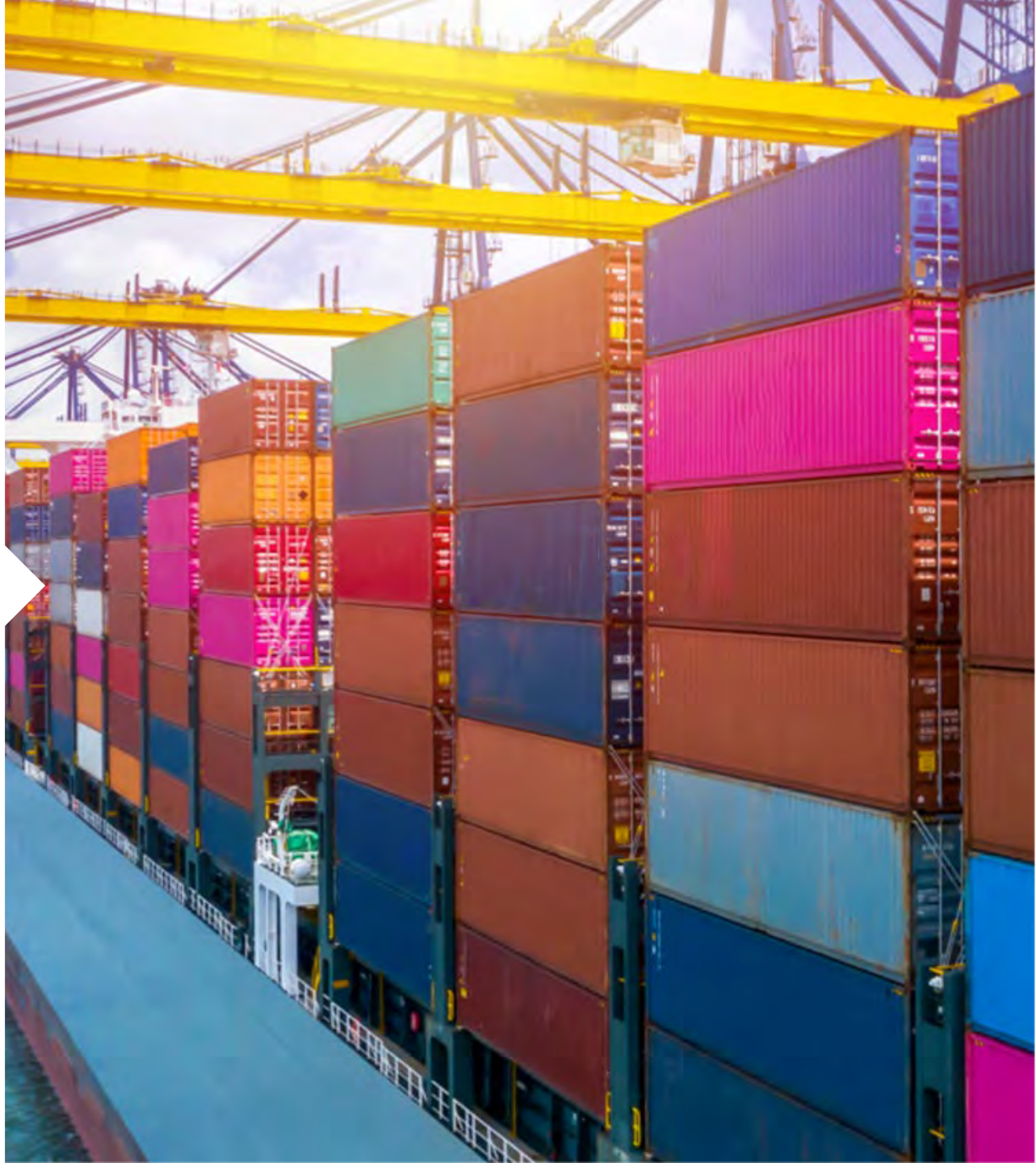
SOLVAY

Progress beyond

Reactive Epoxy Emulsifier

January 2022



The Solvay team

Peng ZHANG
Technical Leader
Coating, Solvay Novecare, Asia Pacific

Mr. Zhang Peng Technical Leader in Solvay is an experienced scientist from China, who has been working in the coatings market for over ten years. Since joining Solvay in 2016, he has worked on the development of new emulsifiers and monomers focusing mainly on industrial coating applications.

Janice NG
Global Project Manager - Industrial Coating
Business Development Manager - APAC

Janice Ng is the global project manager for Industrial coating segment who manages Industrial innovation portfolio. She is also the business development manager for APAC, responsible for all coating opportunities and project developments in Asia. Janice joined Solvay in 2016 and has been instrumental in developing roadmap strategy for growth.

Agenda

1. Key Drivers in Water based conversion

1. Industrial Coating Standards

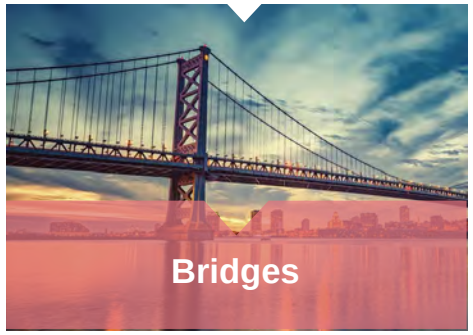
1. Water-based container coating system

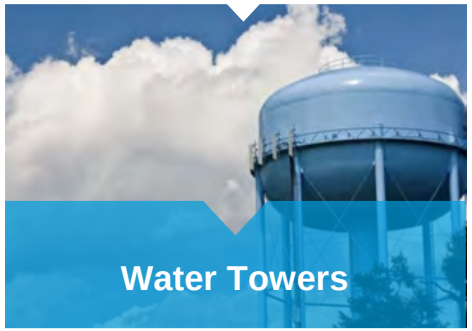
1. Water-based Epoxy emulsion process and formulation

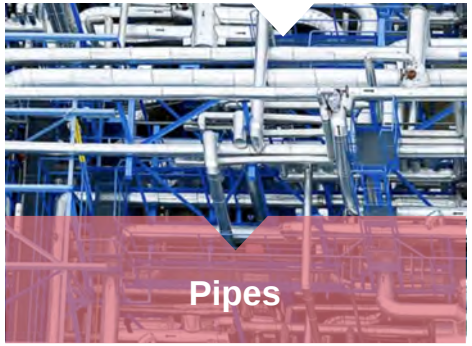
1. Paint formulation and application test

