
QUALITY ELECTRIFIES.
Engineering plastics for **New Mobility**
Pocan® Durethan® Tepex® HiAnt®
QUALITY WORKS.
LANXESS
Energizing Chemistry

NEW MOBILITY
PUSHING TECHNICAL BOUNDARIES

The automotive industry faces significant changes. The electrification of the powertrain for passenger vehicles gains momentum faster and bigger than expected some years ago. Internal combustion engine vehicles lose more and more significance and completely new platforms for cars are being developed by the OEMs.

Besides the electrification further trends in the context of New Mobility can be observed, e.g.

- Growing environmental awareness
- Sustainability
- Autonomous driving
- Digitalization and connectivity
- Car sharing

In many cases, commonly used materials do not meet all arising new requirements. Especially when it comes to engineering plastics, more innovative materials than in the metal industry can be developed meeting the expectations of the automotive industry. The broad versatility of plastics combined with carefully selected additives result in materials with a wide range of outstanding properties.

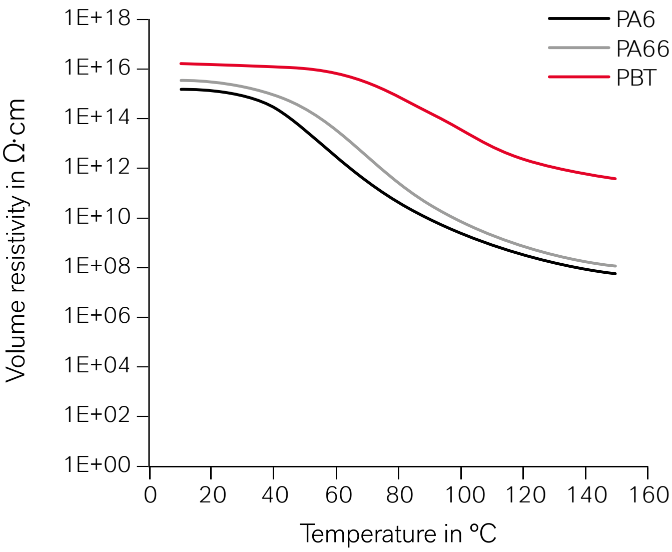
At LANXESS, we are pushing the technical boundaries and we are serving future-oriented growth segments for our Durethan® polyamide (PA6 and PA66) and Pocan® polybutylene terephthalate (PBT) compounds as well as our Tepex® thermoplastic composites. This is based on many years of experience and development expertise pertaining to plastic components for the automotive as well as electrical and electronics (E/E) industries. Our strong knowledge and innovative mindset drives our ability to support our customers when it comes to New Mobility.

CONVINCING
ELECTRICAL PROPERTIES

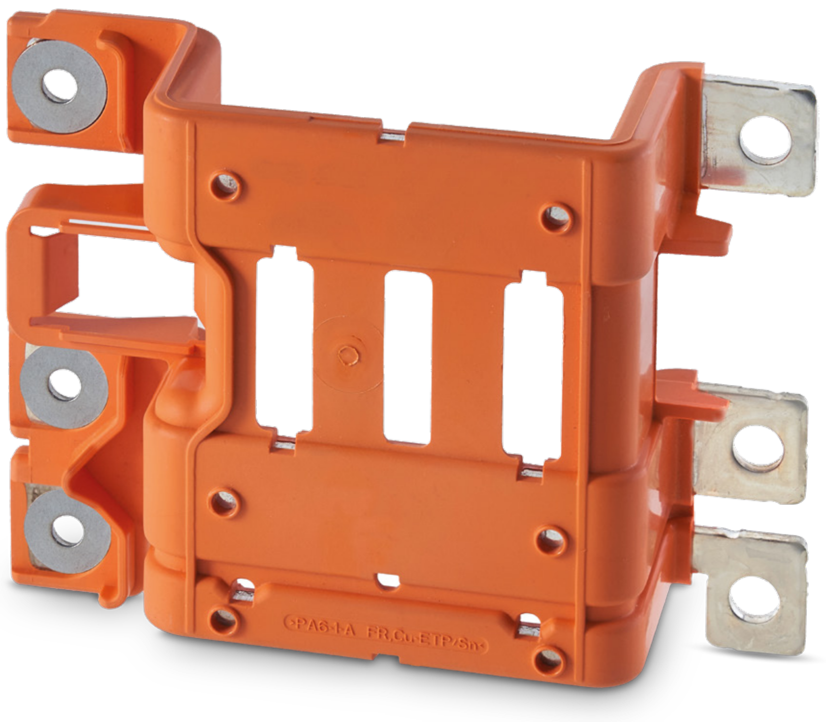
Electrical resistivity, electric strength and tracking resistance are crucial properties when choosing materials for electrical applications. Thermoplastics are proven performers since decades in the E/E industry and therefore the experiences can be transferred to the electrified powertrain.

Increasing requirements for EV applications demand for in-depth knowledge about the material behavior depending on the boundary conditions like humidity or temperature. Extensive testing of the electrical properties at several temperatures is our basis for the design of plastic parts following the highest safety standards.

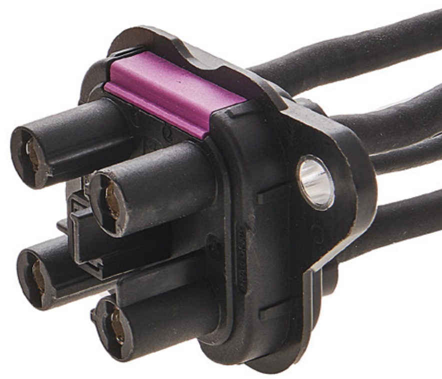
Durethan® and Pocan® show an electrical volume resistivity of approx. 10^{15} Ω·cm at room temperature. This is largely independent of type and quantity of filler. In case of Polyamides, the moisture content may lower the achievable performance. Also, an increased temperature beyond the glass transition will result in lowered values for the volume resistivity.



The electric strength of Pocan® can be considered as nearly constant for typical operating conditions, no matter if unfilled, reinforced or with flame retardancy. Durethan® grades show higher values if the polymer is reinforced or with flame retardant (FR)-system. Contrary to Pocan®, an interdependency between temperature and humidity can be observed for Durethan®. Nevertheless, both materials excel usual requirements for New Mobility applications.



