Luc Perrad, Expartech and Polyguard Products representative in Brussels, Belgium, compares the performance of heat-shrinkable coatings and polymeric tape coatings according to ISO21809-3 and EN12068.

Figure 1. RD-6 girth weld job for a US pipeline.

Testing coating PERFORMANCE

The international standard ISO21809-3 (edited in December 2008) is largely used today as a reference for the major pipeline operators (oil, gas and water companies). The standard describes nine field joint coating systems and includes the required performances for each system:

- Bituminous, petrolatum, wax and polymeric tape coating.
- Heat-shrinkable coatings.
- Fusion bond epoxy (FBE) powder coatings.
- Liquid coatings.
- Polyolefin-based coatings.
- Thermal spray aluminium (TSA) coatings.
- Hot applied microcrystalline wax coatings.

- Elastomeric coatings.
- Non-crystalline low viscosity polyolefin tapes.

Even though polymeric backed mesh coatings like Polyguard RD-6 have successfully been used since 1988 and are included in many reference standards like NACE standard SPO 169-2009 (Control of External Corrosion on Underground or Submerged Metallic Piping Systems), they are not listed in ISO21809-3. Manufacturers like Polyguard are thus participating to ISO committees to add a tenth field joint coating system: polymeric backed mesh coatings.

To assist the ISO committee to qualify the required performances to be included in the ISO21809-3 for polymeric backed mesh coatings, Polyguard RD-6 coating system had been recently tested by the well-known independent laboratory KTA Tator Inc. located in Pittsburgh, Pennsylvania. The tests were conducted according to ISO21809-3 test methods for heat-shrinkable coatings (3 layers polyethylene) and cold applied polymeric tapes.

This article compares the performances required by ISO21809-3 for heat-shrinkable coatings and polymeric tapes with the results of the tests conducted by KTA Tator Inc in December 2012 and November 2014. As the standard EN12068 (edited in August 1998) is still used today by some major oil and gas companies outside North America, the comparison includes the required performances of EN12068 Class C50. Test methods of ISO21809-3 and EN12068 are so similar that we can accept that they are in fact the same. The comparison includes:

- Short-term performance (punctual tests 24 hours after application of the coating): impact and indentation (penetration) resistance, peel strength (adhesion) and lap shear resistance.
- Long-term performance (tests conducted during a relatively long period of time): cathodic disbondment resistance and hot water immersion.

Short-term performance

Impact resistance

The objective of the test is to simulate a mechanical impact on the coating, like a rock fall or the excavator arm hitting the coating surface. In the laboratory, the test consists of dropping a weight from a height. The value of the weight and the height define the value of the impact in Joules (J).

After the impact, the coating is tested with holiday detector (dielectric test).

The impact resistance required for heat-shrinkable coatings and polymeric tapes according to EN12068 Class C50 is 15 J.

ISO21809-3 is requesting 4 J/mm of coating for polymeric tapes and 5 J/mm of coating for heat-shrinkable coatings. As the typical thickness for both systems is between 2 and 3 mm, the impact resistance fluctuates between 8 and 12 J for polymeric tapes and 10 and 15 J for heat-shrinkable coatings.

Polyguard RD-6 coating system passed successfully the impact test with 15 J; which is 6 J/mm of coating (2.5 mm thickness).

Indentation resistance

Small sharp stones can migrate in the soil to the coating surface of buried pipelines. They can apply a high pressure on the surface and penetrate the coating with time.


Figure 2. RD-6 rehab job in the US with SP-6 outerwrap.

In the laboratory, the penetration resistance is tested with a weight equipped with a small pin applied for a couple of days on the coating surface. The pressure of the pin is expressed in newton per square mm (N/mm²). After the indentation test, the coating is tested again with holiday detector (dielectric test).

EN12068 Class C50 and ISO21809-3 are requesting a same indentation resistance for heat-shrinkable coatings and polymeric tapes: 10 N/mm².

Polyguard RD-6 coating passed successfully the indentation test at 10 N/mm².

Peel strength

The peel strength represents the adhesion force on a substrate (steel and plant coating). Adhesion is certainly the most fundamental property: coatings with high adhesion will certainly resist better over time.

In the laboratory, the adhesion is measured by peeling vertically at a constant speed of 10 mm/min. a coating strip of typically 1 in. (25 mm) width. The force to remove the 25 mm width strip coating is measured in newtons. The final unit result is newton per mm (N/mm).

EN12068 Class C50 requires peel strength on steel between 0.5 and 1 N/mm for heat-shrinkable coatings and polymeric tapes while ISO21809-3 requires 1 N/mm for polymeric tapes and 2.5 N/mm for polyethylene heat-shrinkable coatings with an epoxy primer.

Polyguard RD-6 reached 3.4 N/mm on steel during the test at KTA Tator Inc.

