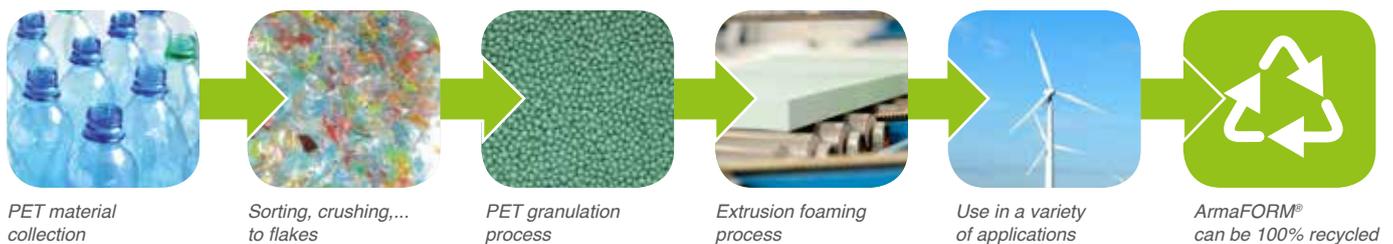


ArmaFORM® PET - the green PET

With the market introduction of ArmaFORM® PET, Armacell paved the way for PET foam cores in the composite industry. But our research did not stop there; as a technology leader, the Armacell global R&D invested several years in the development of a technology that enables the production of structural PET foam boards with consistent, reliable qualities 100% made from post-consumer PET materials, more precisely from recycled beverage bottles.

ArmaFORM® PET in the ecological cycle



Our unique green PET foam meets not only stringent technical requirements of today's composite core materials but also follows the guidelines for circular economy and helps to

preserve and enhance the human environment.

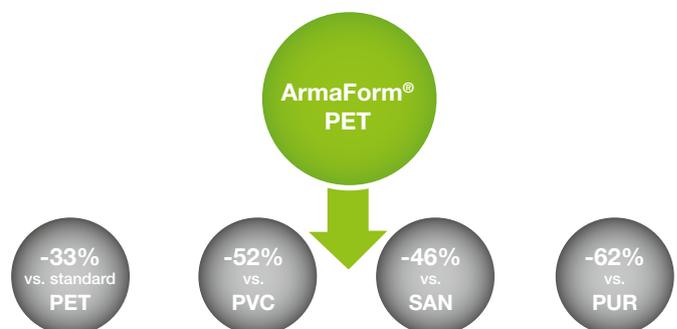
In addition to its sustainable raw material base, ArmaFORM® PET is manufactured according to an energy and resource-optimized production process:

- > No ozone depleting HFC / CFC blowing agents
- > Only halogen-free flame retarded additives
- > 100% re-use of material loss during production

Further more ArmaFORM® PET is fully recyclable at its life cycle end and could be reprocessed into full value raw material if removed properly.

We are proud to say that ArmaFORM® PET outperforms any other structural foam core in the composite industry in terms of environmental benefits, whether competing PET foam or other polymeric foams like PVC, SAN or PUR:

ArmaFORM® PET GR savings on CO₂ emission



Savings on CO₂ emission per kilo foamed product. More detailed information is provided in our technical bulletin „Life Cycle Assessment“.

ArmaFORM® PET is not only green in color, it is a truly sustainable solution. It provides all the known benefits of PET-based structural foams, such as thermal resistance, fatigue behavior, compressive strength, and enables Armacell and its customers to present a real “green” alternative to standard PET foams and other foam core materials currently available in the market.

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ArmaFORM® PET GR: a truly sustainable concept

All our ArmaFORM® PET foam cores are manufactured according to an energy and resource-optimized production process:

- > no ozone depleting HFC / CFC blowing agents
- > only halogen-free flame retarded additives
- > 100% re-use of material loss during production

Additionally our products are fully recyclable at life cycle's end and thus are considered as an environmentally sensitive solution in the composite industry.

