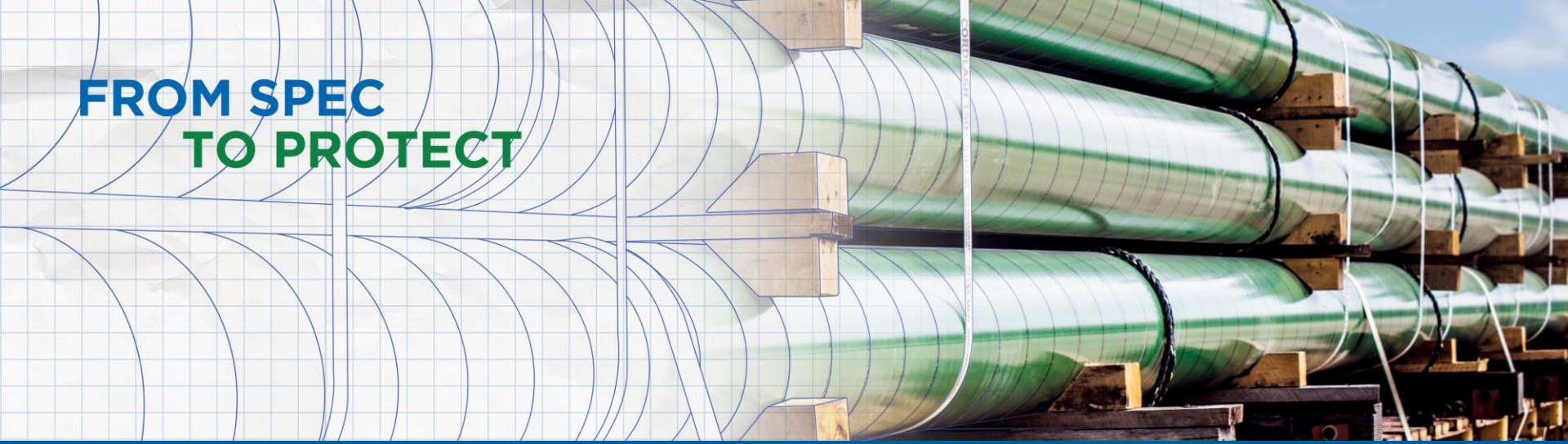


High Operating Temperature Fusion Bonded Epoxy Coatings for Onshore and Offshore Applications

Dr. Jeffrey D. Rogozinski
Global Product Director

SHERWIN-WILLIAMS®

Agenda

- Sherwin-Williams overview
- Global demand and market trends
- Owner and applicator wants and needs
  - High operating temperature (HOT) development
  - Moisture resistant overcoat (MRO) development
- Building performance one layer at a time
- Fitting it all together

ABOUT US

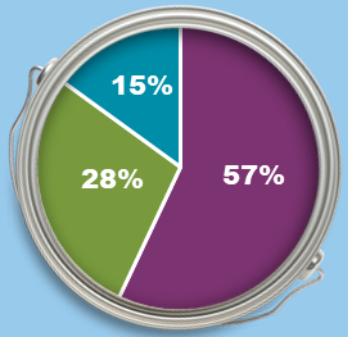
SHERWIN-WILLIAMS®

FOUNDED IN **1866**

61,000+ EMPLOYEES

2019 REVENUES

$17.9 billion



- THE AMERICAS GROUP
- PERFORMANCE COATINGS GROUP
- CONSUMER BRANDS GROUP

SALES BY GEOGRAPHY

- **80%** US / CANADA
- **20%** REST OF WORLD (ROW)

120+ COUNTRIES

4,750+ STORES

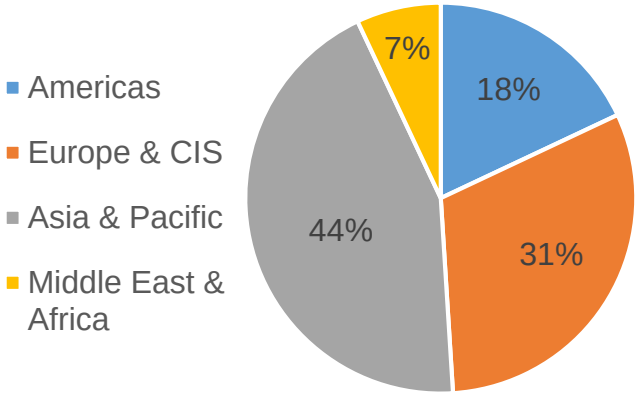
147 MANUFACTURING & DISTRIBUTION FACILITIES

INDUSTRY-LEADING PORTFOLIO OF BRANDS

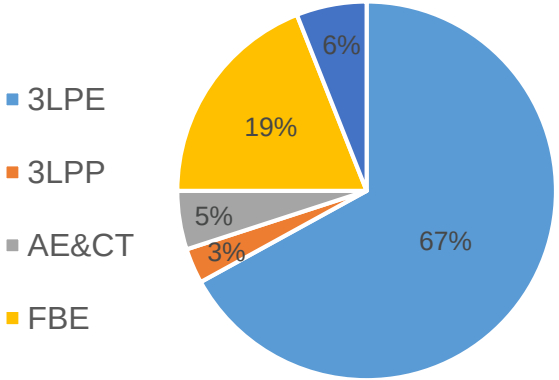
SHERWIN-WILLIAMS · valspar · HGTV HOME by SHERWIN-WILLIAMS · MINWAX · Purdy PROFESSIONAL PAINTING TOOLS · KRYLON · Thompson's WaterSeal · Cabot

Global Demand

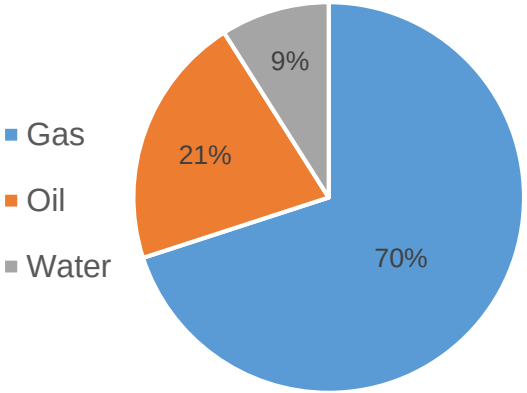
Where are the coatings?



