MEETING FUEL ECONOMY & EMISSIONS REGULATIONS WITH ALUMINUM

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DISCUSSION AGENDA

- What is CAFE?
- The Role of Automotive Aluminum
- Continuous Improvement
- Questions
CORPORATE AVERAGE FUEL ECONOMY (CAFE)
The National Program to reduce greenhouse gas emissions

Improvements in fuel economy for light-duty cars and trucks directly proportionate to reductions in CO2

Program often referred to collectively as CAFE. CAFE is only a portion of the standard.
OPEC OIL EMBARGO

- Members of OAPEC proclaimed oil embargo in Oct. 1973 against Canada, Japan, the Netherlands, the United Kingdom and United States.

- Embargo raised price of oil by 70 percent, cut production by 5 percent and add’l 5 percent cut in production monthly until economic and political objectives were met.

- Peace talks ended embargo in March 1974.
1975: Congress orders NHTSA to regulate & improve fuel economy

1978: First passenger car CAFE standard set for Model Year 78

1985: 1986: NHTSA agrees to lower CAFE standard to 26 MPG for Model Year 1986-1988 due to lobbying by domestic automakers

2000: 2007: April: Supreme Court rules the EPA has authority to set CO2 and other GHG standards

2009: EPA and NHTSA propose new standards for MY 2012-2016 targeting 34.1 MPG by 2016

2011: Obama administration and 13 automakers agree to support a standard of 54.5 MPG by 2025

2012: CO2 and MPG standards for 2017-2025 adopted by NHTSA and EPA

2013: NHTSA to commence on conditional MY2017 and later CO2 and mpg standards

Source: Edmunds.com
MIDTERM REVIEW

- Initial rule included regulatory commitment to conduct a Midterm evaluation in 2017
- EPA will reexamine the GHG standards for model years 2022-2025
- NHTSA will review fuel economy standards based on the best available technical research information
- Could elect to reduce, maintain or even increase the currently agreed to standard
CAFE OVER THE YEARS

Corporate Average Fuel Economy (CAFE) Standards
1978 - 2025

Many vehicles sold today exceed fleet-wide targets

1990: 27.5mpg
2010: 27.5mpg
2025: 61.0mpg
2025: 55.5mpg

Fig. a | Data Source: (Anderson, Terry, 2011) Graph Credit: Fernando Arias
EMISSIONS DECREASES OVER THE YEARS
MEETING FUEL ECONOMY/EMISSIONS STANDARDS

- Advanced engine technologies (diesel, hybrid, electric)
- Efficient transmissions (CVT, 8-speed)
- Aerodynamic designs
- Mass reduction: Increased use of advanced aluminum alloys
- Credits (two types)
  - Off-cycle
  - CAFE
DUCKER WORLDWIDE AUTOMAKER SURVEY

- 2015: Highest growth year
  - First high-volume automotive body and structure (F-150 pickup)
  - Sheet and extrusions – body, closures

- By 2020: multiple OEM will have more than one aluminum-intensive body and multiple aluminum-intensive closure programs

Source: 2015, Ducker Worldwide
THE ROLE OF AUTOMOTIVE ALUMINUM
THE VIRTUOUS CYCLE

Mass Reduction

Lowest Lifecycle Emissions

Better Fuel Economy

Improved Safety

Enhanced Performance

Infinitely Recyclable
1975-2025: 50 YEARS OF ALUMINUM GROWTH

Source: Ducker Worldwide
ALUMINUM BODY COMPONENTS

- Body-in-White
- Bumper Beams
- Shock Towers
- Door and other closure inners
- Fenders
- Deck
- Door outer
- Hood
Aluminum is essential to meeting 2025 fuel economy & emissions standards

Estimate of mass reduction needs now 12% (from 7% in earlier study)

More confidence that aluminum use is consistent with current and future safety objectives

Source: 2015, The National Academy of Sciences
Aluminum favored among designers and engineers to help meet 2025 fuel economy and emissions targets.
ALUMINUM FILLS KEY REQUIREMENTS