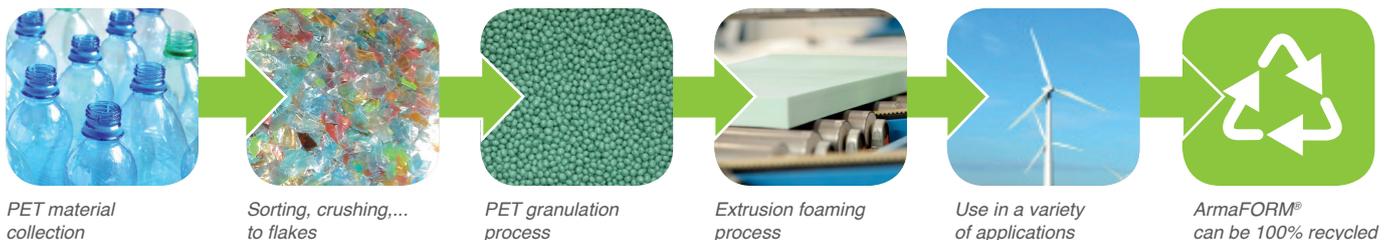
Compared with common core materials, ArmaFORM® PET GR shows an excellent environmental performance regarding global warming potential and energy demand:

The use of ArmaFORM® PET GR enables Armacell and its customers to present a real "green" alternative to standard PET foams and other foam core materials currently available in the market.

Every kilo of recycled PET flakes used to produce ArmaFORM® PET GR reduces CO₂ emission by 63% compared to standard PET foam cores which are made of bottle grade (virgin) PET resin.

(source: Delft University of Technology)

Life cycle of ArmaFORM® PET GR

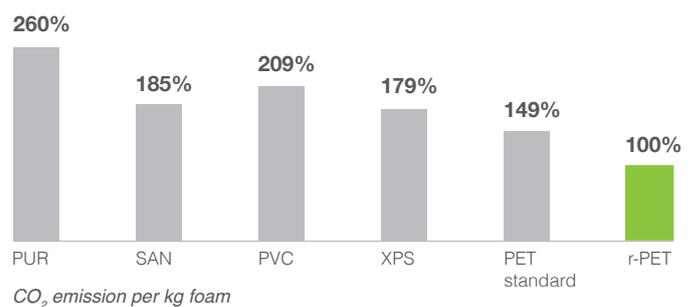


But we did not stop there and have again made a significant contribution to sustainable growth in the composite industry.

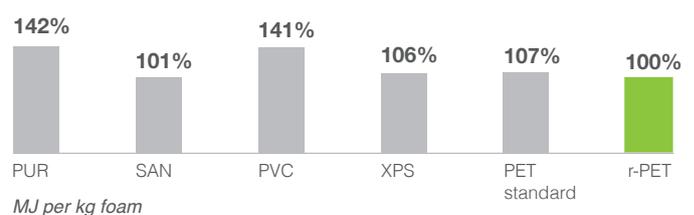
Scientists of the global R&D Team have spent several years in the development of a technology that enables the production of PET foam boards with consistent, reliable qualities 100% made from post-consumer PET materials, called ArmaFORM® PET GR. This "green" PET foam core fulfills not only stringent technical requirements of composites foam cores but also provides sustainable development and brings measurable environmental and socio-economic benefits.

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Global warming potential (Co₂)



Cumulative energy demand (MJ)



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ArmaFORM[®] PET/W GR

Polyethylene Terephthalate based structural foam cores. 100% made of post-consumer PET.

