Henkel TEROSON EP high crash-resistant

STRUCTURAL ADHESIVES

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NEXT GENERATION HIGH CRASH-RESISTANT STRUCTURAL ADHESIVES FOR VEHICLE SAFETY

Car body structures are becoming lighter. And as strict regulations and demands drive lower CO_2 emissions, they are set to become lighter still in the coming years. In their efforts to make cars lighter, manufacturers are pursuing two main avenues: reducing the number of assembled parts, and downgauging the thickness. Both of these require the smart selection of high-strength materials, such as ultra- and high-strength steels (UHS and HSS), or low-density materials such as aluminum.

BIW Material Distribution

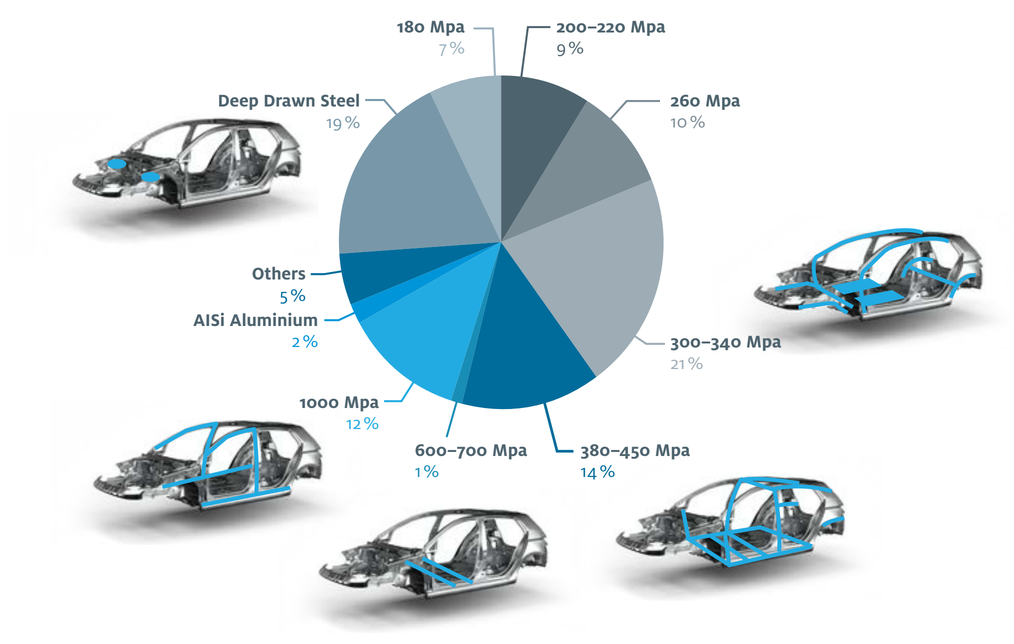


Figure 1: BIW material distribution (Baron et al. Assessing the Fleet-wide Material Technology and Costs to Lightweight Vehicles. CAR 2016)

Vehicle Subsystems

System	Priority	Low	Medium	High
Closures	High	Rear doors	Front doors Decklid	Hood Fenders
BIW	Medium High	C-pillar floor	Shock tower Truck frame	Engine cradle B-pillar A-pillar
Unsprung Mass	Medium	Tires	Brakes	Suspension Wheels
Interiors	Medium	Acoustics Restraints	Trim	Seats Instrument panel
Components	Low	Starter Motors	HVAC	Power steering Electronics
Non-structural	Medium Low	Radiator	Glazing	Exhaust

High ↕ Low

Low ↔ High

Figure 2: Light-weighting priority of vehicle subsystem (Baron et al. Assessing the Fleet-wide Material Technology and Costs to Lightweight Vehicles. CAR 2016)

The areas identified as offering the greatest opportunity to reduce a car's overall weight are the body in white (BIW) and closures. However, these opportunities need to be balanced against legal regulations relating to safety aspects, such as crash performance, as well the need to improve stiffness and to limit noise, vibration and harshness.

