Corrosion : *a Silent Enemy*

Paula Patrão

October 29 / 30 , 2024

4º Encontro com o mercado de Óleos Industriais e Graxas – São Paulo - Brasil

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Corrosion – It is everywhere

The following is an abstract from, “ Now is the time” a paper presented by George F. Hays, PE, Director General, World Corrosion Organization

- At USD 2,2 trillion, the annual cost of corrosion worldwide is over 3% of the world´s GDP

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Metalworking Market Trends

- We estimate the Brazilian MWF´s Market in 35 KT per year
- With the increase in use of heavy machinery and equipment, the growth expectations for the coming year is 3% to 5% .
- This market requires specific demands:
  - Longer storage time, due to logistic complexity.
  - Exportation Increase (higher use of base calcium products)
  - Variety of metal alloys – higher complexity for the current passivators
  - Global Warming – More severe clime issues, demand more robust temporary and long-term corrosion inhibitors

This brings an increase of MWF, specially of corrosion inhibitors and passivators.

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Additives For Metal Protection

- Metals are susceptible to corrosion in atmospheric conditions
- Metal protection fluids protect metal objects from rust and corrosion during machining, transport, storage, and use.

Corrosion Inhibitors

- Single chemistry
- In-process protection

Rust Preventatives

Thin-Film Rust Preventatives

- Imperceptible film
- Temporary indoor or covered protection

Heavy Duty Rust Preventatives

- Outdoor applications with direct impact of sun, rain , etc

Coatings

- Thick film
- Permanent protection in all environments

Temporary

Protection Period

Permanent

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Types of Additives

Rust Preventives

- Protective film applied to metal substrate
- Protect in storage, shipping, longer-term in-process
- Protection ranges from weeks-months-years
- Indoor, outdoor, and acidic environments

Corrosion Inhibitors

- Protect metal while in contact with waterborne fluids
- Protect metal work piece and equipment
- Protection ranges from hours-weeks-months
- In-process and indoor environments

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Rust Preventives and Corrosion Inhibitor Market

Application

- ❑ Shipping and Storage
- ❑ Temporary Protection
- ❑ Long-Term Protection
- ❑ Aerosol Spray Penetrant
- ❑ Machining/Grinding Fluids
- ❑ Stamping/Drawing Fluids
- ❑ Industrial Coatings
- ❑ Automotive Underbody/Inner-Body Coatings
- ❑ Mold Release

Industry

- ❑ Parts Manufacturing
- ❑ Primary Steel Manufacturing
- ❑ Metal Fabrication
- ❑ Transportation
- ❑ Marine
- ❑ Aerospace
- ❑ Industrial Maintenance
- ❑ Military
- ❑ Consumer Retail Products
- ❑ Aftermarket
- ❑ Oil Field
- ❑ Mining

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Corrosion Inhibitors

Corrosion Inhibitors Solutions

	Aluminum Corrosion Inhibitor	Water Based Corrosion Inhibitor	Water-soluble Ferrous Corrosion Inhibitors	Yellow Metal Corrosion Inhibitor	Superior Yellow Metal Corrosion Inhibitor
Type	Non-ferrous	Amine carboxylate	Solid acid	Non-ferrous	Non-ferrous
Metal protection	Al	Fe	Fe	Cu	Cu
Acid number	225	135	180	n/a	n/a
Straight oil					✓
Emulsifiable oil	✓			✓	✓
Semi-synthetic	✓	✓	✓	✓	
Synthetic	✓	✓	✓	✓	
Metal cleaners		✓	✓		
Application notes	Branched alkyl phosphate, water emulsifiable	Best-in-class, very good hard water stability	Low foam, hard water stable	Triazole, oil-soluble	Triazole, oil-soluble

