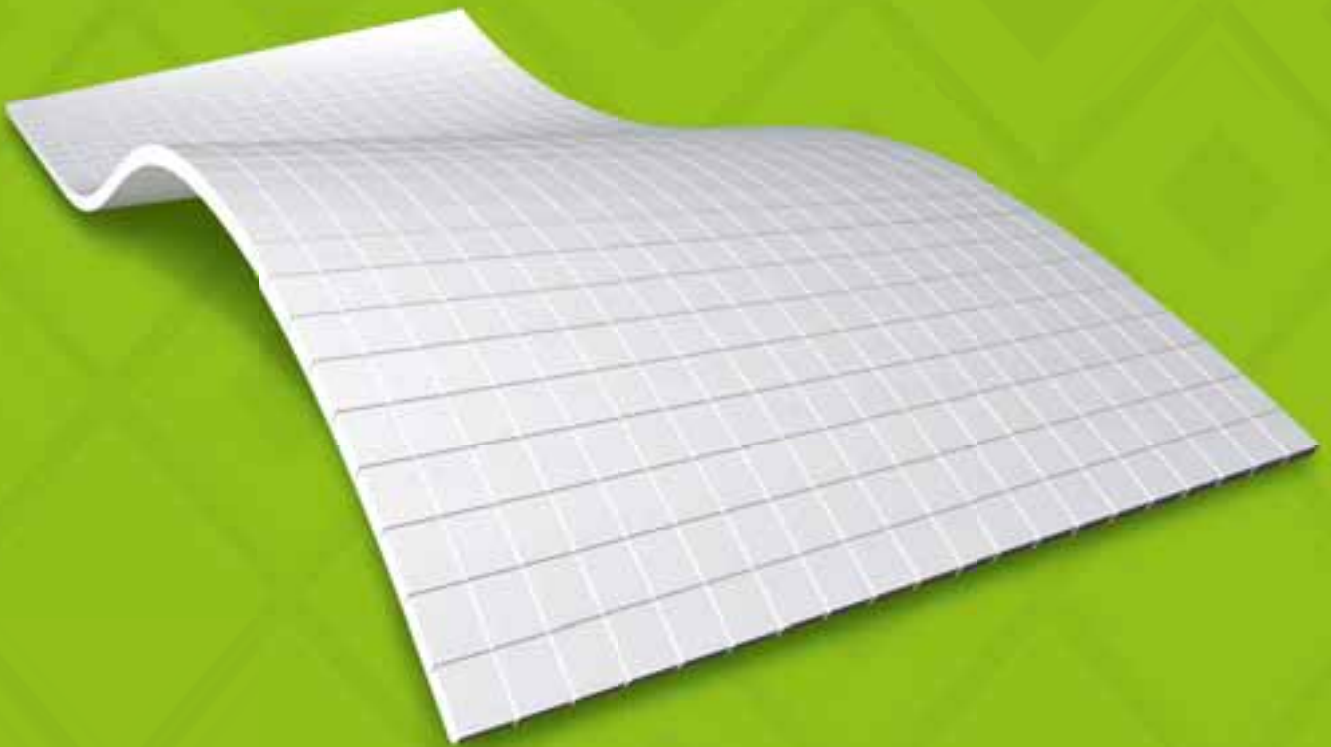


ArmaFORM PET

Lightweight Core for
Strong Structures



Armacell – a global market leader and pioneer in sustainability

Climate protection and sustainability are shaping the political agenda worldwide. Embracing responsibility for future generations means taking energy and resource savings into account in today's decisions. Buildings are a good example: today they are responsible for more than 40% of global energy consumption and account for 1/3 of the greenhouse gas emissions into our planet's atmosphere. By observing environmental needs more carefully in building planning, construction and use, decision makers at all levels can promote the transformation of our building environment towards greater energy efficiency and climate friendliness.

This is second nature to Armacell. Since our company was founded back in 1860 as Armstrong Cork, we have been serving markets with products that promote sustainable building concepts. But also in internal procedures, environmental stewardship is a day-to-day concern. Every industrial company has an unavoidable impact on the environment; our operating principles prescribe that we reduce that impact to a minimum. Combining this legacy with decades of research and experience in polymeric foaming have made us to what we are today, a leading innovator in our markets and a pioneer in sustainability.

