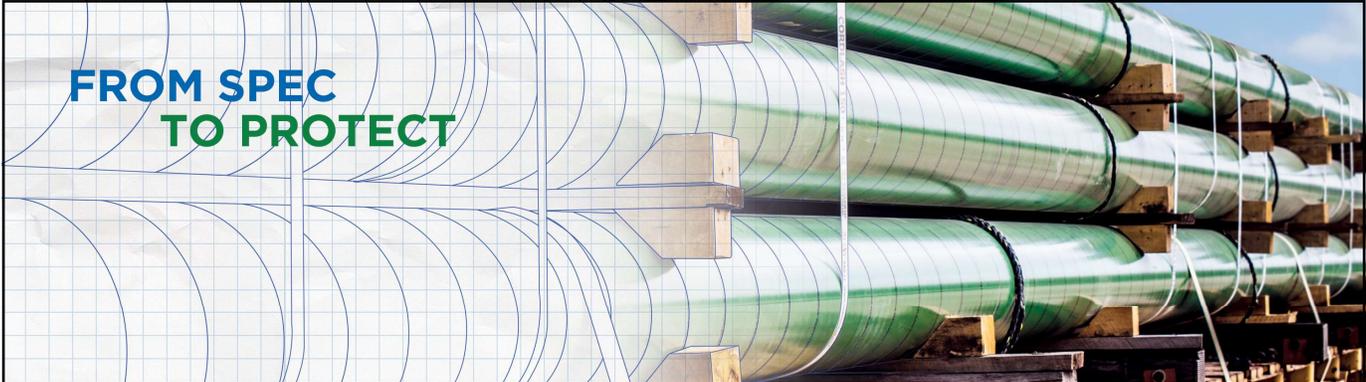


**FROM SPEC
TO PROTECT**



Molecular level composites for advanced fusion bonded epoxy performance

Dr. Jeffrey David Rogozinski
Global Product Director

SHERWIN-WILLIAMS.

Moisture Resistant Overcoat (MRO)

*SHERWIN
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Strong moisture-resistance + **Strong** damage tolerance + **High** flexibility



**Moisture
Resistance**



**Damage
Tolerance**

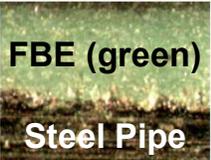
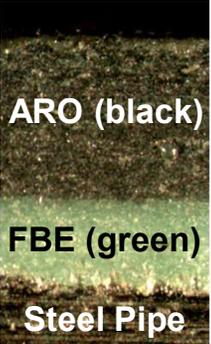


Flexibility



Combines the barrier attributes of historic high operating temperature systems with advanced ARO (abrasion resistant overcoat) technology

Comparison of FBE Based Systems

<p>Standard Single-Layer 16-20 mils (400-500μ)</p>  <p>FBE (green) Steel Pipe</p>	<p>12/12 Dual-Layer 20-28 mils (500-700μ)</p> <p>Applied as a system Pipeclad 2000 12 ± 2 mils (250-350μ)</p> <p>Pipeclad 2060 MRO 12 ± 2 mils (250-350μ)</p>  <p>MRO (brown) FBE (green) Steel Pipe</p>	<p>Standard Dual-Layer 40-60 mils (1000-1500μ)</p>  <p>ARO (black) FBE (green) Steel Pipe</p>	 <p>Polyolefin (white) Adhesive (red) FBE (green) Steel Pipe</p>	<p>Standard 3-Layer 70-150 mils (1750-3800μ)</p>
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Moisture Resistant Overcoat (MRO) Attributes

MRO Abrasion-Resistant Overcoat (ARO)

Dual Layer System	Application	Innovation	Protection	Temperatures
<p>Applied as a dual layer powder system that provides an extremely robust protective coating to the outside of pipes.</p>	<p>Designed to be applied over fusion bonded epoxy (FBE) coatings on the exterior of pipes.</p>	<p>Features an innovation that provides superior protection against moisture and corrosive elements in the environment, while also providing abrasion resistance surpassing typical ARO coatings.</p>	<p>Provides optimum protection for the corrosion protection layer against both moisture uptake, as well as damage throughout storage, transit, construction and service of the pipeline, including during horizontal directional drilling and backfilling.</p>	<p>Pipeclad 2060 MRO is designed for service temperatures up to 150°C or higher dependent upon the base layer of corrosion protection which is applied.</p>

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MROs – Benefits of 12/12 mils (250/250 μ) System

