# Coatings Trends & Technologies SUMMIT

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The Westin Chicago Lombard
70 Yorktown Center | Lombard IL 60148

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# Influence of Formulation Variables on the Performance of Water-Based Direct-to-Metal Coatings

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# Agenda

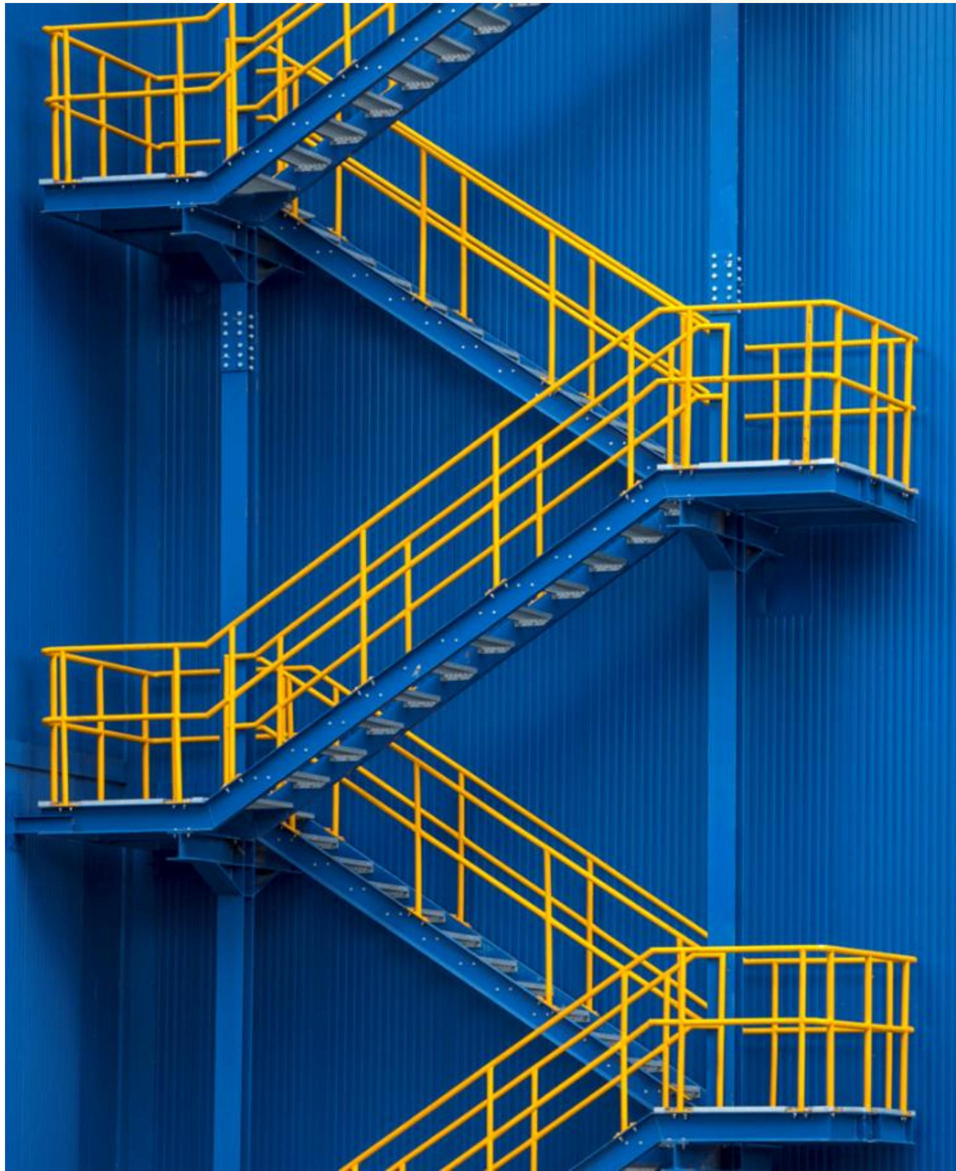
- Trends and performance challenges in waterborne direct-to-metal coatings
- Performance properties a balancing act
- Introduction to EPS <100 g/L DTM Polymer
- Additives experiment outline
- Results and discussion
- Conclusions

# Direct-to-Metal Coatings
## Industry trends

- Customer preferences driving transition from solvent-borne to waterborne systems
- Current challenges facing alkyd resins
- Addressing ever-changing VOC regulations
- Reducing applied costs
- Obtaining anti-blocking properties while maintaining corrosion resistance
- Balancing multi-substrate adhesion with high corrosion resistance

# Performance Needs of a Direct-to-Metal Coating

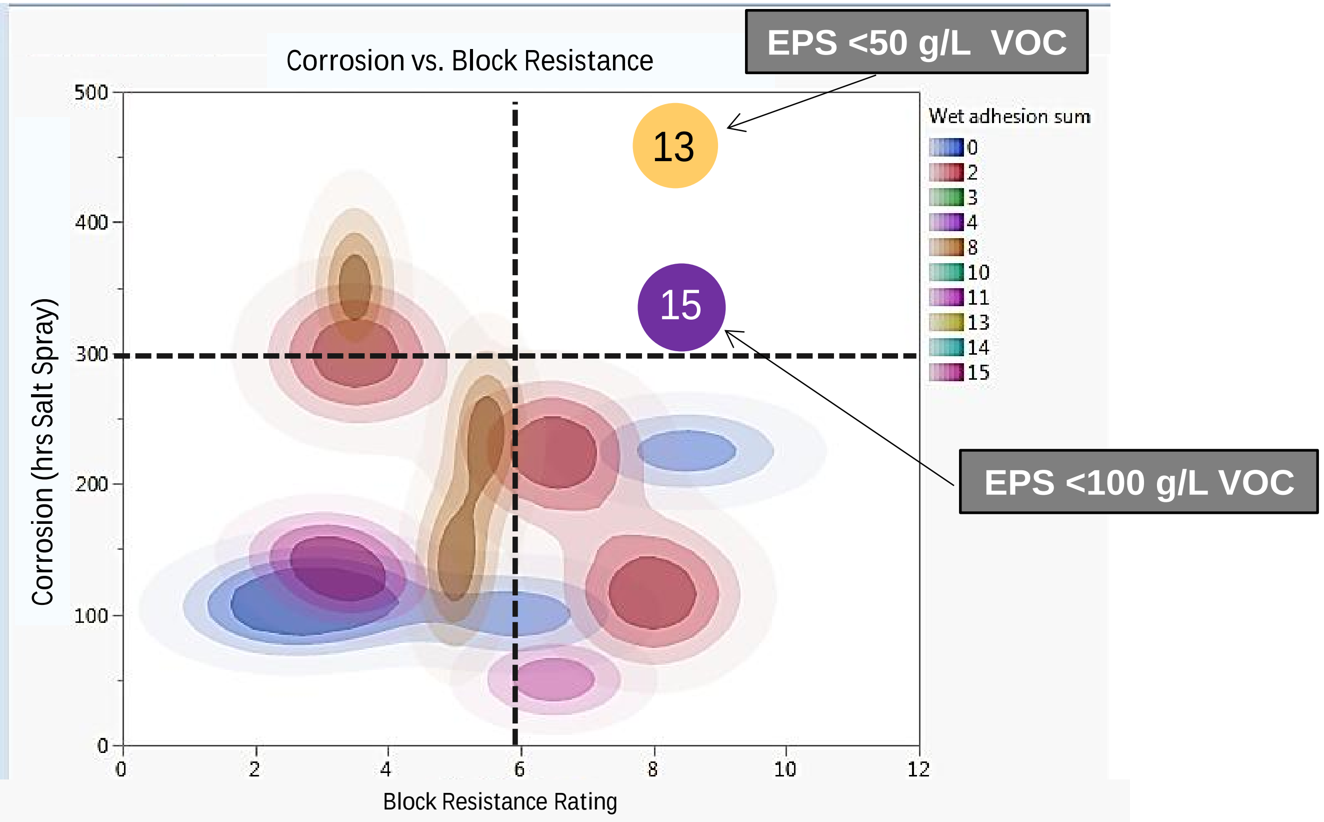
- Coating needs to be block resistant for quick return to service
- Coating needs to adhere to a variety of metal substrates
- Coating needs to protect the substrate from corrosion
- It is desirable to have a coating that retains color and gloss



# Commercial Direct-to-Metal Coating Evaluation Performance Attribute Balance

20 commercial high gloss DTM coatings ranging from 50-250g/L were benchmarked.

