Building better barriers

Kuraray Co., Ltd. is the world leader in EVOH (ethylene vinyl-alcohol copolymer) resins under the EVAL™ trade name. EVAL™ resins have gas barrier properties that are 10,000 times greater than an equivalent thickness of low density polyethylene (LDPE). An EVAL™ layer of only a few microns in a multilayer structure adds a powerful and effective barrier function against gas, odour and chemical substances.

EVAL™’s outstanding barrier properties can add useful function to a wide variety of construction materials, protecting building and construction interiors from the permeation of harmful gases and chemicals, and by prolonging the useful life of heating and cooling systems.

**EVAL™ adds function to domestic pipe applications**

In heating or cooling systems made of monolayer plastic pipe, oxygen can easily permeate through the plastic pipe wall, increasing the risk of corrosion of metal parts in the heating system. To avoid this corrosion and the costs associated with it, several solutions are possible:

- Using corrosion resistant material for the metal parts of the heating system
- Adding rust-preventive agents into the water
- Reducing the oxygen permeability of the pipe

Reducing the oxygen permeability of the pipe is the safest and most economical solution. By adding a functional EVAL™ barrier layer to a multilayer plastic pipe, the oxygen transmission rate is reduced to a minimum.

**Typical coextruded multilayer structure with EVAL™**

**EVAL™ meets building standards**

Germany’s DIN 4726 allows a maximum oxygen gas transmission rate of only 0.32 mg/m² per day at 40°C or less. This requirement can be met with copper pipes, but they remain expensive, inflexible and difficult to install. Plastic pipes coated with a functional EVAL™ barrier layer meet these strict building standards, but offer a reliable, all-plastic and economical alternative to metal structures.

Specific versions of the EVAL™ E and F types have been specially developed for this application. These special EVAL™ pipe grades contain additional anti-oxidants or thermal stabilisers to increase the long-term heat stability of the product and subsequently the service life of the under-floor heating pipes.

**Radon, methane and VOCs**

EVAL™ provides excellent protection against gases such as radon, methane and VOCs (volatile organic compounds). These can be blocked from accumulating in structures by using barrier membranes in the building foundation.
“1 mm of EVAL™ provides about the same gas barrier properties as a 10 metre thick wall of LDPE.”

**Benefits**
- Prevents oxygen from permeating through the wall of the pipe, avoids the need for rust prevention additives
- Excellent barrier against oxygen, other gases, chemicals and odours, even at high temperatures
- Meets the strictest building standards (e.g. DIN 4726)
- Additional anti-oxidants ensure long-term thermal stability and an expected service life that exceeds 50 years
- Flexibility: quick and easy to install, easy lighter weight transport and handling
- Reliable alternative to metal and aluminium pipes
- Additional anti-oxidants in the polymer ensure an excellent oxygen barrier even after prolonged exposure to heat
- Good abrasion resistance

**Amount of oxygen permeation through various polymers**

- LDPE
- Oriented polypropylene
- EVAL™ E
- EVAL™ F
- OPET
### Heating and cooling systems

Multilayer plastic pipe provides an economical, flexible and easy to install solution for heating and cooling systems. Oxygen permeation into the system can be blocked by adding a functional high-barrier EVAL™ layer to the structure. This reduces corrosion and ensures that pipes are compliant with strict DIN 4726 building standards and EN-ISO 21003-2.

**Processing method**
- Pipe co-extrusion, co-extrusion coating

<table>
<thead>
<tr>
<th>Typical applications</th>
<th>Typical structure (in/out)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under-floor heating</td>
<td>PEX/tie/EVAL™</td>
</tr>
<tr>
<td>Wall heating and cooling</td>
<td>PP/tie/EVAL™</td>
</tr>
<tr>
<td>Radiator heating pipe</td>
<td>PEX/tie/EVAL™/tie/PEX</td>
</tr>
<tr>
<td></td>
<td>PE-RT/tie/EVAL™/tie/PE-RT</td>
</tr>
<tr>
<td></td>
<td>PB/tie/EVAL™/tie/PB</td>
</tr>
<tr>
<td></td>
<td>PEX/tie/EVAL™/tie</td>
</tr>
</tbody>
</table>

### Plumbing (sanitary)

Plastic pipes are economical, flexible and easy to install. By adding a functional high-barrier layer of EVAL™, it is possible to use only one universal type of barrier plastic pipe for both plumbing (sanitary) and heating pipe.