Facts and Figures

The company: Armacell International Holding GmbH

Founded: In 1860 the first activity started of Amacell's former parent company Armstrong Cork, which later became Armstrong World Industries. In 2000 Armstrong's insulation product division becomes independent under the name of Armacell.

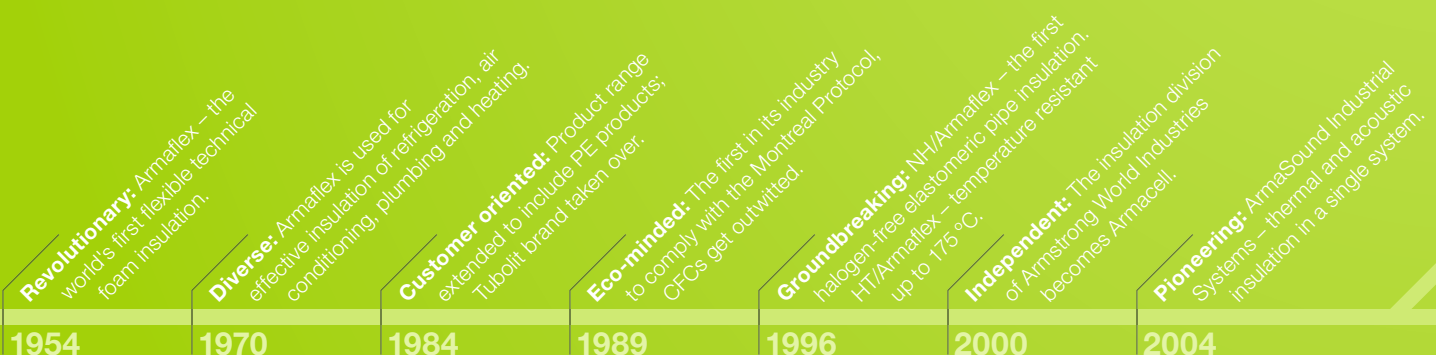
Gross turnover: 448 million euros

Headquarters: Münster (Germany)

Global presence: With 2,500 employees, 19 plants in 13 countries on 4 continents, Armacell has presence in 88 countries.

Established brands:

- Armaflex® (highly flexible, closed-cell elastomeric insulation)
- Tubolit® (thermoplastic pipe insulation)
- OKA® products (covering systems made of PVC and metal)
- Arma-Chek® (highly flexible, non-metal cladding system)
- ArmaSound® (acoustic insulation products and systems)
- **ArmaFORM® (PET foams, which are used as a core material in sandwich constructions)**
- Ensolite® (closed-cell foams in continuous rolls)
- Monarch® (microcellular block foams)