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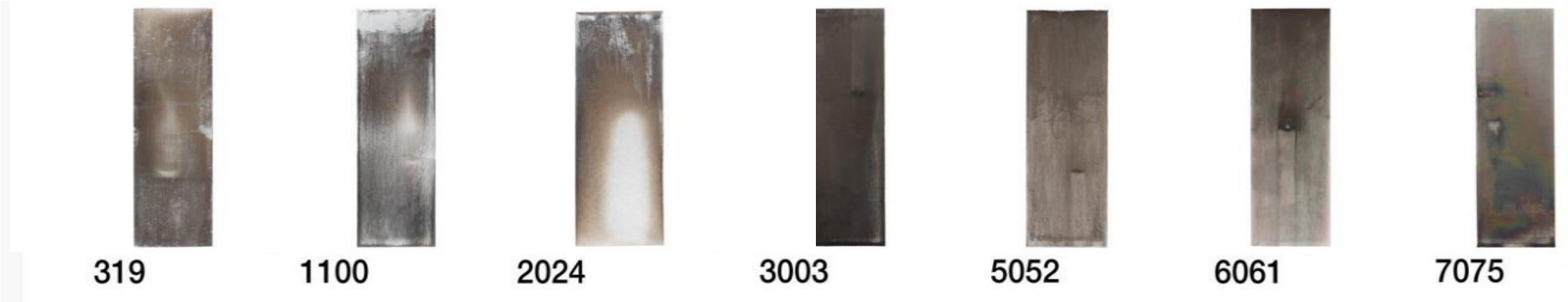
Aluminum Corrosion Inhibitors Solution

Model synthetic metalworking fluid concentrate (pH adjusted with amines)

Ingredient	Purpose	Weight %
Water	Cooling	~70
Water Based Corrosion Inhibitor	Ferrous Corrosion	12
Amines (MEA, TEA, AMP-95)	Alkalinity	13
Yellow Metals Corrosion Inhibitor	Copper passivator	0.1
Block Copolymer or (polymeric ester)	Lubricity	5



Aluminum coupons submerged in 5% solution for 24 hours

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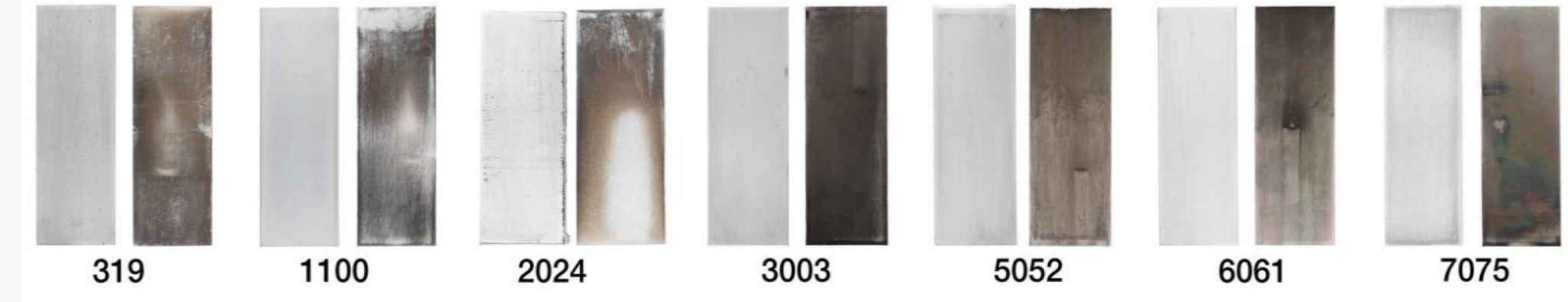
Aluminum Passivator	Aluminum Stain Inhibitor	0.15 to 0.5%



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Preventives:

Thin-Film/Temporary preventive

ASTM B117 Salt Spray

Accelerated Testing for Outdoor Storage & Salt Atmosphere

- Temperature 35 °C
- 5.0% NaCl solution, 95% water
- Cold-rolled carbon steel (AISI 1008)
- Run to failure
  - **Failure Criteria**: >5% rust on panel surface
  - Disregard outer 1/8 inch of panel

Salt Spray used as severe corrosive environment to screen candidates

Thin-Film Rust Preventatives

Barium based RP Package for general rust protection

Level of Protection	% Ba Package	% of Diluents	Salt Spray (hs)
Maximum performance with thin film	20%	80% (solvent)	> 64 hs
General Use	5% to 15%	Balance (solvent)	<8 to >32 hs
Soft Film **	12%	12% Mineral oil + 76% Solvent	> 44 hs