When it comes to electric vehicles, the battery module of an e-car can incur a 500-800 kg additional weight depending on car size and mileage range. This exceeds the weight of a regular internal combustion engine by a factor of two to three. The critical areas for crash safety and battery protection in electrified and hybrid cars include main BIW structures such as the rocker, A- and B-pillars, roof rails, and longitudinal and transverse members. Therefore, the challenge to reduce weight and meet safety and crash-performance requirements is tremendously high, especially for e-cars.

High crash-resistant structural adhesives play a fundamental role in light-weighting vehicles while ensuring they meet crash safety and battery protection requirements. They are designed to have high fracture toughness to resist cracks, to carry a greater load and to diminish impact energy. Furthermore, structural adhesives provide significant benefits in increasing structure stiffness and the durability of bonded structures.

In general, structural adhesives enable light-weighting by joining multi-material parts and allowing them to reduce part thickness. They also facilitate the manufacturing process, reducing complexity and also limiting the need for heat-induced jointing processes such as spot welds or mechanical jointing elements such as rivets.

HENKEL SOLUTION

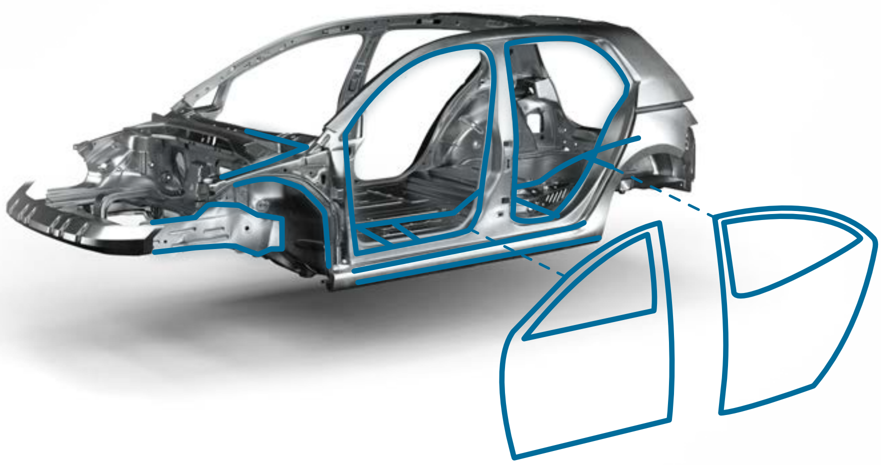


Figure 3: High crash-resistant structural adhesive typical application locations

The next generation of epoxy-based **Henkel TEROSON EP high crash-resistant structural adhesives** provide tailor-made solution to customer's requirements. Henkel's adhesive product development takes into consideration a range of factors:

1. Cured properties: aspects of the adhesive's material chemistry that specifically affect the adhesive's final properties in cured state.

- TEROSON EP high crash-resistant epoxy-based structural adhesives are designed to achieve the high fracture toughness and sufficient stiffness to fulfil or exceed crash safety requirements.
- They are customizable 'one-formulation' adhesives for a broad range of steel and aluminum structures, compatible with the surface chemistry of the bonded substrates to ensure perfect adhesion.

2. Uncured properties: all aspects before curing that are considered in relation to material processing. These are individually customized to OEMs' production line process requirements and constraints, and include:

- Wash-off resistance
- Humidity resistance (open time)
- Weldability or flammability
- Pumpability
- Cure kinetics

3. Engineering properties: aspects that enable car manufacturers to predict and analyze the performance of the bonded structure at full-car level, with numerical simulation during the design development phase.

