

Laboratory Test Results

of a Pre-insulated Pipe with EVOprotect[®]
Diffusion Barrier After Nine Years of Service A



The invisible enemy of efficiency – ageing of PUR insulationA

Ageing of PUR insulation is one of the primary mechanisms leading to increased heat losses in pre-insulated district heating pipes.

Over time, the blowing agents trapped within the closed-cell structure of PUR foam gradually diffuse through the HDPE casing, while atmospheric gases such as oxygen and nitrogen diffuse inward. As a result, the thermal conductivity of the insulation may increase by

more than 30 % (depending on pipe diameter), which directly translates into higher linear heat losses over the operational lifetime of the pipeline.

This phenomenon is a natural physico-chemical ageing process occurring in all pre-insulated pipe systems and constitutes one of the principal causes of the gradual deterioration of the long-term energy efficiency of district heating networks.

Mitigation of PUR ageing through the EVOprotect® diffusion barrierA

The EVOprotect® technology developed by Radpol Pipes significantly reduces gas diffusion by incorporating a polymer EVOH layer permanently embedded within the HDPE casing, positioned between two layers of modified polyethylene.

This construction differs fundamentally from solutions in which the anti-diffusion layer is placed between the PUR foam and the outer casing. Locating the barrier within the casing wall minimizes the risk of mechanical damage during installation and operation. The total thickness of both polyethylene layers together with the integrated barrier complies with the requirements of EN 253+A1:2024-06 (hereinafter EN 253).

A distinguishing feature of the EVOprotect® system is the possibility of applying the EVOH diffusion barrier not only in straight pipe sections but also in prefabricated fittings – an advantage not offered by CONTI-type casing solutions.

Casing pipe sections incorporating the EVOH barrier polymer are also used in the production of heat-shrink sleeves and radiation cross-linked heat-shrink sleeves. Test results obtained by the accredited Research Laboratory of Veolia Energia Warszawa S.A. (test report VWAW/DT/TB/20/0511/MA-DPW/2 dated 13.02.2021) confirm their high quality and performance.

Heat-loss balance analyses demonstrate that omitting the diffusion barrier in fittings and pre-insulated joints reduces the overall energy performance of the district heating system. This confirms the engineering necessity of applying the diffusion barrier consistently in every component of the pre-insulated pipeline system.

Key functions of the EVOprotect® diffusion barrier:

- limitation of gas exchange between PUR insulation cells and the external environment
- long-term stabilization of the thermal conductivity of the insulation
- protection of PUR foam against physico-chemical degradation

Improved design

–three–layer barrier technology

Outer layer of the HDPE casing (not the jacket) – provides mechanical protection of the pre-insulated pipe.

