LUMIFLON™

LUMIFLON™ Resins for Bridge Coatings

AGC

Your Dreams, Our Challenge

Introduction

Fluorourethane coatings based on FEVE (fluoroethylene vinyl ether), have been used globally for over 30 years. This technology has a proven record of outstanding performance with respect to outdoor exposure, offering the highest standard in gloss and colour retention. Besides excellent aesthetic performance, long time corrosion protection is achievable as well and therefore FEVE resins find many applications as part of protective coating systems. One particular application where both long-term aesthetic and protective performance is required are bridge coatings. Steel bridges need to be protected with the best possible anti corrosive coating technology but are also often iconic structures where visual appearance is of importance. Furthermore, repainting bridges is a cumbersome and expensive job which emphasizes the benefits of long lasting coating systems even more.

This technical brochure will detail the use of Lumiflon coatings for Bridge applications. Showing an example of a bridge coated more than 30 years ago in Japan without ever being repainted.

Coatings that passed the new ISO 12944-6 standard, category C5 (very high corrosive environment) and ISO 12944-9 CX (high impact areas) tests protocols, are also shown. These coating were formulated with EU available raw materials and the testing was performed and assessed by COT in Haarlem the Netherlands, an independent research laboratory certified to perform industrial specification testing for the coating industry.

LUMIFLON™

Fluoroethylene vinyl ether (FEVE) resins were developed in Japan in the late 1970's and were first commercialized in 1982. FEVE resins are amorphous A-B type copolymers with repeating units of fluoroethylene and substituted vinyl ether (see Figure 1). Unlike pure fluoropolymers, FEVE resins are soluble in solvents due to the vinyl ether groups. Solvent solubility transforms FEVE resins from high performance polymers into high performance resins for coatings. [1]

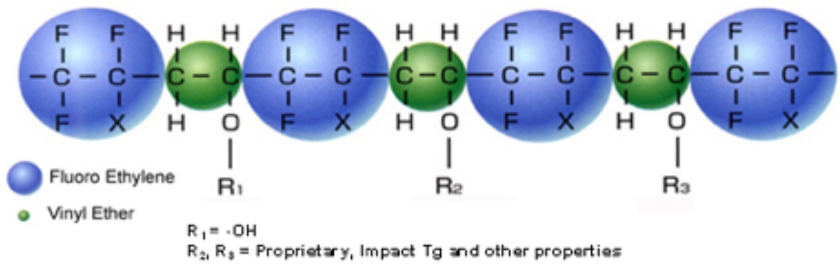


Figure 1. Alternating Structure of FEVE Resins

FEVE resins have characteristics of both fluoropolymers and hydrocarbons. The fluoroethylene groups are the strength of the FEVE resin. These groups are responsible for the polymer's high resistance to UV degradation. The C-F bond is very strong (see Table 1). The energy of this bond is higher than the energy of UV radiation at 290nm which is ~411KJ/mol. The alternating pattern, shown in figure 1, is critical for the extreme UV resistance properties. The chemically stable and UV resistant fluoroethylene units sterically and chemical protect the neighbouring vinyl ether units. [1]

Table 1. Bond energy of Fluoro-Chemicals and Commodity Chemicals [2]

Resin	C-C Chain	KJ/mol	C-F. C-H	KJ/mol
Fluoro Compound	CF3-CF3	414	F-CF2-CH3	523
Fluoro Compound	CF3-CH3	424	CF3CH2-H	447
Commodity Chemical	CH3-CH3	379	CH3CH2-H	411

The vinyl ether groups make FEVE polymers useable as resins for paint. Without the vinyl ether groups, FEVE resins would not be soluble in solvent. This solubility is what allows FEVE resins to be used in a wide array of coating formulations that can be applied in factory or on-site settings. A wide range of curing temperatures can be employed ranging from Room Temperature to 230 °C. The vinyl ether groups also contribute to high gloss and allow for functional groups, like hydroxyl groups, to be incorporated into the structure. Below is a table showing typical properties of FEVE resins. [1]

Table 2. Typical Properties of FEVE Resins

Property	Value
Fluorine Content	20-30 wt%
OH Value	47-170 mg KOH/g
COOH Value	0-15 mg KOH/g
Molecular Weight	M_n = 15000-100000
Specific Gravity	1.4 – 1.5
Morphology	Glassy (T_g = 20-50°C
Solubility Parameter (cal'd)	8.8

As explained above FEVE resins are renowned for their extremely high durability due to the high C-F bond energy. Therefore, they do not degrade under the influence of UV radiation from the sun. Fluorourethane topcoats have been tested in both accelerated and natural weathering. The following figures show the weathering performance typical of fluorourethane coatings based on FEVE resins. Figure 2 shows a comparison of a FEVE coating to polysiloxane and acrylic urethane based coatings in QUV accelerated weathering. The FEVE coating clearly outperforms the other resins which are renowned on their own in the industry for their good weatherability. Furthermore Figure 3 shows South Florida exposure of a clear and a yellow FEVE coating. This data clearly shows the excellent performance of the FEVE based coating technology achieving a gloss retention of around 70% after 10 years of exposure.