WB Industrial Coating Market

Operating more efficiently and more sustainably







Key Drivers for Water based Conversion

Drivers

- Stricter environmental regulation (low VOC regulations, Green Sky in China, etc.)
- Pressure for sustainability (HSE, Resource efficiency etc)
- Differentiation strategy for companies with environmental-friendly claims
- Growing consumer demand for coatings free from odors and potentially hazardous raw materials
- Fast rising demand in Asia, with growing middle class, increasing purchase power

Challenges

- Regulation difficulties
- Perceived lower performance of WB vs SB in demanding applications
- Higher cost of WB formulation resulting in low market acceptance
- Higher WB conversion investment cost

ISO 12944-2:2018 Protective Paint System

General Classification	Corrosion Classification	Applications	Base Coat	Top Coat	Chemical Resistance	Condensation-water Resistance ISO 6270-1	Corrosion Resistance Salt Spray/h ISO 9227
Light Duty	C1 Very Low	• Industry Machinery Coating • General Steel Protection • Temporary Protection	• Baking • 2K PU/2K Acrylic • WB Acrylic • WB Alklyd				
	C2 Low					Low: 48 Medium: 48 High: 120	NA
Mid Duty	C3 Medium	• Automotive OEM, AR • Container Coating • Railway Coating • Bus/Truck Coating	• WB/SB Epoxy • WB 2 K PU • Baking	• WB PUD/2K PU • WB Acrylic		Low: 48 Medium: 120 High: 240	Low: 120 Medium: 240 High: 480
	C4 High					Low: 120 Medium: 240 High: 480	Low: 240 Medium: 480 High: 720
Heavy Duty	C5-Industrial Very High	• Tank, pipe, marine and offshore coating	Mainly solvent based system		Low: 168 Medium: 168 High: 168	Low: 240 Medium: 480 High: 720	Low: 240 Medium: 720 High: 1440
	C5-Marine Very High					Low: 240 Medium: 480 High: 720	Low: 240 Medium: 720 High: 1440
	CX Extreme High	Offshore areas with high salinity and industrial areas with extreme humidity and aggressive atmosphere and subtropical and tropical atmosphere					

China Industrial Coating Standards

RAILWAY

Railway Coating (2020- 50% conversion to WB)

QCR581-2017
Railway coating standard

CONTAINER

Container coating (VOC<100g/L) (100% WB)

JH/T E06-2015
Water-based container coating standard

MARINE

Marine Coating (No Specific VOC regulation)

GB/T6822—2007
Antifouling and anti Corrosion

GB/T6748—2008
Anti corrosion in Marine Coating

GB/T6823—2008
Anti corrosion in ballast tank

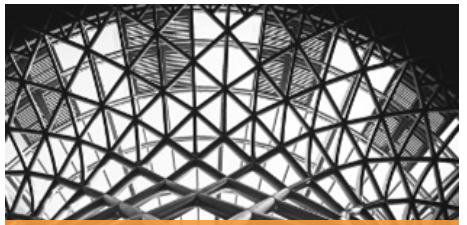
MACHINERY

Machinery (VOC<300g/L)

HGT 4339-2012
Heavy duty machinery

HGT 4757-2014
ACE

GB 30981
Harmful substances in Industrial Coating

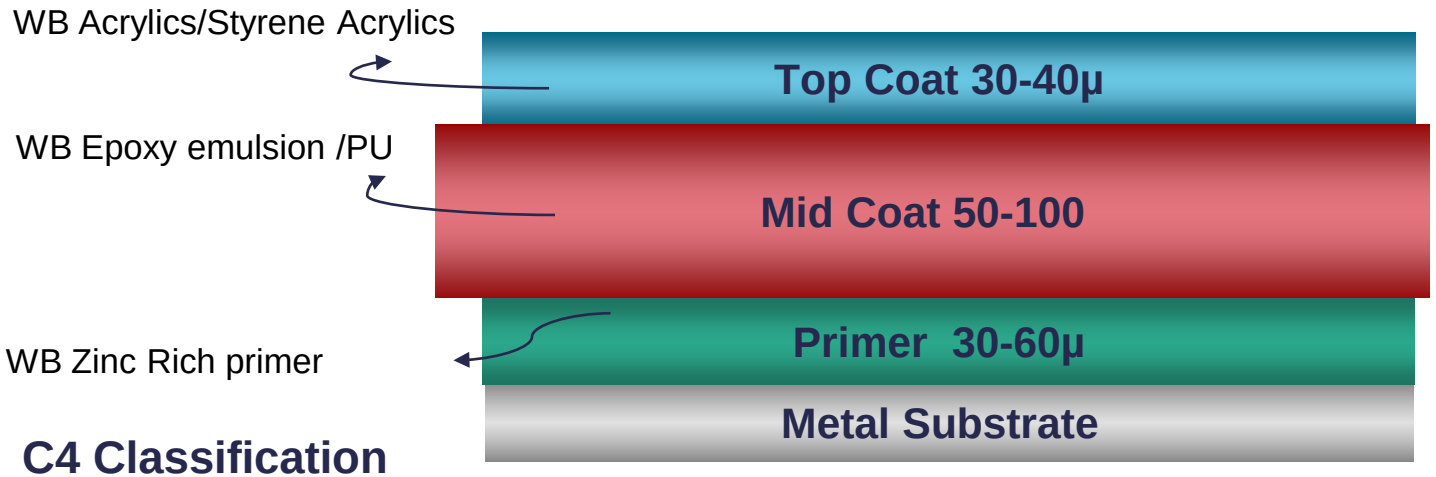


STEEL

Steel Structure (VOC<200g/L)

HGT 5176-2017
Industrial coating in Steel structure

Water based Container Coating



C4 Classification

Properties	Test Method	One Component	Two Components
Thickness	-	80 um	50-80 um
Gloss (60º)	GB/T9754-2007	50-60	50-60
Adhesion	GB/T 9286-1998	≤1	≤1
Pencil hardness	GB/T 6739-2006	H	H
Water Resistance	GB/T 1733-1993	>240h	>240h
Corrosion Resistance	ASTM B117-2011	240h	500h

- Future Trend - Conversion from Solvent to a water-based system
- New regulations for VOC reduction
- Green Environment

Development of Waterborne Epoxy Emulsion

Phase inversion technique (External emulsification)

Advantage: Easy handling, limited reactor requirement
Disadvantage: Worse stability, Poor particle size control and bad corrosion resistance

Chemical structure Modification (Internal emulsification)

Advantage: Better stability, smaller particle size, better application performance
Disadvantage: : Reaction under high temperature is required, complex reactor and process control, emulsion consistency is also a big challenge.