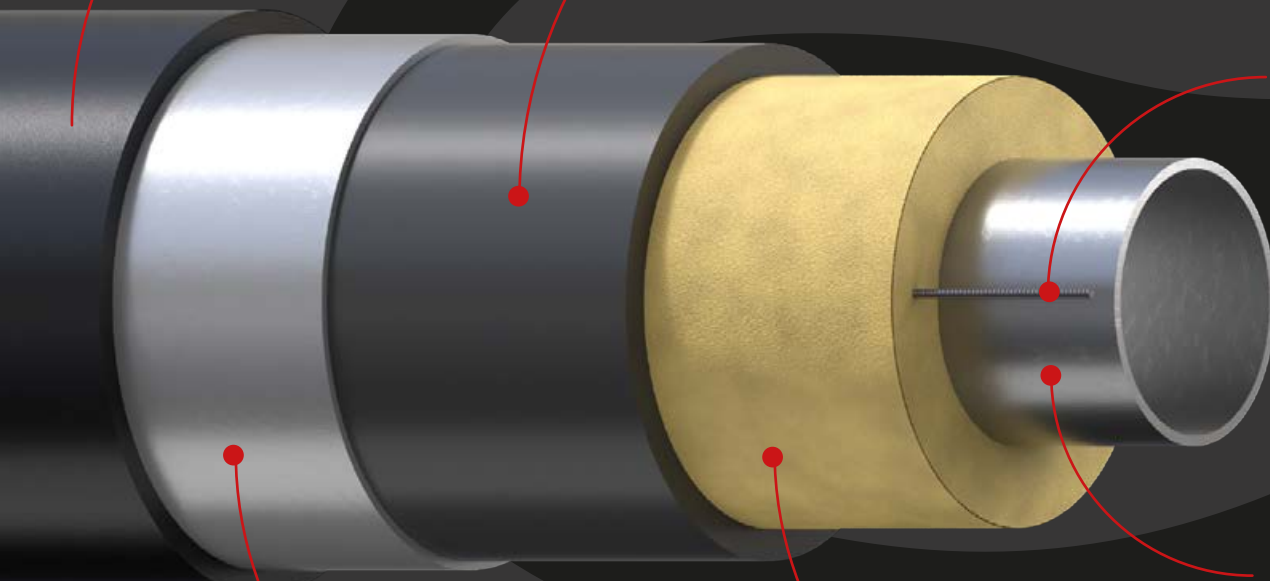
Inner HDPE layer – protects the EVOH diffusion barrier. The corona treatment process increases adhesion between the HDPE casing and the PUR insulation.

Alarm wire.

Conduit pipe (steel).

EVOH layer (diffusion barrier) – positioning the barrier between the casing layers minimizes the risk of mechanical damage.

PUR foam – cyclopentane-blown rigid polyurethane foam, using an environmentally and atmospherically friendly blowing agent, ensuring a low thermal conductivity of the new insulation.



Independent verification after 9 years of serviceA



To verify the long-term durability and performance of pre-insulated pipes equipped with the EVOprotect® diffusion barrier, a 2.970 mm long section of a DN65/140 supply pipe was removed from a building connection located on Daszyński Street in Kielce (Poland). The pipeline section has been in continuous operation since October 2016.

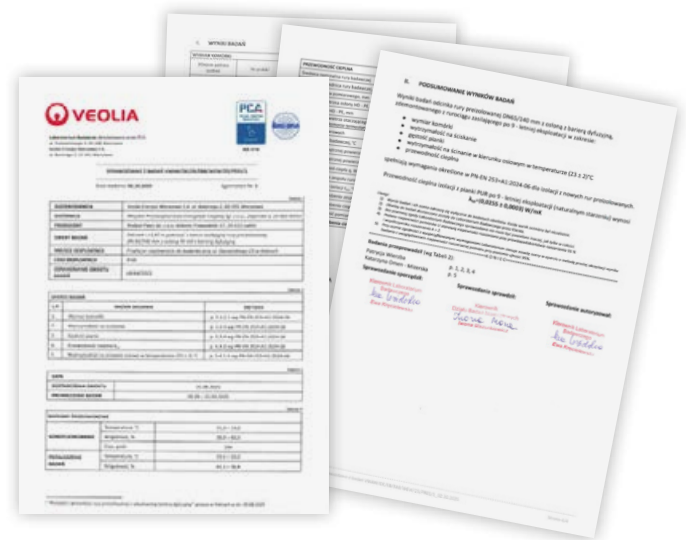
Testing was performed by the accredited Research Laboratory of Veolia Energia Warszawa S.A. in accordance with EN 253.

The results were documented in Test Report No. VVAW/DE/EB/EBB/WEW/25/PR01/1 dated 02.10.2025.

TEST RESULTS AFTER NATURAL AGEING

The table below presents the test results obtained for the Radpol Pipes pre-insulated pipe section with the EVOprotect® diffusion barrier after nine years of service (natural ageing).