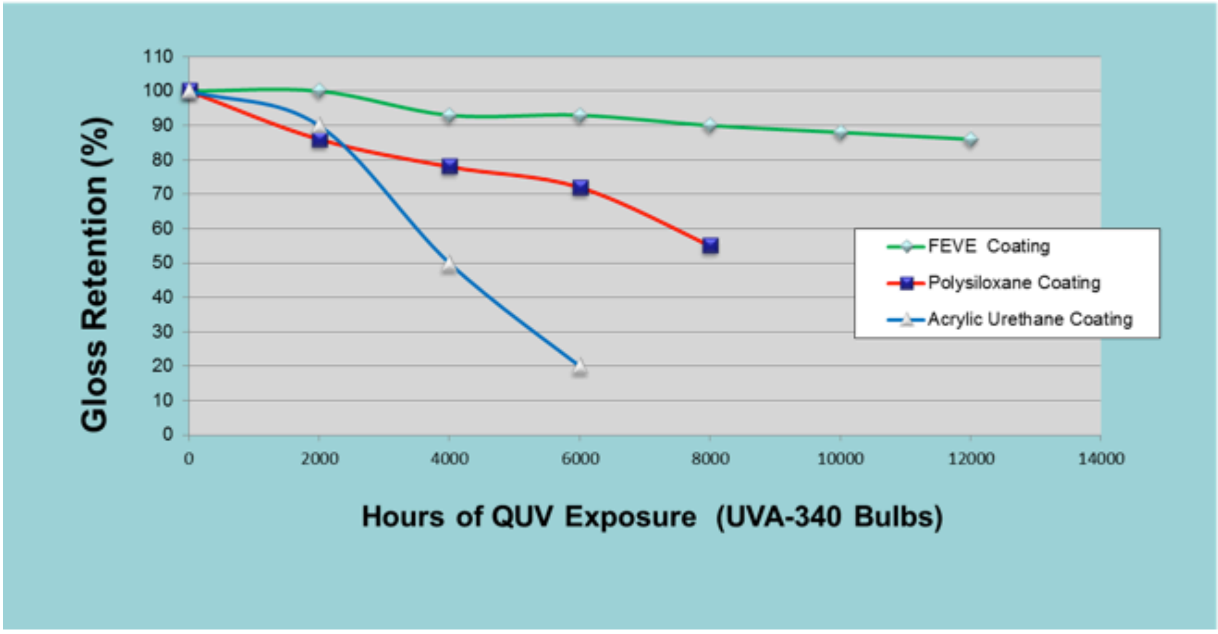


Figure 2. QUV Exposure of an FEVE Based Coating

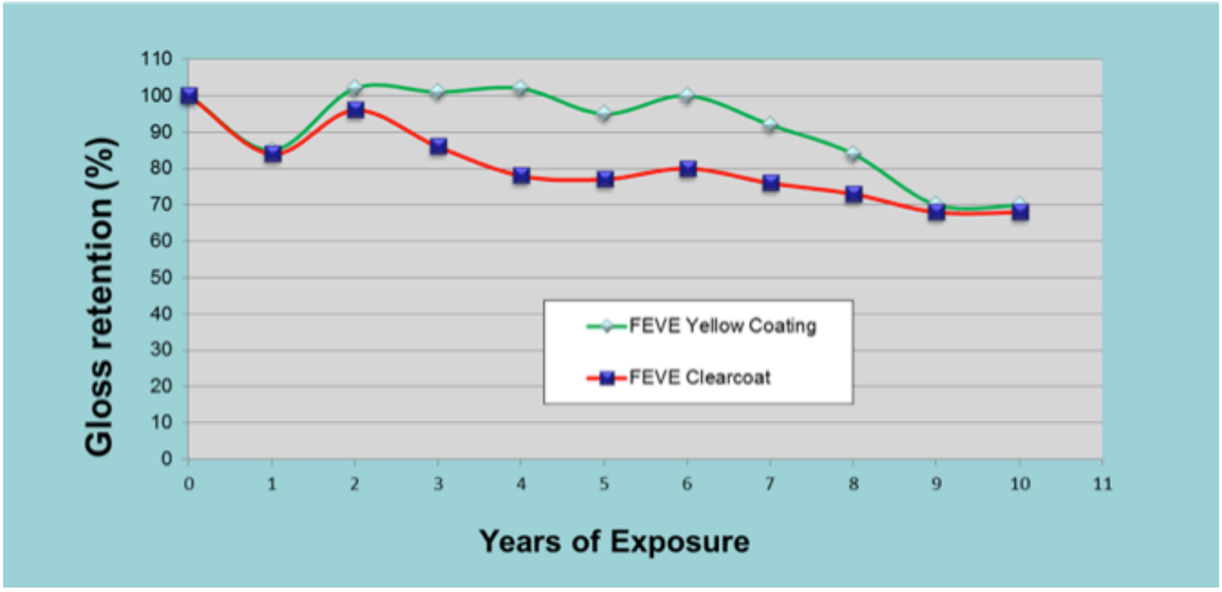


Figure 3. South Florida Exposure of an FEVE Based Coating

Besides excellent gloss and color retention FEVE topcoats also offer a great benefit in terms of general protection of underlying substrates. Due to the high UV resistance and lack of degradation of the resin the coating itself will stay intact much longer than for example an acrylic urethane based topcoat. Figures.4 and 5 show film consumption for the fluoro-polymer coating and polyurethane coating in cross section after 15 year of exposure. A portion of the