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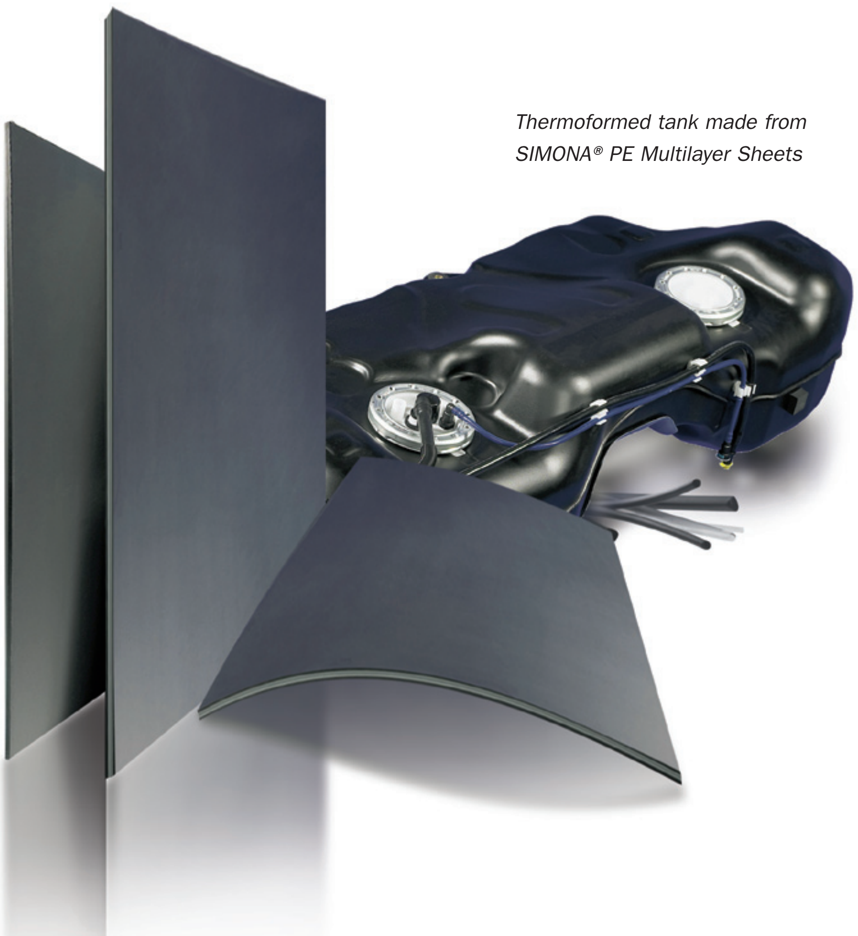
SIMONA® PE Multilayer Sheets

Semi-Finished Plastics with a barrier layer for manufacture of fuel tanks

Paving the way to solutions to modern-day technical problems, plastics have become indispensable when it comes to meeting the demands of a lifestyle centred around comfort and convenience. The car industry is at the forefront of innovative plastics applications.



Thermoformed tank made from SIMONA® PE Multilayer Sheets

Plastics have significant advantages over metals, e.g. they are lighter, can be moulded flexibly and offer exceptional resistance to corrosion. For parts heavily exposed to heat and static, however, plastics lack the necessary strength, rigidity and heat resistance.

But even in those areas in which metal is widely considered the material of choice, plastics are in fact beginning to gain a foothold. In the car industry we find that floor trim, floor pans and heat shields are increasingly manufactured from fibre-reinforced polymers.

Plastics are also gaining ground on metals when it comes to the issue of permeability of gases and liquids. Due to their molecular and organic structure, plastics are essentially gas and liquid permeable. At present, no fully impermeable plastic exists. However, through the development of modern barrier plastics, the overall level gas and liquid permeability may be drastically reduced. The scientific term for permeability is Permeation (see Plastics Expertise section).

EVOH – the barrier plastic

The most widely recognised barrier plastic is EVOH, a statistical copolymer of ethylene and vinyl alcohol. The semi crystalline polymer is characterised by its outstanding gas barrier properties and its very good thermoplastic workability. All standard processes such as extrusion, injection moulding and extrusion blow moulding can be carried out. The lower the proportion of ethylene, the less workable and flexible the polymer becomes, but the more effective the barrier against gases and liquids.