For comparison, the results are referenced against the requirements specified in EN 253.



| Parameter | EN 253 Requirement | Test Results After 9 Years of Service | Quality Assessment |
|--|--------------------|---------------------------------------|---|
| Thermal conductivity of insulation λ_{50} , W/mK | ≤ 0.0290 | 0.0255 | 12% lower than the limit value specified for new insulation |
| Foam density, kg/m ³ | ≥ 55 | 69.6 | Meets the requirement specified in the standard |
| Compressive strength, MPa | ≥ 0.30 | 0.35 | Meets the requirement specified in the standard |
| Axial shear strength at ambient temperature, MPa | ≥ 0.12 | 0.30 | Meets the requirement specified in the standard |
| Cell size, mm | ≤ 0.5 | 0.33 | Meets the requirement specified in the standard |

Assessment of Thermal Properties A

The effectiveness of the **EVOprotect® diffusion barrier** is confirmed by the measured thermal conductivity of the insulation after natural ageing: $\lambda_{50} = 0.0255 \text{ W/mK}$.

This value is more than 12 % lower than the limit value $\lambda_{50} = 0.0290 \text{ W/mK}$ specified in EN 253 for insulation in newly manufactured pre-insulated pipes.

After nine years of operation, the insulation retained thermal performance parameters comparable to those of a new pre-insulated pipe. The test results indicate that the EVOprotect® barrier effectively limits gas diffusion and contributes to maintaining stable thermal properties of the PUR insulation.

„After nine years under operating conditions, the insulation continues to meet performance parameters specified by the standard. Virtually no degradation was observed, the PUR foam retained its cellular structure, and the thermal conductivity remained stable. The test results confirm the effectiveness of the EVOprotect® diffusion barrier and indicate the long-term reliability of the solution”
– Jarosław Żuchowski, President of the Management Board, Radpol Pipes Sp. z o.o.



The thermal conductivity of PUR foam insulation in the pre-insulated pipe with EVOprotect® casing after 9 years of service is:

$$\lambda_{50} = 0.0255 \text{ W/mK}$$



Stability of Mechanical Properties and Structural Integrity A

After nine years of service, the pipe equipped with the EVOprotect® diffusion barrier maintained full mechanical integrity.

The axial shear strength at ambient temperature reached $\text{tax} = 0.30 \text{ MPa}$, which is more than twice the minimum standard value $\text{tax} = 0.12 \text{ MPa}$ specified for new pre-insulated pipes.

No loss of adhesion of the PUR foam to either the steel service pipe or the HDPE casing was observed. The results confirm that the pipe retains a monolithic structure capable of withstanding soil loads during long-term service.

CASE STUDY

Heat Loss Balance in a Reference District Heating Network A

All calculations presented were performed for a reference district heating network section with a total route length of 973.5 m, representing a typical residential distribution layout with pipe diameters ranging from DN32 to DN125. The total pipeline length was assumed as twice this value, accounting for both supply and return lines.

Heat losses were calculated in accordance with the methodology specified in EN 13941-1+A1:2022-05.

THE FOLLOWING ASSUMPTIONS WERE ADOPTED FOR THE ANALYSIS:

- single pre-insulated pipes installed underground, burial depth $H = 1$ m
- soil temperature $T_s = 8$ °C
- heating season temperature regime $T = 78.5/42$ °C (supply/return)
- off-season temperature regime $T = 70/40$ °C (supply/return)
- 220 days of heating season and 145 days outside the heating season
- soil thermal conductivity $\lambda_c = 1.6$ W/mK
- thermal conductivity of new polyurethane insulation in pre-insulated pipes (with and without diffusion barrier) $\lambda_{50} = 0.0262$ W/mK – the calculation value used in analyses according to EN 13941-1; for comparison, the measured value for the pipe sample after 9 years of service was $\lambda_{50} = 0.0255$ W/mK, confirming long-term stability of insulation performance
- aged PUR insulation thermal conductivity values (λ_{50}) for pre-insulated pipes with and without a diffusion barrier were adopted based on Table 6 from: E. Kręcielewska, A. Starobrat, I. Iwko, *Methods for Calculating Heat Losses According to EN 13941-1 in Single and Twin Pre-insulated Pipe Systems. Part 1: Methodology and Assumptions*, Magazyn Instal, 2024, No. 9, pp. 14–23
- STANDARD insulation class for both supply and return pipelines

The model includes both straight pipe sections (77 %) and fittings, branches, and pre-insulated joints (23 %), which have a significant contribution to total heat losses.

