battery protection²

WHITEPAPER

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Enhancing

the Protection of Battery Pack Units in Electrical Vehicles with Hybrid Structural Component Designs

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A fresh new perspective on innovative automotive engineering enables next-generation structural solutions with superior crash performance for EV battery protection. The approach leverages the synergy of specially developed lightweight and high-performance structural foam from Henkel in combination with advanced engineering design by RLE International.

The sheer number and size of battery pack units in electrical vehicles is a major challenge for automotive designers seeking to meet strict crash performance requirements. In many cases, the battery pack tray extends across the entire underbody area between the wheels (Fig. 1) and must be protected against impact from all sides. At the same time, OEMs are under pressure to minimize the weight and cost of structural components designed to protect the batteries against intrusion in the event of an accident.

In a collaborative study by Henkel and RLE International, it was noted that battery crash protection can be optimized by using hybrid structural parts based on a combination of fiber reinforced plastics (FRP) and specially developed high-performance structural foam (Fig. 2). While FRP, e.g. 30 percent glass-filled polyamide, provides a solid frame or carrier in these designs, the structural foam – injected into the carrier at predefined sections – expands in the e-coat oven and creates a stiff connection between the hybrid structure and the other parts of the body-in-white unit. Compared to all-metal platforms, the design freedom and efficient processability offered by FRP and foam materials facilitate the adaptation of each structure to the required geometry, with locally stiffening foam ribs added precisely where needed.

In addition, the hybrid solution offers significant lightweighting opportunities. Part fixation can be done using either traditional fasteners (clips, rivets, screws), welding, or structural adhesives with a potential for further weight savings and easier assembly. Each design is fully engineered and optimized by Henkel and RLE International for all crash load scenarios. Automakers who want to use one and the same vehicle platform for as many different models as possible could simply modify an existing internal combustion engine car platform and replace the traditional metal reinforcements by strategically adding structural foam, as required, thus also saving development time and manufacturing costs.

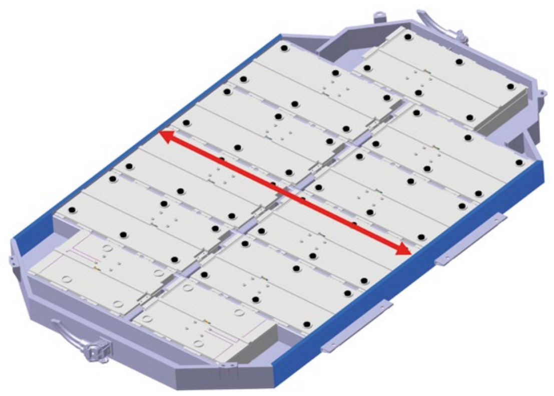


Fig. 1: Typical configuration of EV battery pack units in tray on vehicle underbody

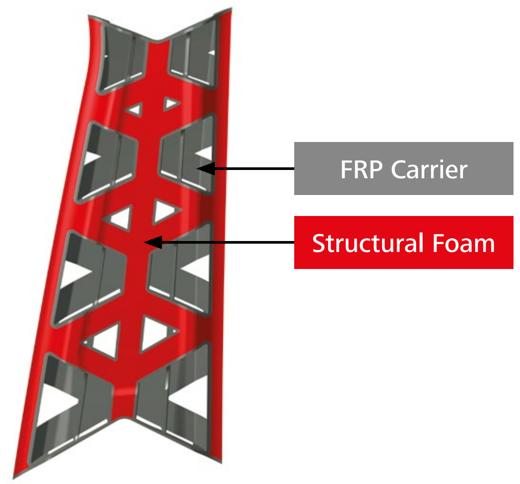


Fig. 2: Design principle of hybrid structural parts combining a carrier molded in fiber reinforced plastic (e.g. PA-GF30) with Teroson® EP 1450 structural foam sections for added stiffness

Optimizing

the Rocker Panel Design

One of the key components for protecting the batteries on the underbody in the event of a crash is the rocker panel or sill that extends along the sides of the tray supporting the battery packs. Premium vehicle OEMs normally specify the intrusion in a side crash scenario according to the USNCAP pole test at 32 km/h at 75° (Fig. 3) to stay below 10 mm.

