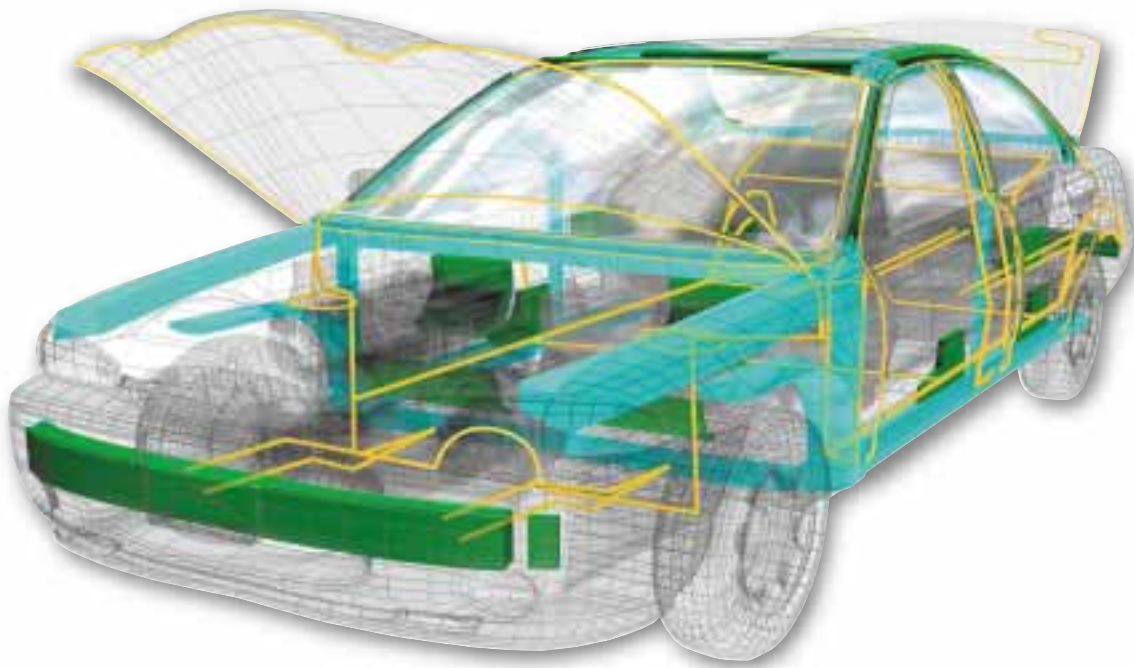


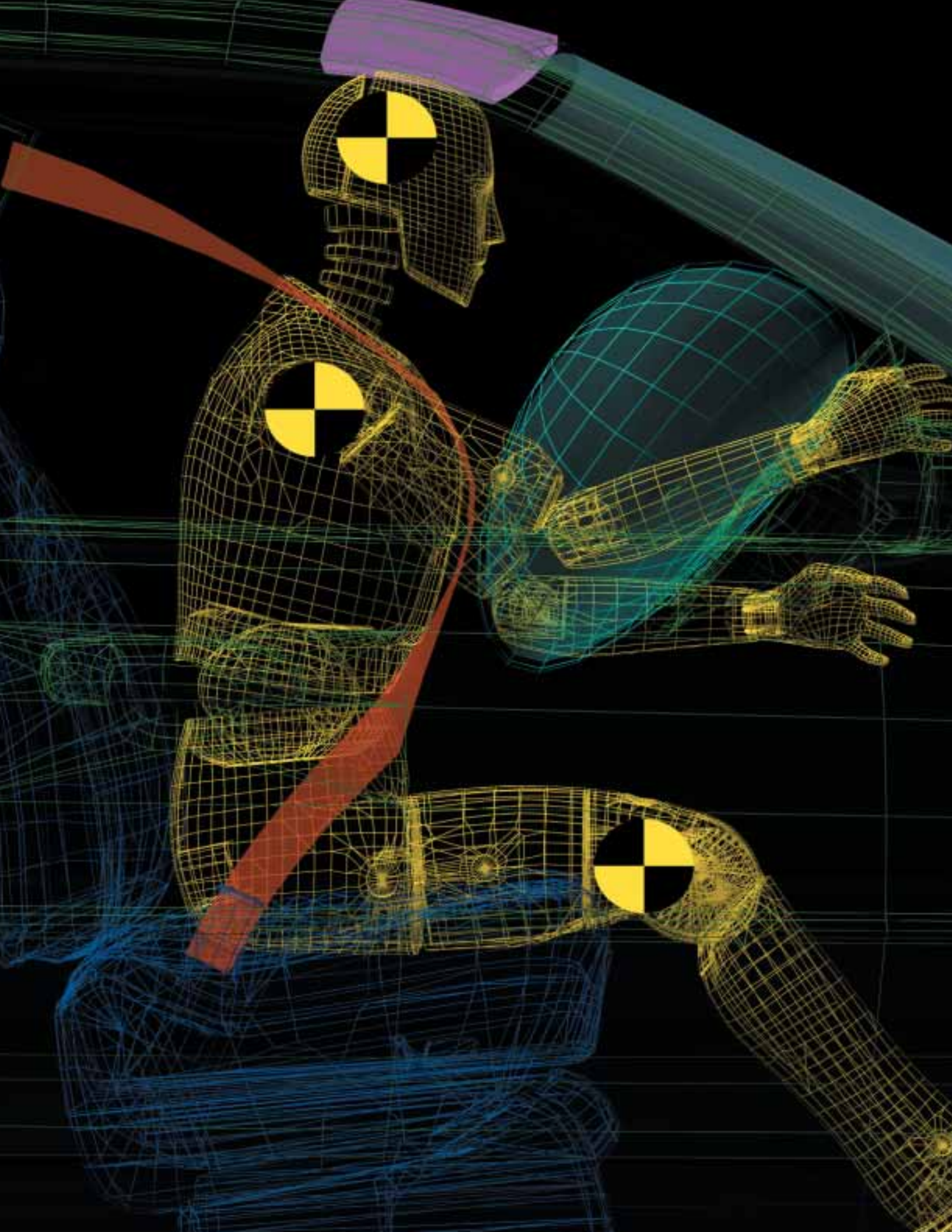


Dow Automotive

Managing Occupant Safety and Vehicle Crashworthiness



I M P A C T E N E R G Y M A N A G E M E N T



Improving Safety and Durability with Science and Technology

Over the past decade, Dow Automotive has committed extensive time and resources to research and develop solutions that improve vehicle safety and crashworthiness. Our vision is to continue to be a global leader in impact energy absorption (EA), body structure reinforcement, and other safety solutions.

Dow Automotive ingenuity has led to the development of innovative EA countermeasures and body structure enhancements that meet or exceed worldwide safety criteria, including EuroNCAP, ECE-21, ECE-R95, US NCAP, IIHS impact tests and FMVSS-201, 208 and 214 requirements. Our materials science heritage and unique understanding of application development enables us to provide a systems approach to managing vehicle crashworthiness. This, combined with our design, engineering, simulation, testing, prototype and processing expertise, produces cost-effective solutions that work.

In cooperation with our customers, Dow Automotive was the first automotive materials supplier to introduce innovative EA solutions such as all-plastic integrated knee bolsters, integrated pillar trim and structural instrument panel (IP) systems, as well as applications of rubber-toughened structural adhesives and polyurethane foam technologies.

