Eco-Friendly Interior Materials

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Agenda

- Fuel Economy
- Interior Automotive Trends
- Sustainability
- Natural Fiber Based Composites
- Environmental Stewardship
- Summary
Vehicle Curb Weight Change*
Lower Mid-Size Segment

Weight increase due to design change(s) and added electronics/safety

*adapted from IHS Automotive
## Lightweighting

### Legislative Emission Standards*

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>Regulatory Metric&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Standard Design Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>FE (mi/gal); GHG (CO&lt;sub&gt;2&lt;/sub&gt; e/mi)</td>
<td>Size indexed</td>
</tr>
<tr>
<td>European Union</td>
<td>CO&lt;sub&gt;2&lt;/sub&gt; (CO&lt;sub&gt;2&lt;/sub&gt;/km)</td>
<td>Mass indexed</td>
</tr>
<tr>
<td>China</td>
<td>FC (l/100 km)</td>
<td>Mass indexed</td>
</tr>
<tr>
<td>Japan</td>
<td>FE (km/l)</td>
<td>Mass indexed</td>
</tr>
<tr>
<td>Canada</td>
<td>GHG (CO2 e/mi)</td>
<td>Size indexed</td>
</tr>
<tr>
<td>South Korea</td>
<td>FE (km/l)</td>
<td>Engine size indexed</td>
</tr>
<tr>
<td>Australia</td>
<td>FC (l/100 km)</td>
<td>Flat</td>
</tr>
<tr>
<td>Taiwan</td>
<td>FE (km/l)</td>
<td>Engine size indexed</td>
</tr>
</tbody>
</table>

<sup>a</sup> GHG = greenhouse gas, FE = fuel economy, FC = fuel consumption

US standards will reflect 54.45 mpg and 166 gCO<sub>2</sub>/mi by 2025

*Source: UC Davis*
Mass Creep Effect on GHG Emissions*

Hybrid powertrains add approx. 9% to vehicle weight

*Source: CARB/UC Davis
# Vehicle Lightweighting Strategy

## Cost of Fuel Efficiency*

Technology advances can reduce fuel consumption but mass may be compromised

<table>
<thead>
<tr>
<th>Technology</th>
<th>Weight (+/-) (lbs)</th>
<th>Fuel Economy Improvement (%)</th>
<th>Cost per 1% FE gain ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbocharged gasoline (with downsizing)</td>
<td>- 44</td>
<td>10</td>
<td>26</td>
</tr>
<tr>
<td>Turbocharged diesel (vs NA gasoline)</td>
<td>+ 220</td>
<td>30</td>
<td>43</td>
</tr>
<tr>
<td>Lightweighting (Al/Mg)</td>
<td>- 617</td>
<td>10</td>
<td>98 - 163</td>
</tr>
<tr>
<td>Advanced stop-start</td>
<td>+ 11</td>
<td>5</td>
<td>52</td>
</tr>
</tbody>
</table>

*Source: Knibb Gormezano & Partners*
Weight Impact on Fuel Consumption

10% Weight Reduction = 5-7% Improvement in Gas Mileage

- Average curb weight 3,755 lbs
- 6% weight save = 37 lbs
- 2025 CAFE standard is 60% more aggressive

To meet 2025 emission standards vehicle weight must be decreased by 370 lb
The interior portion of the vehicle has moved from 14% to 6% of the total weight

*adapted from Source = Audi
Consumer Trends

- Sustainable materials
- Improved fuel economy
- Improved haptics
- Craftsmanship
- Personalization
- Connectivity
- Quiet / less noise

Market is trending to interior component alternatives to fill the gap between hard and foam in place that incorporate natural materials.
Progress in Weight Reduction through Materials Technology

- Affordability of Weight Reduction
- Design
- Material
- Process

Steel
- Aluminum
- High Strength Steel
- Ultra-High Strength Steel

Composites
- Induction Heating
- Mucell
- Thin Wall

Advanced FRP Composites

Multi-material and Process approach to achieve performance and weight
Virtually every component in the vehicle interior is capable of being manufactured with sustainable material:

