High Performance Powder Coatings

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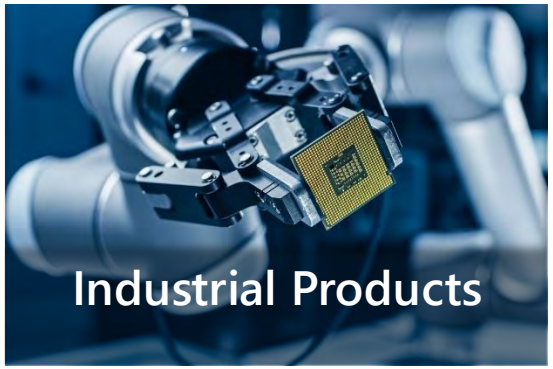
ICL at a Glance

Who We Are



Agriculture

Waste & Water Treatment

Industrial

Personal Care

Energy

Paints & Coatings

Textile & Leather

Transportation

Construction

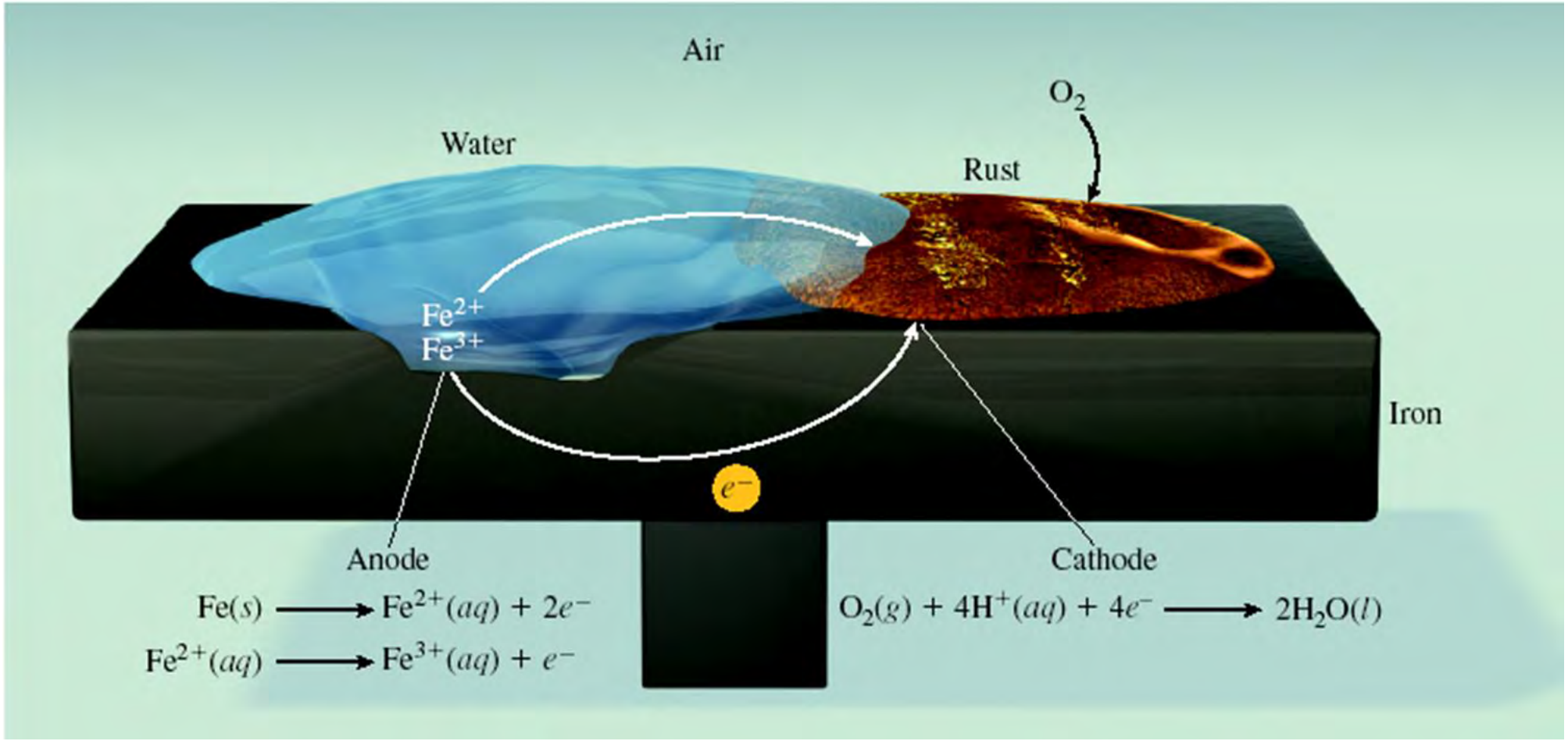
Food

Flame Retardants

* https://icl-group.com

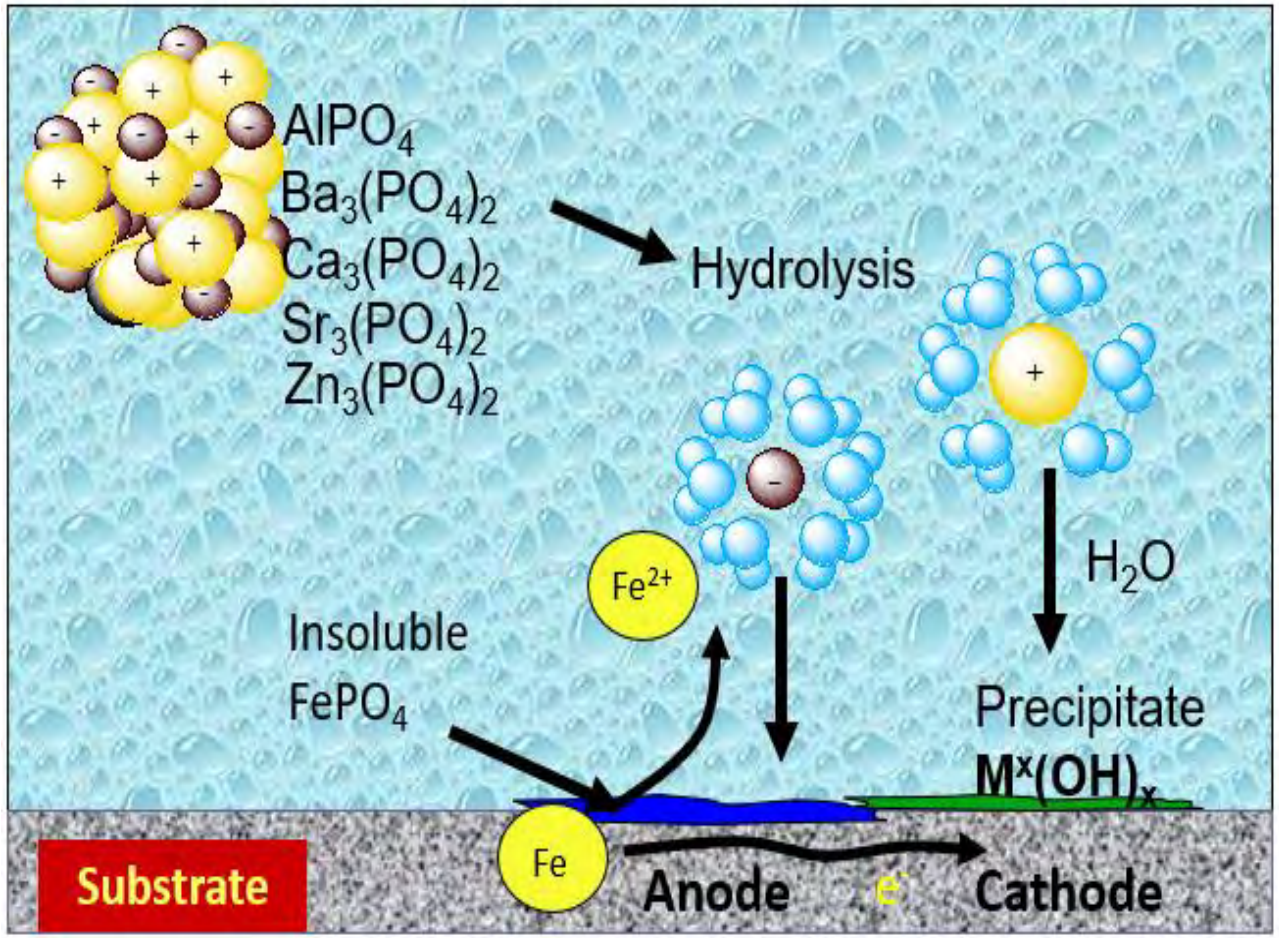
Corrosion Formation & Inhibition

Uniform Corrosion Cell Diagram



Mixed Metal Cation Phosphates

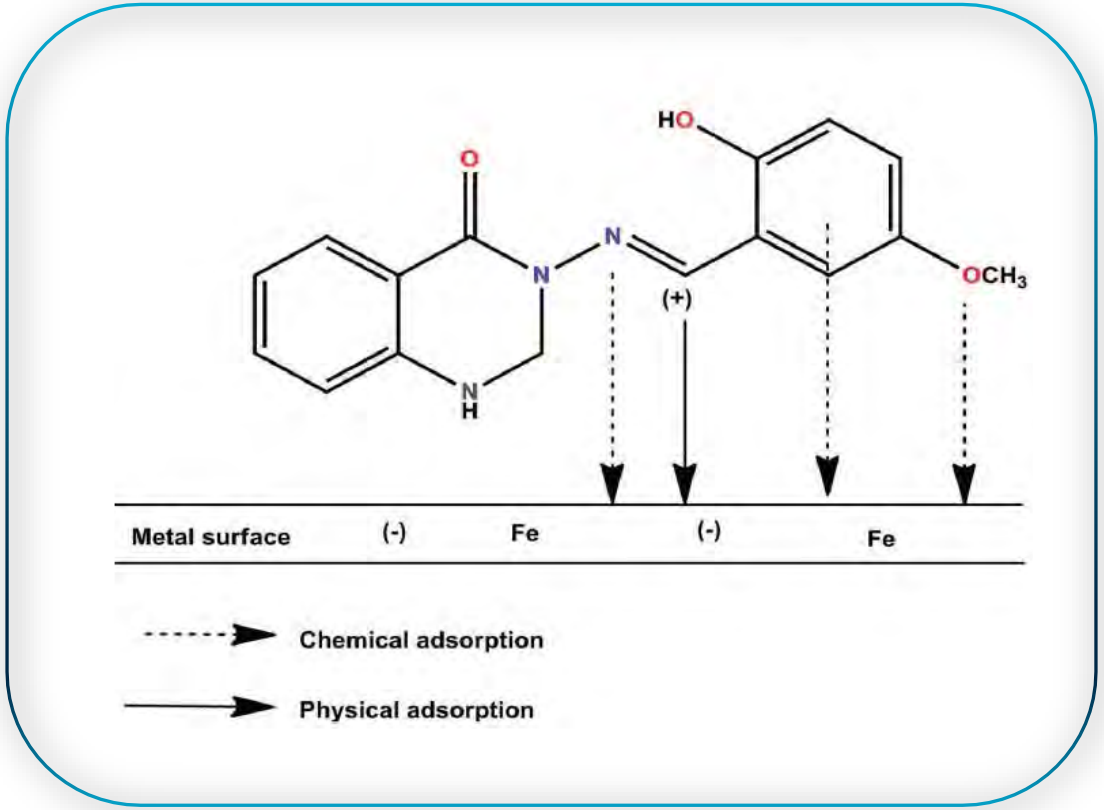
Passivation Mechanism



Phosphate	Ksp
Li3PO4	$2.4x10^{-4}$
CaHPO4	$1.0x10^{-7}$
MgNH4PO4	$2.5x10^{-13}$
AlPO4	$1.3x10^{-20}$
FePO4	$1.3x10^{-22}$
Mg3PO4	$6.3x10^{-24}$
Ba3(PO4)2	$1.3x10^{-29}$
Ca3(PO4)2	$2.0x10^{-29}$
Sr3(PO4)2	$1.0x10^{-31}$
Zn3(PO4)2	$9.0x10^{-33}$
CePO4	$2.9x10^{-34}$

Why Use Organic Corrosion Inhibitors?