■ The conductors of the busbar are overmolded with Durethan B30SFN30



Connector made from Durethan BKV30FN04 for cable harnesses in BEVs

Often materials with a high comparative tracking index (CTI) are requested for high voltage applications. In general, both Durethan® and Pocan® exhibit excellent tracking resistance. Non-reinforced, non-flame retardant materials typically reach the highest classification resp. a CTI A of 600. While glass fiber reinforcement and especially halogenated flame retardants lower the CTI, many halogen-free flame retardants have a positive impact.

Durethan		**CTI A**
non-reinforced	non-FR	600
	halogen-free FR	600
	halogenated FR	250 - 400
reinforced	non-FR	400 - 600
	halogen-free FR	500 - 600
	halogenated FR	400 - 550

Pocan		**CTI A**
non-reinforced	non-FR	600
	halogen-free FR	600
	halogenated FR	250 - 600
reinforced	non-FR	275 - 600
	halogen-free FR	425 - 600
	halogenated FR	175 - 300

Contrary to many other electrical properties the CTI of Durethan® or Pocan® grades is not particularly influenced by typical heat aging or moisture uptake. Evaluations have shown that the tracking resistance is almost not impaired after heat aging.

One of the latest developments is our Pocan® E-grades series that covers glass fiber reinforced Pocan® grades with a CTI A of 600, e.g. Pocan® B3235E (PBT GF30). Additionally, for parts operating in hot and humid environments we offer hydrolysis stabilized grades such as Pocan® B3233HRE (PBT GF30 HR). Furthermore, with Pocan® BFN4231HRE (PBT GF25 halogen free FR HR) a halogen-free flame retardant version is available.

Additional information can be found in our technical information "Electrical properties of Durethan® and Pocan®".

FLAME RETARDANT PLASTICS INCREASE SAFETY

The importance of flame retardant materials is constantly increasing in order to maximize safety aspects in the context of high voltage applications. Thermoplastics are generally flammable. Therefore, carefully selected additives must be added to provide materials for electrical and fire safety.

By means of flame retardants (FR), the flammability of materials and the speed of flame propagation is influenced. Coming from a long history of developments in the E/E industry, we can offer a wide range of polyamides and polyesters which fulfill the specific requirements and tests related to FR materials (e.g. UL 94 V).

The type of FR system used depends on the application and the corresponding specifications. Our products are using either halogenated or halogen-free flame retardants, but none of our FR systems is based on red phosphorus.

FR system	Halogenated	Halogen-free
Advantages	■ High thermal stability - easier processing ■ Low influence on mechanical properties ■ High performance at Glow Wire Ignition Temperature (GWIT) test for PA grades	■ Excellent electrical properties (e.g. high CTI) ■ Less discoloration under UV radiation and heat ■ Better contrast for laser marking 'white on black'
Disadvantages	■ Negative reputation in public ■ Higher density	■ Negative influence on mechanical properties ■ Narrow processing window

The latest generation of our halogen-free flame retardant polyamides is the FN04-series. The major advantages are

- Thermal stability
- Wide processing window
- Reduced outgassing
- Laser weldability
- Colorability

In addition, we offer PBT grades of our BFN series, that convince with further benefits

- Electrical properties hardly dependent on temperature and moisture
- High level of volume resistance, dielectric strength and tracking resistance

Grade	Polymer	GF content [%]	UL 94 V-0 at [mm]
BKV25FN04	PA6	25	0.7
BKV30FN04	PA6	30	0.4
BKV45FN04	PA6	45	0.4
AKV25FN04	PA66	25	0.4
AKV30FN04	PA66	30	0.4
BFN4231HR	PBT	25	0.75
BFN4211	PBT	13	0.4
BFN4221	PBT	20	0.4
BFN4231	PBT	25	0.4

ORANGE ATTRACTS ATTENTION

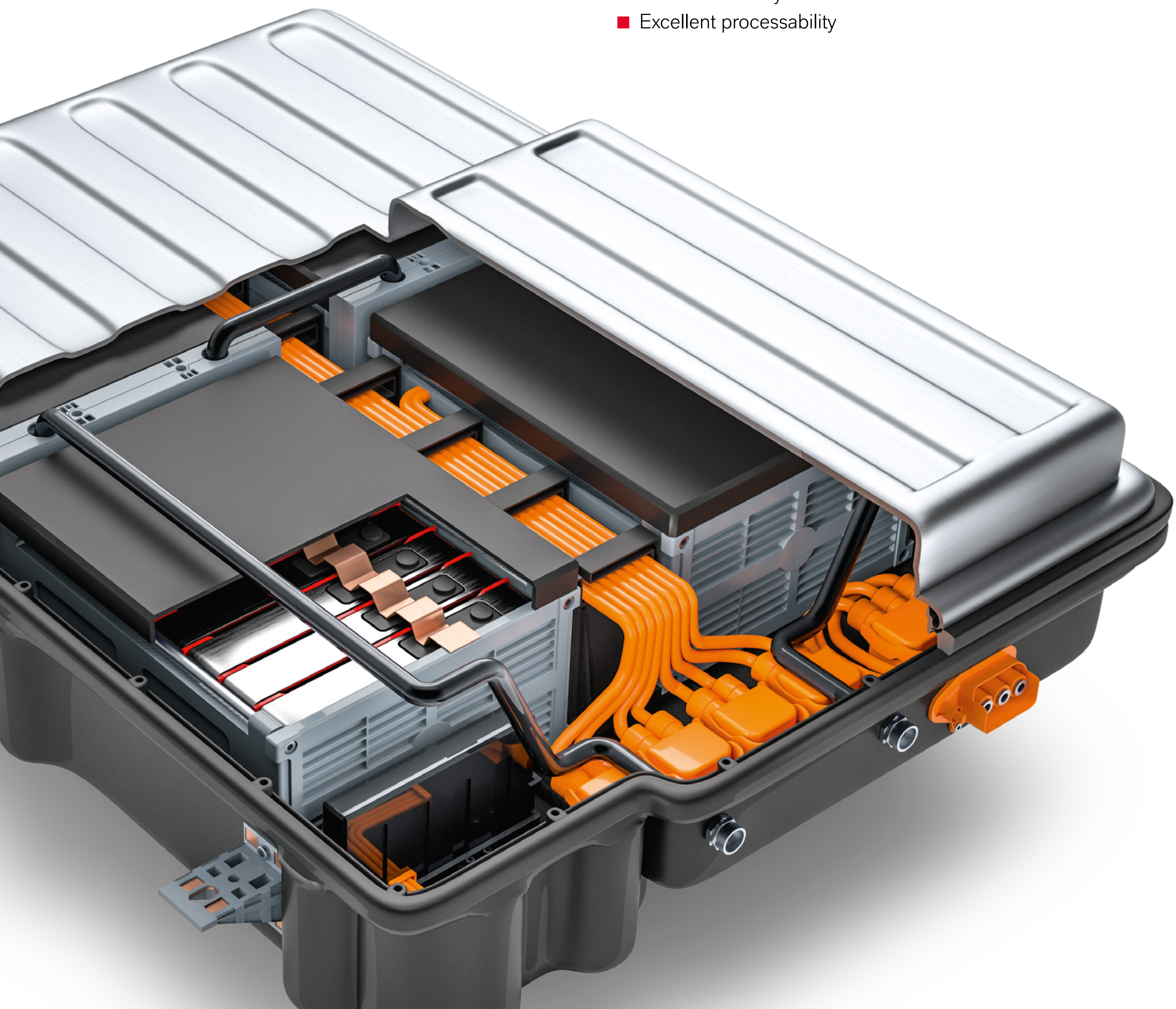
The color orange acts as a warning, not to touch any components under voltage. When using pre-colored plastics, this safety feature is already included in the production process of the application and no additional measures such as painting are needed like in the case of aluminum parts.