**Processing method**
- Pipe co-extrusion, co-extrusion coating

<table>
<thead>
<tr>
<th>Typical applications</th>
<th>Typical structure (in/out)</th>
</tr>
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<tbody>
<tr>
<td>Plumbing (sanitary)</td>
<td>PEX/tie/EVAL™</td>
</tr>
<tr>
<td></td>
<td>PP/tie/EVAL™</td>
</tr>
<tr>
<td></td>
<td>PEX/tie/EVAL™/tie/PEX</td>
</tr>
<tr>
<td></td>
<td>PE-RT/tie/EVAL™/tie/PE-RT</td>
</tr>
<tr>
<td></td>
<td>PB/tie/EVAL™/tie/PB</td>
</tr>
<tr>
<td></td>
<td>PEX/tie/EVAL™/tie</td>
</tr>
</tbody>
</table>
**Gas pipe**

While most commonly used to reduce oxygen permeation into pipes, EVAL™ resins’ functional barrier properties also work against many other gases such as methane and butane to keep them from permeating out. Multilayer plastic pipes containing an EVAL™ barrier layer are an excellent alternative to metal or non-barrier plastic gas pipes, for both domestic (indoor) and outdoor use.

**Processing method**
- Pipe co-extrusion, co-extrusion coating

**Gas barrier properties of EVOH**

<table>
<thead>
<tr>
<th>Gas</th>
<th>GTR ((\text{cm}^3\cdot\text{20µm/m}^2\cdot\text{day.atm}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>(\text{O}_2) 0.18</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>(\text{N}_2) 0.017</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>(\text{CO}) 0.25</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>(\text{CO}_2) 0.59</td>
</tr>
<tr>
<td>Methane</td>
<td>(\text{CH}_4) 0.4</td>
</tr>
<tr>
<td>Ethylene</td>
<td>(\text{C}_2\text{H}_4) 0.1</td>
</tr>
<tr>
<td>Butane</td>
<td>(\text{C}<em>4\text{H}</em>{10}) 0.1</td>
</tr>
<tr>
<td>Chlorine</td>
<td>(\text{Cl}_2) 0.022</td>
</tr>
<tr>
<td>Sulphur Dioxide</td>
<td>(\text{SO}_2) 0.3</td>
</tr>
</tbody>
</table>

Measuring conditions: 23°C - 0%RH (ASTM D1434T) - Properties of EVOH – ethylene content = 32 mol%

<table>
<thead>
<tr>
<th>Typical applications</th>
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<tbody>
<tr>
<td>Gas pipe</td>
<td>PEX/tie/EVAL™</td>
</tr>
</tbody>
</table>
**EVAL™ adds function to outdoor pipe applications**

Plastic pipes provide an economical and corrosion-resistant alternative for pipes used in outdoor applications. By adding a functional barrier layer of EVAL™ to multilayer plastic structures, it is possible to greatly decrease the permeation of gases, chemical agents and odours, either into or out of the pipe.

**Heating systems for snow and ice-free surfaces**

Similar to domestic heating applications, multilayer barrier pipe with EVAL™ can be used to keep outdoor surfaces at temperatures just above freezing. Public walkways and driveways, airport runways and sports fields can thus effectively remain safe and accessible even in difficult winter weather conditions.

