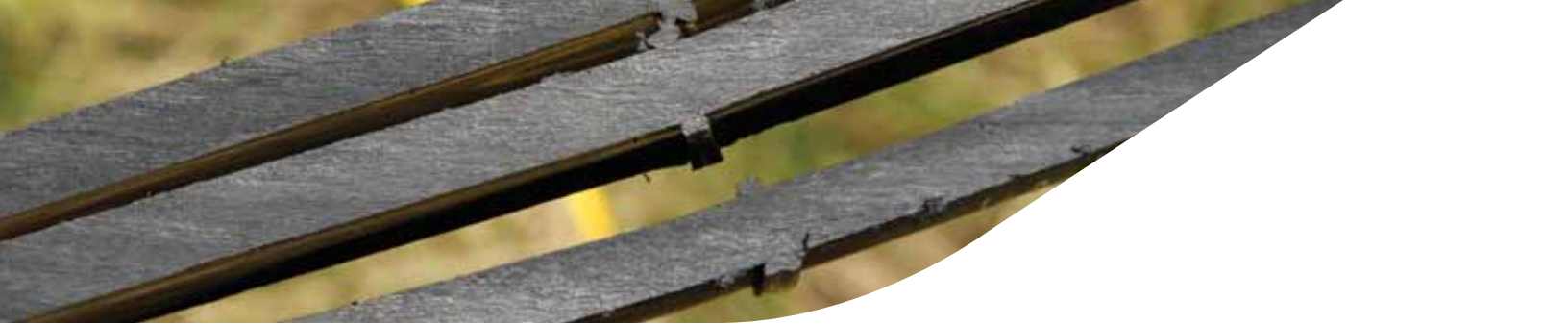


D.O.T. Permitted High-Pressure Polyamide Piping System





RILSAN® PA11 PIPING

You Will Never Go Back to Steel Pipe Again

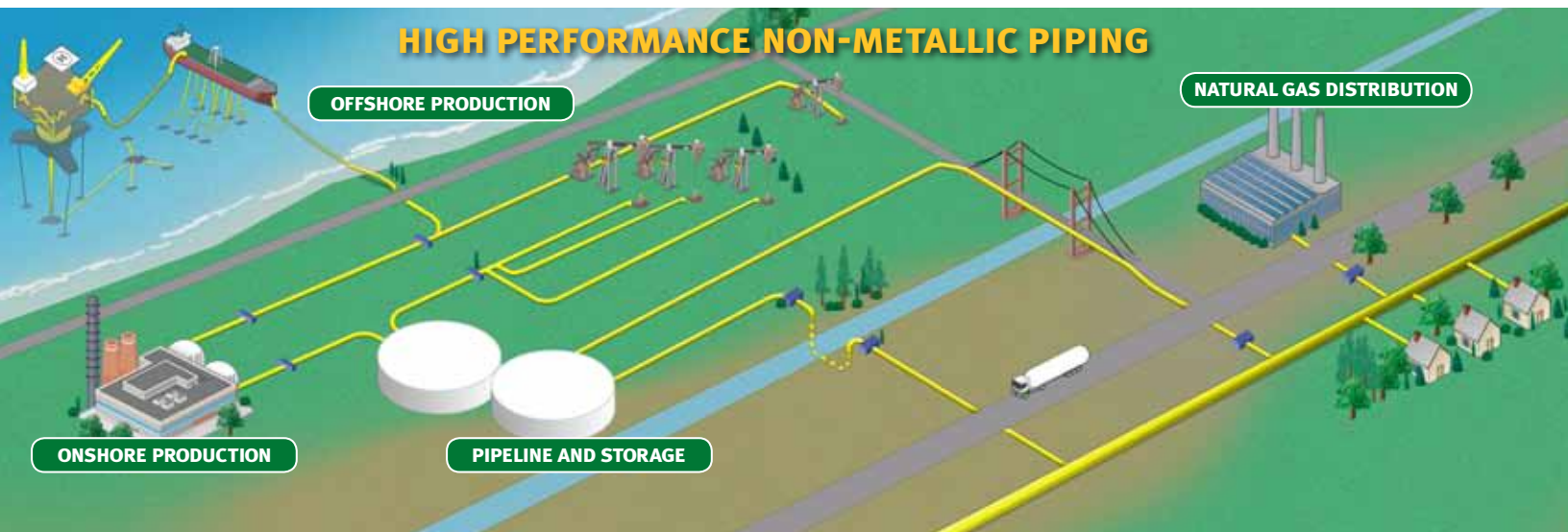
For more than 40 years, Rilsan® PA11 resin has been a material of choice for corrosion free, hydrocarbon transport systems. Rilsan® PA11 thermoplastic material has been used extensively across the entire oil and gas value chain for cost-effective, non-metallic piping systems.

