Lightweight Foams for Enhanced Safety in PCIVs

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Background

- Foams are commonly used in current vehicles for enhanced safety
  - Side impact
    - FMVSS 214
  - Head Impact
    - FMVSS 201/201U
  - Seating/headrests
    - FMVSS 207/202a
  - Bumper Systems
    - FMVSS 581

Primary Foams for Automotive

- Expanded polypropylene (EPP)
  - Good energy absorbing (EA) material
  - Densities ranging 1 – 12 lbs/cubic foot
  - Most widely used thermoplastic foam
  - Easily recyclable (polyolefin)

- Polyurethane, rigid (PU)
  - Excellent energy absorbing material
  - Wide density and chemistry choices
  - Thermoset molding process
  - Generally higher density for given energy absorption

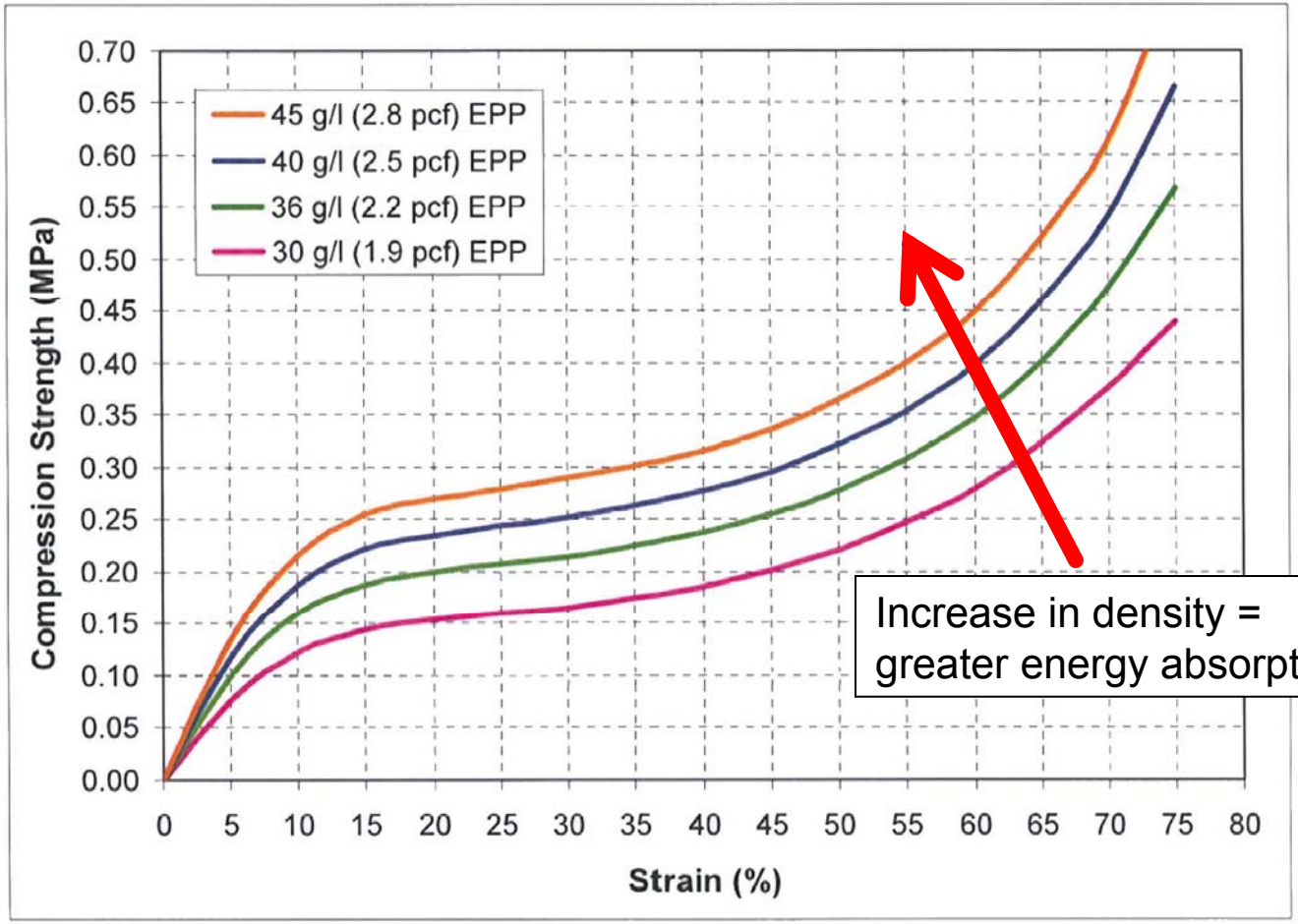
- Expanded polystyrene (EPS)
  - Excellent energy absorbing material
  - Lower cost/lb resin
  - Temperature limited to 170 F