			GR70	GR80	GR100	GR115	GR135	GR150	GR200	GR250 ⁽¹⁾	GR320 ⁽¹⁾
Density	ISO 845	kg/m ³	70 ⁽²⁾	80 ⁽²⁾	100 ⁽²⁾	115 ⁽²⁾	135 ⁽²⁾	150 ⁽²⁾	200 ⁽²⁾	250 ⁽²⁾	320 ⁽²⁾
Compression Strength	ISO 844	MPa	0,75	0,95	1,5	1,8	2,3	2,6	3,6	5,0	7,0
Compression Modulus	ISO 844	MPa	40	57	70	80	90	105	157	210	320
Shear Strength ⁽³⁾	ISO 1922	MPa	0,5	0,55	0,75	0,9	1,2	1,4	1,8	1,9	2,1
Shear Modulus ⁽³⁾	ISO 1922	MPa	13	15	20	25	35	40	50	70	90
Shear Strain ⁽³⁾	ISO 1922	%	15	15	10	10	7	7	5	3	2
Tensile Strength	ASTM C 297	MPa	1,8	2,1	2,4	2,7	3,0	3,4	4,4	4,5	4,8
Tensile Modulus	ASTM C 297	MPa	66	75	105	120	140	190	230	240	350
Thermal Conductivity	at 23 °C	W/mK	0,034	0,034	0,034	0,034	0,037	0,041	0,043	0,047	tbd

Fire performance⁽⁴⁾

B2	EN ISO 11925:2	tbd	B2 ⁽⁵⁾	tbd	tbd					
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Tolerances	Length	Width	Diagonal	Thickness
Dimensions (mm) ⁽⁶⁾	2.448	1.008	⁽⁷⁾	GR70-GR80: 10–150mm GR100-GR320: 5-150mm
Tolerances (mm) at room temperature	+/- 5	+/- 5	≤ 4	≤ 100mm: +/- 0,5 ≥ 100mm: +/- 1

⁽¹⁾ Preliminary data (indication based on a limited number of tests).

⁽²⁾ Tolerances: +/- 5 kg/m³

⁽³⁾ // direction (parallel to the weld)

⁽⁴⁾ For detailed test results and certificates please contact us.

⁽⁵⁾ As of 50mm.

⁽⁶⁾ Standard dimension. Further dimensions on special request.

⁽⁷⁾ Depending on length and width combination.

All values are average production figures.

Minimum values on request.

ArmaFORM[®] PET products are CFC / HFC free.

Physical properties are not affected by variances in colour.

Customs tariff code: 39.21.19.00



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ArmaFORM[®]

ArmaFORM® PET/E GR: 'green' structural foam core

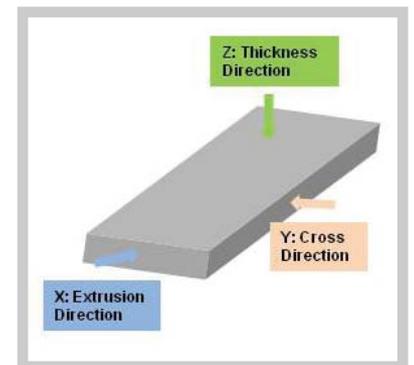
Polyethylene Therephthalate (**Extruded**)

			PET/E GR65	PET/E GR75	PET/E GR110	PET/E GR145	PET/E GR195
Density	ISO 845	kg/m ³	65 ⁽¹⁾	75 ⁽¹⁾	110 ⁽¹⁾	145 ⁽¹⁾	195 ⁽¹⁾
Compression Strength <i>Z-direction</i>	ISO 844	MPa	0,2	0,3	0,6	1,05	1,8
Compression Modulus <i>Z-direction</i>	ISO 844	MPa	9	13	21	43	66
Tensile Strength <i>Z-direction</i>	ASTM C297	MPa	0,55	0,7	1,2	1,5	1,9
Tensile Modulus <i>Z-direction</i>	ASTM C297	MPa	11	14	32	47	70
Shear Strength <i>YZ-direction</i>	ISO 1922	MPa	0,3	0,4	0,55	0,85	1,25
Shear Modulus <i>YZ-direction</i>	ISO 1922	MPa	5	9	14	22	34
Shear Elongation <i>YZ-direction</i>	ISO 1922	%	15	14	10	7	5
Shear Strength <i>XZ-direction</i>	ISO 1922	MPa	0,3	0,45	0,75	1,1	1,15
Shear Modulus <i>XZ-direction</i>	ISO 1922	MPa	8	13	23	34	41
Shear Elongation <i>XZ-direction</i>	ISO 1922	%	10	8	8	7	4
Thermal Conductivity	at 23 °C	W/m·K		0,029	0,032		

