



Maintaining energy efficiency and extending the service life of pre-insulated pipes with EVAL™ EVOH

Emilio Morales – Kuraray America, Houston

Cynthia Teniers – EVAL Europe, Belgium

Kristof Dedecker - Huntsman Polyurethanes, Belgium



CAMPUSENERGY2017

February 20-24 | Hyatt Regency Miami | Miami, FL



kuraray

Outline of presentation

- Function of Pre-insulated Pipes
- Current Challenges of Systems using HDPE Casings
- Introduction of High Gas Barrier EVOH
- Solution with Coextruded Casing Pipe with EVOH
- Aging Experiments with Coextruded Pipe with EVOH
- Summary

PUR pre-insulated pipe systems

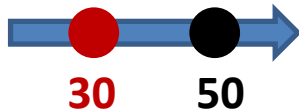


Good mechanical strength & structural properties

λ

Very low thermal conductivity (λ)

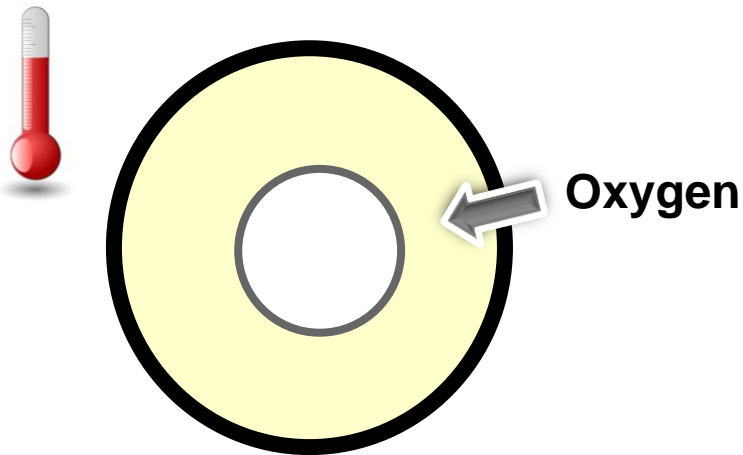
Time (years)



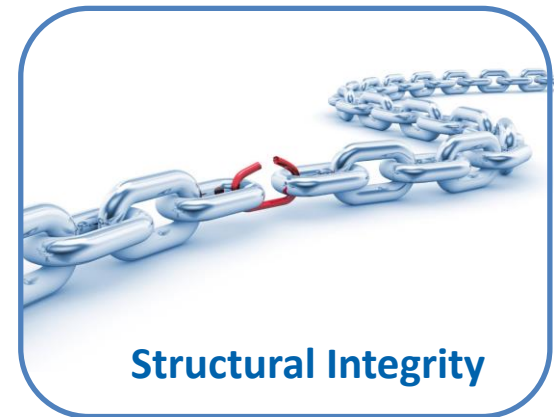
Withstand high temperature inside the service pipe for minimum 30 years

Current Challenges with HDPE Casings

Service life of pre-insulated pipe systems can be *shortened* by *oxidative degradation* of the PUR foam which can endanger the *structural integrity* of the pipe system