Gap in performance for block resistance and corrosion resistance



# Direct-to-Metal Coatings Challenges
## (Corrosion and Block Resistance)

8

4

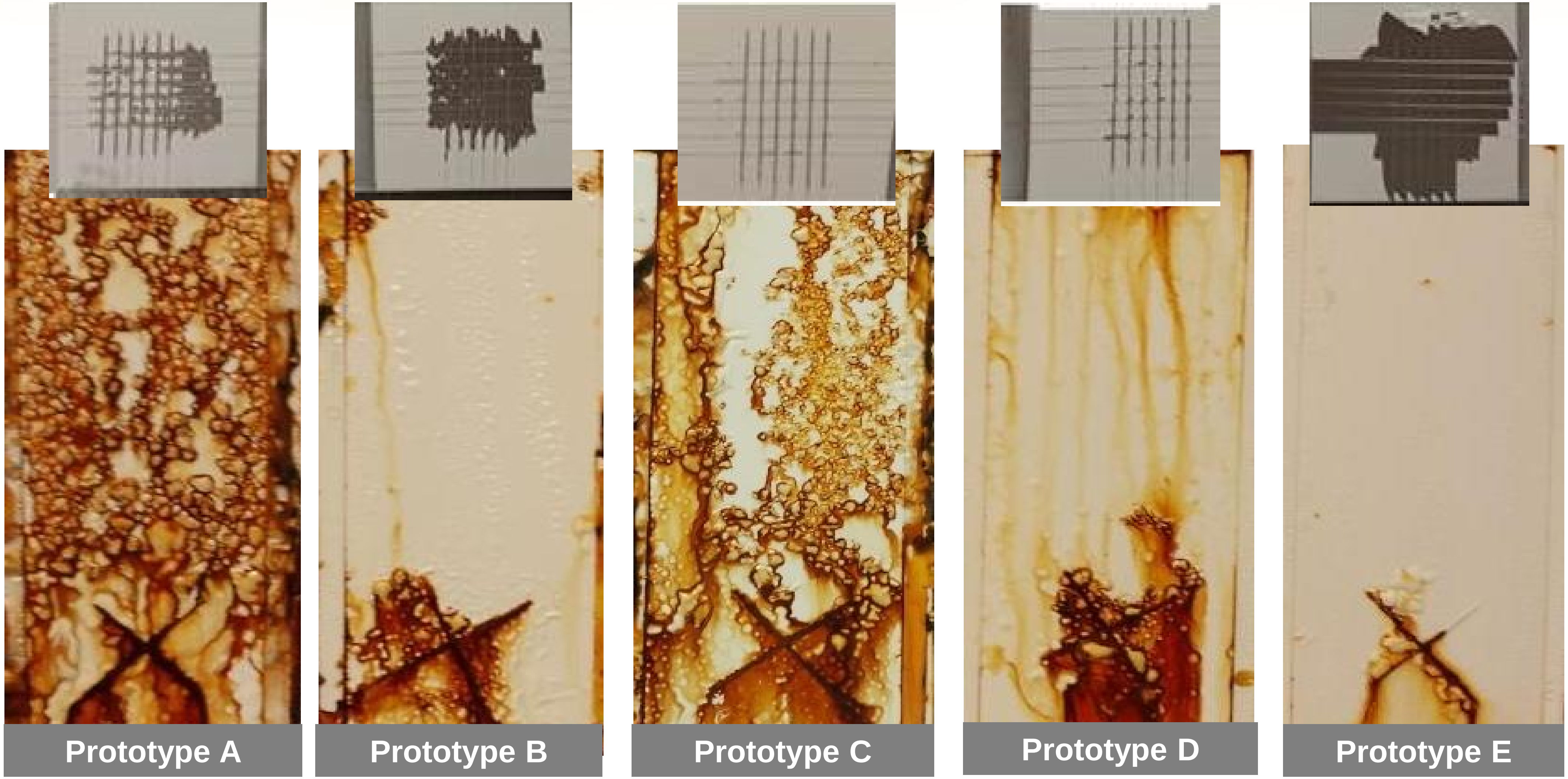
0

Block Rating

Decreasing corrosion resistance with improved block resistance

300hr B117 @ 2mil DFT

# Direct-to-Metal Coatings Challenges
## (Corrosion and Adhesion)




**Aluminum adhesion**

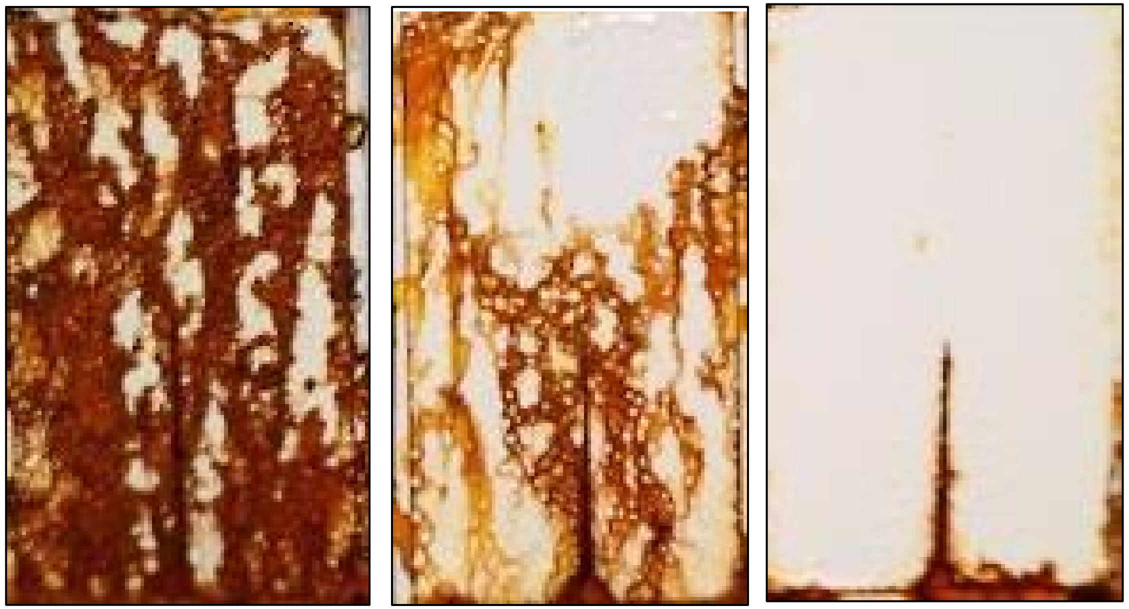
**Using incumbent adhesion technology, attempts to improve aluminum adhesion reduces corrosion performance on steel**