Tolerances	Thickness	Length	Width
Dimensions (mm) ⁽²⁾	50 - 70 (depending on density)	1200 to 5200	up to 1015
Tolerances (mm) at room temperature	+/- 0.7	-7 / +20	+/- 10

⁽¹⁾ Tolerances +/- 5 kg/m³.

⁽²⁾ Please note that the available sizes of non-welded boards are subject to prior discussion. All values are average production figures. Based on extrusion thicknesses 55-66 mm, with changing extrusion thickness mechanical properties can vary. All ArmaFORM® PET products are CFC / HFC free.



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ArmaFORM[®] PET/W FR, GFR

Polyethylene Terephthalate based fire retardant structural foam cores.

			GFR70 ⁽¹⁾	FR100	FR150
Density	ISO 845	kg/m ³	70 ⁽¹⁾	100 ⁽¹⁾	150 ⁽¹⁾
Compression Strength	ISO 844	MPa	0,8	1,5	2,6
Compression Modulus	ISO 844	MPa	30	70	105
Shear Strength	ISO 1922	MPa	0,55	0,85	1,3
Shear Modulus	ISO 1922	MPa	14	20	40
Shear Strain	ISO 1922	%	15	15	8
Tensile Strength	ASTM C 297	MPa	1,6	2,4	3,4
Tensile Modulus	ASTM C 297	MPa	60	105	180
Thermal Conductivity	at 23 °C	W/mK	0,034	0,034	0,041

Fire performance ⁽²⁾

Railway Vehicles	Flammability Smoke density Dripping Toxicity (FED) Edge ignition	DIN 5510-2 DIN 5510-2 DIN 5510-2 DIN 5510-2 DIN 5510-2 / DIN 53438-2	tbd	S4 SR2 ST2 <0.1 K1	S4 SR2 ST2 <0.1 K1
Railway Vehicles Construction	Flammability Smoke density	NF F16-101 NF F16-101	M1** F1	M1*** F1	M1*** F1
Railway Vehicles	FST	EN 45545-2 ⁽³⁾	tbd	conform	conform
Aviation	Flammability Smoke density Toxicity	FAR 25.853/ABD0031 FAR 25.853/ABD0031 FAR 25.853/ABD0031	tbd	fulfilled fulfilled fulfilled	tbd tbd tbd
Construction	Contribution to fire Smoke production Flaming droplets	EN 13823 EN 13823 EN 13823	tbd	D s2 d0	tbd tbd tbd

Tolerances	Length	Width	Diagonal	Thickness
Dimensions (mm) ⁽⁴⁾	2.448	1.008	⁽⁵⁾	5–150mm
Tolerances (mm) at room temperature	+/- 5	+/- 5	≤ 4	≤ 100mm: +/- 0,5 ≥ 100mm: +/- 1

⁽¹⁾ Preliminary data March 2017

⁽¹⁾ Tolerances: +/- 5 kg/m³

⁽²⁾ For detailed test results and certificates please contact us.

⁽³⁾ Final sandwich design to be tested.

⁽⁴⁾ Standard dimension. Further dimensions on special request.

⁽⁵⁾ Depending on length and width combination.

** Tested at 20 mm. *** As of 15 mm.

All values are average production figures.

Our products are CFC / HFC free.

Only halogen-free flame retarded additives.

Physical properties are not affected by variances in colour.