coating was covered with tape and thus was not exposed to sunlight. Under the tape the film was not damaged. The film thickness of each topcoat after 15 years outdoor exposure could be compared to the original film thickness under the tape. After 15 years, the fluoro-polymer topcoat has lost about 1.1μm total (less than 0.1 μm/year), while the polyurethane topcoat has lost 22-28μm (about 2μm/year).

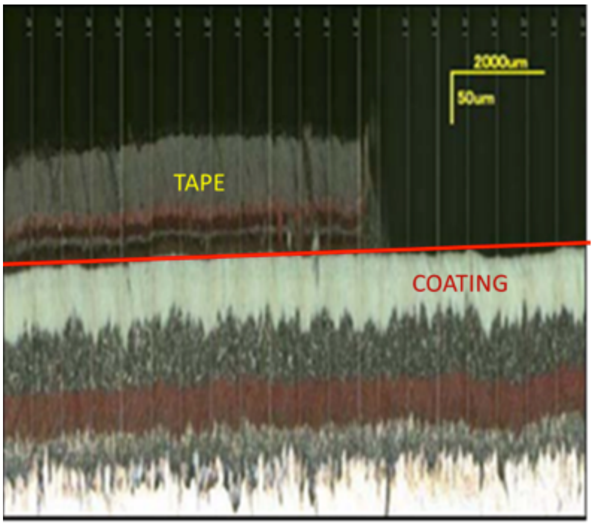


Figure 4. FEVE white coating. 1 micron of erosion after 15 years of exposure

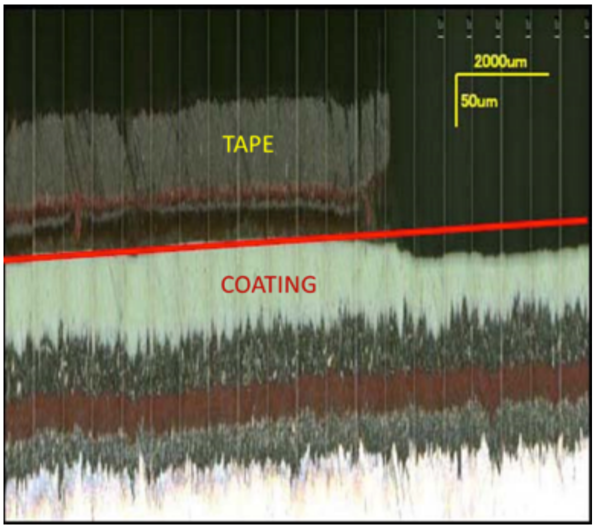


Figure 5. Polyurethane white coating. 22-28 micron of erosion after 15 years of exposure.