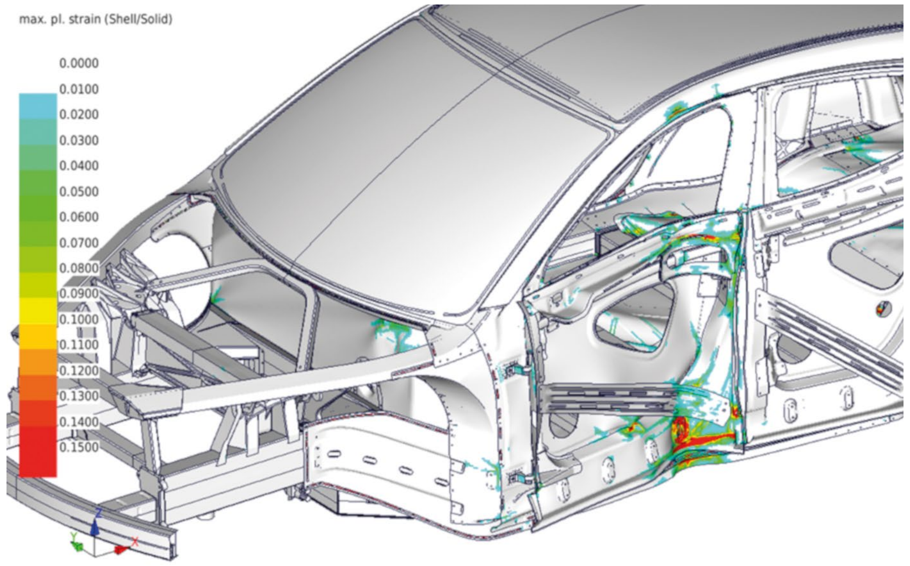


Fig. 3: USNCAP pole crash scenario at 32 km/h and 75° after 45 ms

In subsequent USNCAP pole crash simulations, the new hybrid structural foam concept was further optimized with a target of limiting the intrusion into the battery pack assembly to a maximum of 8 mm. The final design even surpassed those expectations by another 2 mm, leaving the battery housings intact (Fig. 5).

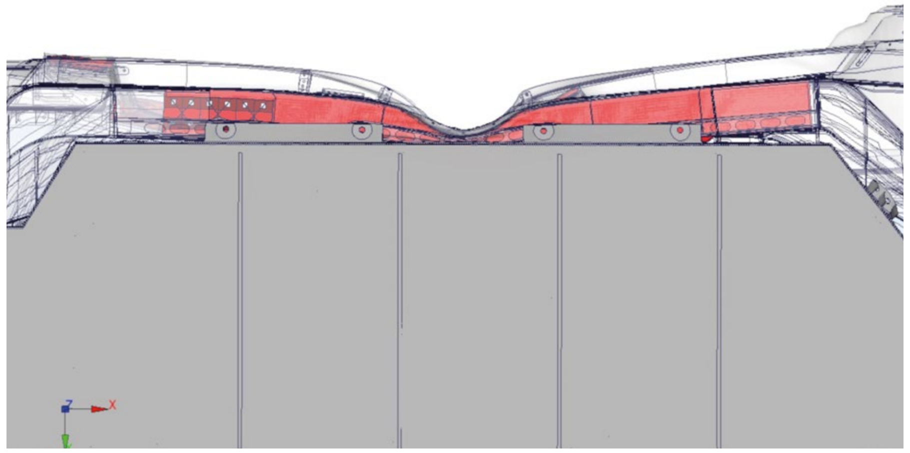


Fig. 5: Optimized rocker panel design showing superior USNCAP pole crash performance

Henkel and RLE International investigated the potential of structural foam sections for reducing the weight of the rocker while ensuring adequate battery protection in an iterative simulation process. The target was to find the perfect balance between deformation and stiffness.
On the one hand, the crash energy needs to be absorbed by deformation of the rocker parts. On the other hand, the parts must be stiff enough to direct the energy from the side impact into the seat cross members.
The study showed that the structure could be significantly improved by intelligent component geometry, with ribs or locally thicker wall sections designed to stiffen specific areas in the rocker more than others. Figure 4 illustrates the concept, which is estimated to save more than 5 kilograms per car.

