Advanced Collaborative Emissions Study (ACES)

Cooperative multi-party effort to characterize emissions and possible health effects of new advanced heavy duty engine and control systems and fuels in the market 2007 – 2010.

Conducted by Health Effects Institute (HEI) and Coordinating Research Council (CRC)

PROJECT SPONSORS

DOE OVT and NETL
Engine Manufacturers Association (EMA)
US Environmental Protection Agency (EPA)
California Air Resources Board (ARB)
American Petroleum Institute (API)
Aftertreatment Manufacturers
Coordinating Research Council (CRC)

June 2008

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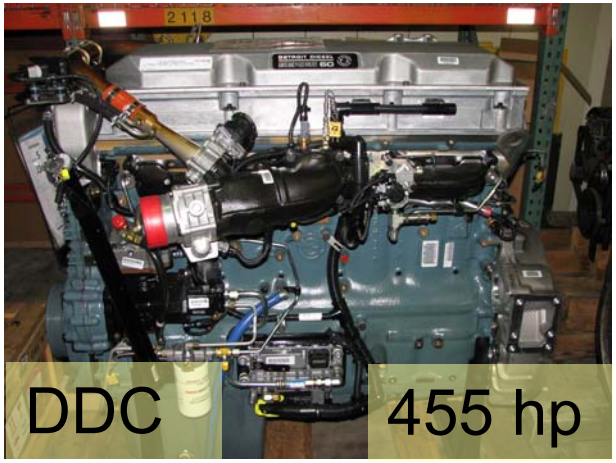
ACES Phase 1 Engines



Evaluating Emissions of Advanced Technology Diesels

- The combination of engines, fuels and oils developed to meet the 2007/2010 emission standards will result in substantially reduced emissions.
- Substantial public health benefits are expected from these reductions.
- Research is necessary to ensure that there are no adverse impacts to public health and welfare.

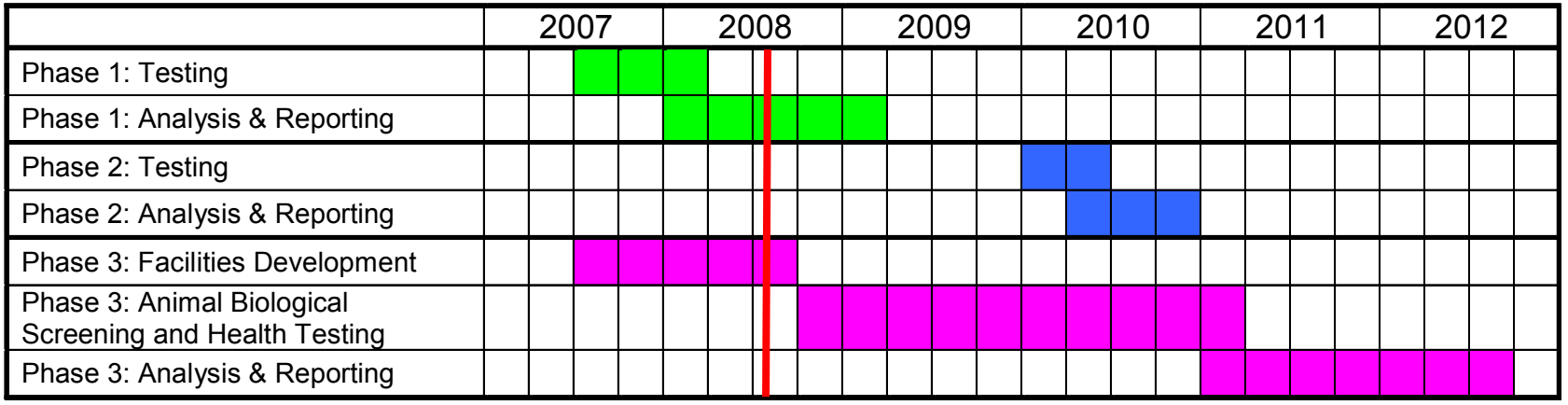
http://healtheffects.org/RFA/ACES-ProjectPlan.pdf

Project Overview

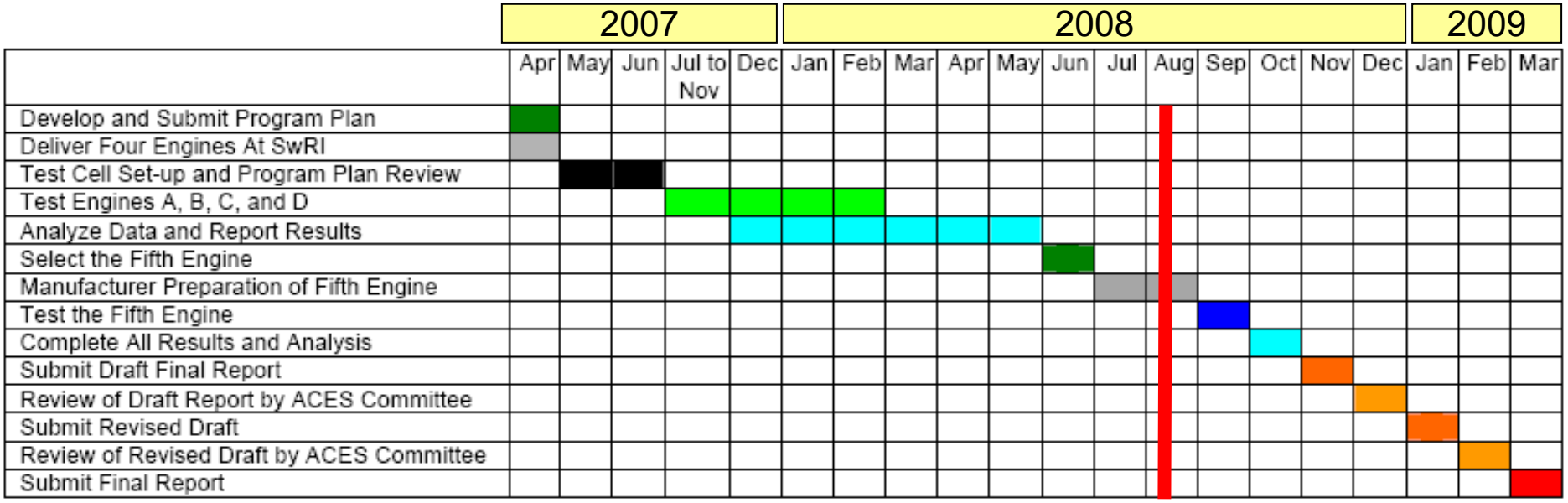
Phases:

1. 2007 Engine Emissions Characterization (Southwest Research Institute (SWRI))
   - *CRC Technical Leader*
2. 2010 Engine Emissions Characterization
   - *CRC Technical Leader*
3. 2007/2010 Engine Health Effects Testing (Lovelace Respiratory Research Institute (LRRI)
   - *Short Term biological screening and Long-Term Health Effects Test on 2007 Engines*
   - *HEI Technical Leader*
   - *CRC Technical Monitor*

