EXECUTIVE SUMMARY

ULSAB-AVC

Advanced Vehicle Concepts

January 2002
EXECUTIVE SUMMARY

The ULSAB-AVC (Advanced Vehicle Concepts) Program is a study undertaken by the global steel industry to showcase the latest high-tech steel grades for automotive applications—Advanced High-Strength Steels (AHSS). This study reveals that use of new AHSS grades in vehicle architectures will provide an unprecedented high level of crash safety performance at no cost increase. At the same time, use of these steels will enable automakers to reduce the environmental impact of their vehicles through increases in fuel economy, significant cost reduction, and steel's inherent ease of recycling.

ULSAB-AVC demonstrates high volume, steel-intensive concepts, Figures 1 and 2, for the popular European C-Class and the North American Midsize-Class (referred to as the PNGV-Class). These designs represent just one possible approach for applying the unique properties of AHSS steel, providing engineering insight into their broad use in vehicles. The resulting concepts provide the foundation to develop vehicles that:

- Meet crash safety requirements anticipated for 2004 -
  - Five star crash performance in both the United States and Europe for:
    - full frontal (US-NCAP),
    - frontal offset (Euro-NCAP),
    - side impact (US-SINCAP), and
    - side pole crash.
- Can be manufactured affordably -
  - Manufacturing cost estimates ranged from $9,500 for the 4-door midsize sedan (PNGV-Class) with a gasoline engine to $10,200 for the same vehicle with a diesel engine. The body structure costs less than $1,000.
- Reduce the automobile's environmental footprint -
  - Gasoline engine version would achieve 52 mpg in U.S. combined driving cycle (48 mpg city/60 mpg highway), and the diesel variant would achieve 68 mpg in U.S. combined driving cycle (62 mpg city/78 mpg highway).
  - Made from steel, the most recycled material in the world.
  - Apply AHSS, using less steel to make improved, high-strength vehicle components.

AHSS - Key Enablers

Advanced high-strength steels are key enablers to the achievements realized in these vehicle concepts. These newly available high-tech steel grades exhibit a superior combination of high strength, crash energy management, excellent formability and dent resistance. They offer vehicle designers more freedom in how they address crushworthiness, packaging, styling and mass reduction.

The principal difference between AHSS and conventional high-strength steel (HSS) is in their microstructure. Conventional HSS is formed by adding certain alloys to the microstructure, whereas AHSS is formed by controlling the cooling rate of the steel. The resultant steel: (Figure 3)

(Continued)
- Is highly formable while attaining high strain hardening capacity, which results in higher strength steel and excellent part forming.
- Can achieve even higher strengths through increased work hardening (i.e., stamping of a part) and bake hardening effects (i.e., post part-forming bake treatment or post paint-operation baking - Figure 4).
- Can be more easily applied to a broader range of component designs, with excellent forming while increasing component strength.
- Can often be substituted for thicker gauge, lower strength steels used in existing component designs with potentially no change in tooling dies.

**Crashworthiness**

Since the ULSAB-AVC Program focused on steel vehicle applications for the year 2004 and beyond, the Program set crash requirement standards that, in some cases, are as much as 60 percent more severe than current U.S. and European crash requirements.

ULSAB-AVC vehicles incorporate unique steel design innovations to achieve five-star crashworthiness, including:

- Bodies-in-white (BIW) comprise more than 80 percent AHSS, with the remaining 20 percent high-strength steels. (Figure 5)
  - Components employ advanced technologies such as hydroforming and tailored blanks for optimized part design and reduced part count.
  - Combination of AHSS and manufacturing technologies results in body structures that contain just 81 major parts, contributing to structural efficiency and lower costs.

- Specific body structure examples of AHSS use are:
  - AHSS steel tailored tube front rails combining 1.3 mm and 1.5 mm thickness materials to optimize efficiency, mass and front crash performance. (Figure 6)

(Continued)
• Dash crash box structure, designed primarily to absorb energy in full frontal and 40 percent offset crash events. AHSS in this structure ensures that crash loads are widely distributed through the vehicle at reduced mass. (Figure 7)

• Fixed seat concept using AHSS seat crossmember and crossmember extension, providing the strength and rigidity needed to maintain passenger compartment integrity in side crash.