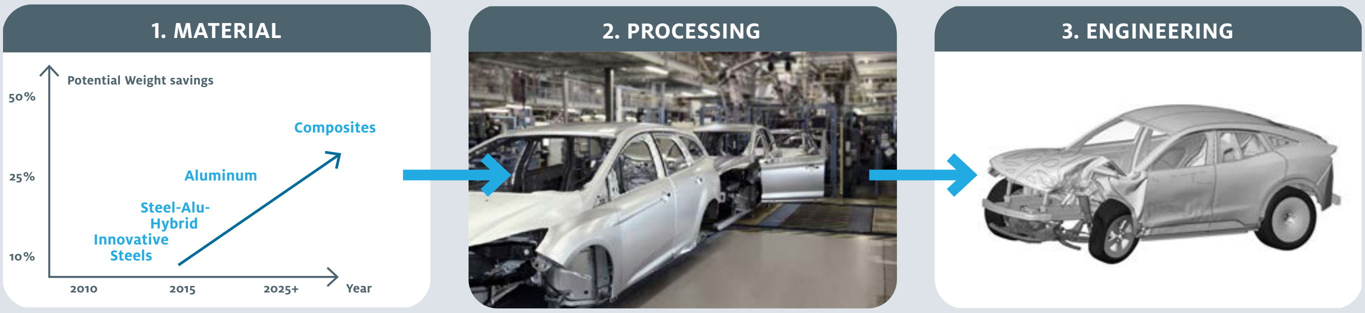


Figure 4: Development of TEROSON EP high crash-resistant structural adhesives covers every trait, from material chemistry to the production process and engineering aspects

CURED PROPERTIES OF HIGH CRASH-RESISTANT STRUCTURAL ADHESIVES

Fracture toughness is the crucial property for crash-resistant structural adhesives. Henkel's advanced toughening technology on the new generation of TEROSON EP high crash-resistant structural adhesives allows the bonded structure to absorb a high degree of impact energy. TEROSON EP high crash-resistant structural adhesives' core-shell rubber technology uses pre-dispersed nanoparticles in the secondary phase to increase the fracture toughness of epoxy polymers. The cavitation and debonding of rubber particles make the matrix more prone to shear-yielding instead of cracking. The resulting ability to resist growth of cracks increases the adhesive's load-bearing capacity. Therefore, impact energy can be more effectively absorbed.

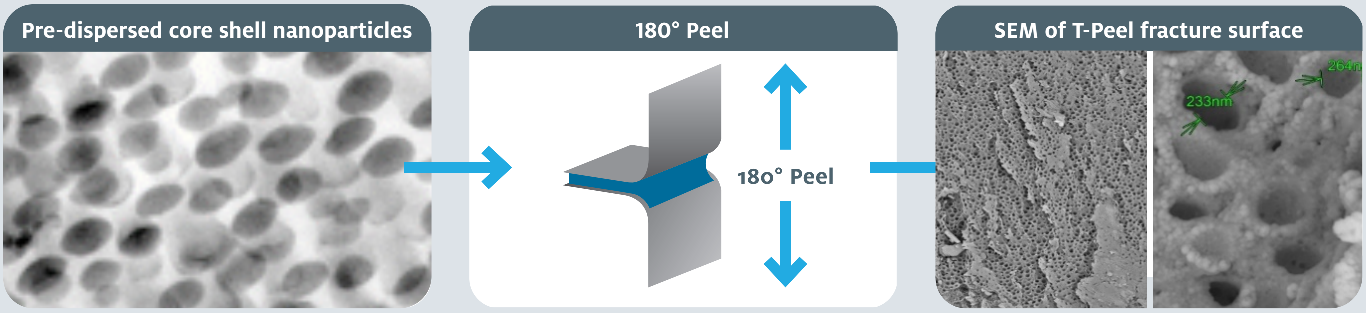


Figure 5: Toughening effect of pre-dispersed rubber nanoparticles on T-Peel fracture surface

Lap shear, T-Peel, and Impact Wedge Peel (IWP) tests on various substrates and different curing temperatures are recognized standards for assessing adhesive toughness and strength. The IWP dynamic resistance strengths for the new generation of high crash-resistant structural adhesives are typically >30 N/mm, measured at 23°C. At -40°C the dynamic resistance is >15 N/mm on Cold Rolled Steel (CRS) and >30 N/mm on Aluminum substrates.