Overall Project Timeline



Phase 1: Detailed Schedule



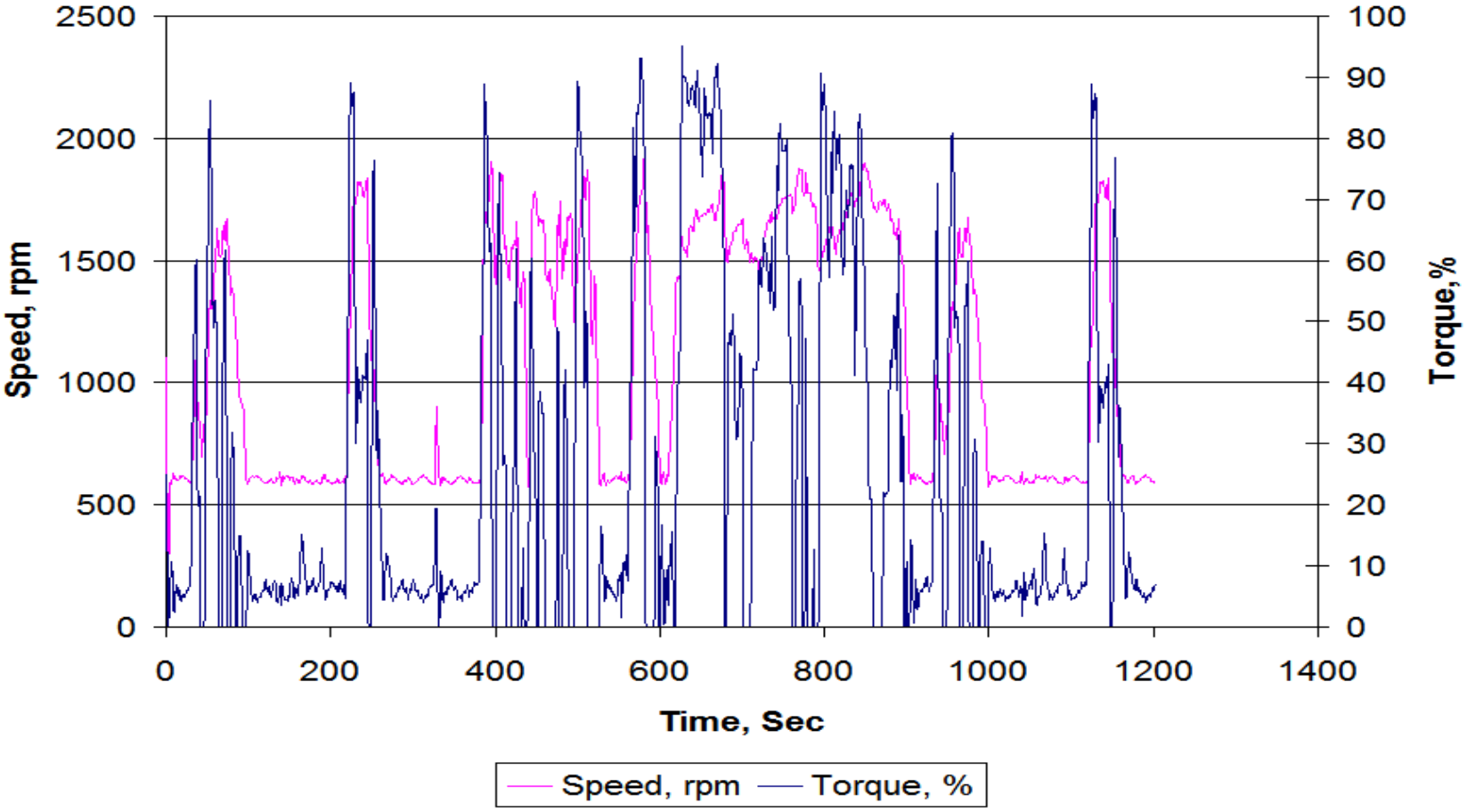
Phase 1 Approach: Detailed Emissions Characterization of 4 Engines

- Manufacturer degreening
- Common 2007 lubricant (Lubrizol)
- Common (commercial) 2007-compliant fuel for testing
- Certification and research test cycles
- Manufacturer support – installation / testing
- CFR 1065 certification-quality procedures
- Exhaust chemical speciation
- PM size & number characterization
- Exposure chamber (no animals)

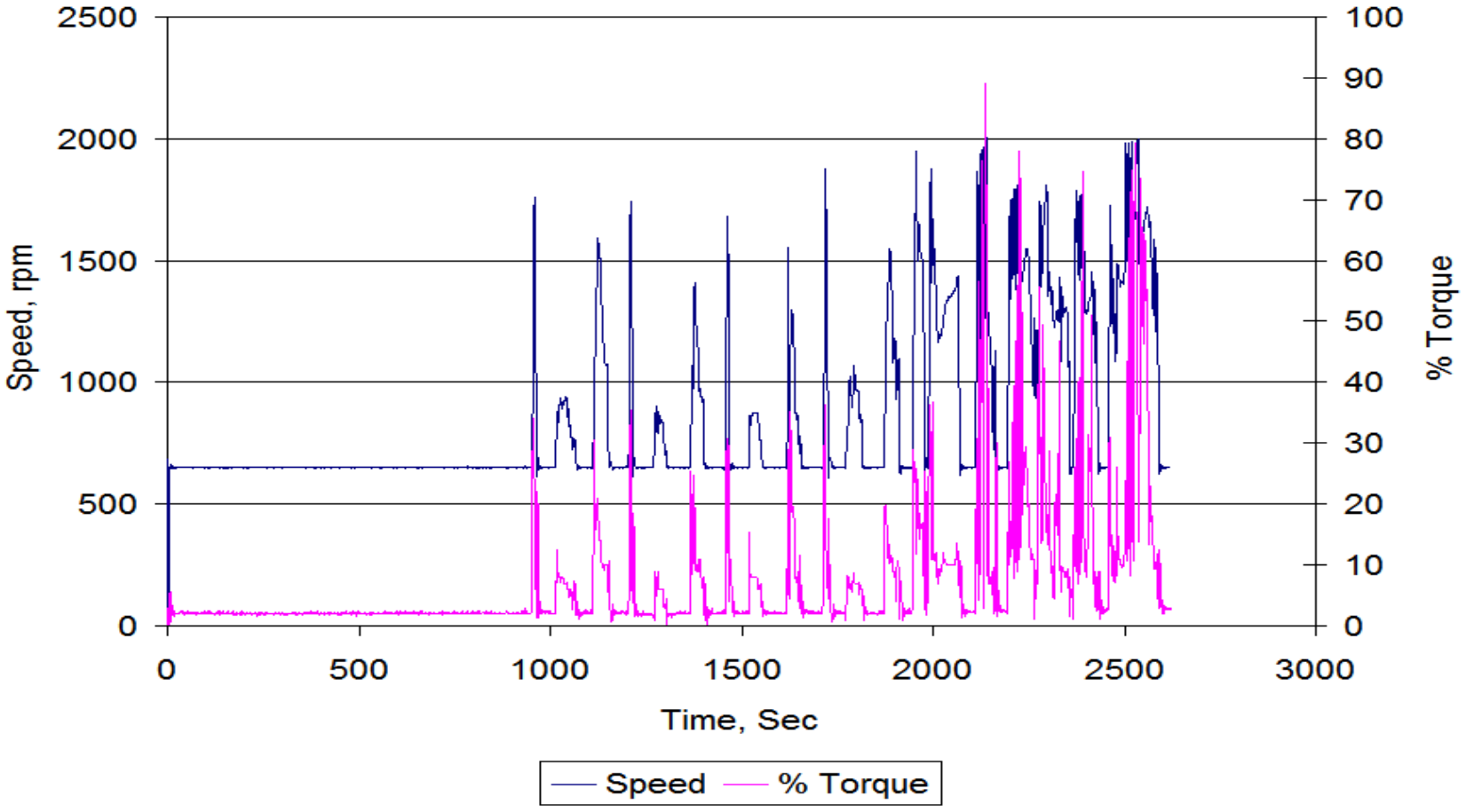
Phase 1 Approach: Test Cycles

- Foundation: HD-FTP
- CRC Project ACES-1
  - E-55/59 database
  - 4 modes: Creep, Transient, 2 Cruise Cycles
  - Composited
    - CARBx-ICT (Idle, Creep & Transient)
    - CARBz-CH (Cruise Cycles)
- CRC Project ACES-1a
  - 16-hour test schedule
- Cycle project reports on CRC website: www.crcao.org