**300hr B117**

# Direct-to-Metal Coatings Challenges
## Effect of Film Build on Corrosion Performance

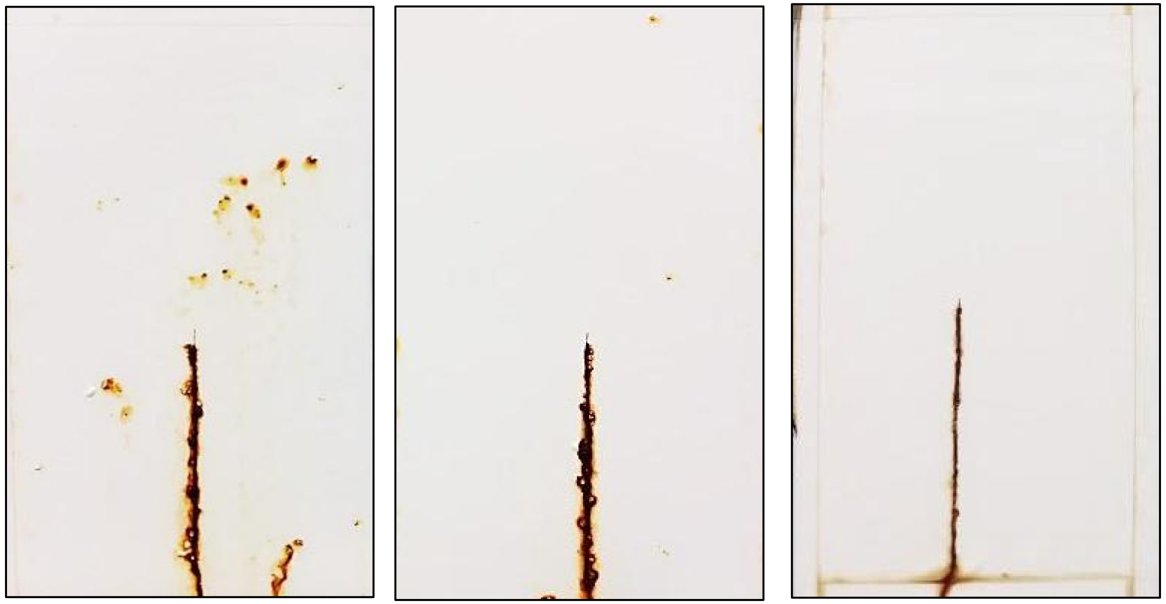
### Corrosion resistance at 250hrs in B117

**Typical Waterborne DTM**



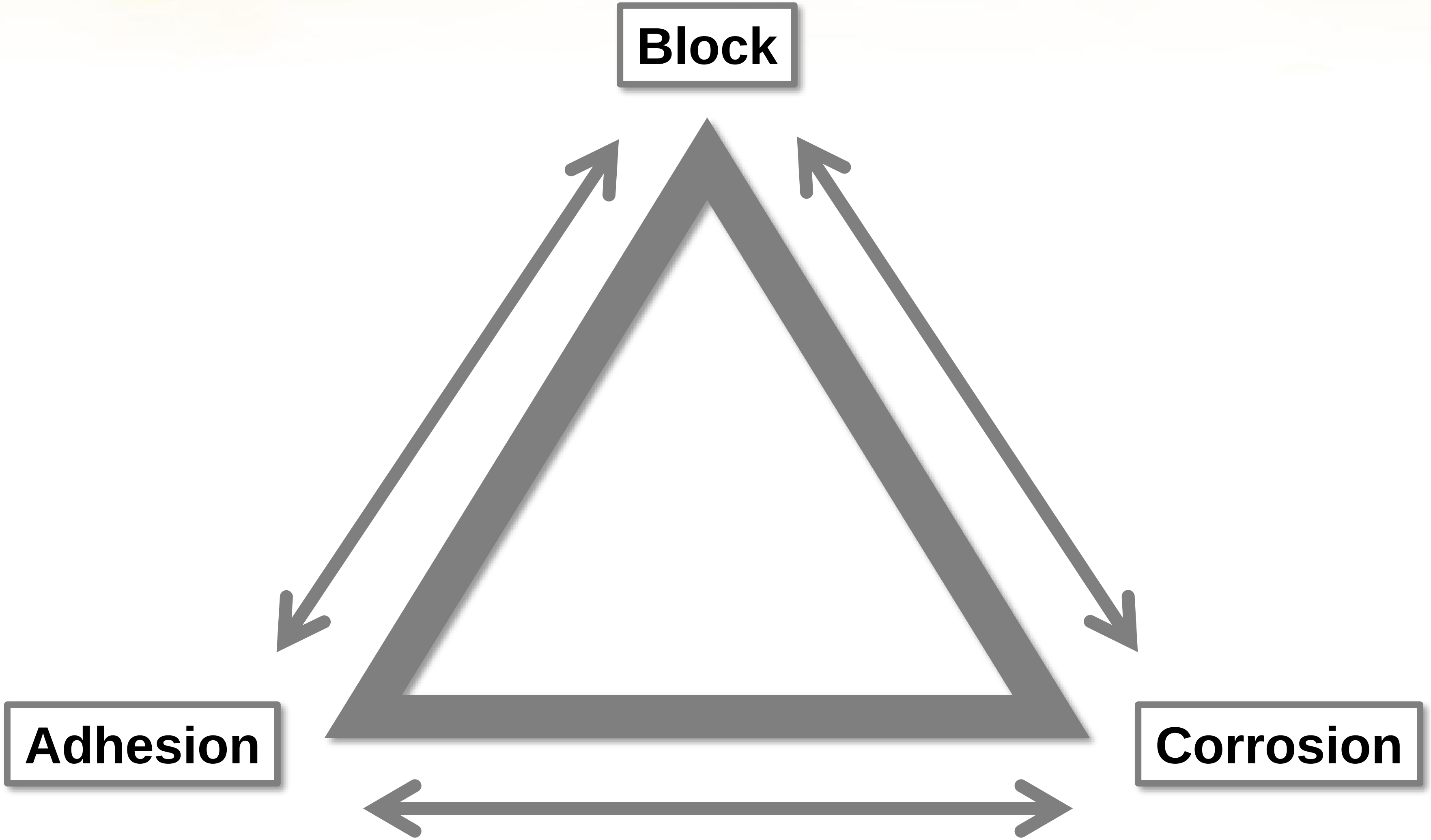
2 mils | 3 mils | 4 mils

**EPS <50 g/L DTM Platform**



2 mils | 3 mils | 4 mils

# Performance Properties Balancing Act



# EPS <100 g/L VOC DTM Performance
## Adhesion/Corrosion Balance

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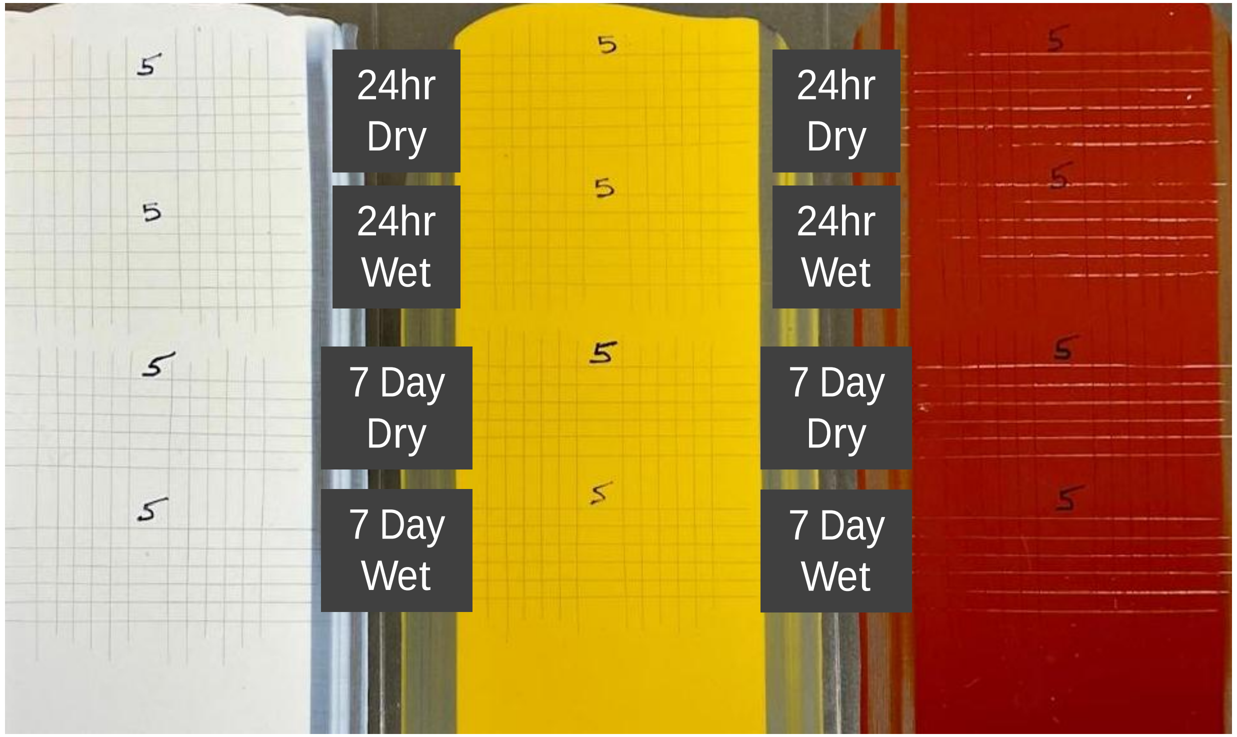
| EPS HG WHT | EPS HG YOX | EPS HG (Tinted) ROX |
|---|---|---|