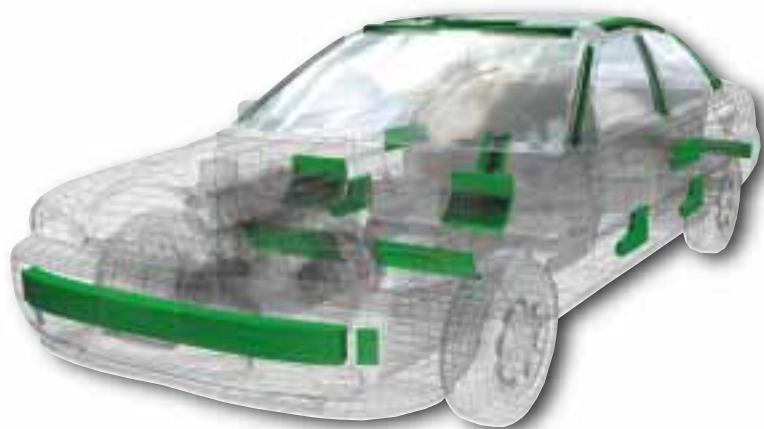
We currently provide a variety of energy management countermeasures for body enhancement to improve crashworthiness with structural bonding adhesives and cavity-filling foam technology. Additionally, we provide interior and exterior applications, comprised of EA foam technologies and molded components, enabled by best-in-class thermoplastic and thermoset resins and adhesives.

Far left: Dow Automotive engineering capabilities help us determine part design to meet customer requirements.

Top right: Raw STRANDFOAM polypropylene foam. Center right: BETAFOAM* polyurethane structural foam injection. Bottom right: BETAMATE* structural adhesive jet spray application.*



Innovative Vehicle Safety and Crashworthiness Solutions



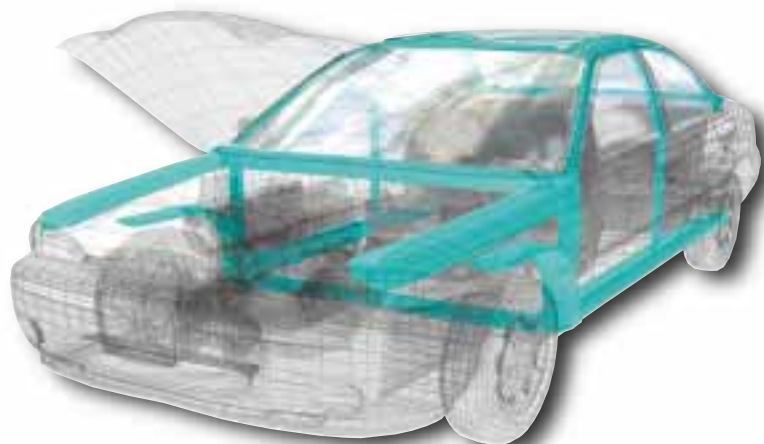
Key application areas

- Headliner countermeasures
- Integrated rib countermeasures for pillar trim
- Front and rear door countermeasures
- Lower IP bolsters
- Steering column countermeasures
- Under carpet countermeasures
- Bumper system countermeasures
- Cavity-filling structural foam for rails, rockers, cross members and joints

Structural bonding

Component reinforcement

Glass retention



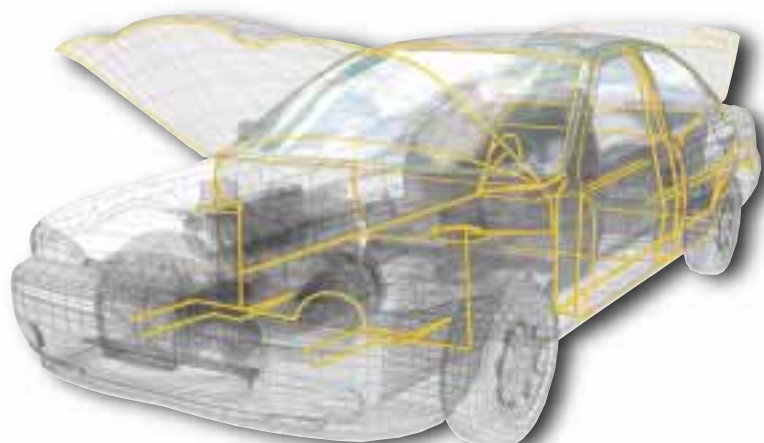
Dow Automotive materials for energy management systems

- Dow PolyPropylene RESiNS*
- MAGNUM* ABS resins
- PULSE* PC/ABS engineering resins
- SPECFLEX* polyurethane foam systems
- STRANDFOAM polypropylene foam
- BETAFOAM polyurethane structural foams
- BETAMATE structural adhesives
- BETASEAL* glass bonding systems

Related products

- PAPI* polymeric MDI
- VORANOL* polyether polyols

*Trademark of The Dow Chemical Company



Top left: EA countermeasures. Center left: Structural foams improve crashworthiness. Bottom left: Joints bonded with structural adhesives.