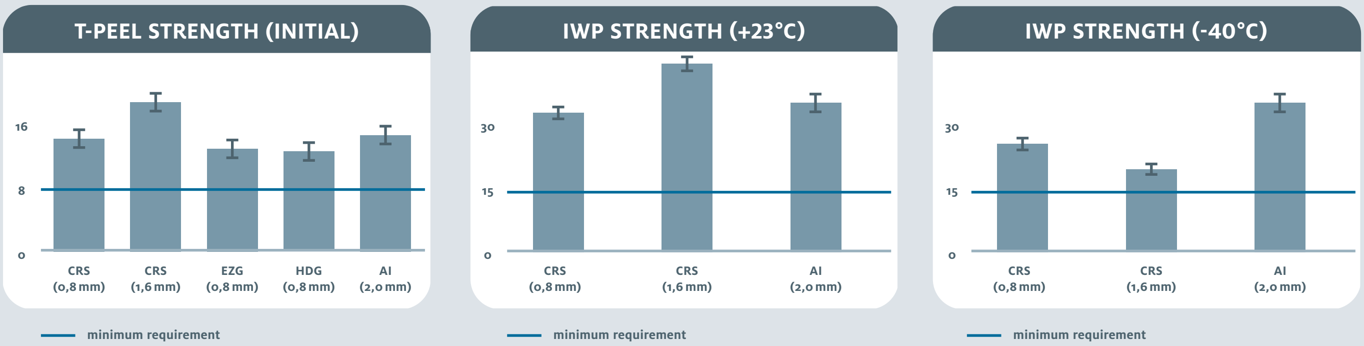


Figure 6: T-Peel and IWP strengths of typical crash-resistant structural adhesive on Cold Rolled Steel (CRS), Electro Zinc Galvanized (EZG) steel and Hot Dip Galvanized (HDG) steel and Aluminum substrates with various thicknesses

A 100% rate of cohesive-type failure of the bond-line under static and dynamic peel loads indicates perfect **adhesion** – even to oily substrate and corrosion protective coatings – ensuring TEROSON EP high crash-resistant structural adhesives work to their full potential in absorbing energy.

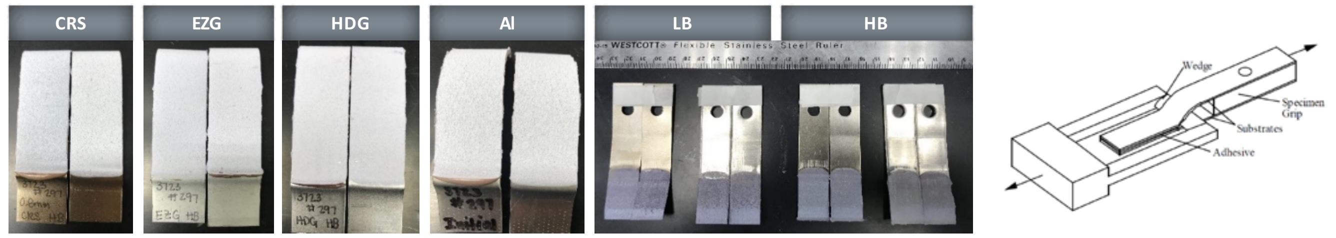


Figure 7: Cohesive-type failures after T-Peel test on Cold Rolled Steel (CRS), Electro Zinc Galvanized (EZG) steel and Hot Dip Galvanized (HDG) steel and Aluminum substrates also after IWP test cured at low (LB) and high bake (HB) temperatures

Modulus is another key feature for a high crash-resistant structural adhesive. A proper modulus level is required to increase and maintain the stiffness and rigidity of bonded structures. TEROSON EP next-generation high crash-resistant adhesives are designed to achieve a modulus of >1500 MPa.