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,

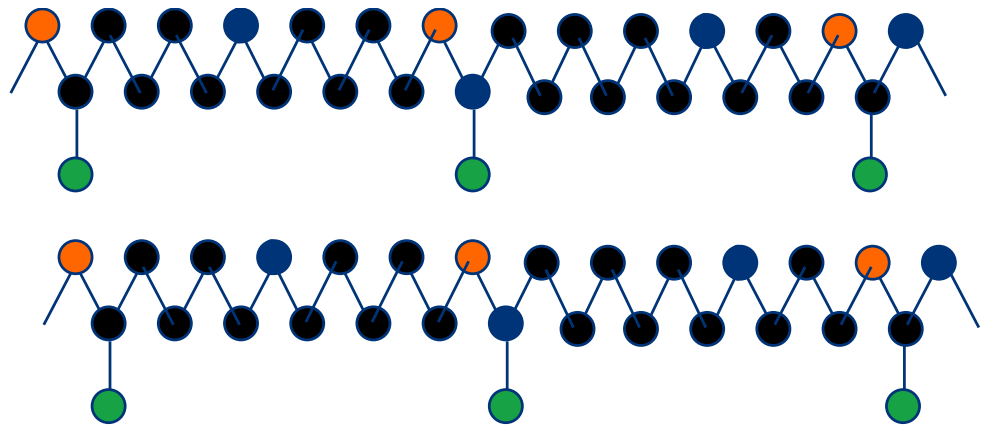
development, testing and evaluation, we introduced a revolutionary grade of Rilsan® PA11, which can be processed into a plastic pipe with exceptional performance characteristics for natural gas transport. Rilsan® PA11 can increase the value, safety and reliability of your pipeline assets at a lower cost, requiring no cathodic protection, with cost effective installation techniques, similar to that of PE piping.



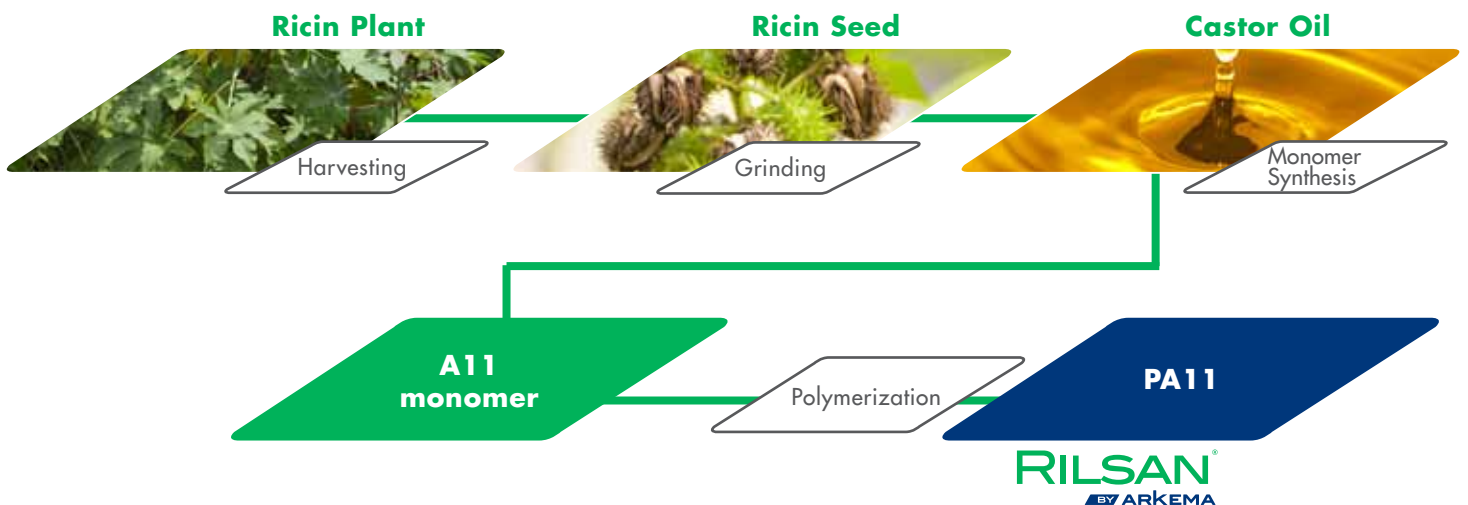


What is Polyamide 11?

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.