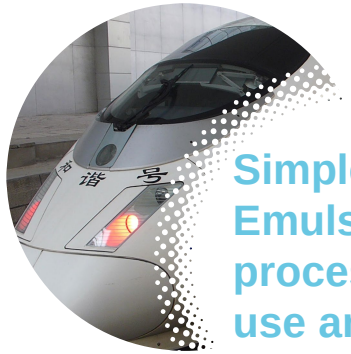
Reactive epoxy emulsification (Reactsurf® 0092)

Combines the advantages of the previous two different techniques. Easy handling with no additional chemical structure modification required.
Good particle size control, Perfect emulsion and paint stability.
Limited investment required with excellent emulsion consistency.
High crosslinking activity with curing agent, better application performance.

REACTSURF® 0092 – Reactive Epoxy Emulsifier

Reactsurf® 0092 is an APE-free, non-ionic reactive emulsifier for epoxy emulsion. It can be used directly in the emulsification process with no reaction required. Reactsurf® 0092 also offers excellent emulsifying ability and corrosion resistance.

Physical Properties	
Appearance	Colorless to light yellow pellet material
Moisture,% (KF Titration@65°C)	1.0% Max
Ionic Charge	Nonionic
epoxy number(mmol/100g)	60-80
pH (5% aqueous solution)	6.0 – 8.0



Simple Emulsification process, easy to use and incorporate

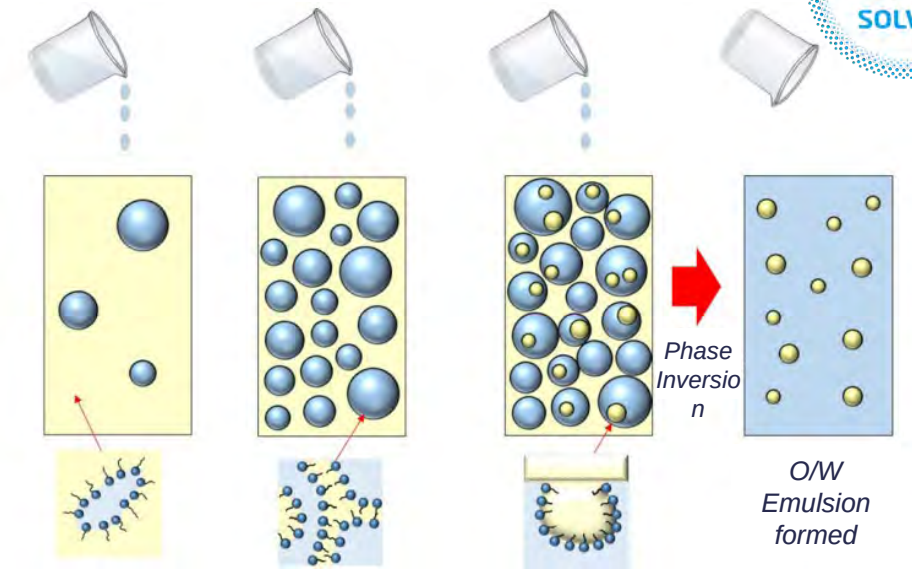
Excellent freeze thaw and storage stability

Good particle size control

Excellent corrosion resistance

Epoxy Emulsion Formulation & Process

	Ingredients		Weight
1	NPES-901 (EW 450-500)	Solid epoxy resin	196g
2	Propylene glycol monomethyl ether	Solvent	32g
3	Reactsurf® 0092	Epoxy emulsifier	24g
4	DI water		148g
	Total		400g
	Target EEW	**Based on total solid**	**490-540**
	Theoretical solid content		**55.00%**



J. S. Komaiko and D. J. McClements, *Comprehensive Reviews in Food Science and Food Safety, Vol 15, 331-352, 2016.*

Add Reactsurf® 0092 into a flask together with epoxy resin and solvent. Dissolve the mixture at 130°C.

Transfer the well dissolved mixture into a jacketed vessel with 40°C circulating condensate water. Disperse the mixture with 1000rpm.

Slowly add water into the vessel within 3hrs. Adjust the stirring speed to match the increased viscosity until the phase inversion point. Stop the feeding and continue grinding for another 1 hour.

Slow down the grinding speed and add the remaining water dropwise into the vessel within 45 minutes. Keep stirring for another 30 minutes after the end of feeding.

Epoxy Emulsion Properties

Reactsurf® 0092 shows strong emulsification ability and excellent emulsion stability.

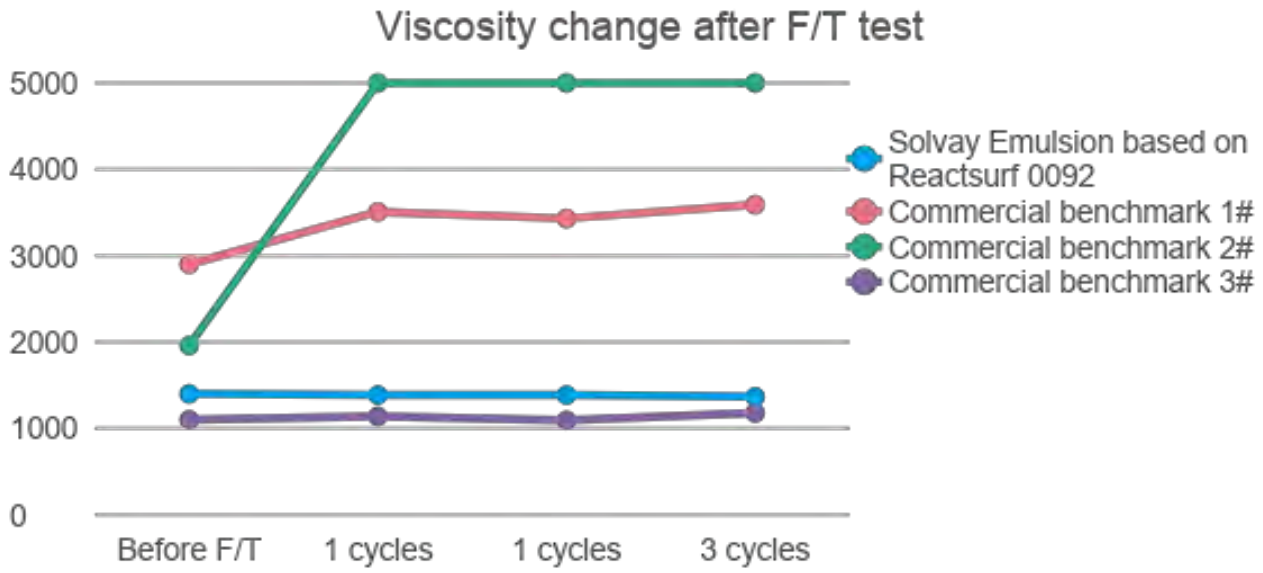
Emulsion properties	
Particle Size (D90)	0.980um
Particle Size (D50)	0.650um
Fineness	20um
Solid content	~55%
After heat storage (50°C 1 month)	
Particle Size (D90)	0.964um
Particle Size (D50)	0.621um
Fineness	20um