Stress durability describes the ability of the structural adhesive to maintain the required mechanical and adhesion properties after undergoing environmental aging cycles under a defined static load. New TEROSON EP high crash-resistant structural adhesives are designed to improve stress durability, with good adhesion on various substrates and good IWP dynamic resistance strength.

STRESS DURABILITY/APGE CYCLING

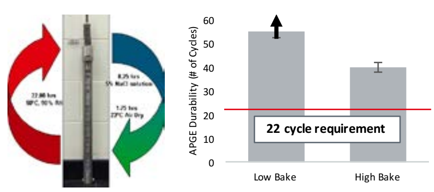


Figure 8: APGE environmental cycling for stress durability test according to ISO 11343 test method

UNCURED PROPERTIES OF HIGH CRASH-RESISTANT STRUCTURAL ADHESIVE

Wash-off resistance is one of the most important pre-cured properties for an adhesive. The rotating movement of body-in-white in the electrocoat bath process can cause coating fluid to flow in all directions and wash-off the applied uncured adhesive bead out of the flange. The wash-off resistance of TEROSON EP new generation high crash-resistant structural adhesives is precisely optimized to the requirements of each car manufacturer.

The wash-off resistance can be customized by controlling the thixotropy and yield stress as well as oil absorption and surface wetting. It ensures that the uncured adhesive stays in place as the body-in-white goes through the e-coat bath process, avoiding e-coat bath contamination.

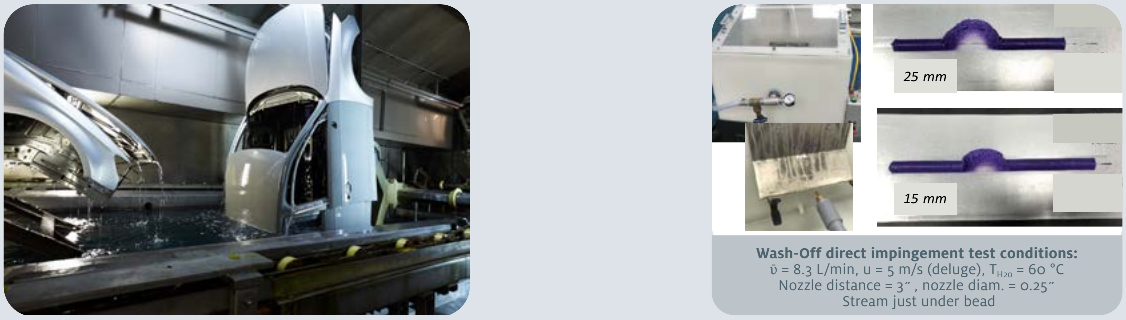


Figure 9: BIW goes through e-coat bath process (left picture) and an example of wash-off resistance test according to GM specific direct impingement test on various bead widths (right pictures)

Humidity resistance is the ability of cured structural adhesive to maintain its performance after exposure to humidity in uncured state. In practical conditions, the exposure of the adhesive in an uncured state – in open or closed bead – occurs if the production line experiences downtime. To ensure good adhesion after exposure, the humidity absorbed must be prevented from diffusing within the uncured bead.

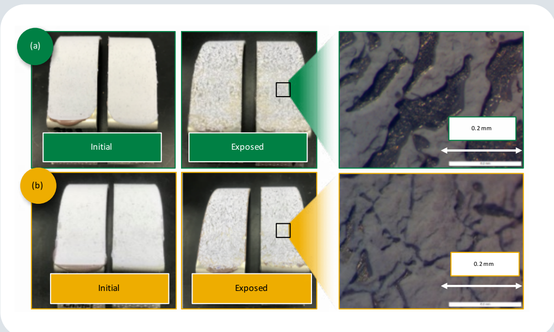
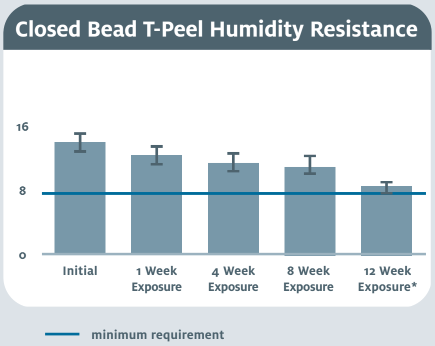