Foam Advantages

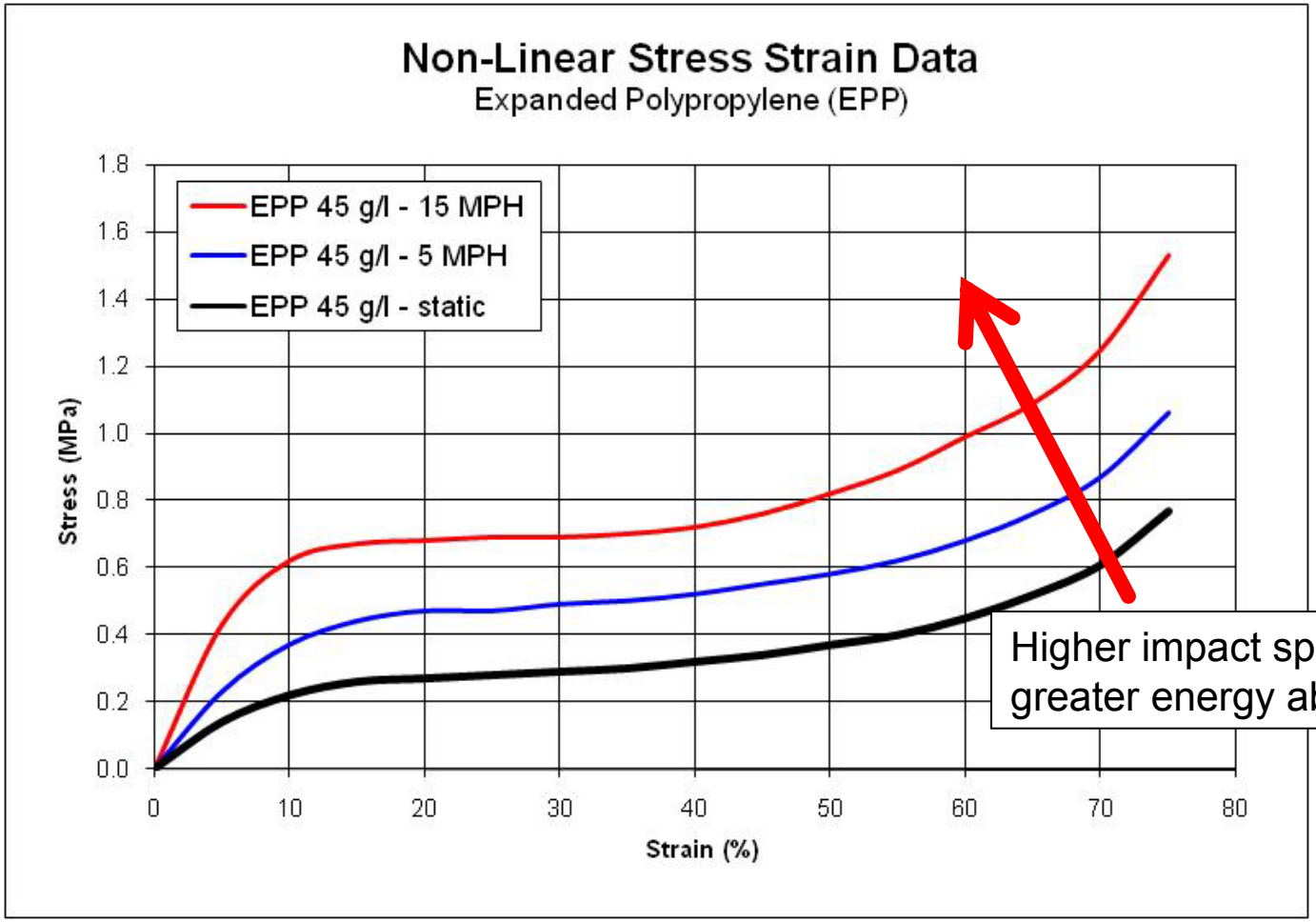
- Good stiffness to weight ratio
- Low tooling investment
  - Versus steel or injection molding
- Fast tooling timing
- Easily molded into complex shapes
- Low pressure process, with large part capability
- Density variation allows tuning for specific applications and requirements