F/T stability of Epoxy Emulsion

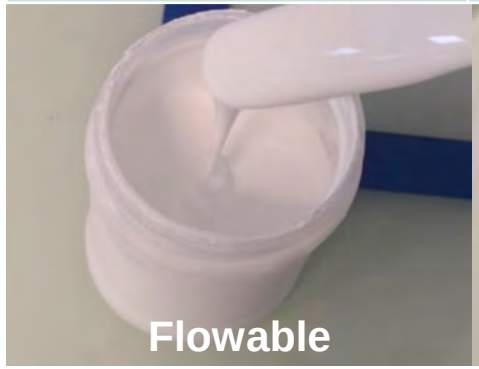
			-10°C 3 cycles		
	Before F/T	Flowability@ -10°C	3 cycles	4 cycles	5 cycles
Solvay Emulsion based on Reactsurf® 0092	1400	flowable	1387	1387	1367
Commercial benchmark 1#	2900	Freeze	3507	3430	3590
Commercial benchmark 2#	1960	Freeze	Gelled	Gelled	Gelled
Commercial benchmark 3#	1100	Freeze	1140	1093	1180

-5° C for 16 hours and RT 8hours, 2 cycles

-10° C for 16 hours and RT 8hours, 3 cycles

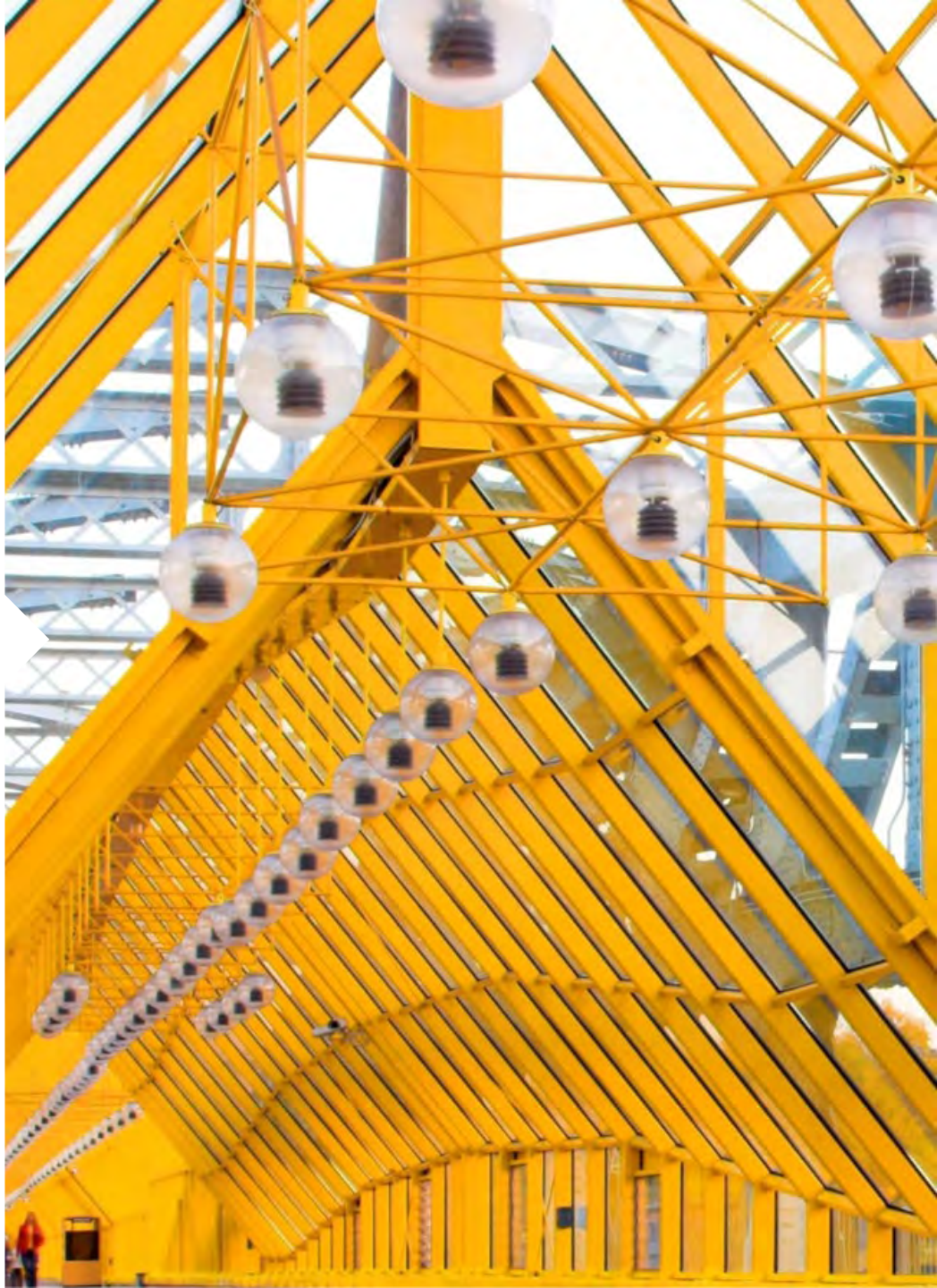


Flowable latex at -10° C for Reactsurf® 0092 emulsion

-10°C Appearance	
Reactsurf® 0092 Emulsion	**Commercial Emulsion**
	
Flowable	**Frozen**

Paint Formulation (Low PVC Red

	Component A	Weight, %
1	Epoxy emulsion (56% solid)	49.0
2	Propylene glycol methyl ether	3.4
3	C12-14 glycidyl ether	2.4
4	Dispersant	2.0
5	Deformer	0.05
6	BaSO4（800 mesh）	13.5
7	Mica	5.0
8	Zinc phosphate	6.0
9	Talc 1500	5.0
10	Iron oxide red	5.0
11	DI water	8.2
Charge all above materials into the vessel and grind until the fineness is lower than 30um. Then add the materials below into the container and mix well.		
12	HEUR thickener	0.3
13	Wetting agent	0.15
	Total	100.0
	Component B	**Agent**
1	Hardener A	22.4
2	Anti-flash rust additive	0.5
3	Adhesion promoter	0.5



