FERRO
Where innovation delivers performance™

Coatings formulation against corrosion: Smart use of Nubirox anticorrosive pigments

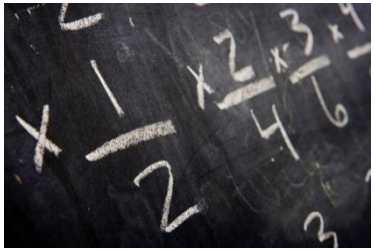
UL Prospector Webinar

14th February, 2018

Agenda

- **Anticorrosive pigments:**
  - What is corrosion? Mechanism of corrosion protection
  - Anticorrosive pigments:
    - Historical evolution
    - Nubirox Zinc based and Non Zinc based pigments:
      - Inhibition mechanism
      - Physical properties
      - Pigment surface treatments

- **Anticorrosive coating formulation:**
  - Formulation parameters
  - Examples of coating formulation:
    - Replacement of conventional Zinc phosphate in a SB Alkyd primer
    - Improving corrosion protection of WB DTM coatings



Corrosion

WHAT IS CORROSION?

Corrosion is a gradual **spontaneous** process as a result of a chemical reaction with the environment that damages the original metal

$+ O_2 / + H_2O$

Spontaneous

Non spontaneous

Entropy: Order → Disorder

Corrosion

COST OF CORROSION

The annual cost of steel corrosion, estimated to be **$2.5 trillion globally,** which is equivalent to **3,4%** of the global GDP (2013)

Source: "NACE International assessment of the global cost of corrosion" 2016

Corrosion

HOW DOES CORROSION OCURR?







Corrosion mechanism

$$Fe \rightarrow Fe^{2+} + 2e^-$$

$$O_2 + 2\,H_2O + 4\,e^- \rightarrow 4\,OH^-$$

Humidity

Contaminants

Temperature

Light

...

Protection

HOW DO WE SLOW DOWN CORROSION?

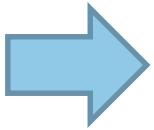
Corrosion cannot be 100% avoided, but we can slow the process down.

Protection

HOW DO WE SLOW DOWN CORROSION?

- **Barrier protection**
  - **Coating**: Impermeability of the paint film, film thickness, pigment selection (e.g., type, morphology, size…)
- **Sacrificial protection**
  - **Cathodic protection**: Zinc Rich Coatings (Zinc Dust).

    Zinc works as sacrificial anode and it is corroded instead of the steel.
- **Inhibitive protection**
  - **Corrosion inhibitors:** Inhibiting the rate of corrosion either chemically and/or electro-chemically (inorganic & organic)
    - Cathodic corrosion inhibitors
    - Anodic corrosion inhibitors
    - pH control



Nubirox anticorrosive pigments

Anticorrosive pigments evolution

TRADITIONAL ANTICORROSIVE PIGMENTS

Chromate based pigments

Zinc Chromate
Zinc Tetraoxychromate
Strontium Chromate
Barium Chromate
Red lead

ALTERNATIVE NON CLASSIFIED AS HAZARDOUS ANTICORROSIVE PIGMENTS

ZINC BASED PIGMENTS

- **Zinc Phosphate**

  Nubirox N2
  Nubirox SP
  (special particle)

- **Modified Zinc Phosphates**

  - Modified with molybdate and organic surface treatment
    Nubirox 102
    Nubirox 106 (special particle)

  -Modified with iron phosphate
    Nubirox 213 (special particle)

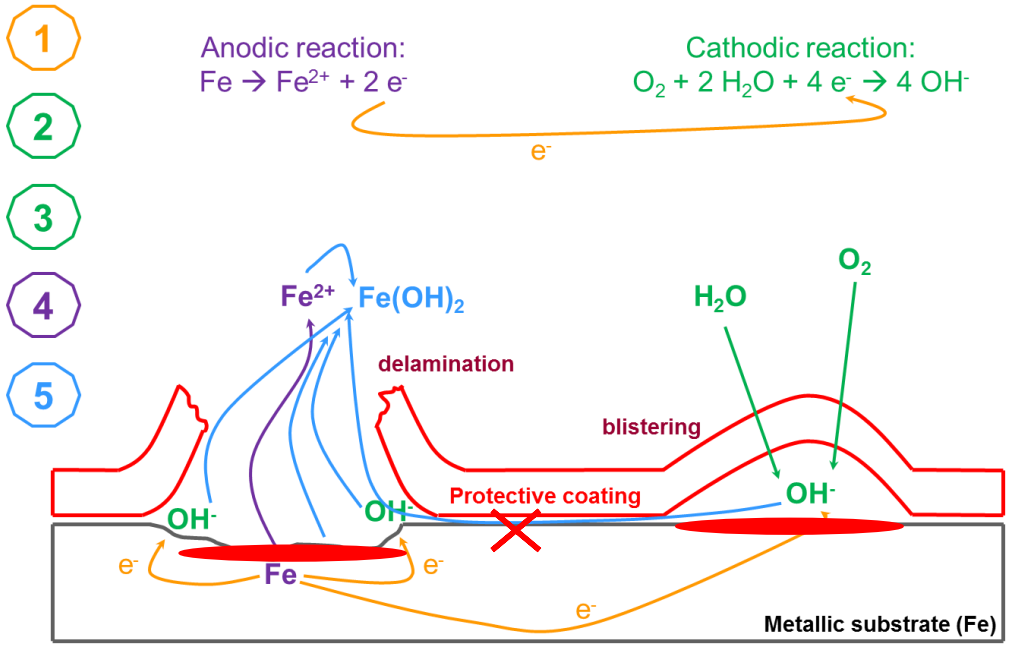
NON ZINC BASED PIGMENTS

Calcium strontium phosphosilicate

Nubirox 301

Nubirox 302
Modified with organic surface treatment

Anticorrosive pigments mechanism

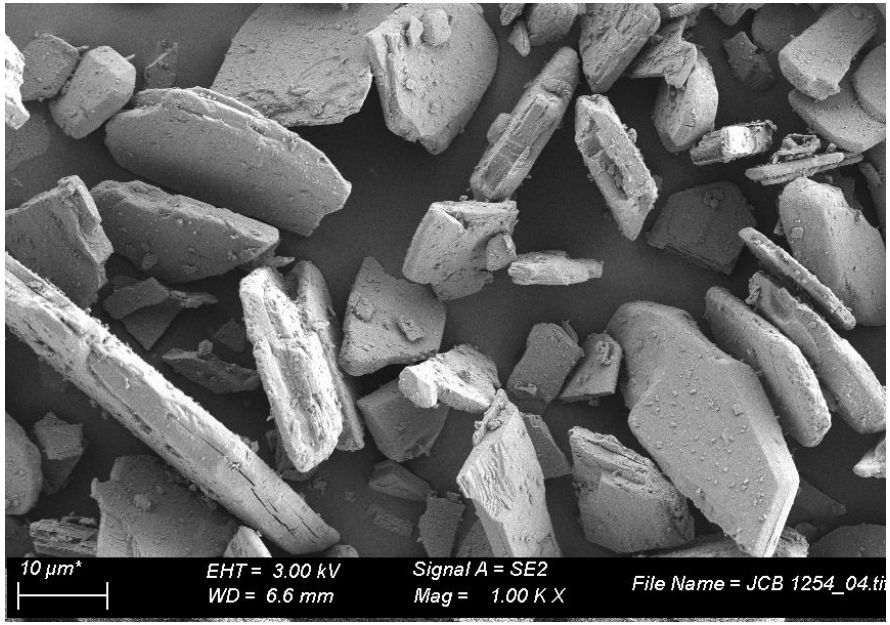


- Zinc phosphate (Nubirox N2, SP, 102, 106 & 213):
  - **Direct anodic passivation:** Zn phosphate complexes
  - **Cathodic inhibition:** basic Zn oxides
- Calcium Strontium phosphosilicate (Nubirox 301 & 302):
  - **Direct anodic passivation:** Ca, Sr, Fe phosphate complexes
  - **Cathodic inhibition:** basic Ca, Sr oxides