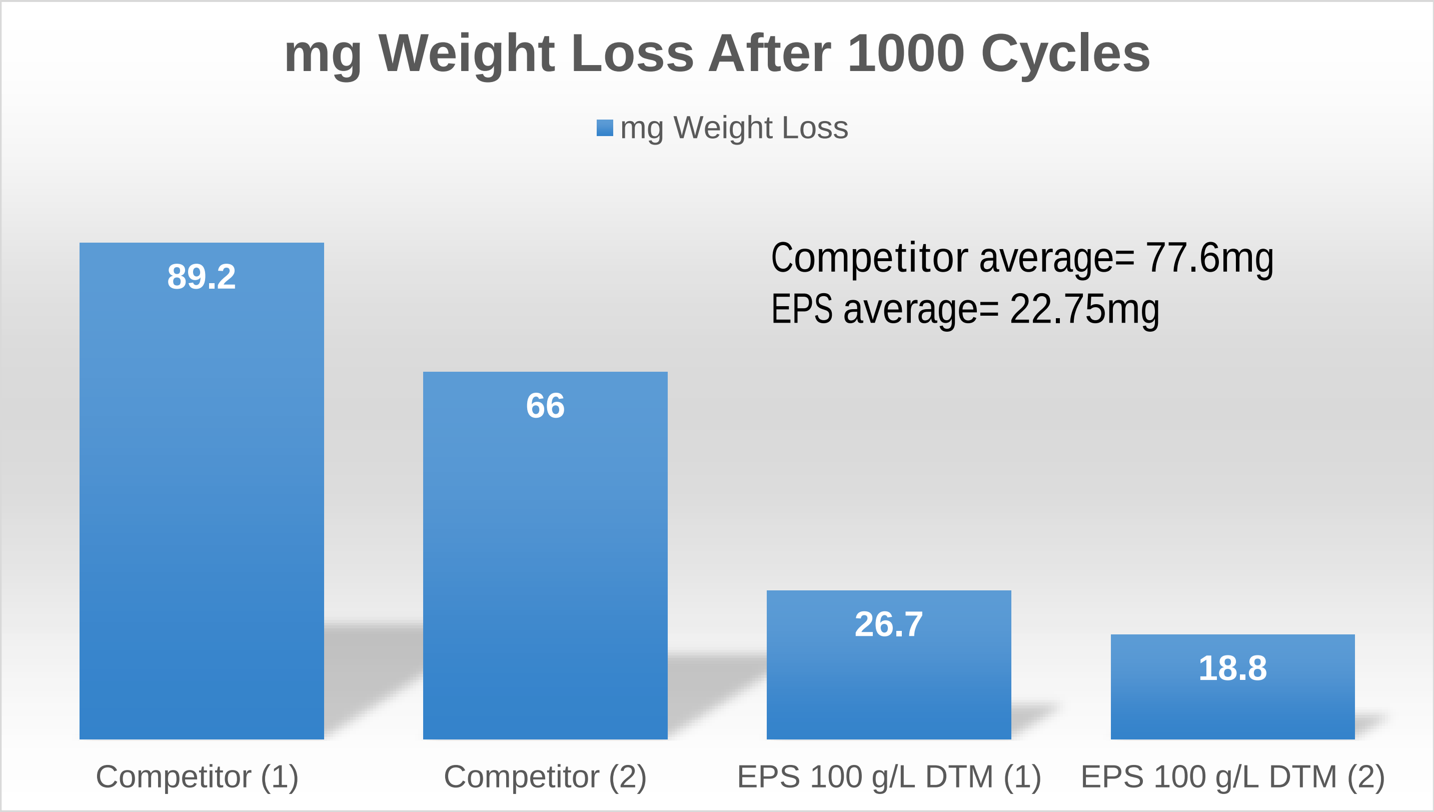



**Substrate= Cold Rolled Steel**

| EPS HG WHT | EPS HG YOX | EPS HG (Tinted) ROX |
|---|---|---|

| 180hrs B117 | 180hrs B117 | 48hrs B117 |
|---|---|---|

# EPS <100 g/L VOC DTM Performance
## Taber Abrasion and Early Water Resistance



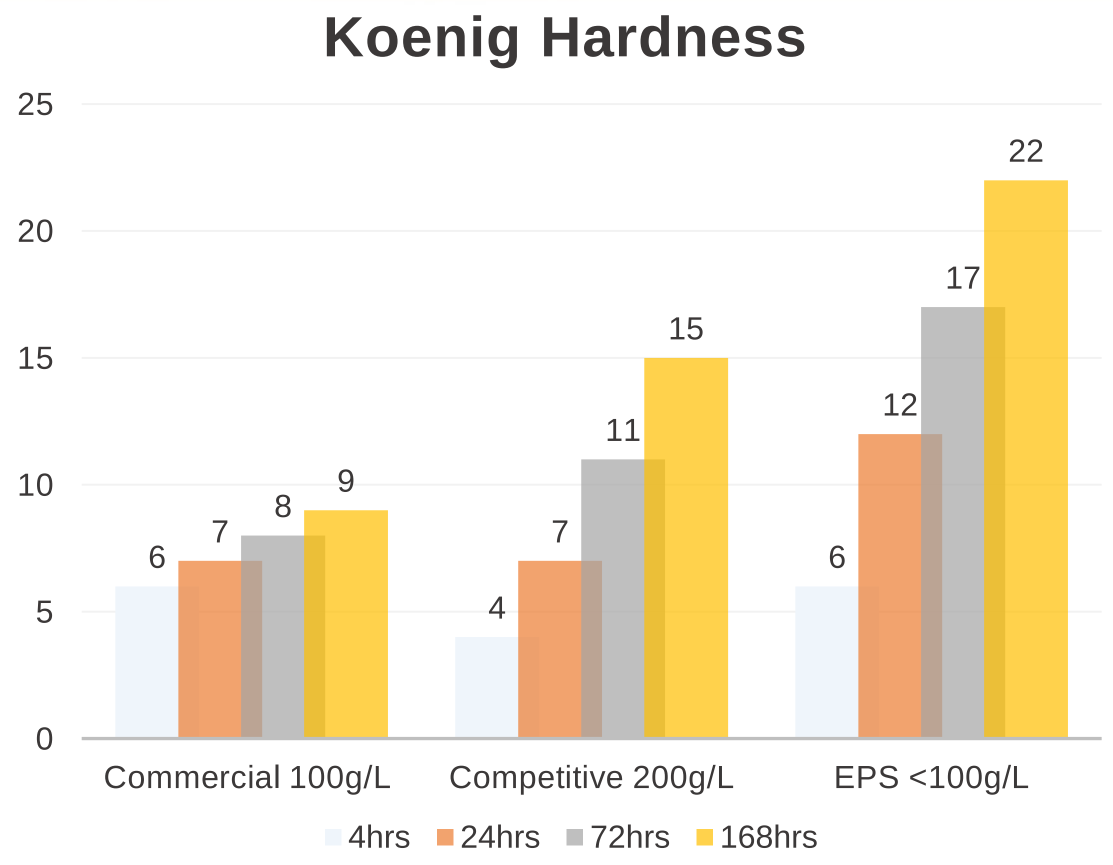

Commercial DTM

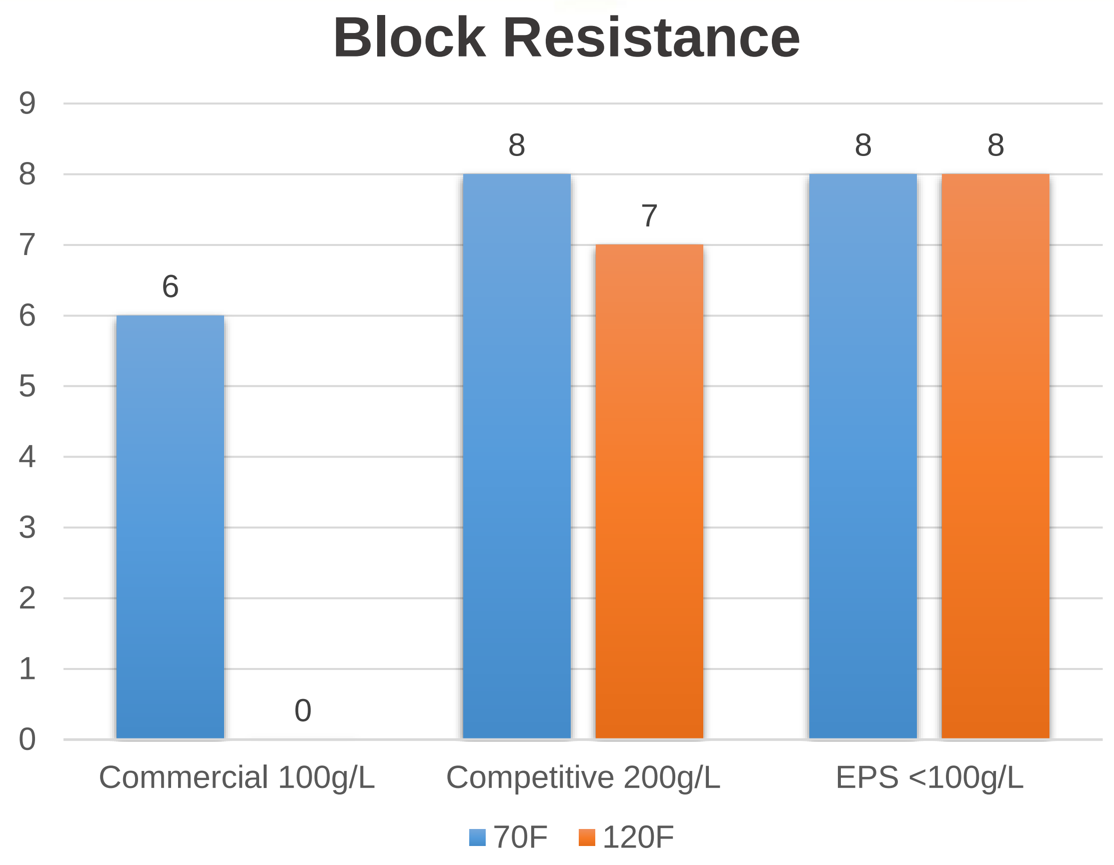
EPS

| Measurement* | Commercial DTM | EPS <100g/L DTM |
|---|---|---|
| Degree of Rust | 0 | 0 |
| Degree of Blistering | #8 Dense | 10 (no blistering) |

*Samples cured 24hrs and immersed in 40℃ water bath overnight

# EPS <100 g/L VOC DTM Performance
## Koenig Hardness and Block Resistance



# Effect of Coating’s Additives on Performance

- Studies were then run to evaluate the effect a coating’s additives had on performance

- Numerous additives can impact corrosion resistance
