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A NOVEL ANTI-CORROSION PIPELINE COATING SOLUTION

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SUMMARY: A novel composite polymeric pipeline coating solution based on a FBE base coat and an outer layer of reinforced polyolefin is presented. Compared with DLFBE, the new coating is a much better moisture barrier and has higher corrosion resistance, with higher flexibility. At half the thickness of a 3LPE, the new coating provides similar corrosion and impact resistance but being more flexible yet harder, more abrasion resistant, less shrinkage, and more difficult to peel, while offering unsurpassed field joint adherence properties and extended operating temperature range to 100°C. The paper compares the performance properties of the new pipeline coating system with conventional DLFBE and 3LPE systems, accordance with AS/NZS 3862, CSA Z245.20/21, and ISO 21809-1 standards. A case history of an actual pipeline project is also presented.

Keywords: Pipeline coating, Polyolefin, DLFBE, 3LPE, Field joint coating

1. INTRODUCTION

This paper highlights the development of SureBond™ 100, a novel composite polymeric pipeline coating solution based on a fusion bonded epoxy (FBE) base coat and an outer layer of reinforced polyolefin polymer.

Anti-corrosion pipeline coating is a critical component for pipeline corrosion protection, working hand-in-hand with a cathodic protection (CP) system. Over the past several decades, pipeline coating solutions used for Australian onshore pipelines have evolved a lot and presently the most popular pipeline coating systems used are either single layer FBE / dual-layer FBE (DLFBE) or three-layer polyethylene (3LPE), with smaller quantities of two layer polyethylene (2LPE/Yellow Jacket). This popularity is due to the exceptional corrosion properties of the provided coating products, which are suitable for Australian installation/operating conditions and temperatures.

2LPE/Yellow Jacket with a rubber modified asphalt sealant and a polyethylene top coat had been applied at Bredero Shaw's Kembla Grange facility and has been a mainstay anti-corrosion coating for the Australian onshore gas pipeline market since 1968. Its thickness and minimum performance requirements are standardized in AS/NZS 1518 [1], and is rated for operating temperatures up to 60°C (55°C as per AS/NZS 1518). Yellow Jacket has excellent handling characteristics, corrosion/moisture/soil stress resistance, field bendability and impact resistance. Its outer thickness can be varied to offer great mechanical protection. With the shut-down of Bredero Shaw's Kembla Grange facilities in 2013, however, 2LPE/Yellow Jacket is no longer supplied to the market.

Single layer FBE and dual layer DLFBE coatings are thin film coatings based on epoxy-resin powder materials. Single layer FBE has been the backbone of pipeline protection since the early 1960's as stand-alone coatings. With increasingly aggressive and varying environments, the traditional stand-alone FBE coating is evolving into a dual-layer DLFBE coating system. DLFBE are usually made of a fusion-bonded epoxy primer, the same or similar to the stand-alone FBE, and, depending on the targeted application, a tougher FBE topcoat (usually called abrasion-resistant overcoat ARO), or a higher flexibility FBE topcoat. Thickness and other coating configuration requirements of both single layer FBE and DLFBE coatings are standardized in AS/NZS 3862 [2] (for single layer FBE only) and CSA Z245.20 [3] (for both single layer FBE and DLFBE). The ARO type DLFBE products have been used on many significant pipeline projects since it was introduced into Australia in 2001 for the Tasmanian Gas Pipeline [4]. Most single layer FBE and DLFBE used in Australia onshore pipelines are rated for operating temperatures from -30ºC up to 80ºC in wet conditions or 105ºC in dry conditions, but new products are currently developed for higher operating temperatures. FBE coatings offer excellent corrosion resistance, act as a good barrier to oxygen, show excellent adhesion to steel and are compatible with a wide variety of field joint coating options (including FBE, two part liquid epoxy/polyurethane and heat shrinkable sleeves), however have relatively weak resistance to handling/installation damage and moisture as well as limited flexibility at higher thickness (>600 µm).