- Act as cathodic or anodic inhibitors
- Heteroatoms and π–electron moieties
  - Corrosion inhibition efficiency: P>S>N>O
- Adsorb on surfaces (physisorption or chemisorption)
- Can enhance adhesion
- Reduced delamination and blistering
- No gloss detriment
- Effective at wide range of temperatures
- Good solubility in water → goes to work quickly
- Can work synergistically with inorganic corrosion inhibitors



Corrosion Inhibition for Powder Coatings

Sustainability of Powder Coatings

- No solvents- No VOCs
- No hazardous waste
- Reduced coatings consumption
- Excellent one coat performance
- Provides scratch- and dent resistant surfaces
- High durability, longer life cycle

- Difficult to achieve thin coats
- High temperature curing
- TGIC technology – high regulatory concerns (toxic)
- HAA technology – non toxic but less durable

As Powder Coatings grow in popularity, higher performance is expected in corrosion resistance adhesion etc.

Corrosion Inhibitor Chemistries

HALOX ® 650

Organic Di-Acid

- Metal affinity adhesive groups (heterocyclic composition)
- Hydrophobic
- Heat stable (<170 °C)

HALOX ® SZP 395

Strontium/Zinc

- Proprietary blend of Sr & Zn phosphosilicates
- Low solubility
- Heavy Metal containing

HALOX ® 430

Di-Calcium Phosphate

- Patented technology combining passivation and ion exchange technology
- Moderate solubility
- Heavy Metal free

HALOX ® CW-314

Tri-Calcium Phosphate

- FDA approved
- Enhances IR reflectance and thermal emissivity
- Low solubility
- Heavy Metal free

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TGIC Polyester Powder Coatings Results

ASTM B-117 ~888 hours ~Cold Rolled Steel

BLANK CONTROL
AVG scribe creep: 27mm
STOPPED at 336 hours

1.5% HALOX 650
AVG scribe creep: 6.7mm

3% HALOX 650
AVG scribe creep: 27mm
STOPPED at 336 hours

3% HALOX 430
AVG scribe creep: 7.0mm

6% HALOX 430
AVG scribe creep: 5.9mm

3% HALOX SZP-395
AVG scribe creep: 8.1mm

6% HALOX SZP-395
AVG scribe creep: 16mm

RAW MATERIALS	%TFW
Uralac® P3400	60-65
TGIC	4-5
BYK 3900 P	0.8-1.2
Benzoin	0.6-0.9
Halox®	1.5-6
Carbon Black	0.4-0.6
TiO2	15-18
CaCO3	8-12
Total	100

	Blank Control	Halox 650		Halox 430		Halox SZP-395	
		1.5%	3%	3%	6%	3%	6%
DFT (mils)	2.86	3.25	3.25	2.9	3.2	3.3	2.95
Gloss (20/60/85)	41/80/94	41/82/95	55/89/97	50/83/96	40/79/95	45/82/95	43/81/96
Mandrel Bend	Pass	Pass	Fail	Pass	Pass	Pass	Pass
MEK Double Rub (50)	Pass	Pass	Slight softening	Pass	Pass	Pass	Pass