What are the coatings?



What is in the pipe?



Source: AMI Consulting, "The global market for steel pipe coating" (www.ami.international)

Market Trends

Extraction

Deeper in the earth

More viscous to pump

Offshore – standalone and under insulation

Conveyance

Varied temperature cycles / soil stresses

Water ingress on pipes

Installation

Damage resistance

Pipeline installation delays

Owner and Applicator Wants

OWNERS:
Enhanced pipe coating value

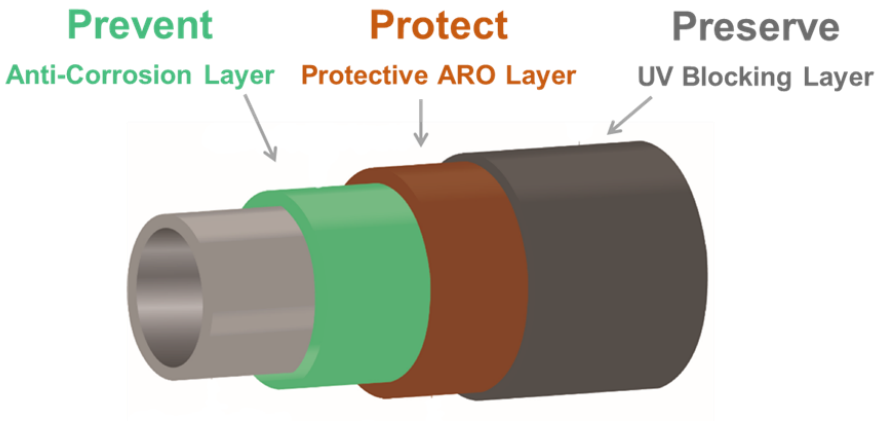
- Increased corrosion protection
- Improved damage resistance
- Higher operating temperatures
- Lower application temperatures
- More moisture resistance
- Installation risk mitigation
- Minimize installation and long-term cost of ownership

APPLICATORS:
Broader application window

- Easier to apply
- Risk mitigation of pipe install delays
- Differentiation through high-performance coating qualities
- Faster through puts
- Less damage to repair

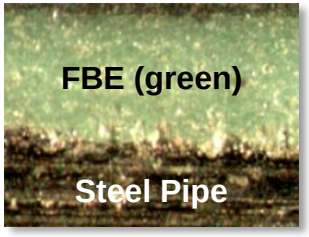
Addressing the Needs

- High Operating Temperature (HOT)
- Moisture Resistant Overcoats (MRO)
- Building Performance One Layer at a Time



Comparison of FBE Based Systems

Standard Single-Layer 16-20 mils (400-500μ)



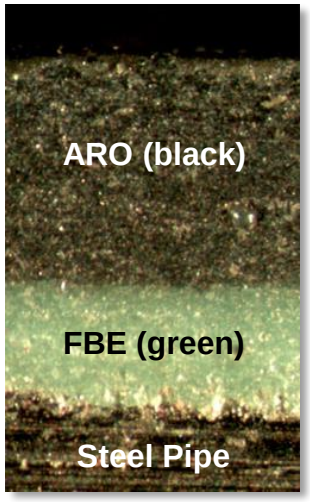
12/12 Dual-Layer 20-28 mils (500-700μ)

Applied as a system

Pipeclad 2000
12 ± 2 mils
(250-350μ)

Pipeclad 2060 MRO
12 ± 2 mils
(250-350μ)

Standard Dual-Layer 40-60 mils (1000-1500μ)

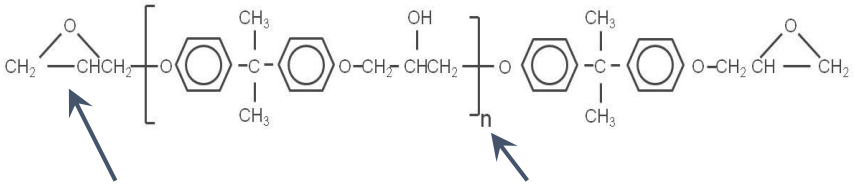


Standard 3-Layer 70-150 mils (1750-3800μ)

High Operating Temperature (HOT)

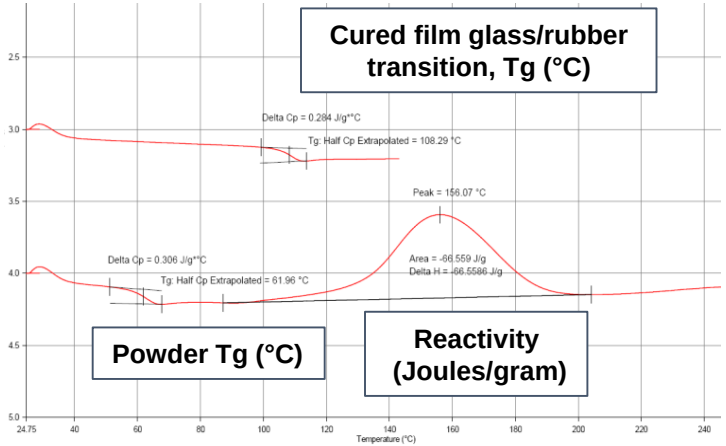
Flexibility

Bisphenol A-Based Epoxy Resin



Polymer Tg

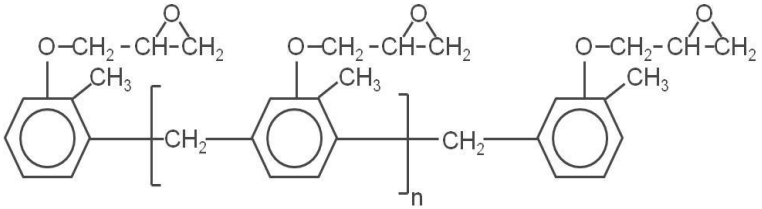
Differential Scanning Calorimeter (DSC) Data