EA Countermeasures Manage More Energy in Less Space

At Dow Automotive, we work with our customers to increase EA efficiency throughout the vehicle. Our goal is to offer materials, components and technology to help you design solutions that absorb more energy and/or require less space.

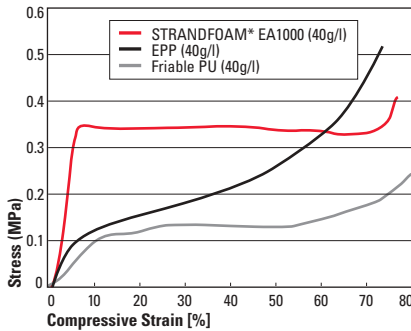
Global safety regulations are becoming increasingly complex and energy management will require increasingly unique solutions. For example, our STRANDFOAM polypropylene foam, unlike other foam countermeasures that compress to manage energy, is designed to compress, buckle and ultimately exhibit controlled fracture during impact. The combination of these three energy-absorbing mechanisms provides significantly improved performance.

Typically, STRANDFOAM exhibits up to 50 percent greater EA impact efficiency than traditional energy management foams in like-for-like testing. Its applications include cost-effective solutions for occupant, pedestrian or vehicle protection systems, wherever packaging space for energy absorption is minimal.



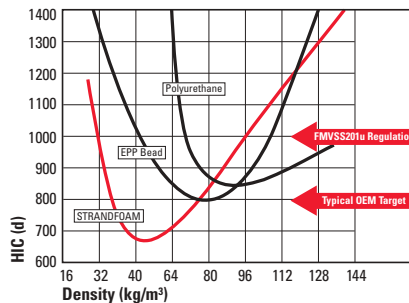
Right: Manufactured through a proprietary process, the extruded strands of STRANDFOAM fuse into an innovative honeycomb foam structure that is responsible for the material's unique energy management properties. Dow Automotive supplies finished STRANDFOAM parts that are cut, shaped or thermoformed to fit a specific packaging space. STRANDFOAM dynamic material models developed by Dow Automotive are also available to our customers using software packages such as LS DYNA3d and PAMCRASH™.

Energy-absorbing foam comparison



When comparing the stress-strain performance of STRANDFOAM versus traditional EA foams at the same thickness and density, the STRANDFOAM exhibits a highly efficient square wave curve, maximizing the energy absorbed. The traditional EA foams show much lower efficiency, with stress ramping up with strain and therefore, requiring more packaging space to absorb the same energy as STRANDFOAM.

EA foam countermeasure comparison



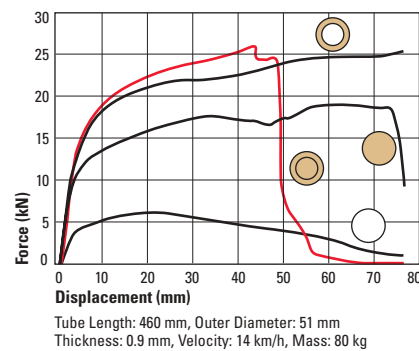
FMVSS-201u head impact tests show STRANDFOAM exceeding the performance of polyurethane and EPP bead, even at a lower density. All samples are 20 mm thickness and the body-in-white head injury criteria baseline is 2200.