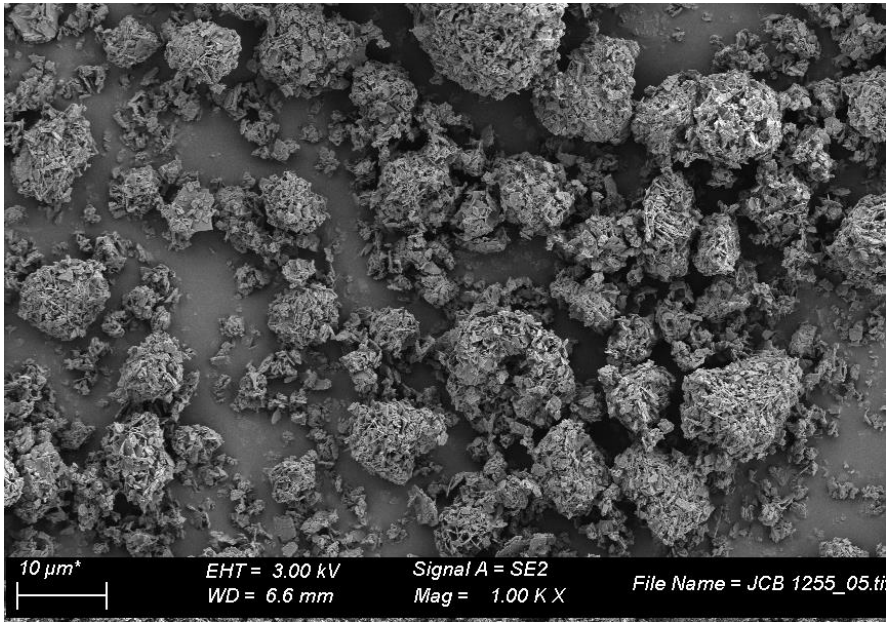
Anticorrosive pigments physical properties

- **Zinc phosphate**: same chemistry but different physics

Conventional Zinc Phosphate
Nubirox N2

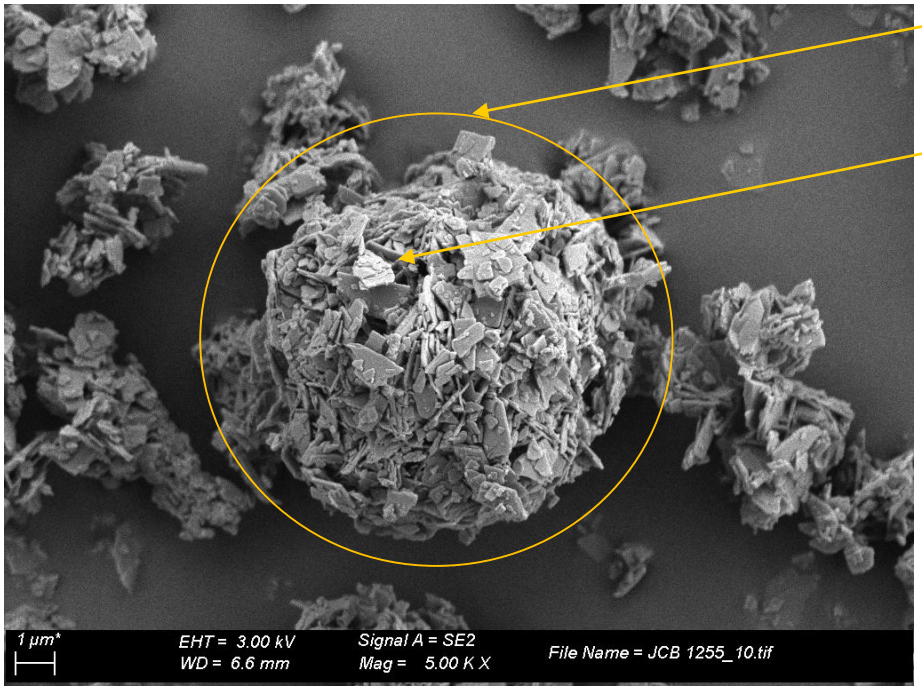


Special particle Zinc Phosphate
Nubirox SP

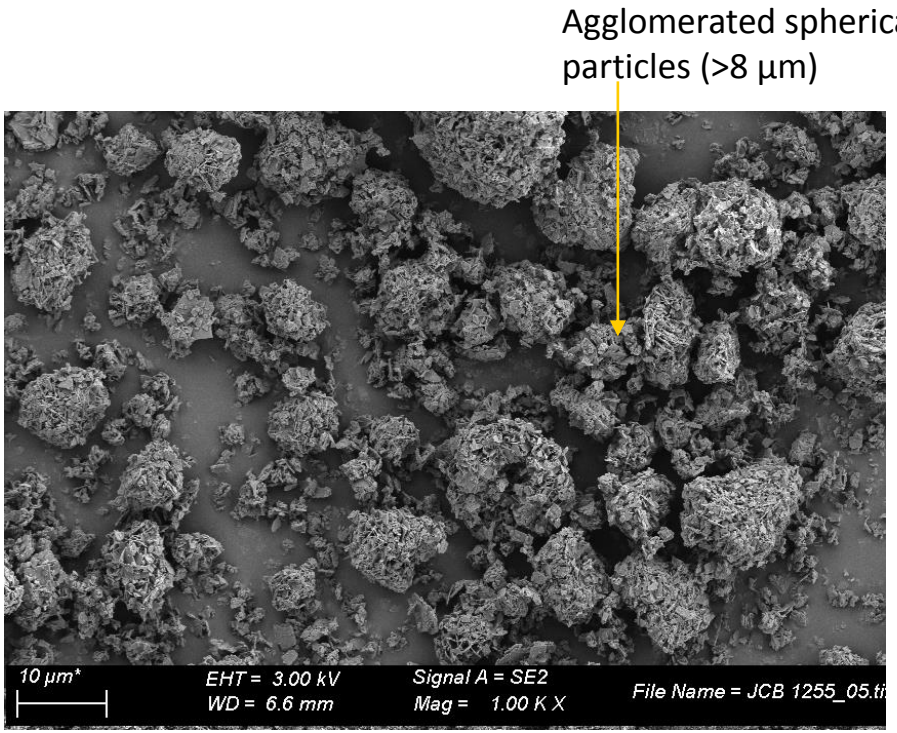


Anticorrosive pigments physical properties

- **Nubirox SP**: Special particle Zinc Phosphate

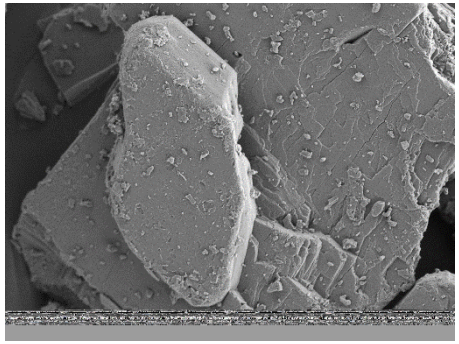
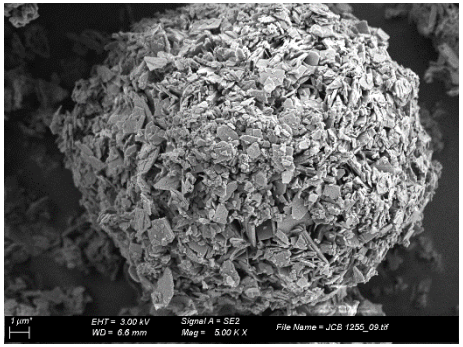


Microscope pictures (SEM)



Anticorrosive pigments physical properties

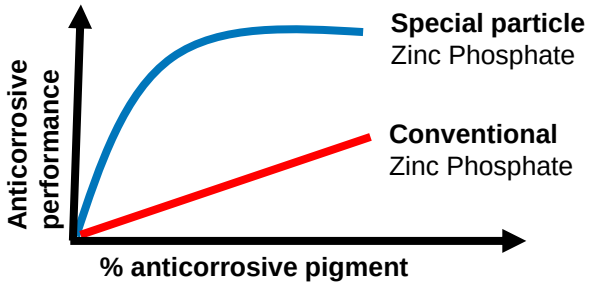
- **Zinc phosphate**: same chemistry but different physics

	Conventional Zinc Phosphate Nubirox N2	**Special particle Zinc Phosphate** Nubirox SP
		
Particle size:	8 -12 µm	<1µm (aggregate 4-10 µm)
Specific surface area (BET):	1 m^2/gr	8-15 m^2/gr
Oil absorption:	~21g/100g	~ 50g/100g

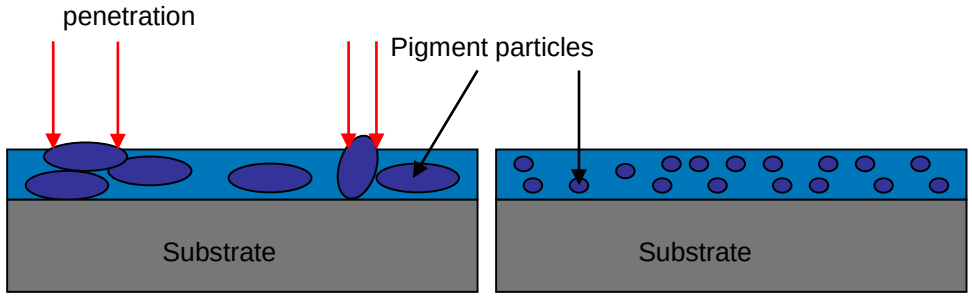
Anticorrosive pigments physical properties

- **Zinc phosphate:** same chemistry but different physics and performance

  - effectiveness



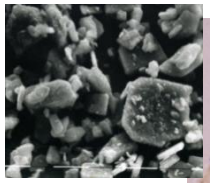
  - performance in thin coatings



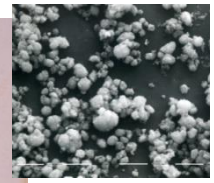
Anticorrosive pigments physical properties