HAA Powder Coatings Results

ASTM B-117 ~552 hours ~Cold Rolled Steel

BLANK CONTROL
AVG scribe creep: 6.3mm

6% HALOX 430
AVG scribe creep: 3.8mm

6% HALOX CW-314
AVG scribe creep: 3.3mm

1.5% HALOX 650
AVG scribe creep: 18mm

1.5% HALOX 650 +
6% HALOX 430
AVG scribe creep: 9.6mm

1.5% HALOX 650 +
6% HALOX CW-314
AVG scribe creep: 11.4mm

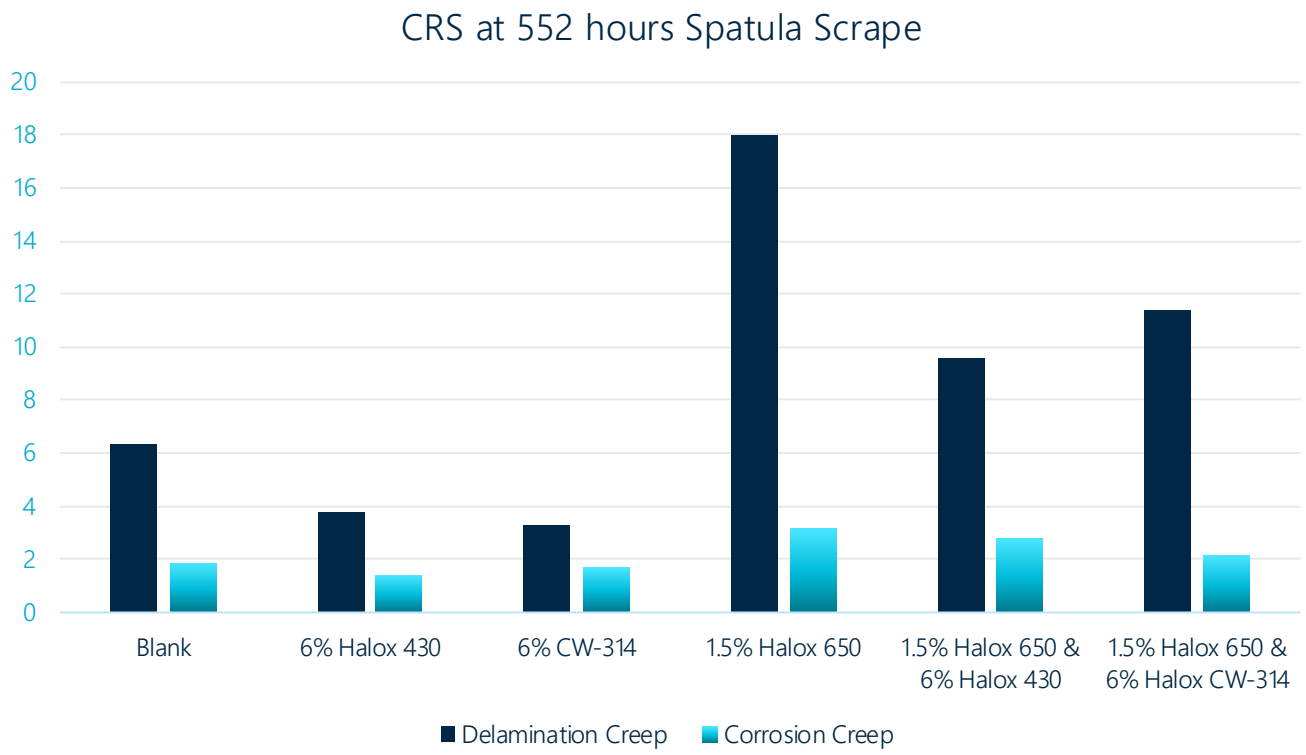
RAW MATERIALS	%TFW
Rucote 9010	68-75
XL-552 PRIMID	3-4
BYK 3900 P	0.8-1.2
Benzoin	0.6-0.9
Halox®	1.5-7.5
Carbon Black	0.5-1
TiO2	17-20
BaSO4	8-12
Total	100

	Blank Control	6% Halox 430	6% Halox CW-314	1.5% Halox 650	1.5% Halox 650 & 6% Halox 430	1.5% Halox 650 & 6% Halox 430
DFT (mils)	2.02	2.34	2.16	2.67	3.28	3.29
Gloss (20/60/85)	66/95.3/97.8	44.2/84.5/95.5	58/92.6/97.2	53.8/91.6/97.2	37.7/88.2/94.2	43.3/88.2/94.2