Customs tariff code: 39.21.19.00

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ArmaFORM[®]

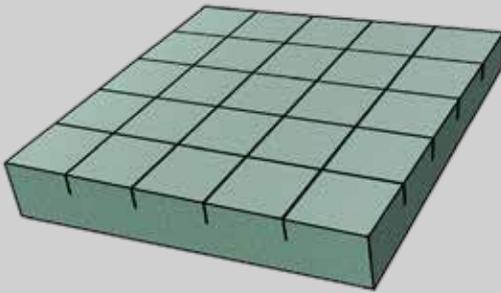
FINISHING OPTIONS

ArmaFORM® PET

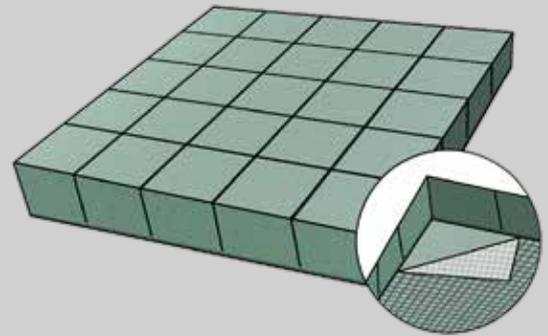
ArmaFORM® PET foam core sheets are available with a variety of finishing options such as grooving, gridscoreing, double contouring and perforation to assist resin flow and air removal or to allow curvature conformability.

This document is meant to give you a general overview of the different converting options Armacell is offering today. Further converting options can be discussed with your sales representative.

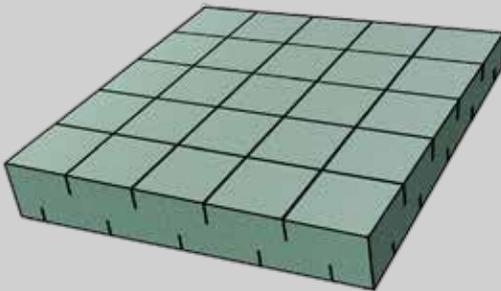
GROOVING



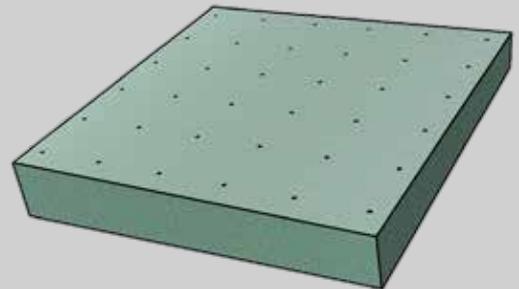
GRIDSCORING



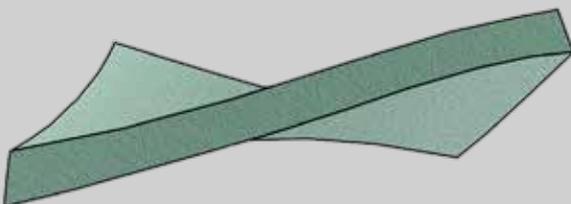
DOUBLE CONTOUR



PERFORATION



THERMOFORMING



→ Grooving (GR)

Groove pattern: 30 x 30 mm
 Width of cut: ≤ 25mm: 0,9 mm
 > 25mm: 1,2 mm
 Depth of cut: 2,0 mm

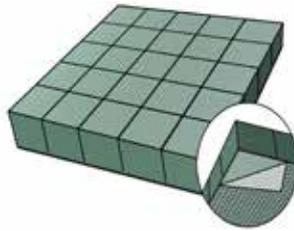


Standard board size: 1008 x 1224 mm
 Minimum foam thickness: 10 mm
 Maximum foam thickness: 100 mm

→ Gridscoring (GS)

Foam is almost cut in 30 mm squares and bonded to lightweight fibreglass scrim on bottom side, creating a flexible core sheet.
 The boards are not cracked.

