Status of Heavy Vehicle Diesel Emission Control Sulfur Effects (DECSE) Test Program

June 7, 1999

DECSE Objective

Determine the impact of fuel sulfur levels on emission control systems that could be implemented to lower emissions of NO_x and PM from on-highway trucks in the 2002-2004 time frame.

DECSE Test Program Overview

- Emission Control Systems
  - Diesel oxidation catalysts
  - Lean-NO_x catalysts
  - NO_x adsorbers
  - Diesel particle filters
- Fuel Sulfur Levels: 3, 30, 150, 350 ppm
- Engines: modern, production engines for source of exhaust

DECSE Test Matrix

TECHNOLOGY	250 HOURS AGING @ each sulfur level					ENGINE	REMARKS
	3	30	150	350	30*		
Diesel Oxidation Catalyst	Special Navistar aging cycle					T444 (Navistar)	High precious metal loading
	Modified OICA aging cycle					ISM 370 (Cummins)	Low precious metal loading
Active Lean-NO_x Catalyst	Special Navistar aging cycle					T444	Low temperature catalyst
	Modified OICA aging cycle					ISM	High temperature catalyst
Continuously regenerating diesel particle filter (CR-DPF) and catalyzed diesel particle filter (CDPF)	80 min. aging cycle using 4 temperature points in sequence					3126 (Caterpillar)	Determine sulfur effect on regeneration temperature
NO_x Adsorber	3	30	150			HSDI (Daimler/Chrysler DDC prototype)	No 350-ppm or regeneration test
	3-hour aging cycle using 9 temperature points in sequence						

* Regeneration experiment

General Selection Criteria for Emission Control Devices & Engines

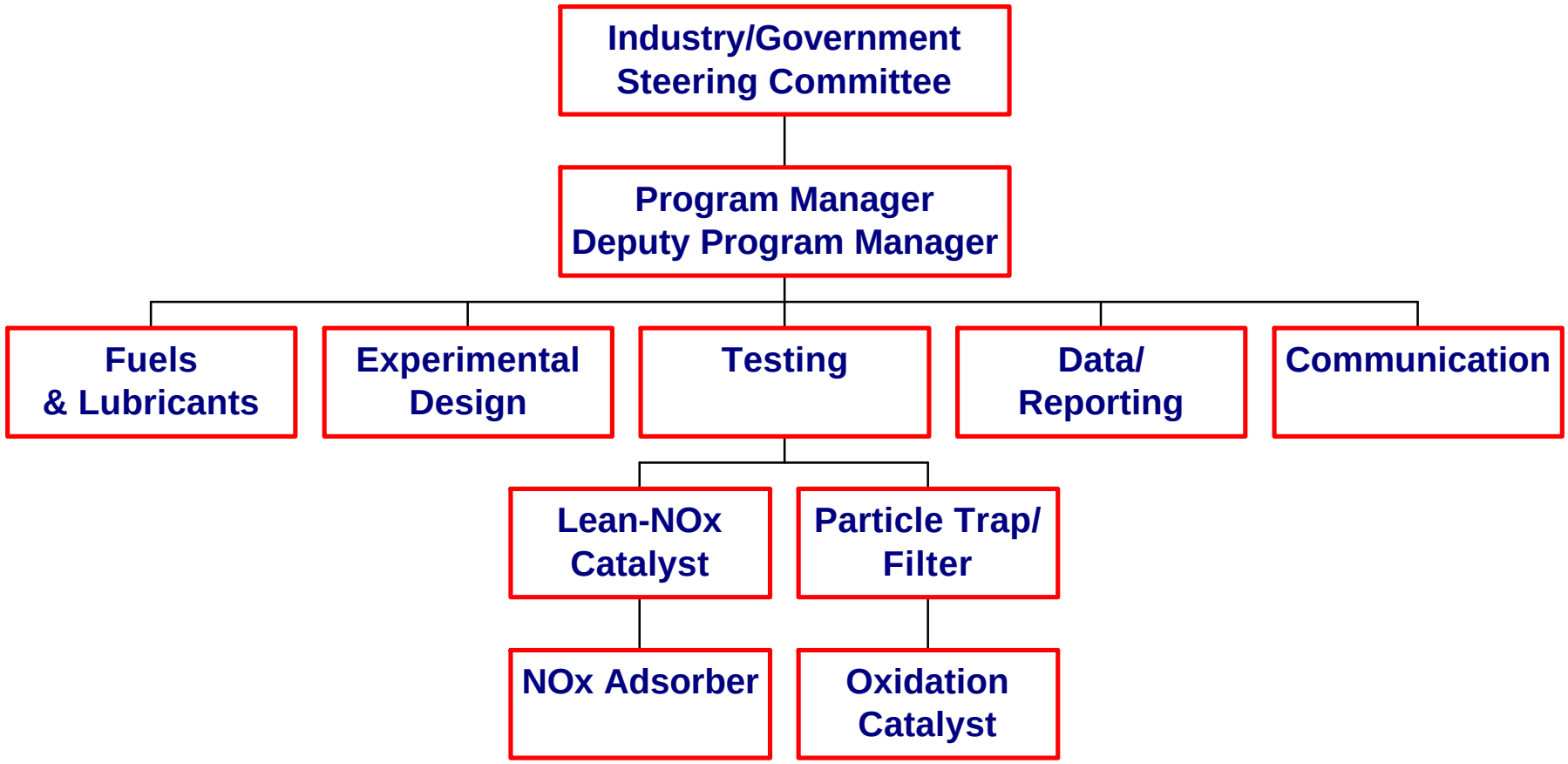
- Emission control devices
  - Commercially available technology -- devices representative of marketplace
  - Developing technology -- state-of-the-art