To cover all further requirements, LANXESS offers a toolbox with many options.. First, one can pick a grade with typical properties like flame retardancy, glass fiber reinforcement or heat stability. Secondly, an orange shade in RAL 2003, 2010 or 2011 can be chosen. As third option for PA6 grades an enhanced color stability for heat aging under harsh condition is available.

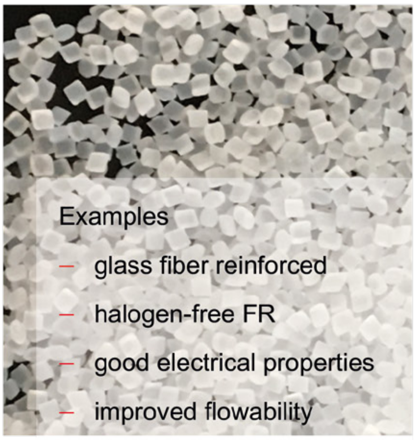
On demand, an UL Yellow card can be provided for orange flame retardant grades. Further grades in orange shades or natural color for self-coloring can be offered, but after adding color masterbatches or colorants to natural-colored grades the UL Yellow Card certification of the original material is no longer valid.

The flame retardant compounds especially developed for HV applications are halogen-free and free from red phosphorous. Further essential characteristics of the product portfolio cover

- Outstanding flame retardancy
- High tracking resistance
- High electric strength
- Halide-free heat stabilization
- Laser markability in white and black
- Excellent processability



Properties of grade



Coloration similar to

Color stability#

Various Durethan and Pocan materials available (with UL Yellow Cards*)!

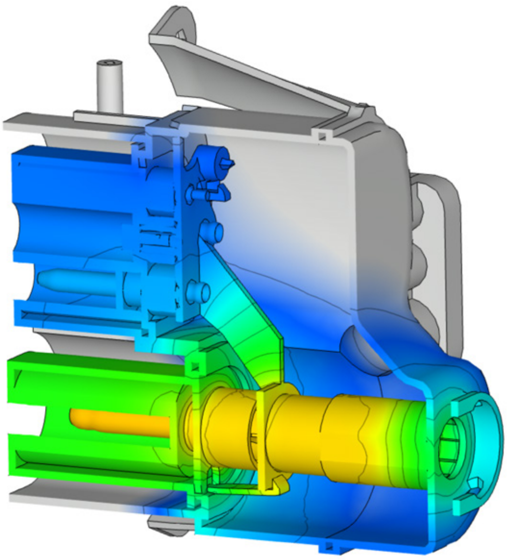
Necessary only for Durethan *Self-coloring of natural grades using masterbatches is possible, but UL Yellow card is not valid afterwards!

Grade	Type	UL 94 classification	CTI A 600 / PLC 0	Remark
Durethan B30SFN30	PA6 FR	V-0 at 0.4 mm	x	Halogen-free FR
Durethan BG30XH3.0	PA6 (GB+GF)30	HB		Low tendency to warp
Durethan BKV20FN01	PA6 GF20 FR	V-0 at 0.75 mm	x	Halogen-free FR
Durethan BKV30FN04	PA6 GF30 FR	V-0 at 0.75 mm	x	Halogen-free FR
Durethan BKV45FN04	PA6 GF45 FR	V-0 at 0.4 mm	x	Halogen-free FR, high modulus
Durethan BKV60EF DUS097	PA6 GF60	HB	x	Improved flowability, high modulus
Pocan A3121	PBT+ASA GF20	HB		Low tendency to warp, improved surface finish
Pocan BF4232HR	PBT GF30 FR	V-0 at 0.4 mm		Hydrolysis stabilized
Pocan BFN4221	PBT GF20 FR	V-0 at 0.4 mm	x	Halogen-free FR

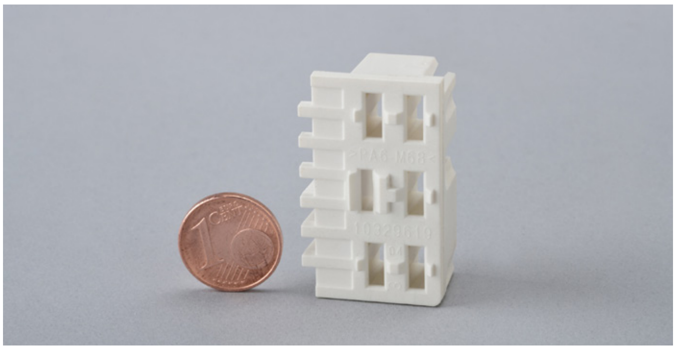
THERMAL CONDUCTIVITY COOLS DOWN

Temperature control is essential for an effective and reliable operation of components like electronics. Metallic heat sinks are established, but a more cost-effective solution is requested since years.