3LPE coatings are multilayer anti-corrosion systems consisting of a layer of FBE primer, a polyethylene-based copolymer adhesive layer and a topcoat of polyethylene (often a high-density polyethylene HDPE for onshore use). Currently there is no Australian standard covering the thickness and minimum performance requirements for 3LPE, and there are discussions of simply adopting the international ISO 21809-1 standard [5] in Australia. While the FBE primer of a 3LPE system offers excellent corrosion resistance and adhesion to steel, the polyethylene topcoat provides good mechanical properties and moisture barrier. 3LPE coatings are therefore used in projects with rough storage or handling conditions, challenging backfill material or harsh climatic/soil conditions. 3LPE is restricted by the properties of the polyethylene and as such its typical operating temperature ranges from -20ºC up to 85ºC in Australia.

Whilst many of these pipeline coating systems have had varied degrees of success and have served the Australian domestic onshore pipeline industry well, there are still new challenges that face the industry due to the many unique market environment and application conditions, such as: handling/installation damage and repair following long distance transportation of coated pipes (now mainly imported from oversea pipe and coating mills) (FBE/DLFBE/3LPE), high flexibility requirement during cold field bending (DLFBE), field joint coating compatibility (3LPE), adhesion loss at cutback during long term storage and transportation due to high residual stresses (3LPE), and weld seam coverage for large diameter pipes (3LPE). The industry therefore has demands for new and innovative pipeline coating systems in order to meet these challenges.

The new anti-corrosion coating system presented in this paper brings to the pipeline industry with many enhanced performance benefits while being able to offer the values through competitive prices. These benefits include:

- Much better moisture barrier, higher corrosion resistance and higher flexibility over FBE/DLFBE;
- Improved hardness and abrasion/penetration/impact resistance over 3LPE, enabling the excellent corrosion and mechanical protection of the new coating system at almost half of the coating thickness of standard 3LPE;
- Non adhesive layer and reduced coating thickness, minimizing associated component thermal mismatch or residual stress;
- Extended operating temperature rating up to 100ºC; and
- Unsurpassed field joint adherence property and compatibility to different field joint coating materials.

The paper compares the performance properties of the new pipeline coating system with conventional DLFBE and 3LPE systems, accordance with AS/NZS 3862 [2], CSA Z245.20 [3] and ISO 21809-1 [5] standards. A case history of an actual pipeline project is also presented.

2. DEVELOPMENT OF A NOVEL ANTI-CORROSION PIPELINE COATING SYSTEM

Figures 1 and 2 illustrate a typical configuration of the novel anti-corrosion pipeline coating system.

The new coating system consists of a 250 µm thick FBE primer and a 1.40-1.65 mm thick of reactive and reinforced polyolefin polymer topcoat. Similar to the case of a 3LPE system, the FBE primer component of the new coating system provides the corrosion resistance, a good barrier to oxygen and excellent adhesion to steel substrate. Unlike 3LPE, however, the new coating system eliminates the use of a layer of adhesive to bond the FBE primer and the topcoat. This is made possible by formulating the polyolefin-based polymer topcoat with reactive functional groups, which undergo the same cross-linking reaction as the FBE primer does while curing. As a result, the bonding process between the reactive topcoat and the FBE primer for the new coating system is very similar to that between the ARO topcoat and the FBE primer for a DLFBE system: the FBE primer is applied first, and then the reactive topcoat is extruded before the FBE completes its gelation. At extrusion, cross-linking reactions take place not only within the FBE primer itself and within the topcoat itself, but also between the reactive groups of the topcoat and FBE reactive sites, creating the perfect conditions for strong chemical interaction and bonding (Figure 3). Once the cross-linking reactions have taken place and the cured coating brought to room temperature, the bonds between the FBE primer and the topcoat of the new coating system are extremely difficult to be broken, making peel resistance testing at room temperature virtually impossible.

