

Collaborative Lubricating Oil Study on Emissions (CLOSE Project)



**Vehicle Technologies
Program Merit Review
Washington, DC**

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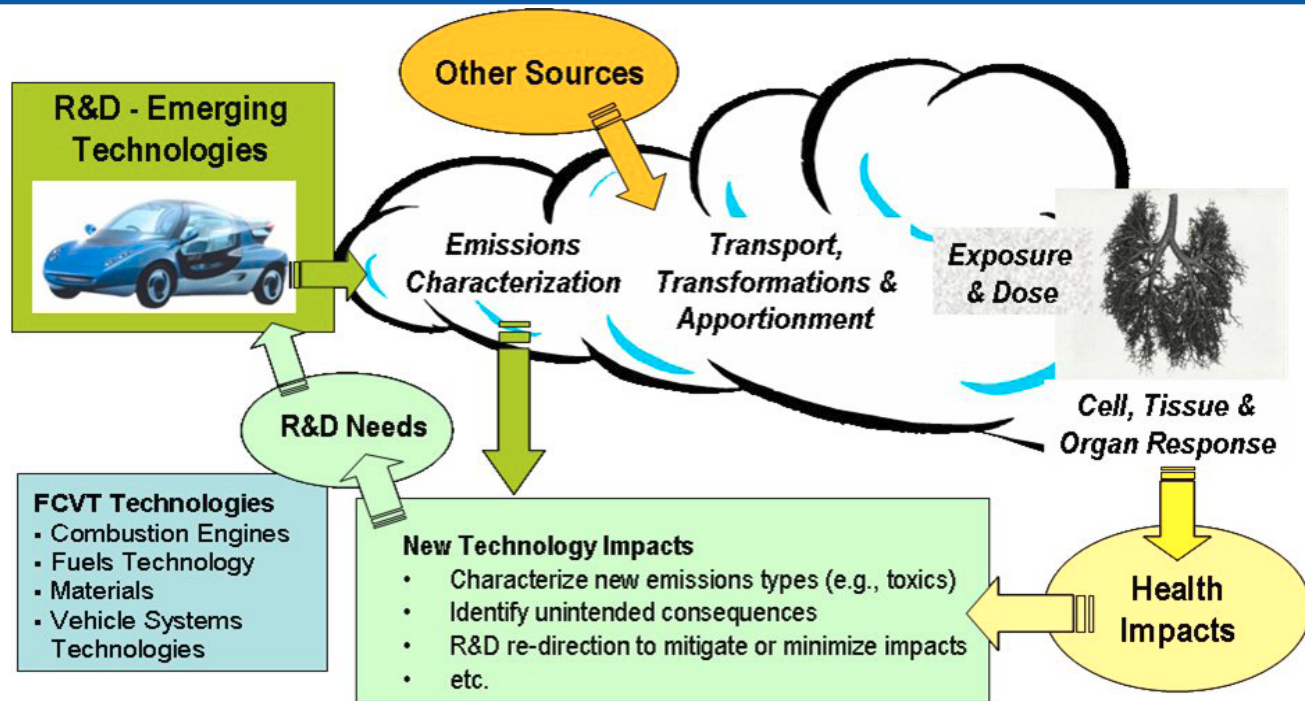
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Project ID: ACE046

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This presentation does not contain any proprietary, confidential, or otherwise restricted information

OVT Health Impacts Program



The objectives of VT Health Impacts Program are:

- To provide a sound scientific basis underlying any unanticipated potential health hazards associated with the use of new powertrain technologies, fuels and lubricants in transportation vehicles; and
- To ensure that vehicle technologies being developed by VTP for commercialization by industry will not have adverse impacts on human health through exposure to toxic particles, gases, and other compounds generated by these new technologies.

Overview

Timeline

- Start Date: April 2007
- End Date: November 2010
- Percent Complete: 80%

Budget

- Total Project Funding \$1.42 MM
 - \$892K FY06-FY10 DOE
 - \$322K CRC
 - \$200K SCAQMD/CARB thru CRADA with NREL
 - \$5K Lubrizol
 - All lubricants provided by American Chemistry Council Product Approval Protocols Task Group (PAPTG)

Barriers

VT Draft MYPP ACE R&D Goals

- Improve engine efficiency while meeting future federal and state emissions regulations
- Lack of data regarding fuel and lubricant interactions on emissions from pre-commercial, future, and in-use combustion engines
- Public understanding/knowledge of potential health impacts of new vehicle technologies

Partners

- South Coast AQMD
- California Air Resources Board
- Coordinating Research Council
- Lubrizol
- American Chemistry Council PAPTG

Relevance

Collaborative Lubricating Oil Study on Emissions CLOSE Project

Objective

Quantify the relative contributions of fuel and engine lubricating oil to motor vehicle particulate matter (PM) and semivolatile organic compound (SVOC) emissions through extensive chemical and physical characterization of emissions under a variety of engine operating conditions

Does the CLOSE Project Pass the “So What” Test?



