Federal Diesel Research Study

September 25, 2009
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California Environmental Protection Agency

Air Resources Board

Overall Program Plan

- Test matrix includes 3 fuels
  - CARB, Federal A, and Federal B
- Testing of 3 engines
  - 2007 MBE4000, 2006 Cummins ISM, 1991 DDC 60
- Chassis dyno testing
  - 10 trucks including 3 CARB vehicles
  - Testing focuses on CARB 50 mph Cruise cycle

Engine Testing Status

- Fuel Analyses in Process (cetane remains)
- Testing on 2007 MBE4000 completed
  - Results discussed in presentation
- 2006 Cummins ISM completed (9-21-09)
- Testing 3rd engine to follow
- Memorandum on engine testing completed by Nov/Dec 2009

Analysis of Test Fuels

Results and Comparison with Approved Property Ranges

Consistency of test fuel properties known to effect NO_x emissions

- Aromatic Hydrocarbon Content
- ✓CARB < Fed. A < Fed. B
- API Gravity
- ✓CARB > Fed. A > Fed. B
- Cetane Number
- ✓CARB > Fed. A > Fed. B
- T50
- ✓CARB < Fed. A < Fed. B

Chassis Dyno Status

- Chassis dyno testing in 1st Quarter of 2010
  - Construction planned for Nov/Dec 2009
  - Commissioning January 2010
- 10 test vehicles
  - Trucks with 2007 MBE4000 and 2006 Cummins
  - CE-CERT's in-house truck with 2000 Caterpillar engine
  - Port indicated they could provide additional vehicles
    - Port indicated they could provide additional vehicles

Engine Parameters

- 2007 MBE4000
  - Equipped with OEM DPF
  - In-line, 6 cylinder, 4-stroke, 12.8 L engine
  - 410 hp @ 1900 rpm
  - Turbo charged with EGR

Engine Parameters

- 2006 Cummins ISM 370
  - In-line, 6 cylinder, 4-stroke, 10.8 L engine
  - 370 hp / 1450 ft-lbs @ 1200 rpm
  - Turbo charged with EGR
- 1991 Detroit Diesel Series 60
  - In-line, 6 cylinder, 4-stroke, 11.1 L engine
  - 350 hp @ 1800 rpm
  - Turbo charged with aftercooler

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Engine Dyno Test Matrix

Test Day				
Heavy-Duty FTP Test Cycle				
Day 1	CCC	AAA	AAA	BBB
Day 2	BBB	CCC		
ARB HHDDT Cruise Test Cycle				
Day 2			CCC	AAA
Day 3	AAA	BBB	BBB	CCC

C = CARB diesel fuel, A = Federal A diesel fuel, B = Federal B diesel fuel

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2007 MBE4000 Results

- NO_x emissions were higher for the Federal B fuel compared with the CARB fuel
- PM, THC, and CO emission levels low and the differences between the fuel were either not statistically significant or were small
- CO_2 increased slightly for Federal B
- Fuel consumption slightly higher for Federal B fuel

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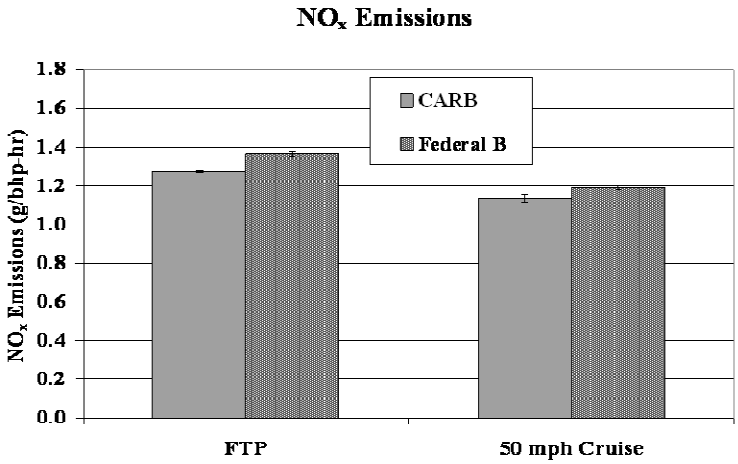
NO_x Results 2007 MBE4000



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NOx Results 2007 MBE4000

		2007 MBE4000	
	CARB vs.	% Difference	P-values
FTP	Federal A	-	-
	Federal B	7.3%	0.000
50 mph Cruise	Federal A	-	-
	Federal B	4.7%	0.000

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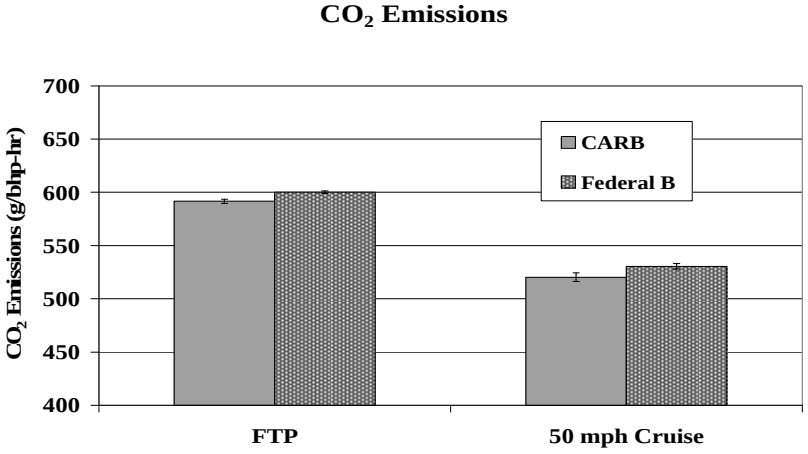
CO_2 Results 2007 MBE4000



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CO_2 Results

		2007 MBE4000	
	CARB vs.	% Difference	P-values
FTP	Federal A	-	-
	Federal B	1.4%	0.000
50 mph Cruise	Federal A	-	-
	Federal B	2.0%	0.000

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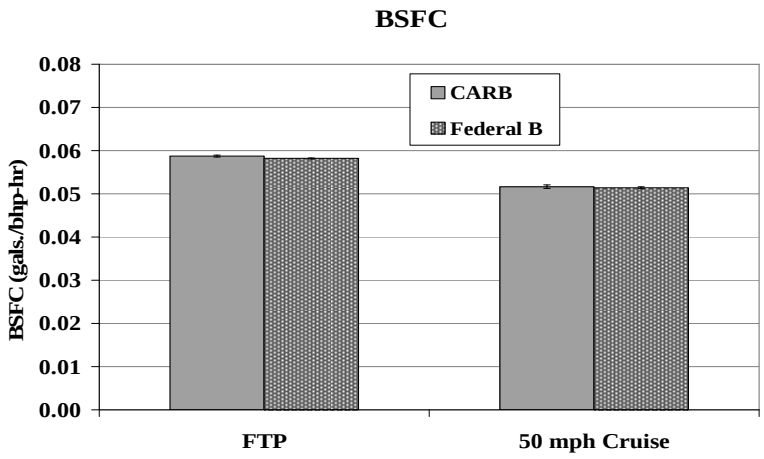
BSFC Results 2007 MBE4000



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BSFC Results

		2007 MBE4000	
	CARB vs.	% Difference	P-values
FTP	Federal A	-	-
	Federal B	-0.9%	0.000
50 mph Cruise	Federal A	-	-
	Federal B	-0.4%	0.255