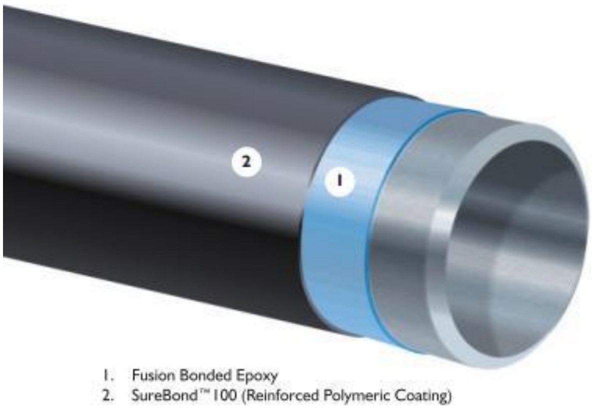

Figure 1 SureBond 100 anti-corrosion coating system

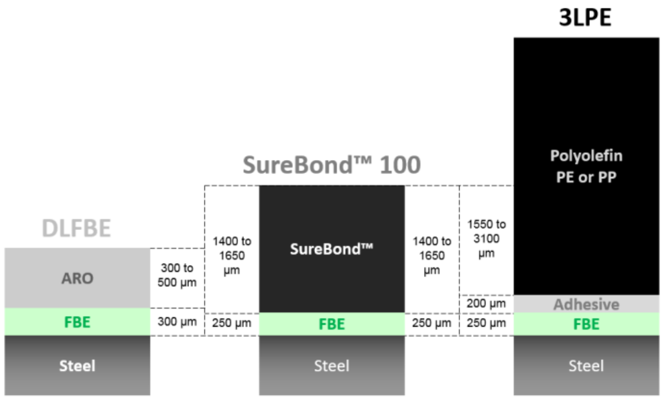

Figure 2 SureBond 100 configuration vs. DLFBE and 3LPE

In addition to introducing reactive groups for the cross-linking reaction, the topcoat formulation of the new coating system is also a homogeneous blend of thermoplastic and thermoset polymers, functional fillers, and compatibilizers. This creates a reinforced composite polymeric layer which is much more rigid and resilient than the standard high density polyethylene (HDPE) materials commonly used in a 3LPE system. The reinforced polymer topcoat enables the new coating system, at half of the coating thickness of a 3LPE, to have the same impact resistance and to withstand application of concrete weight coating by impingement, providing a very high level of mechanical protection across many diverse environments without requiring the use of costly select backfill.

Compared with 3LPE coating systems, the new coating system offers much less risk of coating delamination and cathodic shielding. The unique materials compatibility and application process of the new coating system provides a nearly monolithic profile between the FBE primer and topcoat, which minimizes the diffusion of corroding species such as oxygen and water to the coating – steel interface. Consequently, the adhesion of the new coating system to steel is very stable in service environments and thereby prevents delamination and loss of adhesion. Adhesion stability of this coating system is also demonstrated by its resistance to cathodic disbondment and hot water immersion tests. The reinforced polyethylene topcoat also possesses very good specific coating resistance as shown in Figure 4 with the results of a 60 day Electrochemical Impedance Spectroscopy (EIS) investigation on extruded thick and thin reinforced coating samples at 95°C. These attributes demonstrated that SureBond is very compatible with cathodic protection systems.

Figure 3 The reactive topcoat is extruded before FBE gelation to enable cross-linking reaction for bonding

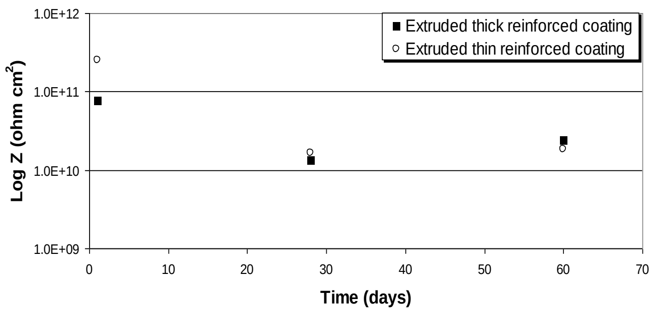

Figure 4 EIS results of 60 days at 95°C show the impedance of the new coating system close to that of a very good FBE