COMPARED VARIANTS

- pipes without a diffusion barrier
- EVOprotect® pipes with a continuous diffusion barrier along the entire pipeline, including fittings and joints



CALCULATE YOUR OWN SAVINGS

The values below illustrate the potential energy savings achievable with pre-insulated pipes equipped with the EVOprotect® diffusion barrier. As heat production costs vary between district heating systems, the economic impact should be assessed individually for each project.

$$\text{Savings [€]} = \text{Saved energy [MWh]} \times \text{Operator's marginal heat production cost [€/MWh]}$$

SUMMARY OF HEAT LOSS CALCULATIONS AND ECONOMIC EFFECTS (30-YEAR SERVICE PERIOD)

| Pre-insulated pipe size | Pipeline section length [m] | Heat losses without barrier A [GJ] | Heat losses with EVOprotect® barrier B [GJ] | Difference A-B [GJ] | Reduction 100(A-B)/A [%] |
|-------------------------|-----------------------------|------------------------------------|---|---------------------|--------------------------|
| DN32/110 mm | 105 | 2,022 | 1,732 | 290 | 14.34 % |
| DN40/110 mm | 233 | 5,206 | 4,432 | 774 | 14.87 % |
| DN50/125 mm | 142 | 3,498 | 3,012 | 486 | 13.89 % |
| DN65/140 mm | 95 | 2,739 | 2,371 | 368 | 13.44 % |
| DN80/160 mm | 69 | 2,007 | 1,763 | 244 | 12.16 % |
| DN100/200 mm | 200 | 5,975 | 5,371 | 604 | 10.11 % |
| DN125/225 mm | 129 | 4,452 | 4,025 | 427 | 9.59 % |
| Total | 973.5 | 25,899 | 22,706 | 3,193 | ≈ 12.3 % |

QUANTIFIED BENEFITS

For the analysed district heating network structure, the application of the EVOprotect® diffusion barrier translates into measurable benefits:

more than ≈ 12 % reduction in heat losses – due to the long-term stability of PUR insulation thermal properties in EVOprotect® pipes

for comparability and scalability, the energy savings were normalised per kilometre of network length: 3,193 GJ / 0.9735 km = 3,279 GJ/km ≈ **911 MWh/km over 30 years**

REDUCTION OF TOTAL COST OF OWNERSHIP (TCO)

The results of the financial analysis provide economic arguments for investors and district heating network operators.

Heat losses during transmission constitute a real component of operational expenditure (OPEX), which directly affects the TCO of district heating infrastructure. Depending on the technical condition of the infrastructure and the quality of PUR insulation, they may ac-

count for several to several tens of percent of the energy introduced into the system. Therefore, maintaining stable insulation parameters over a long service period is of key economic importance.

A low value of the thermal conductivity coefficient λ_{50} means lower transmission losses and lower energy input required to cover them. In practice, the operator needs less heat to compensate losses.

The economic relationship is straightforward:

lower heat losses → lower OPEX → lower TCO of the infrastructure

Choice Without CompromiseA

Independent testing of the pre-insulated pipe with the EVOprotect® diffusion barrier after nine years of service unequivocally confirmed the effectiveness of this solution.

Despite nearly a decade of service under operating conditions, the PUR insulation still meets the requirements of EN 253, maintaining thermal and mechanical parameters typical of new pipes.

The stability of thermal conductivity and high mechanical strength prove that EVOprotect® technology guarantees long-term energy efficiency and operational reliability. **For investors and district heating network operators, these are tangible benefits.**

**TOP
QUALITY
IN EVERY
LAYER.**



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**RADPOL
PIPES**

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