- Engines
  - Medium/heavy-duty preferred
  - Range of engines to provide exhaust temperature characteristic of range of roadway duty cycles
  - Generally, 1998 or 1999 calibration, electronic control, turbocharged, without exhaust gas recirculation

DECSE Organization

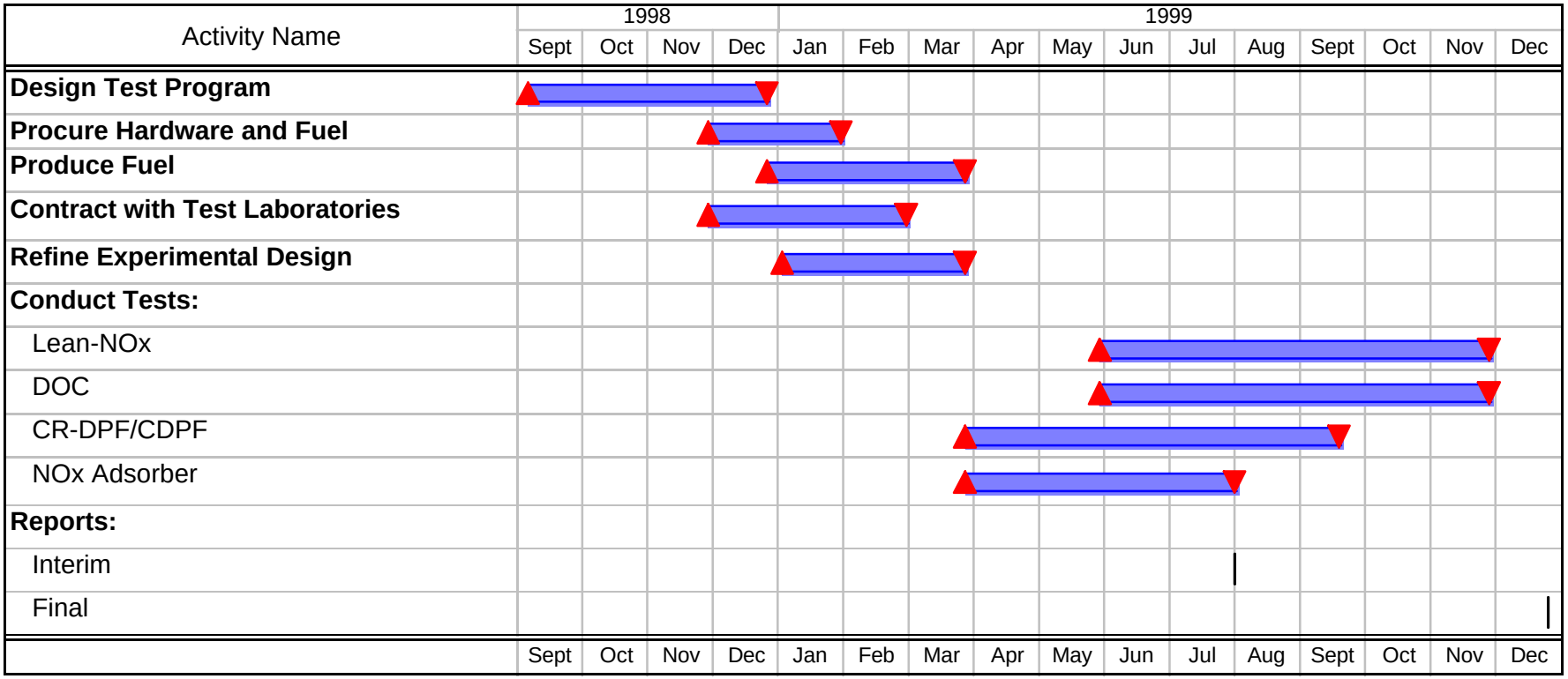
- Sponsors
  - Engine OEMs through Engine Manufacturers Association
  - Manufacturers of Emission Controls Association
  - DOE Office of Heavy Vehicle Technologies through NREL and ORNL
- Independent Test Labs
  - West Virginia University (oxidation and lean-NO_x catalysts)
  - FEV Engine Technology (NO_x adsorber)
  - Engineering Test Services (diesel particle filters)