In Figure 6, two sections of the coating are analysed by Imaging IR (IRT7000[3]). That measurement can detect amide (II) absorbance and quantify it in comparison to theC-H band or C-F band. A chemical map is generated, which shows the distribution of the amide bond through the cross-section. The color gradient of this map directly relates to the concentration of isocyanates. In the case of the Fluoro-polymer, comparing the cross-section which has been light-sealed (map A) and the cross-section which has been exposed (map B) shows that the decomposition of isocyanates is very limited. Indeed, the same intensity in the gradient can be observed with the red color present through the depth of both cross-sections. In the case of the Polyurethane, the protected cross-section (maps C) and the exposed cross-section (map D) show large differences. In the map of the exposed cross-section, the yellow color indicates that the isocyanate concentration is much lower in comparison to that of the protected cross-section in red. UV light has induced the degradation of the isocyanate in the polyurethane coating, even at a 20μm depth from the surface. In practice this means that from a protection point of view one could use a much thinner topcoat if FEVE technology is used thus saving paint and application costs.

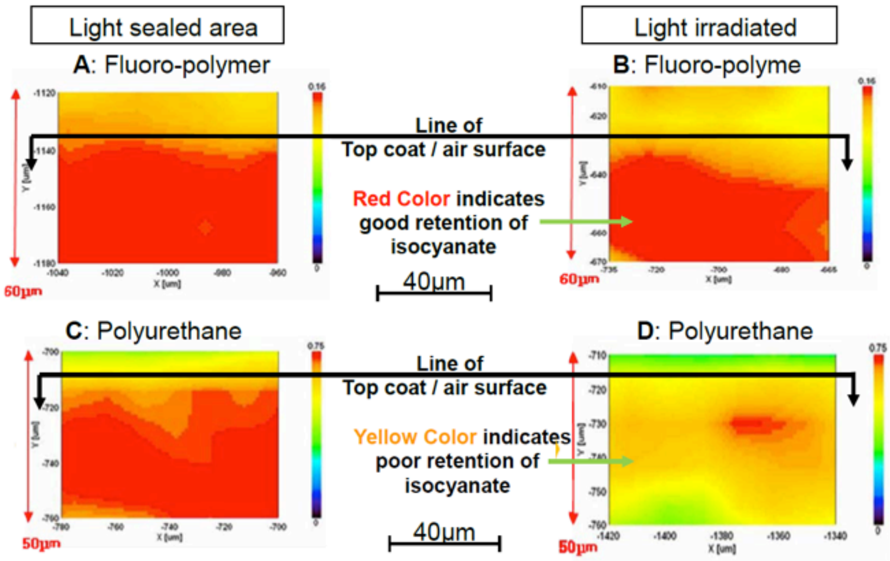
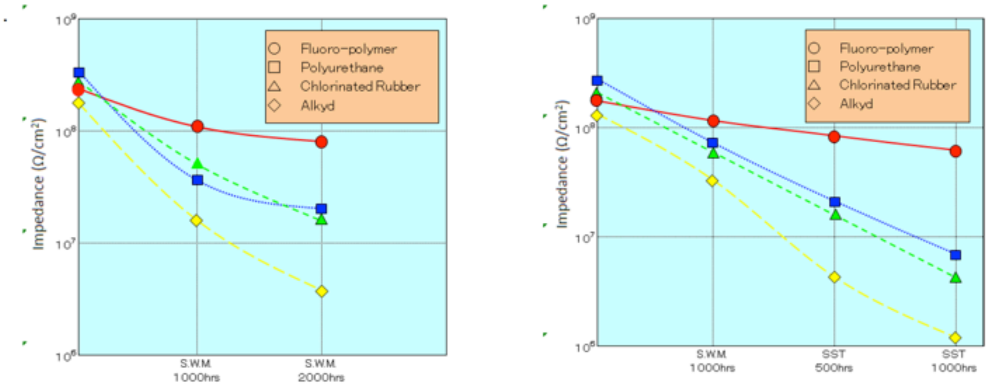


Figure 6. Isocyanates retention of each cross section of coats about mild light seal or irradiated surface area

Finally, in figure 7 Impedance Spectroscopy is shown which demonstrates that using a FEVE based topcoat offers benefits with respect to anti corrosive properties as well. In the experiment a standard corrosion inhibiting primer was used. The only difference is the topcoat technology. Also in this study the fluoropolymer based topcoat shows improved performance over polyurethane technology.



a) Sunshine WM 2000 hrs   b) Sunshine WM 1000 hrs + Salt spray test 1000

Figure 7. Impedance Spectroscopy

Bridge Applications in Japan

Ever since the development of FEVE resins by AGC in the early 80’s the Japanese road authorities have carried out performance testing and evaluations of coating sytems based on FEVE resins. The outstanding dubrability that was found led to the mandatory use of fluorinated topcoats for bridges throughout Japan.

