(PROVEN PROTECTION)

Richard Norsworthy and Chic Hughes, Polyguard Products Inc., USA, *outline the obstacles to effective coating performance and the company's innovative solutions to these problems.*

Even when all the testing is completed, specifications are written and pricing is decided, everyone must consider the possibility of failure if a pipeline coating does not perform as predicted. As with all pipeline coating systems, it may take 15 – 20 years in service to know how the coating will perform under the rigours of soil stress, cathodic protection (CP), varying soil conditions, mechanical damage and other potential hazards. After several years in service, shrink sleeves (SS) and tape coatings with solid film backings (SFB) were found to be easily damaged by soil stress, causing disbondment that led to corrosion problems due to CP shielding. Even though the US Department of Transportation regulations call for use of 'non-shielding coating', most pipeline coating companies do not understand or test coatings for potential CP shielding problems.

Polyguard Products, Inc. took a chance on a new product that was similar to other coating systems. The new coating system consists of a liquid adhesive that is covered by spiral wrapping with a geo-textile fabric backed rubberised bituminous compound and then a non-adhering, non-shielding outer-wrap is applied. Subsequent testing and field testing proved that this coating also had non-shielding or 'fail safe' properties that allows CP (when adequate) to be effective, even if the coating is not applied properly and water does penetrate between the pipe and coating. When selecting a pipeline coating, the 'fail safe'

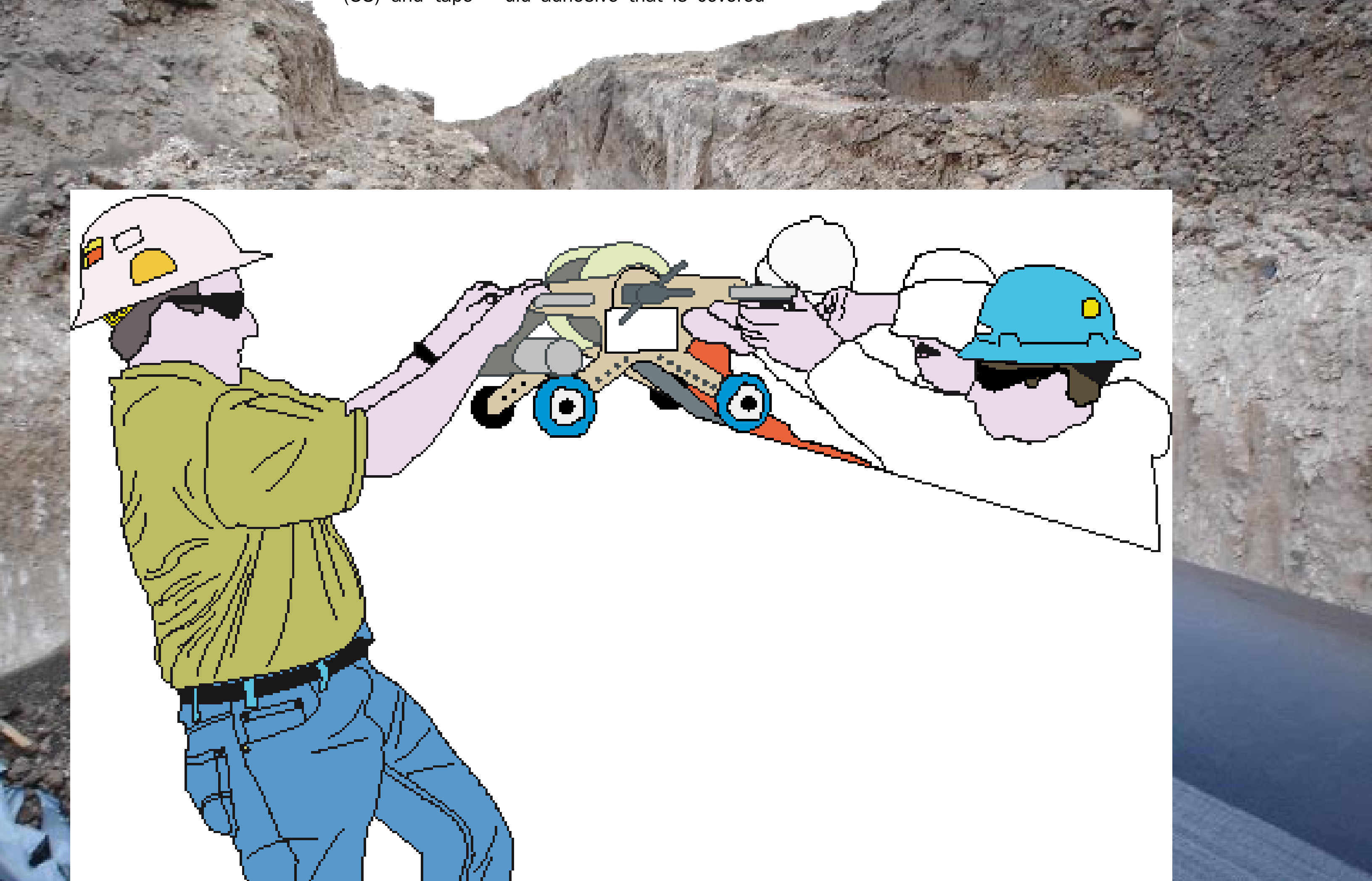

Figure 1. Plant application of Polyguard RD-6 in Chile.