High Operating Temperature (HOT)

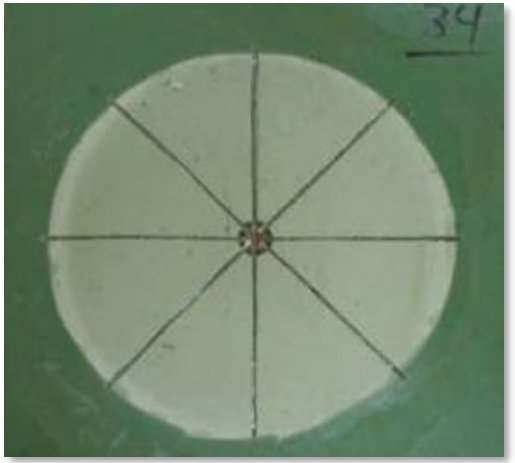
Resin Properties

Epoxy Cresol Novolac Resin



When n = 3 the <u>five</u> epoxy groups per molecule provide high crosslink density

Performance



High Operating Temperature (HOT)

Not Cost Effective and Doesn't Perform

- Stiffen polymer chains
- Reduce polymer segment rotation

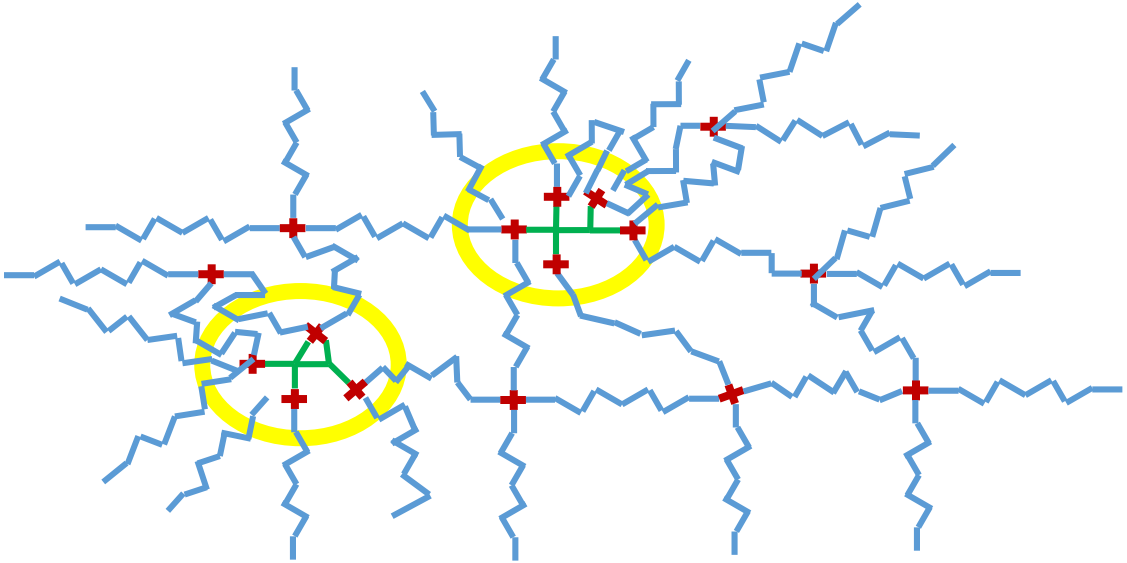
Most Cost Effective and Highest Performance

- Shorten distance between crosslinks

1st GENERATION	2nd GENERATION	3rd GENERATION
Novolac Resin	Shortened Epoxy Resin	Resin Design

1st Generation Polymer Tg

Novolac Resin

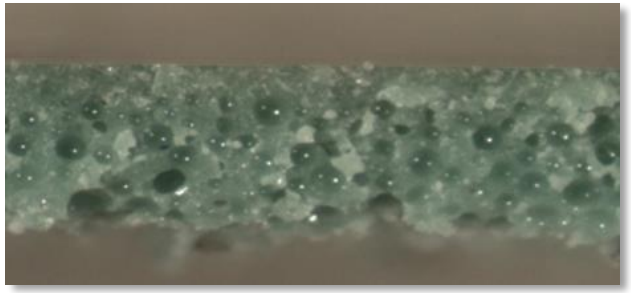


Results: **Higher Tg; Reduced Adhesion; Poor Flexibility; Higher Cost**

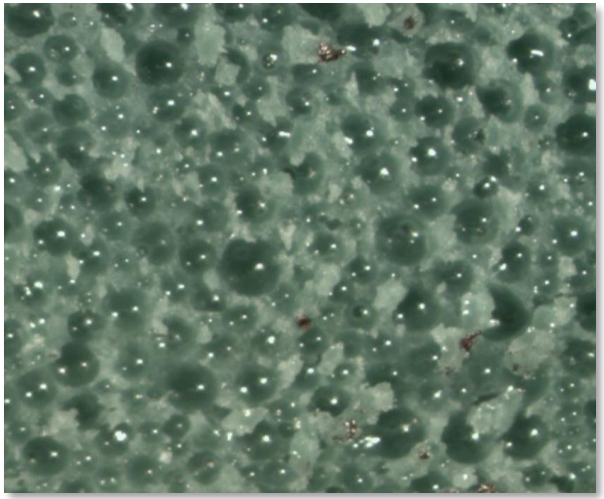
2nd Generation Polymer Tg

Shortened Epoxy Resin

Edge View



Interface View



Results: **Higher Tg; Improved Adhesion & Flexibility; Poor Porosity During Application**