The Daiichi-Mukaiyama bridge was newly build in 1987 (see figure 8). The primer and middle coats were shop applied and the topcoat system, based on a Lumiflon resin system, was applied on site. Color and gloss measurements were taken initially and after 22 and 30 years. Furthermore the coating was inspected for chalking and other degradation signs. As is demonstrated in Table 3 and Figure 9 the paint system performed excellent after 30 years of service life. A gloss retention of over 70% was measured after wiping the coating free of dust and dirt. Also, no rust peeling or cracking was observed. Color measurements could not be compared due to a change in colorimetric techniques throughout the years. However the red color still appears as bright as when it was applied 30 years ago.

Figure 8. Daiichi-Mukaiyama bridge

North face   East face   South face   West face

Figure 9. Daiichi-Mukaiyama bridge inspection after 30 years

Table 3. Gloss Retention.

		Initial	22 years	30 years
Non wiped	Measured value	52.4	46.5	28.3
	Retention	-	88.7%	54%
Wiped	Measured value	52.4	49.9	38.7
	Retention	-	92.5%	78%

Table 4. Appearance Observation after 30 years.

	Part Investigated	**Rust**	**Peeling**	**Crack**
Upstream Side	Brace	0	0	0
	Cross Girder	0	0	0
	Arch Rib	0	0	0
Downstream Side	Brace	0	0	0
	Cross Girder	0	0	0
	Arch Rib	0	0	0

Bridge coatings in Europe

In Europe, most countries have their own specifications for bridge coatings. These specifications are often referring to the ISO 12944 standard for coating performance requirements in different corrosive environment classes. In some countries coating systems first need to be tested according to these requirements at an independent certified testing institute before they can be placed on a qualified product list. After which the coatings can be applied on bridge structures. These specifications only look at the corrosion protection performance of the coating system. Aesthetic longevity is not considered. As of today almost all bridge coating systems in Europe are based on polyurethane or polysiloxane topcoat technology. These systems are able to pass the corrosion testing and as aesthetic durability is not specified there seems to be no need for fluorinated systems. The use of FEVE coating systems will greatly increase the maintenance intervals. Over the lifetime of a bridge it will thus offer significant cost saving. This is recognized more and more in industry, and bridge owners are asking for prolonged durability (> 30 years) both on corrosion and aesthetic performance. A first example of this is an Italian specification for fluorinated coating systems called ANAS IT.CDTG.05.18.

In recent years a number of bridges in Europe have been coated with fluorinated resins as a result of these developments. Figure 10 shows two such examples, one in Switzerland and one in Italy. However, the share of FEVE based coatings in the grand scheme remains small.

Figure 10. European Bridge applications

Specification Testing [3]

Recently, ISO published a new version of its 12944-specification document. The new specification now includes a section on testing for 25 years protection for the different corrosive environments which is mentioned in the 12944-6 section. Furthermore, an added section called 12944-9 now details testing for CX environment and different immersion classes. AGCCE decided to reformulate the Japanese commercial topcoat formulations with EU available raw materials and test these systems to the new ISO standards at the COT research laboratory in Haarlem which is accredited to perform specification testing. Two white coatings and a red coating were tested. All passed the specification testing as will be shown below.

Three topcoat formulations were submitted for specification testing at COT Haarlem. Two different whites, which used a standard TiO2 grade (white 1) and a high durable TiO2 grade (white 2), and a red topcoat were applied. The primer and middle coat for each system was the same. Application and testing of the full coating systems was performed at COT in Haarlem, the Netherlands. Table 5 depicts the different coating systems.

Table 5. Coating system

Coating	White 1 (dft µm)	White 2 (dft µm)	Red (dft µm)
Bonn Zinc No.20 ZHB	60	60	60
Bonnflon primer for steel towers No.630	200	200	200
Bonn Epocoat No.30 HB Grey	30	30	30
Lumiflon Topcoat	30	30	30

The substrates were steel panels blasted to Sa 2.5 grade cleanliness according to ISO 8501-1. Surface roughness Medium (G) according to ISO 8503-1.