Calcium based RP Package for exportation and customers that cannot use Ba

Level of Protection	% Ca Package	% of Diluents	Salt Spray (hs)
Maximum performance with thin film	20%	80% (solvent)	> 80 hs
General Use	15%	Balance (solvent)	>40 hs
Soft Film **	12%	12% Mineral oil + 76% Solvent	> 100 hs

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Petrolatum & Sulfonate-Free Coatings for Long-Term Outdoor Corrosion Protection

Roberto Saruls

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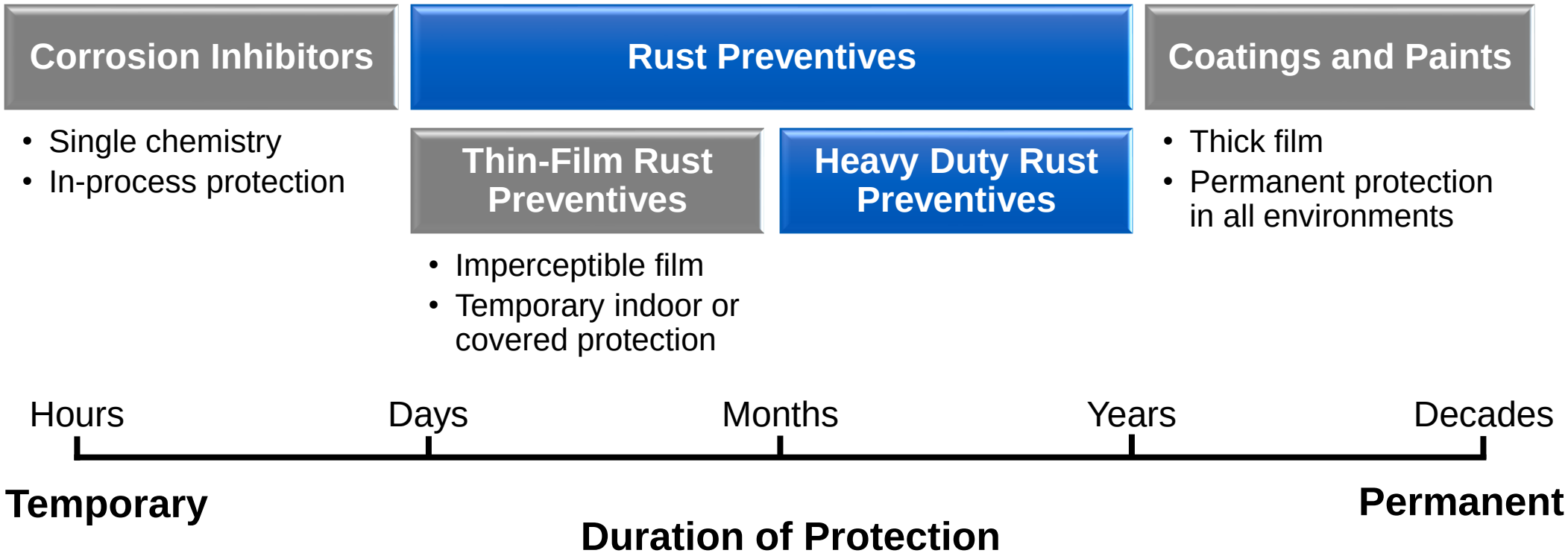

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Heavy Duty Rust Preventives (RPs)

- Form thick, dry films to protect metal surfaces under extreme conditions
- Performance features
  - Premium corrosion protection (years)
  - UV resistance can be important
  - Removability may or may not be necessary
- Applications
  - Maintenance coatings for structures
  - Underbody coatings for vehicles
  - Truck and trailer frames
  - Outdoor applications

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Physical Properties : New Waxy Polymer

Typical waxy polymer	
Appearance	Waxy, colorless solid
Melting point	50-55 °C

Polymer dilution in mineral spirits	
Appearance	Colorless fluid
Form	Liquid/soft paste (dependent on treat rate)