- PM from light-duty vehicle “normal” emitter’s tailpipe = <1-2 mg/mile
- PM from new 2007-compliant heavy-duty diesel trucks = 1-4 mg/mile
- PM from Amy Winehouse’s open window at 60 mph = 5 mg/mile

But Source Apportionment Studies in urban areas suggest that a large fraction of $PM_{2.5}$ comes from mobile sources – Why??

Vehicle, Fuel, Lube, and Temp Test Matrix

Test Temperature	72°F (nominal)				20°F				
Test Lubricant	Fresh		Aged		Fresh		Aged		
Sample Number	1	2	1	2	1	2	1	2	
LD E0 gasoline (normal PM emitter)	✓	✓	✓	✓	✓	✓	✓	✓	Completed
LD E0 gasoline (high PM emitter)	✓	✓	✓	✓	✓	✓	✓	✓	Completed
LD E10 (normal PM emitter)	✓	✓	✓	✓	✓	✓	✓	✓	Completed
LD E10 (high PM emitter)	✓	✓	✓	✓	✓	✓	✓	✓	Completed
MD TxLED diesel (normal PM emitter)	✓	✓	✓	✓	✓	✓	✓	✓	Completed
MD TxLED diesel (high PM emitter)	✓	✓	✓	✓	✓	✓	✓	✓	Completed
MD B20 biodiesel (normal PM emitter)	✓	✓	✓	✓	✓	✓	✓	✓	Completed
MD B20 biodiesel (high PM emitter)	✓	✓	✓	✓	✓	✓	✓	✓	Completed
HD CNG (normal PM emitter)	✓	✓	✓	✓					Completed
HD CNG (high PM emitter)	✓	✓	✓	✓					Completed
HD TxLED diesel (normal PM emitter)	✓	✓	✓	✓					Completed
HD TxLED diesel (high PM emitter)	✓	✓	✓	✓					Completed

LD and MD Driving Cycle: California Unified Cycle (LA-92)

HD Driving Cycle: EPA HD Urban Dynamometer Driving Schedule (heavy duty chassis cycle)

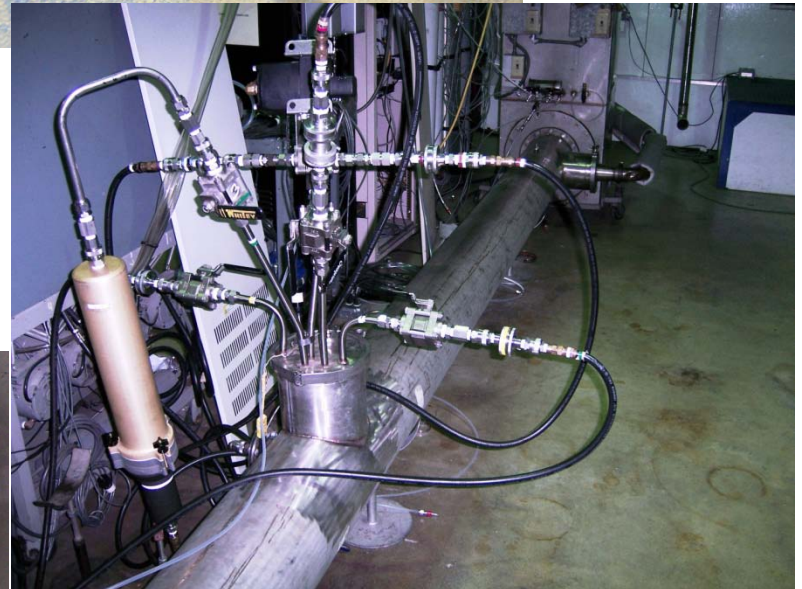
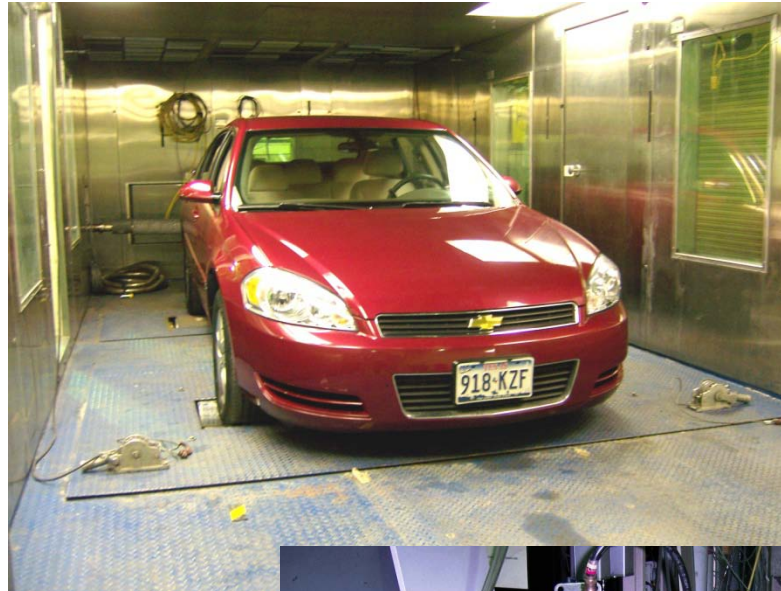
LD Vehicle Testing