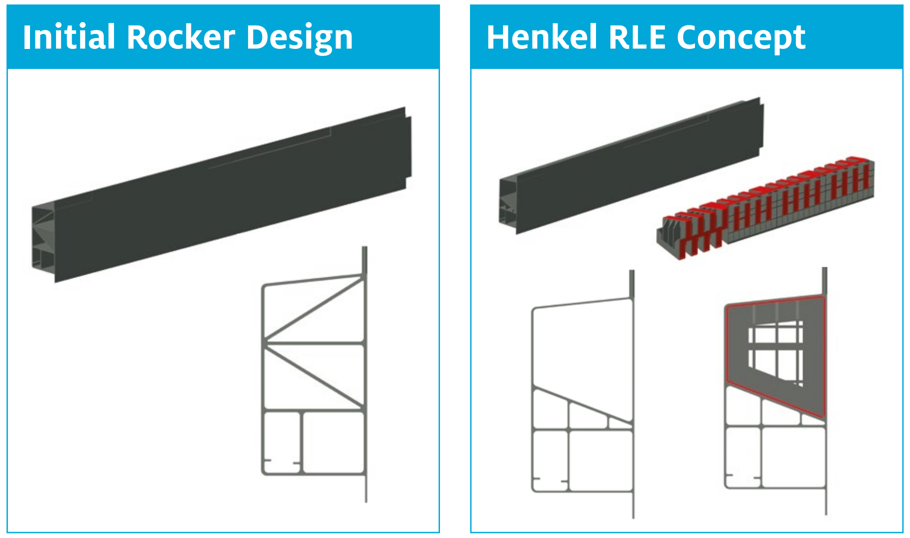
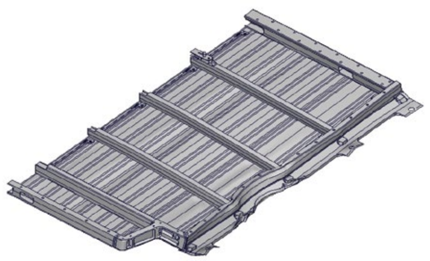


Fig. 4: The hybrid rocker panel design concept (right) uses dedicated ribbing and locally thicker wall sections for adding stiffness while saving overall weight

Moreover, the hybrid structural design also showed a 20 percent better crash behavior when compared to a honeycomb alternative (Fig. 6). Altogether, the iterative process for the hybrid structural rocker design took about six weeks, which can be considered the typical time for parts of this complexity, including all simulation loops.



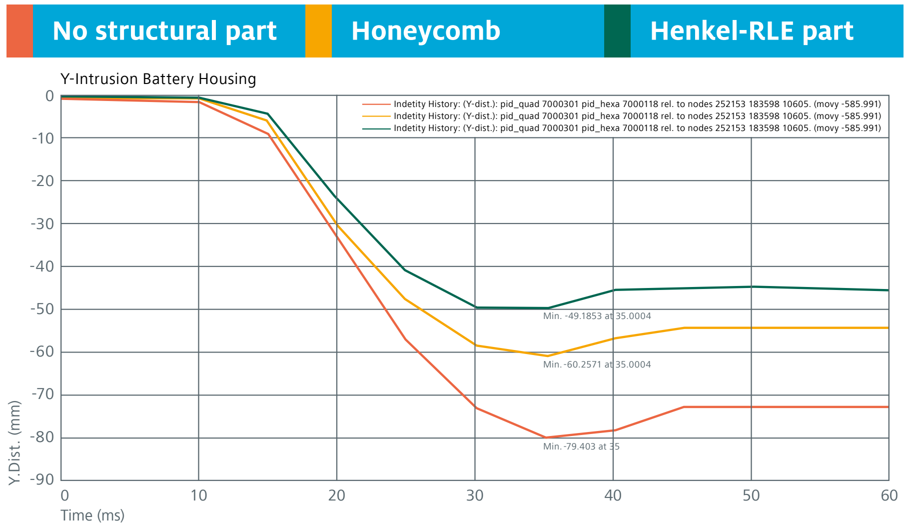


Fig. 6: Crash performance of Henkel/RLE International hybrid structural design vs. honeycomb alternative (with higher intrusion values than in reality due to the use of simplified replacement models)