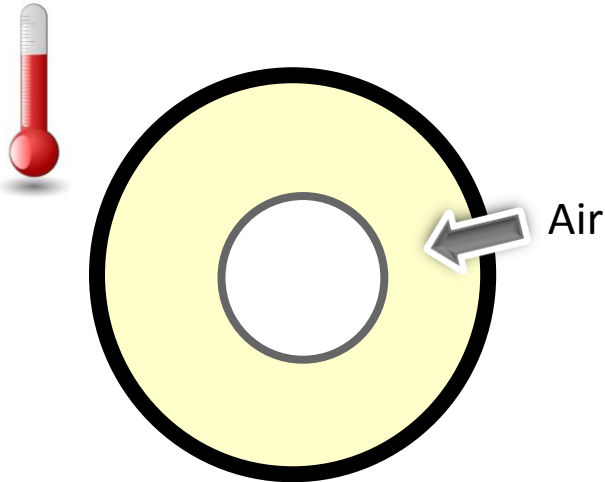


- Service pipe / inner pipe
- PUR insulation foam
- Outer casing pipe

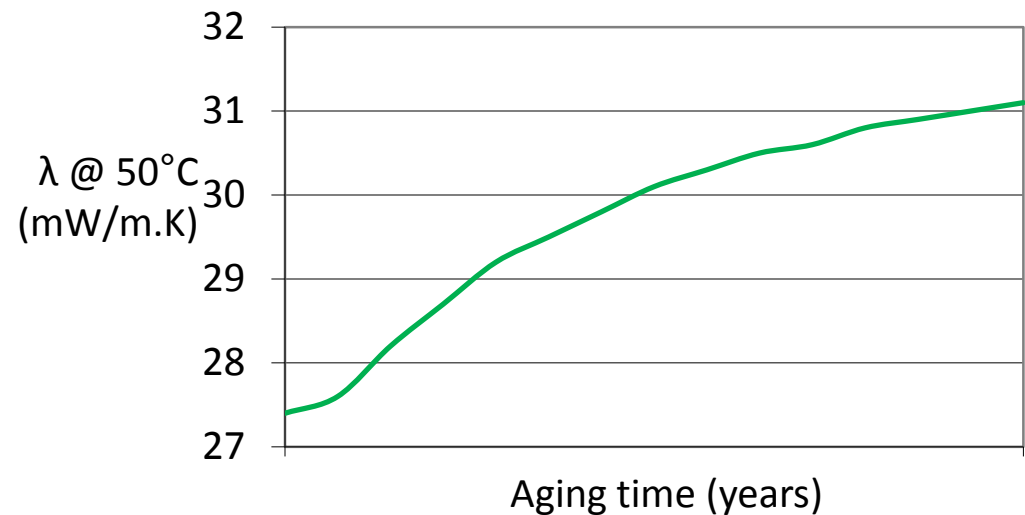


Current Challenges with HDPE Casings

Insulation efficiency of pre-insulated pipe systems is *reduced* over time by the *diffusion of air* into the foam cells which leads to higher *energy losses*

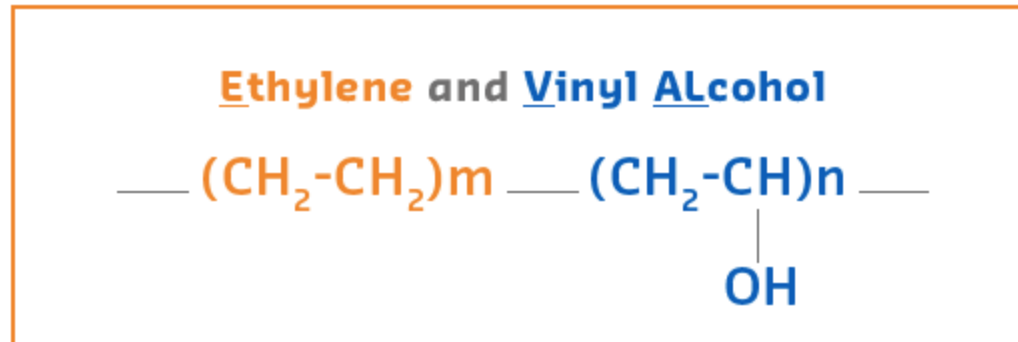


- Service pipe / inner pipe
- PUR insulation foam
- Outer casing pipe



Introduction of High Gas Barrier EVAL™ EVOH

A copolymer, combining the strengths of Ethylene and Vinyl Alcohol



- thermoplastic
- very high gas barrier

Gas Barrier of EVAL™ EVOH

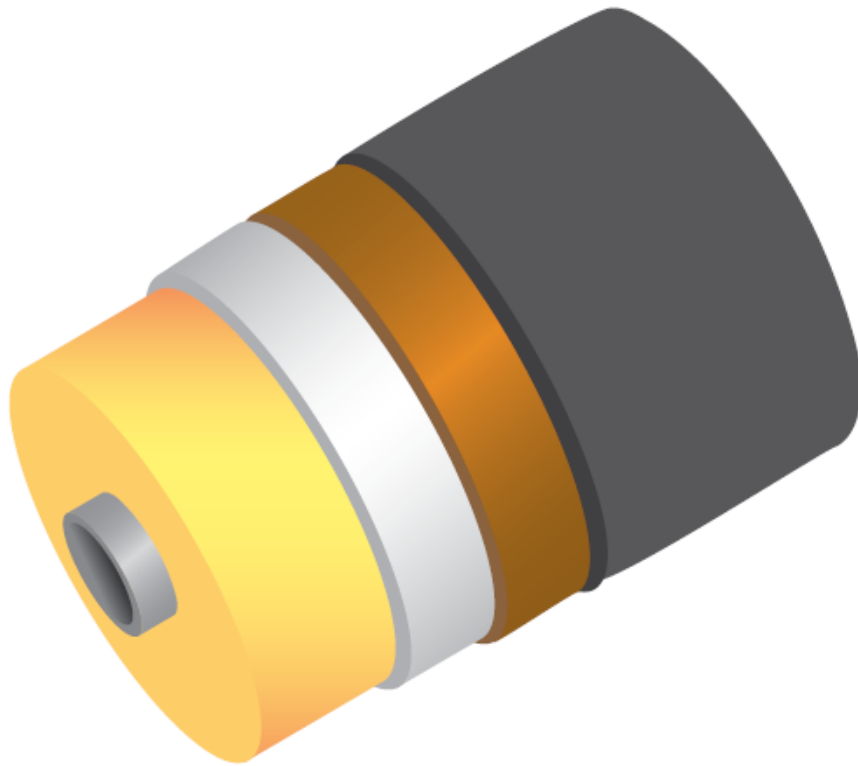
1 mm of EVAL™ F (32 mol% et. EVOH) has the same gas barrier as 9 meters of HDPE