LD normal emitter testing completed

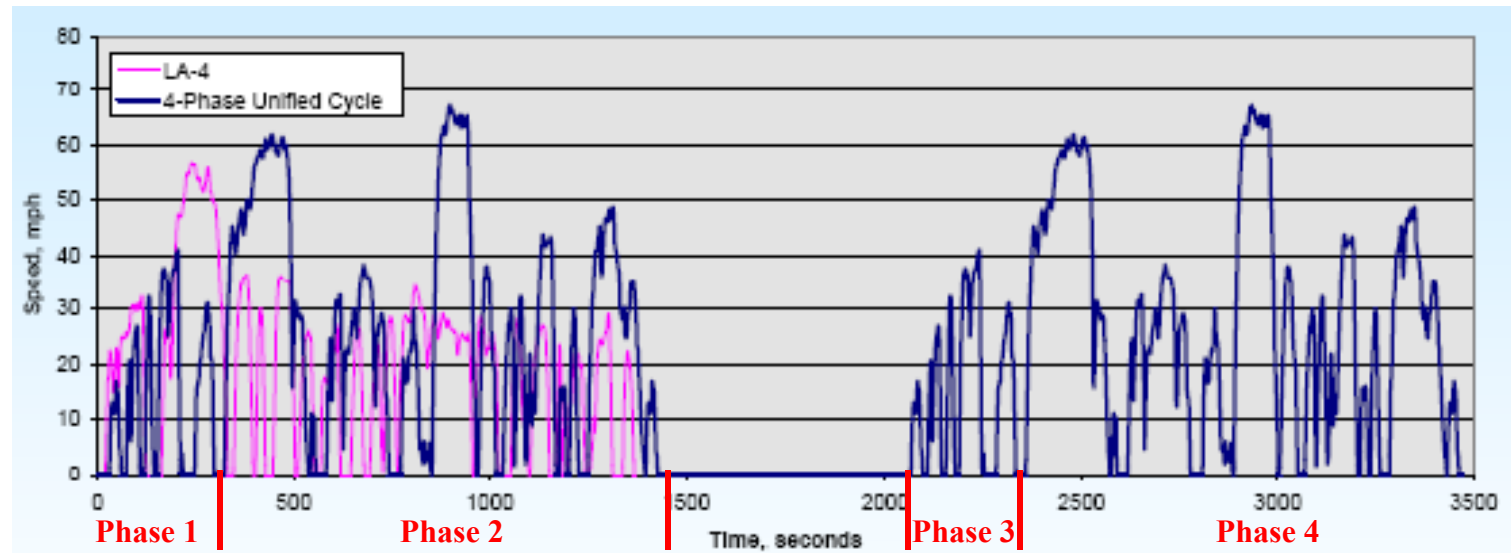
- 2006 Chevrolet Impala with 3.5L V6 engine
- 30,695 miles on odometer
- 5th highest passenger car sales in CY2006
- Based on previous experience, expected PM emission rate > 0.6 mg/mi

Performed follow-on testing with E0 at room temperature to check for vehicle and system drift; also collected ultrafine particles by size for chemical analysis

