MIC – Resistant Lining for Seawater Applications
Corrosion Protection Platform

The Aegion Companies – Services
Corrpro Companies Europe Ltd located at Stockton-on-Tees and Redhill, enables us to serve clients as a manufacturer and supplier of cathodic protection equipment throughout the United Kingdom, Europe and the Middle East.

Since 1985 United has been a global leader in high-performance thermoplastic internal pipeline lining systems for pipeline integrity.

Aegion combines innovative technologies with market-leading expertise to maintain, rehabilitate and strengthen infrastructure around the world.
<table>
<thead>
<tr>
<th>Year</th>
<th>Client</th>
<th>Area</th>
<th>Meters</th>
<th>Size</th>
</tr>
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<tbody>
<tr>
<td>1994</td>
<td>Shell</td>
<td>Brent</td>
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</tr>
<tr>
<td>1995</td>
<td>Shell</td>
<td>Pelican</td>
<td>8100</td>
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<tr>
<td>1996</td>
<td>Shell</td>
<td>Tern to Eider</td>
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<td>16 inch</td>
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<tr>
<td>1997</td>
<td>BP / Shell</td>
<td>ETAP</td>
<td>22300</td>
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<tr>
<td>1998</td>
<td>BP / Shell</td>
<td>ETAP</td>
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<tr>
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<td>BG</td>
<td>Blake</td>
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<tr>
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<td>CNR</td>
<td>Baobab</td>
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<tr>
<td>2005</td>
<td>Talisman</td>
<td>Tweedsmuir</td>
<td>59000</td>
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<tr>
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<td>Marathon</td>
<td>Alvheim</td>
<td>3500</td>
<td>15 inch</td>
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<td>Norsk Hydro</td>
<td>Fram Ost</td>
<td>18000</td>
<td>14 inch</td>
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<tr>
<td>2006</td>
<td>BP</td>
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<tr>
<td>2006</td>
<td>BP</td>
<td>Angola</td>
<td>25000</td>
<td>14 inch</td>
</tr>
<tr>
<td>2010</td>
<td>BP</td>
<td>Angola</td>
<td>53000</td>
<td>12 inch</td>
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<tr>
<td>2012</td>
<td>Statoil</td>
<td>Hyme</td>
<td>20250</td>
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<td>2014</td>
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<td>Statoil</td>
<td>Marine Wave 1</td>
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<td></td>
<td>Total</td>
<td></td>
<td>357,450.00</td>
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</tr>
</tbody>
</table>

Tite Liner Installed for Reel-Lay Applications
History

- System utilized since 1985
- Liner installations worldwide over 30 countries
- More than 20,000 miles installed and in operation worldwide
## Polymer Liner Systems Applications

### Oil & Gas
- Crude oil and oil emulsion
- Sour and wet
- Water injection and disposal systems
- Offshore
- CO2 production and injection

### Industrial
- Chemical slurries
- Sodium carbonate
- Corrosive effluents
- Caustics
- Brine

### Mining
- Tailings
- Concentrate
- Acid lines
- Water lines

### Municipal
- Force sewer mains
- Transmission lines
Corrosion Resistant Polymer Liner Systems Capabilities

Projects from 2” to 52” OD have been successfully completed.

Pipe Size

Pressure

Polymer liners are highly resistant to chemicals and other media such as acids, alkalis and salts which makes its use suitable in almost every process application.

Process Fluid

Water Service (<1% hydrocarbons and no free gas): 70 C
- Hydrocarbon Service (>1% hydrocarbons and no free gas): 65 C
- Gas, Multiphase or Liquid with free gas: 50 C
- Over 100 C possible with alternative liner material

Erosion

Liners offer better abrasion resistance than steel that is why slurry pipelines are often lined with PE to enhance their operational life.

Temperature

The host pipe performs the structural and pressure containment functions whilst the liner provides the necessary corrosion resistance and acts as a barrier only.

Process Fluid
A liner outer diameter is larger (tight) than the nominal steel pipe inside diameter.

The outer steel pipe provides partial restraint to the liner to help resist buckling stresses.

The liner diameter is rolled down mechanically during the liner installation.

The liner remains more tightly fitted against the steel pipe regardless of internal pressure.
United Pipeline Systems developed the Tite Liner® system in 1985. Since then, over 80 million feet of pipelines on six continents have been lined and protected with our internal pipe lining system.

There has not been a single failure of a lined water injection pipeline in operation to date yet the premature failure of unlined systems is commonplace (typically within 7 years of service)
Tite Liner RT® system

• High temperature resistance - up to 203°F (95°C)
• Eliminates internal corrosion in severe applications
• Chemically compatible in broad oil & gas applications
• Withstands highly oxidative conditions
• Superior notch and scratch resistance
• Superior resistance to rapid crack propagation
• Increased flow capacity with reduced friction loss
• Extended service life resulting in lower cost of ownership
• Reliable and safe performance record
Tite Liner® HC system

• High temperature resistance – up to 210°F (100°C)
• Compressed fit liner utilizing the Tite Liner® system
• Excellent performance in hydrocarbon service
• Enhanced resistance to collapse and buckling
• Improved performance in high sour gas environments with ultra-low gas permeation
• Extended service life resulting in lower cost of ownership versus alternatives such as CRA
• Reliable and safe performance record
Safetyliner™ provides excellent protection against internal corrosion and abrasion, and it is still far less expensive than stainless steel or other exotic alloy alternatives.