3. PERFORMANCE OF THE NOVEL ANTI-CORROSION PIPELINE COATING SYSTEM

Various materials and performance tests were conducted as per AS/NSZ 3862:2002 [2] and other international pipeline coating standards such as CSA Z245.20/21 [3] and ISO 21809-1 [5] on FBE and 3LPE coating systems. Results are given in Table 1 and Table 2, showing that the new coating system meets or exceeds the requirements of these Australia and international pipeline coating standards. It can be seen that the new coating system has better resistance to hot water immersion, less cathodic disbondment, and significantly lower water absorption and higher flexibility/abrasion resistance than FBE/DLFBE. It can be also seen that the new coating system is harder, being more penetration/indentation resistant and more resistant to oxidation and thermal ageing than 3LPE. The excellent materials and corrosion protection properties at high temperatures (95ºC and 100ºC) such as cathodic disbondment, hot water immersion resistance, peel adhesion and thermal ageing resistance) shows the new coating be stable in the high temperature operational environments and can therefore be used for an extended operating temperature of up to 100ºC over traditional 3LPE.

The important properties of a pipeline coating system differ during installation and operation the pipeline. During pipeline installation the mechanical properties of the coating tend to be more important than factors related to materials and corrosion protection. Mechanical properties that are important during installation include flexibility, impact resistance, abrasion resistance and gouge resistance. Extensive testing was therefore conducted to compare key performance properties with typical values from conventional FBE/DLFBE/3LPE coating systems at typical coating thicknesses specified by the Australian and international standards illustrated in Figure 5.

Table 1. Materials properties of the new coating against requirements of AS/NSZ 3862, CSA Z245.21 and ISO 21809-1

Topcoat Material Properties	ISO 21809-1	AS NZ 3862	CAN/CSA Z245.21-10	Sure Bond 100
MFR (190°C/2.16kg), g/10min	N/A	N/A	0.15 - 0.80	2.1 - 4.05
Density, g/cm^3	≥ 0.930	N/A	> 0.940	1.13 ± 0.05
Tensile at Yield at 23±2°C, MPa	≥ 15	≥50 (4% elongation min)	≥ 18.5	>18
Elongation at Break (50 mm/min) at 21±2°C, %	≥ 600	N/A	≥ 600	≥30
Vicat Softening Point A/50 (9.8N), °C	≥ 110	N/A	≥ 120	≥110
Water content, %	≤ 0.05	≤4.5% (at 98ºC)	N/A	≤ 0.03
Oxidation induction time (210°C), min	≥ 30 at 210 ºC, or ≥ 10 at 220 ºC	N/A	≥ 10 (at 220 ºC)	≥ 10 (at 220 ºC)
Environmental Stress Cracking Resistance, hours	≥ 1000 (cond A), or ≥ 300 (cond B)	N/A	≥ 300 (cond B)	Not available
Thermal ageing	ΔMFR ≤ 35% (4800 h, 100 ± 3 ºC)	N/A	At least 65% of original tensile stress at yield; min elongation of 150% (2400 ± 24 h, 100 ± 3 ºC)	>2400hrs, to 50% elongation (100 ± 3 ºC)
UV Resistance (7GJ/m^2)	ΔMFR ≤ 35%	No film degradation other than surface chalking within 6 months	N/A	Not available
Hardness, Shore D	≥ 55	N/A	≥ 60	≥60
Abrasion resistance (CS 17 wheels,1000g load,1000 cycles)	N/A	≤60mg	N/A	≤40mg
Dielectric strength (free film)	N/A	≥40V/µm	N/A	Not available
Water permeation (free film)	N/A	≤1.5g.mm/m^2 in 24 hr	N/A	Not available
Volume resistivity	N/A	25ºC, ≥1.0 X 10^{13}Ωm.min; 100ºC, ≥1.0 X 10^{10}Ωm.min (ASTM D257)	N/A	>10^{10} Ω.m^2 (DIN 30670, 100 days, 23 ºC)
Thermal stability (dry and immersion cycling)	N/A	Adhesion rating 2 or better, impact >1.5J (Dry: 100 ºC, 72 h, 4 cycles; Immersion: 110 ºC, 72 h, 4 cycles)	N/A	No delamination after 10 cycles (+23°C to +100°C, +23°C to -70°C, -70°C to +100°C)