Figure 10: (a) Initial and (b) optimized reduction of blistering and interfacial failure due to moisture absorption

The toughened and cured chemistry of TEROSON EP new generation high crash-resistant structural adhesives is designed to reduce blistering and interfacial failure due to moisture absorption after exposure in both uncured open and closed bead.

As a result, strength in T-Peel and IWP tests on steel and aluminum is still well maintained after 168 hours' exposure in open bead and after 12 weeks in closed bead.



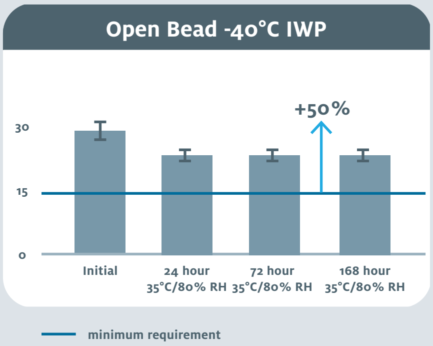
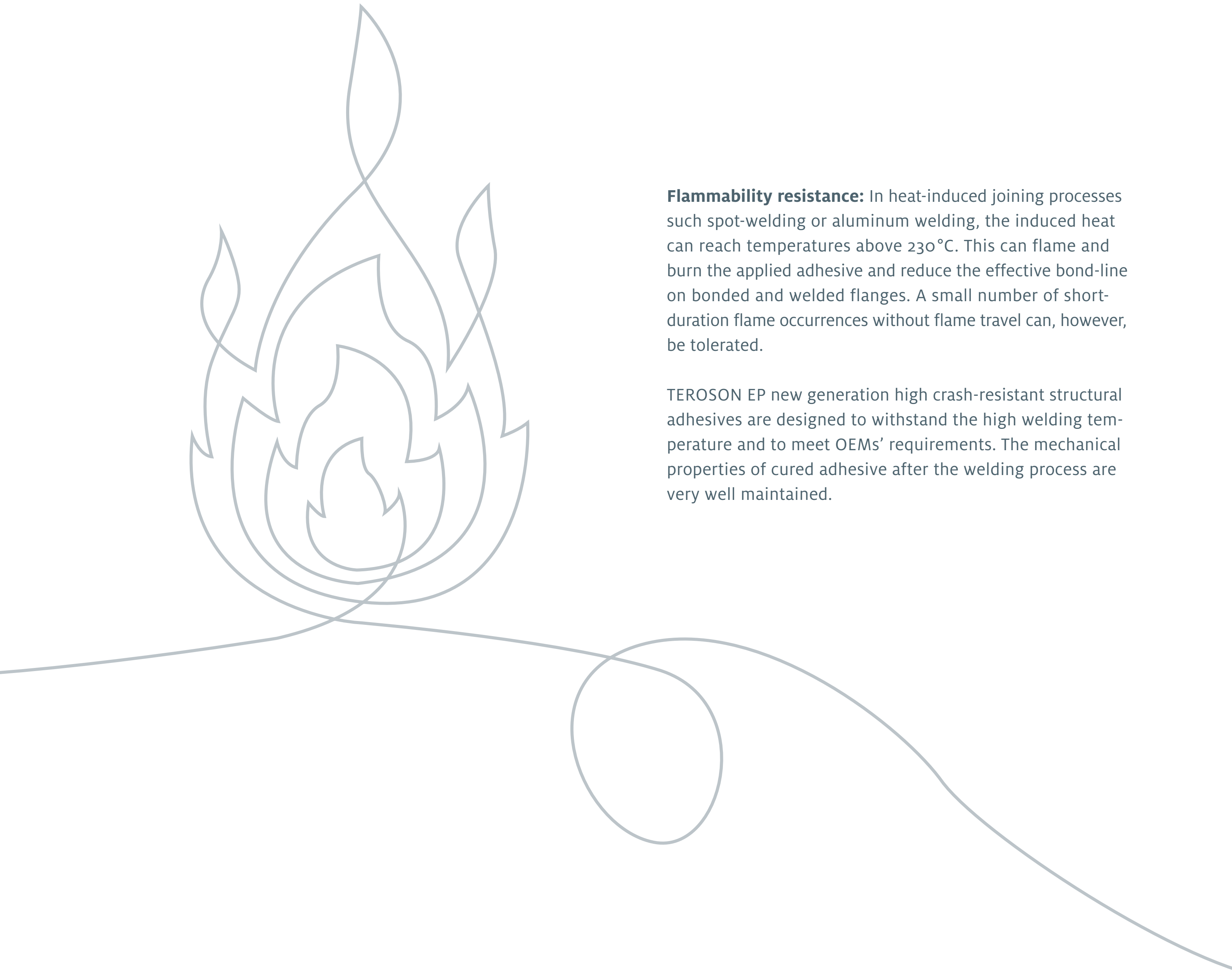