The Durethan® BTC family with a PA6 matrix combines the advantages of a thermally conductive but electrically insulating material. The thermal conductivity was increased by a factor up to 10 in comparison to typical engineering plastics. This offers completely new opportunities for part design regarding thermal management. In addition, the fast and efficient injection molding process supports the economic viability against metallic solutions. Despite the high amount of fillers, the processability is secured as well as the good mechanical properties.



Simulated temperature distribution in a charging inlet



Durethan BTC965FM30 was chosen for the charge controller due to its thermal conductivity and its FR properties

As a first generation of BTC grades Durethan® BTC65H3.0EF and BTC75H3.0EF were developed. The 2nd generation convinces by less anisotropic thermal conductivity (in-plane and through-plane). Also, better mechanical properties in terms of strain at break could be achieved. It is represented by Durethan® BTC67ZH3.0EF and Durethan® BTC77ZH3.0EF. If flame retardancy is required Durethan® BTC965FM30 or Durethan® DPBM65XFM30 can be picked from the portfolio of flame retardant grades.

To gain a better understanding for the advantages of thermally conductive compounds of our BTC family, our HiAnt simulations based on the latest technologies give insights into the thermal management of applications.

	Functional filler	Thermal conductivity		Young's modulus		Strain at break		UL 94 (0.75 mm)
Grade		in-plane	through-plane	d.a.m.	cond.	d.a.m.	cond.	
	[%]	[W/(m·K)]		[MPa]		[%]		
BTC65H3.0EF	65	1.3	1	9,900	3,500	3	5	HB
BTC75H3.0EF	75	1.7	1.4	14,700	6,100	1.8	2.2	HB
BTC77ZH3.0EF	77	1.8	1.7	14,100	5,400	3.2	5.1	HB
BTC67ZH3.0EF	67	1.1	1	8,800	2,960	3.2	13	HB
BTC965FM30	68	2.3	1.3	13,500	5,700	0.7	1.2	V-0
DPBM65XFM30	65	0.9	0.9	12,100	6,000	1.6	2.2	V-0

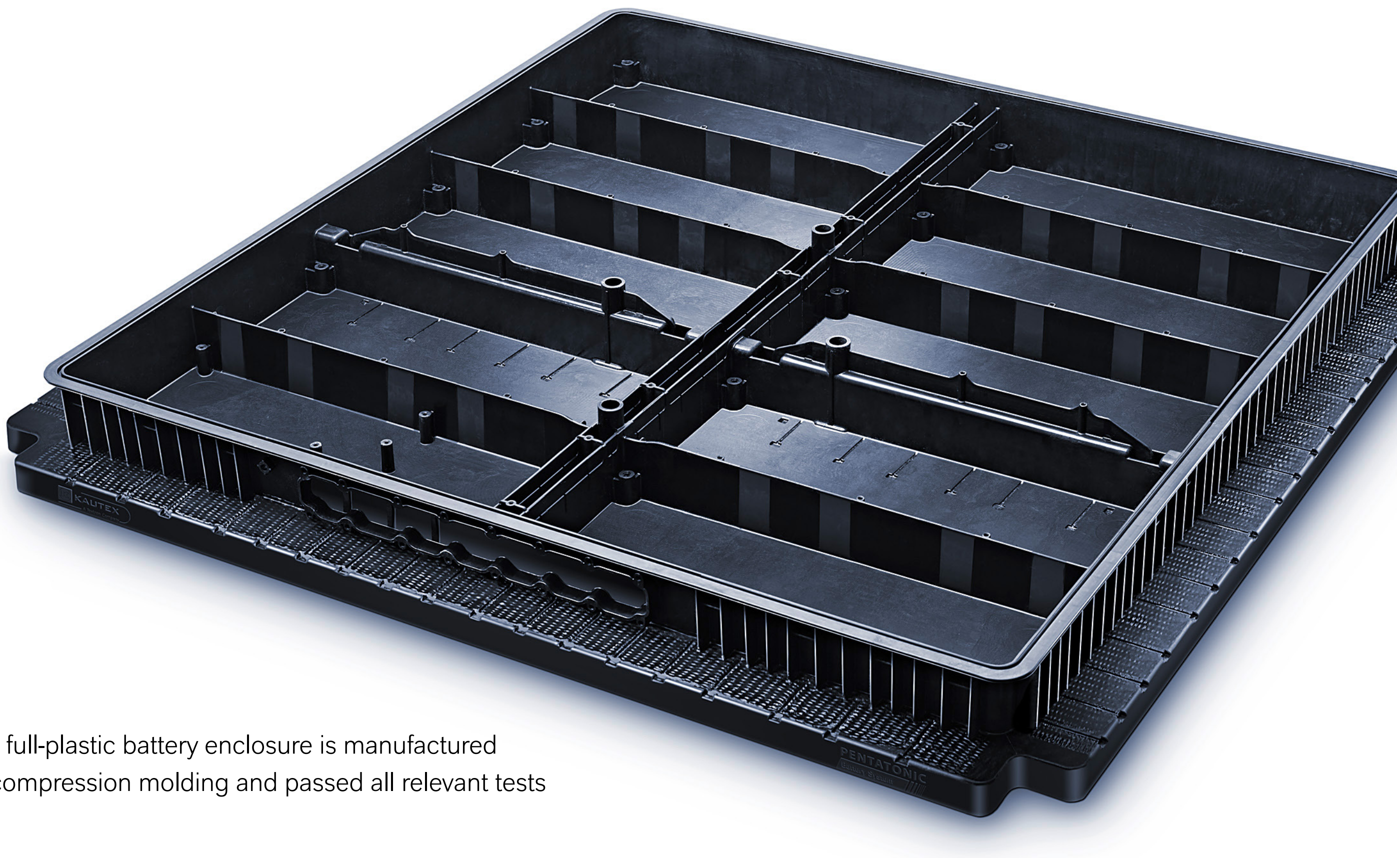
STRONG AND LIGHT
BATTERY ENCLOSURES

The requirements of enclosures for high voltage battery systems are very severe. They must withstand external and internal fire, crash and crush loads to name just a few. In most cases the part designers are choosing metals as the material of choice. But the feasibility of a full plastic housing was proven in the meantime convincing with significant advantages.