Foams are currently one of the most cost effective countermeasures for enhanced safety.

Density Tuning for EA



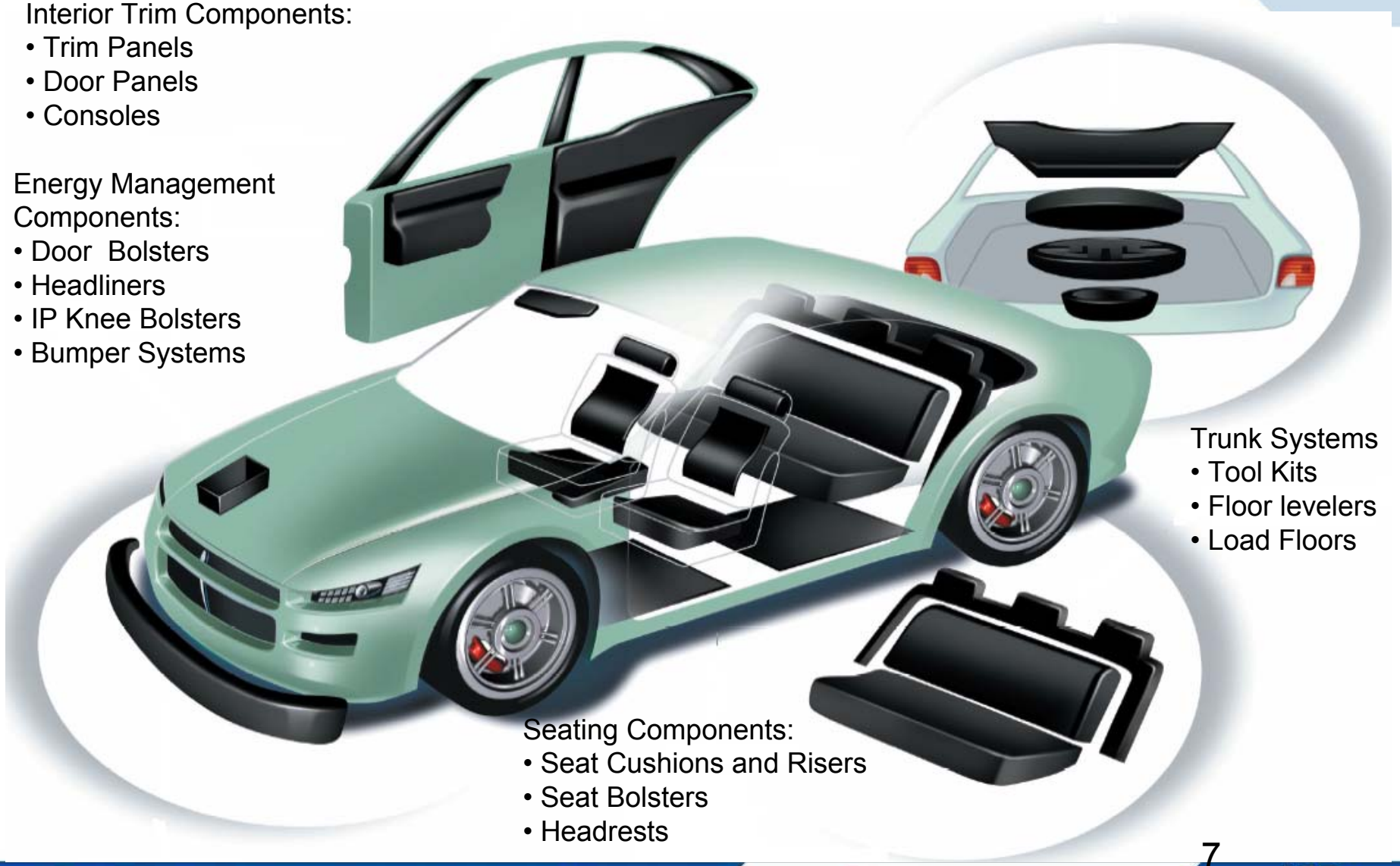
Strain Rate Behavior of Foams



Automotive Foam Applications

Interior Trim Components:
- Trim Panels
- Door Panels
- Consoles

Energy Management Components:
- Door Bolsters
- Headliners
- IP Knee Bolsters
- Bumper Systems

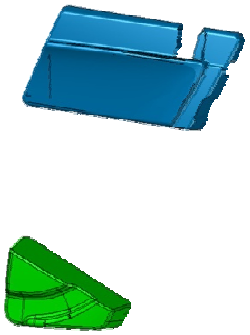


Trunk Systems
- Tool Kits
- Floor levelers
- Load Floors

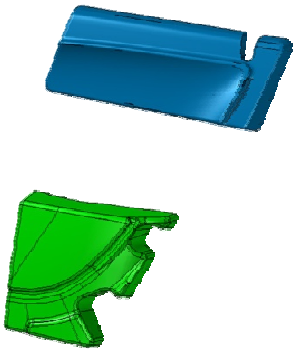
Seating Components:
- Seat Cushions and Risers
- Seat Bolsters
- Headrests

Side Impact

- Upper (thorax) bolsters
  - Generally lighter density
- Lower (pelvic) bolsters
  - Medium density for absorbers
  - High density for pusher blocks