Corrosion Resistance on CRS

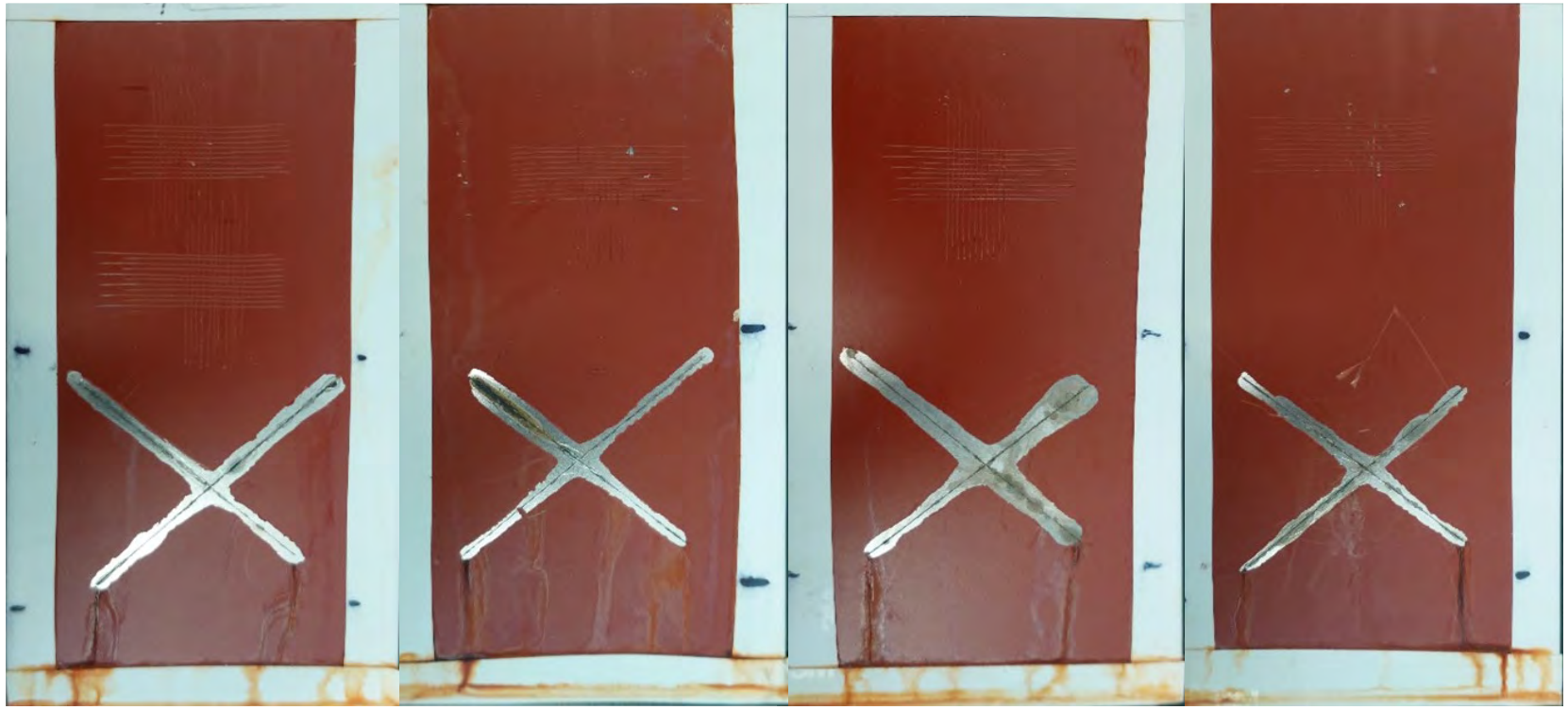
Solvay Emulsion with Reactsurf® 0092	Commercial benchmark 2#	Commercial benchmark 1#	Commercial benchmark 3#

500h Salt spray resistance

In the low PVC red formulation, Emulsion with Reactsurf® 0092 shows the best corrosion resistance, similar to Commercial benchmark 2#, much better than emulsions from Commercial benchmark 1# and Commercial benchmark 3#.

Corrosion Resistance on CRS

Reactsurf® 0092	Commercial benchmark 2#	Commercial benchmark 1#	Commercial benchmark 3#



According to the peel off area, Emulsion with Reactsurf® 0092 clearly shows better corrosion resistance compared to all benchmarks from the market.

Corrosion Resistance on CRS

Reactsurf® 0092	Commercial benchmark 2#	Commercial benchmark 1#	Commercial benchmark 3#

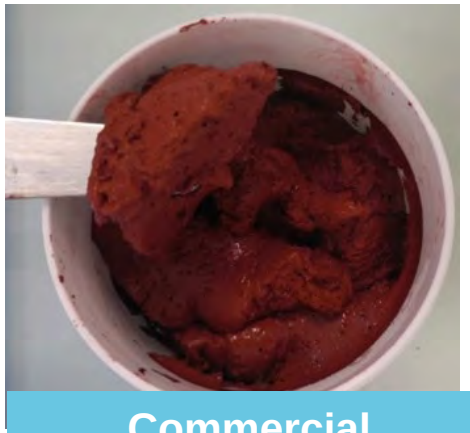
700h Salt spray resistance

After 700hrs, Emulsion with Reactsurf® 0092 still shows satisfactory corrosion resistance.
Also the wet adhesion to CRS is much better than all 3 benchmarks with no peel off.