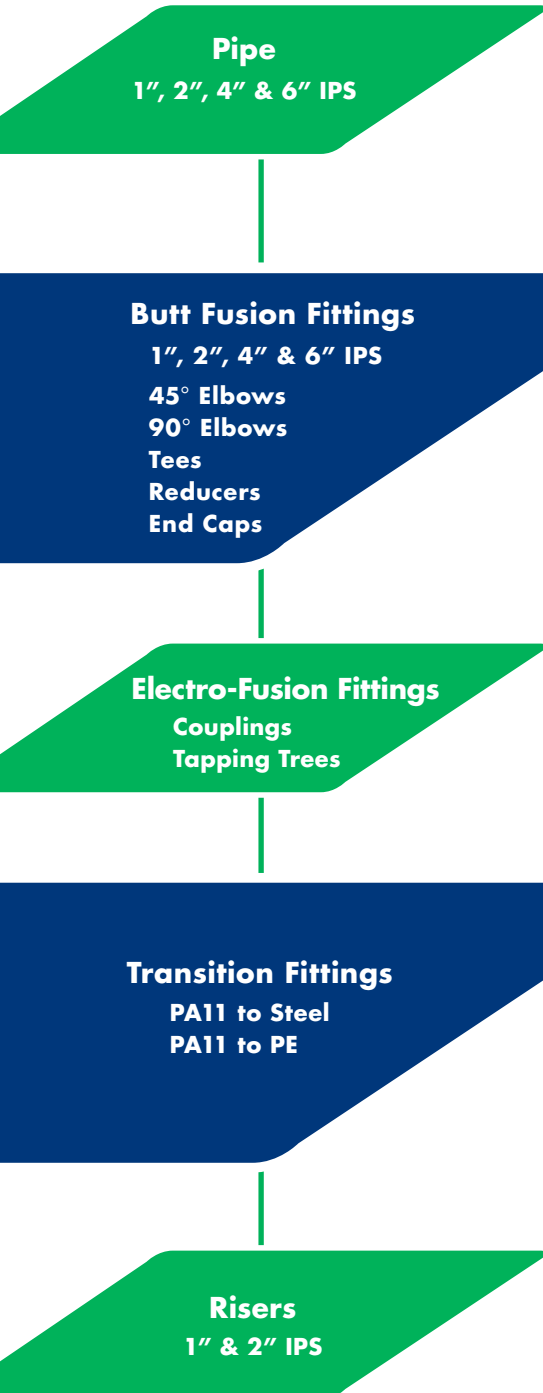


PA11 PRODUCTION



GAS TRANSMISSION & DISTRIBUTION

A Complete Piping System



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 HDBs published in PPI TR-4, with no brittle failure, as follows.

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.

TEMPERATURE °C (°F)	MDPE	HDPE	RILSAN® PA 32316
23°C (73°F)	1,250	1,600	3,150
60°C (140°F)	1,000	800	2,000
81°C (180°F)	N/A	N/A	1,600

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



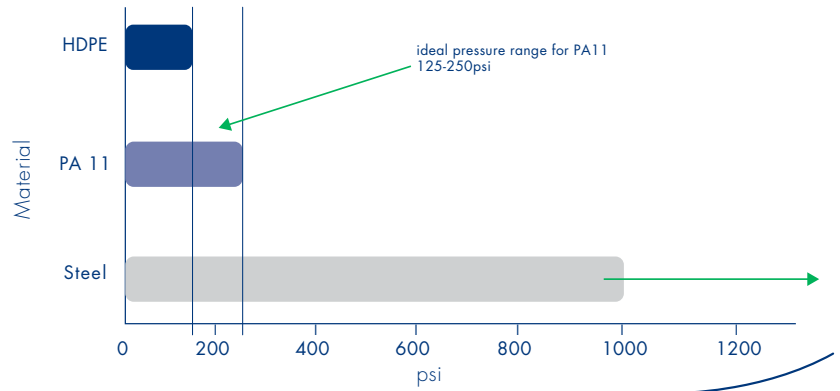
LYAMIDE 11 RILSAN PA32316

When to use Rilsan® PA11

Rilsan® PA11 is specifically designed to give operators a plastic, corrosion 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)

Regulated Gas Distribution



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
SYSTEM CHARACTERISTICS/SPECIFICATIONS			
High MAOP	x	√	√
Corrosion Resistance	√	√	x
Hydrocarbon Resistance	x	√	√
High Temperature Resistance	x	√	√
Slow Crack Growth Resistance	Low	High	High
INSTALLATION CHARACTERISTICS			
Easy Installation	√	√	x
-No Welding	√	√	x
-No Cathodic protection	√	√	x
Low Bending Radii	√	√	x
No Heavy Pipe Handling Equipment Needed	√	√	x
COST COMPARISON			
Total Installed Cost	Low	Moderate	High
Life-Time Maintenance Cost	Low	Low	High

CODES & STANDARDS

ASTM D 2513-99 Annex 5		ASTM F 1733	Specification for PA-11 butt fusion fittings
ASTM F 2945-12	PA material and pipe	NFPA 54	National Fuel Gas Code
CSA B137.12	PA material and pipe	ANSI Z380.1	GPTC Guide Material for PA-11
ASTM F 1973	PA anode-less risers and transition fittings	NFPA 58 LP	Gas Code
ASTM F 2145	Standard Specification for PA-11 Mechanical Fittings	ASME B31.8	Gas Distribution and Transmission Pressure Piping Code
		ISO 22621	Polyamide (PA)-piping systems for the supply of gas for MOP 20 bar

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.