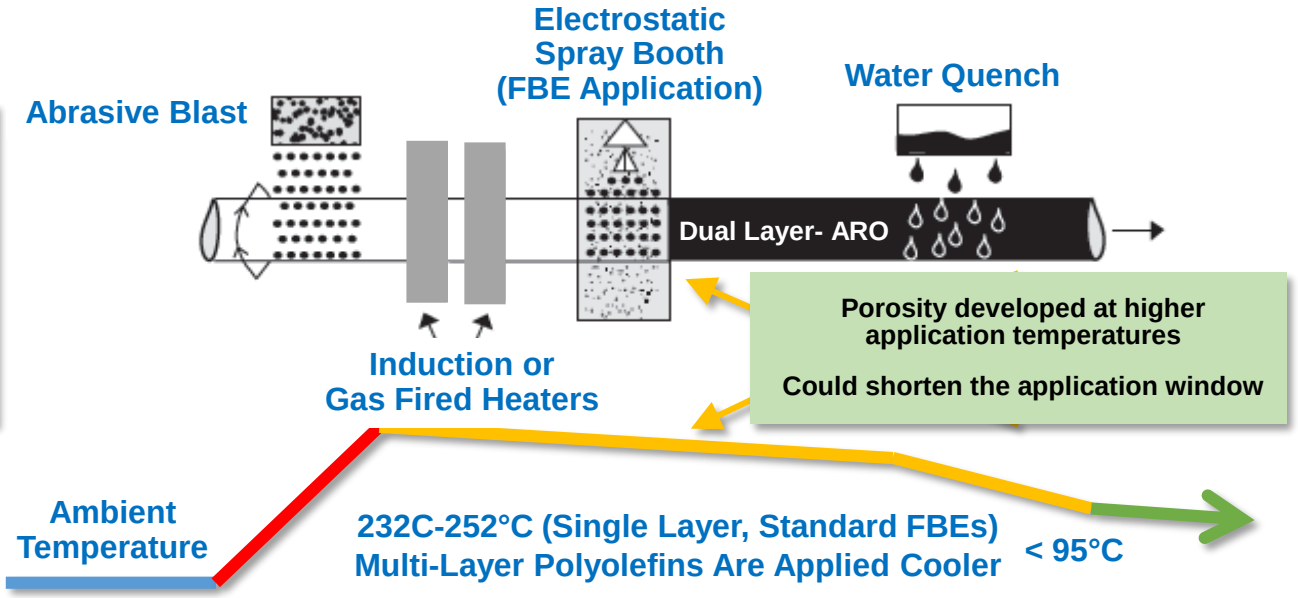
3rd Generation Polymer Tg

Challenge	Achieved	Result
Control the molecule, control the paint	Broad application window our customers required	Higher Tg Better flexibility Lower porosity Best performance

Family of Products		
HOT 120 HOT 120 Flex HOT 120 Flex Roughcoat	HOT 150 HOT 150 Flex HOT 150 Flex MRO HOT 150 Flex Roughcoat	HOT 180 HOT 180 MRO HOT 180 Roughcoat HOT 200

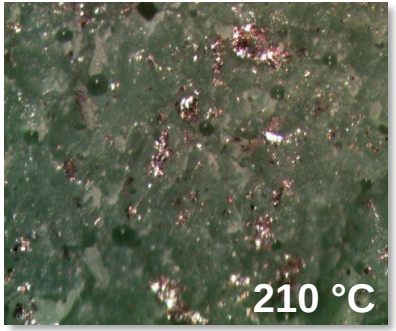
We control the molecule, we control the paint!