Figure 3. Field application of the RD-6 coating system on a 30 in. rehabilitation project in South Texas.

Figure 2. Demonstration of offshore applicator. Typical application takes less then two minutes.

(or non-shielding) characteristics may be more important than other issues that are normally considered.[1]

History

In the mid 1980s, Polyguard recognised the issues facing the pipeline tape coating industry and realised that traditional tape coatings were not the future of the industry. There were numerous reports of traditional SFB tape coating failures in the industry. Associated with these failures were many corrosion problems that could not be detected until there was a leak, or the location was exposed for other reasons.

Many of the corrosion problems were occurring under disbonded, SFB tape coatings where water had penetrated between the coating and the pipe steel. These coatings have solid film backings of high dielectric strength. This meant that cathodic protection currents could not penetrate and corrosion developed. Not all tape coatings failed, but there were enough failures that it became a significant problem. Some pipeline companies, especially those in North America, chose to totally disregard using tape coatings for future applications. Many companies are expressing the same concern with shrink sleeves.[2]

Failure modes

Poor surface preparation led to many failures of SFB tapes. At times, the applicator used the wrong primer or no primer. Over stretching of SFB tapes can leave an inadequate overlap and seal. If not applied with enough tension, the tape would not form a proper bond to the pipe. Some compounds used were a food source for bacteria, leaving only the SFB. The compound used by some did not have adequate thickness to completely fill the helix area of the overlap. Proper heating of the pipe and sleeve is a major concern for application of shrink sleeves.

Soil stress is another leading cause of the tape coating failures. Soil stress (also known as soil force), can occur as a result of backfill settlement, pipe movement, alternating wet and dry conditions in the soil or a combination of these.[3] Soil stress caused wrinkles in a shrink sleeve on a 10 in. pipe which allowed water and SS shielded CP, resulting in significant corrosion.[4] Since SS and SBF tapes stretch easily, the weight and downward movements of the soil can cause the coating to move and wrinkle, especially at the 4 o'clock and 8 o'clock positions. If the coating will stretch during application, soil stress forces can cause further stretching. Contraction and expansion caused by temperature changes in the pipe or the electrolyte can damage coatings. The heat transfer difference between the field applied coating and the plant applied coating can cause the field applied coating to disbond.

The problem

The solid film backings (whether tape or shrink sleeve form) are usually a polyolefin based material that has very high dielectric strength. Electrical resistance of PE (polyethylene) coatings and their susceptibility for an unbonded installation creates a serious problem on pipelines.[5] The high dielectric strength backings will not provide the CP current with a path to the pipe surface to protect the pipe. At openings caused from the disbondment or from holidays caused from damage to the coating, some current could protect the pipe, but penetration beyond these openings was limited.

Since the water under these coatings is now a separate electrolyte from that in which the cathodic protection is located, corrosion develops. The rate of corrosion depends on several issues. 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.[6]

The solution

Polyguard chose to develop a new product that would overcome the bad reputation of the SFB tape and shrink sleeves. Due to this reputation, the company knew it had to work very hard to prove that its product was different.

Considering the cost of surface preparation, Polyguard chose a product that has very good adhesion where the surface preparation is less than desirable for many other types of coatings. Some coatings, such as two part epoxies, require blasted surfaces that are SSPC-SP6 (NACE-3) or higher in quality for them to perform properly. All coatings perform better on blasted surfaces, but the RD-6 provides excellent cathodic disbondment results on wire brushed or power tool preparation (Table 1).

After surface preparation, a liquid adhesive is applied to the pipe surface. The purpose of the thinly applied, rapidly curing liquid adhesive is to fill the surface profile and chemically react with the bituminous compound to enhance the bond to the pipe surface.

A major problem with the solid film backed tapes is the potential for wrinkling from soil stress. Polyguard chose to back its bituminous compound with a geotextile fabric (basket weave of polypropylene strands) that is very strong with limited stretch before breaking. This idea has proven to be very effective against soil stress damage. Table 2 shows a comparison of the tensile properties of several tape coatings.

Another issue with the solid backed tapes is the CP shielding issue. The solid film, usually polyethylene, has a very high dielectric strength and will not allow adequate cathodic protection to the surface of the pipe when water is present under the tape. The geotextile fabric allows current to penetrate to the pipe steel in the event the compound is damaged. Later studies have proven that these strands also support the 'fail safe' characteristics of the RD-6 coating system.