Table 2. Performance properties of the new coating system against requirements of AS/NSZ 3862, CSA Z245.20 and ISO 21809-1

Qualification of Applied Coating	ISO 21809-1	AS/NZS 3862	CAN/CSA Z245.21	Sure Bond 100™
Primer thickness	≥ 0.125 mm	≥ 0.4 mm	≥ 0.12 mm	> 0.25 mm
Adhesive thickness	≥ 0.150 mm	N/A	≥ 0.10 mm	N/A
Total coating thickness	≥ 2.3 - 4.2 mm (min thickness wrt Ø)	≥ 0.4 mm	N/A	≥ 1.65 mm
Degree of cure	ΔTg ≤ 5 ºC	ΔTg ≤ 4 ºC, Cure ≥ 95%	N/A	ΔTg ± 3 ºC
Porosity, degree of foaming	N/A	Rating ≤ 3 (cross sectional and interface)	N/A	Rating ≤ 3 (cross sectional and interface)
Impact resistance	> 7 J/mm at 23 ± 3 °C No holiday	≤ 550 µm = 1.5 J, > 550 µm = 3 J No holiday, at 21 - 25 ºC	≥ 3 J/mm at -30 ± 3 ºC, no holiday	>10 J/mm at 23 °C
Adhesion/peel resistance	≥15 N/mm at 23 ± 3 ºC, ≥3 N/mm at 80 ± 3 ºC,	Rating 2 or better (V-cut adhesion)	≥ 150 N at 20 ± 3 ºC	Cannot be peeled at 23 ºC ≥ 3 N/mm at 80 ºC
Indentation/ penetration resistance	≤ 0.2 mm at 23 ± 3 °C, ≤ 0.4 mm at 80 ± 3 °C	N/A	N/A	≤ 0.1 mm at 23 °C, ≤ 0.3 mm at 80 °C, ≤ 0.4 mm at 100 °C
Elongation at break (50 mm/min)	≥ 400 %	N/A	≥ 300 %	≥ 30 %
Tensile stress at yield	N/A	N/A	≥ 17.0 MPa	≥ 18.0 MPa
Cathodic disbondment	≤ 7 mm (after 24hrs, 65 ± 3 ºC)	≤ 6 mm (after 24hrs at 65 ± 3ºC)	≤ 7 mm (after 24hrs at 65 ± 3ºC)	≤ 5 mm (after 24hrs, 65 ± 3 ºC)
	≤ 7 mm (after 28 days, 20 ± 3 ºC)	≤ 7 mm (after 28 days, 22.5 ± 2.5ºC)	≤ 12 mm (after 28 days, 20 ± 3 ºC)	≤ 5 mm, (after 28 days, 23 ± 3 ºC)
	≤ 15 mm (after 28 days, max op. temp, max 90ºC)	N/A	meets purchaser's spec (after 28days, max design temp)	≤ 15 mm (after 28 days at max op. temp.)
Hot water immersion	Average 2mm and max 3mm (after 48hrs, 80 ± 3 ºC)	Rating 2 or better (after 24hrs, 98 ± 2 ºC)	N/A	Rating 1
Flexibility	No cracking at an angle of 2°/pd at -2 to 0 °C	Min 3.75º/pd for ≤600µm, no cracking; for greater thicknesses, by agreement	2.5 °/pd at -30ºC, -18ºC or 0ºC , no cracking	3 %strain at 0 ºC, -30 ºC
Product stability during application of PE (in process degradation)	ΔMFR ≤ 20%	N/A	N/A	Not available
Thermal cycling	N/A	N/A	N/A	No change after >10 cycles (-50 to 100 °C)
Weathering	N/A	N/A	N/A	>1000 hs retaining 50% of original elongation of topcoat