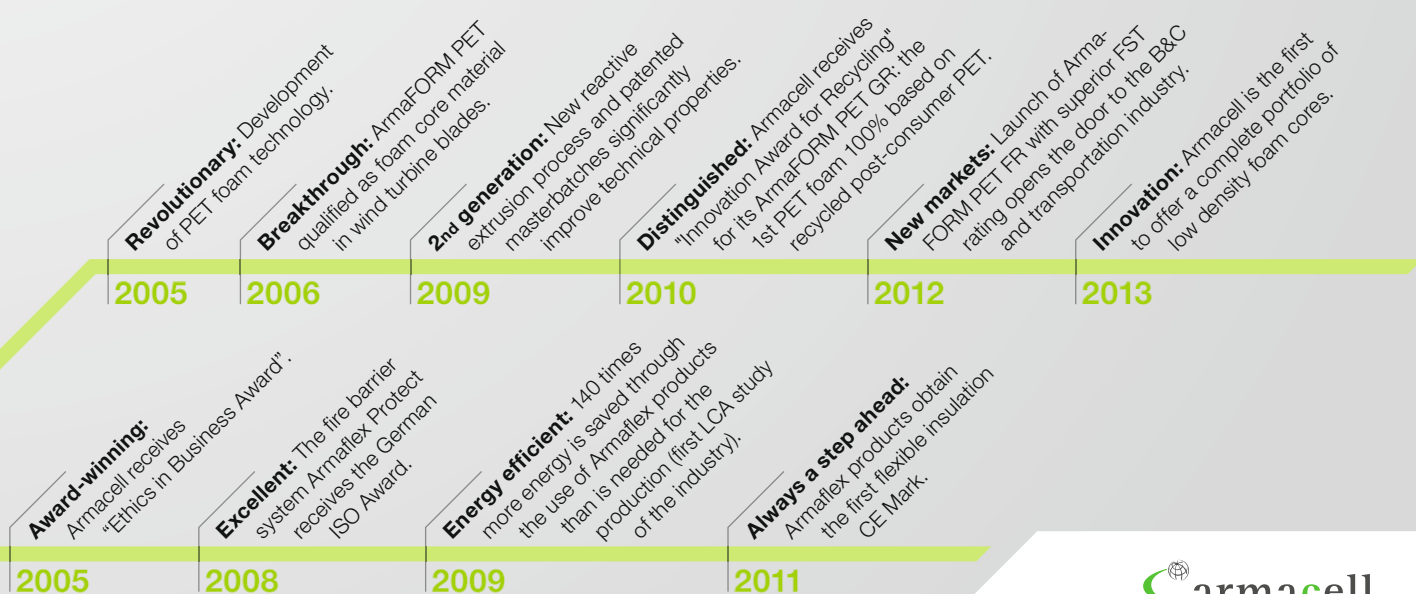
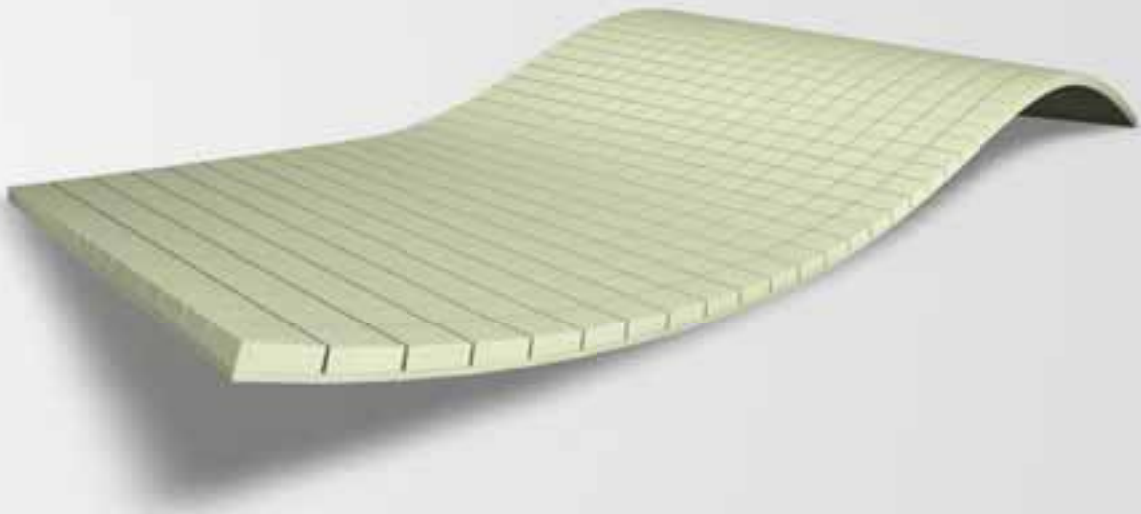


ArmaFORM – the reference for PET foam core technology

ArmaFORM is a continuation of this success. Our innovative, energy-efficient structural PET foam cores for the composites industry are manufactured according to a resource-optimised production process. ArmaFORM PET is fully recyclable and – more importantly – can be made out of 100% recycled products. Armacell scientists have dedicated years to developing production technologies

and special recipes that allow a stable production process using post-consumer PET packaging waste as raw material to produce ArmaFORM PET GR. This "green" version is delivered without compromising on properties. Recent Life Cycle Inventory Study (2011) results show that for every pound of recycled PET flake used, energy use is reduced by 84%; greenhouse gas emissions by 71% ¹⁾.

¹⁾ Life cycle inventory of 100% post-consumer HDPE and PET recycled resin from post-consumer containers and packaging Franklin Associates, January 2011.



Ideal core material: **ArmaFORM PET**

Lightness and high strength, combined with flexibility and a maximum lifespan – these are the key criteria that modern composite materials must fulfil.

On top, ArmaFORM PET is easy to shape thermally and compatible with all resins and manufacturing methods. Your new material for infinite possibilities.

ArmaFORM PET AC



The standard among innovative composites – light, stable and extremely strong – for use in a variety of areas.

ArmaFORM PET GR



Made of 100% recycled PET packaging waste – ideal for ecological concepts.