Waxy polymers are light in color and melt at low temperatures when undiluted

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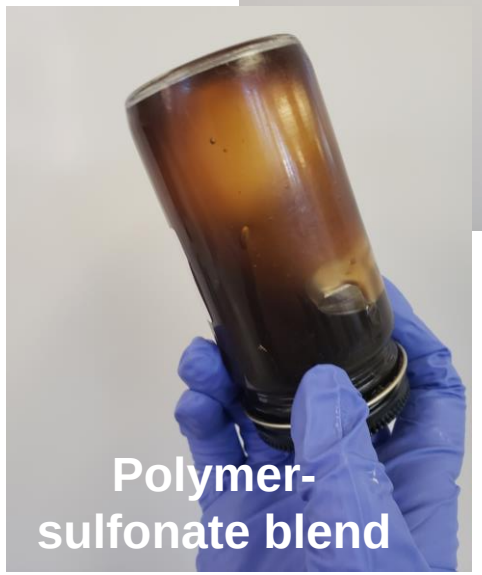
Solubility and Additive Compatibility



Waxy Polymer Dilutions	
Diluent	**Stability, 6 weeks**
Mineral spirits, 60 °C flash pt	Stable
Naphthenic oil	Stable
Group I paraffinic oil	Stable
Group II paraffinic oil	Stable
Waxy Polymer-Additive Blends	
Additive	**Stability, 6 weeks**
Overbased and neutral calcium sulfonates	Stable
Fatty acid	Stable
Polyisobutylene thickener	Stable

Waxy polymers are compatible with common metalworking diluents and additives

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Key Performance Criteria

How do waxy polymer formulations compare to traditional chemistry?

- Film properties
- Corrosion protection
- UV resistance
- Removability

Film Properties

- Waxy polymer was diluted in solvent to make a finished rust preventive
  - Solvent: mineral spirits with flash point of 60 °C
  - Comparable activity to formulation using traditional chemistry
  - No other components used
- Film formed by waxy polymer dilution is clear, dry to the touch, and non-tacky
- Film formed by traditional chemistry is dark brown, dry to the touch, and non-tacky

Waxy polymer dilution forms a clear coat when drawn down

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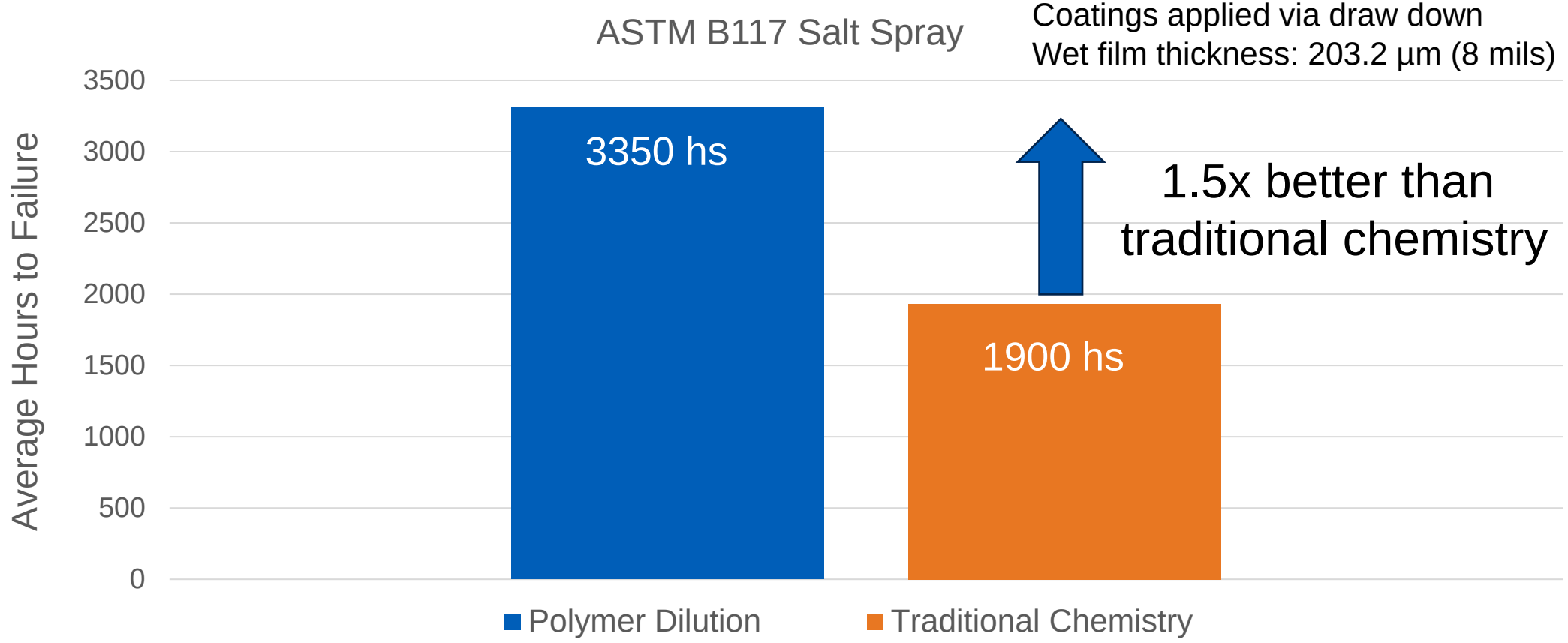
Corrosion Protection: Salt Spray

