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See MSDS for Health & Safety Considerations.

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For more than 40 years, Rilsan® PA11 resin has been a material of choice for corrosion free, hydrocarbon transport systems. Rilsan® PA11 thermoplastic material has been used extensively across the entire oil and gas value chain for cost-effective, non-metallic piping systems.

From offshore flexibles, risers and umbilicals in the upstream segment, to liners and coatings for transmission in the midstream segment, to low pressure gas distribution, gas station piping and automotive fuel lines in the downstream segment, Rilsan® PA11 has been providing innovative solutions to the entire oil and gas industry. Arkema brings its extensive experience from successful oil and gas piping applications to the natural gas industry with a high pressure pipe that combines the technological advantages of plastic pipe with the pressure capabilities of steel pipe. After years of dedicated research, development, testing and evaluation, we introduced a revolutionary grade of Rilsan® PA11, which can be processed into a plastic pipe with exceptional performance characteristics for natural gas transport. Rilsan® PA11 can increase the value, safety and reliability of your pipeline assets at a lower cost, requiring no cathodic protection, with cost effective installation techniques, similar to that of PE piping.

What is Polyamide 11?
Polyamide 11 (PA11) is a semi-crystalline, thermoplastic material derived from castor oil, making the neat resin 100% bio-based. It can be extruded into pipe, much like traditional plastic piping materials such as PE. However, its molecular structure, particularly the amide functional groups resulting in hydrogen bonding, yields outstanding mechanical properties and hydrocarbon resistance.
For more than 40 years, Rilsan® PA11 resin has been a material of choice for corrosion-free, hydrocarbon transport systems. Rilsan® PA11 thermoplastic material has been used extensively across the entire oil and gas value chain for cost-effective, non-metallic piping systems. From offshore flexibles, risers and umbilicals in the upstream segment, to liners and coatings for transmission in the midstream segment, to low pressure gas distribution, gas station piping and automotive fuel lines in the downstream segment, Rilsan® PA11 has been providing innovative solutions to the entire oil and gas industry.

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Rilsan® PA11 piping

You Will Never Go Back to Steel Pipe Again

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What is Polyamide 11?

PA11 Production

HUGG PERFORMANCE NON-METALLIC PIPING

OFFSHORE PRODUCTION

NATURAL GAS DISTRIBUTION

ONSHORE PRODUCTION

PIPELINE AND STORAGE

Ricin Plant

Ricin Seed

Castor Oil

Harvesting

Grinding

Monomer Synthesis

A11 monomer

Polymerization

PA11
Gas Transmission & Distribution

Leader in Performance

Long-term Hydrostatic Stress
The long-term hydrostatic stress performance of Rilsan® PA11 is well established through the ASTM D2837 method. The material has earned HDUs published in PPI TR-4, with no brittle failure, as follows.

<table>
<thead>
<tr>
<th>Temperature °C (°F)</th>
<th>Rilsan® PA11 32316</th>
</tr>
</thead>
<tbody>
<tr>
<td>23°C (73°F)</td>
<td>1,250</td>
</tr>
<tr>
<td>60°C (140°F)</td>
<td>1,000</td>
</tr>
<tr>
<td>81°C (180°F)</td>
<td>N/A</td>
</tr>
</tbody>
</table>

The HDB at elevated temperatures gives operators a plastic piping solution when the system needs to withstand high operating temperatures, such as bridge crossings or buried installations next to steam lines.

SCG Resistance Rilsan® PA11
No PENT failures at a stress of 350 psi at 80°C, after > 2000 hr
No crack growth was observed after one week, at 80°C during the Cone Test
No failures using the Notched Pipe Test at 80°C and 290 psig (20 bars) test pressure

When to use Rilsan® PA11
Rilsan® PA11 is specifically designed to give operators a plastic piping free solution when conditions exceed that of which PE can perform.

- Pressures up to 250 psi
- Elevated Temperatures
- Hydrocarbon Contaminated Soil (no chemical de-rating)

Value Proposition
The value of Rilsan® PA11 pipe can be quantifiable when compared to that of steel piping. The measurable economic advantage is embedded in the reduced installation cost and minimal maintenance cost of PA11 compared to steel.

Using a typical case study from a PA11 pipe installations, PA11 provides a significant upfront savings (CapEx), as well as reduced annual operating expenses, contributing to significant lifetime savings for PA11 compared to coated steel.

4” SDR 11
Capex Savings $64,000 per mile
Maintenance Savings $6,300 per mile annually

PROPERTY
PE PIPE | RILSAN® PA11 PIPE | STEEL PIPE
--- | --- | ---
High MAOP | √ | | √ |
Corrosion Resistance | √ | | x |
Hydrocarbon Resistance | x | | √ |
High Temperature Resistance | | | √ |
Slow Crack Growth Resistance | Low | | High |

INSTALLATION CHARACTERISTICS

Easy Installation | √ | | x |
- No Welding | √ | | x |
- No Cathodic Protection | √ | | x |
Low Bending Radii | √ | | x |
No Heavy Pipe Handling Equipment Needed | √ | | √ |

COST COMPARISON

<table>
<thead>
<tr>
<th>Cost Comparison</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Installed Cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Life-Time Maintenance Cost</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Gas Transmission & Distribution

A Complete Piping System

Pipe
1", 2", 4" & 6" IPS

Butt Fusion Fittings
1", 2", 4" & 6" IPS
45° Elbows
90° Elbows
Tees
Reducers
End Caps

Electro-Fusion Fittings
Couplings
Tapping Trees

Transition Fittings
PA11 to Steel
PA11 to PE

Risers
1" & 2" IPS

Leader in Performance

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The long-term hydrostatic stress performance of Rilsan® PA11 is well established through the ASTM D2837 method. The material has earned HDBs published in PPI TR-4, with no brittle failure, as follows:

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4" SDR 11
Capex Savings: $64,000 per mile
Maintenance Savings: $6,300 per mile annually

Slow Crack Growth
Rilsan® PA11 shows excellent resistance to slow crack growth (SCG), as studied by several methods: PENT (ASTM 1473), Cone Test (ISO 13480:1977[E]), Notched Pipe Test (ISO 13479:1997[E]). No crack growth was observed in any of these tests.