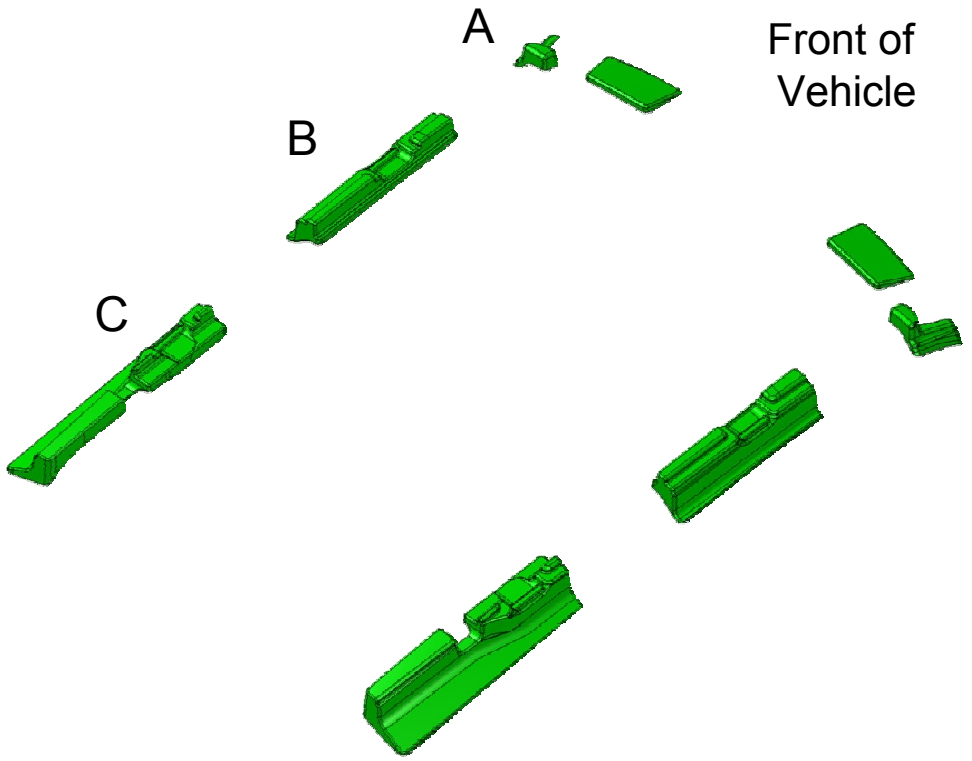
Rear Door
Upper and Lower



Front Door
Upper and Lower

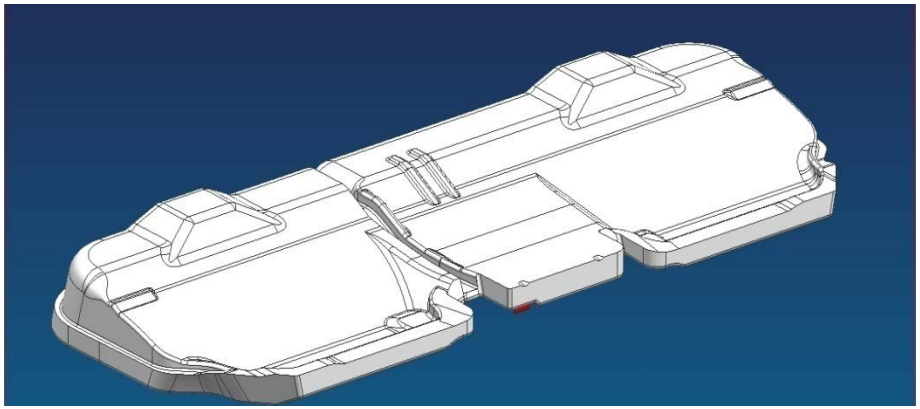
Head Impact

- Bonded to headliner
- Provides head impact protection in specific locations
- Density and shape variations to meet specific vehicle requirements.



Seating Components

- Headrest Cores
  - FMVSS 202A
- Seat Cushions
  - Anti-submarine features



Rear seat cushion with anti-submarine features