Substrate: 1008 steel Q panels
Coatings applied via draw down
Wet film thickness: 203.2 µm (8 mils)



At equivalent activity, waxy polymer performs 1.5x better than traditional chemistry

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ASTM D1014 Outdoor Exposure

- Coated panels are placed on outdoor racks
  - 45° angle facing south
  - Exposed to Cleveland, OH environment
  - Panels set out quarterly to account for seasonal variation
- Advantages
  - Natural test atmosphere
  - Can choose test environment
- Disadvantages
  - Length of test (run until failure)
  - Seasonal, regional variability

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Corrosion Protection: Outdoor Exposure

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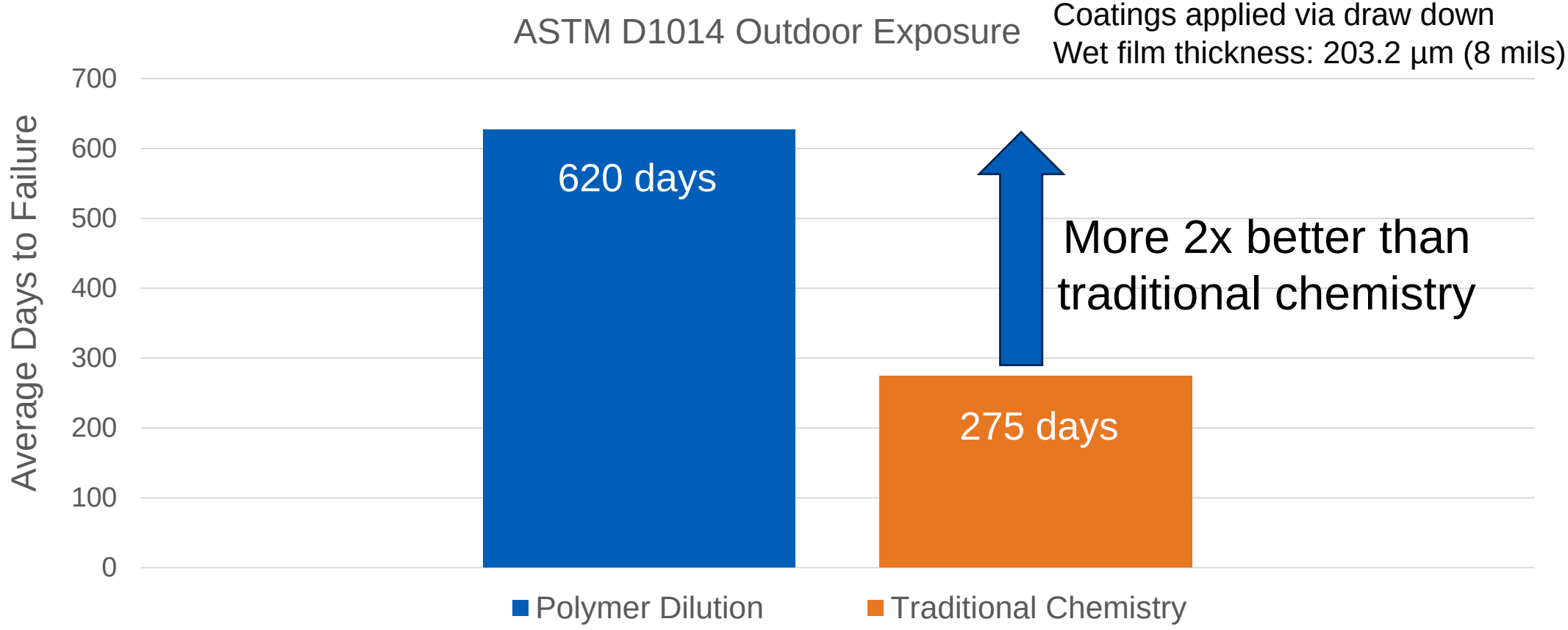