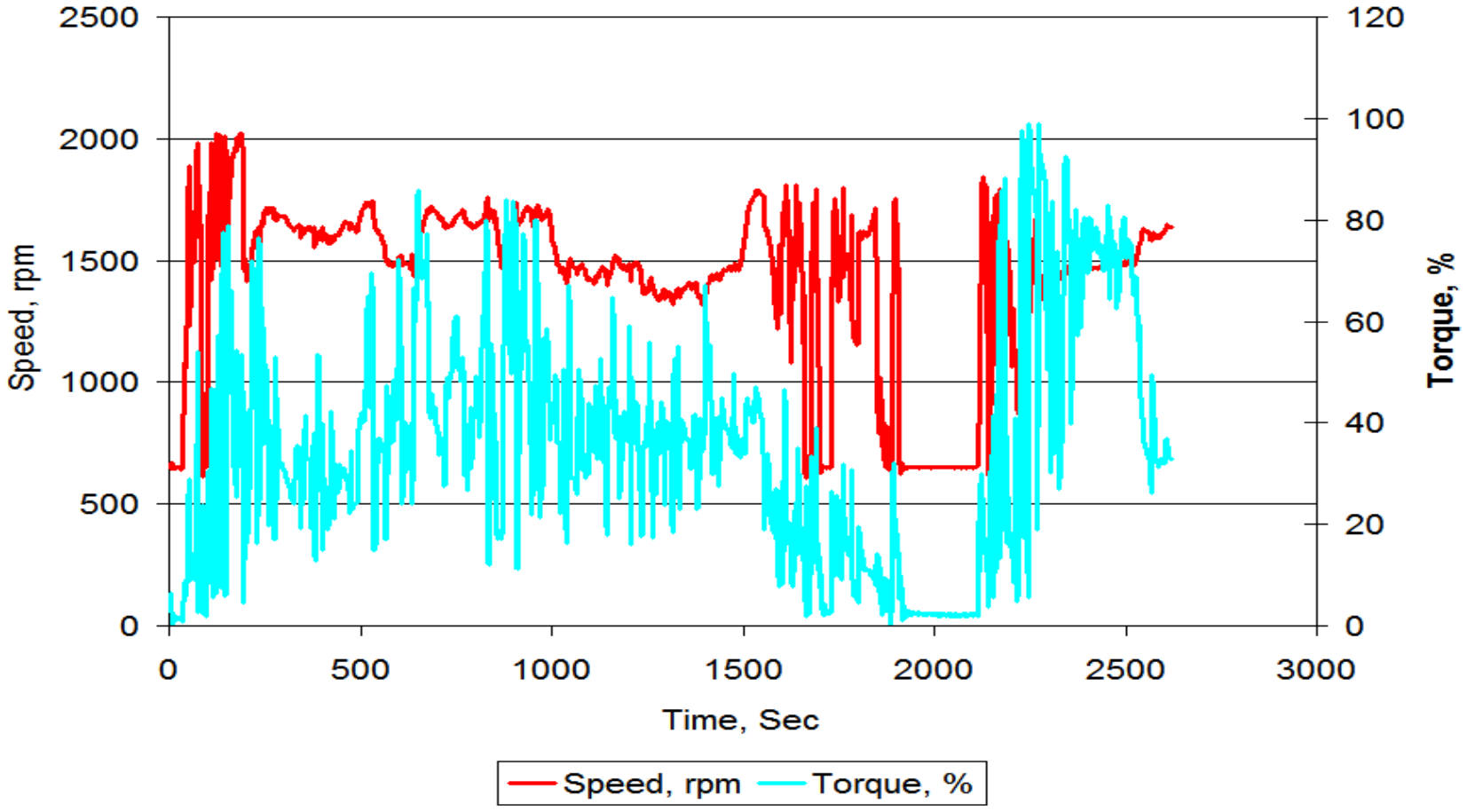
Phase 1 Test Cycles: HD-FTP



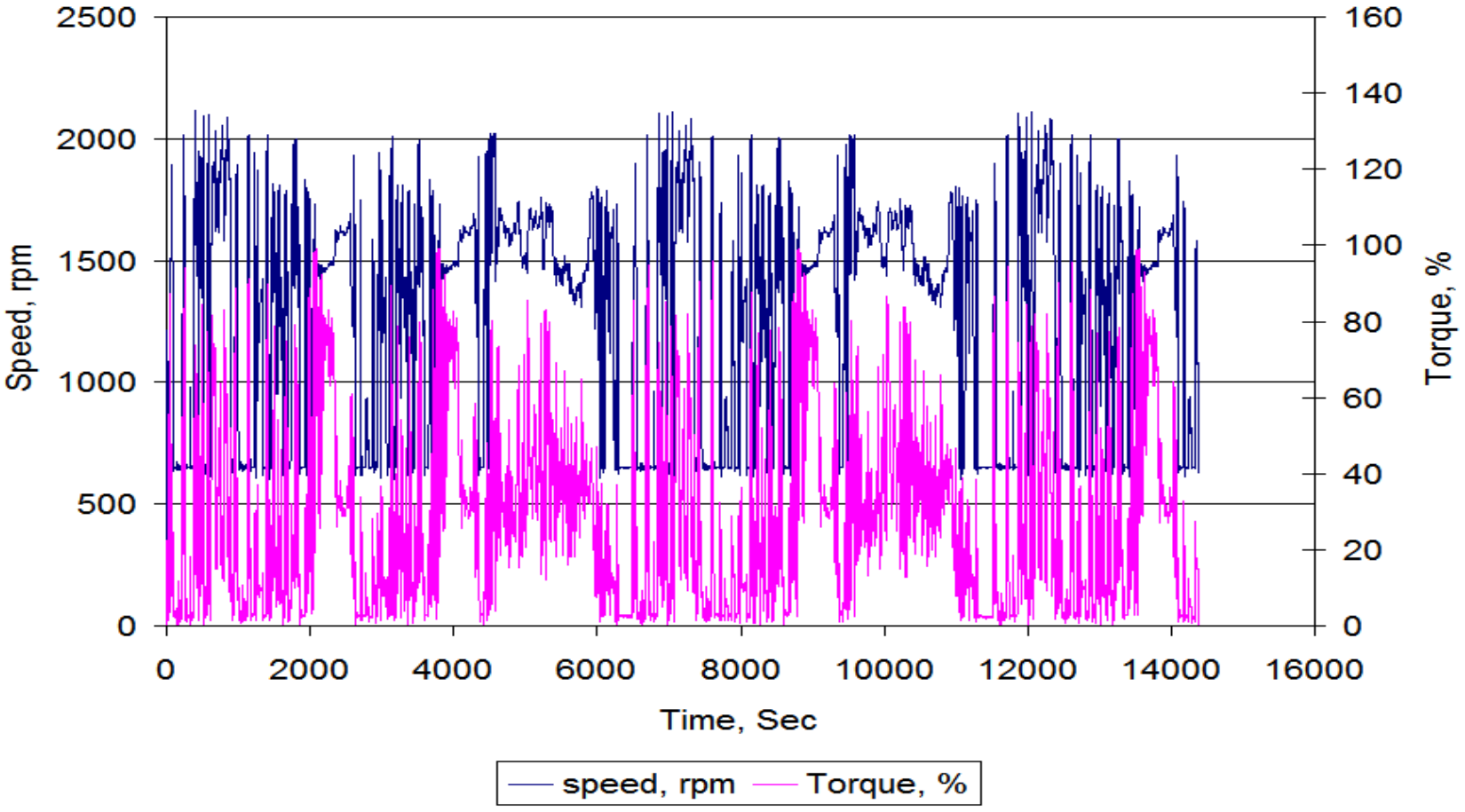
Phase 1 Test Cycles: CARBX-ICT (Idle, Creep, Transient)