Showed LD data at previous Me Review Meeting



Four-Phase Unified Driving Cycle vs. LA-4 Test Cycle

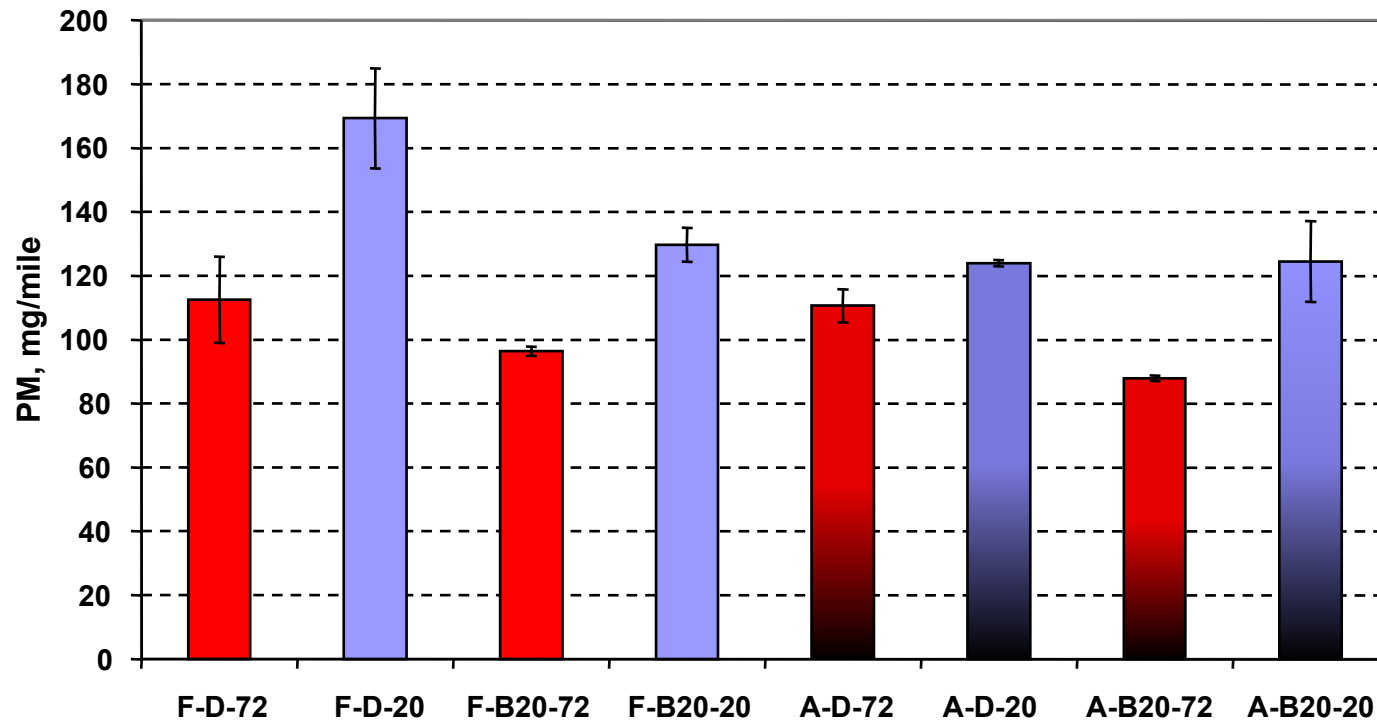


Medium-Duty Diesel Normal Emitter PM Emissions –

Emissions Increase at 20°

(Runs shown in test order, left to right)

Preliminary Data – Only One Vehicle (error bar = std. dev. of replicate runs)



Red = 72° testing; Blue = 20° testing;