Paint Formulation (High PVC Red formulation)

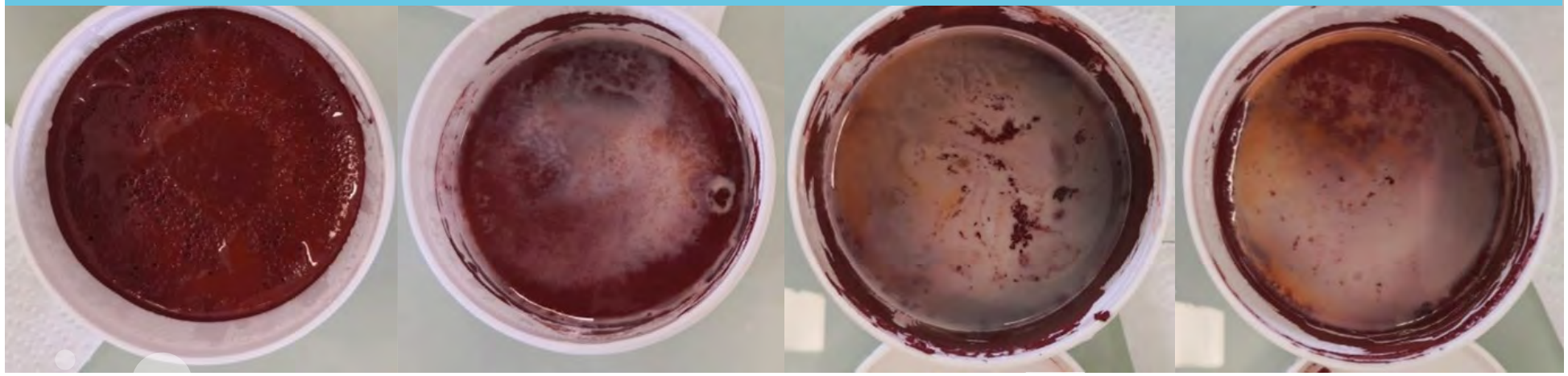
	Component A	Weight, %
1	Epoxy emulsion (56% solid)	35.0
2	Propylene glycol methyl ether	6.0
3	C12-14 glycidyl ether	3.0
4	Dispersant	2.5
5	Deformer	0.05
6	BaSO4（800 mesh）	13.0
7	Mica	8.0
8	Zinc phosphate	6.0
9	Talc 1500	11.5
10	Iron oxide red	6.0
11	DI water	8.5
Charge all above materials into the vessel and grind until the fineness is lower than 30um. Then add the materials below into the container and mix well.		
12	HEUR thickener	0.3
13	Wetting agent	0.15
	Total	100.0
	Component B	**Agent**
1	Hardener A	35.0
2	Anti-flash rust additive	6.0
3	Adhesion promoter	3.0

Paint stability



	KU viscosity	
	Initial	After 50°C 3 weeks
Emulsion with Reactsurf® 0092	81.3	133.6
Commercial benchmark 2#	92	134.9
Commercial benchmark 1#	116.2	Gelled
Commercial benchmark 3#	88.3	139.3

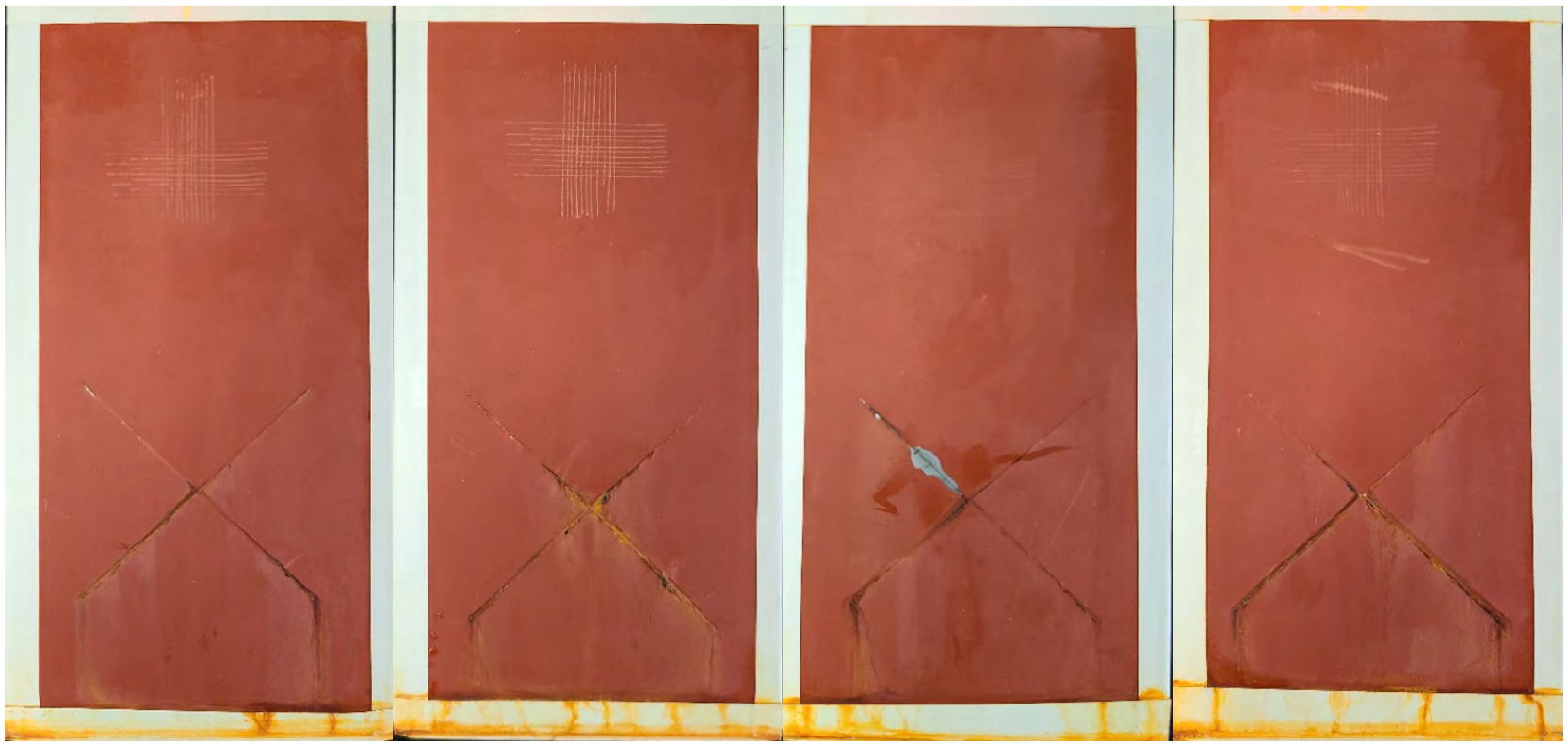
Commercial benchmark 1# | **Commercial benchmark 2#** | **Emulsion with Reactsurf 0092** | **Commercial benchmark 3#**



Emulsion with Reactsurf® 0092 shows similar paint stability as Commercial benchmark 2# and Commercial benchmark 3#, much better than Commercial benchmark 1#.

