Introduction:

Due to the nature and conditions of Corrosion Under Insulation (CUI) extensive testing procedures are vital to be able to identify a coating system which is suitable for CUI and will provide long lasting protection in such harsh environments. This report shows the procedures and results of Performance Polymers CUI testing program, this incorporates a diverse range of testing methods which the resulting coating will be subjected to in a CUI environment. Thermaguard™ CUI 650 is specifically formulated to combat CUI & this report is the presentation of its testing results regarding PPBV's CUI testing program.

Performed by; J.Reynolds (Development Chemist, PPBV)

Method:

All testing will be in accordance to the appropriate ISO standard for each specific test.

Tabulated test procedure:

Panels were prepared by solvent cleaning and blast cleaning to Sa 2 ½ standard (8501-1), blasting profile (R_z) 40-75µm, followed by approx. 2 x 150µm DFT Thermaguard™ CUI 650 & competitor 1 via airspray application on 5mm steel panels. Unless otherwise stated.

Thickness of the coating system was measured according to ISO 2808.

All coated panels were cured for 7 days @ 23^{o}C and approx. 50% RH before testing.

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PPBV's Corrosion Under Insulation (CUI) table to state types of environments where each test will be require high performance:

Test type	Exposure in practice
CUI test: To simulate a typical CUI environment of which the coating can demonstrate long term durability in such an aggressive scenario.	The subjected coating will be in a CUI environment throughout its required service life.
Thermal resistance: Demonstrates that the coating can endure high temperatures without any degradation occurring.	Substrate temperatures are likely to be elevated and cyclic throughout service life.
Salt spray: The product is able to provide high levels of anti-corrosive protection of the substrate while waiting for and during its service life.	Waiting for service, during transit and during service.
Hot water immersion: Immersion is a part of CUI hence the coating must be able to endure to prevent any corrosion of the substrate.	During a CUI environment, waiting for service or during transit.
Adhesion: To demonstrate the coating is capable of adhering to the required substrate which sufficient strength to provide long term service life.	Continuous throughout service life.
Chemical resistance: High performance against acidic, alkaline & hydrocarbon chemical environments demonstrates the coating can perform without degrading from corrosive foreign contaminates.	During service from leaching insulation, waiting for service & during transit or spillages on-site.
Impact resistance & cylindrical mandrel testing: Demonstrates the coating is flexible and hard and it can endure stresses applied to the coating in practice. Good adhesion is also essential to obtaining high performance.	During service with maintenance procedures & during transit.
Pencil hardness: Demonstrates the coatings film hardness & the physical state of the polymer in question.	During transit and service life.
Abrasion testing: Abrasion testing will show the levels of; film hardness, cohesive and adhesive strength of the coating system.	During transit and service life.

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Test results of Thermaguard™ CUI 650 & competitor 1:

Test type	ISO standard	Test procedure	Length of test (days)	Results	
				Thermaguard™ CUI 650	Competitor 1 (market leader)
Corrosion Under Insulation (CUI)	N/A	16 hours @ 204°C. Thermal shock (water, 23°C). 8 hours in HWI (95°C). Repeat 80 cycles.	122	No cracking, delamination or blistering. Small rust spots under film dolly pull of test. (Figure 1)	No cracking, delamination or blistering. Heavy rusting under film after dolly pull of test. (Figure 1)
Adhesion: **cross cut & pull-off**	2409 4624	PosiTest AT-A Automatic Adhesion Tester. Ambient. Heat cured (1h @ 250°C).	8	5A – cross cut (X-CUT). 5 mPa 100% cohesive – dolly. (ambient) 7 mPa – 100% cohesive – dolly (250°C heated) (Figure 2, ambient pull off test)	4A-5A – cross cut (X-CUT) 2.2 mPa 100% adhesion failure (ambient) 4-5 mPa 100% cohesive (cured @ 250°C) (Figure 2, ambient pull off test)
Salt spray	7253	Q-FOG cyclic corrosion chamber. Ambient. Heat cured (1h @ 250°C). 1440h.	60	Max 2mm corrosion creep & no blistering. (Figure 3 & 4, ambient salt spray during and after time exposure)	Unmeasureable corrosion creep. Poor ambient corrosion resistance. Spot rusting after both ambient & heat cured. (Figure 5 & 6, ambient salt spray during and after time exposure)
Hot water immersion	2812/2	Immersion for 1000h @ 90°C.	42	No corrosion, blistering or adhesion loss.	Blistering and small spot rusting, rust under dolly after adhesion test.
Impact resistance	6272-1	TQC Direct impact tester.	8	15 cm (ambient & heated)	25cm (ambient)
Cylindrical mandrel (bend)	1519	TQC Cylindrical bend test 100mm (SP1820). 0.75mm panels	8	32 mm Microcracking, no adhesion loss Ambient and heated (250°C)	Cracking at both ambient and heat cured (1 hour @ 250°C) loss of adhesion at edges of substrate.
Pencil hardness	15184/ASTM 3363	TQC Pencil Hardness Test (750g) VF2377.	8	7H (ambient cured 7 days).	2H (ambient 7 days).
Thermal resistance	N/A	Heat to 650°C. Allow to cool to ambient temperature.	8	No cracking, blistering or adhesion loss.	No cracking, blistering or adhesion loss.
Abrasion resistance	7784-3	Taber Abraser (Abrader) – Model 5135.	8	Passes 500 cycles Ambient 110µm film loss Heated 250°C 98µm film loss	Fails 500 cycles Ambient – fails to the substrate
Chemical resistance	ISO 2812-4:2007 (method A)	Using HCL & H_2SO_4 10%, Diesel and NaOH 50%.	8	HCl, H_2SO_4 & hydrocarbon - No removal of coating or blistering. Discolouration from chemical. NaOH – Discolouration, slight removal of film to approx. 280µm. (Figure 7)	HCl – removal of coating - 200µm remaining H_2SO_4 – removal of coating - 80µm film remaining Hydrocarbon (diesel) – removal of coating to the substrate NaOH - discolouration of film (Figure 8)