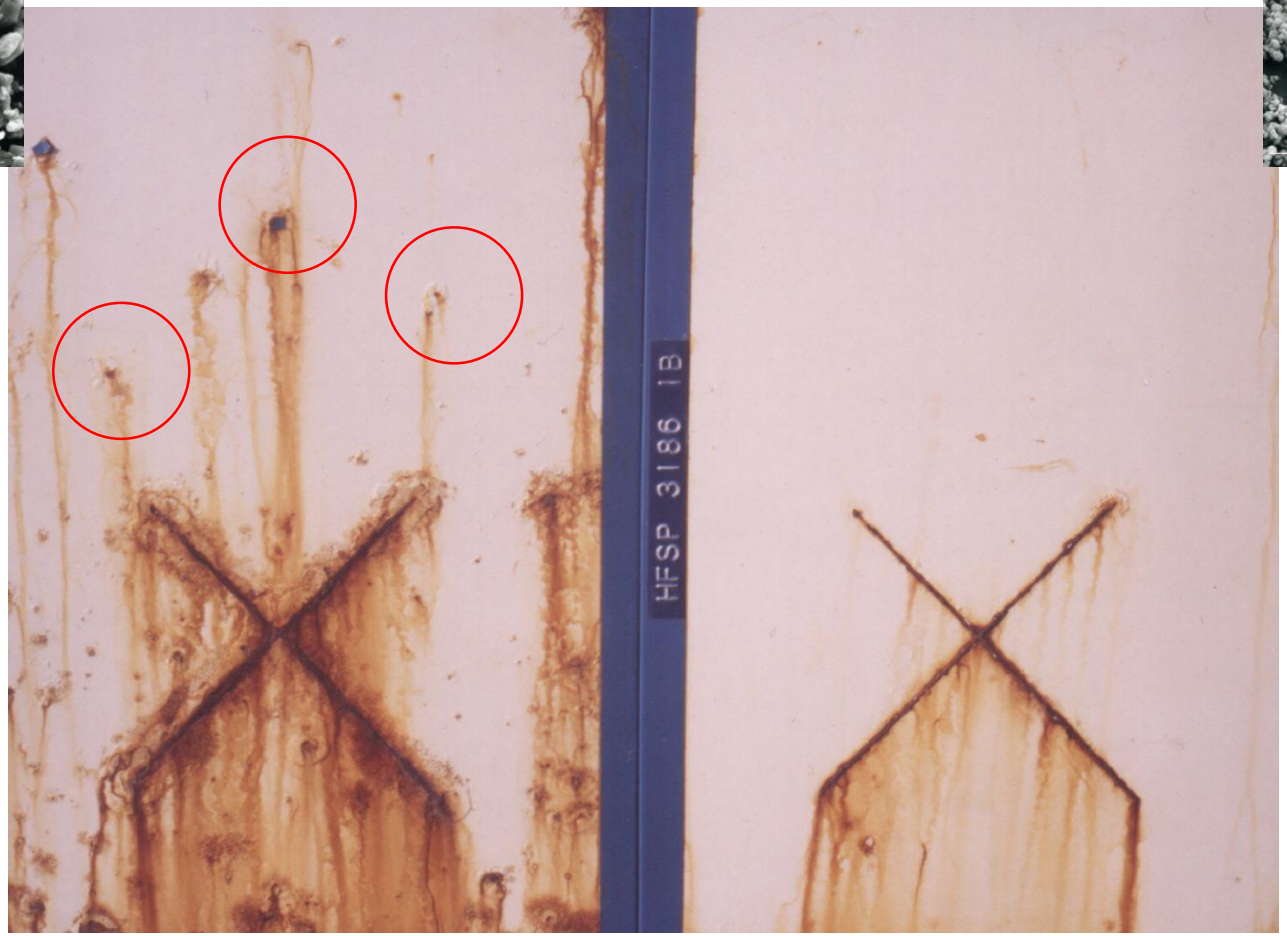
- **Zinc phosphate:** performance in thin coatings

Conventional Zinc Phosphate
Nubirox N2



Special particle Zinc Phosphate
Nubirox SP



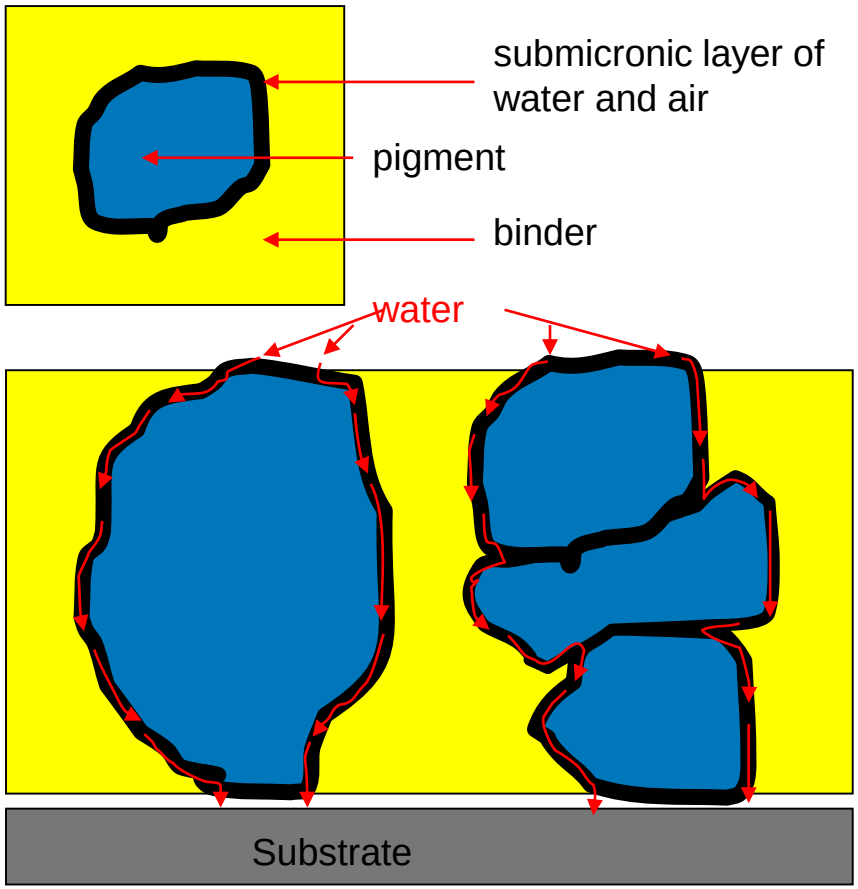


Solvent based system
Long oil air drying alkyd resin
CPV=35 **10% anticorrosive pigment**
Application on satndardized cold rolled steel panels S-46 (Q-Panel) Dry film thickness**~20µ**
300 hours of exposure in Salt Spray (ASTM B-117).

Zinc based Nubirox

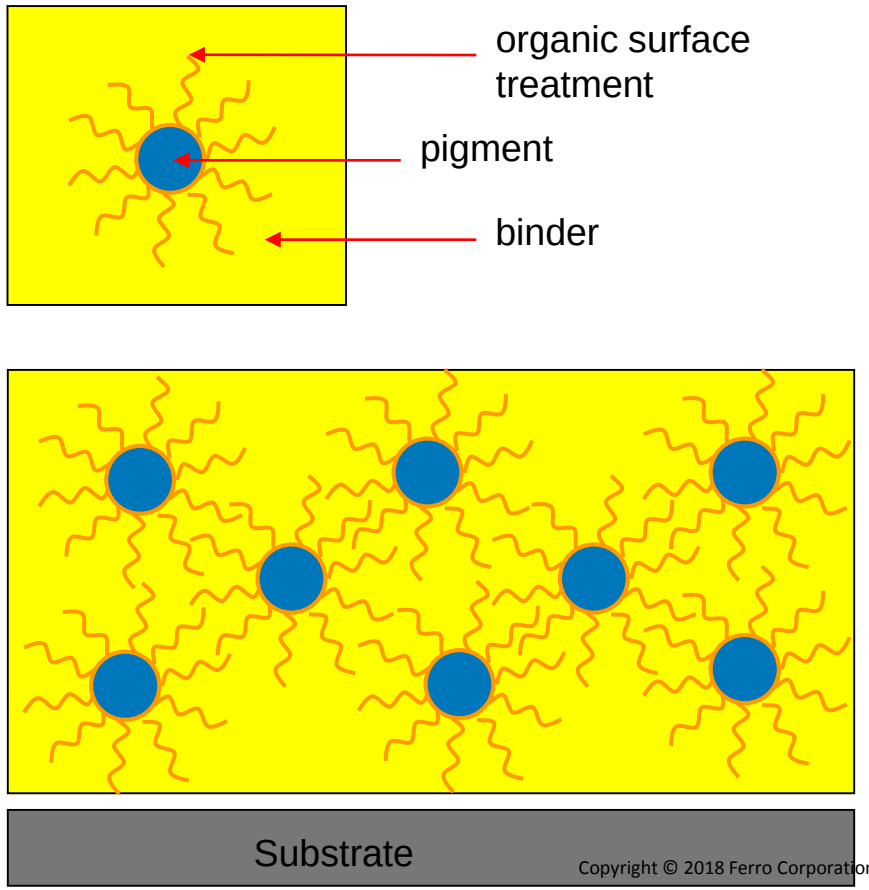
- **Nubirox 100 series:** Nubirox 102 & Nubirox 106
  - Modification with molybdate and organic surface treatement