ISO 12944-6 Testing results

Test Specification:	ISO 12944-6
Corrosivity Category:	C5
Durability range:	very high
Test regime:	2

Table 6. Assessment after Cyclic Ageing test: White 1

Cyclic Ageing ISO 12944-6 Annex B Exposure 2688 hours			COT sample number 1-6-18/0344			
			Panel 1.3	**Panel 1.10**	**Panel 1.13**	**Rewquirement**
Q	ISO 4628-2	Blistering	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-3	Rusting	Ri 0	Ri 0	Ri 0	Ri 0
Q	ISO 4628-4	Cracking	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-5	Flaking	0(S0)	0(S0)	0(S0)	0(S0)
	Corrosion from scribe (mm)		2.1	2.5	2.6	≤ 3.0
	ISO 4624	Adhesion (MPa)	9.5	7.4	8.4	≥ 2.5 MPa No A/B break unless ≥ 5MPa
		Break area (%)	100% C	100% C	100% C	
			8.3	8.4	8.3	
			100% C	100% C	100% C	
			9.2	7.8	9.6	
			100% C	100% C	100% C	

Table 7. Assessment after Cyclic Ageing test: White 2

Cyclic Ageing ISO 12944-6 Annex B Exposure 2688 hours			COT sample number 1-6-18/0345			
			Panel 2.10	**Panel 2.13**	**Panel 2.14**	**Requirement**
Q	ISO 4628-2	Blistering	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-3	Rusting	Ri 0	Ri 0	Ri 0	Ri 0
Q	ISO 4628-4	Cracking	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-5	Flaking	0(S0)	0(S0)	0(S0)	0(S0)
	Corrosion from scribe (mm)		2.6	3.0	2.2	≤ 3.0
	ISO 4624	Adhesion (MPa)	9.2	8.6	7.9	≥ 2.5 MPa No A/B break unless ≥ 5MPa
		Break area (%)	100% C	100% C	100% C	
			8.8	9.5	8.1	
			100% C	100% C	100% C	
			9.1	8.3	9.0	
			100% C	100% C	100% C	

Table 8. Assessment after Cyclic Ageing test: Red

Cyclic Ageing ISO 12944-6 Annex B Exposure 2688 hours			COT sample number 1-6-18/0346			
			Panel 19	**Panel 20**	**Panel 21**	**Requirement**
Q	ISO 4628-2	Blistering	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-3	Rusting	Ri 0	Ri 0	Ri 0	Ri 0
Q	ISO 4628-4	Cracking	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-5	Flaking	0(S0)	0(S0)	0(S0)	0(S0)
	Corrosion from scribe (mm)		2.8	2.2	2.7	≤ 3.0
	ISO 4624	Adhesion (MPa)	10.3	9.8	7.8	≥ 2.5 MPa No A/B break unless ≥ 5MPa
		Break area (%)	100% C	100% C	100% C	
			8.8	8.8	7.7	
			100% C	100% C	100% C	
			8.0	8.9	8.9	
			100% C	100% C	100% C	

ISO 12944-9 Testing results

Test Specification:	ISO 12944-9
Corrosivity Category:	CX
Immersion Category:	Im4

Table 9. Assessment after Cyclic Ageing Test: White 1

Cyclic Ageing ISO 12944-9 Annex B Exposure 4200 hours			COT sample number 1-6-18/0344			
			Panel 19	**Panel 20**	**Panel 21**	**Requirement**
Q	ISO 4628-2	Blistering	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-3	Rusting	Ri 0	Ri 0	Ri 0	Ri 0
Q	ISO 4628-4	Cracking	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-5	Flaking	0(S0)	0(S0)	0(S0)	0(S0)
	Corrosion from scribe (mm)		3.7	3.2	2.9	≤ 9.0 mm (CX)
	ISO 4624	Adhesion (MPa)	9.0	9.0	7.6	≥ 2.5 MPa No A/B break unless ≥ 5MPa
		Break area (%)	100% C	100% C	100% C	
			9.8	7.9	8.9	
			100% C	100% C	100% C	
			9.2	8.8	8.4	
			100% C	100% C	100% C	

Table 10. Assessment after Cathodic Disbondment test: White 1

Cathodic disbondment ISO 15711 - Method A Exposure 4200 hours	COT sample number 1-6-18/0344			
	Panel 1.11	**Panel 1.12**	**Panel 1.17**	**Requirement**
Disbondment diameter (mm)	6	6	6	
	-	-	-	
	-	-	-	
	-	-	-	
ECD (mm)	0	0	0	≤ 20 mm

