ULSAB-Advanced Vehicle Concepts

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United States Steel Corporation

February 19, 2003
Great Designs in Steel
U.S. Partnership for a New Generation of Vehicles (PNGV)
EUCAR

PNGV Class

C-Class

Structural Platform for achieving...

- Anticipated crash safety requirements for 2004
- Improved fuel efficiency
- Environmental performance
- High volume manufacturability
- and at no additional cost
Program Achievements

Highest Star Ratings Potential 4x★★★★★★

Manufacturing Costs: $9,500 (Gasoline) $10,200 (Diesel)

Fuel Consumption: 52 mpg (Gasoline) 68 mpg (Diesel)

Vehicle Mass: 2200 lbs. (Gasoline) 2273 lbs. (Diesel)
Materials – Strength vs. Formability

- Low Strength Steels (<210MPa)
- High Strength Steels
- Ultra High Strength Steels (>550MPa)

Elongation (%)

Yield Strength (MPa)

Conventional HSS
AHSS
MART

Materials – Strength vs. Formability

- IF
- Mild
- IS
- BH
- TRIP
- CMn
- DP, CP
- HSLA
- MART

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Advanced High-Strength Steels

• AHSS grades provide a composite structure of unique steel phases (Ferrite, Austenite, Martensite)

• The interaction of the phases with each other and strain result in mechanical properties that provide advantages in automotive applications

• AHSS grades provide the performance of HSS grades with improved formability that results from the high work hardenability
## Expectation of Improved Crash Safety

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Full Frontal</td>
<td>USNCAP 35 mph Full Frontal Pass Test Criteria</td>
<td>USNCAP 35 mph Full Frontal 5-Star</td>
<td>* Same Energy * 5 star Criteria</td>
</tr>
<tr>
<td>Offset Frontal</td>
<td>AMS 34 mph 50% Offset Intrusion &lt; 150mm</td>
<td>Euro NCAP 40 mph 40% Offset Intrusion &lt; 150 mm</td>
<td>* 38% More Energy * Same Intrusion</td>
</tr>
<tr>
<td>Side Impact</td>
<td>EEVC Side 31 mph 950 kg trolley Intrusion &lt; 8m/sec</td>
<td>SINCAP 38.5 mph 1370 kg trolley Intrusion &lt; 7m/sec</td>
<td>* 122% More Energy * Reduced Intrusion</td>
</tr>
<tr>
<td>Side Pole</td>
<td>Event Not Considered</td>
<td>Side Pole 20 mph Intrusion &lt; 8m/sec</td>
<td>No Equivalent Event</td>
</tr>
<tr>
<td>Rear Impact</td>
<td>US FMVSS 301 4000 lbs trolley Intrusion &lt; 120mm</td>
<td>US FMVSS 301 4000 lbs trolley Intrusion &lt; 50mm</td>
<td>* Same Energy * 60% less intrusion</td>
</tr>
<tr>
<td>Roof Crush</td>
<td>FMVSS 216 (Rollover) 1.5 x Veh. Wt. Intrusion &lt; 127mm</td>
<td>Roof Crush (Roll Over) 2.5 x Veh. Wt. Intrusion &lt; 127mm</td>
<td>* 66% More Energy * Same Intrusion</td>
</tr>
</tbody>
</table>
100% High-strength steel (HSS) body structure
Over 80% Advanced high strength steels (AHSS)
Insights to future applications of steel
Only 81 major parts in body structure
PNGV-Class body only 481 lbs (218 kg)
Materials & Processes - PNGV-Class

- Dual Phase
- BH
- Mart
- TRIP
- IF
- HSLA
Cost Avoidance by Part Consolidation

- Innovative Design
- Advanced Processing
  - Laser-Welded Blanks
  - Tubular Hydroforming
Material Evolution

Percent Body Structure

Material Strength

<table>
<thead>
<tr>
<th>% Body Structure</th>
<th>ULSAB-AVC (218 Kg)</th>
<th>ULSAB (203 Kg)</th>
<th>Yr2000 Ref (270 Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref</td>
<td>UHSS</td>
<td>HSS</td>
<td>Mild</td>
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</tbody>
</table>

Body Mass

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## Manufacturing Cost Assessment

<table>
<thead>
<tr>
<th>Body Structure Costs</th>
<th>ULSAB</th>
<th>AVC</th>
<th>PNGV</th>
<th>ULSAB</th>
<th>Reference Structure</th>
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<tbody>
<tr>
<td>Steel Cost</td>
<td>$468</td>
<td></td>
<td></td>
<td>$416</td>
<td>$369</td>
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<tr>
<td>Forming Cost</td>
<td>213</td>
<td>250</td>
<td></td>
<td>281</td>
<td>328</td>
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<tr>
<td>Assembly Costs</td>
<td>291</td>
<td>281</td>
<td></td>
<td>328</td>
<td>369</td>
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<tr>
<td>Total Body Structure Costs</td>
<td>$972</td>
<td>$947</td>
<td></td>
<td>$979</td>
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<table>
<thead>
<tr>
<th>Tooling Investment Cost</th>
<th>$40.3 M</th>
<th>$51.2 M</th>
<th>$68.0 M</th>
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</thead>
<tbody>
<tr>
<td>Parts Count (major parts only)</td>
<td>81</td>
<td>96</td>
<td>135</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Body Structure Mass</th>
<th>218 Kg</th>
<th>203 Kg</th>
<th>270 Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crash Requirements</td>
<td>2004</td>
<td>2000</td>
<td>2000</td>
</tr>
</tbody>
</table>
Closures
Chassis and Suspensions

Wheels

Front & Rear Suspension

Engine Cradle

Bumper System
Summary

- A new class of advanced automotive materials that are unique in microstructure and material behavior
- In automotive design, these grades provide unprecedented opportunity for improving crash performance while reducing mass and cost
- THE SOLUTION to meet the structural material requirements for the next generation of automotive applications
- ULSAB-AVC is an example of the application of these new materials (AHSS) in a full vehicle design
ULSAB-AVC NOW REQUIRES:

- Application of the principles of this specific program to your designs.

- Solutions to the manufacturing challenges necessary to fully apply these principles.
Addressing These Concerns Through:

- American Iron and Steel Institute
- International Iron and Steel Institute
- Auto/Steel Partnership
- ULSAB-AVC
- United States Department of Energy
- Government Labs
- Universities
2003 Great Designs in Steel Seminar

Manufacturing Issues of AHSS
- Formability
- Weldability
- Springback
- Laser welded blanks
- Die wear issues

Performance Issues of AHSS
- Fatigue
- Crash (Strain Rate)
- Spot Weld Fatigue
- Repairability