Grid pattern: 30 x 30 mm
 Width of cut: ≤ 25mm: 0,9 mm
 > 25mm: 1,2 mm



Standard board size: 1008 x 1224 mm
 Minimum foam thickness: 10 mm ≥ 100 kg/m³
 15 mm ≤ GR80
 15 mm ≤ FR100
 Maximum foam thickness: 50 mm

→ Double Contour (DC)

Both sides of the foam core are cut in both directions to a depth of > 50% of the core thickness, creating a somewhat flexible core sheet.

Groove pattern: 30 x 30 mm
 Width of cut: ≤ 25mm: 0,9 mm
 > 25mm: 1,2 mm
 Depth of cut: > 50% of the foam



Standard board size: 1008 x 1224 mm
 Minimum foam thickness: 15 mm
 Maximum foam thickness: 95 mm

→ Perforation (P)

Thickness ≤ 60 mm

Hole pattern: 32 x 32 mm
 Hole diameter: 3 mm

Thickness ≥ 60 mm

Hole pattern: 32 x extrusion thickness*
 Hole diameter: 5 mm



Standard board size: 1008 x 1224 mm
 1008 x 2448 mm **
 Maximum foam thickness: 140 mm

* Extrusion thickness depending on density 45-85mm.
 ** Except 250 kg/m³.

→ Scrim (S)

Our foam core sheets can be delivered with or without fibreglass scrim.
 Maximum foam thickness: 150 mm

Minimum foam thickness: 10 mm ≥ 100 kg/m³
 15 mm ≤ GR80
 15 mm ≤ FR100

→ Thermoforming (T)

Due to its pure thermoplastic nature PET core is well suited for thermoforming to create both two and three-dimensional shapes without the stress concentrations in the core. Thermoforming is carried out by heating the PET core to its softening point and forcing it against the contour of a female or male mould. Among others, the final temperature is depending on foam thickness and density, as a starting guidance you can say that thermoforming PET core takes place between 185 - 210°C. After the material has cooled down to room temperature the part remains in its new shape with close to zero spring-back effect.



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Document No.: DSCm20160214, Rev00

ArmaFORM[®] PET MC: a multi-density PET foam core

It is common practice for composite sandwich solutions to combine different densities in one foam core to improve impact and point load resistance and at the same time keeping the weight at its minimum. Bonding the different core material layers together requires the use of adhesives and cutting or perforating the foam sheets, both increasing production costs and adding extra weight.

Due to its thermoplastic nature, ArmaFORM[®] PET opens new ways of processing the core into a multi-layered concept: the thermo-welding process. This process provides a uniform and well controlled bond line every time and eliminates the core stress concentration induced by cutting the foam.

ArmaFORM[®] PET MC benefits

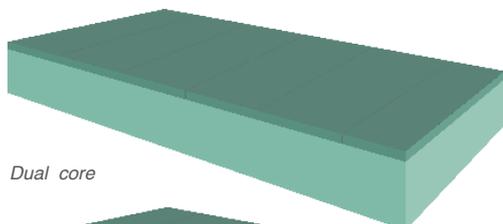
- > Better strength-to-weight ratio
- > Higher impact and point load resistance
- > Increased sandwich stiffness
- > Superior screw retention without additional reinforcement
- > 100% made of recycled PET and 100% recyclable after use phase



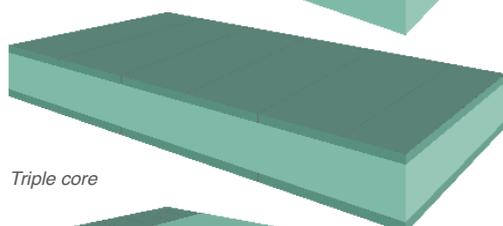
High density top layer for impact and point load resistance.

Low density core for bending strength and stiffness.