Figure 11: T-Peel and IWP at -40°C strengths after humidity exposure on open and closed beads (: 3 months uncured exposure 35°C at 85% RH)*



Flammability resistance: In heat-induced joining processes such spot-welding or aluminum welding, the induced heat can reach temperatures above 230°C. This can flame and burn the applied adhesive and reduce the effective bond-line on bonded and welded flanges. A small number of short-duration flame occurrences without flame travel can, however, be tolerated.

TEROSON EP new generation high crash-resistant structural adhesives are designed to withstand the high welding temperature and to meet OEMs' requirements. The mechanical properties of cured adhesive after the welding process are very well maintained.

ENGINEERING OF HIGH CRASH-RESISTANT STRUCTURAL ADHESIVE

Predicting the performance of bonded structures in the full car using numerical analysis is now standard in the car development process. Numerical simulation can provide a good prediction of adhesive performance in different load cases, which increases confidence in the behavior of car structures as a whole in real situations. In the early development phase, simulation results give designers crucial information about which direction they need to take their design in.

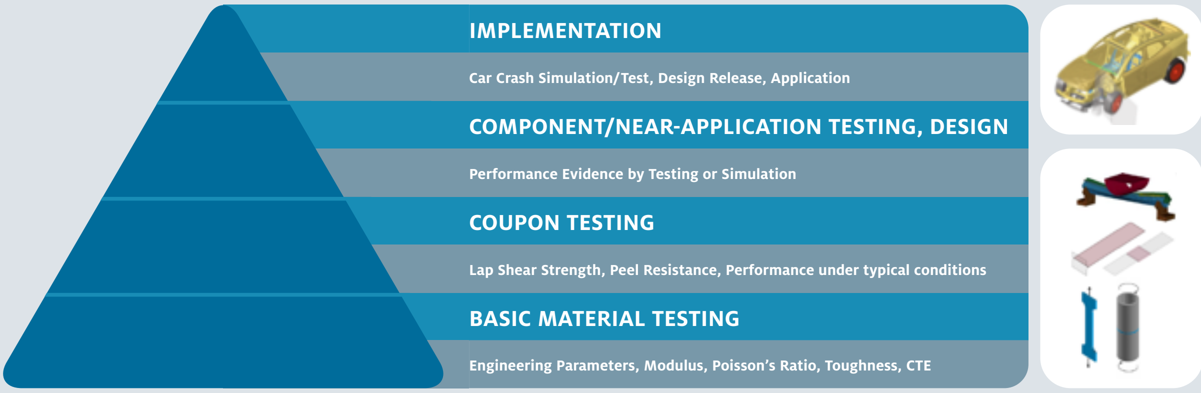


Figure 12: Engineering process from generating, validating and final implementation of simulation material data input of Henkel's structural adhesives

Henkel provides the state-of-the-art simulation material data input for TEROSON EP high crash-resistant structural adhesives. The data input is validated through coupon and near-application-level testing to achieve high prediction accuracy.