Waxy polymer dilution offers superior outdoor performance to traditional chemistry

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Accelerated Ultraviolet Light (UV) Testing

- QUV cabinet exposes coatings to ultraviolet light designed to mimic solar radiation
- Cyclic conditions (ASTM G154)
  - 8 hours exposure to UV light (wavelength of 340 nm)
  - 4 hours darkness/condensation
  - UV intensity and energy similar to high noon conditions for 16 hours a day
- Panels exposed for 500 hours and then evaluated for signs of failure
- Coating failure: corrosion, cracking, color change, chalking, etc.

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Evaluation of UV Resistance

- After 500 hours of UV exposure, the polymer film is still transparent and shows no rust
- After 500 hours of UV exposure, the film with traditional chemistry has significant discoloration and some rust present
- Traditional chemistry has poor resistance to prolonged UV exposure

Images taken after 500h of Cycle A UV exposure
Area of evaluation in red

Polymer Dilution

Traditional Chemistry

Waxy polymer dilution is more resistant to UV exposure than traditional chemistry

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Heavy Duty Film Removal

- Power washer used to remove heavy duty rust preventive films
- Films are exposed to an alkaline cleaning solution for 60 s
  - Temperature: 170 °F (76.6 °C)
  - Spray pressure: 25 PSIG
- Removability is evaluated using a copper sulfate test
  - After rinsing, panels are placed in a 5% $CuSO_4$ solution
  - If copper plates on the surface of the panel, the coating has been removed completely