A layer thickness of just a few µm is sufficient to achieve a barrier effect. For this reason the expensive EVOH is used almost exclusively as one of several layers in a multilayer composite. It can be combined with all standard bulk plastics such as e.g. PE, PP, PS, PET, PC through application of an adhesion promoter as an additional layer. Polyamide, by contrast, forms a composite with the EVOH at extrusion temperatures without the need for an adhesion promoter.

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EVOH barrier plastic is resistant to oils of any type, organic solvents, fuels, herbicides and fungicides, pesticides, numerous gases such as oxygen and hydrogen, but also odours and aromas.

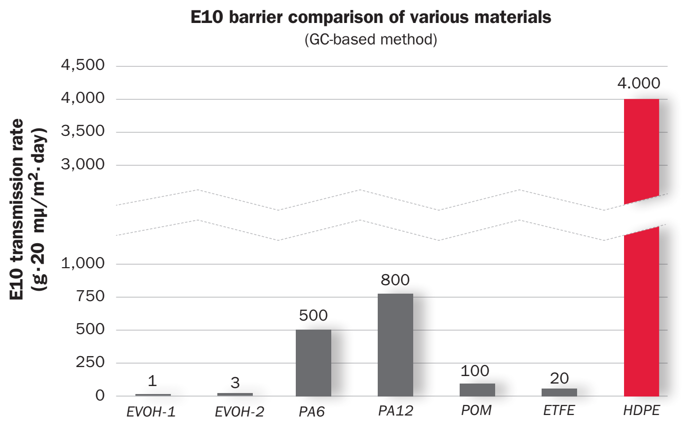
In modern plastic fuel tanks, the EVOH layer guarantees compliance with the very low emissions limits in Europe and the USA. Figure 1 shows the permeation of a fuel with 10% ethanol (E10) on different plastics. In comparison to HDPE, the barrier effect against hydrocarbons is enhanced by a factor of 4,000. The barrier effect against hydrogen is improved by a factor of 1,000 in comparison to PP.

SIMONA® PE Multilayer Sheets

SIMONA® PE Multilayer Sheets are polyethylene sheets with a barrier layer of EVOH. The barrier effect of the EVOH layer against fluids containing hydrocarbons and the outstanding thermoforming properties of polyethylene combine to open up new possibilities in fuel tank manufacture. The outstanding barrier effect of the EVOH layer will also make a significant contribution towards meeting future emissions limits for fuel tanks.

SIMONA® PE Multilayer Sheets consist of two outer layers of high-density polyethylene (PE-HD), a barrier layer of Ethylene Vinyl Alcohol (EVOH) as a diffusion barrier and double-sided adhesion promoter layers (Fig. 2). The two adhesion promoter layers are necessary since the barrier plastic, EVOH, does not naturally bond with PE. The structure of the layer may vary – both in the number of layers as well as in the relative thicknesses of the individual layers.

The figure shows the permeation of a fuel with 10% Ethanol (E10) through different plastics. In comparison to HDPE, the barrier effect against hydrocarbons is enhanced by a factor of 4,000.



Source: EVAL Europe

Figure 1

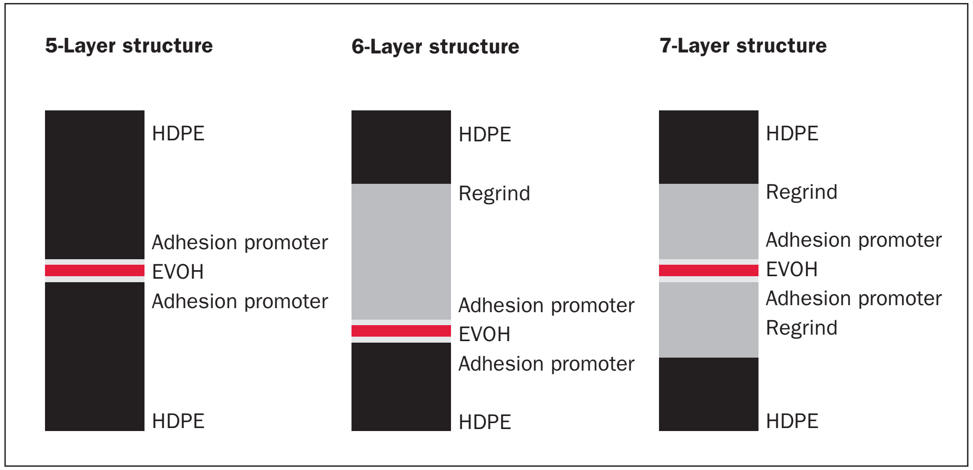


Figure 2: Examples of the structure of SIMONA® PE Multilayer Sheets

To keep costs down, any offcuts are regranulated and integrated into the layer structure of the sheet as a regrind layer in a defined material cycle. The regrind can either be applied as a single layer as in blow moulding or alternatively as a layer on both sides of the diffusion barrier.