SCG Resistance Rilsan® PA11
No PENT failures at a stress of 350 psi at 80°C, after > 2000 hr
No crack growth was observed after one week, at 80°C during the Cone Test
No failures using the Notched Pipe Test at 80°C and 290 psig (20 bars) test pressure

Regulated Gas Distribution

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>PE PIPE</th>
<th>RILSAN® PA11 PIPE</th>
<th>STEEL PIPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSTEM CHARACTERISTICS/SPECIFICATIONS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High MAOP</td>
<td>x</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Corrosion Resistance</td>
<td>√</td>
<td>√</td>
<td>x</td>
</tr>
<tr>
<td>Hydrocarbon Resistance</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>High Temperature Resistance</td>
<td>x</td>
<td>√</td>
<td>x</td>
</tr>
<tr>
<td>Slow Crack Growth Resistance</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

INSTALLATION CHARACTERISTICS

- Easy Installation | √ | √ | x |
- No Welding | √ | √ | x |
- No Cathodic protection | √ | √ | x |
- Low Bending Radii | √ | √ | x |
- No Heavy Pipe Handling | √ | √ | x |
- Equipment Needed |

COST COMPARISON

- Total Installed Cost | Low | Moderate | High |
- Life-Time Maintenance Cost | Low | Low | High |
Rilsan® PA11 can provide the same proven benefits and performance to the midstream sector that it has demonstrated in regulated gas distribution.

**Performance**
PA11 is inherently resistant to hydrocarbons and does not require chemical de-rating for gas, oil, and dry/wet gas mixtures.

## Operating Pressure (psi) for PA 32316 Polyamide 11 (PA 11) Pipe For Gas Gathering, Multiphase, Low Vapor Pressure Liquid & Oilfield Water Services

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
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<th>&lt;73 to ≤ 90°F</th>
<th>&lt;90 to ≤ 130°F</th>
<th>&lt;130 to ≤ 170°F</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3150</td>
<td>UNREGULATED</td>
<td>UNREGULATED</td>
<td>UNREGULATED</td>
<td>UNREGULATED</td>
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<tr>
<td></td>
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<td>0.5</td>
<td>0.5</td>
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<tr>
<td></td>
<td>2000</td>
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<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>1600</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**Service Design Factor (DFs)**
- 0.5
- 0.5
- 0.5
- 0.5
- 0.5

**SDR**
- 21
- 17
- 13.5
- 11
- 9
- 7.3
- 6.3

<table>
<thead>
<tr>
<th>SDR</th>
<th>158</th>
<th>125</th>
<th>100</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>197</td>
<td>156</td>
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<tr>
<td>13.5</td>
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<td>302</td>
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<td>160</td>
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Dry gas, gaseous hydrocarbons, and wet gas containing aliphatic hydrocarbons (including diesel) have no adverse effect on expected service life of PA11 piping systems. A Design Factor (DF) of 0.5 is recommended. For water, recommended DF is 0.5. In case of high aromatic hydrocarbons (like gasoline), an additional chemical DF of 0.5 should be applied.

Consider Rilsan® PA11 for your next midstream piping project.

**Don’t Neglect Corrosion Use Rilsan® PA11**

Rilsan® PA11 is a cost-effective choice to replace Steel Piping Systems in most natural gas line environments and applications. Available in lightweight coils and easily installed by conventional PE methods, Rilsan® PA11 can increase the value, safety and reliability of your pipeline assets at a lower cost.

Over Four Decades of Reliable Service in Various O&G Piping Systems

- **1970**: First Offshore Flexible Hose
- **1972**: Low-Pressure Gas Distribution in Australia
- **1972**: First Offshore Flexible Hose
- **1970**: Mid-1970’s - Low-Pressure Gas Distribution in Australia
- **1972**: First Offshore Flexible Hose
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- **1995**: PA11 High-Pressure Gas Piping System Project Initiated
- **2000**: DOT Approval for High-Pressure Natural Gas Transport
- **2005**: 1.5 Million Fittings Installed to Date
- **2010**: First Installation After DOT Approval
- **2014**: 35 Miles of PA11 Gas Pipe Installed to Date

**Midstream & Gas Gathering**
Rilsan® PA11 can provide the same proven benefits and performance to the midstream sector that it has demonstrated in regulated gas distribution.

**Codes & Standards**
- ASTM D 2513-99
- Annex 5
- ASTM F 2945-12: PA material and pipe
- CSA B137/12: PA material and pipe
- ASTM F 1973: PA anode-less risers and transition fittings
- ASTM F 2145: Standard Specification for PA11 Mechanical Fittings
- ASTM F 1733: Specification for PA-11 butt fusion fittings
- NFPA 54: National Fuel Gas Code
- ANSI Z300.1: Gas Code
- NFPA 58 LP: Gas Distribution and Transmission Pressure Piping Code
- ASME B31.8: Polyamide (PA)-piping systems for the supply of gas for MOP 20 bar
- ISO 22621: Polyamide (PA)-piping systems for the supply of gas for MOP 20 bar

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