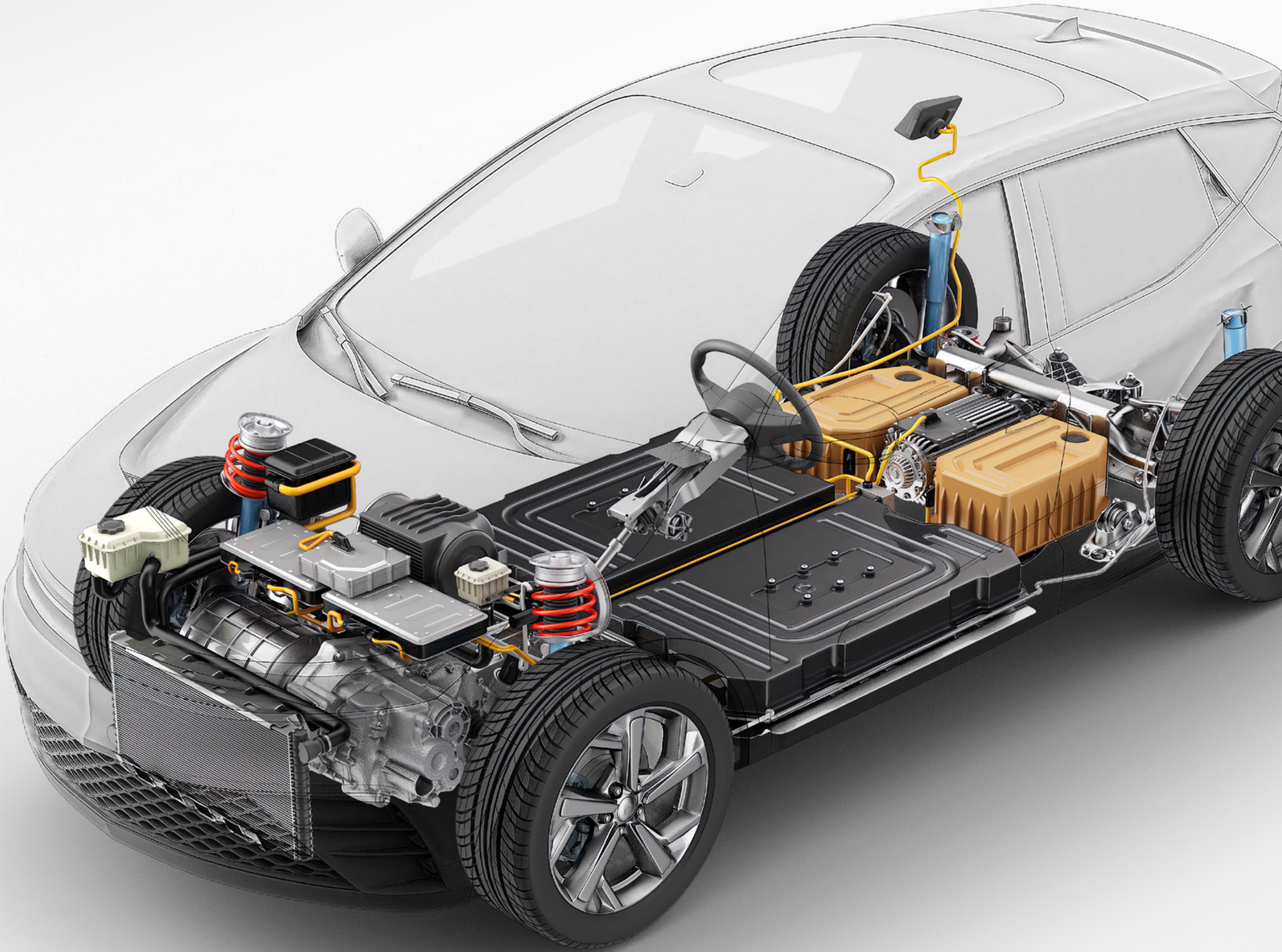
Based on sophisticated CAE work the part was designed to bear the mechanical loads. Simultaneously, all further features for a fully operational prototype were taken into account. Finally, parts were molded with our Durethan® B24CMH2.0, a non-reinforced PA6. Even though glass fibers up to 45% were added during the DLFT process, the material showed excellent flowability resulting in low press forces. This can be transferred directly into low investments for mold and machines, because typical battery enclosures have dimensions easily beyond 1,400 mm x 1,400 mm. The outer crash structure was locally reinforced with our Tepex® dynalite 102-RGUD600 composite to provide sufficiently high resistance against deformation. The mechanical properties of the material and the part resulted in passed tests according to ECE R100 resp. GB 38031.

In case of smaller battery packs injection molding is an attractive alternative process. Durethan® BKV50PH2.0 (PA6 GF50) or BKV240XCP (PA6 GF40) are possible options that offer an excellent compromise between stiffness and toughness. With an enhanced performance in terms of fatigue respectively impact resistance the materials contribute to the longevity of the battery enclosure.

Independent of process, the plastic solution offers weight savings in the range of 15% and more. Also, the carbon footprint is lowered by up to 40% and recyclability is possible for thermoplastics. Beside the aspect of sustainability, the costs can be reduced by function integration and less re-work. Due to the one-piece-tray the tightness is inherent and further assembly or welding steps are superfluous.



■ The full-plastic battery enclosure is manufactured by compression molding and passed all relevant tests



REINFORCED WITH TEPEX®

The stiffness and strength of thermoplastics are mainly influenced by the used fibers. The longer the fibers are, the higher are the mechanical properties.

To overcome the natural limitations of injection molding grades with short fiber reinforcement, Tepex® was developed in various combinations of fiber type, length and matrix.

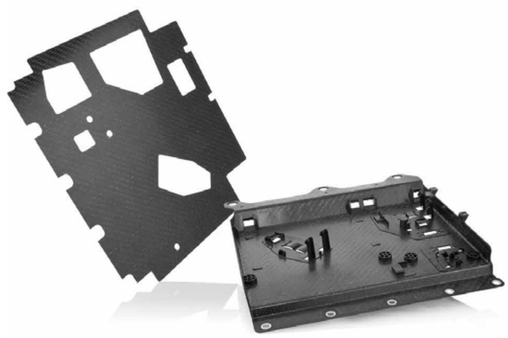
Tepex® dynalite consists of one or more layers of semi-finished textile products with continuous fibers embedded in a thermoplastic matrix. The fibers are typically made out of glass and/or carbon in form of fabrics. Matrix materials are thermoplastics such as PA6 or PA66. The production process enables fully impregnated and consolidated semi-finished products. It can be combined with typical plastics processing and is ideal as local reinforcement for structural applications. Alternatively, large flat areas can be designed with much less wall thickness.