Corrosion Resistance on CRS

Emulsion with Reactsurf® 0092	Commercial benchmark 1#	Commercial benchmark 2#	Commercial benchmark 3#

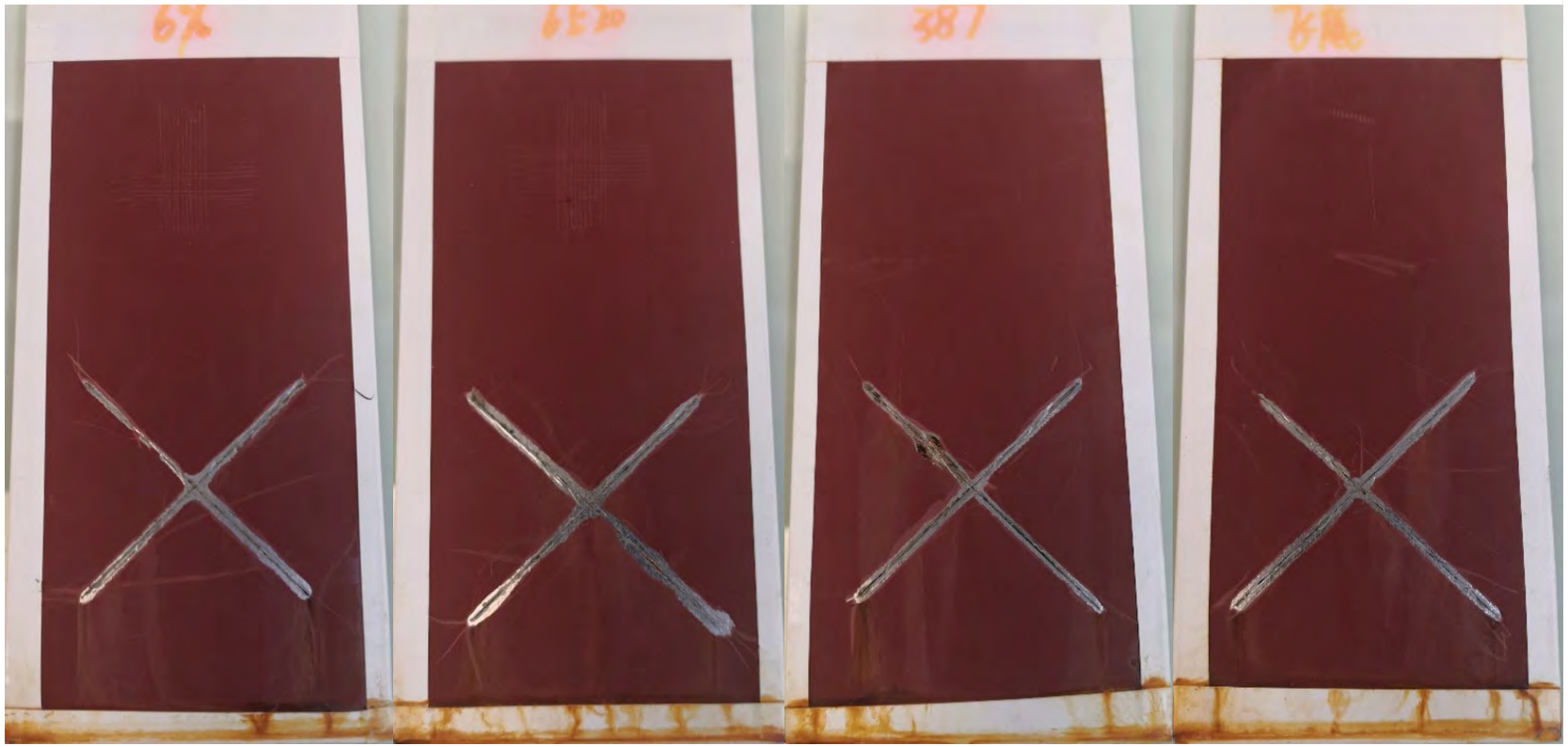


400h Salt spray resistance

In the high PVC formulation, Emulsion with Reactsurf® 0092 also shows better corrosion resistance than all Benchmarks.

Corrosion Resistance on CRS

Emulsion with Reactsurf® 0092	Commercial benchmark 1#	Commercial benchmark 2#	Commercial benchmark 3#