		Gas transmission rates (GTR) (cm ³ .mm/m ² .day.atm)		
Material	Test Conditions	N ₂	O ₂	CO ₂
EVAL™ FP101B * ¹	25°C, 0% RH	0.00034	0.0054	0.016
EVAL™ FP101B * ¹	20°C, 65% RH	-	0.0060	-
HDPE* ²	22°C	22	70	247

*¹ Gas transmission rate (ISO 14663-2)

*² Extending the Service Life of Pre-insulated Pipes – Analyses of Diffusion Rates through PE and Impact on Aging, EuroHeat&Power, Vol 11/2009, 48-53 – Material: HE3470 produced by Borealis

Solution with Coextruded Casing Pipe with EVAL™ EVOH



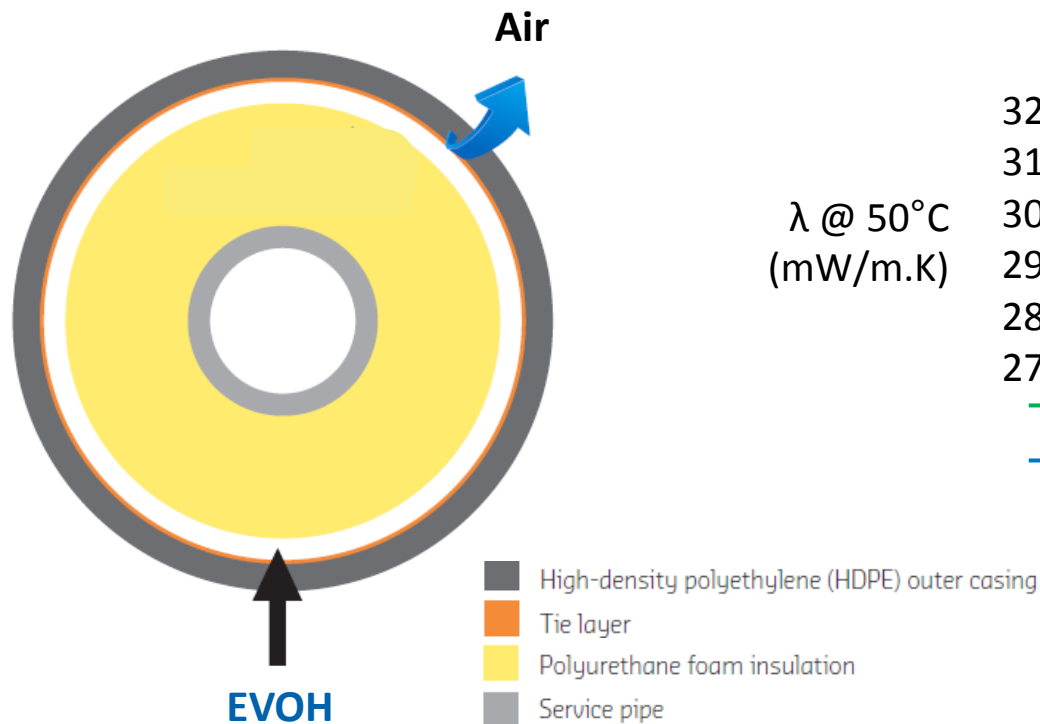
- High-density polyethylene (HDPE) outer casing
- Tie layer
- Barrier EVAL™ EVOH
- Polyurethane foam insulation
- Service pipe

Solution with Coextruded Casing Pipe with EVAL™ EVOH

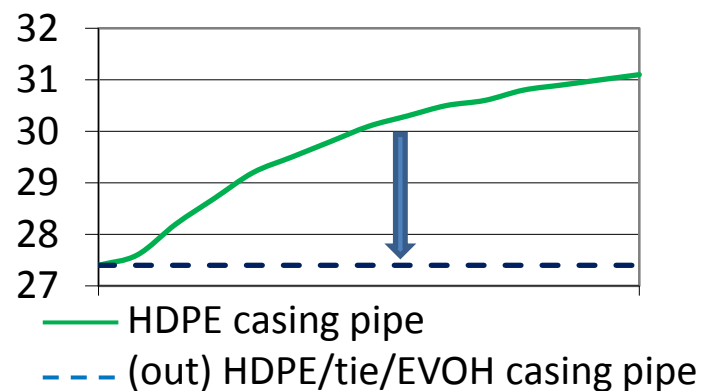
Incorporate a barrier layer into the casing pipe

Maintain insulation efficiency

Reduce energy loss, minimize operating costs of overall network



λ @ 50°C
(mW/m.K)