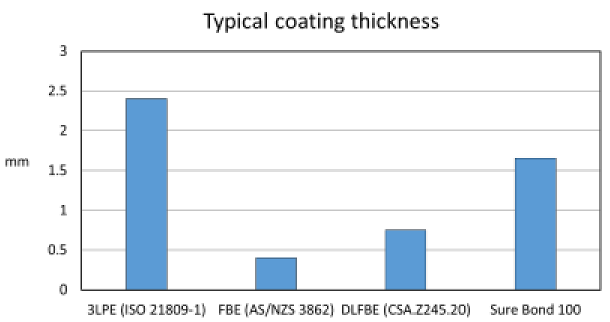

Figure 5 Comparison of various typical total thickness for various pipeline coating systems

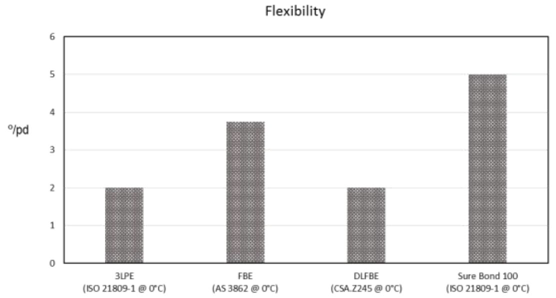

Figure 6 Average flexibility values for various pipeline coating systems at 0ºC

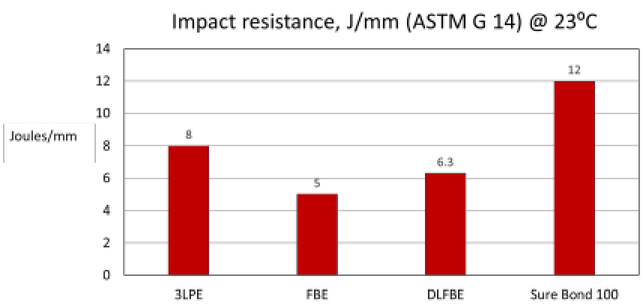

Figure 7 Impact resistance for various pipeline coating system at 23ºC

Figure 8 No holiday damage was detected at 20 Kv on the new coating system after concrete impingement

The flexibility of a coating system impacts the ability of the coated pipe to be subjected to field bending and hydrostatic testing for onshore pipeline and the ability to be reeled for offshore pipeline laying. The average flexibility values for various coating systems determining using at 0ºC are presented in Figure 6, which shows that the new coating system has significantly higher flexibility over FBE, DLFBE, and 3LPE.

The impact resistance reflects the ability of a pipeline coating to withstand the forces encountered during backfill of the pipeline trench. Testing of the coating impact resistance generally involves dropping of a known weight from a known height and measuring the energy required to penetrate the coating. The average impact resistance values for various pipeline coating systems determined at 23ºC using ASTM G14 standard test method are presented in Figure 7. Such measurements are useful in selecting a coating thickness to suit pipeline backfill construction and soil conditions. The results suggest that the new coating system can achieve the same or better impact strengths at almost half of the coating thickness of a 2.2-3.5mm conventional 3LPE. For offshore pipeline application with a concrete weight coating, the adequate coating thickness of the anti-corrosion coating system is also required in order to ensure no damage to the anti-corrosion coating film during the concrete impingement process. Figure 8 shows that no holiday damage was detected at 20 Kv on the new coating system after concrete impingement.