Structural Integrity Improves Body Crashworthiness

Dow Automotive can help you enhance the effectiveness of vehicle body structure to dissipate and absorb energy without adding weight or significant cost. In many cases, we can help decrease both weight and cost by engineering materials solutions that enable thinner vehicle wall construction and reduced steel support structures and mechanical fasteners. Typical and evolving body enhancement product applications include:

- ▶ BETAFOAM polyurethane structural foams that are formulated for injection into vehicle cavities to improve stiffness and impact resistance.
- ▶ Structural foam inserts that offer easy installation, tunable design variables and cost savings versus competitive inserts.
- ▶ BETAMATE structural adhesives that create a continuous bond between components, potentially realizing more than a 40-percent increase in body stiffness.
- ▶ BETASEAL glass bonding systems that make the windshield and rear screen an integral part of the vehicle structure and meet globally mandated safety requirements for rollover and roof crush.

Force/displacement



BETAFOAM improves load distribution, and the cellular solid material can be used to fill vehicle cavities during body manufacturing and/or assembly.

Body enhancement technologies

While EA countermeasures focus on improving safety for passengers and pedestrians, body enhancement solutions advance total vehicle crashworthiness. The design of the body structure is guided by the deformation behavior and structural integrity of all parts, components and systems. The integrity of hollow body sections is improved significantly by using BETAFOAM inside the cavities. BETAFOAM will fill any cavity shape or contour, enabling engineers enhanced design capabilities. Additionally, BETAFOAM enables you to achieve an overall mass reduction of approximately 8 percent of a body-in-white structure at the same or better performance levels as the baseline. Stiffness improvements in bending and torsion can potentially exceed 100 percent.



Bending trials show the difference in performance between a tube injected with BETAFOAM and one that is hollow. Top left: The BETAFOAM-filled tube shows good endurance and minimal stress. Correlation can be achieved between crash and stiffness finite element analysis (FEA) and computer-aided engineering (CAE) simulations, both static and dynamic. Bottom left: Meanwhile, the tube without BETAFOAM is crushed.

Right: BETAFOAM performance can be simulated with FEA to evaluate its impact on vehicle design and safety. The critical areas to be injected with BETAFOAM can then be identified and treated accordingly.



Achieving Advanced Body Crashworthiness with Metal Bonding

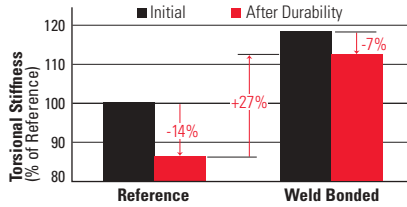
In structural bonding, our expertise has strengthened our ability to match great ideas with achievable outcomes. BETAMATE structural adhesive advantages benefit both metal and plastic bonding applications.

Metal bonding

- ▶ Increases crash resistance of the bonded structure versus thermal or mechanically fitted joints.
- ▶ Reduces thickness and cross sections of body structures.
- ▶ Improves static and dynamic vehicle stiffness; ensures conservation over time; and lowers fatigue due to continuous bond lines.
- ▶ Increases corrosion protection of gaps for fitted flanges.
- ▶ Improves acoustical performance of the vehicle body due to increased Eigen frequencies up to 2.5 Hz.
- ▶ Decreases process costs due to spot-weld reduction.
- ▶ Enables multi-material designs for body construction.

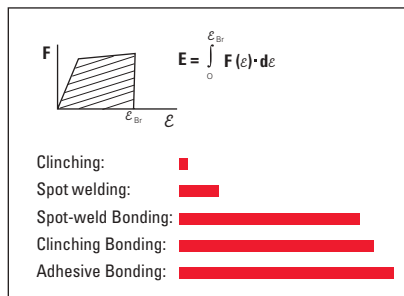
In addition, these adhesives bond dissimilar substrates—like metals (including steel, aluminum or magnesium), plastics and composites—so are ideal for all typical car body components. The structural bonding technology can also be combined with most thermal and mechanical fitting technologies.