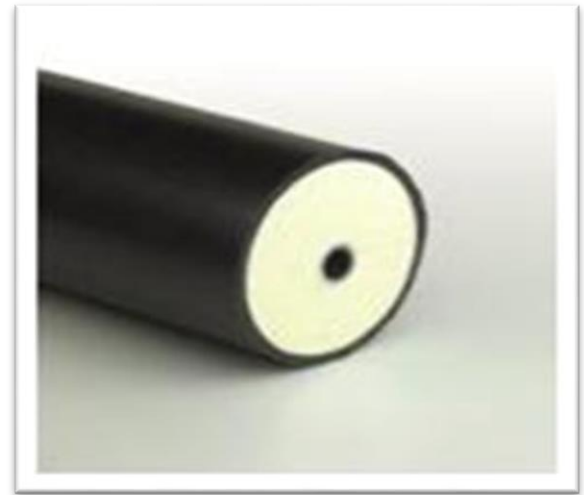
Aging Experiments with Coextruded Pipe with EVOH

Using EN253 Standard: Aged Thermal Conductivity (λ) and foam cell gas analysis

1. Determine initial gas cell composition of **freshly made pipes**
2. Determine the cell gas composition of **aged pipes**
Aging conditons: **150 days in oven at 90°C**, 1 m pipe samples

Composition of cell gases determined
by modified gas chromatography

*Foam cell gas composition expressed as partial
pressure of a gas within the foam cells*

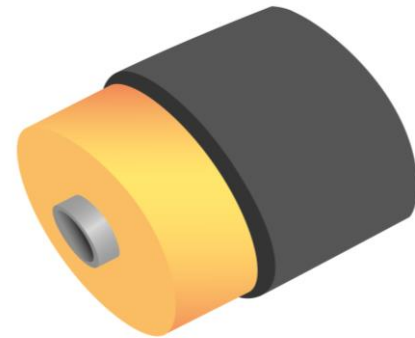


Pipe samples accelerated aging study

Cyclopentane blown pipe; OD 75/DN 15 mm (following EN 253)

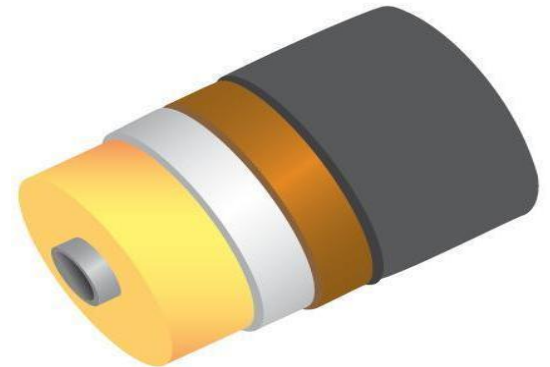
Pre-insulated pipe with a HDPE casing “Blank or control sample”

- Thickness
 - HDPE = 3.5 mm
- Length = 6 m



Pre-insulated pipe with a 3-layer casing HDPE/tie/EVAL™ EVOH

- Thickness
 - HDPE = 3.1 mm
 - **EVAL™ FP101B = 160 micron**
 - Tie = 60 micron
- Length = 6 m



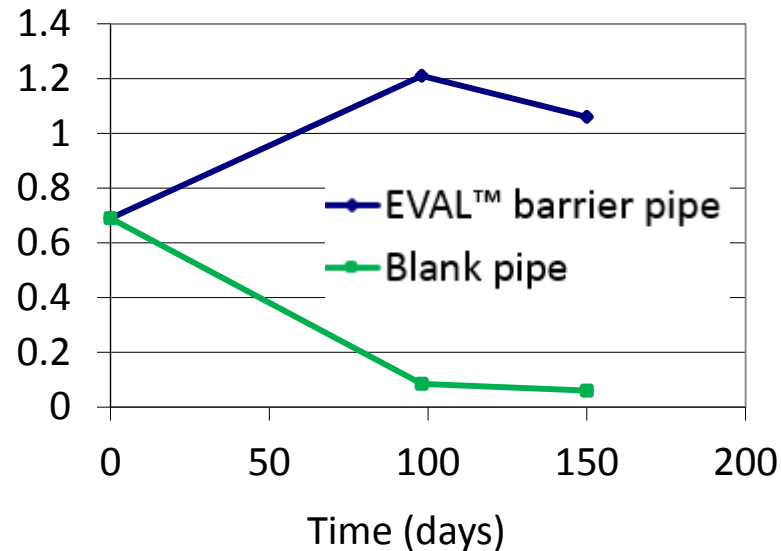
Aging Experiments with Coextruded Pipe with EVOH

Composition after aging (150 days at 90°C)

1 meter sealed pipe samples (cut edges sealed with epoxy)