Tepex® flowcore's feature are fibers with a finite length in the range of several centimeters, making this material suitable for compression molding. The flowcore family can be combined with Tepex® dynalite. Typically, the continuous fibers are placed on the outside of the laminate, while the long fibers are placed in the center. This produces a fiber composite with maximum flexural strength that also supports molding of complex components.

The most commonly used fiber is glass, but many materials are also available with carbon fibers.

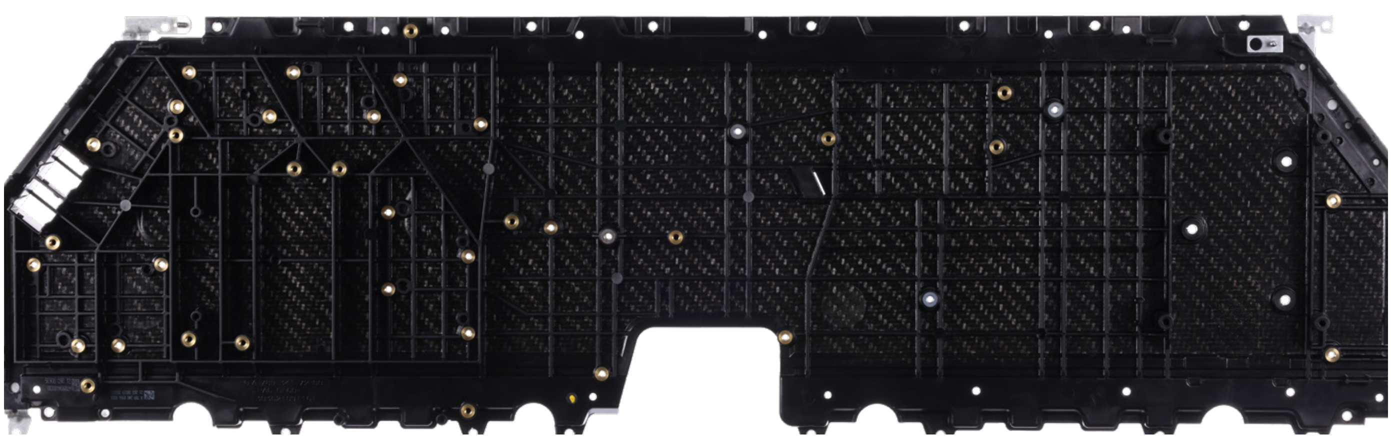
One application in series production is a battery support plate for a luxury sedan BEV with a high demand for mechanical performance.

The used Tepex® dynalite 102-RG600(4)/47% consists of PA6 and fibers. These are roving glass in form of a balanced fabric and contribute 47% of the volume. The overall thickness of the semi-finished product is 2.0 mm. After heating the material up over melt temperature, it is overmolded by Durethan® BKV60H2.0EF DUS060 – a grade with 60% glass fibers. Both materials have a very strong connection, because they are based on the same matrix (PA6).



■ Tepex dynalite enables thin-wall technology for a carrier of electronic components

The possibility of functional integration becomes also obvious by the example of the carrier plate. Several electronical components are fixated on the part by the injection molded areas, whereas the flat areas proof the potential of Tepex® thin-wall technology. By these measures costs and weight can be saved significantly.



■ Battery support plate for luxury BEV sedan made of Tepex dynalite-102-RG600 and Durethan BKV60H2.0EF DUS060

APPLICATIONS ON DIET

Since decades the automotive industry strives for further weight-savings without performance loss on the same cost-level. High performance plastics contributed and contribute with their unique properties already nowadays to reaching this goal.

The latest innovation is the hollow-profile hybrid technology. With this new lightweight design technology, metallic hollow profiles can be functionalized on conventional injection molding machines with plastic compounds. The results are plastic-metal composite components that boast far greater torsional stiffness and strength than could previously be achieved with other technologies for functionalizing hollow profiles. The fact that reasonably priced hollow profiles with relatively large dimensional variations can be used helps to make the process more cost-effective. Despite high pressures during the overmolding of the thin-walled hollow profiles, they do not need any inner support elements from the inside to avoid collapsing.

Another approach to combine steel or Aluminum with thermoplastics is the original plastic/metal hybrid technology. A metallic sheet instead of a tube is inserted in the mold and subsequently plastics are injected into the cavity of the tool. This allows for reducing wall thickness of metal inserts and minimizing the amount of plastic used in injection molding. For both hybrid technologies highly reinforced polyamide 6 types are recommended. One example is the easy-flowing Durethan® BKV60H2.0EF DUS060, which has a short glass fiber content of 60 percent by weight. With its high strength and stiffness, these compounds further enhance the performance of the corresponding components.

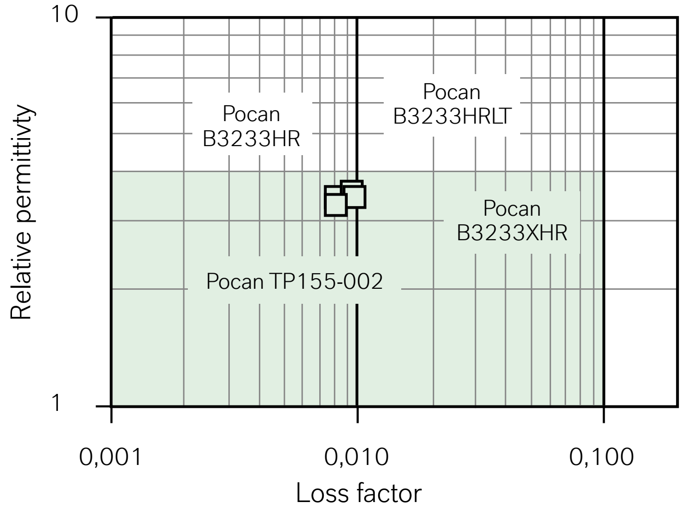
Alternatively highly reinforced PBT grades can be chosen for mechanically demanding applications like the electronic junction box found in various trucks from Volvo and Renault. The used Pocan® T7391 is a (PBT+PET) blend with 45% glass fibers and exhibits superior stiffness, excellent surface quality, high heat and weathering resistance, dimensional stability and low warpage.