Stiffness increase



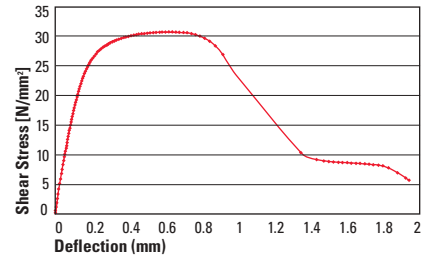
Body in white with extensive use of adhesives in joints shows improved torsional stiffness by more than 15 percent. The improved stress-corrosion performance translates into better long-term aging performance and a net 27-percent gain.

Hybrid joining and energy uptake

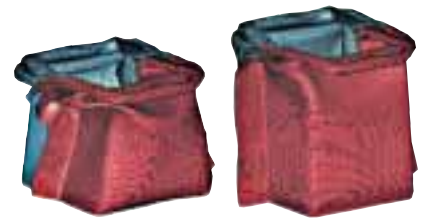


Bonded structures have superior energy uptake over mechanical or thermal technologies.

Stress versus strain



The perfect stress/strain response of a joint bonded with BETAMATE shows effective energy absorption at higher shear strains. Also, BETAMATE shows high impact resistance at high strain rates within a wide temperature window from 90 °C down to -40 °C, which helps ensure the full effectiveness and security of this bonding technology. BETAMATE is available in a variety of grades to fit a wide range of applications.



Under crash conditions, simulated with a computer model, BETAMATE structural adhesives enable the metal to absorb impact energy.

Plastic Bonding Advancements

When compared with traditional fastening methods, including vibration welding, ultrasonic welding and mechanical fasteners, Dow Automotive plastic bonding technologies offer significant advantages.

Plastic bonding

- ▶ Increases vehicle structural integrity without adding weight or cost.
- ▶ Stiffens the vehicle to improve flexural strength and distortion, impact and fatigue resistance, while reducing vibration and noise.
- ▶ Reduces fatigue, corrosion and failure commonly found around spot welds and fasteners.
- ▶ Reduces cost through parts and assembly operations consolidation.

Bondable substrates

Plastic blends and alloys

- ABS and alloys
- Acrylics
- Polycarbonate and alloys
- Polypropylene and compounds
- Polyethylene
- Thermoplastic polyesters
- Polyamide and compounds
- Vinyl polymers

Composites and thermosets

- RRIM polyurethane
- SRIM polyurethane
- Sheet molding compound (SMC)
- Bulk molding compound (BMC)
- Polyester composites
- Epoxy composites
- Vinyl ester composites
- Glass filled thermoplastics
- Long fiber thermoplastics

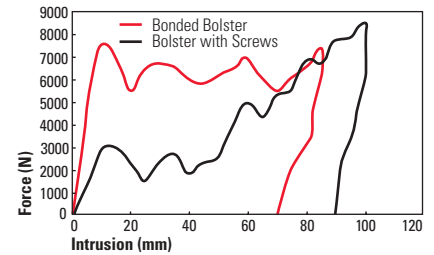
Metals

- Cold rolled steel
- Aluminum
- Stainless steel
- E-coated steel
- Corrosion-resistant coatings