- Instrument Panel Skins (*leather wrap* vs vinyl)
- Headliner (kenaf based)
- Seats
- Foam (NOP seat and IP)
- Carpet (bio-based polyol)
- Package Tray
- Load Floor
- Hard Trim (*bio-fillers*)
  - Door Bolsters
  - IP Pillars
  - GB Doors/Bins
Environmental and Sustainable Targets

Optimize
- Utilize Correct Materials for Each Application
- Utilize Renewable/Natural Resources
- Utilize Recycled Materials - PIR & PCR

Reduce
- Reduce/Eliminate Shipments to Landfill – (manage waste streams)
- Reduce Part Weight
- Reduce Carbon Footprint

Improve
- Improve Product Performance
- Improve Product Competitiveness
Renewable Resins & Sustainable Solutions

Renewable/Bio-based materials
- Soy-based and castor-oil based urethane foams
- Bio-based polymer use in components (PHA)
- Bio-based or natural fillers/reinforcements

Recycled Materials
- Post Industrial Recyclate from sources outside of IAC
- Post Consumer Recyclate
- ‘Home” regrind – develop innovative outlets for scrap streams

Lightweight Materials
- Foamed (CFA)
- Gas Insertion Process, e.g., Mucell
- Nano fillers and additives
Environmental Impact Over Product Lifecycle
Life Cycle Analysis (LCA)

- Evaluate the impact of component production (including freight and recylclate)

<table>
<thead>
<tr>
<th>Consumption of Energy</th>
<th>Emissions</th>
<th>Toxicity Potential</th>
<th>Risk Potential</th>
<th>Consumption of Raw Materials</th>
<th>Land Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Described by Primary Energy</td>
<td>• Described by categories - Air - Water - Solids</td>
<td>• Definition for hazardous materials used by EU law • Maximum possible hazard used</td>
<td>• Risk assessment approach • Based on published statistical data (e.g. insurance associations)</td>
<td>• Materials are weighted according to reserves and global consumption</td>
<td>• Index calculated by assessment criteria and impact factors</td>
</tr>
</tbody>
</table>

*Data acquisition and calculation is done according to ISO 14040 and 14044 (ecological part)*
# Interior Trim
## Carbon Fiber/ Natural Fiber Mat Technology

### General Description
Molding process to provide flat or 3-dimensional fiber mats that are compressed to make trim substrates

### Key Benefits
- Less weight - reduce part thickness to 1.5-2.0mm
- Eco-friendly use of raw material, renewable resource, and recycled content
- Improved performance with less weight
- Increase design flexibility if used with pre-formed mats
- Potential replacement for glass filled products
- Lower energy in manufacturing versus glass fibers (60%)
- Potential improvement in force deflection response for impact testing

### Comparison to Current Products
- Weight save as compared to injection molded/ woodstock bolster/ natural fiber of 35-50%
- Cost neutral
- Utilizes re-claimed material (carbon fiber)

*Provides equivalent performance at reduced weight*
Natural Fiber Bolster Manufacturing Process

1. Local Raw Material
2. Opening/ Blend with PP Binders
3. Produce Mat on Carding/Needle Line
4. Pack
5. Heat Mat and Compression Mold
6. Cut Blanks
Carbon Footprint
Green House Gas Impact*

Natural Fiber Bolster

ABS Bolster

Total GHG Impact per Part: $0.0016

Total GHG Impact per Part: $0.9432

*assume $2.35 CO$_2$/ ton
Summary

- Weight reductions being mandated
- **Natural Fiber Based Materials Emerging**
  - Local raw material stream to meet GHG emission standards
  - Cost effective Solutions required
  - OEMs beginning to embrace sustainable materials
  - Performance standards cannot be compromised
- Recycling must be envisioned up front