

# Advanced Collaborative Emissions Study –Emissions Characterization

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# Overview

- Timing
- Engines tested
- Emission test cycles
- Fuel/oil issues
- Emissions measured
- Possible results

# 2007 Heavy-Duty Diesel Engines

- Catalyzed particulate trap
- About 4 prototypes to be tested
  - Cummins
  - Mack
  - Volvo
  - Detroit Diesel Corporation

# 2010 Heavy-Duty Diesel Engines

- Again, 4 engines with particulate traps
- Manufacturers have not selected final NOx control system for production
  - NOx absorber
  - Selective catalytic reduction (SCR) – urea
  - Engine modifications
- Different manufacturers may use different approaches

# 2010 Heavy-Duty Diesel Engines

- Single engine of 4 characterized to be selected for detailed (and expensive) health testing
  - Will be hard to select single engine if different NOx control approaches used or if each engine has different emissions
  - Rigorous selection criteria not yet set
- Duplicate engine will also be obtained and characterized

# 2010 Heavy-Duty Diesel Engines

- Characterization and validation study to be done at health lab to ensure sampling is properly done
- During health testing
  - Routine emissions will be monitored continuously
  - Detailed emissions characterization to be done in middle and at end of health testing

# Emission Test Cycles

- EPA heavy-duty driving cycle
- Engine (not vehicle) testing
- Possibly some CARB driving cycles
  - Developed as part of CRC E55/59 program
  - 4 modes
  - Idle
  - Creep (very low speed, lots of idle time)
  - Transient (typical urban)
  - Cruise (on-highway with some acceleration/deceleration from idle)

# Emissions Characterization

- Emissions to be characterized during normal operation (engine properly tuned etc.)
- Engine to be operated as in-use and meeting manufacturers' specifications
- Malfunction conditions not included
- Emission testing to be done at standard temperatures
- Low and high temperature conditions not included

# Emissions

- Compare initial emission results to manufacturers' data to assure engine is operating properly
- Triplicate emission testing to establish variability
- Blank sample of background

# Fuel Specifications

- Low sulfur diesel fuel
- Typical of fuel to be in-use in 2007-2010 time frame
- Specifications for
  - Cetane 40-45
  - Aromatics 35-45%
  - Polycyclic aromatic hydrocarbons 8-10%
  - Distillation range (initial, 10%, 50%, 90%, end points)
  - Sulfur 12-15- ppm
- Use single batch of fuel for all testing if possible

# Oil Specifications

- Oil typical of those to be used in 2007-2010 engines
- Specifications
  - Sulfated ash 0.8-1.0%
  - Phosphorus 0.08-0.1%
  - Sulfur 0.25-0.50%

# Emissions

- Regulated emissions
  - HC, CO, NO<sub>x</sub>, PM
  - Size distribution of PM
- Unregulated emissions
  - List of 800 compounds
  - 3 categories by importance
    - Must be measured – about 190 compounds
    - Should be measured if reasonable to do so
    - Measured if it done concurrently with higher priority compounds or at little additional cost

# Emissions

- CARB diesel air toxics list
- EPA mobile source air toxics list
- EPA list of 16 key POM compounds
- Compounds listed in EPA Diesel Health Assessment Document
- South Coast Air Quality Management District list of toxics
- National Renewable Energy Laboratory Gasoline/Diesel PM Split Study
- Various nitrogenous species

# Unregulated Emissions – Categories of Compounds

- Metals/elements
- Inorganics
- Gas/particle hydrocarbons
- Branched alkanes
- Cycloalkanes/cycloalkenes
- Alkenes/alkynes
- Aromatics
- Halogenated compounds
- PAH compounds
- Nitro-PAH/oxygenated PAH
- Aldehydes/ketones
- Urea and other nitrogen compounds

# Measurement Issues

- Artifact loss/formation for PM collection may be a serious problem in characterizing emissions from 2007 and later diesel engines
- Nitro-PAH compounds being formed?
- CRC E66 project examining improved methods of PM collection
- National Renewable Energy Laboratory is funding work on to investigate occurrence of nitro-PAH artifact formation during sampling of 2007-like diesel emissions

# Possible Bioassay Type Tests

- Possible short term bioassay type tests (Ames tests and others) being considered to supplement emissions characterization
- An issue is how would such results be used in informing decisions on which engine to select for health testing?
- Another issue is can these results be used to select or tailor the long term health tests?
- Are such results affected by artifacts?
- No agreement yet on value of doing bioassay tests

# What Could the Results Be?

- HC, CO, NOx, and PM should be well controlled
- Will remaining PM be mostly small amounts of sulfates with trace of organics?
- Will more nitro compounds (e.g., nitro PAH) be found? (Artifact issue?)
- Will PM size distribution (ultra fines) be an issue?

# Utility of Results

- Will see if new unregulated compounds are being emitted
- Quantify emission reductions for unregulated compounds
- Will be used to inform health testing (can tailor specific health tests to address compounds/composition found)
- Update EPA speciation profiles (NREL/CRC E75 project)

# Summary

- HEI ACES emissions characterization is divided into 2 parts
  - 2007 engines
  - 2010 engines
- Comprehensive emission measurement over typical driving cycle(s)
- Comprehensive chemical characterization of emissions