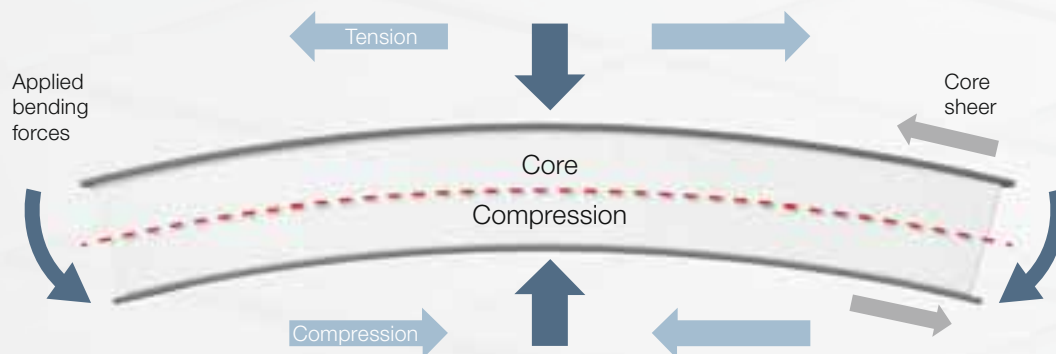
ArmaFORM PET FR



Best-in-class fire properties (NF F16-101 (M1/F1), DIN 5510, FAR 25.853) for applications with stringent flame, smoke and toxicity requirements.



The sandwich concept



A sandwich structure consists of two relatively thin, yet strong and stiff, skins or facings on both sides of a thick, yet lightweight, core material. The skins take up the normal stresses in-plane and give the structure a hard-wearing surface. The core material absorbs the shear forces generated by out of plane loads, distributing between the skins and spreading them over a

larger area, while maintaining the skins at a fixed distance.

The result is a greatly improved bending strength and rigidity compared to monolithic materials. If you double the core thickness further, the weight increase is negligible, while the stiffness is multiplied by a factor of 4 and the strength is doubled.

Unique characteristics of **ArmaFORM**[®]



Superior mechanical properties, excellent compression strength and high shear modulus.



Outstanding fatigue resistance (threshold > 60%) for maximum lifespan.



Easy to shape by thermoforming (3D), offering **freedom in design**.



Easy to process with most types of resin and production methods.



High processing temperature of 150 °C (with short term curing temperature up to 180 °C).



Excellent **thermal insulation** properties.



Closed-cell structure means **extremely low water and resin absorption** (no corrosion and degradation over time).



Good screw retention.

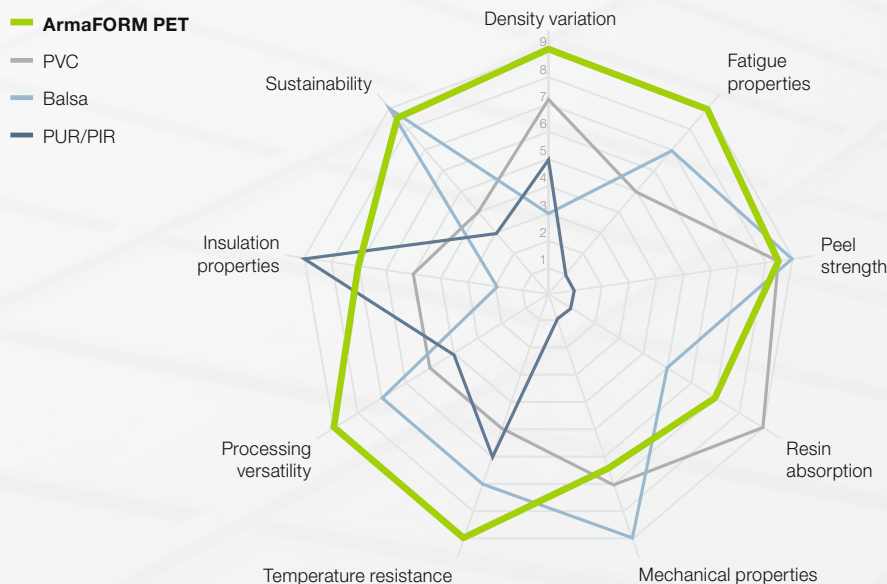


100% recyclable.

Please find technical data sheets for download as well as further information on our website: www.armacell-core-foams.com.