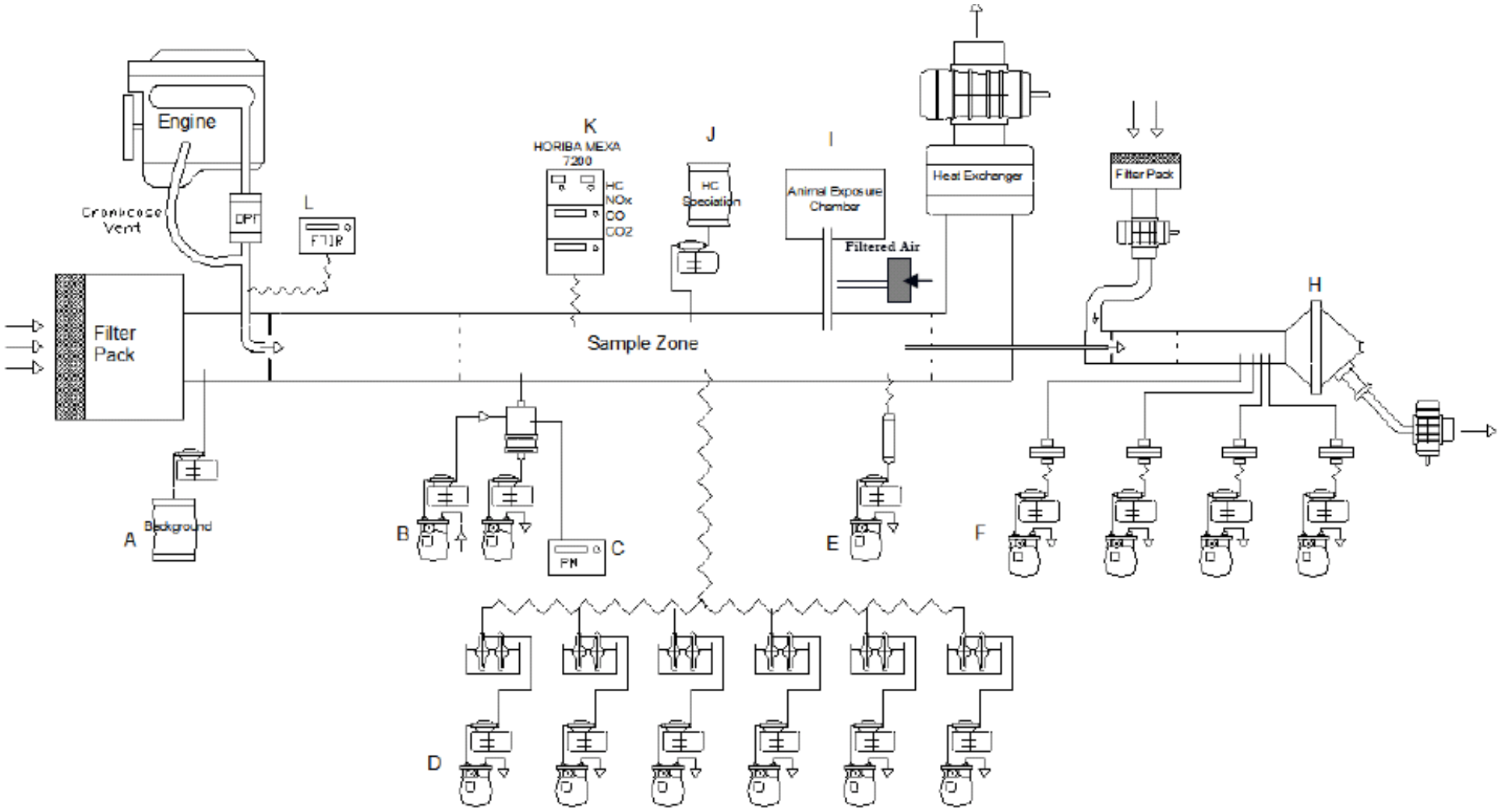
Phase 1 Test Cycles: CARBZ-CH (Cruise, High Speed Cruise)



Phase 1 Test Cycles: 16-hour Cycle (4-hour Repeat)