![Hydroformed Body Side Members](image)

Figure 8. Hydroformed body side members

• AHSS hydroformed side roof rails that effectively disseminate crash energy along the roof at a reduced part count. This component, combined with an AHSS rocker section, creates the stable body side ring needed for side impact protection. (Figure 8)

Reducing Vehicle Environmental Footprints, Affordably

AHSS applications in automobiles yield significant benefits to the environment, while maintaining affordable manufacturing costs. ULSAB-AVC vehicles feature dramatic increases in fuel efficiency and reduction in CO₂ emissions. According to calculations using the U.S. Combined Driving Cycle (combination of city and highway driving) requirements, (Table 1)

ULSAB-AVC vehicles use either a gasoline or diesel engine and manual transmission with automatic gearshift actuator.

AHSS means less impact on natural resources:

- AHSS can be applied at thinner gauges than conventional steels for reduced overall vehicle mass, while actually improving component strength and maintaining crash performance. (Figure 9)
- Thinner gauges mean less steel tonnage is needed for high-volume manufacture.
- AHSS has the same recyclability attributed to conventional steel.
- Steel’s recycling rate is far higher than that of any other material, capturing more than twice as much tonnage as all other materials combined.
- Steel’s established recycling loop and the ease with which steel scrap is magnetically reclaimed helps today’s designers make end-of-life total vehicle recycling a vital part of product planning.

![Simulated Hat Channel Crash Tests](image)

Figure 9. Dual Phase AHSS substitution for conventional HSS yields up to 24% mass reduction in this part example

<table>
<thead>
<tr>
<th>U.S. Driving Cycle</th>
<th>PNCV-Class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gasoline</td>
</tr>
<tr>
<td>CO₂ emissions (Combined)</td>
<td>198</td>
</tr>
<tr>
<td>Combined [g/km]</td>
<td>52</td>
</tr>
<tr>
<td>City [mpg]</td>
<td>48</td>
</tr>
<tr>
<td>Highway [mpg]</td>
<td>60</td>
</tr>
</tbody>
</table>

**Average manual & automatic transmission modes.

Table 1: Fuel Economy Results

ULSAB-AVC vehicles are steel-intensive designs, including suspensions, seat structures and wheels, as well as the BIW. Consequently, these vehicles offer the benefits of steel’s well-known recycling heritage.
**Big Benefits, Little Cost Impact**

AHSS use has little impact on manufacturing costs, while offering high-tech advantages of higher strength with excellent formability. Table 2 compares:

- **ULSAB-AVC PNVG-Class AHSS vehicle body structure investment with**
- **UltraLight Steel Auto Body (ULSAB), a high-strength steel body structure**
- **Reference Structure vehicle, representing current body structure costs.**

Tooling investment is perhaps the most interesting evidence of ULSAB-AVC's affordability, with a cost savings of about 40 percent over a conventional vehicle.

Table 3 summarizes the total vehicle manufacturing costs:

These manufacturing costs include:

- $1,400 BIW manufacturing cost.
- $580 approximate BIW steel material cost.

For as little as 15 percent of the total vehicle cost, the BIW concept designs offer optimized body structures that meet considerably more aggressive safety requirements than applied in any other vehicle structures and are fully recyclable.

**Affordability Comparison**

An analysis (Figure 10) comparing ULSAB-AVC PNVG-Class diesel-powered vehicle variant (in accordance with PNVG criteria) with other PNVG-related concepts, as well as current Midsize vehicles, revealed manufacturing costs that are:

- One-third to one-fifth the projected selling prices of PNVG diesel hybrids.
- One-half the projected selling price of current Midsize gasoline vehicles.

The ULSAB-AVC PNVG-Class vehicle offers design options for achieving improved fuel economy and superior crash performance in high volume production vehicles that can be sold profitably at competitive prices.
ULSAB-AVC offers near- and long-term solutions for affordable, safe and environmentally responsible vehicles. AHSS and related manufacturing technologies provide the means to develop vehicle architectures that are safe and efficient at reduced mass and affordable costs.

This document was prepared by:
Automotive Applications Committee of the
American Iron and Steel Institute
2000 Town Center, Suite 320
Southfield, Michigan 48075-1123
1.800.STEELWORKS
http://www.autosteel.org
http://www.ulsab-avc.org
http://www.steel.org

The following companies are represented on the AAC:

Bethlehem Steel Corporation
Dofasco Inc.
Ispat Inland Company
National Steel Corporation
Rouge Steel Company
United States Steel Corporation