Your benefits with ArmaFORM PET as core material

Compared with other plastics such as PVC and PUR/PIR, **ArmaFORM PET** is easier to recycle, extremely resistant to temperatures, in combination with excellent fatigue properties.



Stability and light weight mean new possibilities

In an ever more complex world with fierce competition for market share, the demand for efficient products is increasing exponentially. Most of the current growth is driven by substitution. New and better products replace existing solutions. Openness to new concepts, speed of implementation and the willingness to innovate are indeed factors that set successful companies apart from those who are merely followers. Sandwich composites belong to the category of products with huge substitution potential. It is mainly due to weight savings that they are becoming

more and more popular in structural design. Yet there are other benefits prompting design engineers to take a closer look at sandwich composites: Low maintenance and repair costs, positive environmental aspects, ease of installation, design flexibility and low thermal conductivity. These factors will have a greater or lesser impact, also depending upon the strategic choice of the right core material. And that is where ArmaFORM PET comes into play, offering tremendous benefits to a broad area of applications in Wind, Building & Construction, Transport and General Industry.

Wind Energy

Wind Energy is faced with the challenge of achieving grid parity. This requires more effective components at a lower cost. A challenge difficult to meet. Since qualifying our first **ArmaFORM PET** products for wind turbine blades, we have continued to innovate in the development of PET foam and will never rest in improving our own production efficiencies. Supporting the OEMs in their endeavour of delivering clean energy at an acceptable cost to the world, we have always shared efficiency increases with our partners and consistently improved our overall value proposition. 100% supervised quality; superior fatigue properties and excellent strength to weight ratios are just a few examples, besides attentive customer service, that have made Armacell the supplier of choice for leading players in this industry.

Rotor Blades / Nacelles / Spinners / Housing

Transport

Used as a core material in composites, **ArmaFORM PET** helps to reduce the weight of rail and road vehicles by up to 50% compared with conventional metal components, thus reducing fuel consumption and carbon emissions. Because of their excellent water resistance, all **ArmaFORM PET** foam cores are perfectly suited for boat and ship building applications. Screw retention is an additional key benefit for all markets. The **ArmaFORM FR** range meets the most relevant international fire and smoke regulations for rolling stock, as well as for the aviation market.

Rail & Road and Aviation: Body Structure / Interior Panelling / Floors / Roofs / Cabin Modules

Marine: Boat Hulls / Cabin Interior / Decks / Superstructures / Furniture





Building and Construction

Buildings are made to provide shelter. But they also shape the landscape around us. Thermal formability is just one benefit of **ArmaFORM PET** in sandwich composites, allowing exceptional freedom of design for architects. Other benefits like low thermal conductivity, ease of installation, light weight and long free spans, the possibility of combining with all types of decorative surfaces, no corrosion and low maintenance and repair cost, make **ArmaFORM PET** in sandwiches an ever more often preferred choice for architects and engineers to substitute existing building materials.

Roofs / Façades / Domes / Bridges



General Industry

ArmaFORM PET is ideal in any scenario in which sandwich elements can save money thanks to low weight, easy workability, low maintenance and high durability. An early discussion with our specialists can help to improve your design – and save money. We are happy to assist.

Advertising Panels / Water & Chemical Tanks / Food Trolleys / Cold-storage Rooms / Sport & Leisure etc.

Acting responsibly: Contributing to sustainable growth

Preserving and enhancing the quality of the environment around us is an essential part of any modern business. This has been an integral part of Armacell's business strategy and a key pillar behind its corporate philosophy. Employees worldwide are aware of this commitment and share common goals.

Among other initiatives, Armacell created environmental guidelines which are based on the following principles:

- Only manufacturing products which represent no hazard to the environment when used as they are intended by customers and consumers.
- Conserving natural resources by using raw materials and energy responsibly.
- Using environmentally-friendly technology in research and production. By doing so, the company also increases safety in the workplace, whilst protecting the community and environment.
- Avoiding and reducing waste; recycling and using environmentally-friendly disposal methods.
- Minimizing the risk of pollution to air, land and water.
- Preparing for potential dangerous situations in order to protect both people and the environment.

Besides acting responsibly, the product range of Armacell also contributes to energy conservation by its inherent properties. As a testimony to this, the company was the first manufacturer of flexible technical insulation materials to carry out an eco-balance analysis (Life Cycle Assessment).