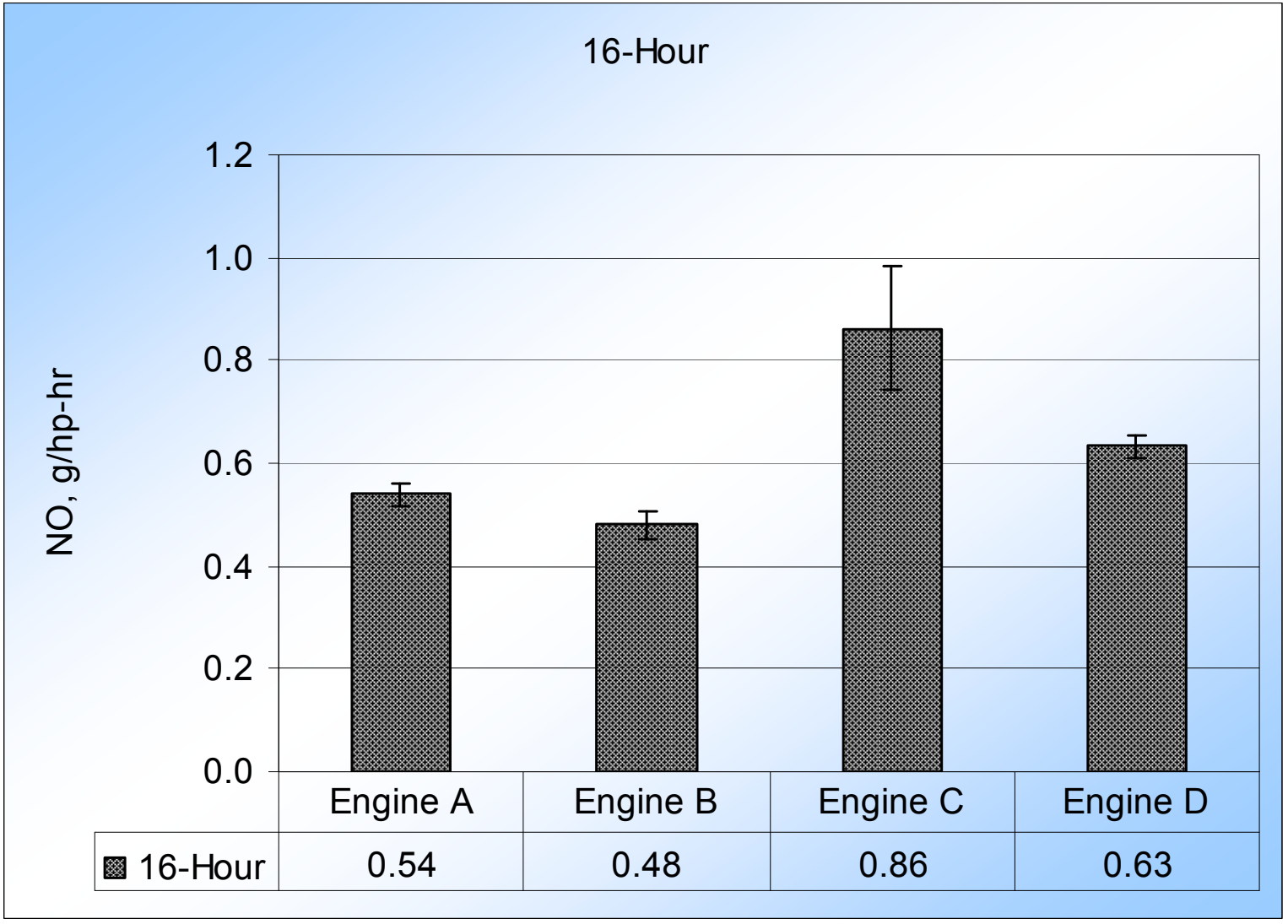
Overall Experimental Setup



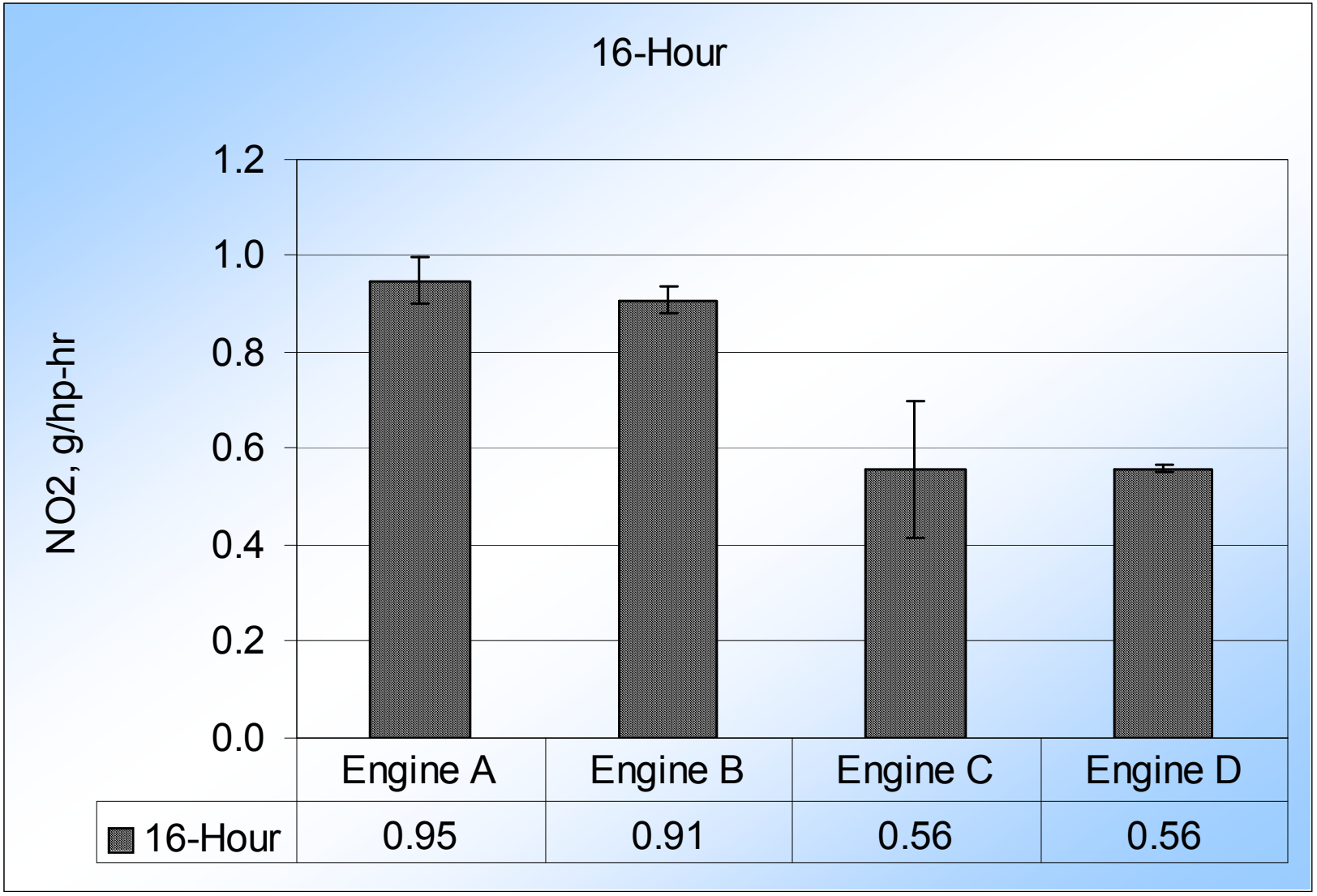
Phase 1 Status

- Testing of engines A, B, C, D complete
- Data analysis and review of summary tables for engine selection complete
- HEI Engine Selection Process Result: Engine B
- Engine B Degreening in Process
- Transition to Phase 3 in process