Maximizing

the Potential

The benefits of the new rocker panel design in terms of battery protection and lightweighting can be maximized when translating the hybrid structural concept to other vehicle parts that can have an impact on the integrity of the battery units, such as the lower A and B pillars, the bumpers and the rear impact plate. US/EU NCAP front crash simulations at 64 km/h and 40 percent overlap as well as IIHS small overlap crash simulations at 64 km/h with optimized bumper bar and lower A pillar designs showed no intrusion into the battery housing and cells at all (Fig. 7 and Fig. 8). Although the rocker starts to kink in these tests, the behavior is within acceptable limits. Similar results were found when evaluating the rear crash behavior according to FMVSS301 with optimized bumpers and side members.

Based on these tests, the weight reduction achievable alone with optimized hybrid rocker, pillar, bumper and rear side member components can reach up to more than 10 kg per car.

The structural foam used in the hybrid designs is an epoxy based Teroson® EP material from Henkel that delivers high strength and stiffness at extremely low weight. The non-cured injected foam is resistant to normal automotive washing and phosphating solution as well as to electro-dip coating. It cures within 15 minutes when passing through the e-coat oven. The current material technology features a commercially available grade (EP 1450) with extensive approvals from automakers worldwide. Typical properties are listed in Table 1.

Several OEMs are already using the material in various lightweight hybrid structural parts, replacing traditional steel reinforcements. Further grades in the pipeline are being developed with a focus on lowering the cured foam density, increasing the foam expansion beyond 100 percent and reducing the required curing time.