Table 11. Assessment after Immersion test: White 1

Immersion test ISO 2812-2 – ISO 15711 Exposure 4200 hours			COT sample number 1-6-18/0344			
			Panel 1.1	**Panel 1.5**	**Panel 1.7**	**Requirement**
Q	ISO 4628-2	Blistering	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-3	Rusting	Ri 0	Ri 0	Ri 0	Ri 0
Q	ISO 4628-4	Cracking	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-5	Flaking	0(S0)	0(S0)	0(S0)	0(S0)
	Corrosion from scribe (mm)		8.2	8.2	9.3	≤ 6.0 mm
	ISO 4624	Adhesion (MPa)	100% C	100% C	100% C	≥ 2.5 MPa No A/B break unless ≥ 5MPa
		Break area (%)	8.2	8.2	9.3	
			100% C	100% C	100% C	
			8.2	8.2	9.3	
			100% C	100% C	100% C	
			100% C	100% C	100% C	

Table 12. Assessment after Cyclic Ageing test: White 2

Cyclic Ageing ISO 12944-9 Annex B Exposure 4200 hours			COT sample number 1-6-18/0345			
			Panel 2.3	**Panel 2.8**	**Panel 2.9**	**Requirement**
Q	ISO 4628-2	Blistering	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-3	Rusting	Ri 0	Ri 0	Ri 0	Ri 0
Q	ISO 4628-4	Cracking	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-5	Flaking	0(S0)	0(S0)	0(S0)	0(S0)
	Corrosion from scribe (mm)		3.7	3.8	3.5	≤ 9.0 mm (CX)
	ISO 4624	Adhesion (MPa)	8.5	7.6	7.8	≥ 2.5 MPa No A/B break unless ≥ 5MPa
		Break area (%)	100% C	100% C	100% C	
			8.6	9.9	8.1	
			100% C	100% C	100% C	
			7.6	7.0	9.3	
			100% C	100% C	100% C	

Table 13. Assessment after Cathodic Disbondment test: White 2

Cathodic disbondment ISO 15711 - Method A Exposure 4200 hours	COT sample number 1-6-18/0345			
	Panel 2.6	**Panel 2.11**	**Panel 2.12**	**Requirement**
Disbondment diameter (mm)	6	6	6	
	-	-	-	
	-	-	-	
	-	-	-	
ECD (mm)	0	0	0	≤ 20 mm

Table 14. Assessment after Immersion test: White 2

Immersion test ISO 2812-2 – ISO 15711 Exposure 4200 hours			COT sample number 1-6-18/0345			
			Panel 2.15	**Panel 2.19**	**Panel 2.20**	**Requirement**
Q	ISO 4628-2	Blistering	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-3	Rusting	Ri 0	Ri 0	Ri 0	Ri 0
Q	ISO 4628-4	Cracking	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-5	Flaking	0(S0)	0(S0)	0(S0)	0(S0)
	Corrosion from scribe (mm)		0	0	0	≤ 6.0 mm
	ISO 4624	Adhesion (MPa)	9.2	7.3	7.1	≥ 2.5 MPa No A/B break unless ≥ 5MPa
		Break area (%)	100% C	100% C	100% C	
			8.5	6.3	8.4	
			100% C	100% C	100% C	
			8.3	6.9	7.9	
			100% C	100% C	100% C	

Table 15. Assessment after Cyclic Ageing test: Red

Cyclic Ageing ISO 12944-9 Annex B Exposure 4200 hours			COT sample number 1-6-18/0346			
			Panel 11	**Panel 13**	**Panel 14**	**Requirement**
Q	ISO 4628-2	Blistering	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-3	Rusting	Ri 0	Ri 0	Ri 0	Ri 0
Q	ISO 4628-4	Cracking	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-5	Flaking	0(S0)	0(S0)	0(S0)	0(S0)
	Corrosion from scribe (mm)		3.5	3.8	3.8	≤ 9.0 mm (CX)
	ISO 4624	Adhesion (MPa)	7.9	7.8	9.1	≥ 2.5 MPa No A/B break unless ≥ 5MPa
		Break area (%)	100% C	100% C	100% C	
			6.5	6.6	8.9	
			100% C	100% C	100% C	
			8.4	7.6	8.7	
			100% C	100% C	100% C	

Table 16. Assessment after Cathodic Disbondment test: Red

Cathodic disbondment ISO 15711 - Method A Exposure 4200 hours	COT sample number 1-6-18/0346			
	Panel 5	**Panel 10**	**Panel 16**	**Requirement**
Disbondment diameter (mm)	6	6	6	
	-	-	-	
	-	-	-	
	-	-	-	
ECD (mm)	0	0	0	≤ 20 mm