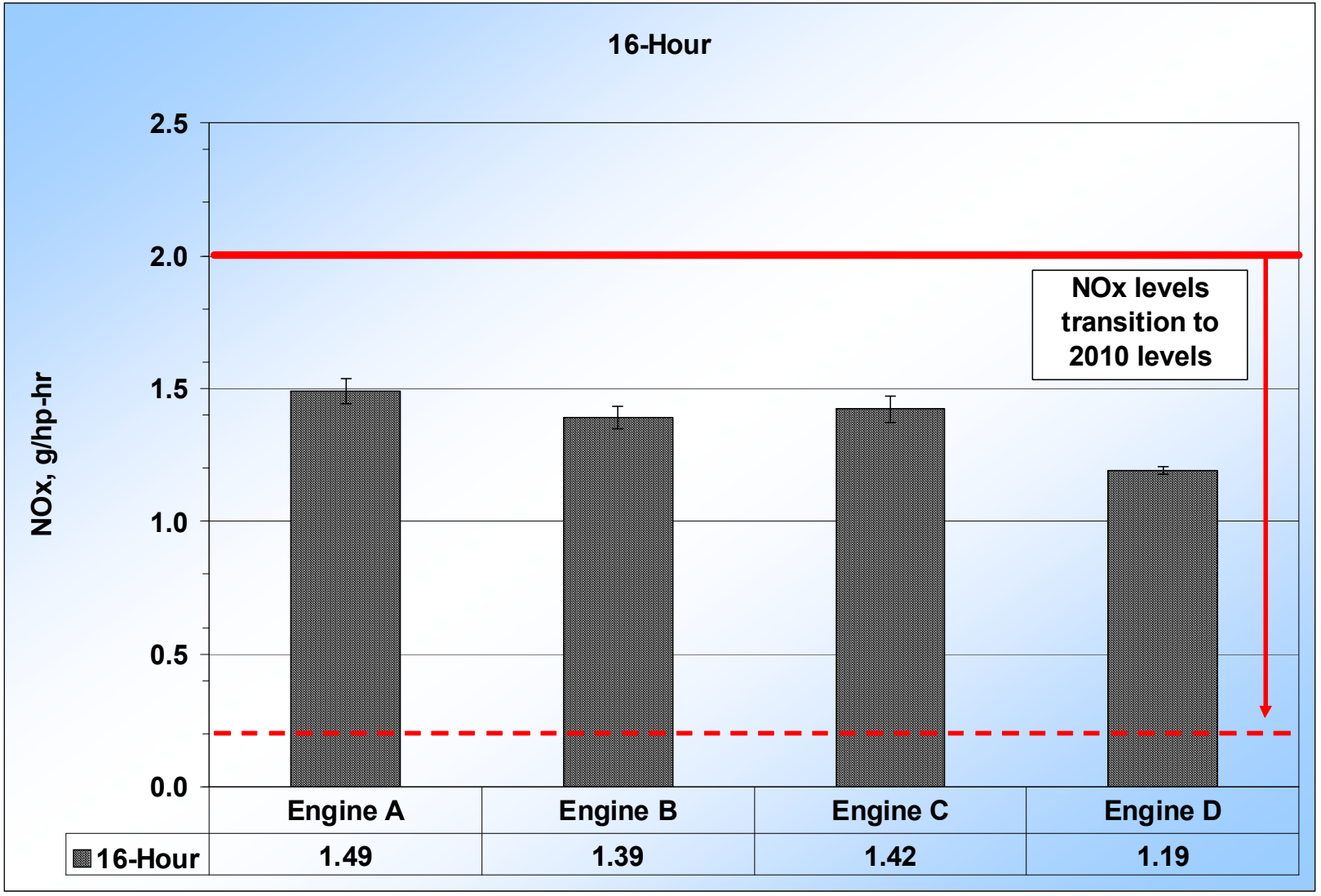
Phase 1 Data: NO



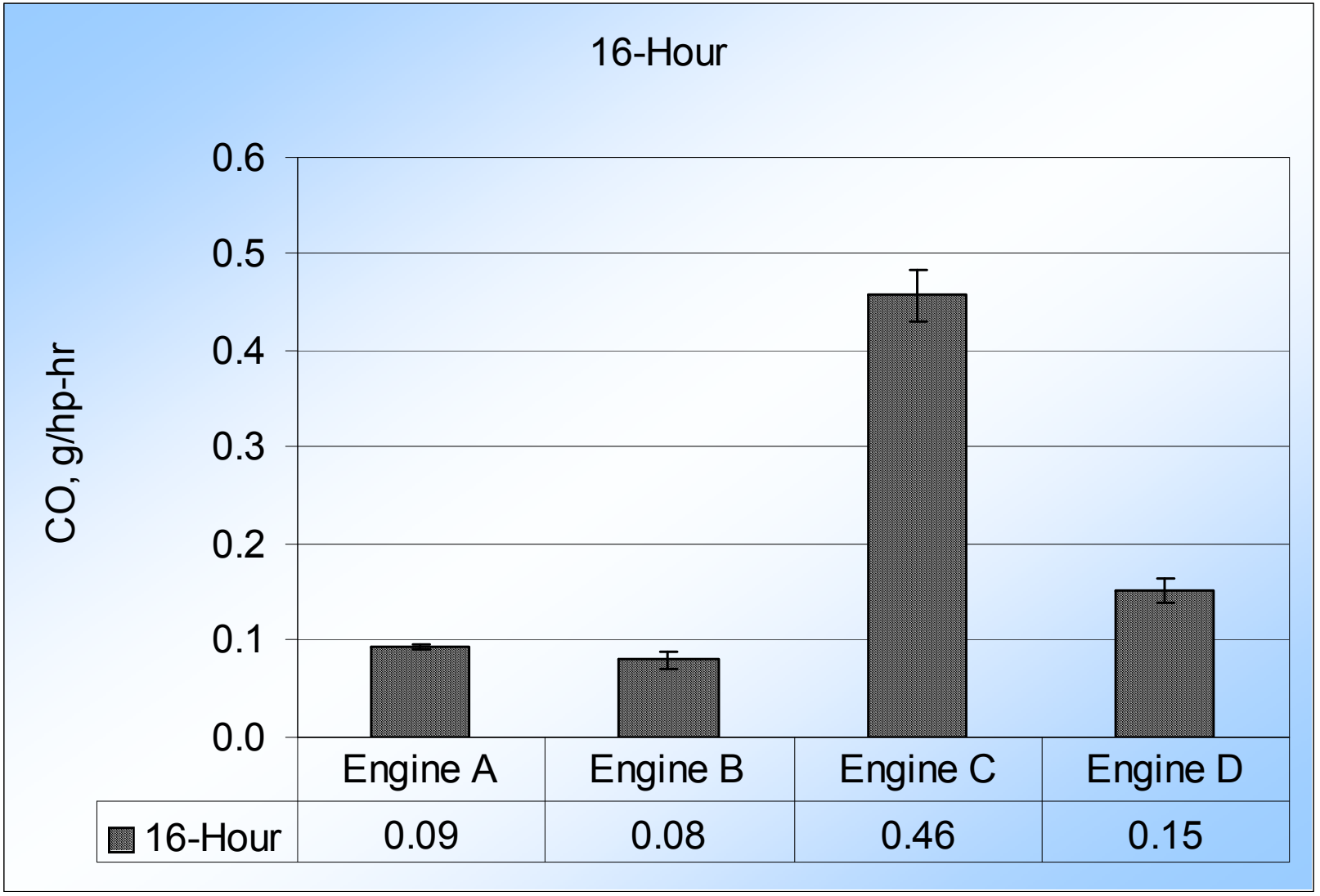
Phase 1 Data: NO_2



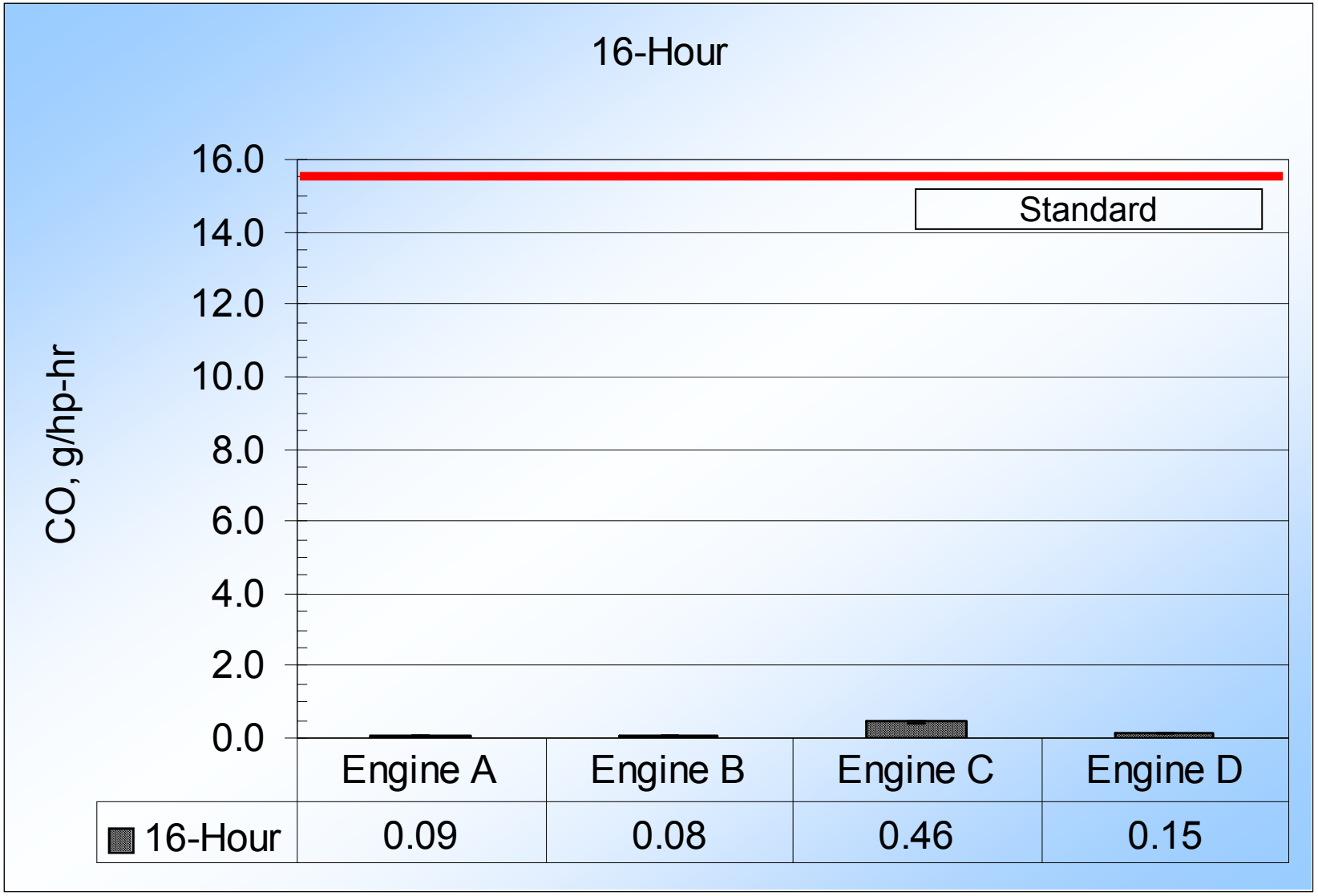
Phase 1 Emissions Data: NO_X



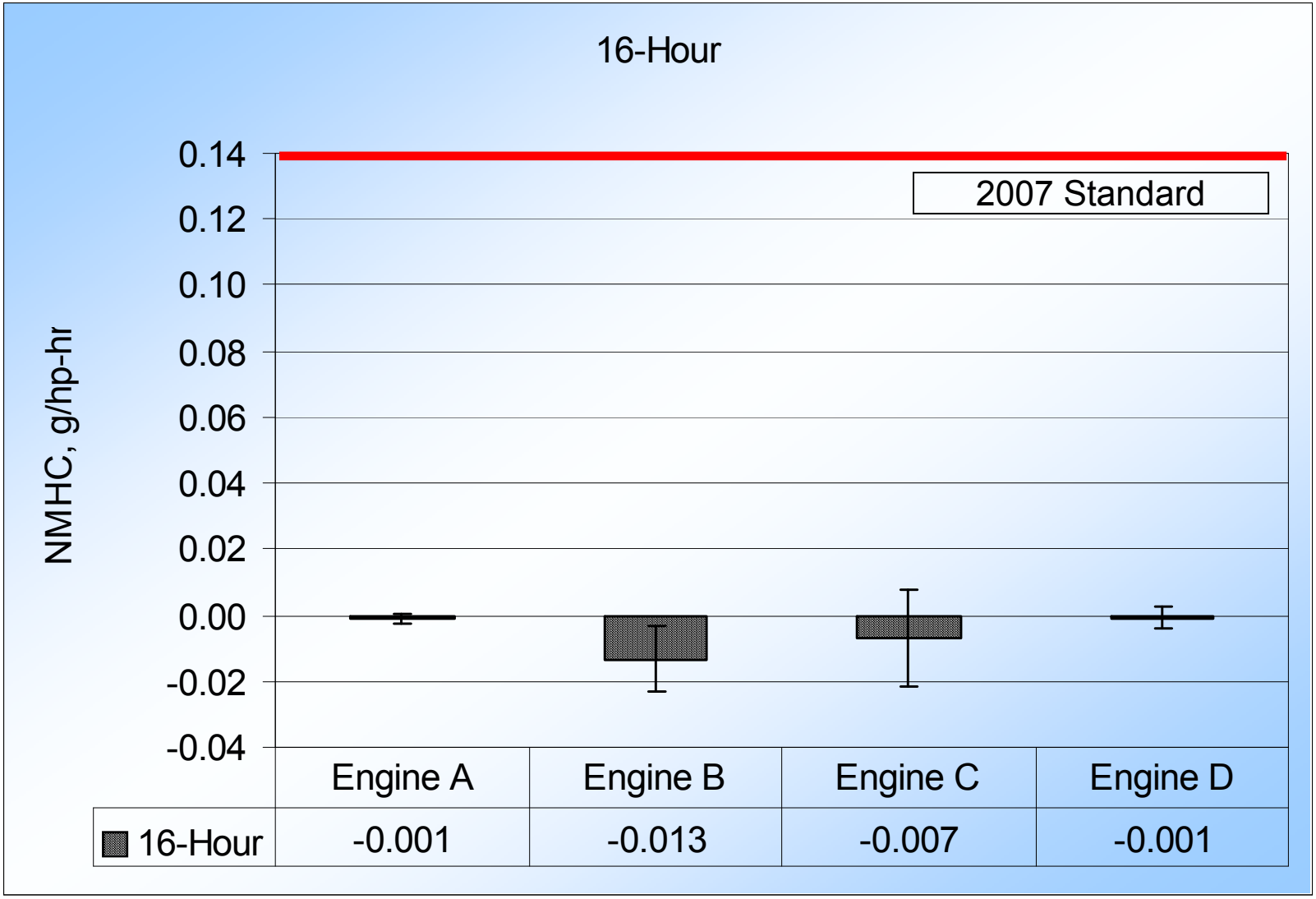
Phase 1 Data: CO



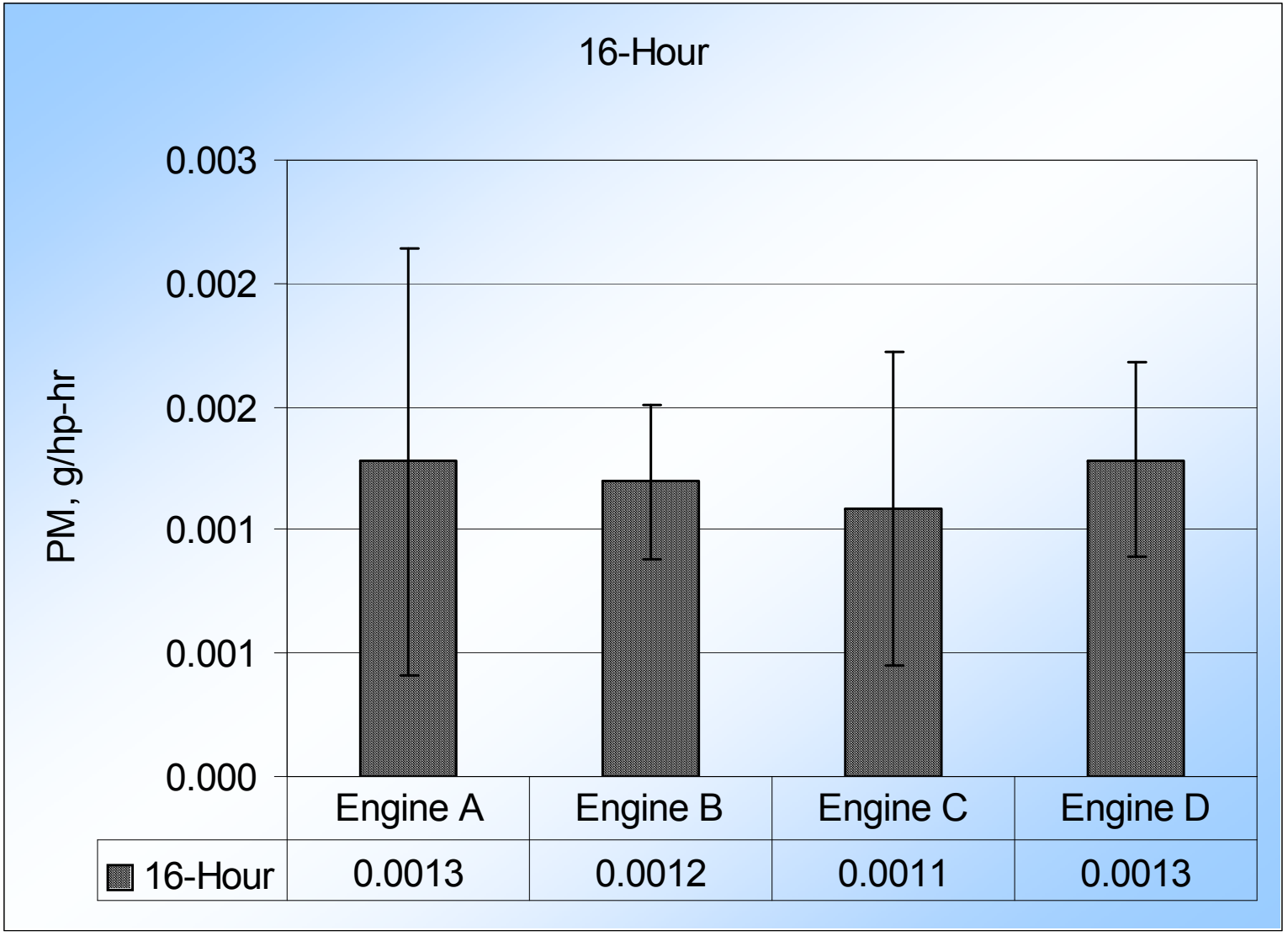
Phase 1 Data: CO



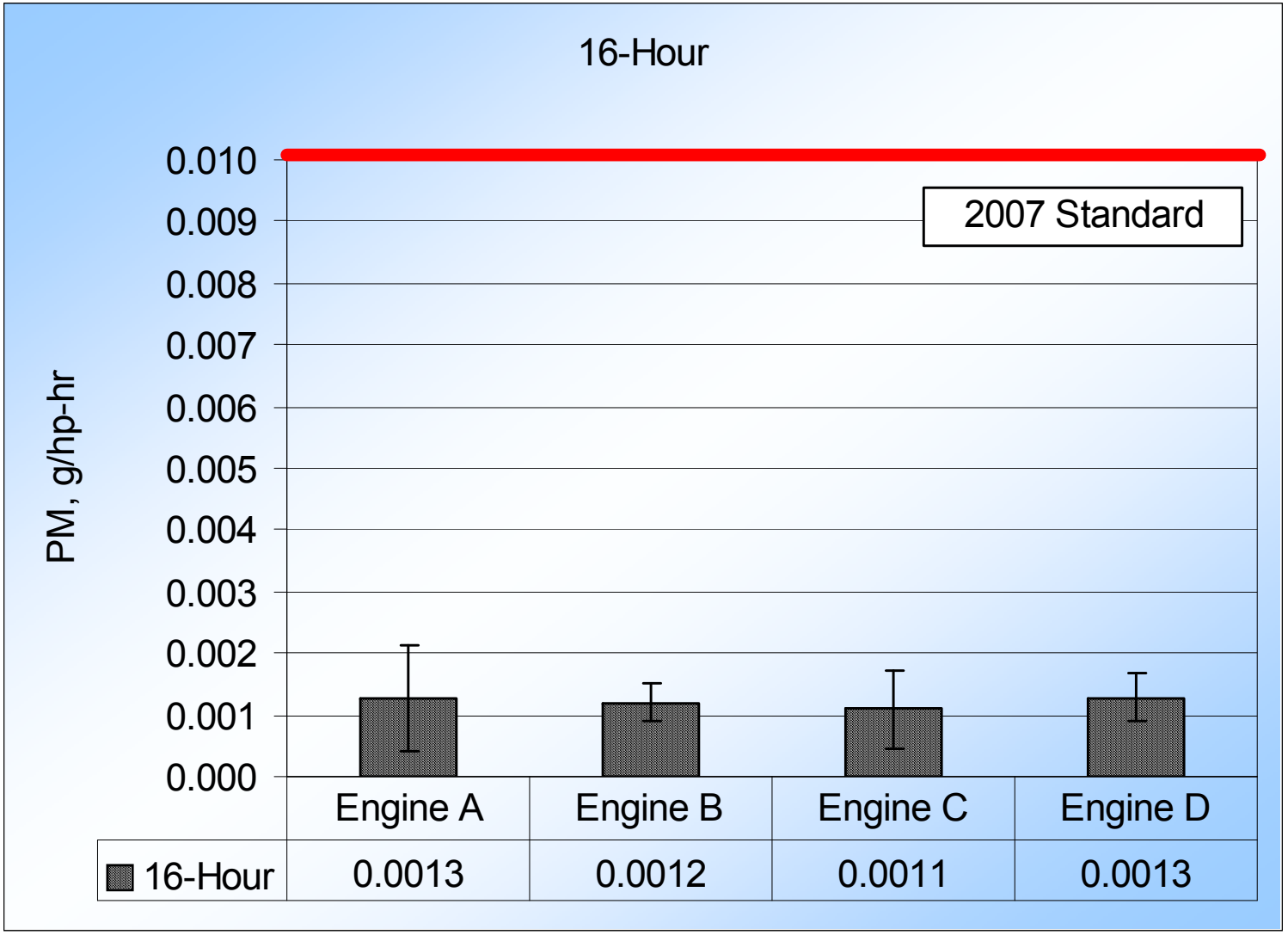
Phase 1 Data: NMHC



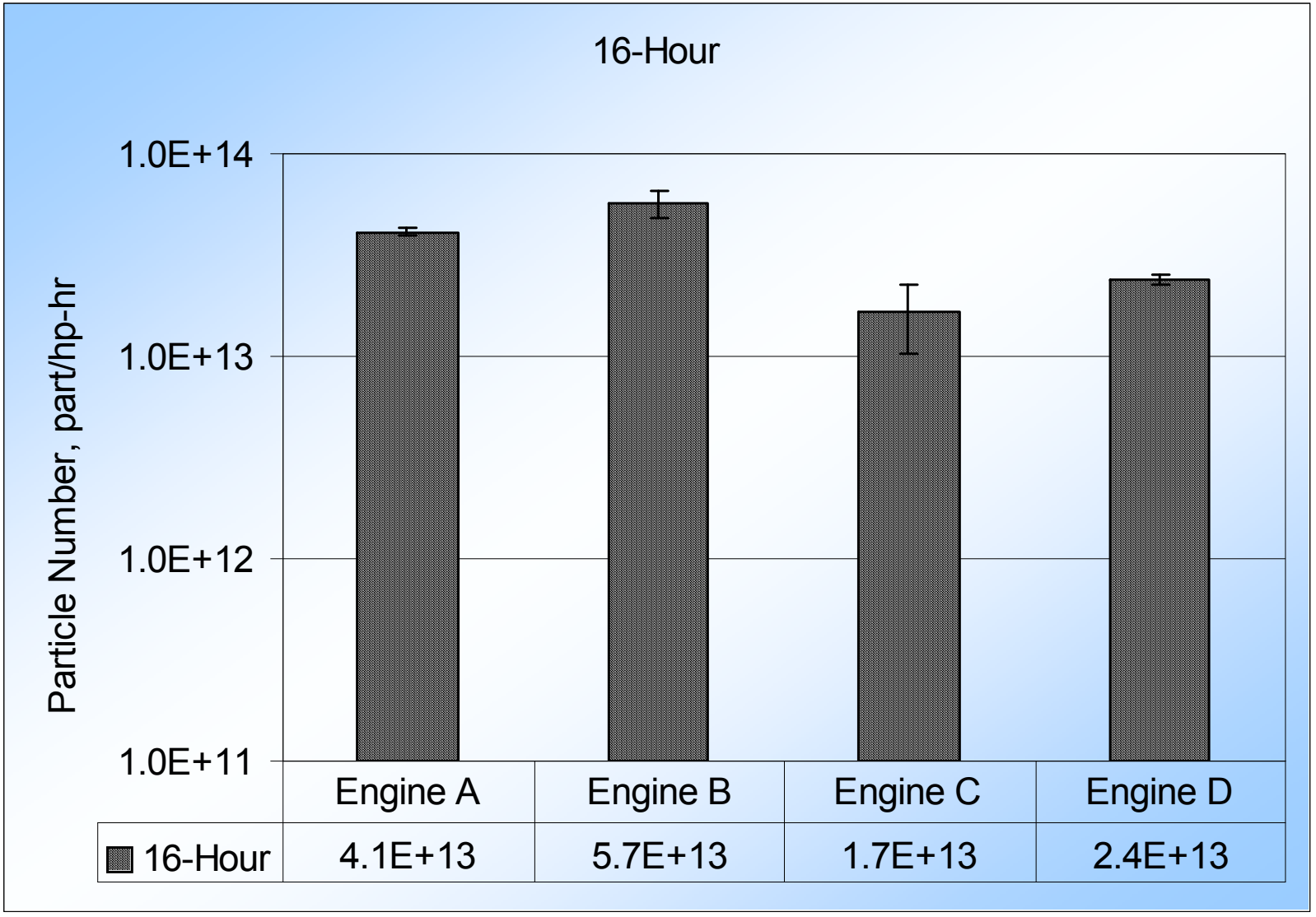
Phase 1 Data: PM Mass



Phase 1 Data: PM Mass w/Standard



Phase 1 Data: PM Number



Phase 1 : More Data / Analysis To Come!

Subset of Data – Engine Selection

Number	Emissions Components	Engine A	Engine B	Engine C	Engine D	Background Corrected
1	NO, g/hp-hr	0.54	0.48	0.86	0.63	Yes
2	NO2, g/hp-hr	0.95	0.91	0.56	0.56	Yes
3	Carbon Monoxide, g/hp-hr	0.09	0.08	0.46	0.15	Yes
4	PM Mass, g/hp-hr	0.0013	0.0012	0.0011	0.0013	No
5	PM Number, Part./hp-hr	4.13E+13	5.67E+13	1.66E+13	2.38E+13	No
6	EC (mg/hp-hr)	0.20	0.27	0.26	0.22	No
7	OC (mg/hp-hr)	1.53	0.24	0.26	0.52	No
8	Total Metals, µg/hp-hr	62.37	62.15	28.88	89.91	No
9	Inorganic Ionic Species, mg/hp-hr	3.84	3.09	2.86	2.47	No
10	Carbonyl compounds (mg/hp-hr)	4.99	1.64	4.40	2.44	Yes
11	single ring aromatic compounds, mg/hp-hr	0.35	1.20	0.81	0.69	Yes
12	Total PAHs (mg/hp-hr)	0.55	0.73	0.84	0.80	No
13	Total Nitro PAHs (µg/hp-hr)	0.44	0.77	0.86	0.58	No
14	Total oxygenated PAHs (µg/hp-hr)	6.25	5.96	3.76	3.29	No
15	Nitrosamines (µg/hp-hr)	32.54	28.06	52.89	25.82	No
