CoolCab Truck Thermal Load Reduction

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DOE Vehicle Technologies Program
Advanced Vehicle Testing Activity
CoolCab Project

2008 Annual Merit Review
February 28, 2008
CoolCab Truck Thermal Load Reduction

**THE CHALLENGE**

Trucks idle for driver comfort. Idling consumes more than $2 billion in fuel per year for long-haul trucks.

Varying thermal conditions inhibit the use of idle reduction technologies.

**THE SOLUTION**

Design efficient thermal management systems that keep the cab comfortable without the need for engine idling.

Solar Reflective Glazings

NREL infrared testing identified potential to reduce heating and cooling loads with improved insulation.

- 1500W for typical heating – 20% improvement over baseline
- Reducing the load will enable idle reduction technologies
- 838 million gallon savings potential with no idling
CoolCab – Advanced Technologies

- Exhaust Heat Recovery
- Insulation
- IR Reflective Materials
- Comfort Based Air Distribution
- Advanced Seating – Low Mass
- Advanced Glazings or Shades
- Efficient HVAC Equipment
## Accomplishments

<table>
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<tr>
<th>Project</th>
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<tr>
<td>Idle Reduction Technology Validations</td>
<td>2003-2006</td>
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<td>Infrared Image Testing – Schneider National</td>
<td>2005</td>
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<td>Truck Cabin Test – Volvo</td>
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<td>2007</td>
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Infrared Image Test – Schneider National

- Investigate potential for improving cab efficiency
- Qualitative comparison
  - Identify high heat loss areas
  - Note areas with greatest potential for improvement
CoolCab Testing with Volvo

- Volvo truck at NREL for testing
  - 77-inch sleeper cab
  - On-board idle reduction technologies
    - Bergstrom battery electric A/C
    - Airtronic diesel-fired heater

- Objectives
  - Quantify truck cabin heat transfer
  - Identify potential areas for improvement

- Approach
  - Co-heat tests to determine UA
    - Measure effect of sleeper curtain and window shades
    - Insulate windows to quantify loss
  - Measure air exchange rate
  - Solar soak tests
    - Soak with windows insulated
  - Infrared imaging
Volvo Test Results

- **Heat transfer**
  - UA = overall heat transfer Coefficient = 65 W/K
  - 15% reduction (improvement) with sleeper curtain closed
  - 20% reduction with windows covered

- **Solar heat soak**
  - $\Delta T = \text{temperature rise above Ambient} = 15^\circ\text{C}$
  - $\Delta T = 5^\circ\text{C}$ with windows covered

- **Air leakage rate**
  - \(\sim 1\) air change per hour
CoolCab Testing with International

- International truck at NREL
  - ProStar sleeper cab tractor
  - Electric HVAC system with battery APU

- Objectives
  - Quantify truck cabin heat transfer
  - Predict HVAC system load requirements

- Began spring 2007
International Test Results

- **Heat transfer**
  - $UA =$ overall heat transfer Coefficient = 50 W/K
  - 20% reduction (improvement) with sleeper curtain closed
  - 25% reduction with arctic curtain
  - 13% reduction with windows covered

- **Solar heat soak**
  - $\Delta T =$ temperature rise above Ambient = 11°C
  - $\Delta T =$ 7°C with windows covered

- **Air leakage rate**
  - ~0.5 air change per hour
FY08 Work Plan – Thermal Modeling

- Previously developed model for International
  - Fluent CFD
  - Radtherm
- Validate with test data
  - Solar soak air temperatures predicted within 3°C
  - Apply multiple configurations
- Parametric runs – impact of enhanced thermal technologies
  - Baseline A/C case
  - Increased cab insulation
  - Solar reflective glass
## Class 8 CFD Analysis

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<tr>
<th></th>
<th>No Curtain</th>
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<th>No Curtain Shades</th>
<th>Curtain</th>
<th>Curtain 2X Insulation</th>
<th>Curtain Shades</th>
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</thead>
<tbody>
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<td>Sleeper T (°F)</td>
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<td>73.1</td>
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<td>Sleeper BTU</td>
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<td>A/C inlet temp</td>
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<td>Cab Temp (°F)</td>
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<td>23.5 %</td>
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FY08 – HVAC Load Calculation Tool

- Input key parameters
  - Truck cab geometry
  - Material properties
  - Climatic conditions

- Outputs
  - Calculate heating and cooling loads
  - Estimate potential load reduction

- Working with industry to define requirements
  - Truck OEMs
  - Idle reduction technology manufacturers
  - 21st Century Truck
Contact Information

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www.nrel.gov/vehiclesandfuels/fleettest