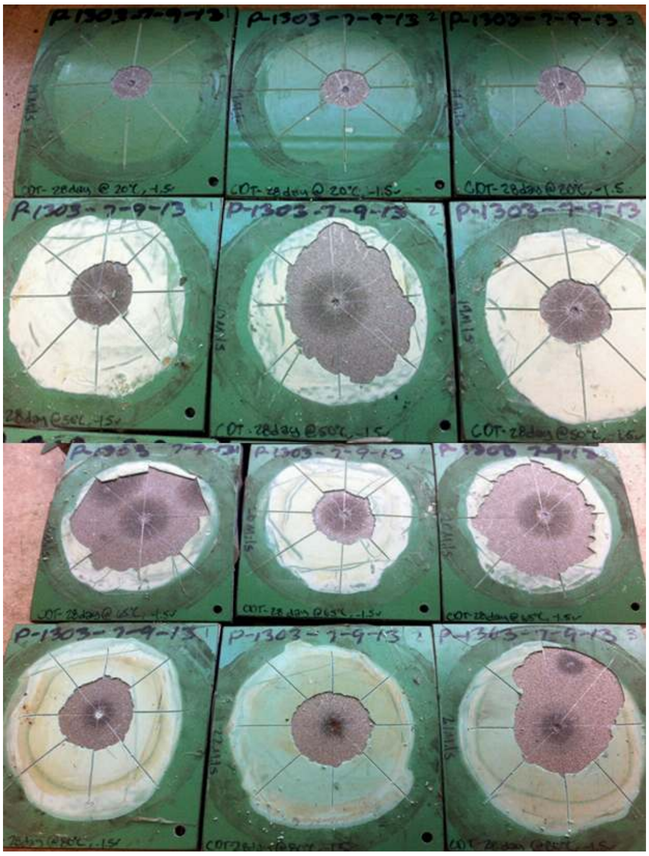

Figure 3. Cathodic disbondment testing.

Table 1. Requirements ISO21809-3 – maximum cathodic disbondment at 23°C

Types of coating	Code	Maximum cathodic disbondment
Hot applied bituminous tape	1A	20 mm
Petrolatum tape	1B	20 mm
Wax tap	1C	12 mm
Polymetric tape	1D	15 mm
Heat shrinkable sleeves without primer	2A	10 mm
Heat shrinkable sleeves with primer	2B	8 mm
Liquid coatings	4A, 4C and 4D	8 mm
Liquid coatings polyurethane	4B	10 mm
Cast polyurethane	4E	10 mm
Polyolefin-based coatings	5	7 mm
Thermal spray aluminium	6	No requirement
Hot applied microcrystalline wax coatings	7	14 mm
Elastomeric coatings	8	7 mm
Non-crystalline low viscosity polyolefin tapes	1E	0 mm