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APPLICATION	PERFORMANCE
<ul style="list-style-type: none"> • Faster throughput (applies at single layer speeds) • Fewer holidays “on the rack” • Superior damage resistance for handling and storage 	<ul style="list-style-type: none"> • Improved moisture barrier – less “steam jacking” in HOT systems
INSTALLATION	
<ul style="list-style-type: none"> • Improved damage tolerance (gouge, impact, tabor abrasion), reduced DCVG detectable holidays after backfill • Reduces installation cost (less field repairs because of reduced mechanical damage, reduce the amount of padding required during pipeline installation) • Higher intrinsic dielectric strength – fewer “false positive holidays” on right of way • More cost-effective field joints compared to three-layer systems • Field joints coated with same dual powder system maintain coating integrity of entire pipeline 	

Moisture Resistant Overcoat (MRO)

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Application Characteristics:

- At single layer speed
- Utilizes existing equipment
 - Same application booths as dual layer
 - Final DFT
 - ✓ 12 mils (300 μ) Pipeclad® 2000
 - ✓ 12 mils (300 μ) Pipeclad® 2060



High Performance

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Exceptional Cathodic Disbondment Resistance: 56 days @ 65°C

Long-term Performance:

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



FBE alone 20 mils
(500µ)

FBE/MRO @ 10/10 mils
(250/250µ)

Moisture Resistant Overcoat (MRO)

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95°C Hot Water Soak, 90 Days

Long-term Performance:

- Superior performance in long term wet conditions



Existing
Technology
Delaminates

New "MRO"
No Change

Moisture Resistant Overcoat (MRO)



Improved Dielectric Properties:

- Less moisture uptake
- Fewer issues with wet/dry sponge holiday detection (fewer “false positives”)



Moisture Resistant Overcoat (MRO)



Damage Tolerance:

- 20-24mils (500-600μ)
- Flexibility over 3°/pd at -30°C
- Impact at over 3J at -30°C

3°/pd @ -30°C

Sample	Mandrel	Coating Thickness	Result (Pass/Fail)
1	5.75	20-22 mils	No cracking: Pass
2	5.75	21-24 mils	No cracking: Pass
3	5.75	22-23 mils	No cracking: Pass



Impact Testing

Temperature	Impact Joules	# of Specimens	Holiday Detection	Result (Pass/Fail)
Ambient (25°C)	3.0 Joules	3	No holidays	Pass
0°C	3.0 Joules	3	No holidays	Pass
-30°C	3.0 Joules	3	No holidays	Pass

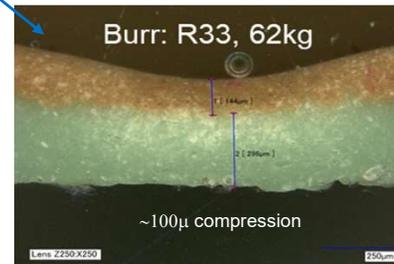
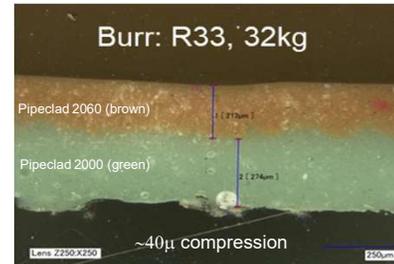
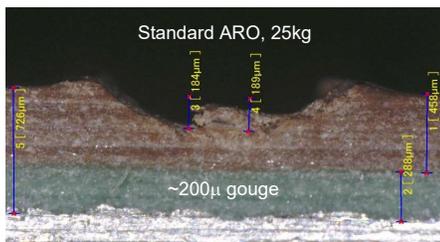


Moisture Resistant Overcoat (MRO)

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Damage Tolerance:

- Over 50% better gouge resistance than standard ARO
- Illustrates “compressive” behavior for HDD applications
- 30% less labor abrasion mass loss than standard ARO



Moisture Resistant Overcoat (MRO)

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Backfill Drop Test:

- Raised rocks 10ft (3m) above pipe
- ~3in (~7.6cm) aperture
- Let them drop

Field Testing: Del Rio, Texas



Moisture Resistant Overcoat (MRO)

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Backfill Drop Test:

- Appeared as if there were holidays, however...