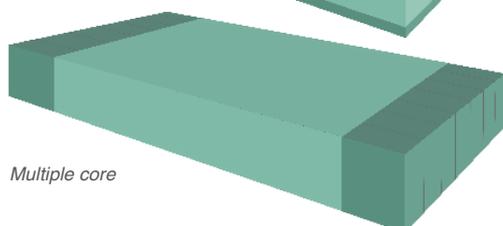
ArmaFORM[®] PET MC - the combination of different densities in one foam core



Dual core



Triple core



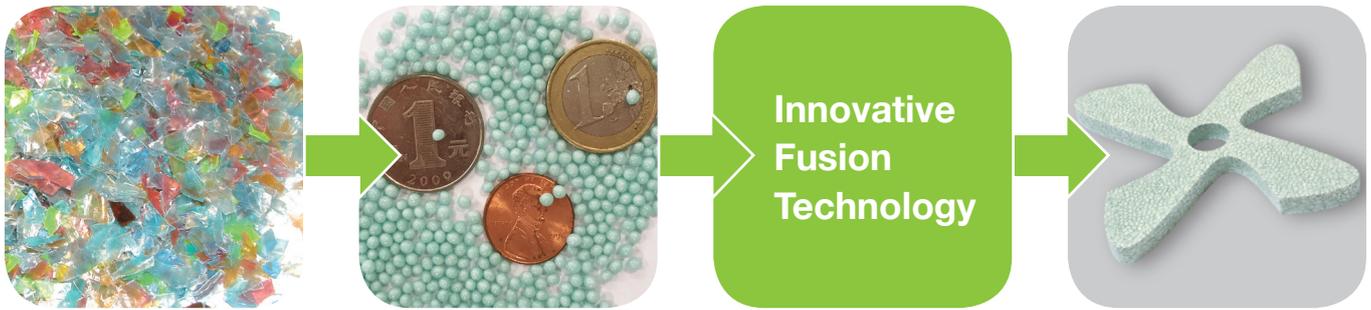
Multiple core

ArmaFORM[®] PET MC applications

ArmaFORM[®] PET MC is designed to replace traditional Plywood-XPS and other multi-ply panels used in a variety of applications like load bearing floor panels in lightweight trucks and trailers, side wall insulation panels in refrigerated trucks, in modular housing or accessible areas like scaffolding platforms, pedestrian bridges, stage panels and many more.

From PET beads to 3D shaped foam parts

Armacell continuously creates innovation and now offers particle foams based on PET. This new development enables the manufacturing of ready-to-use parts from foamed PET beads on an industrial scale.



Starting from recycled PET flakes, the polymer is granulated and further processed by Armacell's patented technology to produce foamed PET beads. A new technology has been developed for the fusion of the loose beads to yield custom shaped ready-to-use foam parts. This novel technology is highly automated and not restricted to a particular density.

PET beads combine the high mechanical properties of structural core foams with the advantages of particle foams to offer lightweight and strong three-dimensional foam parts which are producible in nearly any shape. Some of the most interesting and impressive features of PET beads are:

Cost-effective manufacturing of 3-D shaped foam parts for serial production

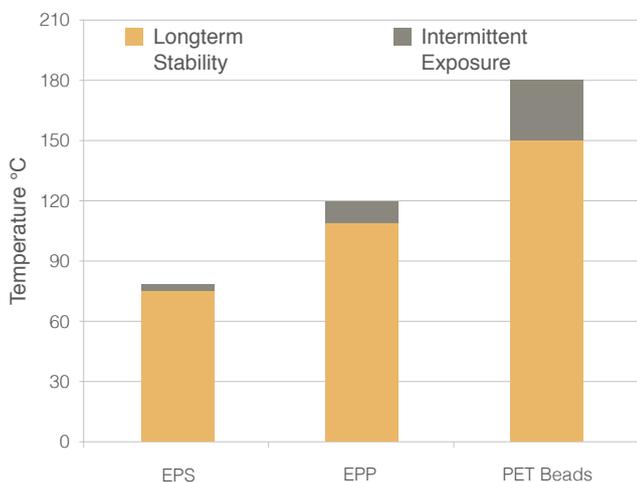


Figure 1: Temperature Stability (°C)

The new moulding technology does not require further production steps like milling and avoids any scrap. It is virtually a waste-free production.