Hollow profile hybrid technolgy demonstrators

ADAS ON
A NEW LEVEL

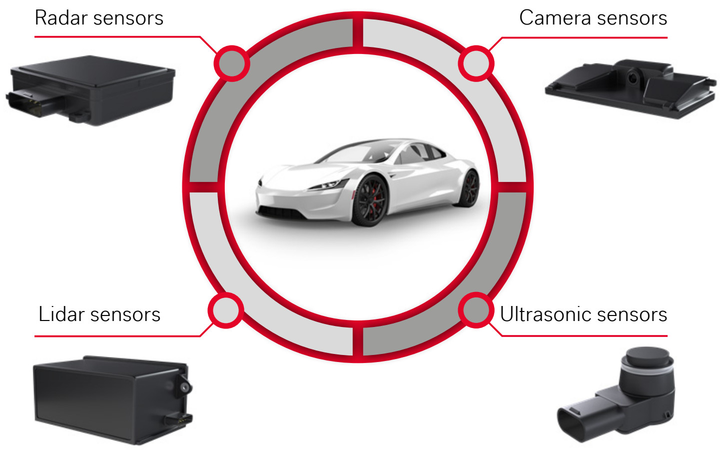
Advanced Driver Assistance Systems (ADAS) are getting more and more complex on the journey towards autonomous driving. Sensors are the connection to the surroundings of the vehicle and their increasing number per car is correlating with the autonomy level.

Most of them are working with radar, lidar, ultrasonic waves or with imaging. They all have in common that the materials for the housing must provide high dimensional stability, laser-markability and superior durability, to name just a few. Very often laser welding is being used to join a cover to a housing. As a pre-requisite one of the materials for the components of the housing needs to be laser transparent. Additionally, a stabilization against hydrolysis in humid air at elevated temperature is advantageous. Both grades Pocan® B3216HRLT 904040 and Pocan® B3233HRLT 904040 are highly recommendable, because they are laser transparent and hydrolysis stabilized.



■ Several Pocan grades are suitable as material for radomes (green area)

The functions of the different sensor types are varying strongly and consequently the requirements are divers as well. The front of a radar sensor – the so-called radome – must be radar-transparent. Test results of Pocan® B3233HR and Pocan® B3233XHR prove their suitability for this kind of applications.



■ Typical applications for ADAS

On the other hand, the back of the housing needs to provide electro-magnetic shielding. The carbon fiber reinforced Durethan® BCF30H2.0EF shows very good values with respect to the shielding of radar waves.

LANXESS has carried out extensive tests on numerous compounds in its portfolio, including measurements of one-way attenuation and specific transmission and reflection as a function of frequency and material thickness. Feel free to contact the LANXESS team in order to get more information.

INFRASTRUCTURE
LET'S GET CHARGED

The expansion of the charging infrastructure in public, commercial and private places is speeding up significantly. Increasing number of charging stations and wall-boxes are the most obvious sign for a continuing acceptance of e-mobility. Reliable material solutions to produce components and charging plugs are key for a safe operating at high voltages.

Wallboxes are getting more and more popular, because owners of electric vehicles are able to charge their cars at home. They also act as design element in private houses that can be customized. Durethan® as well as Pocan® grades are well suited to fulfill the structural and optical requirements of wallboxes, i.e. excellent surface quality, nice look and feel, high strength and superior stiffness. Durethan® BKV30FN04 is an outstanding material for the mounting structure, combining high mechanical performance with superior FR properties (UL 94 V-0 at 0.4 mm).

Charging couplers and inlets are the connection between electric vehicle and charging device. They have to fulfill high requirements regarding dimensional stability, flame retardancy as well as electrical properties. For charging coupler housings, Pocan® DPCF2200 (PBT+PC halogenated FR) is the material of choice, since it offers excellent surface quality in combination with high impact strength at low temperatures as well as good flame retardant properties.

Inductive charging as potential future technology is a very convenient way to re-power your battery. By means of induction, the car battery is charged either stationary in car parks or in car ports and garages – or even automatically while driving via special road surfaces with incorporated inductive coils. This requires product solutions that are convincing in every respect: both in terms of the required material properties and from an economic point of view. Various Durethan® grades or thermoplastic composites such as Tepex® are the materials of choice in the manufacture of car and base pads as well as frames in cars and entire loading systems.