What Automakers Want:

1. **Weight reduction**
2. **Fuel economy/CO\textsubscript{2} gains (regulatory compliance)**
3. **Safety**
4. **Affordability**
5. **Performance**
   - 0-60; handling; ride; noise, vibration, harshness (NVH); braking, etc.
   - Payload, towing capacity
AUTOMOTIVE MATERIAL MIX SHIFT - LIGHTER

### 2015
- **Mild Steel**: 17%
- **HS Steel**: 14%
- **FR AHSS**: 5%
- **All Other Steel**: 16%
- **Iron**: 8%
- **Al Str Castings**: 1%
- **All Other Al**: 8%
- **Other Metals**: 3%
- **Copper**: 1%
- **Non Metallics**: 23%

### 2025
- **Mild Steel**: 12%
- **HSLA**: 7%
- **AHSS**: 11%
- **Other Steel**: 16%
- **Iron**: 8%
- **Rolled Al**: 4%
- **Ext Al**: 1%
- **AL Str Castings**: 1%
- **Cast Al**: 8%
- **Copper**: 1%
- **Other Metals**: 3%
- **Non Metallics**: 25%

**Aluminum**
- **2015**: 10% (3700 lbs.)
- **2025**: 13% (3427 lbs.)
MASS REDUCTION WITH ALUMINUM

- 1.0 lb. of aluminum replaces 1.6 lbs. of steel
  - Body: -40% mass
  - Curb mass: Up to -12%

- Improved fuel economy
  - 10% achievable

- Reduced life-cycle CO₂ emissions
  - 20% achievable

- Improved safety
  - Without downsizing
  - Increase crush space without increasing weight
  - Reduce kinetic energy

- Cost advantage compared to other fuel economy improvement technologies
MULTI-MATERIAL VEHICLES: THE NEW NORMAL

© Cadillac

CT6

© Chrysler

Pacifica

© BMW

7-Series

© Mercedes-Benz

S-Class

© BMW

i3

© Chevrolet

Malibu
ALUMINUM-INTENSIVE VEHICLES

Body-in-White and Closures
MEETING STANDARDS IN THE REAL-WORLD

- **EPA**: Ford F-150 already meeting 2024 standards
- **Ducker Worldwide**: By 2020, multiple OEMs will have more than one aluminum-intensive body and multiple aluminum-intensive closure programs
1. **Weight Reduction**
   - 320+ Kg (12%) of curb mass shaved with help of aluminum
   - Majority of curb mass reduction achieved via aluminum body-in-white and closures
     - Body: - 250 Kg (39%)

Source: Ford Motor Company
BENCHMARK: FORD F-150

2. Fuel Economy/CO₂

- Highest EPA-estimated fuel economy ratings of any full-size gas-powered pickup in America. (19 city/26 hwy/22 combined)**

- Aluminum-bodied Ford F-150 named “Best Environmental Performance” for achieving "the highest level of protection for the environment throughout its life-cycle.“***

*Source: EPA  
**Source: Ford Motor Company  
***Source: Automotive Science Group
3. **Safety**
   - Improvement in every category for aluminum-bodied model
   - 5-star safety rating from the National Highway Traffic and Safety Administration

<table>
<thead>
<tr>
<th>Year/Make/Model</th>
<th>Overall</th>
<th>Frontal Crash</th>
<th>Side Crash</th>
<th>Rollover</th>
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</thead>
<tbody>
<tr>
<td>2015 Ford F-150 4x4</td>
<td>⭐⭐⭐⭐⭐</td>
<td>⭐⭐⭐⭐⭐</td>
<td>⭐⭐⭐⭐⭐</td>
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<tr>
<td>2014 Ford F-150 4x4</td>
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<td>⭐⭐⭐⭐⭐</td>
<td>⭐⭐⭐⭐⭐⭐</td>
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</table>

Source: safercar.gov
3. **Safety (cont.)**

- 2016 F-150 SuperCab named “**IIHS Top Safety Pick**” in April 2016
- Only full-size pickup awarded a “good” rating in all categories
BENCHMARK: FORD F-150

4. **Consumer Affordability**
   - 2015 base model just $395 more than the 2014 version, despite array of new equipment and technology.
   - MSRP increase typical when launching complete redesign.