- Impact of particle size on gloss visible (Halox CW-314 lowest particle size)

Corrosion Data – Cold Rolled Steel

Delamination vs corrosion creep



BLANK CONTROL
AVG scribe creep: 6.3mm

6% HALOX 430
AVG scribe creep: 3.8mm

6% HALOX CW-314
AVG scribe creep: 3.3mm

- Halox 430 & Halox CW-314 showed best performance
- Halox 430 best performance in corrosion creep
- Halox CW-314 best performance in delamination

Key Takeaways

In TGIC Powder Coating Systems all Halox CI's demonstrated significant advantage in Corrosion Protection – with Halox 430 performing the best at 6% loadings

In HAA Powder Coating Systems both Calcium Phosphate based CI's performed the best Halox 430 & Halox CW-314 at loading levels of 6%

Gloss was impacted by all CI's with CW-314 showing the least impact due to particle size.

No Synergistic level between organic and inorganic CI's was observed at the tested loading levels. Further optimization required for additional benefits.

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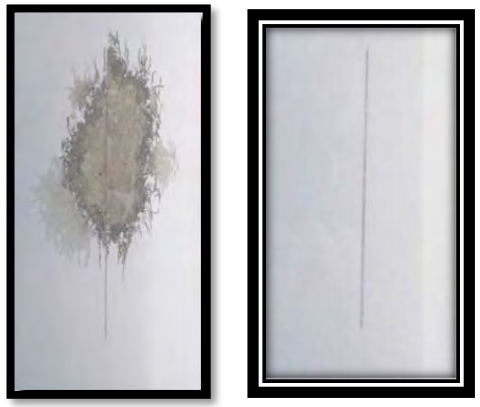
Versatility of Calcium-Phosphates

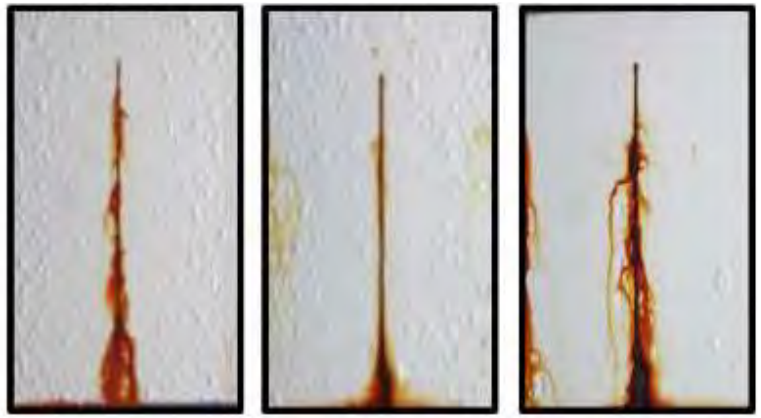
- Zn-free & label free technologies
- **Halox 430:** Patented Di-Calcium Phosphate combined with Ion exchange technology with superior performance in C4/C5 environments
- **Halox CW-314:** Tri-Calcium Phosphate based technology (Patent pending) with superior performance in flexible cool roof coatings

2K Water Based Polyurethane
on Bare Aluminum 3003
Dry Film Thickness: 75 µm
ASTM B117: 2000 h



Blank | **2% - HALOX 430**
0.5% - HALOX 550

Elastomeric Roof Coating
CRS
Dry Film Thickness: 330 µm
ASTM B117



Blank
96 h | **With Primer**
144 h | **HALOX CW-314**
336 h

WB Light Industrial DTM Epoxy
CRS
Dry Film Thickness: 100 µm
ASTM B117: 168 h

Blank | **5% HALOX**
CW-314 | **5% HALOX**
430

Outlook

- ✓ Continue to focus on sustainable solutions to fight corrosion
- ✓ Continue to investigate current chemistries for more effective synergies
- ✓ Partner with industry experts to advance the corrosion management initiative

GRAZIE MILLE !

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