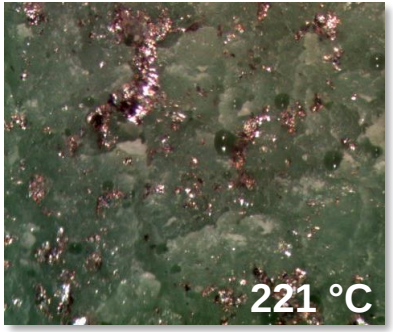
Broad Application Window

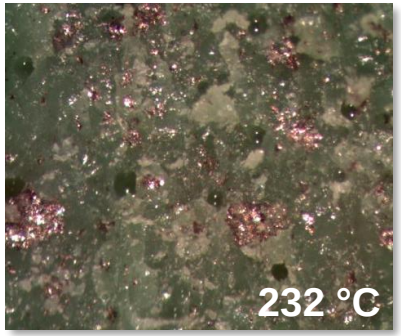


Broad Application Window

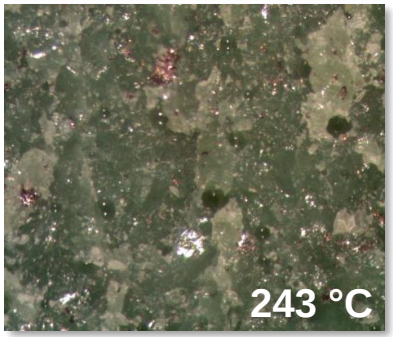
Very Low Porosity

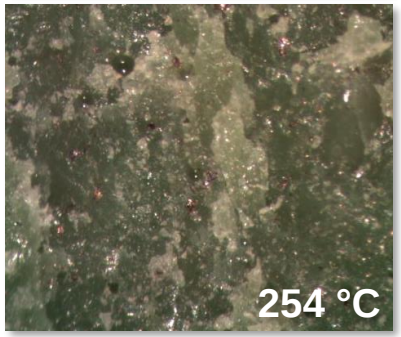






HOT 150 Flex Coating applied by fluid bed dip to 300-400 µm

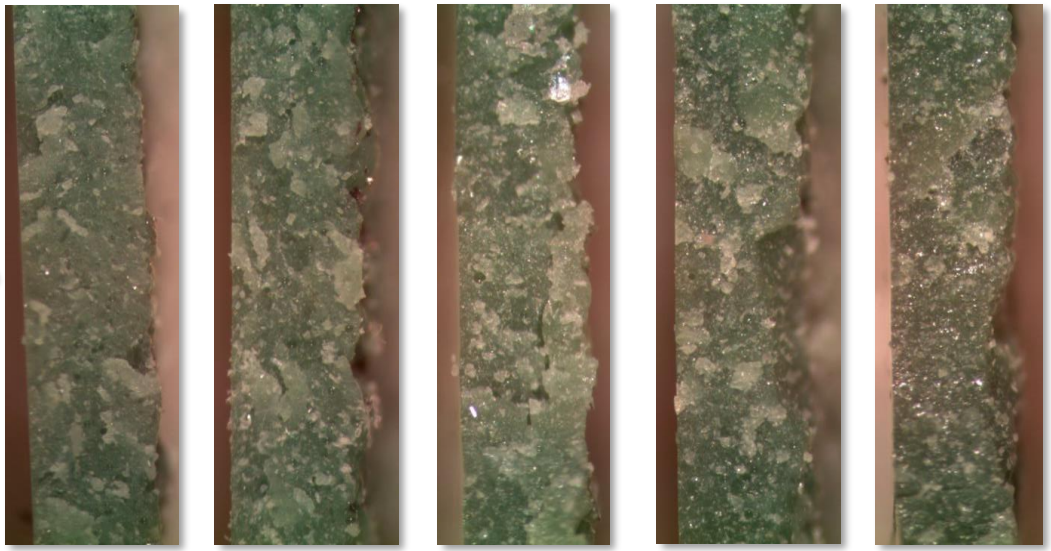




Broad Application Window

Very Low Porosity

HOT 150 Flex Coating
applied by fluid bed
dip to 300-400 µm



App. Temp. (°C)	210	221	232	243	254
Porosity Rating	1	1	1	1	1

Broad Application Window

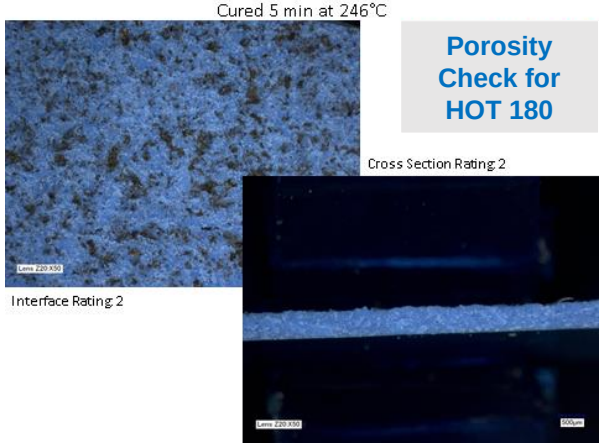
Very Low Porosity

Temperature Range: 232°C-260°C
Porosity Ratings: 1-2 (CSA)