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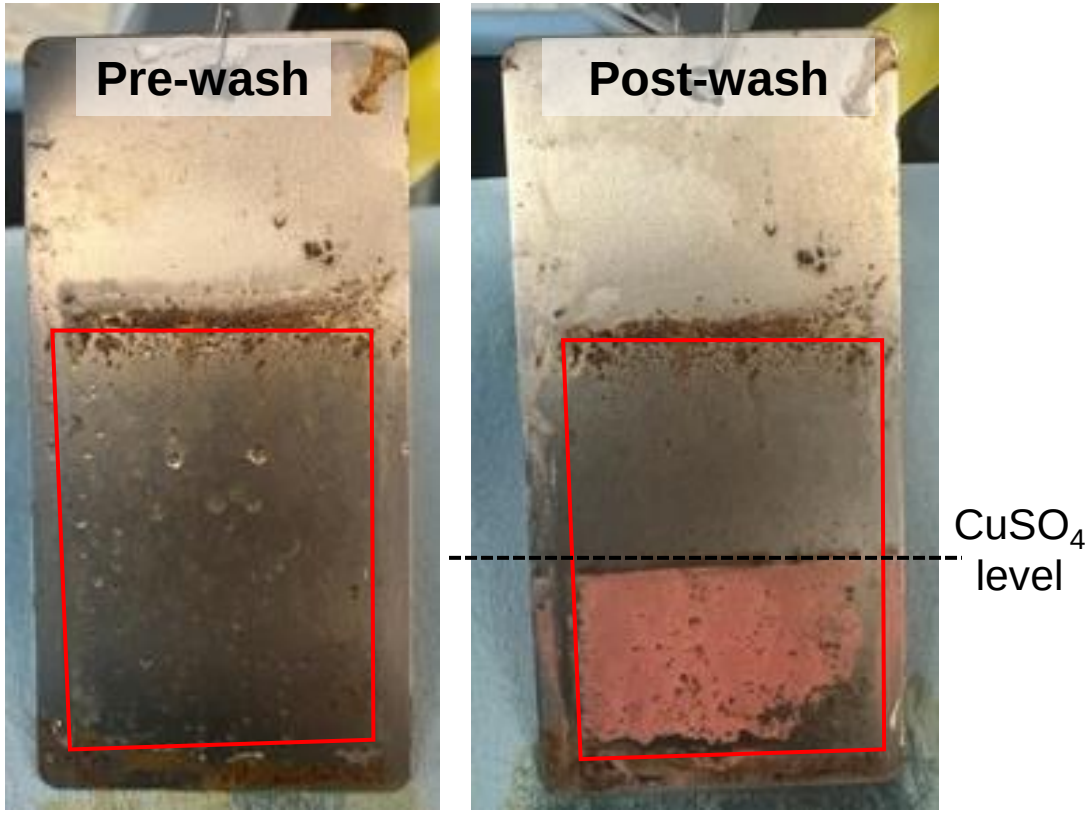
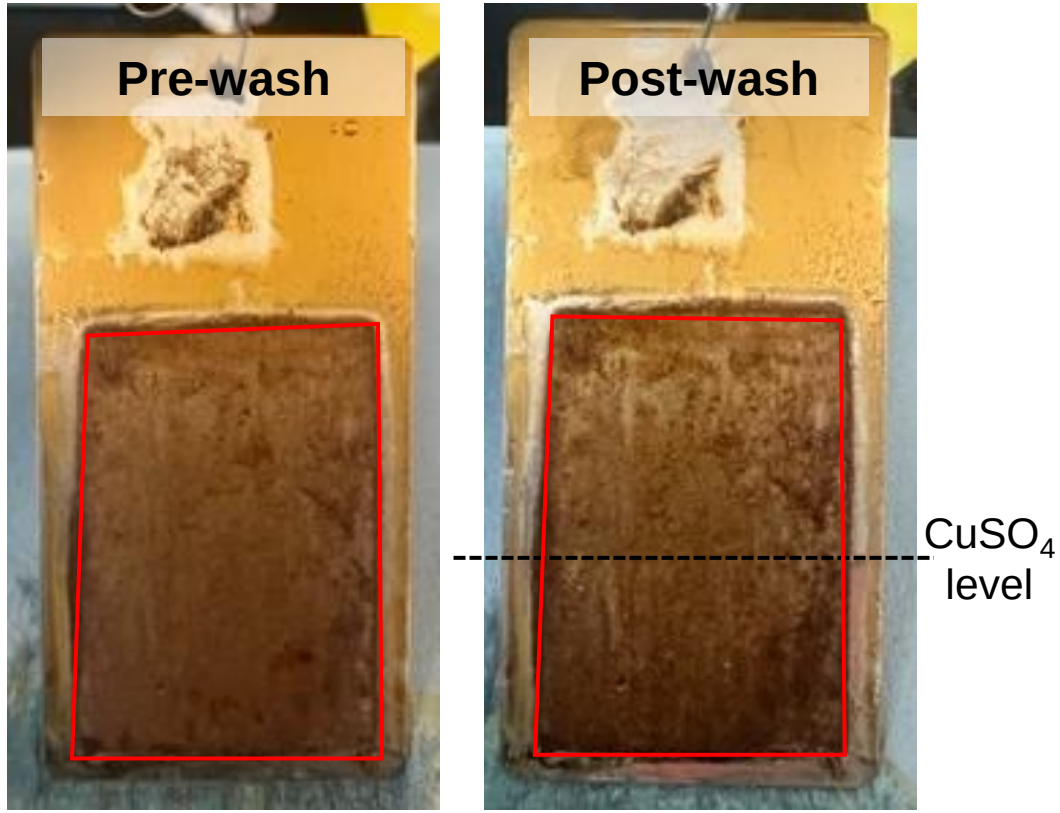
UV Resistance and Removability

Images taken after 500h of Cycle A UV exposure
Area of evaluation in red



Polymer Dilution



Traditional Chemistry

Waxy polymer film is removable after UV exposure

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Conclusions

- Waxy polymers are a new, versatile heavy-duty film-forming technology
- Waxy polymers can be readily formulated into solvent-based heavy duty rust preventive formulations which:
  - Provide 3000+ hours of salt spray protection and 600+ days of outdoor protection
  - Are UV-resistant and removable even after sustained UV exposure
  - Are easier to be removed with alkaline cleaning solution
- Waxy polymers can complement and extend existing rust preventive technologies

Waxy polymer has better performance to traditional chemistry in all areas

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