Blow-moulded tank shells

The classic production process for fuel tanks made from PE is extrusion blow moulding. A plastic tube is extruded as a parison. Air is pressed into the parison through a blow pin, until it expands to fit the tank shape of the blow mould. Petrol pump, level gauge, sensors and if necessary valves are now fitted into the blow moulded tank through holes which are cut into the tank wall after the moulding process. After the components have been fitted, the holes are either welded closed again or, in the case of service holes, covered by screw-on sealing caps. The process of fitting components into the tank after moulding is cost-intensive and leads to potential leaks.

Twin-sheet process

The twin-sheet process, through which the tank is assembled from two thermoformed PE Multilayer Sheets, offers a new alternative to blow moulding. The process was developed by Visteon and Delphi for the manufacture of car fuel tanks in order to improve its permeation properties. The great advantage of the twin-sheet process is that tank components can be placed in their optimum position in the tank, before the two tank halves are welded together. Thus, service holes in the tank wall become largely superfluous. In the twin-sheet process, finished tanks ideally need only two holes, one for the petrol feed and one for ventilation of the tank.

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Tanks produced by means of the twin-sheet process thus meet the strict emissions limits specified by CARB (California Air Resources Board).

Welding without reducing the barrier effect

The exceptional workability of PE and the outstanding barrier effect of EVOH are excellent reasons to use SIMONA® PE Multilayer Sheets in the design of industrial tanks for storage and transport of diffusive liquids such as fuels, solvents, chemicals and perfumes. The outstanding barrier effect also lends itself to the manufacture of gas tanks designed for short-term use. As indicated above, long-term impermeability cannot, in principle, be achieved without fitting aluminium foil or metalisation.

The joining technique is of central importance when it comes to retaining the overall barrier effect in the joint between the parts. Alongside pinch welding, lap welding and hot-plate butt welding are all viable options. When manufacturing car fuel tanks by means of twin sheet thermoforming or blow moulding, pinch welding is the method of choice.

Figure 3 shows the pinch welding joint of two 7-layer sheets. The barrier layer in the centre surrounded by the adhesive promoter layer can be seen as a light stripe. The sheets are pinched by the welding tool in such a way that, due to the geometry of the welding tool (here: to the left), a very small

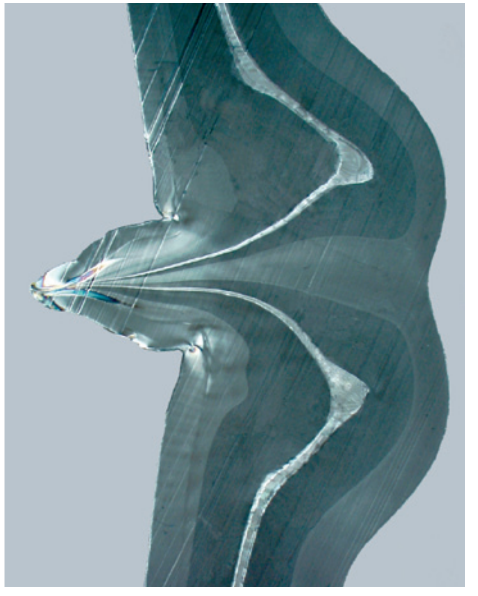

Figure 3: Pinch-off weld

quantity of the material flows in certain spots from the edges of the pinch into the correspondingly designed mould. Pressure and temperature are selected to create a material bond between the two sheets. Random burst testing is carried out by the tank manufacturer in the course of the quality assurance process, showing that the tank begins to crack at the point at which the wall is thinnest.

