2012 National Equipment Fleet Management Conference

Advanced GHG Rule
Vehicle Speed Limiter and
Automatic Engine
Shutdown Prorate Strategies
& Advanced Technologies

David McKenna
Director,
Powertrain Sales
EPA and DOT/NHTSA have published final GHG and FE standards for heavy duty vehicles
- Mandatory from model year 2014
- New targets model year 2017

Sold trucks must be equipped with EPA approved features (e.g. aerodynamic kit)
- "Innovative technologies" = Super Econodyne generates credits

Canada and Mexico likely to follow

EPA promises a Phase 2 regulation in 2020 with an integrated vehicle approach that could be harmonized with EU
EPA’s GHG Emissions Standards, and NHTSA’s Fuel Efficiency Standards

- Separate engine and vehicle standards
- NHTSA standard is aligned with EPA CO₂ standard
  - NHTSA don’t cover other GHG emissions
- Three engines categories
  - Light Heavy-Duty
  - Vocational
  - Tractor
- Three types of heavy-duty vehicles
  - Heavy-duty Pickup Trucks and Vans
  - Vocational Vehicles, incl. buses
  - Combination Tractors
- Both standards allow early compliance from 2013
- Standards will be subject to future tightening (post 2020)
Pro-rated Speed Limiters Credit Generators

Allows for:
- Expiration
- Increased speed for passing
- Benefit is most sensitive to expiration mileage values

Effective speed = \(\text{ExF} \times \left(\text{STF} \times \text{STSL} + (1-\text{STF}) \times \text{DSL}\right) + (1-\text{ExF}) \times 65 \text{ MPH}\)

- \(\text{ExF} = \) expiration point miles/1,259,000 miles
- \(\text{STF} = \) max # of allowable soft top operation hours per day / 3.9 hours for day cabs
- \(\text{STF} = \) max # of allowable soft top operation hours per day / 7.3 hours for sleeper cabs
- \(\text{STSL} = \) the soft top speed limit
- \(\text{DSL} = \) default speed limit
Anti-idle Credit Generators

Prorated credit factors:
- Expiration
- Allowable idle time per year
- More sensitive to expiration mileage

Effective AES Input:
- \( = 5 \text{ g CO}_2/\text{ton-mile} \times (\text{miles at exp./1,259,000 miles}) \times \)
- \[1-(\text{maximum allowable number of idling hours per year}/1,800 \text{ hours})\]
## Fuel Consumption & GHG

### Truck Tractors Class 7 and 8

- NHTSA fuel consumption standards

<table>
<thead>
<tr>
<th></th>
<th>Fuel consumption standards MY 2016 (gallons/1000 ton miles)</th>
<th>Fuel consumption standards MY 2017 and later (gallons/1000 ton miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day cab</td>
<td>Sleeper cab</td>
</tr>
<tr>
<td></td>
<td>Class 7</td>
<td>Class 8</td>
</tr>
<tr>
<td>Low roof</td>
<td>10.5</td>
<td>8.0</td>
</tr>
<tr>
<td>Mid roof</td>
<td>11.7</td>
<td>8.7</td>
</tr>
<tr>
<td>High roof</td>
<td>12.2</td>
<td>9.0</td>
</tr>
</tbody>
</table>
## Fuel Consumption & GHG

### Heavy-Duty Vocational Vehicle
- NHTSA fuel consumption standards

|                       | Fuel consumption standards MY 2016 (gallons/1000 ton miles) |         |         |
|-----------------------|-------------------------------------------------------------|---------|
|                       | Light Heavy Vehicles | Medium Heavy Vehicles | Heavy Heavy Vehicles |
| Class 2b-5            | 38.1                                                          | 23.0    | 22.2    |
| Standard              | 36.7                                                          | 22.1    | 21.8    |

Source: Page 920
Fuel Efficiency

Class 2b-8 Vocational Vehicles

- Vehicle-based standard calculated via a vehicle simulation model (GEM)
- Only one input parameter
  - tire rolling resistance

<table>
<thead>
<tr>
<th>CO₂ (gram/ton-mile) standards for Vocational vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Heavy-Duty Class 2b-5</td>
</tr>
<tr>
<td>MY 2014-2016: 388</td>
</tr>
<tr>
<td>MY 2017-: 373</td>
</tr>
<tr>
<td>Medium Heavy-Duty Class 6-7</td>
</tr>
<tr>
<td>MY 2014-2016: 234</td>
</tr>
<tr>
<td>MY 2017-: 225</td>
</tr>
<tr>
<td>Heavy Heavy-Duty Class 8</td>
</tr>
<tr>
<td>MY 2014-2016: 226</td>
</tr>
<tr>
<td>MY 2017-: 222</td>
</tr>
</tbody>
</table>