Cured 3 min at 260°C

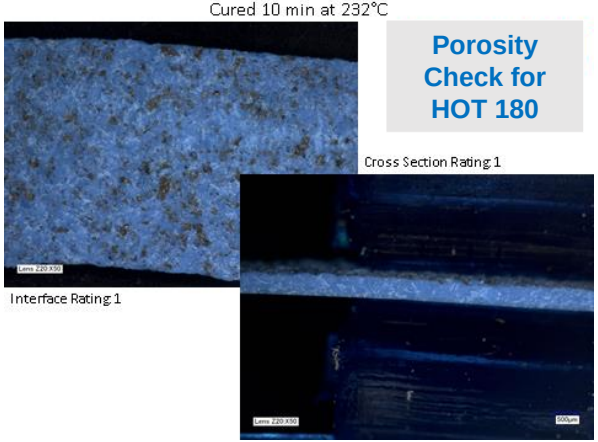
Porosity Check for HOT 180

Cured 5 min at 246°C



Porosity Check for HOT 180

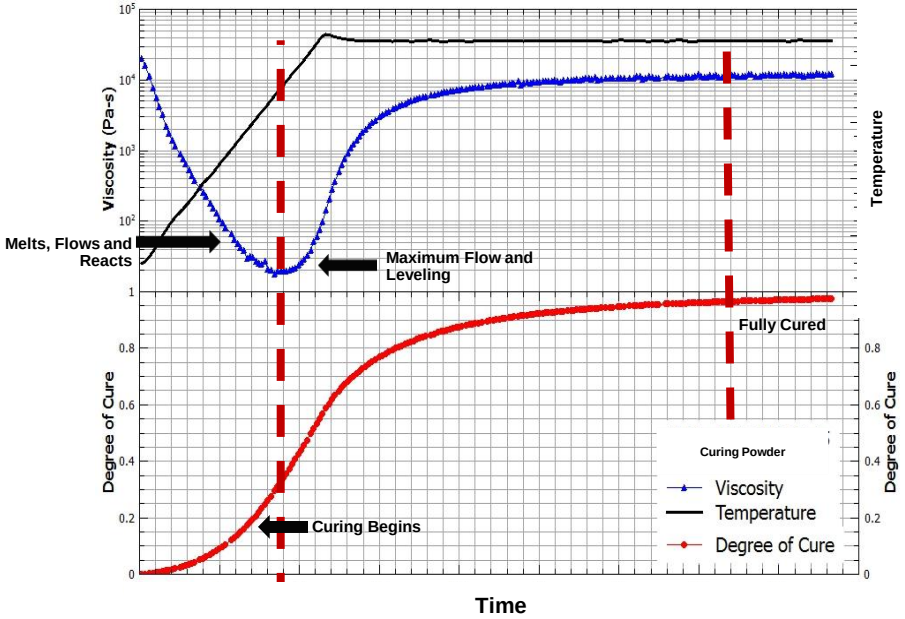
Cured 10 min at 232°C

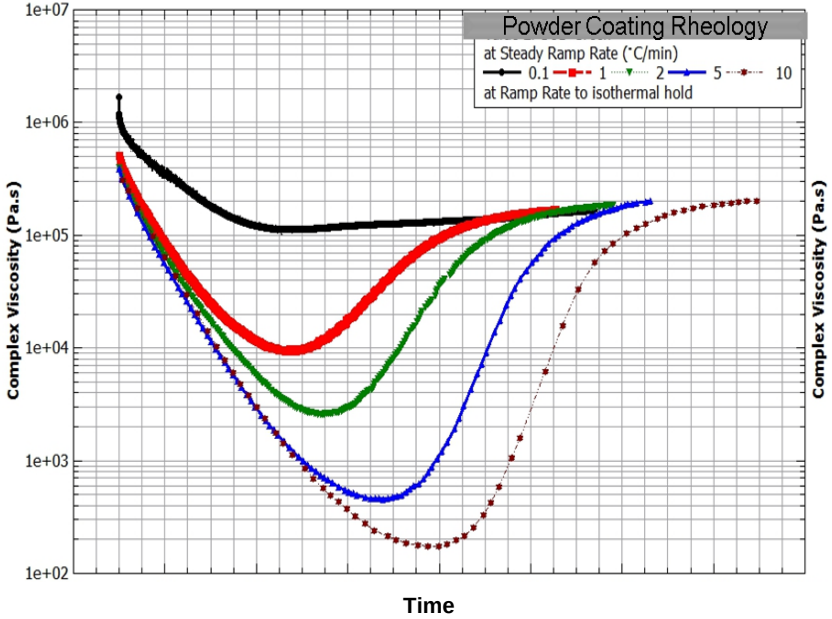


Porosity Check for HOT 180

Broad Application Window

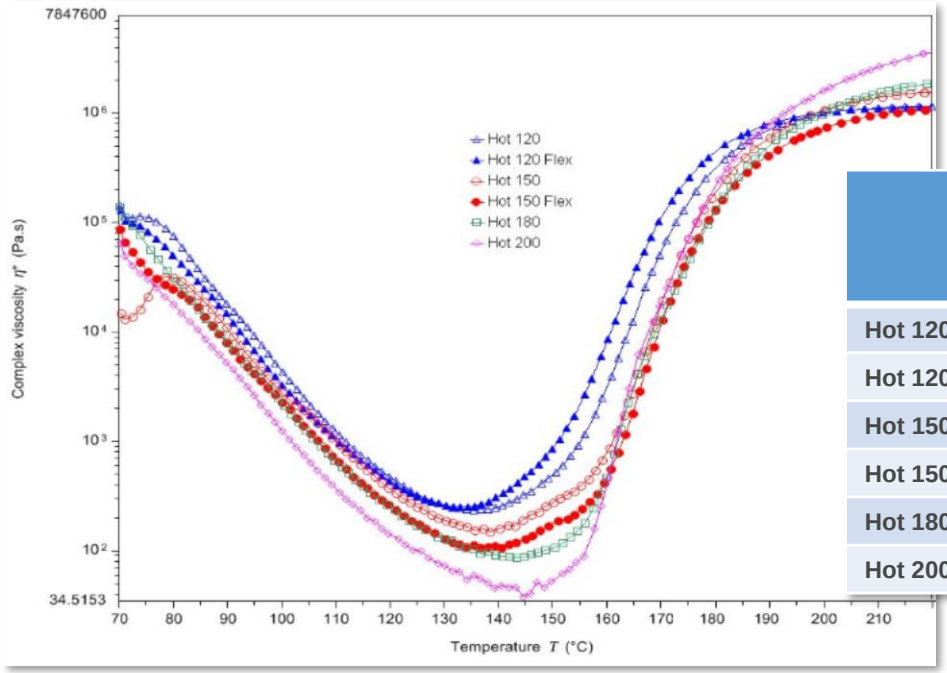
Rheo-Kinetic Profiles





Optimizing for Application

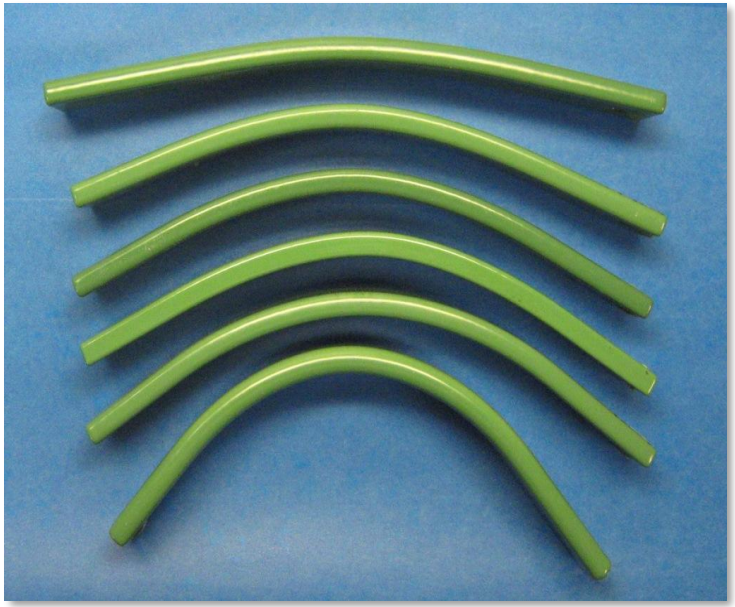
HOT OD Product Rheokinetics



HOT OD Properties

	Cured Film TG (°C)	Flexibility (°/PD @ °C)	Min Eta (Pa*sec) / Temperature (°C)	Flow Index (1/Pa)
Hot 120	125-135	2.5 @ -30	235 / 136	1.15
Hot 120 Flex	125-135	3.0 @ -30	253 / 134	1.03
Hot 150	155-165	2.0 @ -30	149 / 138	1.78
Hot 150 Flex	155-165	2.5 @ -30	107/137	2.65
Hot 180	175-185	2.0 @ -30	87 / 143	3.17
Hot 200	195-205	1.2 @ 23	38 / 145	5.87

High Operating Temperature (HOT)



Test bars are conditioned and bent to various radii at temperatures of
-45°, -30°, 0°, 5°, 10° or 25°C

First Generation
Cracking at
1.5°/ PD at 25°C

Third Generation
Performing at
2.0°/ PD at -30°C

High Operating Temperature (HOT)

Pipeclad HOT 180
- 1.4°PD at -40°C reelable
- 2.5°PD at -5°C

Pipeclad HOT 150
- 1.4°PD at -40°C reelable
- 2.0°PD at -30°C

Pipeclad HOT 150 Flex
- 3.0°PD at -30°C
- 4.0°PD at 0°C
- 5.5°PD at 25°C

Reelable Flexibility!