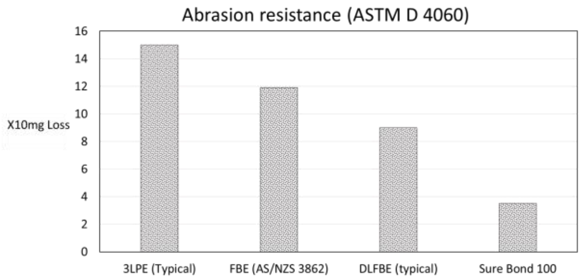

Figure 9 Abrasion resistance for various pipeline coating system (CS17, 1 kg load @ 1000 cycles)

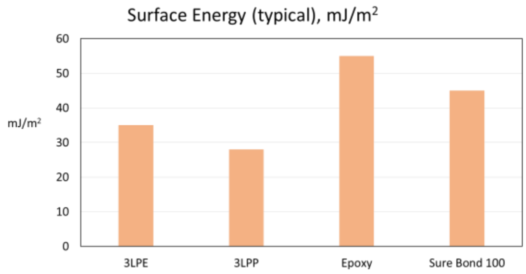

Figure 10 Surface energy values of different mainline coating systems

Abrasion and gouge resistance measurements are used to simulate in ground pipeline movement as well as the impact of activities such as directional bores for road and river crossings. Figure 9 presents the average abrasion weigh losses for various pipeline coating systems determined as per ASTM D4060 using CS17 wheels after 1 kg load and 1000 cycles. The abrasion resistance values of FBE and 2LFBE products were very scattered from one to another product, and many would not meet the Australian AS/NZS 3862 standard requirement for ≤60 mg. However, it can be seen that the new coating system shows improved abrasion resistance than FBE/2LFBE/3LPE. Table 3 compares the gouge resistance of DLFBE, 3LPE and the coating system at 50ºC as per CSA Z245.20. In terms of gouge depth, DLFBE had the least penetration. However all these coating system passed the holiday testing at 7.5Kv and the new coating system behaved similarly to 3LPE in gouge resistance at 50ºC.

Table 3 Gouge resistance comparison among DLFBE, 3LPE and the new coating system

Gouge Resistance (CSA Z245.20, cl 12.5) @ 50 ℃			
Coating System	**3LPE**	**DLFBE**	**SureBond 100**
Average depth of penetration, mm	0.91	0.4	0.90
Holiday detection at 7.5Kv	Passed	Passed	Passed

4. FIELD JOINT COATING COMPATIBILITY

Field joint coating reliability is one of the key concerns by pipeline corrosion engineers and operators. The performance of a field joint coating needs to match the mainline product to avoid corrosion weak spot in the corrosion protection integrity chain. This requires that the field joint coating be fully compatible with and strongly bonded to the mainline coating, and be equivalent or similar in performance properties to the mainline coating.

The novel approach of incorporating polar structural and cross-linkable reactive groups into the new coating formulation resulted in a higher surface energy of the coating film than polyethylene and polypropylene (Figure 10). The higher surface energy and reactive groups makes the new coating system behave very similarly as FBE and DLFBE in terms of field joint coating compatibility. As a result, the new coating system is fully compatible with and strongly bonded to a wide variety of available field joint coating options, including FBE, two part liquid epoxy/polyurethane and heat shrinkable sleeves.

Table 4 Overlap interface bonding between the new pipeline coating system and its two field joint coating options

Tested item	Tested location	Temperature	Result
Field Joint Coating Option 1: GTS-SB Heat Shrinkable Sleeve			
Cross cut adhesion	Overlap	23ºC	Rating 1
Cross cut adhesion	Overlap	100ºC	Rating 1
Hot water immersion adhesion after 7, 14, 21, and 28 days	Overlap	95ºC	Rating 1
Field Joint Coating Option 2: HBE-SB Liquid Epoxy			
Cross cut adhesion	Overlap	23ºC	Rating 1
Cross cut adhesion	Overlap	100ºC	Rating 1
Hot water immersion adhesion after 7, 14, 21, and 28 days	Overlap	95ºC	Rating 1

When most existing field joint coating products currently available in Australia may be used, two standard field joint coating options for the new coating system are presented: 1) the use of a GTS-SB heat shrinkable sleeve (HSS) and 2) the use of a HBE-SB two pack liquid epoxy coating. The GTS-SB HSS is very similar to in application but with higher performance than GTS-65 and GTS-80 – the two HSS products that were used and familiar with by the Australian pipeline industry. The HBE-SB liquid epoxy coating is specifically formulated for compatibility with the new coating system to ensure long term bonding through cross-linking. Table 4 shows the results of the overlap interface bonding between the new coating system and its two field joint coating options, determined as per ISO 21809-3 [6]. Rating 1 means no removal of coating other than that caused by insertion of the flat point of knife blade at the intersection point (usually less than 1 mm), demonstrating the excellent cross cut dry adhesion and wet adhesion after long term hot water immersion for the both field joint options.