    - Surfactants, dispersants, coalescents, flash rust inhibitor, neutralizer, and anticorrosive additives just to name a few

# Starting Point Formulation
## High Gloss White



| Weight (lbs.) | Volume (gal) | Material |
|---|---|---|
| 60.00 | 7.20 | Water |
| 4.50 | 0.45 | Dispersant |
| 4.01 | 0.55 | Surfactant |
| 3.51 | 0.40 | Antifoam |
| 2.00 | 0.27 | pH Buffer |
| 190.00 | 5.56 | Titanium Dioxide |
| 600.0 | 69.77 | EPS <100 g/L Polymer |
| 67.80 | 7.89 | Water |
| 30.00 | 3.96 | Coalescent |
| 5.00 | 0.57 | Low VOC Plasticizer |
| 2.50 | 0.28 | Biocide |
| 15.00 | 1.80 | Sodium Nitrite 4% |
| 6.00 | 0.66 | HEUR Thickener |
| 10.00 | 0.40 | Corrosion Inhibitor |
| 993.43 | 100.00 | TOTALS |

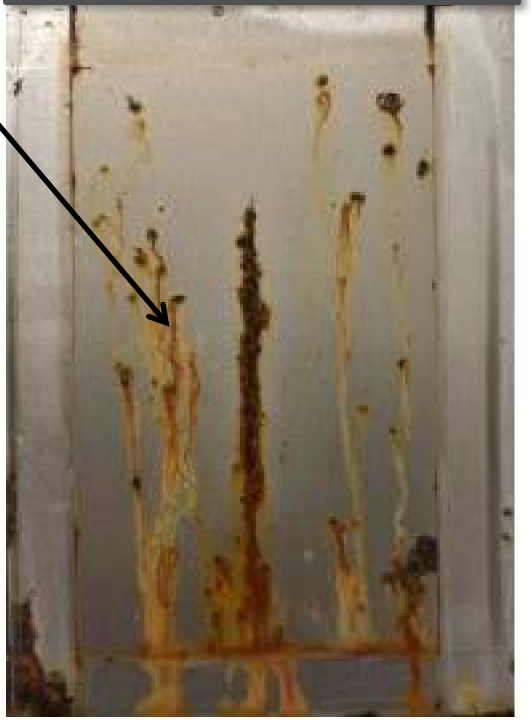
Formulation Physicals

- Weight Solids: 54.47%
- Volume Solids: 41.32%
- WPG: 10.00 lbs./gal
- VOC: <100 g/L
- Viscosity: 95-100 KU
- pH: 9.0-9.5