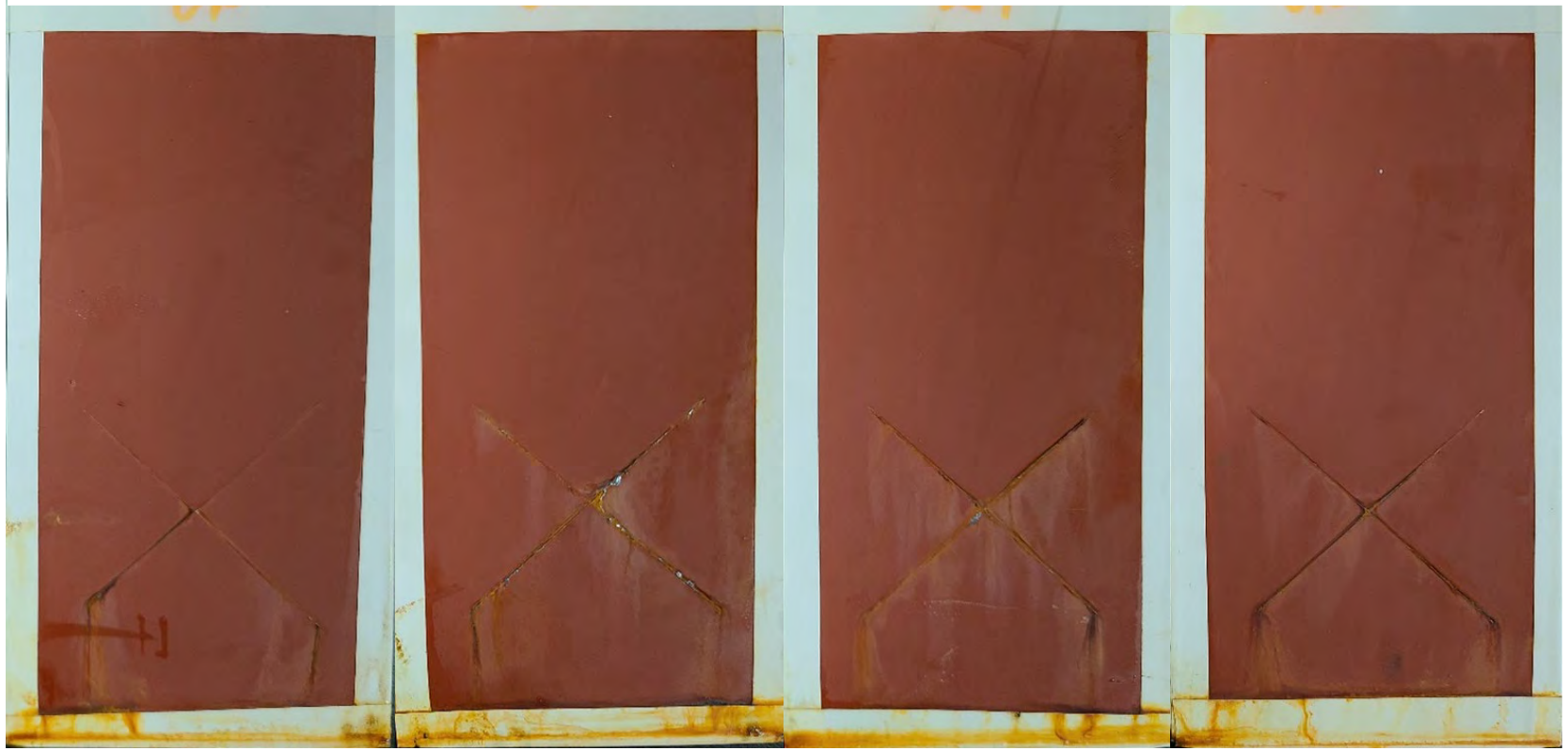


400h Salt spray resistance

According to the scratch performance, Emulsion with Reactsurf® 0092 shows the best corrosion resistance.

Corrosion Resistance on CRS

Emulsion with Reactsurf® 0092	Commercial benchmark 1#	Commercial benchmark 2#	Commercial benchmark 3#



500h Salt spray resistance

After 500 hrs salt spray test, Emulsion with Reactsurf® 0092 shows excellent corrosion resistance.

Adhesion

		CRS plate				Tin Plate			
		Reactsurf® 0092	Benchmark 1#	Benchmark 2#	Benchmark 3#	Reactsurf® 0092	Benchmark 1#	Benchmark 2#	Benchmark 3#
Hardener A	GB/T 9286	0	0	0	0	0-1	0-1	0-1	0-1
	ASTM D3359	5B	5B	5B	5B	4B-5B	5B	5B	5B
Hardener B	GB/T 9286	0-1	0	0-1	0-1	0-1	0-1	0	0-1
	ASTM D3359	5B	5B	5B	5B	5B	5B	5B	5B

Impact Resistance

		Reactsurf® 0092	Benchmark 1#	Benchmark 2#	Benchmark 3#
Hardener A	Face up	50	50	50	50
	Face down	<30	<30	<30	<30
Hardener B	Face up	50	50	50	50
	Face down	30	30	30	<30

Pendulum Hardness and MEK Resistance

Pendulum Hardness of Epoxy Paint

		Reactsurf® 0092	Benchmark 1#	Benchmark 2#	Benchmark 3#
Hardener A	CRS plate	253/239	262/281	272/253	270/268
	Tin plate	256/253	303/301	318/325	289/278
Hardener B	CRS plate	246/239	202/206	235/232	233/241
	Tin plate	270/271	226/223	246/242	253/245

MEK Resistance of Epoxy Paint

		Reactsurf® 0092	Benchmark 1#	Benchmark 2#	Benchmark 3#
Hardener A	Tin plate	4	4	4	4
Hardener B	Tin plate	3	3	3	3

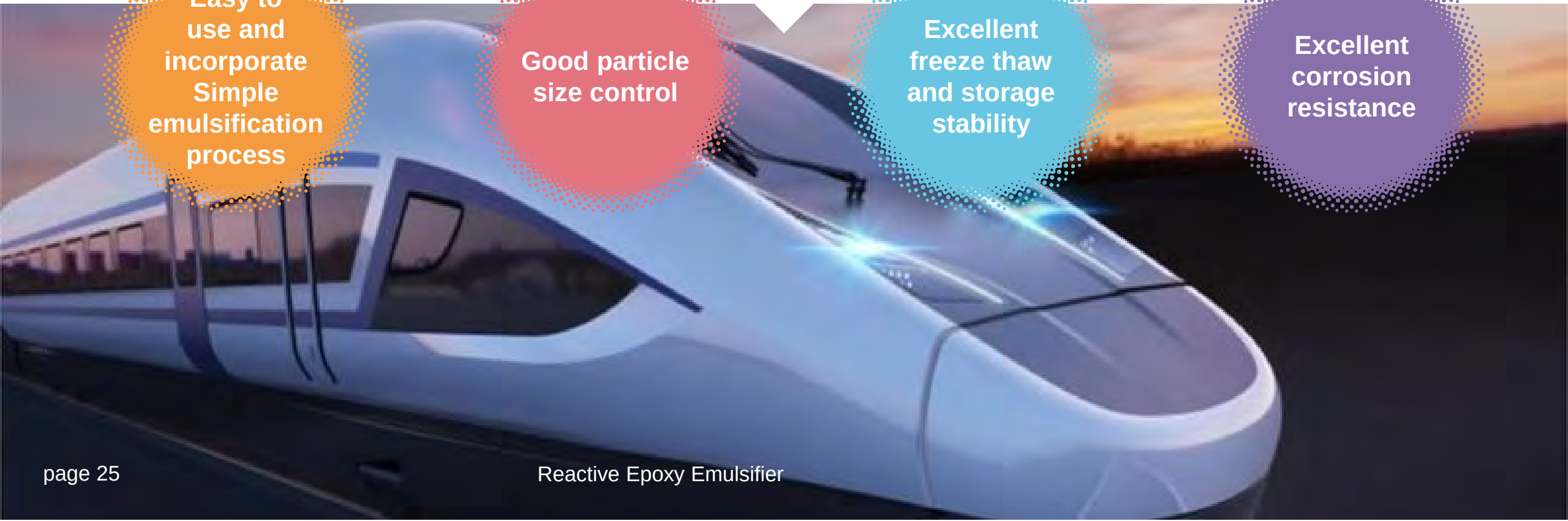
Level	Chalking	Softening	loss of gloss
5	No	No	No
4	Slightly	Slightly	Slightly
3	Medium	Medium	Medium
2	Serious	Serious	Serious
1	Extremely serious	Extremely serious	Extremely serious

Conclusion

Any further enquiries, please contact:

Janice NG - Global Project Manager - Industrial Coating
janice.ng@solvay.com

Progress beyond



Thank you

Progress beyond

Visit our website to find more information.
www.solvay.com/en/solutions-market/coatings