Lap shear resistance

Shear resistance is critical for large diameter buried pipelines due to the high soil stress applied on the coating; especially at the 4 and 8 o'clock positions. For heat-shrinkable coatings and polymeric tapes, the lap shear resistance is measured by peeling horizontally at a constant speed of 10 mm/min. a coating piece of typically 1 x 1 in. (25 x 25 mm). The final unit result is newton per square mm (N/mm^2).

EN12068 Class C50 requires lap shear resistance of 0.05 N/mm^2 for heat-shrinkable coatings and polymeric tapes while ISO21809-3 requires this same value for polymeric tapes and 1 N/mm^2 for heat-shrinkable coatings (3 layer polyethylene).

Tested according to ISO21809-3, Polyguard RD-6 reached 0.18 N/mm^2 during the test at KTA Tator Inc.

Polymeric tapes present poor shear resistance. They generally fail (disbond) at the 4 and 8 o'clock positions on large diameter pipelines; therefore they are today rejected in the oil and gas North America market.

The high shear resistance value from ISO21809-3 for 3 layers polyethylene heat-shrinkable coatings comes from the hotmelt adhesive layer, which absorbs the soil stress. This layer connects the epoxy primer (anti-corrosion layer) with the polyethylene outer layer (mechanical protection layer).

The soil stress resistance of polymeric backed mesh coatings comes from the outer layer (the mesh) that is non-elastic, strong and applied with high tension. The polypropylene mesh backing of the Polyguard RD-6 coating system contracts after application, increasing adhesion and soil stress resistance.

Lap shear test methodology from ISO21809-3 conducted for heat-shrinkable coatings or polymeric tapes is therefore not relevant for polymeric backed mesh coatings. Real life results, or modified lab protocols with tubular substrates would give higher results.

Long-term performance

Cathodic disbondment resistance

When ionic current from the anode bed reaches exposed steel surface to be cathodically protected, gaseous hydrogen (H2) is produced. The gas pushes and disbonds the 'healthy' coating: that is cathodic disbondment.

Cathodic disbondment test method consists of boring a 6 mm dia. hole into the coating and exposing the coated sample to ionic current during 28 days. After this period, the extension of the original hole is measured in mm.

According to EN12068 Class C50, the maximum disbondment for heat-shrinkable coatings and polymeric tapes is between 10 and 20 mm:

- 10 mm if the peel strength is minimum 0.5 N/mm.

Figure 3. RD-6 being applied in the US.

- 20 mm if the peel strength is minimum 1 N/mm.

EN12068 admits that high peel strength coatings have poor cathodic disbondment resistance and conversely; which is a typical general rule for polyethylene coatings.

Cathodic disbondment resistance is more critical than high peel strength:

- Cathodic disbondment forces are applicable throughout the whole coating's life.
- Cathodic disbondment is tested during 28 days (long-term test).
- Peel strength is never applied for the lifespan of the coating.
- Peel strength test takes place once, 24 hours after coating application (short-term test).

ISO21809-3 allows maximum 15 mm disbondment for polymeric tapes and 8 mm for heat-shrinkable coatings (3 layers polyethylene).

The Polyguard RD-6 coating system scored particularly well at KTA Tator Inc. With 0 mm disbondment after 28 days exposed to ionic current, this coating system largely exceeds the required performances of heat-shrinkable coatings and polymeric tapes; and this with excellent adhesion (peel strength).

Figure 4. USA girth weld installation.

Hot water immersion

The conclusions of the 'Pipeline Protection Conference' of November 2005 in Cyprus was: hot water immersion, followed by adhesion testing, is probably the best screening/qualification test to ensure long-term reliability of buried pipeline coatings.

After 28 days immersed in hot water (maximum operating temperature), peel strength test (adhesion) is conducted.

EN12068 does not require this test; while ISO21809-3 requests 0.4 N/mm for polymeric tapes and 1.5 N/mm for heat-shrinkable coatings.

Again, the Polyguard RD-6 coating system scored very well at KTA Tator Inc with more than 3 N/mm after 28 days in hot water.

Conclusion

According to international standards like EN12068 and ISO21809-3, which are largely used for field applied coatings, performances of polymeric backed mesh coatings are better or equivalent to heat-shrinkable coatings and polymeric tapes:

- Mechanical resistance (impact and indentation): equivalent.
- Adhesion to steel and plant coating (peel): better.
- Lap shear resistance: equivalent.
- High soil stress resistance.
- Cathodic disbondment resistance: much better.
- Peel strength after hot water immersion: much better.
- Non-shielding properties: proven by Polyguard RD-6 since 1988.[1]

References

1. NORSWORTHY, R. and J. STRONG, 'Choosing a sufficient coat', *World Pipelines*, November 2013.