Particles not well wetted



Particles with organic surface treatment

Nubirox 102 & Nubirox 106

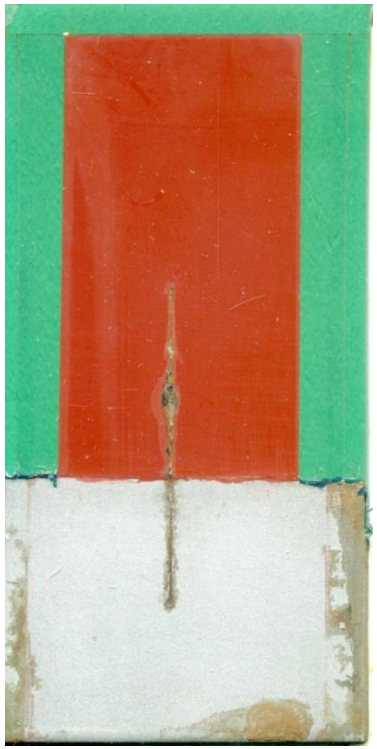


Zinc based Nubirox

- **Nubirox 106**
  - Based on special particle Zinc Phosphate
  - High pigment effectiveness at low loading level in many SB and WB paint systems

Without anticorrosive pigment	**Nubirox 106**	**Conventional Zinc Phosphate**
	5% dry film volume (5.7% t.f.w.)	**8%** dry film volume (9,3% t.f.w.)

FORMULA EPPAA 18951



FORMULA EPPAA 18953

FORMULA EPPAA 18952

Water based system
Epoxy resin: **Beckopox EP384W/53WAMP** Hardener: **Beckopox EH623W/80WA**
49% solids in volume **CPV/CPVC=0.6**
Standardized **blasted hot rolled steel panels** F130S1 (Espancolor) DFT**~140µ**
890 hours of exposure in Salt Spray (ASTM B-117).

Zinc based Nubirox

- **Nubirox 213**
  - Modification with Iron Phosphate
  - Specially suitable for alkyd and epoxy primers used to protect steel substrates

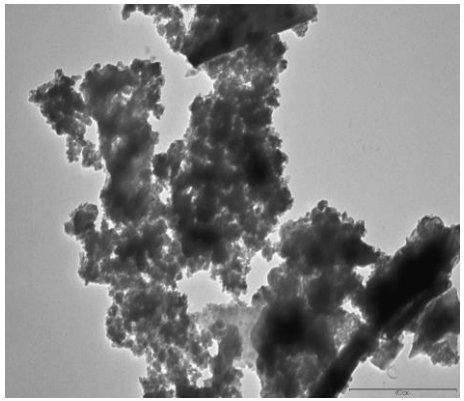
Without anticorrosive pigment	**9.5%** dry film volume (10.7% t.f.w.) **Conventional Zinc Phosphate**	**9.5%** dry film volume (10.0% t.f.w.) **Nubirox 213**
		
FORMULA EPPA 12878	*FORMULA EPPA 12879b*	*FORMULA EPPA 12883b*

Solvent based system
Epoxy resin: **Uneresin 5471X75** Hardener: **Unedur 5415X70**
40% solids in volume **CPV/CPVC=0.7**
Standardized **blasted hot rolled steel panels** F130S1 (Espancolor) DFT**~60µ**
741 hours of exposure in Salt Spray (ASTM B-117).

Non Zinc based Nubirox

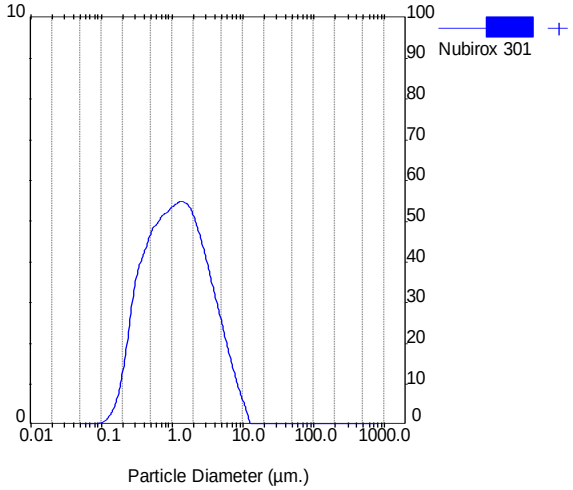
- **Nubirox 300 series**
  - Nubirox 301 & Nubirox 302 based on Calcium Strontium Phosphosilicate

Particle shape



SEM (scanning electron microscope)

Particle size distribution



Malvern Mastersizer S Ver 2.19

Specific surface area

	Specific surface area (m2/g)
Zinc Phosphate	1
Nubirox 301	21

Particle characterization:

Elemental particles <1µ forming aggregates and agglomerates up to <10µ

D(v,0.5)=1.15µ

- More active surface (allows lower pigment dosage)
- **Lower effect on gloss (DTM applications)**

Non Zinc based Nubirox

- **Nubirox 302**
  - Organic surface treatment to improve binder compatibility and performance

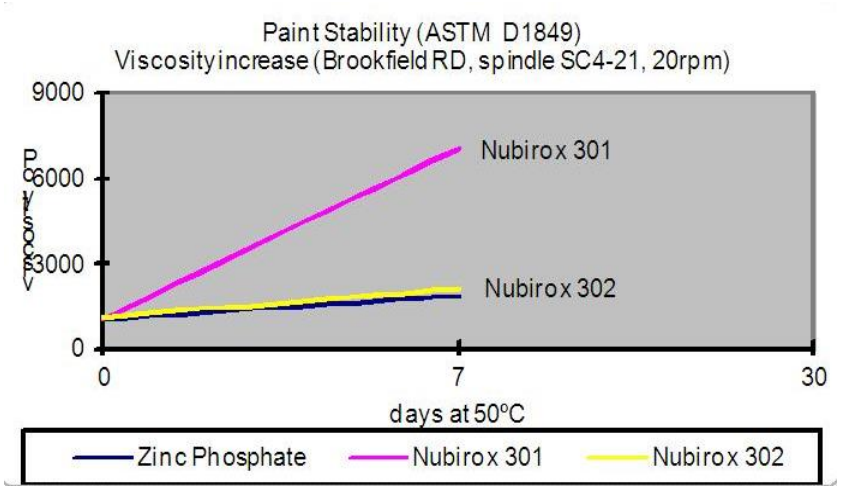
Nubirox 301

Its alkalinity makes it reactive with acidic binders, like short oil alkyds, but not with main long oil alkyds (usually with low acid values).

Nubirox 302

Its organic treatment protects the pigment from reacting with the acid binder.

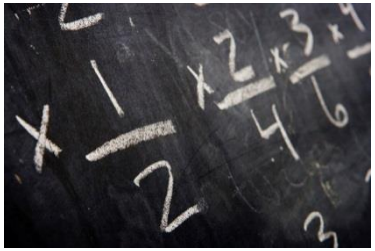
Short Oil Alkyd primer with Synolac 7503X60 (Cray Valley)
50% solids in volume PVC/CPVC=0.7 **6% Active pigment** in volume of dry film
Viscosity measurements in Brookfield RV (spindle SC4-21, 20 rpm)



Agenda

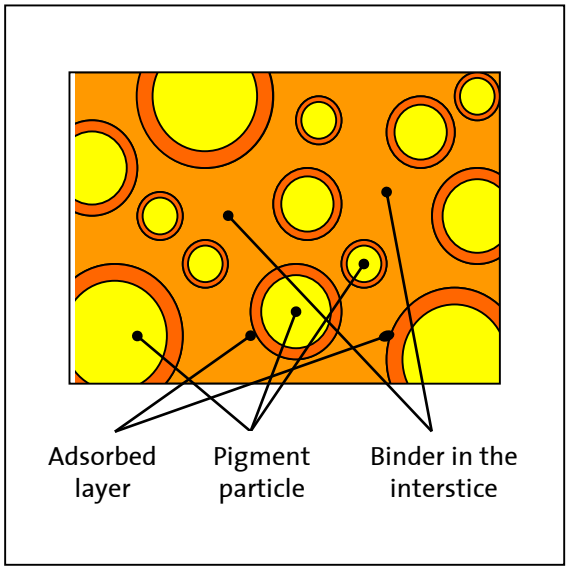
- **Anticorrosive pigments:**
  - What is corrosion? Mechanism of corrosion protection
  - Nubirox anticorrosive pigments
    - Zinc based Nubirox: mechanism, particle shape and modifications
    - Non-Zinc based Nubirox: mechanism, particle and modifications

- **Anticorrosive coating formulation:**
  - Formulation parameters
  - Examples of coating formulation:
    - Replacement of conventional Zinc phosphate in a SB Alkyd primer
    - Improving corrosion protection of WB DTM coatings



Formulation

- **PVC “Pigment volume concentration”**
  - A paint film is a volume: formulation parameters must be fixed in volume units.