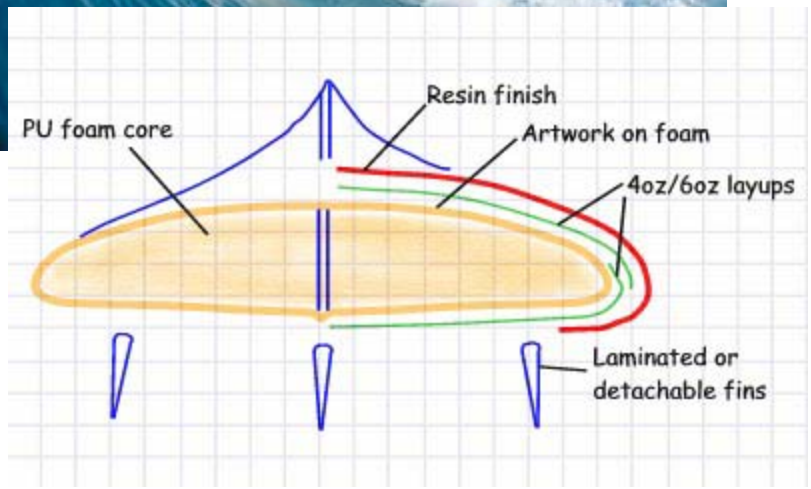
Bumper Systems

- Front and Rear Bumper EA foam
  - 2.5 and/or 5.0 MPH
- Pedestrian Protection Systems

Other Applications

- Foams can be used as fillers to enhance structure and performance
  - Foam filled cavities
    - Decrease buckling
    - Improve energy absorption
  - Sandwich Panels/Structures
    - Light weight foam between high modulus layers
    - Provides high cross section moment of inertia