To further enhance the soil stress resistance, the RD-6 system includes the use of a non-adhering, non-shielding outer wrap which provides a 'slip plane' that is free to move and slip as the soil settles around the pipe. The outer wrap is damaged, but the coating is protected. The outer wrap must not shield cathodic protection. At the time of writing, the company has not heard of any cases of soil stress damage to the RD-6 when the outer wrap has been used.

Proof in the field

The Polyguard RD-6 coating system was first used in 1988 on a 26 in. test section in South East Texas that is known for severe soil stress. Approximately 100 ft of pipe was coated. After seven months, the coating was checked for soil stress and found to be in excellent condition. Over the next few years, many major oil and gas companies began to approve this coating for field and girth weld applications.

In the early 1990s, several recoat projects on 30 in. and 36 in. natural gas lines were carried out in South Texas. This area is known for severe soil stress problems. One section was uncovered after several years on the 36 in. line, with no wrinkling or disbondment from soil stress. Many other major and minor rehabilitation projects have been completed since this time.

In 2005, a Canadian company exposed a 20 in. pipeline that had been coated with RD-6 in 1994 – 1995. The coating was described to be in excellent condition with no wrinkles and excellent adhesion.

The RD-6 continued growing in popularity and companies began to use not only as a rehabilitation coating, but also for girth welds. One such project was approximately 200 miles of 12 in. pipe for a products line in East Texas.

Table 1. Information provided from joint industry test performed in 1996 by Chart Coating Services Ltd., Canada

Coating type	Cathodic disbondment test (21 °C/70 °F, 90 days)		
	Blast (mm)	Power tool (mm)	Hand tool (mm)
Two part epoxy 1	4	27	37
Two part epoxy 2	6	18	28
Two part epoxy 3	3	8	19
Two part epoxy 4	5	38	Total
Tape with primer 5	5	10	14
Tape with primer 6	11	14	21
Polyguard RD-6 with primer 7	**0**	**7**	**8**
Hot applied tape 8	15	6	16
Shrink sleeve with primer 9	0	8	12
Shrink sleeve with primer 10	3	40 % of test	33
Shrink sleeve 11	8	11	18

Table 2. Comparison of tensile properties for several tape coatings

System	Break strength (lbs/in. width)	Elongation (%)
1	14	454
5	4	641
6	18	243
8	59	153
12 Polyguard RD-6	**116**	**23**
13	19	533
14	12	302
15	13	522

Information from Paper 00769 - Corrosion 2000 - 'Addressing soil stress and CP shielding by using a woven geo-textile fabric backed tape system with a rubber modified bituminous compound'.

Other girth weld and fabricated piping coating projects range from Alaska (30 miles of girth welds on a 10 in. with extruded polyolefin), to projects in West Africa (parts of the Chad/Cameroon project), and South America. Many engineering companies have adopted this coating for girth welds and fabricated piping.

There have been rare problems with the RD-6 in the field. In the 20 years of the RD-6 being used in the field, Polyguard has had less than 10 reported problems. There were no reports of corrosion in these situations. In two cases, water was found under the RD-6 because of poor application techniques. However, in both cases the cathodic protection had raised the pH of the water to 10 or above proving the 'non-shielding' properties of this coating system.

Polyguard has proven through field and laboratory testing that the RD-6 coating system has 'fail safe' properties.[7] With 'fail safe' or 'non-shielding' coating systems, if disbondment occurs and water penetrates, corrosion on the pipe is significantly reduced or eliminated when adequate CP is available. Some call this characteristic CP Friendly, CP Compatible or Partial Shielding. The point is that the pipe may be considered 'safe' from significant corrosion if there is a 'failure' of its adhesion and adequate CP is available

Continued growth and development

Polyguard has now developed a coating system for offshore application on lay barges that is very fast and provides 'non-shielding' properties. The RD-6 OS has been tested to ensure it will not be damaged by the hot foam infill materials used to fill the space left at the girth weld areas on concrete weight coated pipelines used in offshore construction.

The company continues to develop other coating systems that will provide 'non-shielding' properties, such as those for higher temperature performance from 95 ˚C (205 ˚F) and higher. Research is in progress to develop various compounds and specialised products for a variety of corrosion problems that exist in the oil and gas industry, from production to the end user.

Conclusion

The RD-6 pipeline coating system now has a proven history of 20 years of in-service use. The rare field problems have only been proof of the 'fail safe' properties. At this time, there have been no reports of corrosion when the RD-6 has been improperly applied and water did penetrate. Unlike other tape coatings and shrink sleeves, the cathodic protection current was allowed to protect the pipe surface and prevent any significant corrosion. This is proven from the high pH under the RD-6 in the field and laboratory and visual observations.

Polyguard strives to continue to provide the pipeline industry with "fail safe" coatings that are easy to apply, require minimal surface preparation, and provides many years of problem free service life.

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