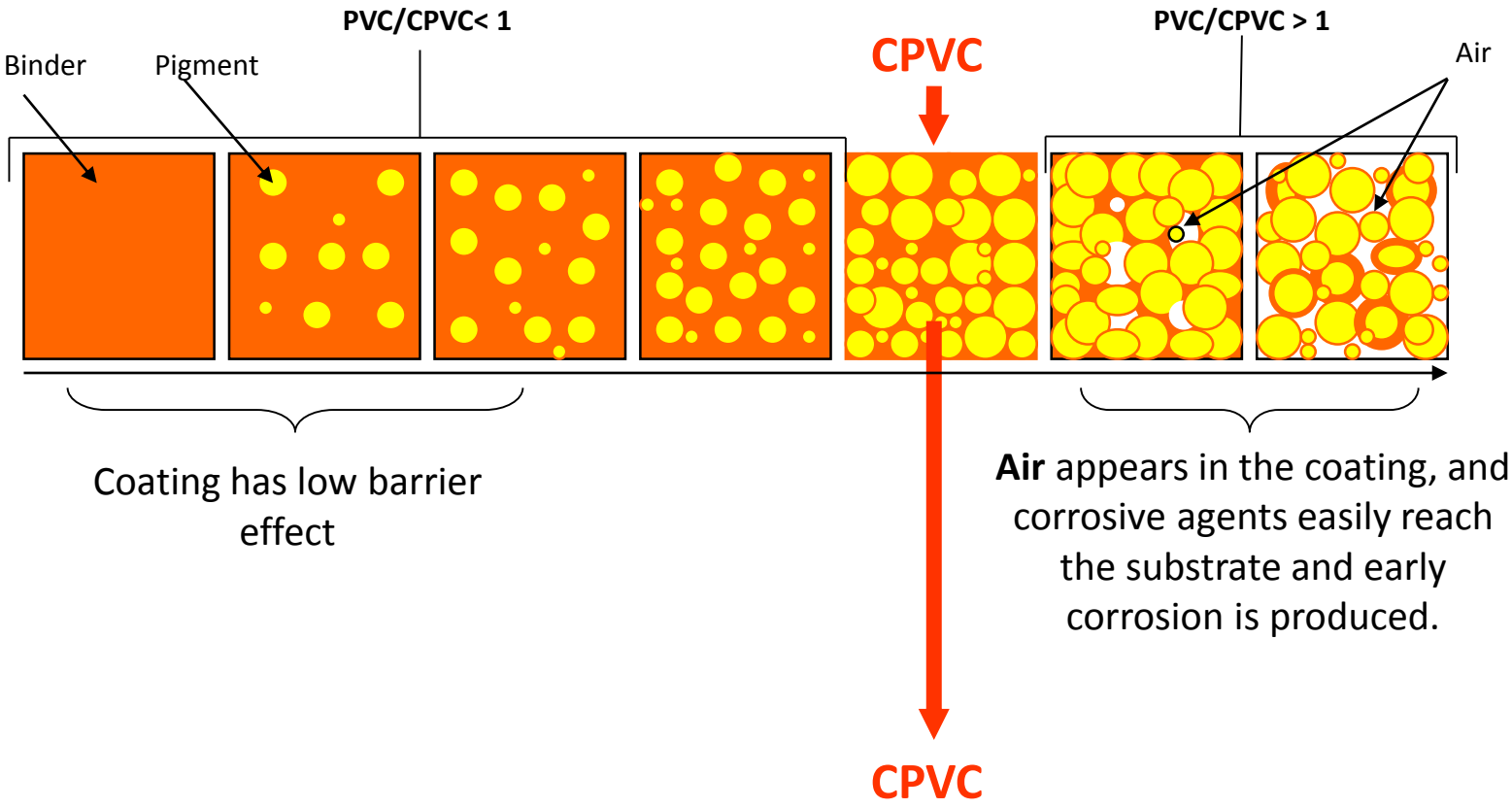
$$PVC = \frac{V_{pigment}}{V_{total\,dry\,film}} = \frac{V_{pigment}}{V_{pigment} + V_{binder}}$$

$$V_{pigment} = V_{color\ pigment} + V_{anticorrosive\ pigment} + V_{fillers}$$

$$V_{binder} = V_{adsorbed\ binder} + V_{free\ binder}$$

Formulation

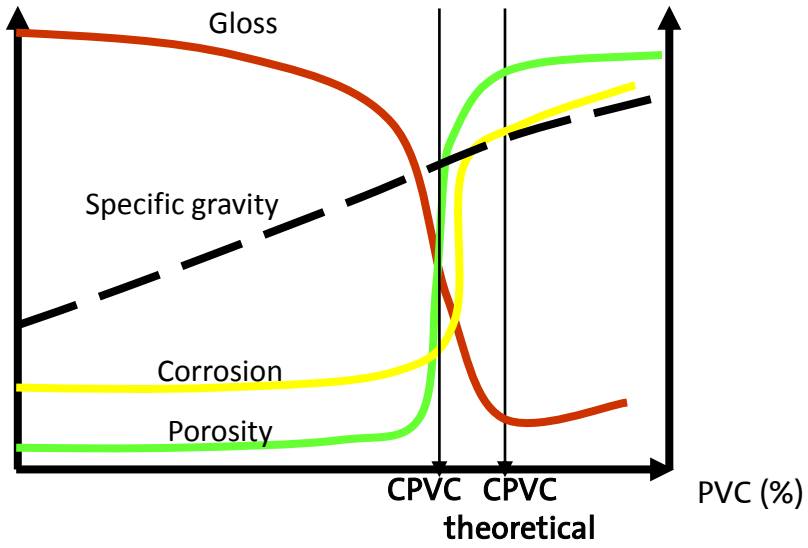
- **CPVC "Critical pigment volume concentration"**



CPVC is just the **PVC** where there is just enough binder to wet all the pigments and fill the voids between particles.

Formulation

- **PVC/CPVC ratio**



- **CPVC**: Characteristic of each pigment package and binder. Experimental.
- **Theoretical CPVC**: Calculated as the CPV for 100 grams of pigment and the grams of oil according to the oil absorption.

$$CPVC_{theoretical} = \frac{\frac{100\ g_{pigment}}{\rho_{pigment}(g/l)}}{\left(\frac{100\ g_{pigment}}{\rho_{pigment}(g/l)}\right) + \left(\frac{g_{oil\ adsorved}}{\rho_{oil}(0.93g/l)}\right)}$$

100 $g_{pigment}$: grams of pigment for oil absorption value

$\rho_{pigment}$: pigment specific gravity

$g_{oil\ absorbed}$: grams of oil (oil absorption value)

ρ_{oil}: specific gravity of linseed oil (0.93g/l)

Formulation

- **Effect of PVC/CPVC ratio on performance**

PVC/CPVC = 0.60

PVC/CPVC = 0.75

PVC/CPVC = 0.95

Close to CPVC (PVC/CPVC~1)

Solvent based system
Phenolic modified short oil alkyd
50% solids in volume **5% of anticorrosive pigment (Nubirox 213)**
Standardized cold rolled steel panels S-46 (Q-Panel) DFT **~40µ**
400 hour of exposure in Salt Spray (ASTM B-117).