# Clear Coatings
## Coalescent Impact

Use of hydrophilic coalescents can impact field rusting

10% Water Miscible A



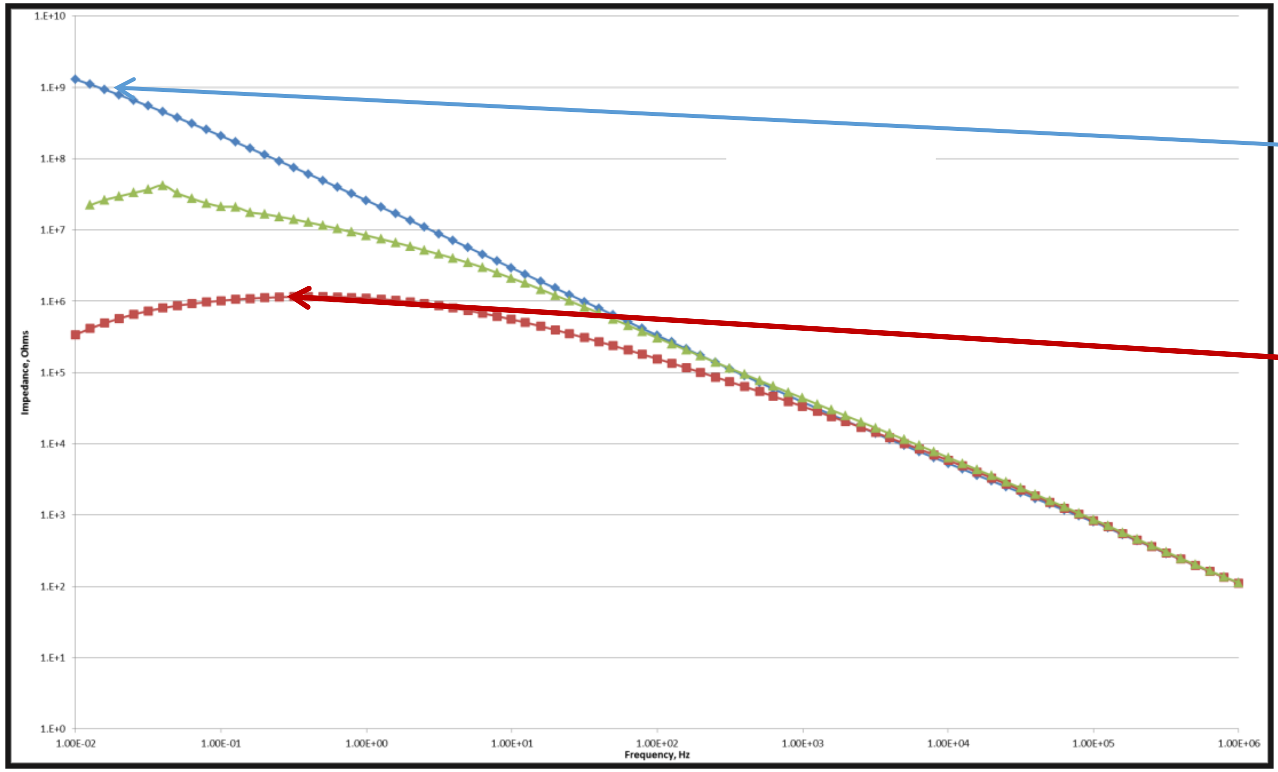
10% Water Miscible B

10% Polymer Miscible

The use of hydrophobic (polymer miscible) solvents is recommended

# Clear Coatings EIS Analysis
## Bode Plot with Various Solvents

Impedance (Ohms)
Exponential scale




Frequency (Hz)
Exponential scale

Polymer Miscible solvents

Water Miscible solvent

**Impedance of hydrophobic solvent coalesced film is orders of magnitude higher than one with water miscible**

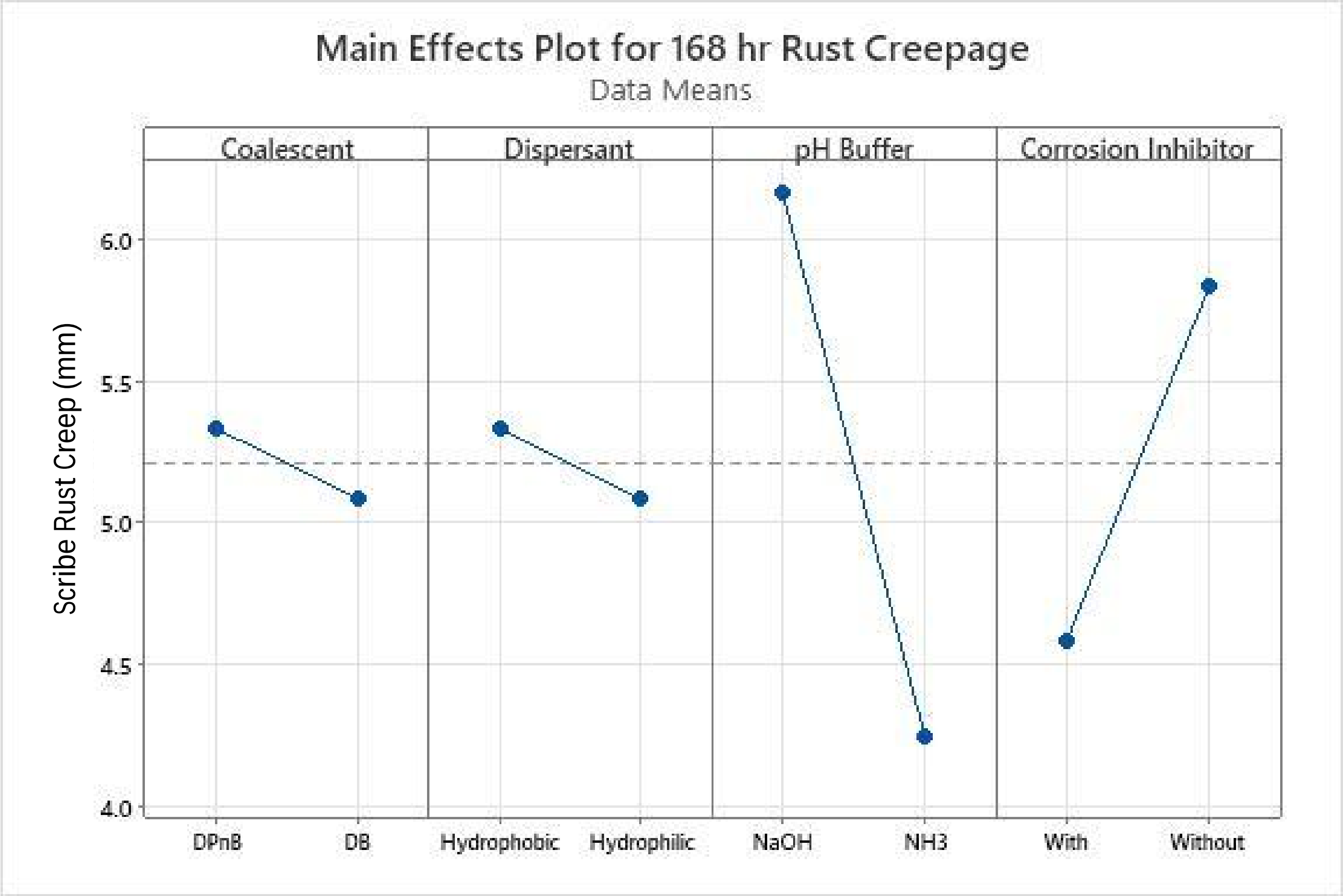
# Experimental Design

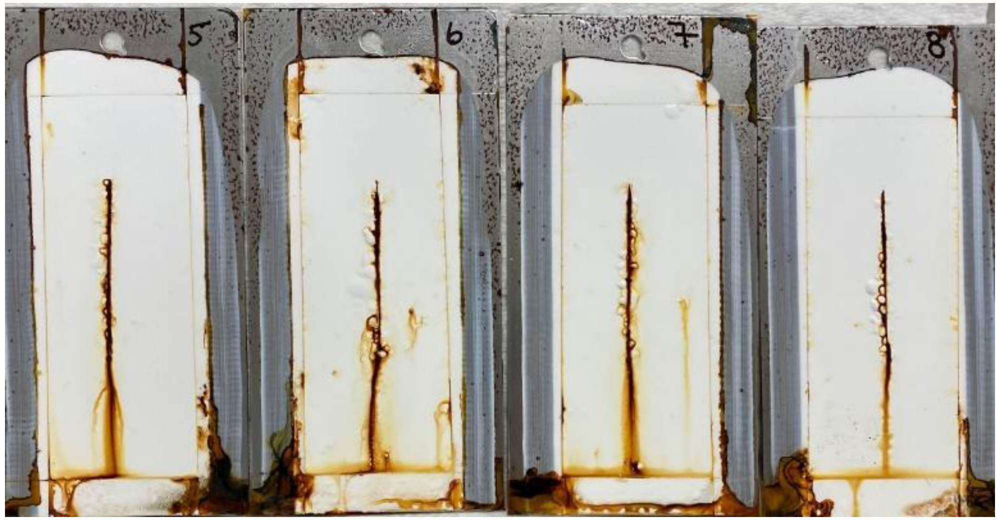
| RunOrder | Solvent | Dispersant | Neutralizer | Corrosion Inhibitor |
|---|---|---|---|---|
| 1 | Water Miscible | Hydrophobic | Volatile | Present |
| 2 | Water Miscible | Hydrophobic | Non-volatile | None |
| 3 | Water Immiscible | Hydrophilic | Volatile | None |
| 4 | Water Miscible | Hydrophobic | Volatile | None |
| 5 | Water Immiscible | Hydrophobic | Non-Volatile | Present |
| 6 | Water Immiscible | Hydrophilic | Non-Volatile | None |
| 7 | Water Immiscible | Hydrophobic | Volatile | None |
| 8 | Water Miscible | Hydrophilic | Non-Volatile | None |
| 9 | Water Miscible | Hydrophilic | Non-Volatile | Present |
| 10 | Water Immiscible | Hydrophobic | Non-Volatile | Present |
| 11 | Water Miscible | Hydrophilic | Volatile | Present |
| 12 | Water Immiscible | Hydrophilic | Volatile | Present |