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Conclusion:

To provide and methodise a testing procedure which will subject the coating to extremely harsh environment of which can replicate the expected conditions during its required service life has been established. The test results of the Thermaguard™ CUI 650 was compared to the market leading coating of choice (Competitor 1) for CUI prevention during its testing program stated above. This testing program combines all parameters which are required for long service life in CUI conditions, the coating shows it is very resistant to Corrosion Under Insulation environments and provides exceptional protection for steel which is likely be exposed in a CUI environment.

Signed:

Development Chemist

Performance Polymers b.v.

Director

Performance polymers b.v.

Figures:

Figure 1

Figure 2

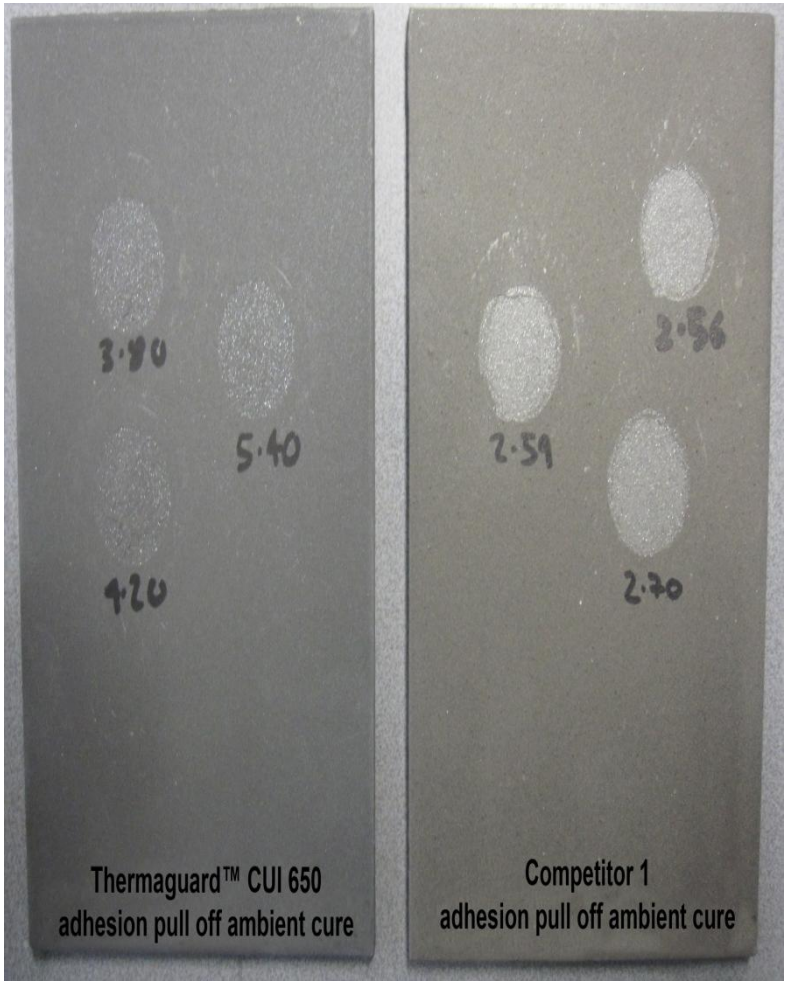

Figure 3 & 4 (Thermaguard™ CUI 650)

Figure 5 & 6 (Competitor 1)

Figure 7 (Thermaguard™ CUI 650)