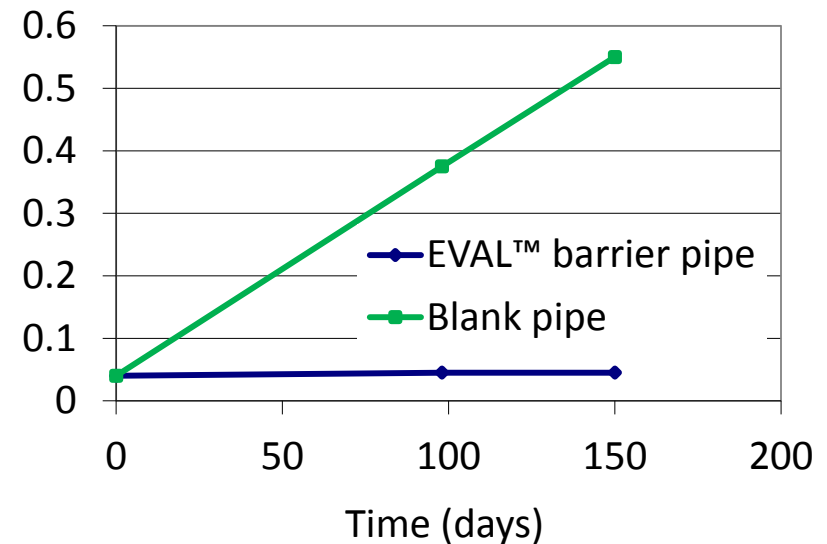
Carbon dioxide

Partial pressure
 CO_2 (bar)



Air (Nitrogen & Oxygen)

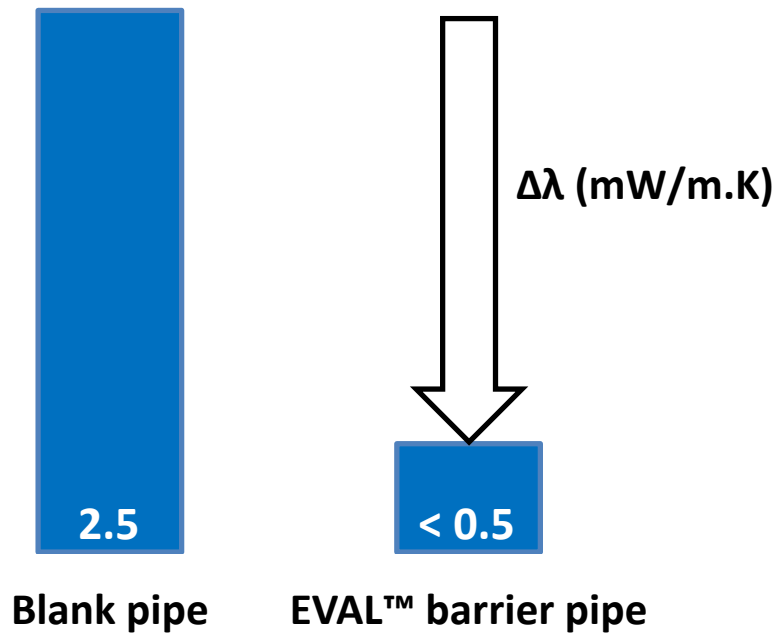
Partial pressure
air (bar)



Impact on thermal conductivity

EVAL™ barrier pipe leads to substantial reduction in $\Delta\lambda$

$$\Delta\lambda @ 90^{\circ}\text{C} = \lambda_{\text{after 150 days}} - \lambda_{\text{initial}}$$