Formulation Case 1

- **SB Alkyd primer:**

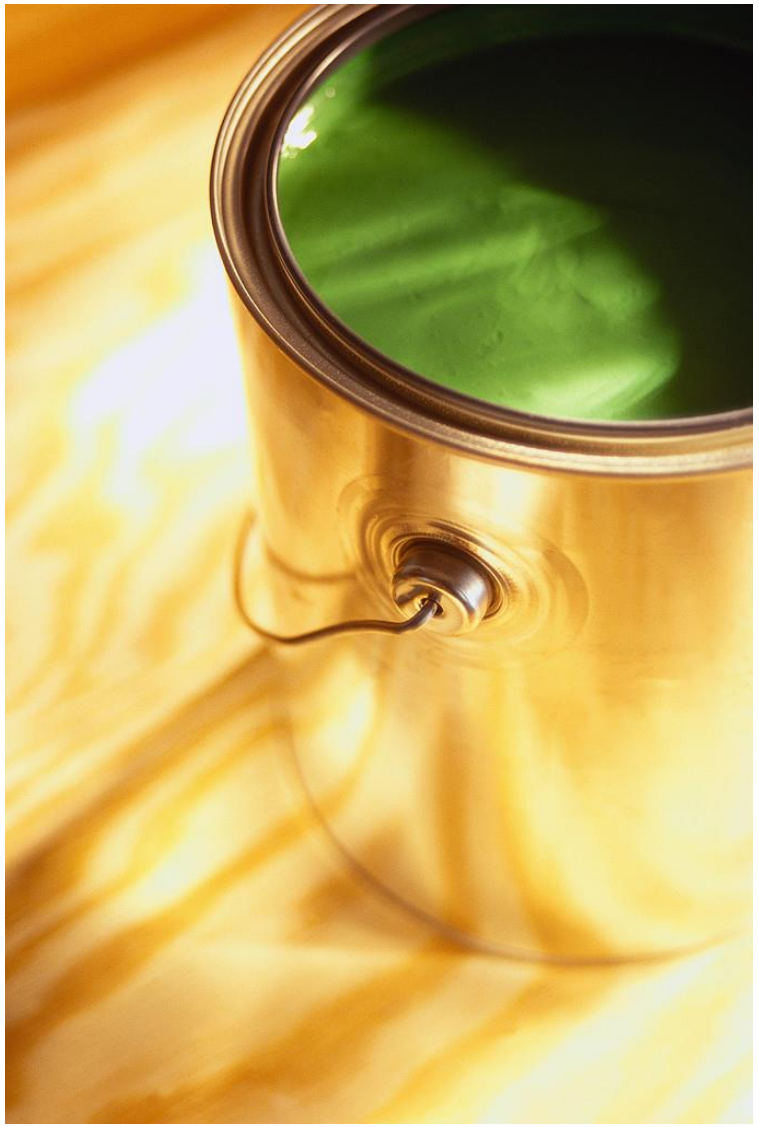
  Replacement of conventional Zinc Phosphate

  - **Direct replacement**

    Replacement 1:1 in weight

  - **Reformulation**

    Differences only due to anticorrosive pigment effectiveness

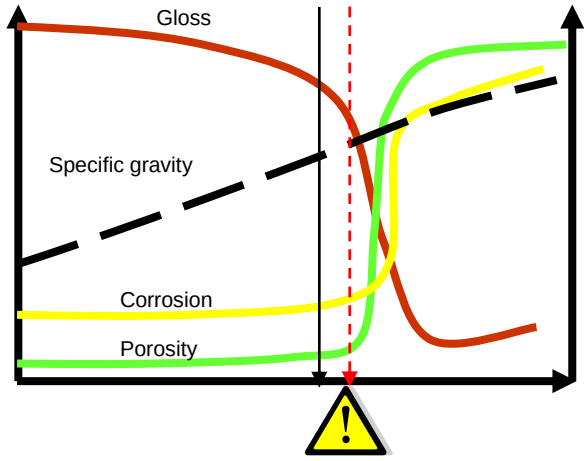


Formulation Case 1

FORMULA	FUNCTION	A % weight	B % weight
Synolac 7503X60	Alkyd resin	21.81	21.81
Bentone 34 (10% in xylene)	Rheological additive	4.60	4.60
Calcium Naphtenate 4%	Wetting agent	0.41	0.41
Xylene	Solvent	10.98	10.98
Tioxide TR92	Titanium dioxide	7.56	7.56
Zinc Phosphate	Antic. Pigment	**7.36**	-
Nubirox 106	Antic. Pigment	-	**7.36**
Micral 2	Calcium carbonate	15.43	15.43
CBI-5 Talc	Micro talc	10.55	10.55
Synolac 7503X60	Alkyd resin	19.29	19.29
Cobalt Naphtenate 6%	Dryer	0.12	0.12
Synresol E-22	Anti-skinning agent	0.21	0.21
Dowanol PM	Solvent	1.68	1.68
	Pigment Volume Concentration	36.1%	36.3%
	PVC/CPVC	**0.70**	**0.74**
	Non-volatile contents, volume	50.0%	50.0%
	Non-volatile contents, weight	66.3%	66.3%
	Anticorrosive pigment volume in dry film	**6.0%**	**6.2%**

	Specific gravity (g/cm^3)	Oil absorption (g oil/100g pig)
Zinc Phosphate	3.3	20
Nubirox 106	**3.2**	**40**

Weight replacement
less free binder



Formulation Case 1

FORMULA	FUNCTION	A % weight	B % weight	C % weight	D % weight
Synolac 7503X60	Alkyd resin	21.81	21.81	↑ 23.86	22.66
Bentone 34 (10% in xylene)	Rheological additive	4.60	4.60	4.70	4.68
Calcium Naphtenate 4%	Wetting agent	0.41	0.41	0.39	0.40
Xylene	Solvent	10.98	10.98	10.60	10.99
Tioxide TR92	Titanium dioxide	7.56	7.56	7.51	7.49
Zinc Phosphate	Antic. Pigment	**7.36**	-	-	-
Nubirox 106	Antic. Pigment	-	**7.36**	**7.48**	**1.24**
Micral 2	Calcium carbonate	15.43	15.43	↓ 14.12	18.36
CBI-5 Talc	Micro talc	10.55	10.55	↓ 9.66	12.56
Synolac 7503X60	Alkyd resin	19.29	19.29	↑ 19.70	19.60
Cobalt Naphtenate 6%	Dryer	0.12	0.12	0.13	0.13
Synresol E-22	Anti-skinning agent	0.21	0.21	0.20	0.12
Dowanol PM	Solvent	1.68	1.68	1.68	1.69
	Pigment Volume Concentration	36.1%	36.3%	33.6%	35.4%
	PVC/CPVC	**0.70**	**0.74**	**0.70**	**0.70**
	Non-volatile contents, volume	50.0%	50.0%	50.0%	50.0%
	Non-volatile contents, weight	66.3%	66.3%	65.6%	65.7%
	Anticorrosive pigment volume in dry film	**6.0%**	**6.2%**	**6.0%**	**1%**

	Specific gravity (g/cm^3)	Oil absorption (g oil/100g pig)
Zinc Phosphate	3.3	20
Nubirox 106	**3.2**	**40**

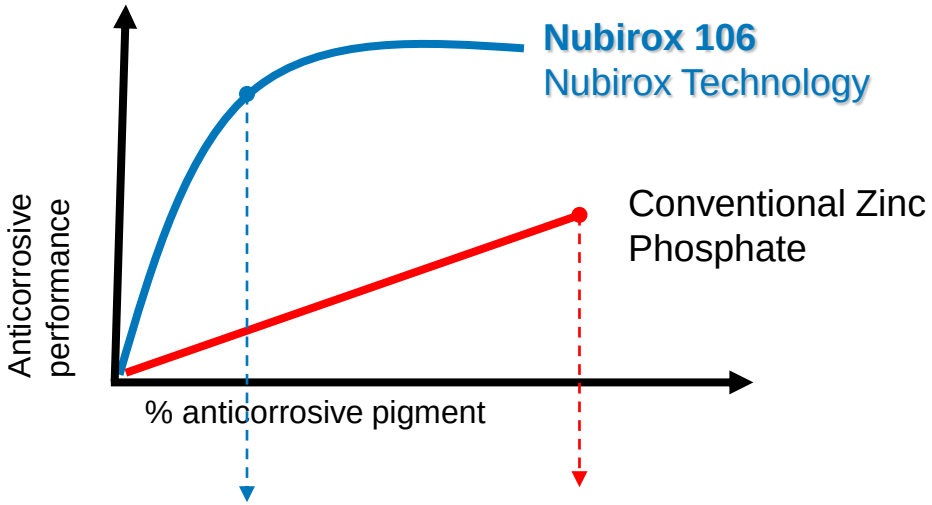
Weight replacement **less free binder**

Reformulation at **same PVC/CPVC**

Cost-effective reformulation

Formulation Case 1

- **Nubirox 106**: Pigment effectiveness at low loading level



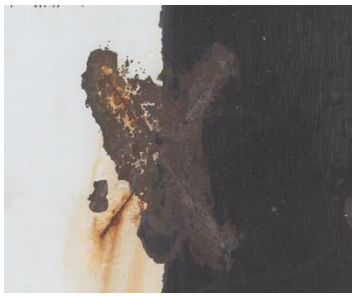
Negative control

Formula AC10423

1.2% Nubirox 106

Formula AC10432

7.3% Conventional Zinc Phosphate



Formula AC10427

Solvent Based system **Phenolic modified short oil alkyd**
50% solids in volume, **CPV/CPVC=0.7**
Application on standardized cold rolled steel S-46 (Q-Panel) DFT **~35µ**
525 hours of exposure in Salt Spray (ASTM B-117).