Reel Lay
- 20.5 ft (6.25m) equivalent radius
- 1.22% strain
- 1.40°ppd

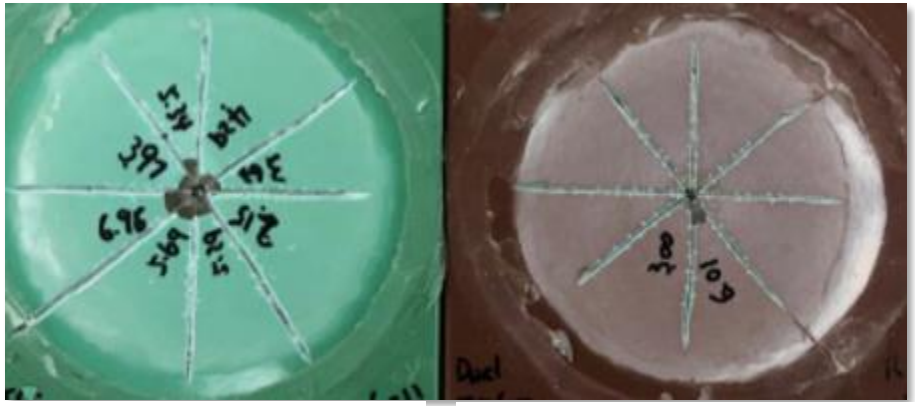
S-Lay
- 120 ft (36.6m) equivalent radius
- 0.30% strain
- 0.34°ppd

High Performance

Exceptional Cathodic Disbondment Resistance
56 days @ 65°C

Long-term Performance

- **Elevated temperature**, long duration CDT testing
- Illustrates **demonstrable improvement** vs. similar thickness FBE without the MRO
- **Lower water vapor** transmission rates



FBE alone 20 mils (500 micron)

FBE/MRO @ 10/10 mils (250/250 micron)

High Performance

95ºC Hot Water Soak, 90 Days

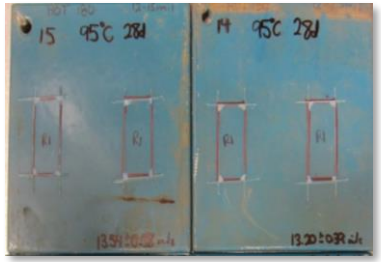
Long-term Performance

Superior performance in long-term wet conditions

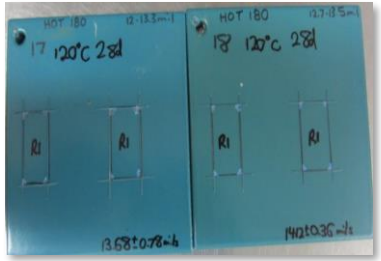
Existing Technology Delaminates

New “MRO” No Change

High Performance



95°C
28 days



120°C
28 days

120°C
366 days

- Pipeclad® HOT 180
- Hot tap water immersion
- Adhesion was excellent, even after 366 days at 120°C

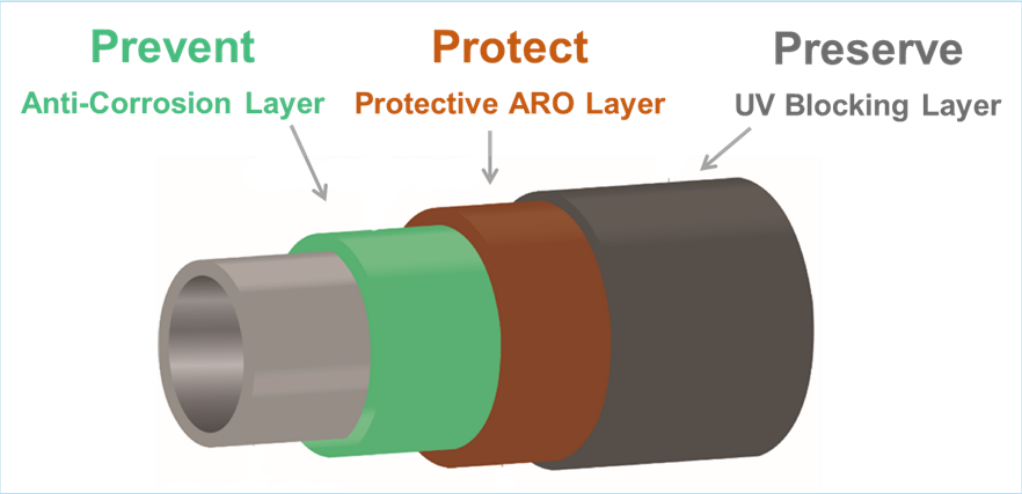
High Operating Temperature (HOT)

We control the molecule, we control the paint!