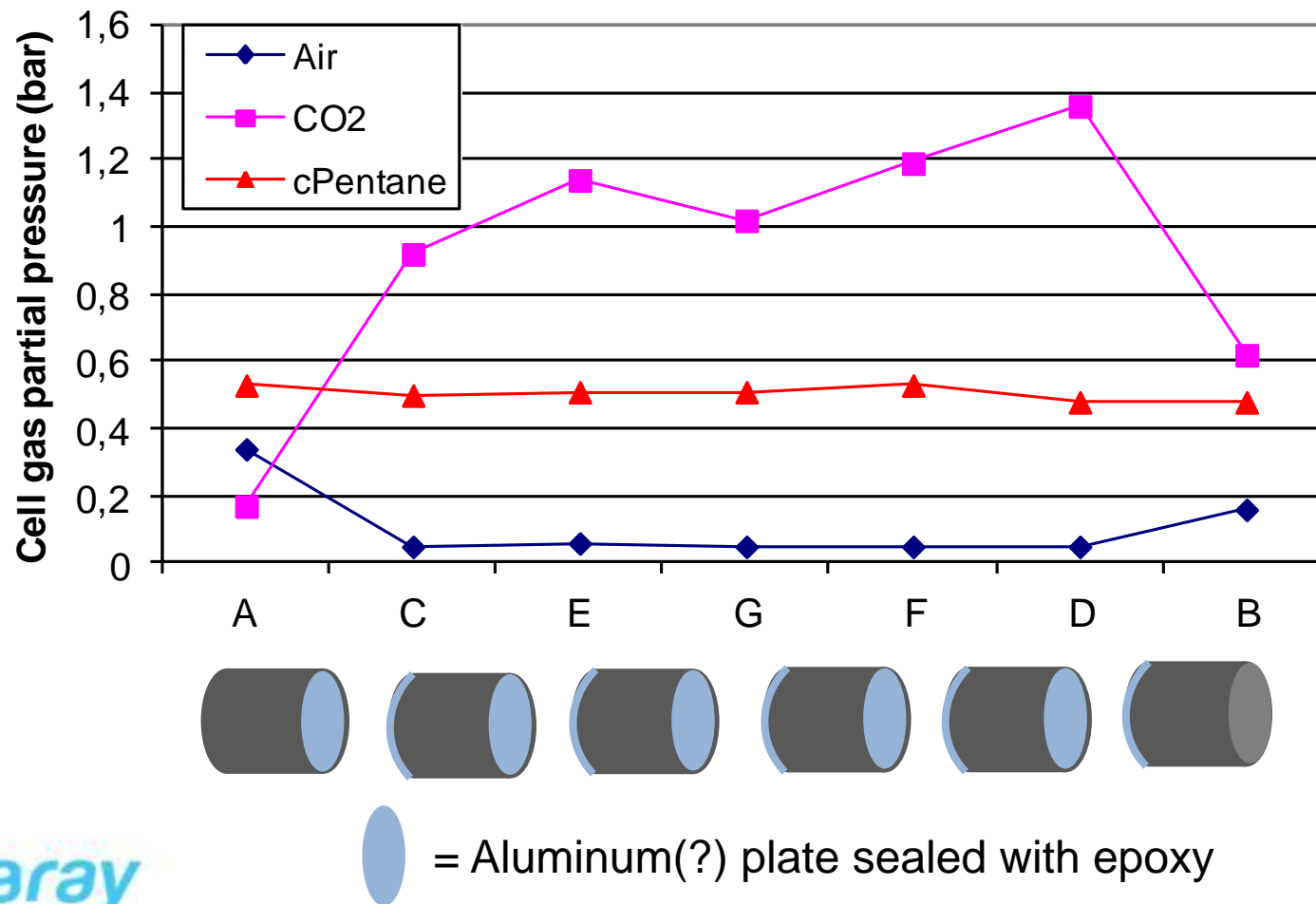


Note:

Value of $\Delta\lambda$ depends on pipe design, foam characteristics and aging conditions

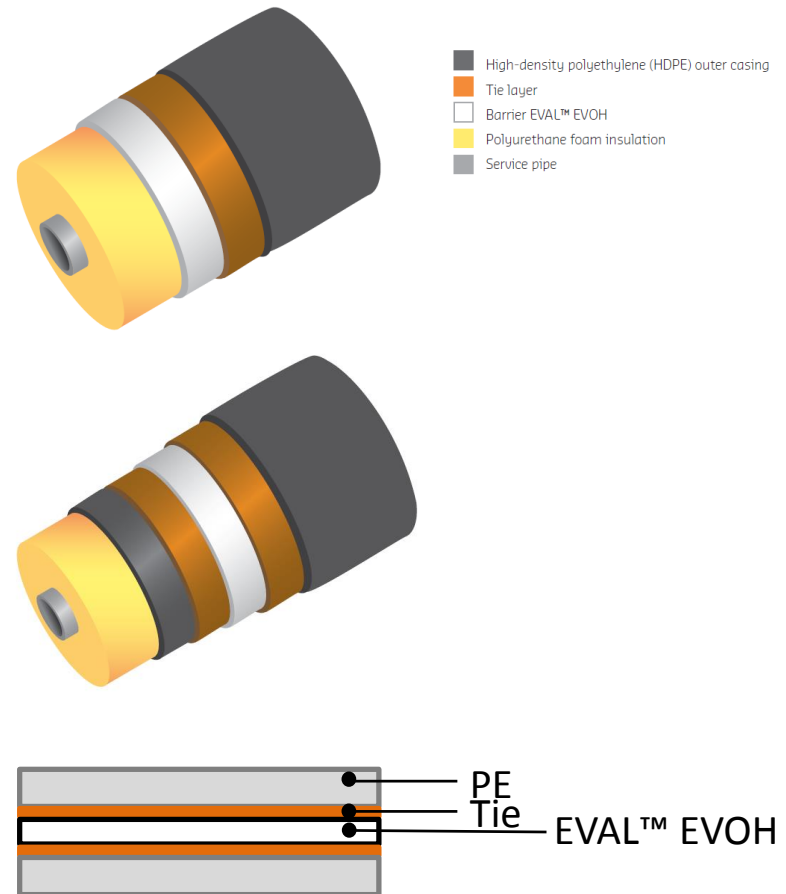
Aging Experiments with Coextruded Pipe with EVOH

Composition after aging (150 days at 90°C) amongst six (1 meter long) pipe segments



Other Methods of Implementation of EVOH Barrier

- **3-layer** casing pipe
HDPE/tie/EVAL™ EVOH
 - Direct adhesion between EVAL™ EVOH & PUR (without corona treatment)
- **5-layer** casing pipe
HDPE/tie/EVAL™ EVOH/tie/HDPE
- **Coextruded film for continuous process**
HDPE/tie/EVAL™ EVOH/tie/HDPE