16	1-3 Butadiene	0	0	0	0	Yes

CRC ACES Panel

Reynaldo Agama	Caterpillar	Hector Maldonado	California Air Resources Board
James Ball	Ford Motor Company	M. Matti Maricq	Ford Motor Company
Nicholas Barsic	John Deere	Mani Natarajan	Marathon Petroleum Company LLC
Steven Cadle	General Motors R&D Center (Retired)	Ralph Nine	US Department of Energy / National Energy Technology Laboratory
Maria Costantini	Health Effects Institute	Robert Okamoto	California Air Resources Board
Annemoon van Erp	Health Effects Institute	Charles Schleyer	ExxonMobil
Timothy French	Engine Manufacturers Association	Shirish Shimpi	Cummins
Thomas Hesterberg	International	Joseph Somers	US Environmental Protection Agency
Donald Keski-Hynnila	Detroit Diesel	Chris Tennant	CRC
Chris Laroo	US Environmental Protection Agency	Urban Wass	Volvo AB
Douglas Lawson	National Renewable Energy Laboratory		

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Backup Slides

Fuel Supply

- Commercial fuel
  - Aromatics not unusually low
  - Unusual additive packages avoided
  - Goal: broadly representative
- 13,000 gal
  - Split between Phase 1 and Phase 3
  - Links testing at both facilities

TEST	Results
Cetane number	42.7
Cetane Index	43.1
Lubricity HFRR microns	331
Gravity, specific	.8563
Gravity API	33.75
Sulfur mg/kg	4
Aromatics wt%	24.12
PAH wt%	7.95
Flash Point Penske-Martin °C	63.5
viscosity cSt at 40 °C	2.59
Stability mg/100 ml	0.91
IBP deg F	284.9
T10 deg F	414.6
T50 deg F	495.3
T90 deg F	583.9