Formulation Case 2

- **<u>WB Alkyd DTM for multisubstrate aplication:</u>**

  Addition of anticorrosive pigments

  - **Direct replacement**

    Replacement in weight of color pigment or extender

  - **Reformulation**

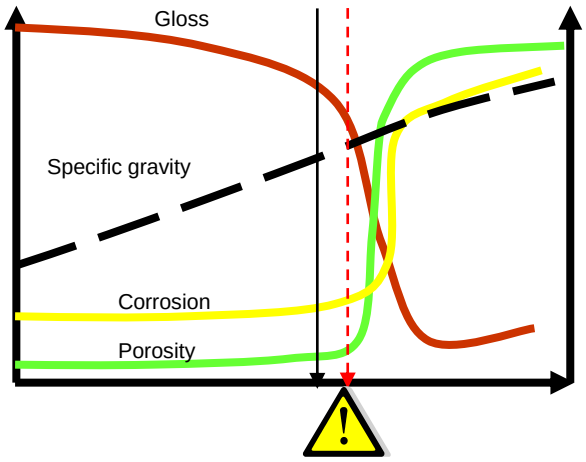
    Differences only due to anticorrosive pigment effectiveness

Formulation Case 2

		A	B
FORMULA	**FUNCTION**	**% weight**	**% weight**
Water		8,99	8,99
Byk 024	Defoamer	0,12	0,12
Disperbyk 190	Dispersing agent	1,52	1,52
Tioxide TR92	Titanium dioxide	28,77	24,77
Nubirox 302	Antic. Pigment	-	**4,00**
Nubirox 106	Antic. Pigment	-	-
Uradil AZ760	Medium oil alkyd emulsion	58,12	58,12
Additol VXW4940 (1:1 water)	Drier	1,28	1,28
Nubirox FR-10	"Flash rust" inhibitor	0.50	0.50
Byk 348	Levelling agent	0.23	0.23
Acrysol RM-8W	PU-thickener	0,47	0,47
	Pigment Volume Concentration	19,3%	20,2%
	PVC/CPVC	**0.36**	**0.40**
	Non-volatile contents, volume	49,7%	50,1%
	Non-volatile contents, weight	61,3%	61,4%
	Anticorrosive pigment volume in dry film	**0%**	**3,7%**

	Specific gravity (g/cm^3)	Oil absorption (g oil/100g pig)
Titanium dioxide	4,1	21
Nubirox 302	**2,9**	**45**

TiO_2 Weight replacement
less free binder



Formulation Case 2

		A	B	C	D
FORMULA	**FUNCTION**	**% weight**	**% weight**	**% weight**	**% weight**
Water		8,99	8,99	8,90	9,56
Byk 024	Defoamer	0,12	0,12	0,13	0,12
Disperbyk 190	Dispersing agent	1,52	1,52	1,38	1,43
Tioxide TR92	Titanium dioxide	28,77	24,77	↓ 21,77	↓ 23,07
Nubirox 302	Antic. Pigment	-	**4,00**	**4,38**	-
Nubirox 106	Antic. Pigment	-	-	-	**3,87**
Uradil AZ760	Medium oil alkyd emulsion	58,12	58,12	↑ 60,84	↑ 60,04
Additol VXW4940 (1:1 water)	Drier	1,28	1,28	1,34	0,66
Nubirox FR-10	"Flash rust" inhibitor	0.50	0.50	0.53	0.52
Byk 348	Levelling agent	0.23	0.23	0.24	0.24
Acrysol RM-8W	PU-thickener	0,47	0,47	0,49	0,49
	Pigment Volume Concentration	19,3%	20,2%	18,2%	18,8%
	PVC/CPVC	**0.36**	**0.40**	**0,36**	**0,36**
	Non-volatile contents, volume	49,7%	50,1%	49,7%	49,7%
	Non-volatile contents, weight	61,3%	61,4%	60,1%	60,8%
	Anticorrosive pigment volume in dry film	**0%**	**3,7%**	**4,0%**	**4,0%**

	Specific gravity (g/cm^3)	Oil absorption (g oil/100g pig)
Titanium dioxide	4,1	21
Nubirox 302	**2,9**	**45**

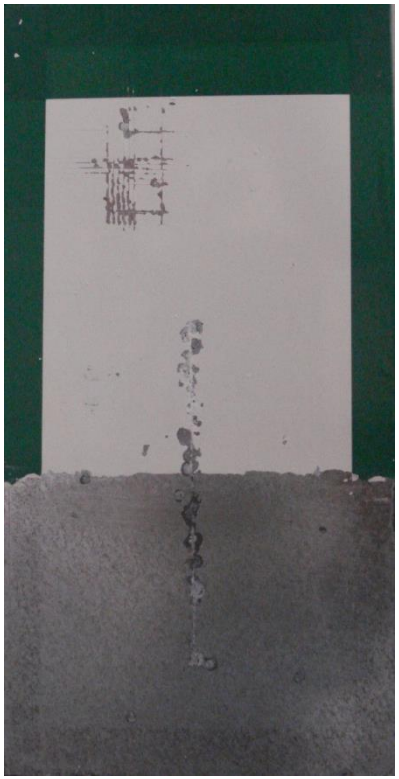
TiO_2 Weight replacement **less free binder**

Reformulation at **same PVC/CPVC**

Reformulation at **same PVC/CPVC**

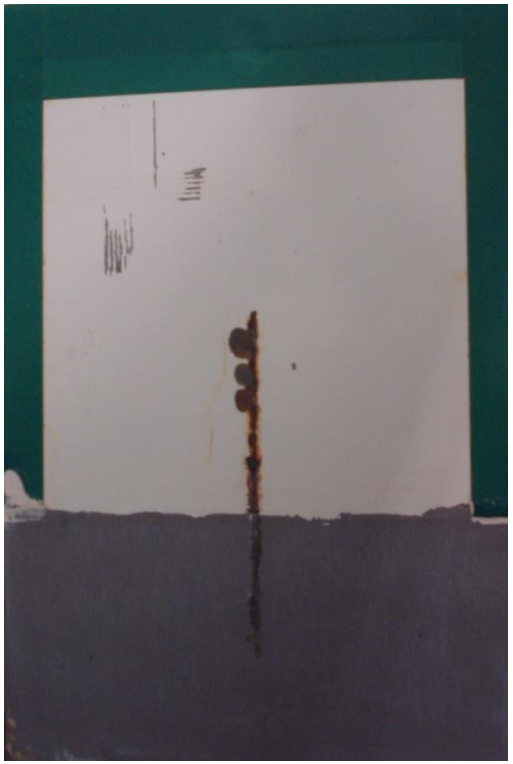
Formulation Case 2

Water based system	Uradil AZ 760 is a medium oil alkyd emulsion based on soybean fatty acids	50% solids in volume CPV/CPVC≈ 0.36	Application on standardized **galvanized Steel SG015 (Espancolor)** Dry film thickness **~45µ**	**2800 hours** of exposure in Salt Spray (ASTM B-117)

Without anticorrosive pigment	**4%** dry film volume (3,9%total formula weight) **Nubirox 106**	**4%** dry film volume (4,4%total formula weight) **Nubirox 302**
		
FORMULA AA 19666	*FORMULA AA 19667*	*FORMULA AAA 19670*
Gloss (60º): 98 **Gloss (20º): 93**	**Gloss (60º): 93** **Gloss (20º): 79**	**Gloss (60º): 96** **Gloss (20º): 85**

Formulation Case 2

Water based system	Uradil AZ 760 is a medium oil alkyd emulsion based on soybean fatty acids	50% solids in volume CPV/CPVC≈ 0.36	Application on standardized **cold rolled steel panels S-46 (Q-Panel)** Dry film thickness **~45µ**	**500 hours** of exposure in Salt Spray (ASTM B-117)

Without anticorrosive pigment	**4%** dry film volume (3,9%total formula weight) **Nubirox 106**	**4%** dry film volume (4,4%total formula weight) **Nubirox 302**
		
FORMULA AA 19666 **Gloss (60º): 98** **Gloss (20º): 93**	*FORMULA AA 19667* **Gloss (60º): 93** **Gloss (20º): 79**	*FORMULA AAA 19670* **Gloss (60º): 96** **Gloss (20º): 85**

Formulation Case 2

Water based system	Uradil AZ 760 is a medium oil alkyd emulsion based on soybean fatty acids	50% solids in volume CPV/CPVC≈ 0.36	Application on standardized iron phosphated steel panels Bonderite 1000 (R-36-I from Q-Panel) Dry film thickness ~45µ	500 hours of exposure in Salt Spray (ASTM B-117)

Without anticorrosive pigment

FORMULA AA 19666

Gloss (60º): 98
Gloss (20º): 93

4% dry film volume
(3,9%total formula weight)