DECSE Organization Chart



April 14, 1999

DECSE Schedule



June 4, 1999

DECSE Resources ($000)

	Government	Industry	Total
Direct Funding	1,500	310	1,810
In-Kind Contributions	400	1,200	1,600
Total	1,900	1,510	**3,410**

April 14, 1999

Diesel Particle Filters

- Study Questions
  1. How does fuel sulfur level affect the required filter regeneration temperature?
  2. What is the effect of fuel sulfur level on mass emissions of sulfate?
- Emission Control Devices
  - Both continuously regenerating diesel particle filters (CR-DPF) and catalyzed diesel particle filters (CDPF)
  - Commercial technologies to be used -- those that maximize the number of applications, i.e., technologies that regenerate at lowest possible temperature
- Engine
  - Caterpillar 3126
  - Used in applications resulting in low exhaust temperature (e.g., <300C)

Diesel Particle Filters (continued)

- Test Conditions & Test Cycles
  - Steady state measurement of pressure drop and determination of balance point temperature
  - Stabilized OICA 13-mode measurement with emissions analysis, including engine-out SO_2
  - PM measurements at peak torque and road-load conditions

Diesel Oxidation Catalysts

- Study Questions
  1. What is the impact of fuel sulfur level on generation of particulate matter (PM) by oxidation catalysts?
  2. What is the effect of fuel sulfur level on catalyst activity during short-term aging, and how does this differ from the effects of thermal stressing?
  3. How well do oxidation catalysts recover when operating on near-zero sulfur level fuel after being exposed to higher fuel sulfur levels?
- Emission Control Devices
  1. Device #1 - commercial, in-use technology, low precious metal loading
  2. Device #2 - technology formulated for maximum reductions in PM, CO and HC emissions, assuming very low fuel sulfur levels.

Diesel Oxidation Catalysts (continued)

- Engines
  1. For device #1, a Cummins ISM 370 heavy-duty engine with relatively high exhaust temperature over the OICA test cycle
  2. For device #2, a Navistar T-444 E, 7.3-liter engine with relatively low exhaust temperature over a simulated FTP (light-duty) cycle

- Test Conditions
  - Device #1 tested on FTP, heavy-duty cycle (hot start) and stabilized OICA cycle
  - Device #2 tested on Navistar 9-mode and an engine cycle simulating light-duty FTP 75 chassis cycle

Lean NO_x Catalysts

- Study Questions
  - What is the effect of fuel sulfur level on:
    1. NO_x reduction efficiency
    2. rate of deactivation of catalyst
    3. ability of catalyst to recover
    4. production of sulfate
- Emission Control Devices
  1. Device #1 - state-of-the-art, base metal catalyst (higher temperature)
  2. Device #2 - state-of-the-art, precious metal catalyst (lower temperature)
- Engines
  1. For device #1, a Cummins ISM heavy-duty engine with relatively high exhaust temperature over the OICA test cycle
  2. For device #2, a Navistar T-444 E, 7.3-liter engine with relatively low exhaust temperature over a simulated FTP75 chassis cycle

Lean NO_x Catalysts (continued)

- Test Conditions
  - HC reductant injection system to use low sulfur, base fuel and limit fuel economy penalty to four percent
  - Device #1 tested on stabilized OICA 13-mode cycle
  - Device #2 tested on Navistar 9-mode cycle

NO_x Adsorber

- Study Questions
  - 1. What effect does fuel sulfur level have on fresh NO_x adsorber performance?
  - 2. How is the rate of deterioration of NO_x performance affected by fuel sulfur level up to 250 hours?
- Emission Control Device
  - State-of-the-art device
  - System calibrated to require less than 4 percent fuel economy penalty for regeneration
  - Maximum NO_x reduction of greater than 80 percent
  - NO_x reduction of at least 30 percent at the temperatures of 150C and 500C on the base fuel
- Engine
  - Daimler-Chrysler, Detroit Diesel Corp. 1.9-liter, with turbocharger, intercooler, electronic control, common rail fuel injection, EGR (for constant load during lean/rich cycling)

NO_x Adsorber (continued)

- Test Conditions
  - Fresh device for each of three fuels (3, 30, 150 ppm)
  - Devices aged 250 h for each fuel sulfur level with NO_x removal efficiency determined every 50 h
  - Aging sequence is a cycle of 9 temperatures (150 to 450 to 150C) for 20 minutes at each temperature at rated engine speed with rich/lean times set for 4 percent fuel consumption penalty at each point

Conclusion

DECSE test program is well under way to providing data on effects of sulfur levels in diesel fuel on performance of emission control technologies.