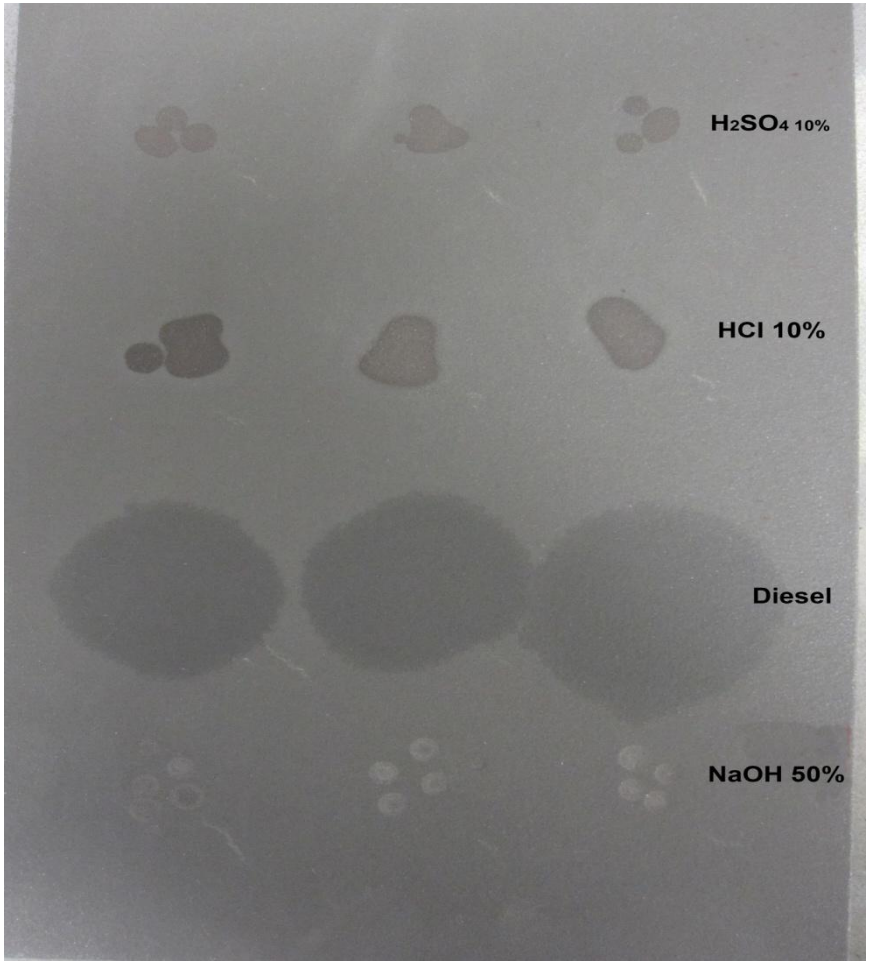

Figure 8 (Competitor 1)

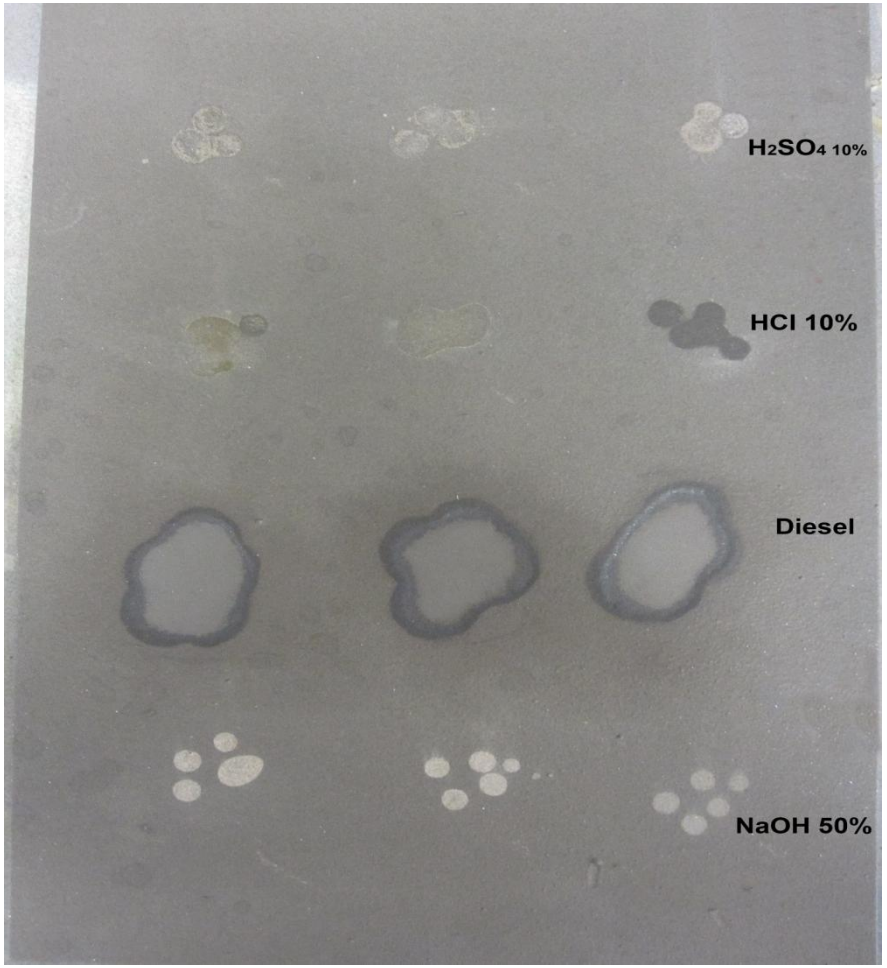

Figure 9 (overview of some test methods of the PPBV CUI test program)