**Processing method**

- Pipe co-extrusion, co-extrusion coating

<table>
<thead>
<tr>
<th>Typical applications</th>
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<tbody>
<tr>
<td>Garage and car park entrance and exit ramps</td>
<td>PEX/tie/EVAL™</td>
</tr>
<tr>
<td>Open-air car parks and car decks</td>
<td>PP/tie/EVAL™</td>
</tr>
<tr>
<td>Sports grounds</td>
<td>PEX/tie/EVAL™/tie/PEX</td>
</tr>
<tr>
<td>External staircases</td>
<td>PE-RT/tie/EVAL™/tie/PE-RT</td>
</tr>
<tr>
<td>Platforms</td>
<td>PB/tie/EVAL™/tie/PB</td>
</tr>
<tr>
<td>Bridges</td>
<td>PEX/tie/EVAL™/tie</td>
</tr>
<tr>
<td>Tennis courts</td>
<td></td>
</tr>
<tr>
<td>Airport runways</td>
<td></td>
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<tr>
<td>Concrete activation</td>
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</tbody>
</table>

**District heating**

Multilayer plastic pipes are quite common for smaller district heating pipelines. They are extremely flexible, and are therefore simple and quick to assemble. Multilayer plastic pipes are of low weight compared to metal pipes and thus allow easy handling. They offer lower transport costs while long lengths of pipe can be delivered. Multilayer plastic pipes do not corrode from the outside, and reduce corrosion within the system by blocking oxygen permeation.

**Processing method**

- Pipe co-extrusion, co-extrusion coating

<table>
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<tr>
<th>Typical applications</th>
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<tbody>
<tr>
<td>District heating</td>
<td>PEX/tie/EVAL™/insulation foam/outer jacket</td>
</tr>
<tr>
<td></td>
<td>PB/tie/EVAL™/insulation foam/outer jacket</td>
</tr>
</tbody>
</table>

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

In areas with a high population density and limited landmass, there is increased pressure to reuse land that may be tainted or contaminated. As more previously industrial sites are redeveloped, it is necessary to ensure that potable water supplies are protected from possible outside contamination.

Drinking water pipes with an EVAL™ EVOH barrier offer a reliable, safe and full plastic solution that makes for an excellent barrier against contaminants. They are resistant to chemicals and to chemical and gas permeation. They prevent corrosion and leakage, are easily installed and can be produced on conventional pipe co-extrusion equipment.

**Processing method**
- Pipe co-extrusion

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<tr>
<td>Drinking water barrier pipes</td>
<td>HDPE/tie/EVAL™/tie/HDPE</td>
</tr>
</tbody>
</table>
Building and construction film
Radon is a radioactive gas that derives from the natural decay of uranium in the ground and can increase the risk of lung cancer under prolonged exposure. Although it does not present a risk outdoors (it quickly disperses), it can indoors: a house or building built upon contaminated ground risks an infiltration of radon gas through openings, construction joints and cavities. Normal building insulation may help contain the gas, resulting in levels of concentration that may pose serious health hazards to the inhabitants.

EVAL™ EVOH resins serve as an excellent barrier against radon, forming a tight barrier between the ground and the foundation of a building. They also present great flex-crack resistance, making for a safe, flexible, reliable and durable barrier. In addition, EVAL™ resins are also used as a methane and VOC (volatile organic compounds) barrier film for brown field development and recovery.

Potential EVOH geomembrane applications:

Landfill liners
Inclusion of EVOH into existing geomembrane designs greatly improves the performance of geosynthetic liners to protect soil, water and air quality and offers a cost effective alternative to expensive remediation of contaminated sites.

Other opportunities
- Barrier for building foundations
- Heap leach mining
- Concrete liners
- Oil sand tailings
- Biodigestors
- Roofing membranes (breathable films)

Processing method
- Blown and cast film, film co-extrusion

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<tr>
<td>Building and construction film</td>
<td>PE/tie/EVAL™/tie/PE</td>
</tr>
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</table>
A variety of EVAL™ grades have been developed specifically for different methods of production and secondary processing. The perfect balance of required properties is achieved by using Kuraray technology to modify the ratio of ethylene to vinyl alcohol in the copolymer. The result is the widest available range of EVOH grades.

**EVAL™ M type**
has the lowest ethylene content available, and provides the highest barrier for automotive and flexible applications.

**EVAL™ L type**
has a very low ethylene content and is suitable as an ultra-high barrier grade in flexible, bottle and sheet applications.

**EVAL™ F type**
offers superior barrier performance with long-term run stability, and is widely used as the standard grade for flexible, automotive, bottle and tube applications. Specific versions exist for coating and pipe applications.