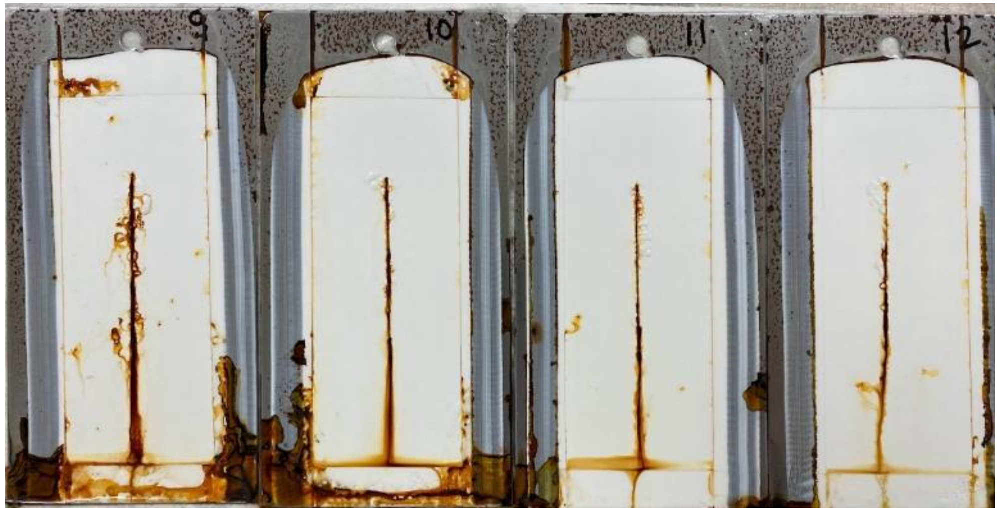
4-factor fractional factorial design was used to test the effects of various formulation additives on DTM performance

This experiment evaluated the effects of coalescing solvents, dispersants, neutralizers, and corrosion inhibitor on the liquid water uptake, electrochemical impedance, and the adhesion of the coating. These bulk film properties were contrasted with QUVA, and salt spray results to test for correlation coefficients.