Additionally, the applicable high service temperature level of up to +180°C can significantly speed up further processing steps since fast curing resins could be employed to equip the foamed part with skins. Finally, by reducing production steps and cycle times, cost benefits can be realized.

Microcellular closed cell foam

The fine and smooth surface structure provides good adhesion to facing layers and avoids unnecessary resin or additional treatment. PET beads are compatible with all common resin systems and thermoset materials. The homogeneous and small cells ensure unchanged high mechanical properties (compression & shear) over the entire foam part and good insulation properties at the same time.

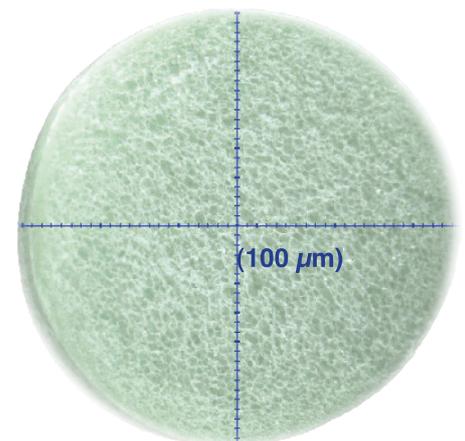


Figure 2: Cell Size (µm)

Sustainability

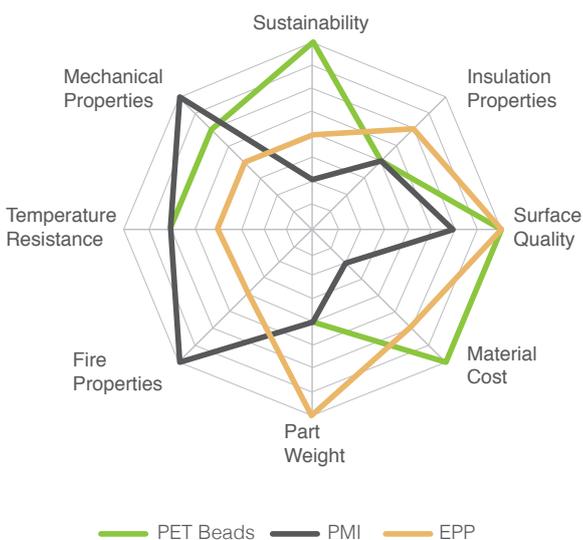
PET beads are manufactured and processed in an eco-friendly manner without using FCHCs. Furthermore, grades with tailored fire retardancy characteristics have been developed which employ the newest generation of halogen-free flame retardants.

Being made from 100% recycled PET and recyclable again after their use phase, PET beads represent a highly sustainable alternative to comparable materials in the market.

Preliminary technical data

Density	ISO 845	kg/m ³	200 *
Compression Strength (10 % deformation)	ISO 844	MPa	1,26
Compression Strength (25 % deformation)	ISO 844	MPa	1,71
Compression Modulus	ISO 844	MPa	28,31
Shear Strength	ISO 1922	MPa	0,79
Shear Modulus	ISO 1922	MPa	21,77
Shear Elongation	ISO 1922	%	3,6
Tensile Strength	ISO 527-2	MPa	0,5

* Further densities under development. Please contact us for more information.



Our offer

- › High mechanical properties
- › Superior temperature resistance
- › Tailored fire properties
- › Good resistance to chemicals & oils
- › Freedom of design
- › Closed-cell structure
- › Good insulation properties
- › Made from 100% made from recycled PET
- › 100% recyclable after use-phase

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