Field Testing: Del Rio, Texas



Moisture Resistant Overcoat (MRO)

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Backfill Drop Test:

- Hand wiped away “pulverized” rock dust
- No holidays
(NACE SP01888 @ 3000V)
 - 12 mils (300 μ) FBE
 - 12 mils (300 μ) MRO

Field Testing: Del Rio, Texas



Moisture Resistant Overcoat (MRO)

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Field Flexibility Test:

- “Wrinkled” the pipe
- No cracks or holidays (NACE SP01888 @ 3000V)
 - 12 mils (300 μ) FBE
 - 12 mils (300 μ) MRO

Field Testing: Del Rio, Texas



Moisture Resistant Overcoat (MRO)

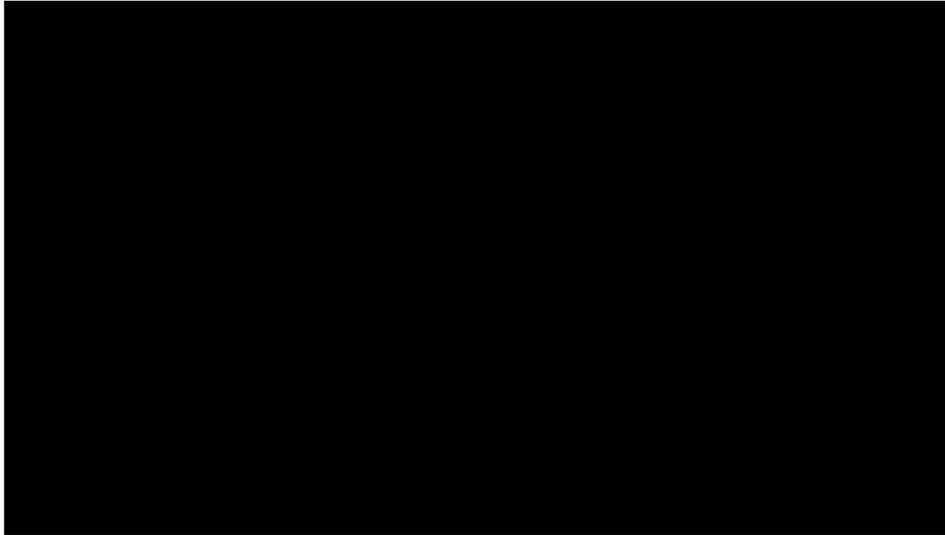
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Whistler Project, Southwest Texas, USA



Moisture Resistant Overcoat (MRO)

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Moisture Resistant Overcoat (MRO)

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Applicator Testimonial

Good afternoon,

We recently ran your new MRO powder for a test run to see how it would perform. All testing passed well within specifications. The two things that really stood out were impact and flexibility. We were able to bend straps up to 3.5° per pipe diameter without any cracking or disbondment. We were able to do an impact from as high as our apparatus would go (which is about 4 feet) without any holidays being created.

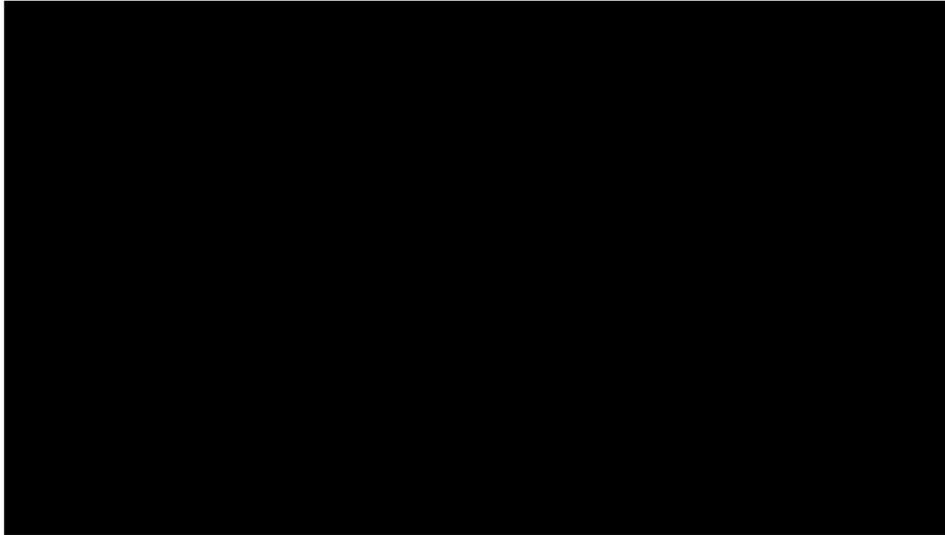
Below is some information on what our parameters were when coating using this powder:

- *Pipe OD: 10"*
- *Pipe wall: .375"*
- *Line Speed: 42 feet per minute*
- *Coating temperature: 467°-471°F*
- *Millage: 26-30 overall; split: 12-14 FBE; 15 -18 MRO*

Feel free to contact me if you need any further information or have any questions concerning our recent run. Thank you.