Source: Page 668

Mack Lehigh Valley, Press Event
June 20, 2012
Fuel Consumption Impactors

CO₂ reduction for different features
- Example: Class 8 high roof sleeper cab

- SmartWay bin III (cd 0.60) 5.5
- Adv. SmartWay bin IV (cd 0.52) 10.7
- Adv. SmartWay II bin V (cd 0.47) 13.6
- Tires SmartWay (Steer 6.6, Drive 7.0) 3.0
- Tires Adv. SmartWay (Steer 5.7, Drive 6.0) 5.5
- Weight reduction Al wheels (lb -400) 0.3
- Idle reduction after 300 sec 5.0
- Speed limiter (63 mph) 3.1
- Speed limiter (60 mph) 7.2
- Needed reduction vs Conventional tractor 14.1

CO₂ gram/ton-mile
Fuel Consumption Profile

1. Idle Truck Stationary
   - Idle Speeds
   - Idle Shutdowns
   - PTO Settings

2. Acceleration
   - Powertrain
   - Shift RPM
   - Tires

3. Cruise at Steady Vehicle Speed
   - Aerodynamics
   - Tires
   - Cruise RPM

4. Deceleration
   - Tires
   - Aerodynamics

Duty Cycles
What uses Fuel When

Innovative Technologies are Required
High engine fuel efficiency + mDRIVE transmission optimization + Super C125 overdrive axles

Result: Complete system optimization, including hardware and software
Complete vehicle system evolution, providing exceptional fuel efficiency while maintaining excellent performance and drivability.

Evolution on all the Powertrain and vehicle components MP8-445SE, mDRIVE, C125 axles and software.

The SE package is designed to “down speed” the engine speed by approximately 200 rpm at highway speeds.

This reduces CO$_2$ and increases highway fuel economy about 2% over today’s vehicle performance.

At 65 mph, the engine will cruise at 1160 rpm (instead of 1380 rpm).

CoPilot Readout Screen:

- 1160 RPM
- 62 MPH
- 12$^{th}$ GEAR
Super Econodyne MP8

Engine Load At 65mph

Best Fuel Efficiency Here

Good Fuel Efficiency Here

Torque Curve

Torque

Idle 1150 1450

RPM

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**Sweet Spot Optimization**

**MP8-445SE Package**

- Much broader “sweet spot” of engine operation than typical Mack Econodyne engine.
- Allows engine to operate at maximum efficiency, even at road speeds higher than 65 mph.
LoadSense Variable Torque

- Adjusts the usable engine torque to suit the vehicle’s overall weight
- Time to speed is the same empty or loaded
- Maximum engine power is always available on GCW’s of 74,000 lbs. or higher
- mDRIVE and Manuals
Fuel Efficiency

- Smooth Cruise

Reduces cruise set point when climbing hills (based on torque demand) → Less power required, saves fuel

Increases cruise set point when going downhill → makes up for time lost in uphill → provides higher speed at bottom of next hill, saves fuel

Vehicle speed

Torque

Vehicle Cruise Control set Speed

Mack Lehigh Valley, Press Event
June 20, 2012
### Fuel Consumption Top 10 Impactors

<table>
<thead>
<tr>
<th>Rank</th>
<th>Category</th>
<th>If You Use or Have:</th>
<th>Instead Of:</th>
<th>MPG Improves By:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>DRIVERS</strong></td>
<td>Best Drivers</td>
<td>Worst Drivers</td>
<td>Up to 35%</td>
</tr>
<tr>
<td>2</td>
<td><strong>SPEED</strong> With Poor Aerodynamics</td>
<td>If you go slower by: 5 MPH</td>
<td>No Change</td>
<td>10 - 15%</td>
</tr>
<tr>
<td>3</td>
<td><strong>TIRES</strong> Deep Lug ➔ Rib</td>
<td>STEER / DRIVE / TRAILER Rib / Rib / Shallow Rib</td>
<td>STEER / DRIVE / TRAILER Rib / Deep Lug / Rib</td>
<td>6 - 14%</td>
</tr>
<tr>
<td>4</td>
<td><strong>IDLING</strong> With A/C on @ 1000 RPM</td>
<td>Zero Idle Time</td>
<td>50%</td>
<td>7 - 10%</td>
</tr>
<tr>
<td>5</td>
<td><strong>TRAILERS</strong></td>
<td>Single Van</td>
<td>Double Van</td>
<td>6 - 10%</td>
</tr>
<tr>
<td>6</td>
<td><strong>AERODYNAMICS</strong> With Cab Roof Devices</td>
<td>Full Roof Fairing</td>
<td>Nothing</td>
<td>Up to 15%</td>
</tr>
<tr>
<td>7</td>
<td><strong>SPEED</strong> With Excellent Aerodynamics</td>
<td>If you go slower by: 5 MPH</td>
<td>No Change</td>
<td>4 - 10%</td>
</tr>
<tr>
<td>8</td>
<td><strong>TIRES</strong> Lug ➔ Rib</td>
<td>STEER / DRIVE / TRAILER Rib / Rib / Shallow Rib</td>
<td>STEER / DRIVE / TRAILER Rib / Lug / Standard Rib</td>
<td>4 - 9%</td>
</tr>
<tr>
<td>9</td>
<td><strong>ENGINES</strong></td>
<td>Cruise Control</td>
<td>No Cruise Control</td>
<td>Up to 6%</td>
</tr>
</tbody>
</table>