The barrier layers of the two Multilayer Sheets flow leftwards together almost to the edges. This reduces the layer thickness from around approx. 250 µm to a few µm. The gap between the two EVOH layers only amounts to a few micrometers at the tapered end. Tests and computer simulations have shown that due to the extremely narrow gap between the two EVOH layers, the permeation is significantly less than that across the whole of the remainder of the tank surface. SIMONA has carried out hot-plate butt welding tests which show that the EVOH barrier layer in the weld seam is structured in such a way to ensure a barrier effect in the weld seam.

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Plastics Expertise

Permeation of plastics

Permeation is the process by which a material (permeate) penetrates a solid body, e.g. a plastic. The force driving this is the concentration or pressure gradient.

In the case of a fuel tank, we have a concentration gradient from inside the tank filled with fuel through the tank wall to the atmosphere outside. The fuel wants to penetrate outwards through the tank wall, during which the quantity of the leaking fuel depends on the solubility of the fuel and its diffusion speed in the HDPE tank wall material.

The permeation (permeability) of a liquid or a gas through a plastic is expressed by a permeation coefficient at 0 % relative humidity and 23 °C. In the case of a gas we use the unit [$m^3 \cdot 20\,\mu m/m^2/d/atm$]. The value specifies the volume of gas in cm^3 which permeates a 20 µm thick and 1 m^2 plastic film at a pressure difference of 1 atm per day. For liquids, the weight (in g) of the medium which permeates through the test sample per day is determined. The unit is [$g \cdot 20\,\mu m/m^2/d$].

To measure carbon emissions of cars, a so-called SHED test is performed, during which the object to be tested is placed in a chamber and the weight loss through permeation of the fuel through the tank wall per day is measured. Entire cars, as well as individual components (Mini SHED), can be tested. The allowable total emissions from cars in California (CARB: California Air Resources Board), the global benchmark, only amounts to 0.35 g/d based on PZEV (Partial Zero Emission Vehicle). On the basis of this definition, the fuel tank system may only account for 0.054 g/d.

New Business Unit

SIMONA brings together key activity strands: Mobility, Life Sciences and Environmental Technology

SIMONA is establishing a new Business Unit for plastics applications in the mobility, life sciences and environmental technology sectors. The unit will function as a central point of contact for customers operating within these areas.

Mobility in this context refers to the whole automotive sector, including commercial and agricultural vehicles, aircraft, and rail and water vehicles. "Life sciences" embrace medical and orthopaedic technology, as well as pharmaceutical and bio-technology. Products behind the concept of environmental technology include SIMONA® PVC-C, SIMONA® E-CTFE, and in future the fully fluorinated plastics such as PFA and FEP, currently under development by SIMONA. These products have a range of applications in the area of energy generation as well as in the chemical process industry. In this context these include all kinds of energy technologies, including for example coal-fired power stations, geothermal energy, solar energy and wind power. Within the chemical process industry the new Business Unit serves the "high end" composite construction area with the products referred to above. This means that the new materials possess a higher degree of chemical and heat resistance.

Future markets provide a key focus for the new Business Unit.

Individual solutions

SIMONA is steadfastly focused on customers' requirements for individualised products and services. Customers are offered the added benefit of customer-specific finishing of SIMONA® semi-finished products. Besides established "off-the-shelf" materials, new and up-to-the-minute technical materials are of particular importance to the new Business Unit.

Example applications

SIMONA® PE Multilayer Sheets for motor vehicle fuel tanks provide a successful example application in the mobility field. The milled panels from PE Multilayer Sheets used in the new BMW Z4's tank system are a recent example of increased value added provided by SIMONA® products. Boot liners made from thermoformed SIMONA® PE-AR, available through retail outlets for many vehicle models, show a further application in the automotive field. PE-HD sheets with a co-extruded surface layer and slip-resistant properties are used for this purpose.

To cite examples from the life sciences area, SIMONA provides APET tubes for mobile dialysis machines, and sheets manufactured from a range of materials for use in orthopaedic and rehab technology.

SIMONA sees the aircraft construction industry as an example of a future market for the new Business Unit. More stringent requirements regarding weight reduction, together with growing design flexibility, mean that the interior fittings of aircraft are increasingly manufactured from thermoplastic materials. They are used, for example, in overhead lockers, wall panels, and cabin seat tabling. There are real challenges here to meet requirements in terms of fire protection properties, customised colour schemes, and surface designs and finishes.