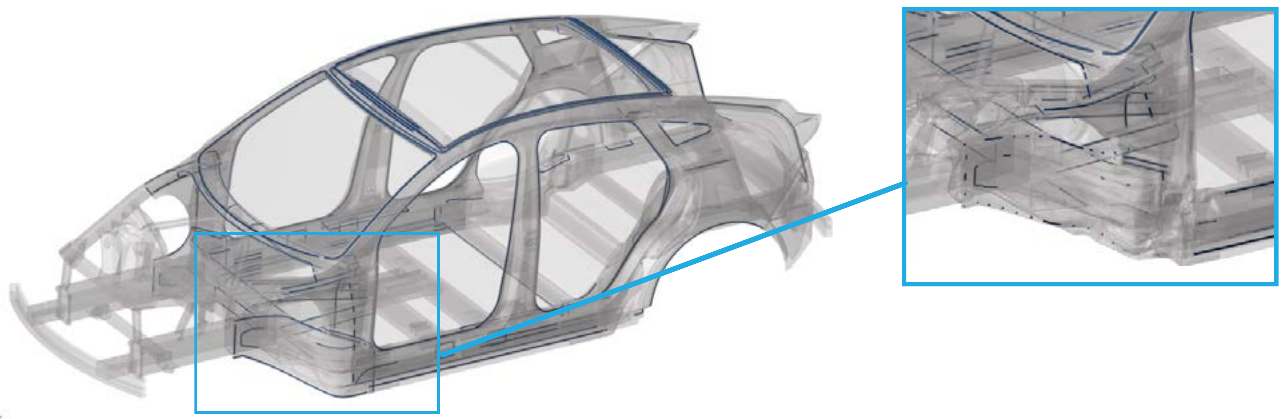


Figure 13: Failure prediction of high crash-resistant structural adhesive in BIW in IIHS small overlap crash

PORTFOLIO OF HIGH CRASH-RESISTANT STRUCTURAL ADHESIVES

Henkel Product TEROSON	E-Modulus*	LSS**	Impact Peel Resistance***	Special Properties
EP 5014	1500 MPa	38 MPa	36 N/mm	Medium viscosity
EP 5016 C	1600 MPa	30 MPa	35 N/mm	Medium viscosity
EP 5018	1600 MPa	34 MPa	40 N/mm	Excellent impact peel resistance and medium viscosity
EP 5089	1700 MPa	32 MPa	32 N/mm	Medium viscosity
EP 5089 EU	2000 MPa	28 MPa	32 N/mm	High viscosity and wash-off resistance
EP 5090	2400 MPa	32 MPa	34 N/mm	Medium viscosity and excellent humidity resistance
EP 5091	2000 MPa	28 MPa	34 N/mm	Medium viscosity, special wash-off resistance and excel-lent humidity resistance
EP 5092	1800 MPa	28 MPa	34 N/mm	Medium viscosity and excellent wash-off resistance
EP 5095	1600 MPa	30 MPa	33 N/mm	Medium viscosity, non-heated follower plate application, high wash-off resistance
EP 5150	1800 MPa	30 MPa	42 N/mm	Excellent stress durability, excellent impact peel resistance with low to medium viscosity

**: E-Modulus (ISO 527-1), **: LSS (ISO 4587) 2 mm/DC04, ***Impact Peel Resistance (ISO 11343) 1 mm/DC04*

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GET IN TOUCH WITH US

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