Moisture Resistant Overcoat (MRO)

The Three Ps:
Prevent – Protect – Preserve

- Building pipeline performance, one layer at a time
- Families of products to suit end user requirements

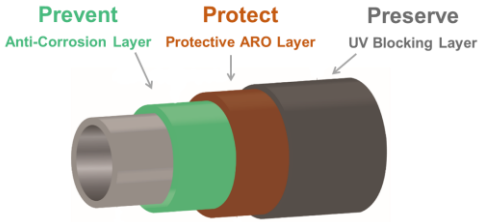


Building Performance, One Layer at a Time…

SHERWIN WILLIAMS

Prevent	Protect	Preserve
FBE Single Layer & Primer (up to 110°C) Pipeclad 2000 **High Operating Temp (up to 200°C)** Pipeclad HOT 120 Pipeclad HOT 120 Flex Pipeclad HOT 150 Pipeclad HOT 150 Flex Pipeclad HOT 180 Pipeclad HOT 200 (in development) **Low Application Temp FBE** Pipeclad LAT	**Abrasion Resistant Overcoats** Pipeclad 2040 Pipeclad 2040 Flex **Moisture Resistant Overcoats** Pipeclad 2060 MRO Pipeclad HOT 150 Flex MRO Pipeclad HOT 180 MRO **Textured Fusion Bonded Epoxy** Pipeclad Roughcoat Pipeclad HOT 120 Roughcoat Pipeclad HOT 150 Flex Roughcoat	**Fusion Bonded Polyester** Pipeclad PTA50057 **Acrylic Latex Overcoat** Pipeclad UV Protect

Families of FBE, MRO and ARO to suit end user performance requirements

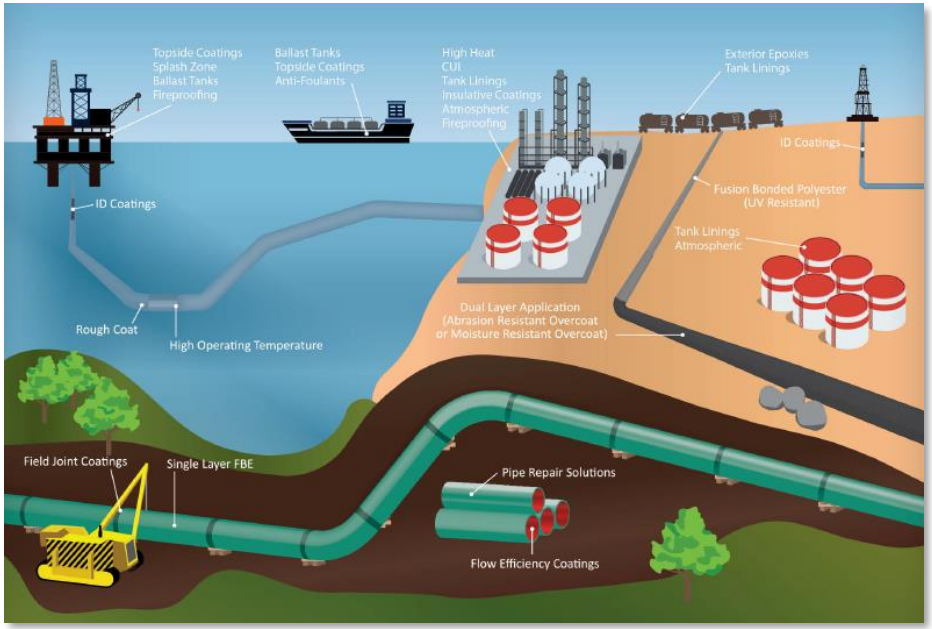


We control the molecule, we control the paint!

Fitting It All Together

From Exploration to Transportation:

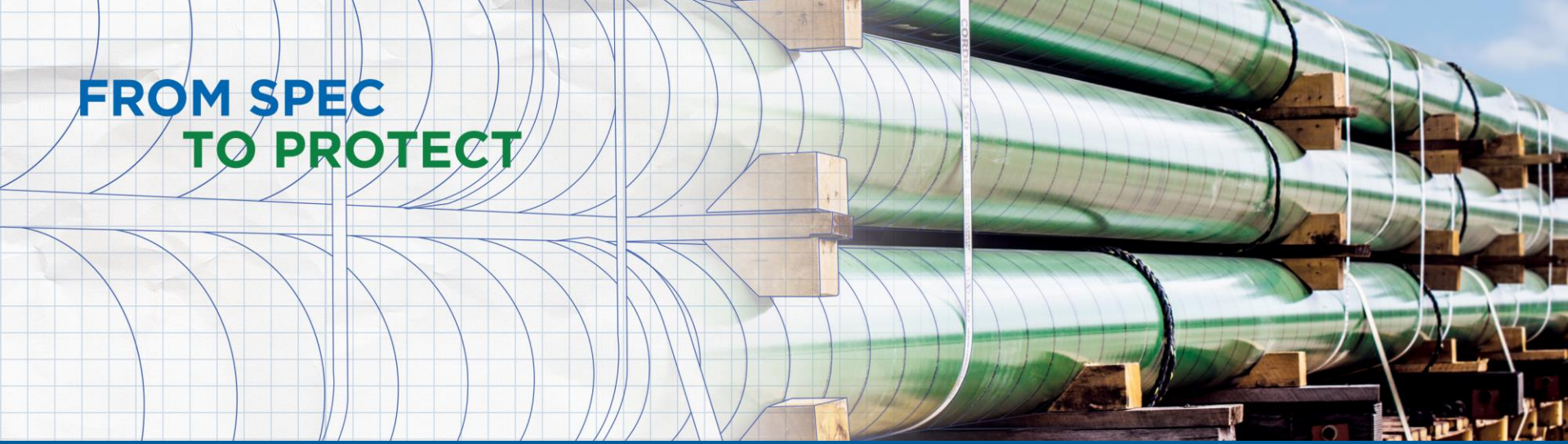
Sherwin-Williams offers a full portfolio of coatings for the oil & gas market



“Powered by Pipeclad®” Informational Series

“Powered by Pipeclad®” Technology Discussion Topics

- High Operating Temperature (HOT) Fusion Bonded Epoxy Coatings for Onshore and Offshore Applications
- Moisture Resistant Overcoats: Advances in Damage Tolerance and Barrier Properties
- Effects of UV Exposure and Risk Mitigation
- Internal Flow Efficiency Coatings for Natural Gas Transmission; Differentiating Value and Safety



THANK YOU

SHERWIN-WILLIAMS®