FBP deg F	628.8

Overall Experimental Setup *Legend*

A Background bag sample of dilution air for HC, CO, CO_2, NO_x, IHC
B Double Dilution for PM, 47mm 2007 System with Standard Residence Time
C Regulated PM Following CFR Part 1065
D Impingers: carbonyls and alcohols
E Sorbent traps for nitrosamines, hazardous air pollutant compounds
F Auxiliary PM samples on 47 mm Fluoropore filters and impingers for elements, ions, inorganic acids, pH, cyanide, mercury (only if previously found in fuel), hexavalent chromium, SO_2
G XAD traps for semi-volatile compounds: PAH, N-PAH, , hopanes, steranes, carpanes, polar organics, high molecular weight alkanes and cycloalkanes, etc.
H Filter (8x10-inch Zefluor) for particulate-phase semi-volatile compounds: PAH, N-PAH, dioxins, hopanes, steranes, carpanes, polar organics, high molecular weight alkanes and cycloalkanes, etc.
I Animal Exposure Chamber (No Animals Present). PM mass using Teflo filter, size and number using EEPS, real time PM using DMM-230, and OC/EC collection using a pair of quartz filters will be taken from this chamber. The connection between the chamber and the full flow CVS will have a similar setup to that between the CVS and the 8 by 10 inch filter.
J Proportional bag sample for hydrocarbon speciation of C_2 through C_{12} compounds
K Horiba MEXA 7200 for THC, CO, CO_2, NO_x. Secondary NO_x analyzer in NO mode for determining NO_2 by difference
L FTIR for nitrogen compounds