The study revealed that 140 times more energy is saved through the use of Armaflex products than is needed for its production, transport and disposal. In the production of the elastomeric material approximately 0.5 kg of CO₂ are emitted per running meter of Armaflex, however the product prevents the emission of 80 kg of CO₂ over a service life of 20 years. This means that Armaflex saves 150 times more greenhouse gas emissions than what is used in its production.

Emphasis has also been placed on the social dimension of sustainability in supporting local community projects, such as child fostering in Sri Lanka or Habitat for Humanity in the US. In addition, Armacell joined the UN initiative Global Compact in 2006, the world's most important network for sustainable business.

Facts and Figures

Quality and Environmental Management:

ISO 9001 and ISO 14001, quality and environmental certificates obtained for the vast majority of the manufacturing sites.

Armacell Code of Conduct: This document, created in 2011, is based on values and principles which apply throughout Armacell and commit all employees worldwide to behave ethically.

Conserving resources, avoiding CO₂: With Armaflex, 140 times more energy is saved than is needed to manufacture the product. 100% of Armacell production waste is recyclable.

Environmental initiatives in Armacell facilities:

In 2007, an innovative exhaust air combustion system was installed at the company headquarters in Münster. With the largest environmental investment in the history of the company, measurable air pollutants have been reduced by approximately 90%.

Establishing or supporting major sustainable

organisations: UN Global Compact, Eif (European Industrial Insulation Foundation), CEFEP (European FEF and PEF interest Group).

Sustainable Construction: Support to Green Building Certification systems, such as LEED, Breeam, DGNB and corresponding national programs.

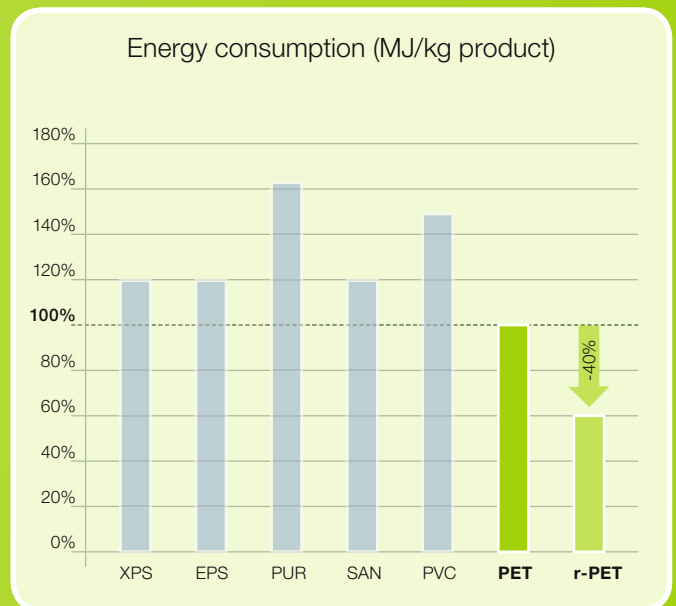
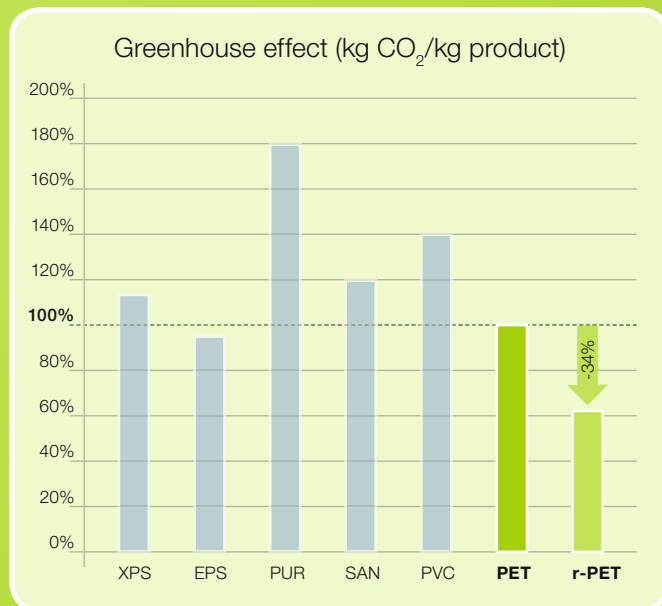
ArmaFORM PET GR – a truly sustainable concept

“Caring for Climate”, a UN Global Impact Initiative, highlights the responsibility of businesses to reflect the needs of climate protection. A principle we have fully endorsed as well in our PET production: the product is fully recyclable, we re-use 100% of our material process loss in internal recycling, and we do not use any ozone-depleting HFH or CFC blowing agents.