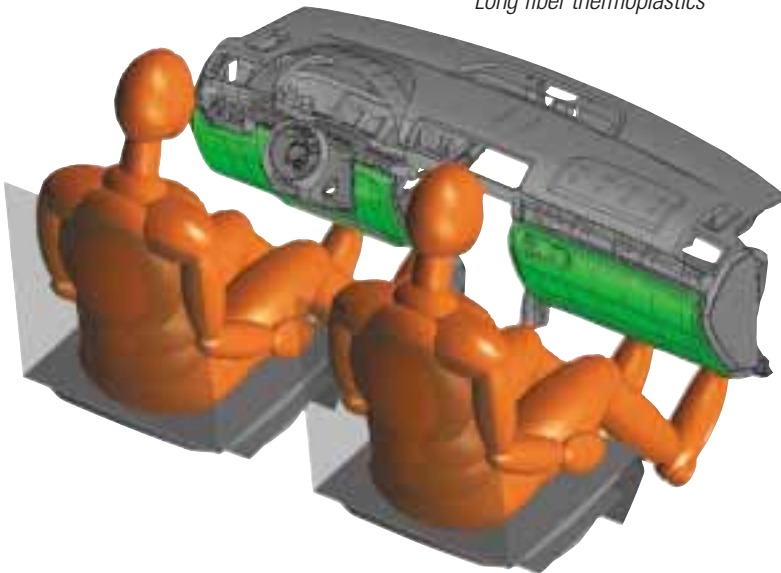
Other materials

- Glass
- Ceramic
- Painted surfaces

Stress deflection curve



The IP assembled with mechanical fasteners (screws) demonstrated more intrusion and higher loads and stress peaks in the material. The bonded IP showed less intrusion, lower loads and better stress distribution.



Bonded plastic bolsters help absorb more energy in occupant knee impact. During crash testing, Dow Automotive has found that bonded knee bolsters help absorb energy more efficiently with reduced intrusion and lower stress peaks.

Full-service Program Support from Dow Automotive

Access to our research and development teams, and emerging materials are readily available. Our experienced chemists, engineers and material scientists are focused on developing materials that address current and anticipated customer needs.

Because Dow Automotive is a business unit of The Dow Chemical Company, we provide a consistent, reliable source of materials and significant cost efficiencies. We also offer a complete range of materials for the transportation industry: plastics, structural and direct glazing adhesives, films, foams, sealants, underbody coatings and fluids.

Application development and design

When you work with Dow Automotive, you have access to application development and design expertise drawn from years of experience in the automotive industry. Our ability to listen to and interpret your needs enables us to deliver a custom solution for your vehicle requirements. This includes computer-aided design and engineering, FEA, including correlated dynamic material model development, concept development and material selection capabilities.

CAE validation and testing

Dow Automotive provides comprehensive in-house prototyping, testing and validation services to verify the best solution. We perform static and dynamic material property characterization and state-of-the-art component-level impact testing including head, side and frontal impact. Using Dow Automotive's environmental chamber, we can also replicate hot, cold or ambient in-vehicle conditions. With some materials, like BETAFOAM and BETAMATE, we can support every prototype stage in the OEM vehicle development process.

Our simulation testing capabilities can be fine-tuned to replicate real-world, immediate needs. As an example, we can evaluate material densities, impact type and impact speed for STRANDFOAM. This offers good correlation with reality and is the kind of support you'll only get from Dow Automotive. In addition, our engineering labs employ the latest equipment to evaluate structural foam and adhesive operation requirements and applications.

Processing

Our Technical Service & Development specialists understand and have experience with numerous systems and processing technologies including:

- ▶ Blow molding
- ▶ Extrusion
- ▶ Gas-assist injection molding
- ▶ Low-pressure injection molding
- ▶ Automated adhesive bead
- ▶ Swirl and spray applications
- ▶ Body and paint shop processes

This enables us to recommend the optimum processing method and equipment selection for your application. Production services for part fabrication that include cutting, shaping and thermoforming, are also available.

Top right: In-house testing capabilities enable us to verify material performance and compliance with global safety requirements. Bottom right: Ribbed, integrated pillar trim is just one example of Dow Automotive's EA expertise at work.

Right: When it comes to managing safety and vehicle durability through delivering body structure integrity improvements and components, Dow Automotive offers the longevity in the marketplace, materials science technology, design, testing and engineering capabilities, and application know-how to create innovative solutions. And, we have access to global facilities and personnel to effectively anticipate and respond to your needs. For full-service-supported solutions that meet design, packaging, weight and cost requirements while adding superior performance, play it safe and call Dow Automotive.





MISES STRESS (MPa)
TOP LAYER



BODY PANEL STRESS ANALYSIS

EISEX BODY PANEL DEFORMATION
ABAQUS V4-9-1
PROCEDURE 2 TIME STEP 1

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INCREMENT 488 1 327



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