Source: Ford Motor Company
5. **Performance**

- Mass reduction = increase load-carrying performance

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*Based on F-150 SuperCrew Cab with 3.5 L Ecoboost engine and 6.5 ft. bed*

*Source: Ford Motor Company*
CONTINUOUS IMPROVEMENT
## ALUMINUM POISED TO MEET 2025 DEMAND

### NAFTA Aluminum Rolling Capacity (Sheet and Plate)

<table>
<thead>
<tr>
<th></th>
<th>Total S&amp;P</th>
<th>Body Sheet*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2015</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demand</td>
<td>10.6 B lbs.</td>
<td>1.1 B lbs.</td>
</tr>
<tr>
<td>Total Capacity</td>
<td>12.6 B lbs.</td>
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<tr>
<td>Domestic</td>
<td>11.3 B lbs.</td>
<td>1.5 B lbs.</td>
</tr>
<tr>
<td>Imports</td>
<td>1.3 B lbs.</td>
<td>-</td>
</tr>
<tr>
<td><strong>2025</strong></td>
<td></td>
<td></td>
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<tr>
<td>Demand</td>
<td>13.1 B lbs.</td>
<td>3.7 B lbs.</td>
</tr>
<tr>
<td>Opportunity</td>
<td>+0.5 B lbs.</td>
<td>+2.1 B lbs.</td>
</tr>
</tbody>
</table>

* Unique cold rolling, finishing, HT, coating

Sources: Harbor, Ducker Worldwide
DECREASED ENERGY USE

Sources: Aluminum Association
REDUCED CARBON FOOTPRINT

Sources: Aluminium Association
Aluminum-intensive vehicles offer lowest life cycle energy (↓20%) and CO₂ impact (↓17%) vs. modern steel vehicles.

Use phase contributes over 90% of life cycle impacts.

Steel vehicle’s higher use phase energy and CO₂ cancels out production phase advantage.

Source: 2014, Oak Ridge National Laboratory
ALCOA MICROMILL™ TECHNOLOGY

Industry Breakthrough

✓ 20 min. vs. 20 days ✓ 40% more formable ✓ 30% stronger than incumbent

...to 20 minutes with the Micromill™

Melt/Cast Hot / Cold Mill

...and reducing the footprint to ~150 ft

Just one-quarter the size of a conventional mill

Source: Alcoa Inc.
Advanz 7000-series

- Designed for unsurpassed vehicle lightweighting and passenger safety
- Yield Strengths above 500 Mpa; above 600 Mpa in development
- Good elevated temperature formability
- Gauge Range of 1 mm - 3.0 mm

Source: Novelis
PRODUCTION PROVEN: HIGH-VOLUME JOINING SOLUTIONS

Chapters:
- Introduction to Joining
- Fusion welding
- Arc welding
- Beam welding
- Resistance welding
- Brazing
- Solid state welding
- Mechanical joining
- Adhesive joining
- Hybrid joining techniques
- Joining of dissimilar materials

[bit.ly/atgjoining]
SUMMARY
## IN SUMMARY

<table>
<thead>
<tr>
<th>Metric</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift to aluminum is accelerating</td>
<td>Ducker</td>
</tr>
<tr>
<td>Aluminum is safe</td>
<td>NHTSA</td>
</tr>
<tr>
<td>Saves more weight than steel</td>
<td>ORNL</td>
</tr>
<tr>
<td>Cost effective; offers greatest ROI</td>
<td>EDAG</td>
</tr>
<tr>
<td>Lowest life cycle carbon footprint</td>
<td>ORNL</td>
</tr>
<tr>
<td>Energy: (\downarrow) 20%</td>
<td></td>
</tr>
<tr>
<td>(\text{CO}_2: \downarrow) 17%</td>
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</tbody>
</table>
QUESTIONS