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Your contact

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Head of Business Unit Mobility, Life Sciences and Environmental Technology

Dr. Jochen Coutandin has worked for SIMONA AG for over nine years. After joining SIMONA AG he worked for six years as Head of Research and Development. The Business Development Department was then established, and he took over its direction. Since 1 July Dr. Coutandin has held the post of Head of the newly-created Business Unit for Mobility, Life Sciences and Environmental Technology.

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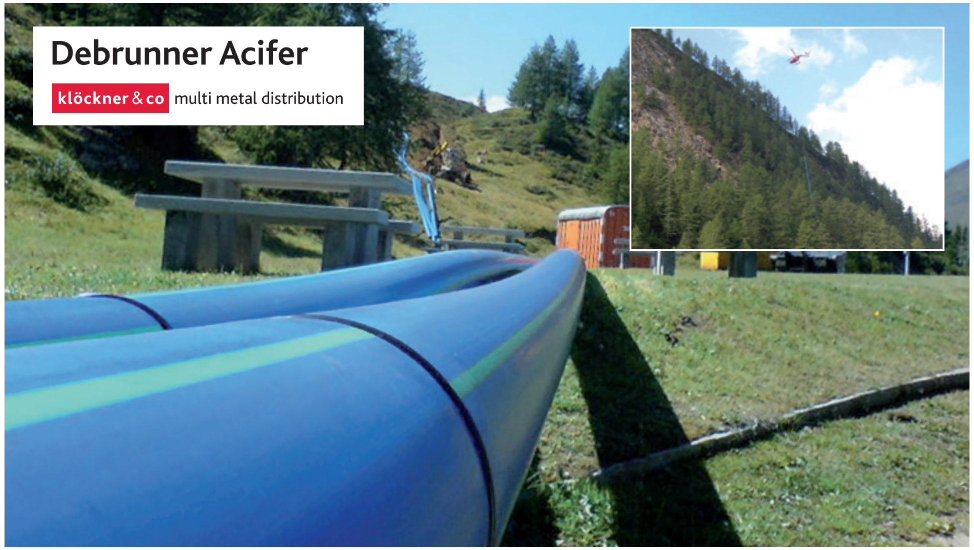
Project Report

Tough conditions for SIMONA® Pipes at the Simplon Pass



Rough terrain calls for pipes with properties that provide maximum protection. Pipe trains measuring 60 metres in length were transported by helicopter.

On account of its North-South axis, the Simplon Pass is one of the most important traffic routes connecting Germany to Italy. This part of the A9, with a length of 42.5 km, runs between Brig in Switzerland and Gondo in Italy at an altitude of over 2,000 metres. The road was widened in the 1970s and 1980s in order to cope with the higher volume of traffic. It is used by 850,000 vehicles a year, 10% of which are lorries. Owing to extreme environmental influences and rising demand for water, the existing fire-fighting and supply lines have to be renewed.

Task

At the Simplon Pass an old cast-iron pipe (d 90 mm) is to be replaced by a modern plastic pipe for the Bergalpe-Brig region and the A9 national road.

At this altitude the soil is very poor and stony. As regards open-trench laying of new pressure pipelines, however, it is not financially viable to transport fine sandy bedding material up to this altitude. Therefore, Debrunner Acifer AG Visp, as the supplier to the installation company Reinhard Heinzen, placed particularly high demands on the new pressure pipe:

- Good abrasion resistance
- High stress crack resistance
- Good resistance to point loads (e.g. stones, fragments)
- Excavated soil to be used as backfill material
- High resistance to slow crack growth

Solution

SIMONA® PE 100 SPC RC-Line drinking water pipes with SVGW and DVGW approval meet all requirements specified. The multi-layered pipe consists of an inner pipe made of PE 100 RC (RC = “high resistance to crack”) and a protective jacket made of modified polypropylene (SIMONA® PP Protect). The surface of the pipe provides protection against dangerous notches and cracks caused by stones and fragments. Even very deep scores fail to reach the inner pipe when exposed to subsequent service loads. The individual pipes delivered were welded on the ground by Reinhard Heinzen to make up 60 m pipe trains and then flown into position by a helicopter. A total of 3,000 m SIMONA® PE 100 SPC RC-Line drinking water pipes (d 200–250 mm) were laid. In order to maintain the water supply during the construction phase, a PE 100 pipe was installed provisionally.

The 40-year-old cast-iron pipe (top) is replaced by a new pressure pipe (bottom); a provisional pipe made of PE (centre) ensures temporary supply.

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