Foam Cores in Structural Components



Cavity/Void Filler

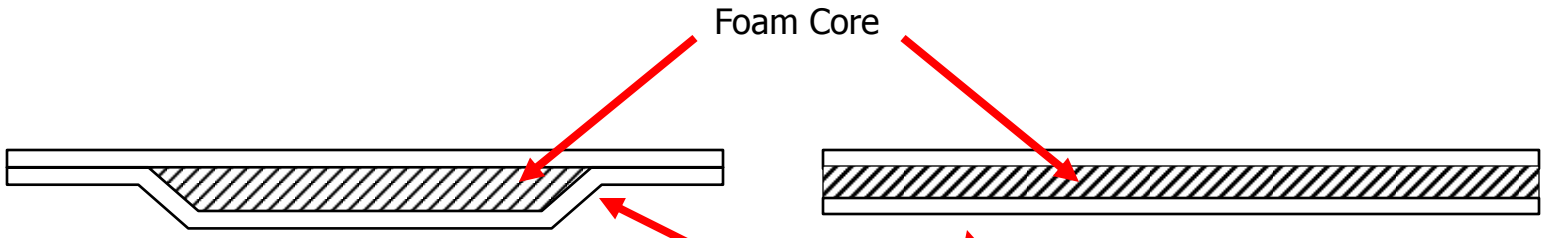
2006 Cadillac DTS / Buick Lucerne

- RIM polyurethane foam is injected into the cavity of the rocker panel
  - Limits lateral structural deformation of the B-pillar
  - Improves crash performance and reduces buckling of thin wall structures
  - Reduces costs vs. steel reinforcements
  - Reduced assembly times

Foam Cores in Automotive

- Molded foam cores can be used to create structural components
  - Pre-form for carbon fiber or other composite materials
    - Materials wrapped/applied to foam
    - Foam aids manufacturing AND provides energy absorption during impact
  - Foam core for sandwich panels
    - Load floors
    - Seating
    - Doors/door modules

Sandwich Panels



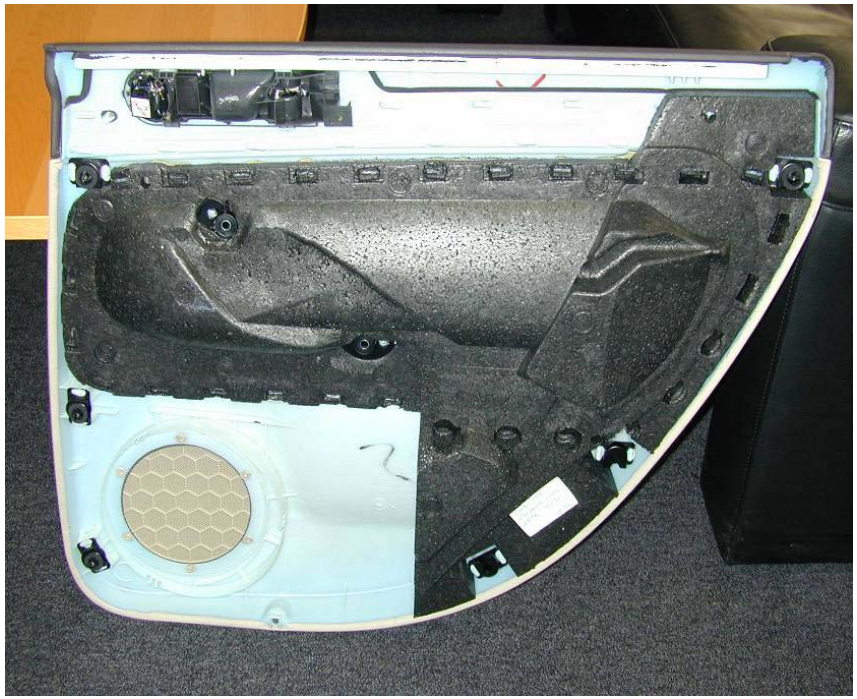
Sandwich panel load floor on the 2006 Ford Escape

Skin material:

- Thermo-formable composites
  - PP/TPO film
  - Natural Fiber/PP Composite
  - Hardboard
- Carbon fiber composites
- Combinations of the above

How can Foams Compliment PCIVs?

- Interior occupant protection
  - Additional foam pieces
  - Larger pieces to provide additional energy absorption
  - Integration of foam with functional components



Door panel insert combining EPP foam with armrest and decorative Class “A” surface.

How can Foams Compliment PCIVs?

- Exterior and Structure
  - Bumper absorbers
    - Front and rear crash
  - Pedestrian impact protection
- Foam filled cavities
  - Composite box sections
    - Structure
    - Improved energy absorption
  - Sandwich panels
    - Seating structures
    - Load floors

Summary

- Foams are an integral part of current vehicle safety systems

- Additional foam can be used to augment and improve safety in PCIVs.
  - Additional and/or improved foam components
  - Foams for enhancement of structure and crash performance of composites
    - Sandwich panels
    - Foam filled steel cavities
    - Foam filled composite structures