Summary

Benefits of EVOH for the preinsulated pipe industry

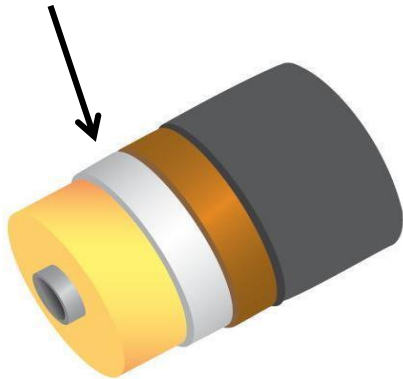
- **Extend potential service life**
Minimize oxidative degradation of PUR foam
- **Reduce energy loss, minimize operating costs overall network**
Maintain insulation efficiency
- **Enable discontinuous & continuous production process**

Thank you

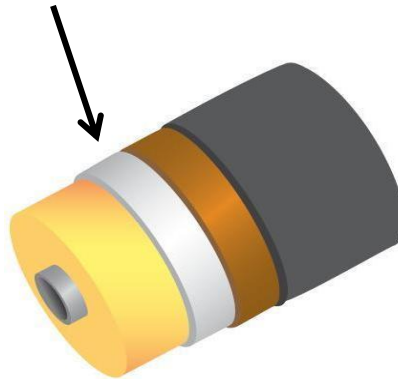
Emilio Morales
emilio.morales@kuraray.com
+1(832)729-3251

Outline

Barrier layer



EVAL™ EVOH
Barrier layer

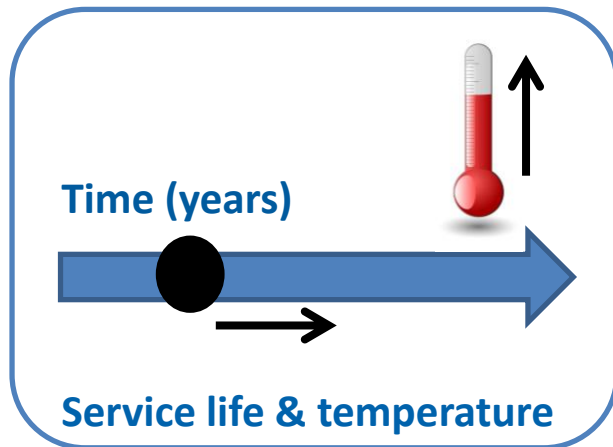


Proof of concept



Expected impact on temperature resistance

**EVAL™ barrier pipe – Higher maximum service temperature or
Longer service life**



Continuous calculated operating temperature (CCOT) – EN 253

- Possible **underestimation** of **foam degradation** due to incoming oxygen at longer term
- Possible **overestimation** of **maximum service temperature**

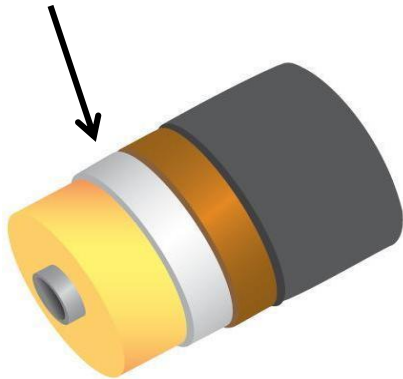
EVAL™ barrier pipe allows to minimize long term foam degradation

Very good initial adhesion between PUR foam & EVAL™ barrier layer

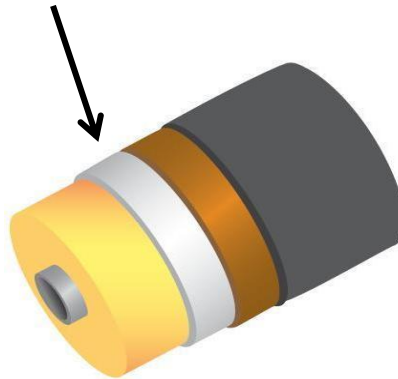
- Shear adhesion freshly made pipe: 0.35 MPa