Moisture Resistant Overcoat (MRO)

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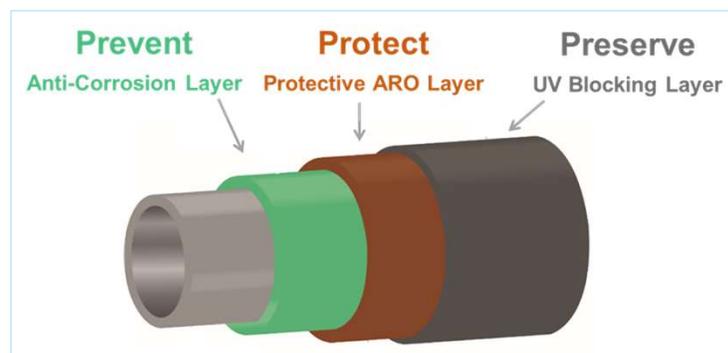


Moisture Resistant Overcoat (MRO)

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The Three Ps: Prevent – Protect – Preserve

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

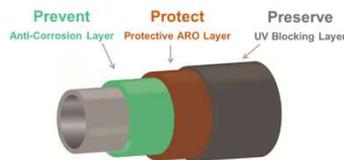


Building Performance, One Layer at a Time...



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

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



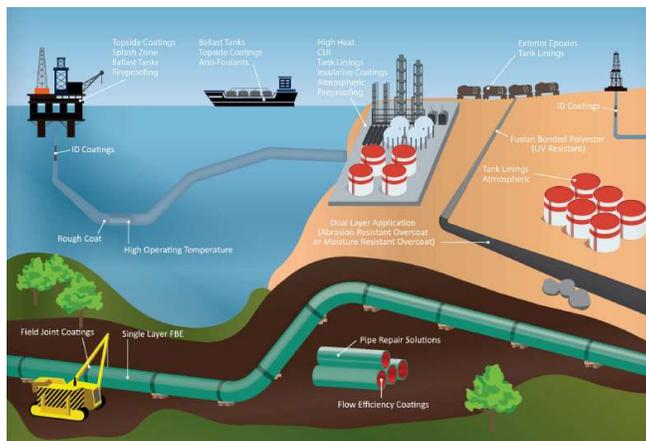
We control the molecule, we control the paint!

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



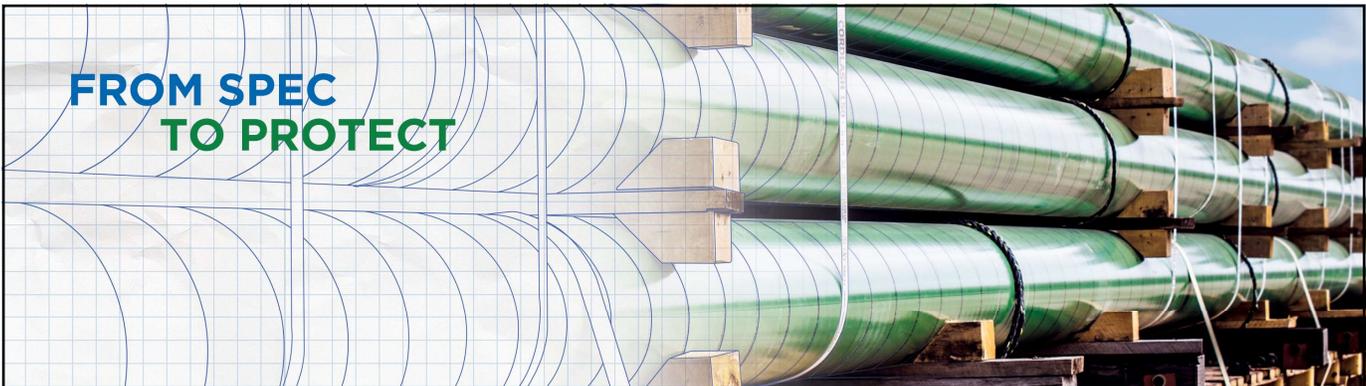
“Powered by Pipeclad®” Technology Discussion Topics

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