Applications include low pressure oil & gas gathering lines, up to 315 psi, and water transfer lines used for hydraulic fracturing.

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

TEMPERATURE (°F)	73 TO ≤ 90°F	<90 TO ≤ 130°F	<130 TO ≤ 170°F	<170 TO ≤ 180°F
HDB (PSI)	3150	2500	2000	1600
	UNREGULATED	UNREGULATED	UNREGULATED	UNREGULATED
Service Design Factor (DFs)	0.5	0.5	0.5	0.5
SDR				
21	158	125	100	80
17	197	156	125	100
13.5	252	200	160	128
11	315	250	200	160
9		313	250	200
7.3			317	254
6.3				302

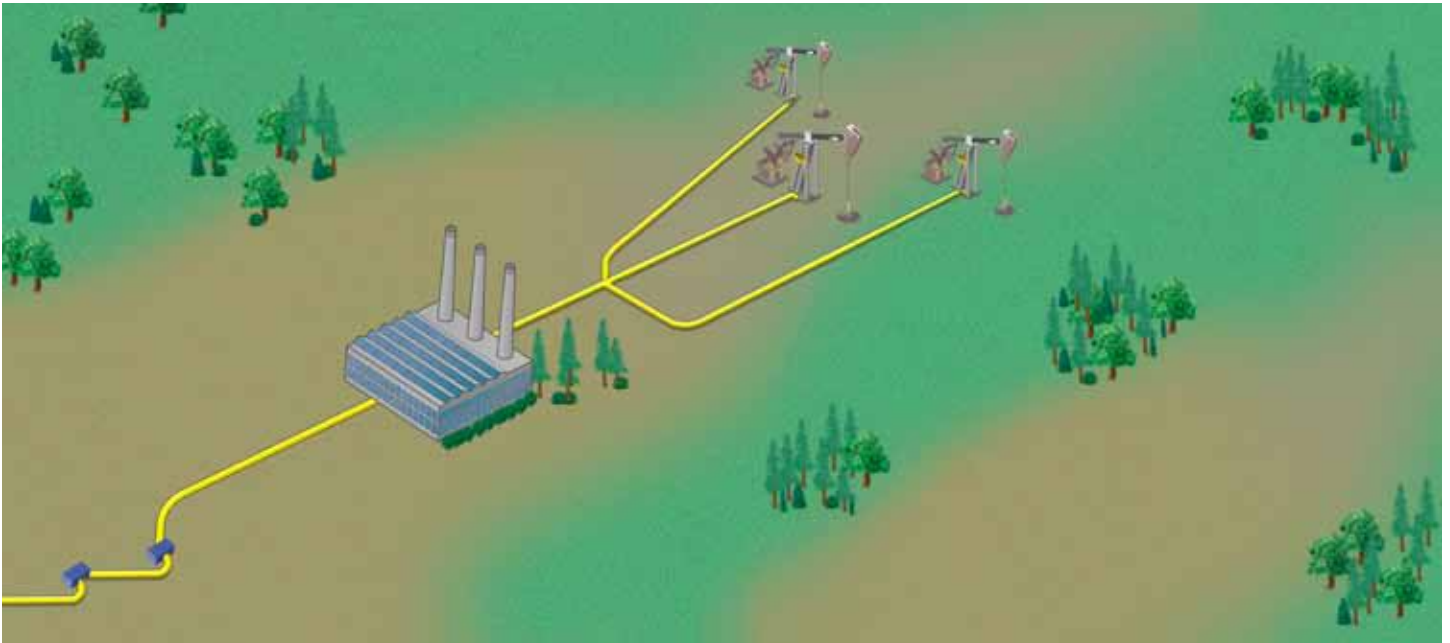
Dry gaseous hydrocarbons and wet gas containing aliphatic hydrocarbons (including diesel) have no adverse effect on expected service life of PA-11 piping system. A Design Factor (DF) of 0.5 is recommended. For water, recommended DF is 0.5. In case of high aromatic hydrocarbons (like gasoline), an additional chemical DF of 0.5 should be applied.

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





Consider Rilsan® PA11 for your next midstream piping project.



DON'T NEGLECT CORROSION USE RILSAN® PA11

Rilsan® PA11 is a cost-efficient 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.

2000

2005 - 1.5 Million Fittings Installed to Date

2008 - DOT Approval for High-Pressure
Natural Gas Transport

2010

2010 - First Installation After DOT Approval

2014

2014 - 35 Miles of PA11 Gas
Pipe Installed to Date



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See MSDS for Health & Safety Considerations.

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