■ Durethan BKV20FN01 is the material of choice for components of the wallbox

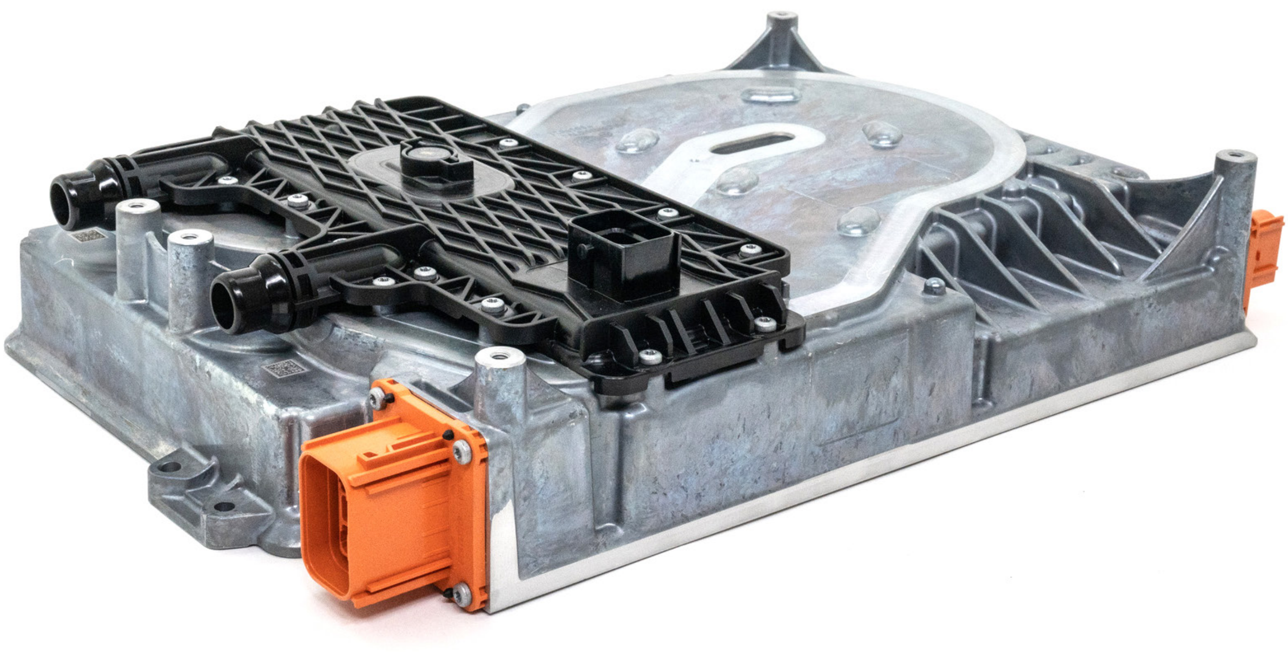
THERMAL MANAGEMENT OF THE ELECTRICAL POWERTRAIN

The thermal management of internal combustion engine vehicles is mainly dominated by water/glycol as coolant at temperatures around 120 °C. In this area PA66 such as Durethan® AKV35HRH2.0 is a proven performer for applications in the cooling system due to its superior resistance against water-glycol coolants.

But the coolant temperatures in some areas of the powertrain for BEVs are significantly lower offering opportunities for polyamide 6 as well. Durethan® BKV50PH3.0, a 50% glass fiber reinforced PA6, shows very good performance after exposure to coolant. As an example, it offers rather similar strength and elongation even after prolonged storage at 110 °C as a PA66 GF50 HR.

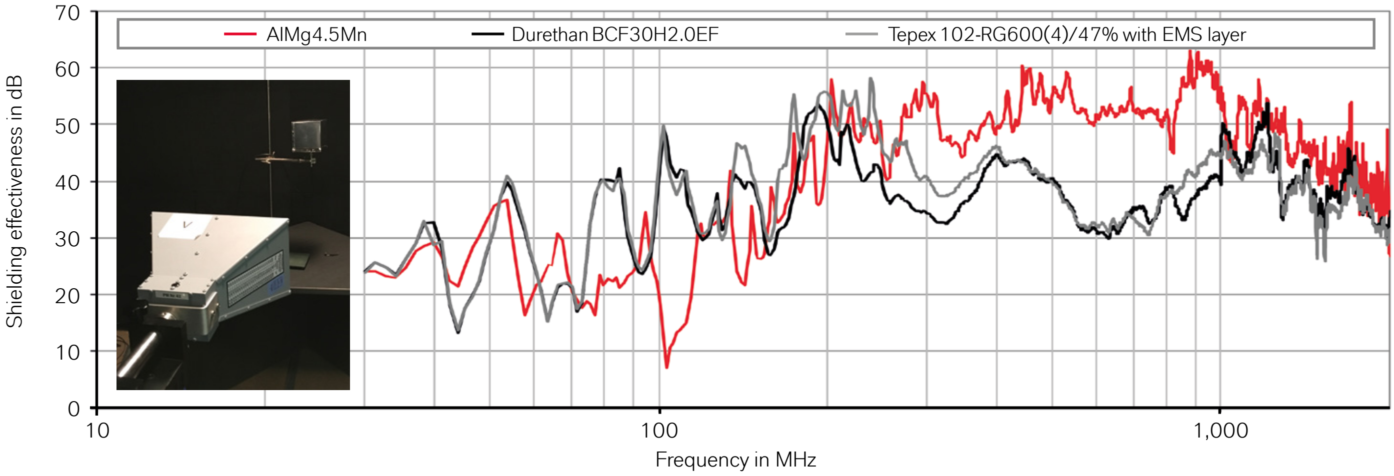
At coolant temperatures below 80 °C there is barely any difference in the aging behavior of PA6 to PA66. We therefore recommend the use of glass fiber reinforced PA6 grades, especially our special Durethan® BKV Performance grades, in applications such as coolant inlets, fluid lines, connectors or coolant tanks. A cover for an on-board charger is composed of Durethan® BKV50H3.0. It withstands temperatures of up to 85 °C during vehicle operation and burst loads of up to 10 bar is achieved. Long-term tests on test specimens also revealed that the mechanical properties of the compound in water-glycol mixtures hardly diminish even after 1,500 hours of storage at 110 °C and a pressure of 1.5 bar.

Apart from water/glycol as coolant many OEMs and tier suppliers are working on cooling systems based on dielectric fluids. Their electrical properties allow the electronics to be immersed in the fluids without any electrical malfunctions in combination with an excellent cooling efficiency. Many combinations of dielectric fluids and LANXESS grades are part of investigations on the compatibility of these two materials. On request the latest information can be shared.



Cover for on-board charger made from Durethan BKV50H3.0

MATERIALS ENABLING ELECTROMAGNETIC SHIELDING



■ Shielding effectiveness of Durethan and Tepex with EMS layer compared to aluminum

In order to avoid dangerous malfunctions sensitive electronic devices must be protected against electromagnetic interferences. The frequency of the respective waves ranges from 100 Hz for power electronics over several MHz for DC motors up to 78 GHz for radar sensors.

Durethan® BCF30H2.0EF is a PA6 equipped with 30% carbon fibers optimized for injection molding. These are electrically conductive and due to the high volumetric amount, the compound is conductive as well. It can be used for the production of covers and housings of sensors or electronic devices, because it exhibits a good shielding performance in the MHz to GHz frequency range. If flame retardancy is requested, a version with 25% carbon fiber content with a UL 94 V-0 classification is available containing a halogen-free flame retardant system.

Our continuous fiber reinforced thermoplastic material Tepex® can be equipped with one or more shielding layers. During the production process either on both outer sides or in the center of the lay-up EMS measures are applied, e.g. metallic meshes or aluminum foils. The semi-finished product can be heated up and thermoformed. A simultaneous function integration by overmolding is also possible if polymer is on the surface of the respective area. It is well suited to produce covers for on-board chargers, power electronics and battery enclosures.

Alternative effective ways to realize shielding in plastic parts are secondary measures, i.e.

- Application of a coating with shielding properties, e.g. by thermal spray, galvanization, physical vapor deposition (PVD) or conductive paint application
- Insertion of a shielding film, non-woven or mesh during injection molding (In-Mold-Decoration process)

A major advantage of both processes is that many Durethan® and Pocan® grades can be used for the injection molded component. In this way additional characteristics such as flame retardancy or thermal conductivity can be added to the part.

LANXESS Energizing Chemistry

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