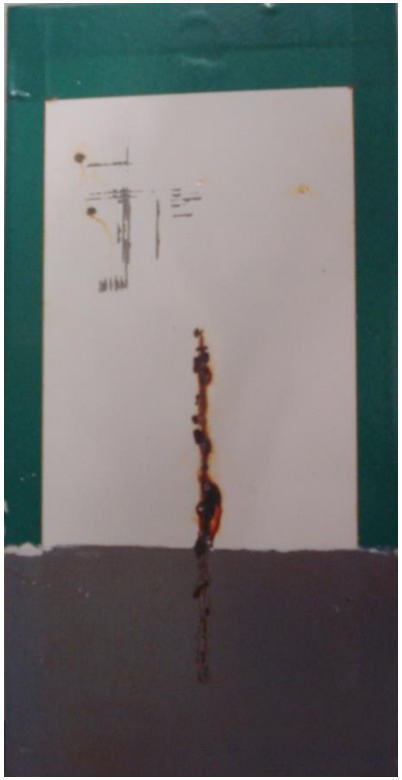
Nubirox 106

FORMULA AA 19667

Gloss (60º): 93
Gloss (20º): 79

4% dry film volume
(4,4%total formula weight)

Nubirox 302



FORMULA AAA 19670

Gloss (60º): 96
Gloss (20º): 85

Formulation Case 2

- **Nubirox 302:** good gloss/performance balance

Gloss

Panel evaluation	Control	4% Nubirox 106	4% Nubirox 302
Gloss 60º	98	93 (-5%)	96 (-2%)
Gloss 20º	93	79 (-15%)	85 (-9%)

Anticorrosive performance on Galvanized steel

Panels exposed 2800h in Salt Spray test	Control	4% Nubirox 106	4% Nubirox 302
Rusting at the scribe (ASTM D1654)	5 (3.5mm)	**7 (1.5mm)**	**9 (0.5mm)**
Rusting on the panel (ASTM D610)	8G (0.1%)	7G (0.3%)	**9 (0.03%)**
Adhesion at the scribe (ASTM D1654)	2 (50%)	**6 (10%)**	**9 (1%)**
Adhesion "cross cut" (ASTM B3359)	0B	**1B**	**1B**

Anticorrosive performance on Cold rolled steel

Panels exposed 500h in Salt Spray test	Control	4% Nubirox 106	4% Nubirox 302
Rusting at the scribe (ASTM D1654)	5 (3.5mm)	**6 (3mm)**	**7 (2mm)**
Rusting on the panel (ASTM D610)	8G (0.1%)	**9G (0.03)**	**9G (0.03%)**
Adhesion at the scribe (ASTM D1654)	5 (15%)	**7 (5%)**	**9 (1%)**
Adhesion "cross cut" (ASTM B3359)	5B	5B	5B

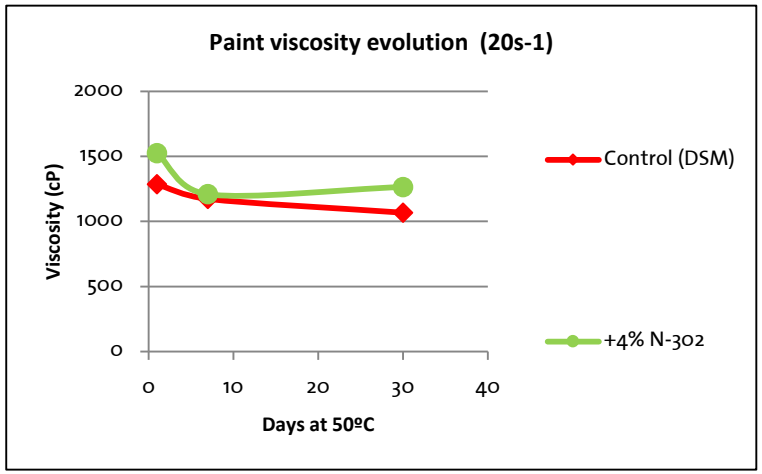
Anticorrosive performance on Phosphated steel

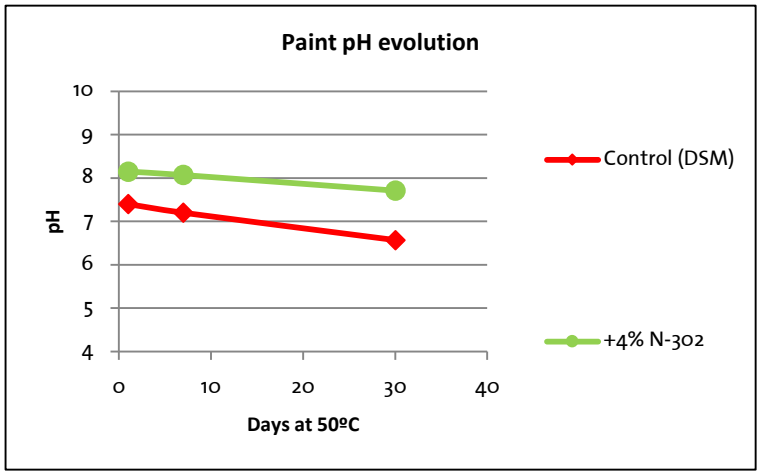
Panels exposed 500h in Salt Spray test	Control	4% Nubirox 106	4% Nubirox 302
Rusting at the scribe (ASTM D1654)	4 (6mm)	**7 (1.5mm)**	**7 (1.5mm)**
Rusting on the panel (ASTM D610)	7G (0.3%)	**8G (0.1%)**	**9G (0.03%)**
Adhesion at the scribe (ASTM D1654)	0 (90%)	**8 (2%)**	**9 (1%)**
Adhesion "cross cut" (ASTM B3359)	4B	3B	1B

Formulation Case 2

- **Nubirox 302:** good paint stability

Package stability (ASTM D1849): Viscosity, pH and settling evolution after 7 and 30 days at 50ºC.





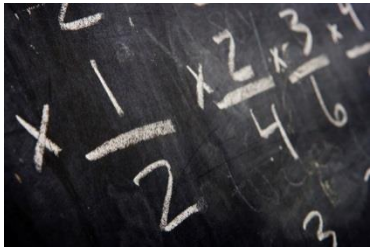
	Settling (ASTM D-869)		
	initial	7 days at 50ºC	30 days at 50ºC
Control	10	6	2
+4% N-302	10	8	6

Conclusions

- **Anticorrosive pigments:**
  - Not only is the chemistry important…

    also physical properties of pigment particles:
    - More active surface
    - Better performance in thin film systems
  - Modifications improve performance of Zinc based pigments
  - Non Zinc based anticorrosive pigments benefits

- **Anticorrosive coating formulation:**
  - Bear in mind formulation parameters
    - Adjust free binder volume to the desired properties
    - Pigment replacement in weight could be dangerous
    - Benefits of cost efficient replacements



Thank you

PATRÍCIA PÉREZ MASNOU
Corrosion Inhibitors Product & Technical Service Manager
P +34 933.140.343
M +34 634.650.016
E patricia.perez@ferro.com
Ferro Performance Pigments Spain
C/Pablo Iglesias, 98-100
08908 L'Hospitalet de Llobregat (Barcelona)

About Ferro Corporation

FERRO
Where innovation delivers performance™

Ferro Overview

- Founded 1919 as Ferro Enameling Company in Cleveland, Ohio USA
- Worldwide leader in production of glass enamels, porcelain enamels, ceramic tile coatings and high performance pigments
- Approximately 5,680 associates working in 27 countries
- 2016 sales of $1.15 billion

Approaching centennial as a growing innovator of glass-based coatings and color solutions

FERRO
Where innovation delivers performance™

Diverse Customer Base, Singular Promise

- We serve manufacturers in 100+ countries and in diverse markets.
- Our customers turn to us for innovative solutions and a commitment to delivering ***new possibilities for their products, businesses and customers.***

Building and Construction

Automotive

Appliances

Electronics

Household Furnishings

Industrial Products

Ferro's Core Technologies

- Color and glass science
- Particle engineering
- Surface application technology
- Formulation

The Way We Work: Ferro Core Values

Customer Focus	Our customers are why we exist; we build trusting relationships that are built on customer needs and a genuine interest in making customers successful.
Accountability for Performance	We work to the highest performance standards, prioritizing safety, environmental stewardship, creating value for customers and Ferro shareholders.
Innovative Thinking	We seek new ideas for technologies and business processes, always looking for ways to improve and better serve our customers.
Teamwork and Collaboration	We are committed to a work environment of trust and respect, and work together to consistently deliver value to our customers and shareholders.

FERRO
Where innovation delivers performance™

For more information on

Ferro Pigments Business Unit,

visit www.ferro.com



Disclaimer for commercial products

- Ferro can certify only those parameters in the Technical Data Sheet for our products. Ferro is not responsible for any use, misuse, handling or storage conditions that may act to the detriment of the specifications of our products, or pose a risk to human health or the environment.

  Due to the fact that there are a multitude of formulations, manufacturing processes and end uses, Ferro strongly recommends that customers conduct performance testing under their own testing program, and carry out appropriate verifications in order to determine the ultimate suitability of our products, and comply with existing laws and regulations.