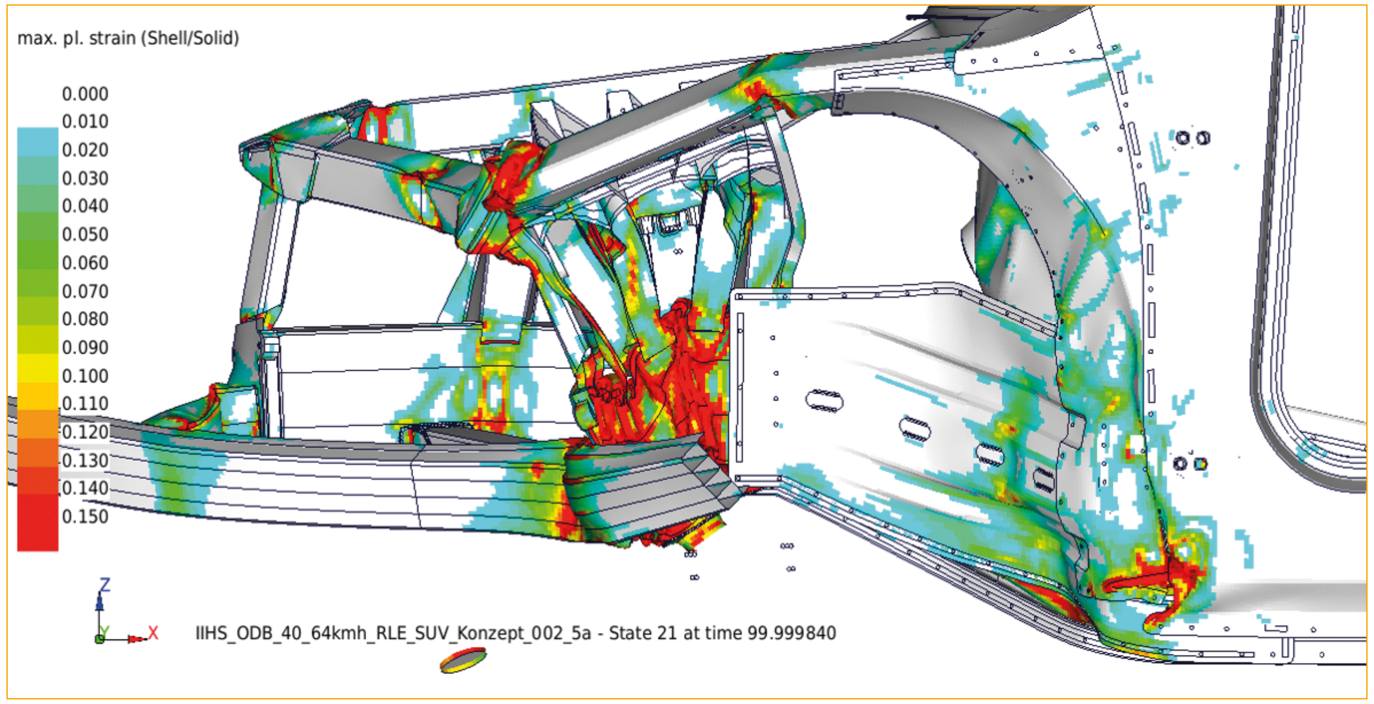


Fig. 7: No intrusion into the battery segment of the vehicle in US/EU NCAP front crash simulation at 64 km/h (maximum plastic strain shown at 100 ms) with higher intrusion values than in reality due to the use of simplified replacement models

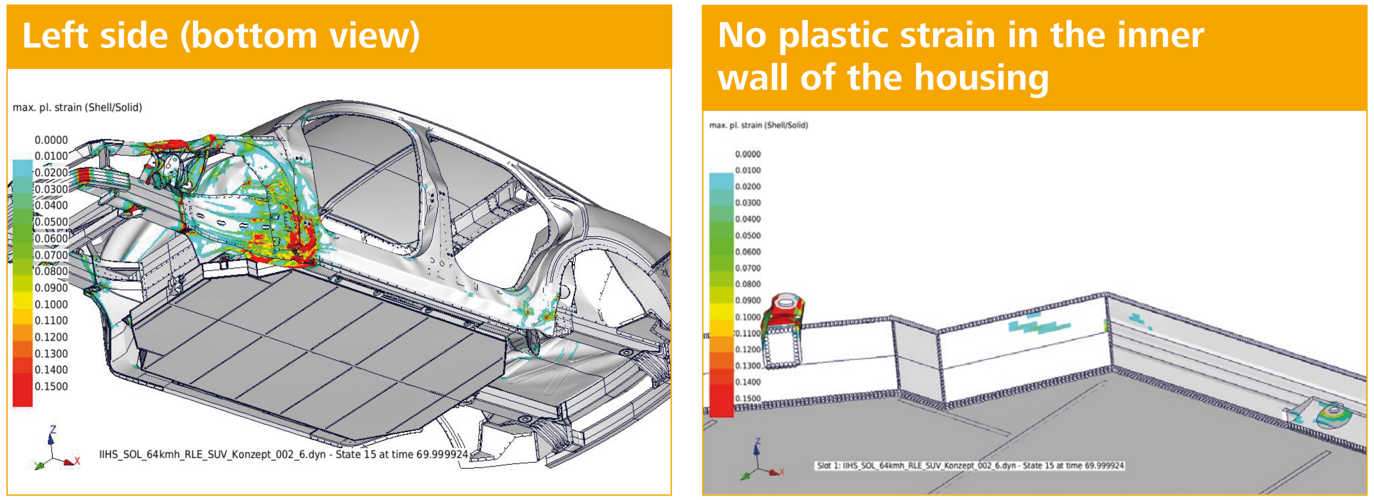


Fig. 8: No intrusion into battery tray wall in IIHS small overlap crash simulation at 64 km/h

Properties

of Teroson® EP structural foam

(based on typical test results)

Uncured	
Color	gray
Consistency	solid
Density at delivery	approx. 1.3 g/cm³
Solids Content	> 99 %
Colour	grey
Consistency (3h, 105˚C)	solid
Cured	
Recommended curing conditions:	
mini:	15 min 155°C (keep)
maxi:	20 min 195°C (keep)
Density after expansion	approx. 0.6 g/cm³
Expansion	> 100 %
Compression test	
Compressive strength	> 10 MPa
Compression modulus	> 450 MPa
Lap shear strength	
Substrates	galvanized steel
Bonding area	20 x 25 mm
Layer thickness	2 mm
Strength	> 2 MPa
Glass transition	> 100°C
temperature range	
(Tg) DMTA (40 Hz, 2 K/min)	
Corrosion resistance	
Salt spray test (35°C solution 5 %, 500 hours)	no corrosion, no loss of adhesion
Corrosion test (VDA 621-415)	no corrosion, no loss of adhesion
Water absorption	< 0.5 % weight increase
(24h, 98 % humidity, 40°C) In service temperature	-30 to 80°C