The advanced design of the Safetyliner™ product has proven especially effective in applications such as CO2, sour gas, 3-phase oil and tailings pipelines.
Annular Gas Management

- Active Re-Injection (LinerGuard™)
- Keeps annular pressure between 5-10 psi. (collapse proof)
- Pipeline pressure up to 1,500 psi.
- One compressor per 5km of pipeline.
- Needs 30 Amp service

Safetyliner™
Installation Lengths

• Pull lengths are determined primarily by liner size, pipeline geometry, terrain, accessibility and host pipe cleanliness.

• Pull lengths are limited by the anticipated forces acting on the liner during installation.

• Minimum 40D bends are recommended to maximize pull section lengths.

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Typical Avg. pull length</th>
</tr>
</thead>
<tbody>
<tr>
<td>2”</td>
<td>400 meters</td>
</tr>
<tr>
<td>3”</td>
<td>500 meters</td>
</tr>
<tr>
<td>4”</td>
<td>600 meters</td>
</tr>
<tr>
<td>6”</td>
<td>700 meters</td>
</tr>
<tr>
<td>8”</td>
<td>800 meters</td>
</tr>
<tr>
<td>10”</td>
<td>800 meters</td>
</tr>
<tr>
<td>12”</td>
<td>800 meters</td>
</tr>
</tbody>
</table>

\[ R = 40D \]
Liner – End Terminations

- Several methods available for end termination.
- Flanged or Flangeless Systems Available.
Flanged Connection

- Liner sections are terminated by fitting flange adapters over raised faces of steel flanges.
- Compression between adapters establishes seal. A steel retaining ring controls compression and provide a secondary seal.
- Pressure seal, no gasket required, tested to 5000psi
Tite Liner® system flange fittings have been used since 1985 to provide a tight seal and restrained joint in pressures up to and over 5,000 psi. Each raised face steel flange is machined to match the inside diameter of the steel pipe and inspected to verify that the raised face dimension is correct. A radius that matches the radius of the polyethylene flange-fittings is manufactured by United Pipeline Systems to exact dimensions to ensure superior performance of the completed flange connection.
United has developed a patented, unique flange connection for use in slurry and non-slurry pipelines. Our steel flange and polyethylene flange-fittings are both machined with specially designed interlocking surfaces that provide uniform geometry across the joint.
The WeldTite connectors allow for:

- Allows for the connection of two HDPE lined sections of pipe without the use of flanges.
- End sealing on the HDPE liner.
- Restrains HDPE liner from pull-out.
- All wetted materials are corrosion resistant.
- Uninterrupted (smooth) internal bore.
WeldTite™ EF welded connection is similar in function to the CRA product. All wetted materials are thermoplastic and the continuously smooth inside diameter of the connection makes it ideal for abrasive (slurry) applications.
Rotolining

Lined Fittings
The Tite Liner® system is best installed in long, straight sections. Standard fittings such as tees, short radius elbows and special configurations can be protected with factory lined polyethylene or other suitable internal coatings. United can furnish special fittings internally lined with polyethylene to match the exact dimensions of the pipe sections.

RMB Products
We work with RMB Products to provide rotational lining.
Rotational lining process

- Surface blasted to near white metal
- Powder loaded into part and part encapsulated
- Rotated on two axis in an oven
- Powder melts and forms a mechanical bond with substrate
- Bond strength greater than tensile strength of material
- Plastic on flange face trimmed to provide flat sealing surface
Rotational Lining Solutions

• Maximum dimensions for rotolined structures:
  • 8ft diameter x 20ft length
  • 10ft diameter x 12ft length
• Our state-of-the-art technology uses different high performance thermoplastics to internally protect steel structures, such as:
  • Manifolds and well heads
  • Tees
  • Bends and reducers
Liner Materials

- Fluid transported
- Gas Vapor Pressure
- Operating and test pressures
- Operating temperature
- Handling and Storage
- Installation technique
Mic-Resistant HDPE Lining for Seawater Applications

Antimicrobial nano additive

- Novel corrosion solution
- Provides added protection to standard PE
- Easily incorporated into coatings and surfaces
- Neutralizes microorganisms
- Inhibits corrosion
- Environmentally safe – ionic killing mechanism
- Effective in extreme environments
- Tested with many different bacteria, molds and fungi and thus far it has been effective with everything.
Problem Definition

- Two types of corrosion cause majority of problems in seawater applications:
  - Aqueous corrosion
  - Microbiologically influenced corrosion (MIC)
- MIC can cause further problems with organism growth on the biofilm
- MIC responsible for 40% of structural failures in oil and gas production
- Cost of corrosion $1 trillion in 2013
- MIC 25% of total US annual cost
Biological testing

Tested per ASTM E2180 & ASTM E2149 using Staphylococcus bacteria
Biological Testing Results

- All bacteria eliminated in 3 hours with only 3% anti-microbial additive by weight
- Test pieces exposed to significantly higher concentrations of bacteria than would be expected in service.
- 99% of harmful, corrosion-inducing bacteria neutralized
Where flow is less than the self cleansing flow velocity. Over time a biofilm layer will form on standard polyethylene. Causing High friction loss due to deposition.
HDPE Liner Systems

- **System Benefits**
  - Long term corrosion solution
  - Fast Installation
  - Long Pull Lengths
  - Chemical Resistance
  - Biological Resistance
  - No Pressure Limitation
  - Leak-Free Connections
  - Increased Operating Efficiencies