**EVAL™ T type**
was specially developed to obtain reliable layer distribution in thermoforming, and has become the industry standard for multilayer sheet and thermoformed flexible applications.

**EVAL™ J type**
offers thermoforming results even superior to those of T, and can be used for unusually deep-draw or sensitive sheet-based applications.

**EVAL™ C type**
can be used for high-speed co-extrusion coating and cast flexible applications.

**EVAL™ H type**
combines high-barrier properties with long-term run stability and thermoformability. The higher ethylene content allows easier processing and longer running times on older co-extrusion equipment, especially for blown flexible structures.

**EVAL™ E type**
has a higher ethylene content that allows for greater flexibility and even easier processing.

**EVAL™ G type**
has the highest ethylene content, making it the best candidate among standard EVAL™ grades for stretch and shrink film applications.
Environmental benefits of EVAL™ resins

As the impact we create on our environment becomes an ever greater concern, the world continues to look for solutions that are truly sustainable. EVAL™ resins can help, providing valuable function to building and construction applications even while reducing impact on the environment throughout the entire lifecycle of the product.

A one millimetre thickness of EVAL™ EVOH has about the same gas barrier properties as ten metres of LDPE. With such high performance, EVAL™ layers of only a few microns can add real function to multilayer plastic structures. Barrier performance previously only available from metal can thus be added to lightweight and easy to install structures based on recyclable and recoverable plastics.

**Recyclable and recoverable**
EVAL™ EVOH is recyclable, and is commonly used as part of a regrind structural layer in rigid packaging and automotive applications. It can also be used for post-consumer recycling, and will not disrupt polyolefin recycling streams.

EVAL™ has excellent and safe energy recovery properties, often reducing the amount of extra fuel necessary for energy generation from the thermal disposal of sorted waste. Under perfect combustion, the few microns of EVAL™ in the structure emit only small amounts of CO₂ and water vapour.

In addition to ISO 9001:2000, EVAL Europe nv is compliant with ISO 14001:2004 and ISO/TS16946 standards.

**Better efficiency, longer life**
EVAL™’s barrier properties help improve the performance of heating and cooling systems, prolonging the effectiveness of insulation and helping to avoid corrosion. The result is systems that last longer, waste less and use energy more efficiently.

**Reliable protection**
EVAL™ barrier also helps block chemical and radon gas permeation. Ground contamination and odours are safely kept out of water systems. Chemicals are not allowed to leach into nearby soil. Radon gas is not allowed to enter and accumulate in homes.
Introducing Kuraray and EVAL™

Kuraray Co., Ltd. was established in 1926 in Kurashiki, Japan, for the industrial manufacture of chemical fibres. As the world’s largest producer of vinyl acetate monomer (VAM) derivatives, Kuraray has long been a leader in high gas barrier technology and development. Today the Kuraray Group consists of around 70 companies, employing approximately 7,000 people worldwide.

Kuraray has been manufacturing and marketing ethylene vinyl-alcohol copolymers (EVOH) under the name EVAL™ since 1972, and remains the world leader in EVOH production and market development.

EVAL™ is one of Kuraray’s core businesses and is produced globally in Japan, the USA and Europe. The sales and technical development of EVAL™ is supported by specialised local teams in each region.

**Building better barriers**

EVAL™ resins help conserve resources at all stages of the product life cycle and help reduce waste. EVAL™ is widely used as a functional gas and flavour/aroma barrier in food, cosmetic and health care packaging, and as a gas, solvent and odour barrier in construction, industrial, agricultural and automotive fuel system applications.

The development of structures for optimized use in construction is supported by local technical development teams in Asia, the Americas and Europe.
EVAL™ the world’s leading EVOH

Europe
EVAL Europe nv (Antwerp, Belgium)
Capacity: 24,000 tons/year
Europe’s first and largest EVOH production facility

Americas
Kuraray America Inc. (Pasadena, Texas, USA)
Capacity: 35,000 tons/year
The world’s largest EVOH production facility

Asia-Pacific
Kuraray Co. Ltd. (Okayama, Japan)
Capacity: 10,000 tons/year
The world’s first EVOH production facility

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