Conclusion

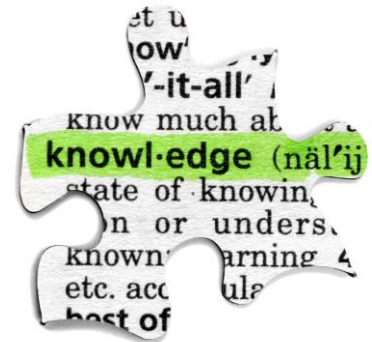
Barrier layer



EVAL™ EVOH
Barrier layer

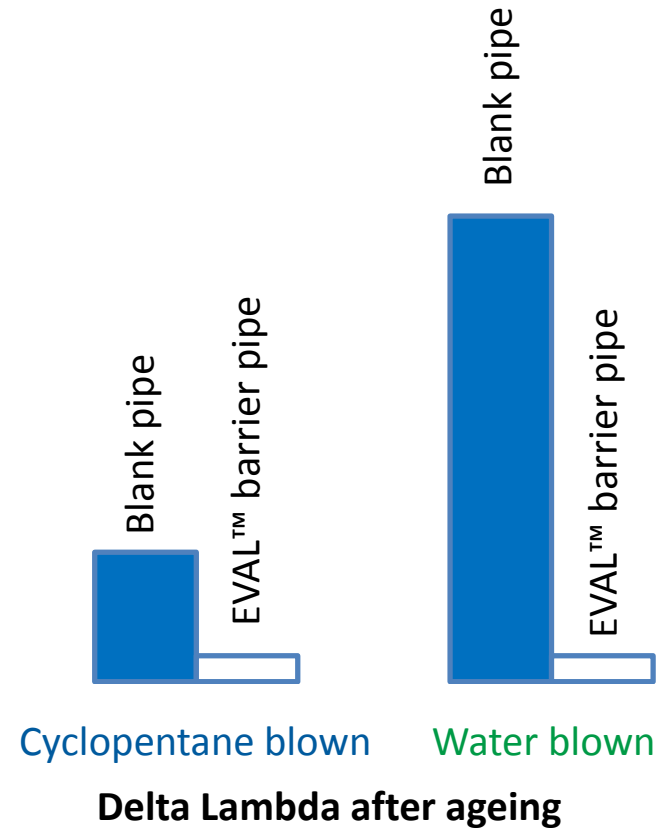
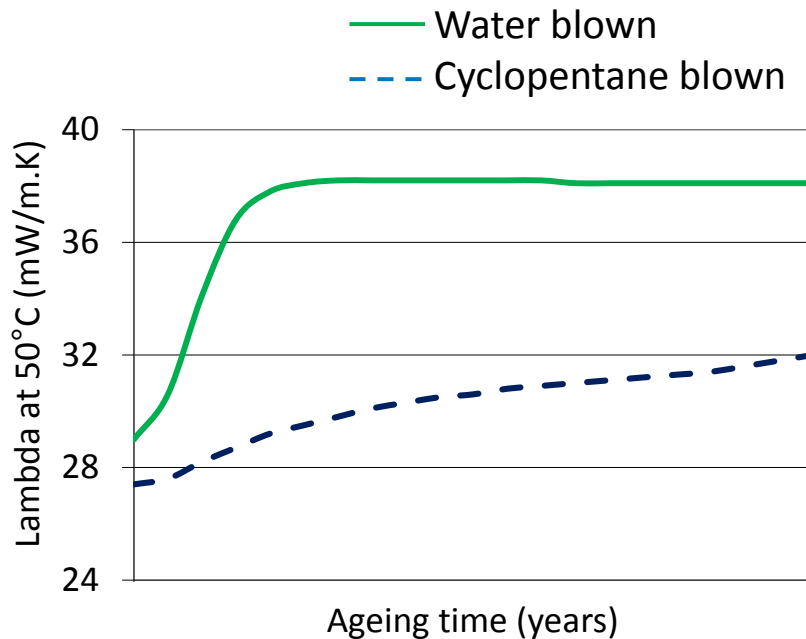


Proof of concept



Pre-insulated pipes with EVOH barrier

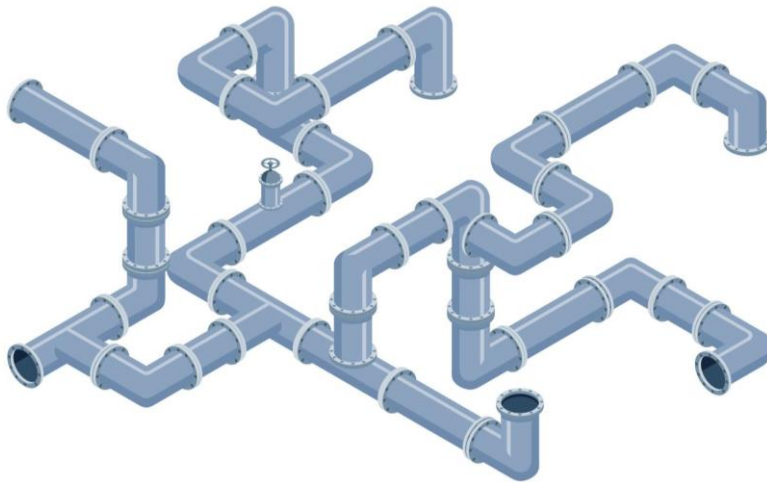
Even bigger benefits for water blown pipes



Pre-insulated pipe systems with EVAL™ EVOH barrier

Additional challenge

Implement the same concept into joint systems & fittings



- EVAL™ EVOH is **compatible** with current **welding** techniques (butt & electrofusion)
 - EVAL™ EVOH = **thermoplastic**
- Today EVAL™ barrier fittings are already **commercially available**
- Development projects are ongoing