Table 1

Leveraging

the Synergies

The battery protection study by Henkel and RLE International arose from a mutual understanding of the engineering challenges that the automotive industry is facing in the light of megatrends, such as electromobility, car sharing and autonomous driving. New material and design solutions are required to reduce weight, increase safety and meet increasingly strict environmental regulations. The growing number of electronic systems in modern cars and last but not least the integration and protection of batteries in electric vehicles play a crucial role in development and manufacturing.

The strategic alliance formed by Henkel and RLE International is targeted at expanding the value creating opportunities of their combined expertise and becoming the premier engineering solution provider for the mobility industry from concept design, product selection and testing through to manufacturing and launch. The combination of Henkel's best-in-class material science with RLE International's cutting-edge engineering capabilities offers competitive synergies for customers to enable next generation automotive design solutions with new levels of lightweighting and enhanced passenger safety at faster turnaround times. With development centers in the U.S., China, Germany, the United Kingdom, India and Australia, the partners are well positioned to implement the technology of hybrid structural parts with close proximity to customer locations around the world. The encompassing approach ensures maximum process security and sustainability of all development, engineering and material processes.

Summary

of the whitepaper

In a joint initiative to leverage the synergies of their combined product and engineering capabilities, Henkel and RLE International have opened a fresh new perspective on innovative automotive design. In addition to helping drive weight reduction and cost control in next-generation vehicles, the dedicated use of structural foam in optimized hybrid components can also provide significant improvements in stiffness and strength to meet demanding crash performance levels. The partners' battery protection study for electrical vehicles has proven the validity of the technology.

About RLE

International

The RLE INTERNATIONAL Group is one of the world's leading development, technology and consultation service providers to the international automotive industry. With more than 30 years of experience and a global concept, about 2,000 engineers and specialists constantly keep abreast of technological progress and to add value for the international partners along the value chain. For more information, please visit **www.rle.international**

About Henkel

Henkel operates globally with a well-balanced and diversified portfolio. The company holds leading positions with its three business units in both industrial and consumer businesses thanks to strong brands, innovations and technologies. Henkel Adhesive Technologies is the global leader in the adhesives market – across all industry segments worldwide. In its Laundry & Home Care and Beauty Care businesses, Henkel holds leading positions in many markets and categories around the world. Founded in 1876, Henkel looks back on more than 140 years of success. In 2017, Henkel reported sales of 20 billion euros and adjusted operating profit of around 3.5 billion euros. Combined sales of the respective top brands of the three business units – Loctite, Schwarzkopf and Persil – amounted to 6.4 billion euros. Henkel employs more than 53,000 people globally – a passionate and highly diverse team, united by a strong company culture, a common purpose to create sustainable value, and shared values. As a recognized leader in sustainability, Henkel holds top positions in many international indices and rankings. Henkel's preferred shares are listed in the German stock index DAX. For more information, please visit **www.henkel.com**

Authors

David Caro is Head of Global Engineering Transport and Metal SBU at Henkel and has more than 20 years of international experience in automotive. After joining Henkel in 2001, he held roles in the company's operations in North America, Germany and Spain. David has degrees in Mechanical Engineering from Polytechnic University of Barcelona and in Business Administration from IESE Business School, University of Navarra.

Tobias Wigand is Project Manager for new business development at RLE International in Munich. He joined RLE in 2014 and has developed and launched several body designs over the past five years together with various premium car manufacturers. Tobias has eight years experience in automotive, including BIW and electronic components, such as connected electric motors. He holds a diploma in Mechanical Engineering from the University of Applied Sciences in Würzburg-Schweinfurt, Germany.

Thank you.

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