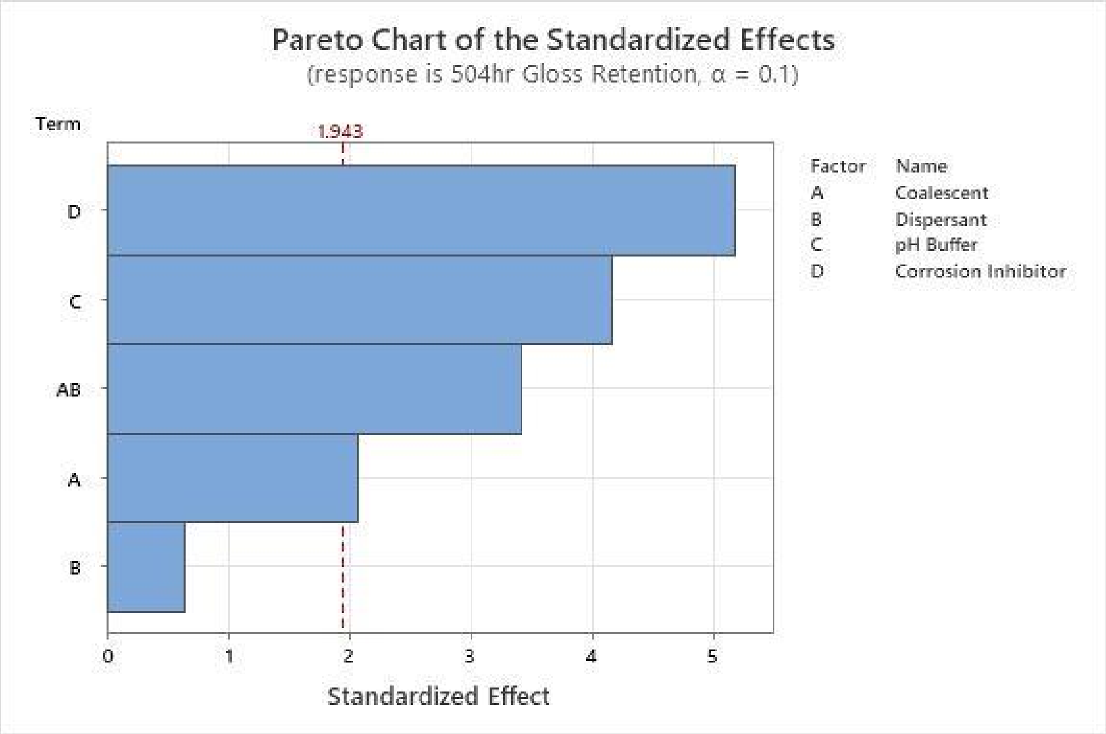
# Main Effects – B117 Salt Spray

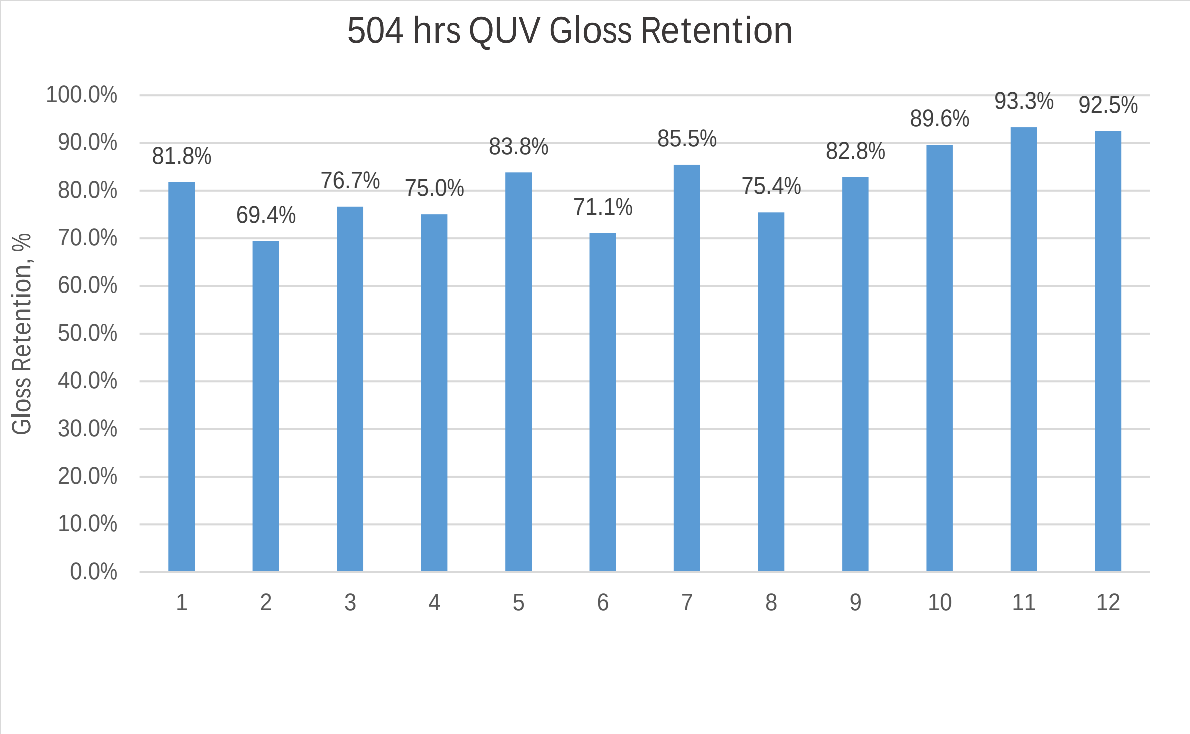


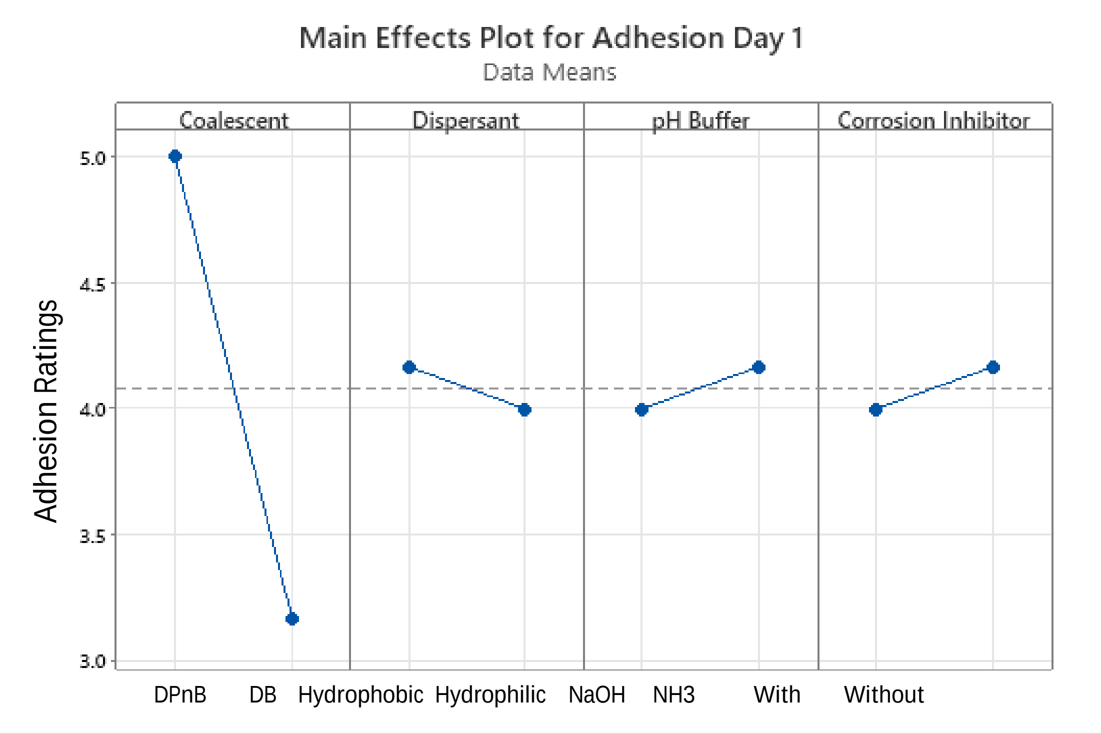
# Main Effects – QUV Gloss Retention

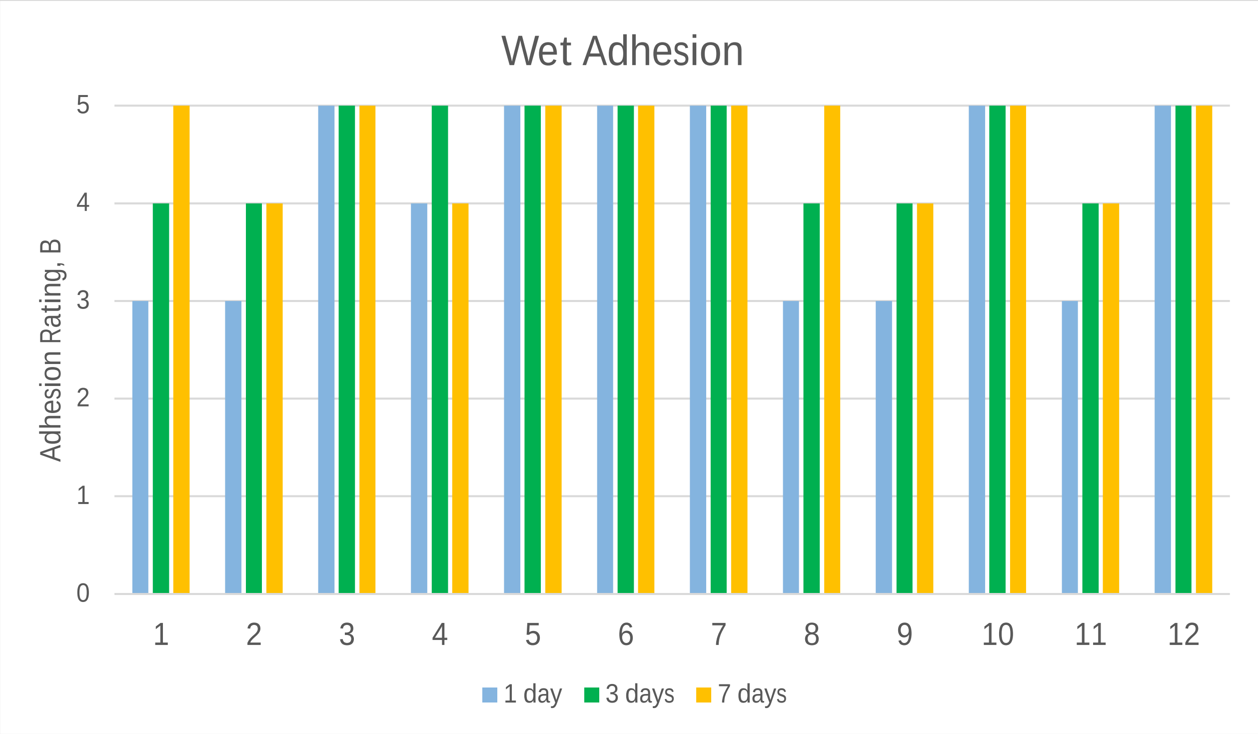



- Including the corrosion inhibitor was the primary factor for improving gloss retention
- The volatile buffer also noticeably improved the gloss retention in QUV

# Main Effects – 1-day Wet Adhesion - CRS



# Coatings Additive Experiment

## Findings and Conclusions

- The EPS polymer can achieve 100% film adhesion (5B wet and dry) within 7 days of curing. However, studying the DTM formulations with 1-day wet adhesion performance was more meaningful. The coalescing agent DPnB, an immiscible solvent, was preferred for producing the highest wet adhesion after 1 day.

- To minimize rust scribe development, this study suggests using a volatile pH buffer that does not remain in the coating. Additionally, incorporating a corrosion inhibitor can decrease creepage. However, formulations without a corrosion inhibitor also exhibited low scribe creep.

- A combination of a volatile pH buffer and a corrosion inhibitor resulted in the highest gloss retention.

# Results

# New Acrylic Resin for High-Performance General Industrial and Railcar Coatings

Formulate direct-to-metal coatings at <100g/L VOC, with excellent hardness, block resistance and early water resistance, using the new EPS polymer, which also offers superior corrosion resistance without the use of anti-corrosion pigments.

# QUESTIONS

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