5. PIPELINE PROJECT EXAMPLE

Rotary Pipeline - a jetty line from the Port of Fujairah (POF) to IL&FS Prime Tank Terminal to transport multiple oil products has recently been installed in the United Arab Emirates. The pipe sizes of the pipeline ranged from 6.63" to 30” in diameter with wall thickness of 7.11 mm to 12.70 mm. The client originally specified the use of 3LPE coating systems of 3.05 mm (for pipe size <20”) to 3.55 mm (for pipe size >20”), but soon decided to switch the use of the new coating system. The coating work was successfully executed by Bredero Shaw’s Ras Al Khaimah (RAK) facility in Q4 2013. Project ITP and requirements were easily passed. Excellent production qualification test results were obtained, including zero cathodic disbondment at 20 ±5 ℃ and 65 ±5 ℃ for 48 hours @ -1.5 volts (Figure 11) and average cathodic disbondment of 3.20 mm at 23 ±2 ℃, 2.53 mm at 65 ±2 ℃ and 2.72 mm 85 ±2 ℃ for 28 days @ -1.5 volts. No damage was observed after pipe storage and field handling as seen from Figure 12, while the pipes were being stencilled in field.

Figure 11 Zero cathodic disbondment was obtained after 48 hours at 65ºC @ -1.5 volts

Figure 12 No damage of the new coating system was observed during field stencilling

6. CONCLUSIONS

A novel composite polymeric pipeline coating solution was developed, based on a FBE base coat and an outer layer of reinforced polyolefin. The new anti-corrosion coating system brings to the pipeline industry with many enhanced performance benefits while being able to offer the values through competitive prices. These benefits include:

- Much better moisture barrier, higher corrosion resistance and higher flexibility over FBE/DLFBE;
- Improved hardness and abrasion/penetration/impact resistance over 3LPE, enabling the same if not better corrosion and mechanical protection of the new coating system at almost half of the coating thickness of standard 3LPE;
- Non adhesive layer and reduced coating thickness, minimizing associated component thermal mismatch or residual stress;
- Extended operating temperature rating up to 100^{o}C; and
- Unsurpassed field joint adherence property and compatibility to different field joint coating materials.

The new coating system meets and exceeds the performance property requirements of existing AS/NZS 3862, CSA Z245.20 and ISO 21809-1 standards. The production and field testing results of the actual pipeline project in hot environment climates in UAE, which is similar to Australia, showed that the new pipeline coating system can perform as equivalent to or better than 3LPE and DLFBE in pipe handling characteristics, installation behaviour and overall product performance.

7. ACKNOWLEDGMENTS

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9. AUTHOR DETAILS

Dr. S.W. Guan has more than 30 years of experience in corrosion and protective coatings and is Chair of NACE TG353 for multi-layer polyolefin pipe coatings and Chair of NACE TG281 for field applied polyurethane coatings. He is responsible for all technical aspects and strategic markets for Bredero Shaw Asia Pacific, and also a NACE CIP Instructor.

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S. McLennan, Senior Business Development Manager for Australia, has almost 30 years of pipe coating industry experience with Bredero Shaw/ShawCor in business development and general management roles in Europe, Africa, and Australia. He has been based in Perth since 2008.

P. Mayes, is an independent business professional with 30 years of experience in coating application and advising on pipeline protective coating properties, selection and compatibility in Australia. Peter is a long term member Australian coating Standards CommitteeME38-8. Recently retired from ISO committee covering 21809 series and previously an adviser to the APIA Research and Standards Committee, with a lengthy involvement with Research projects. He is currently a consultant to ShawCor Australia.