Table 17. Assessment after Immersion test: Red

Immersion test ISO 2812-2 – ISO 15711 Exposure 4200 hours			COT sample number 1-6-18/0346			
			Panel 8	**Panel 17**	**Panel 18**	**Requirement**
Q	ISO 4628-2	Blistering	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-3	Rusting	Ri 0	Ri 0	Ri 0	Ri 0
Q	ISO 4628-4	Cracking	0(S0)	0(S0)	0(S0)	0(S0)
Q	ISO 4628-5	Flaking	0(S0)	0(S0)	0(S0)	0(S0)
	Corrosion from scribe (mm)		0	0	0	≤ 6.0 mm
	ISO 4624	Adhesion (MPa)	7.6	8.6	6.0	≥ 2.5 MPa No A/B break unless ≥ 5MPa
		Break area (%)	100% C	100% C	100% C	
			7.5	8.5	8.8	
			100% C	100% C	100% C	
			6.8	7.6	9.4	
			100% C	100% C	100% C	

All three coatings systems passed the requirements for test methods showing their outstanding protective performance in the toughest environments.

Conclusion

FEVE resins offer great benefits for use in bridge coating paint systems. The technology has a proven record of accomplishment in Japan of over 30 years performance. Furthermore, the testing carried out at COT has verified the performance of coating systems formulated with EU available raw materials to the highest ISO 12944 specification standards.

References

[1] Kristen Blankenship, "Formulation Techniques Using FEVE Resins in Waterborne and High Solids Coatings," Proceedings of the Forty-Second Annual International Symposium of Waterborne, High Solids, and Powder Coatings Symposium, p. 251 (2015).

[2] E. Bure, "Smart Fluorinated Organic Molecules", Molecular structure and energetics vol.3, Chap.4 pp141-191(1986)

[3] Testing and application of coatings performed at: COT Haarlem, The Netherlands (http://www.cot-nl.com/?lang=en)

Appendix 1

Formulations

The topcoat formulations that were used in the testing can be found below.

White 1

Pigment Paste		(Parts by Weight)
LUMIFLON™	LF 200	16.7
Solvent	Xylene	14.08
Dispersant	Disperbyk-163*	1.18
Pigment	Ti-Pure R-960**	26.95
	Total	58.9
** BYK-Chemie*		
*** DuPont*		
Let Down		**(Parts by Weight)**
Pigment paste	Above described	58.9
LUMIFLON™	LF 200	39.5
Defoamer	BYK-141*	0.1
Catalyst	1/1,000 DBTDL (Xylene)	0.4
Rheology modifier	BYK-430*	0.6
Thickner	BYK-431*	0.5
	Total	100.0
** BYK-Chemie*		
Paint Formulation		
Main pack	Above described	100
Hardener	Desmodur N3300***	6.1
**** Covestro*		

White 2

Pigment Paste		(Parts by Weight)
LUMIFLON™	LF 200	16.7
Solvent	Xylene	13.66
Dispersant	Disperbyk-163*	1.6
Pigment	PFC-105**	26.95
	Total	58.9
** BYK-Chemie*		
*** ISK ; Ishihara Sangyo Kaisha*		

Let Down		(Parts by Weight)
Pigment paste	Above described	58.9
LUMIFLON™	LF 200	39.5
Defoamer	BYK-141*	0.1
Catalyst	1/1,000 DBTDL (Xylene)	0.4
Rheology modifier	BYK-430*	0.6
Thickner	BYK-431*	0.5
	Total	100.0
** BYK-Chemie*		

Paint Formulation		
Main pack	Above described	100
Hardener	Desmodur N3300***	6.1

Red

Pigment Paste		(Parts by Weight)
LUMIFLON™	LF 200	68.38
Solvent	Xylene	10.3
Solvent	Butyl acetate	12.77
Dispersant	Disperbyk-163*	3.1
Pigment	Holtint Red F2R (type1)**	4.4
Matting agent	ACE MAT OK412***	0.05
	Total	99.0
** BYK-Chemie*		
*** Hollandia International*		
***Evonik Resource Eficiency		
Let Down		**(Parts by Weight)**
Pigment paste	Above described	99.0
Defoamer	BYK-141*	0.2
Catalyst	1/1,000 DBTDL (Xylene)	0.3
Thickner	BYK-431*	0.5
	Total	100.0
** BYK-Chemie*		
Paint Formulation		
Main pack	Above described	100
Hardener	Desmodur N3300****	7.33
**** *Covestro*		

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