But we did not stop here and have made again a significant contribution to sustainable growth: Scientists of the global R&D Team of Armacell have spent several years to develop a technology that enables the production of PET foam boards in consistent, reliable qualities made 100% from post-consumer PET packaging materials (r-PET). While "cradle to cradle" recycling of PET bottles is common

practice and r-PET bottles are considered a valuable raw material, Armacell has developed the capability to recycle a PET packaging waste stream, which to a large degree ends up on landfills or goes to incineration, but it is now used to produce ArmaForm PET GR.

Making the post-consumer r-PET requires 70% less energy and produces 80% less CO₂ per unit than the virgin PET resin ¹⁾. Using such r-PET as a raw material for our foaming process, a 30% reduction of the carbon footprint is possible compared to the use of virgin PET resin. The results of comprehensive LCA review ²⁾ are depicted in the two charts indicating the relative greenhouse effect (CO₂ emissions) and energy consumption of various foams, including that of ArmaFORM PET GR (made of r-PET).



ArmaFORM PET GR – You won't find a more sustainable solution for foam cores used in the composite industry!



¹⁾Life cycle inventory of 100% post-consumer HDPE and PET recycled resin from post-consumer containers and packaging Franklin Associates, January 2011.

²⁾Armacell LCA report, data from 2011.

Complete monitoring for 100% safety

Our products and processes reflect the highest quality standards for products and services in line with ISO 9001:2008. We use state-of-the-art technology for production, control and monitoring in the ArmaFORM PET manufacturing process. For instance, we have implemented fully integrated ERP and Six Sigma process monitoring systems, which enable full 100% quality control of important product properties relevant to the reliable performance of a sandwich composite:

Challenge No. 1: Density variation

The mechanical properties are all related directly to the density of the foam core. The physical properties of the sandwich panel thus depend on close density control of the core.

The ArmaFORM PET Solution:

Density variation is kept at a very low level (< 5%), because ArmaFORM PET production features 100% in-line control. Monitoring density information continuously and using that information to adjust process parameters prevents failures of the sandwich due to uncontrolled density variations.

Challenge No. 2: Thickness variation

Stiffness is an important characteristic of a sandwich composite that increases exponentially with the thickness of the core material. Small variations in core thickness already have a big impact. Reliable performance of the sandwich depends heavily on compliance of the delivered core material board thickness with the requirements as calculated and



requested by the design engineer. Additionally, thickness variation in the interface between two core sheets could result in local buckling or kinking of the sandwich face sheets.

The ArmaFORM PET Solution:

Automated, 100% in-line control measures every single board to ensure the precise thickness tolerance range.

Challenge No. 3: Surface damage or impurities

Surface damage and impurities can lead to delamination of the sandwich skin and subsequent blistering in and failure of the sandwich panels.

The ArmaFORM PET Solution:

All individual boards are subjected to in-line optical scanning. Screening the foam core sheets for surface damage and impurities ensures reliable adhesion between the foam core and the FRP laminates and prevents failure of the sandwich elements. When the system is outside the specified tolerances, the slicing line stops and an operator has to intervene.

The final product is continuously compared against the original approved material, including visual inspection and packaging requirements. Above and beyond these in-line measurements and inspections, a series of additional tests are performed regularly to guarantee the utmost quality and reliability.

Unique: 100% traceability

Every single **ArmaFORM PET** board produced is identified by a unique barcode. This allows the traceability from the final product to the raw material used to manufacture that product. It is also possible to access the archived parameters of the entire product process, simply by scanning the barcode.



Convenient solutions worldwide

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There are not always standard solutions when it comes to using GRP Composite Sandwiches with whatever kind of core material. Simply tell us what you are thinking of and we will tell you how it can be done. We can gladly work with you to develop a concept that offers you all the benefits of this innovative foam core material and fulfils your particular industry requirements – worldwide, no matter where you are.

Thanks to our close network of partners in all aspects of the composite industry, from engineering and design to converting and manufacturing, we guarantee you a project involving close consultation and support - exactly the way you need it.

We'll show you what's possible. Simply ask.

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