Solid = Fresh (F) lube; Gradient = Aged (A) lube

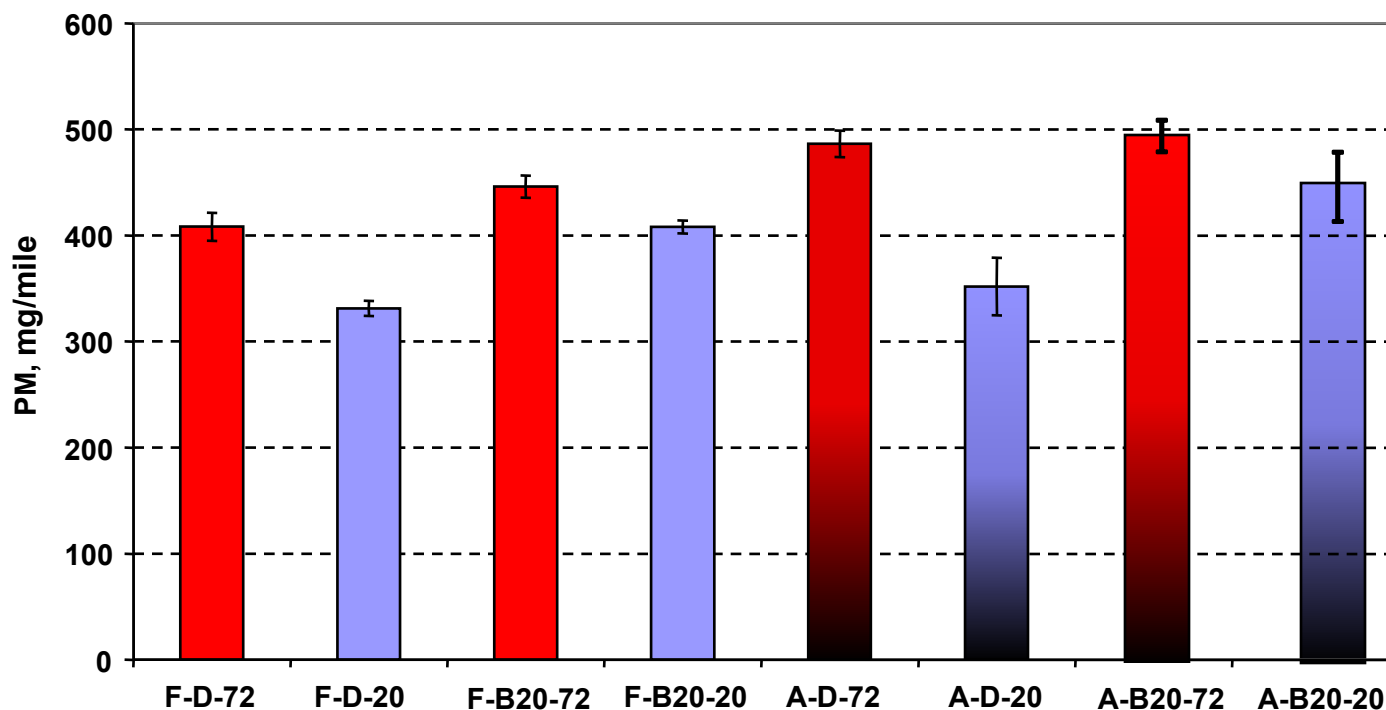
Fuels: TxLED (D) and B20

Medium-Duty Diesel High Emitter PM Emissions –

~4x Higher than Normal Emitter; Emissions Decrease at 20°

(Runs shown in test order, left to right)

Preliminary Data – Only One Vehicle (error bar = std. dev. of replicate runs)



Red = 72° testing; Blue = 20° testing;

Solid = Fresh (F) lube; Gradient = Aged (A) lube
Fuels: TxLED (D) and B20

CLOSE Milestones – FY09 and FY10

- Significant delays encountered in testing the MD diesel vehicles; mechanical problems with high emitter and with dyno testing facility
- Modifications to contracts now in place; additional funds (total \$165K: \$135K from DOE/NREL and \$30K from CRC) to cover additional chemical analyses of fuels and exhaust samples and vehicle procurement and evaluation
- Difficulties in HD vehicle recruitment also, but SCAQMD provided funding to ship the two CNG HD buses from the South Coast Air Basin. All CNG bus testing completed as of January 2010
- DRI chemical analyses of MD diesel normal and high emitter emissions data have been delivered to SwRI
- “Fresh” and “aged” lubricants have been shipped to Elemental Analysis Inc. for detailed elemental analysis
- SwRI and DRI are evaluating relative contributions of fuel and lubricant to exhaust emissions using available complex analytical data as they become available (new \$65k contract from NREL with internal funds)
- Project review meeting was held at SwRI in February 2010 to review analyses of LD vehicle emissions data; review meeting later this year to review analyses of MD and HD emissions data
- Project to be completed by November 30, 2010

Orion V Bus with a DDC S-50G CNG engine



Thanks to Mike Bogdanoff (SCAQMD) and Foothills Transit

Conclusions from CLOSE Project

None today; study in progress at present time; data from only the MD diesel vehicles presented; testing from the HD CNG and diesel buses completed; detailed analyses/source apportionment of exhaust from all vehicle samples now underway. Study findings will be reviewed by all CLOSE Project sponsors before being submitted for publication.

Come back next year for CLOSE Project conclusions!