



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.

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PROJECT SPONSORS

DOE OVT and NETL

Engine Manufacturers Association (EMA)

US Environmental Protection Agency (EPA)

California Air Resources Board (ARB)

American Petroleum Institute (API)

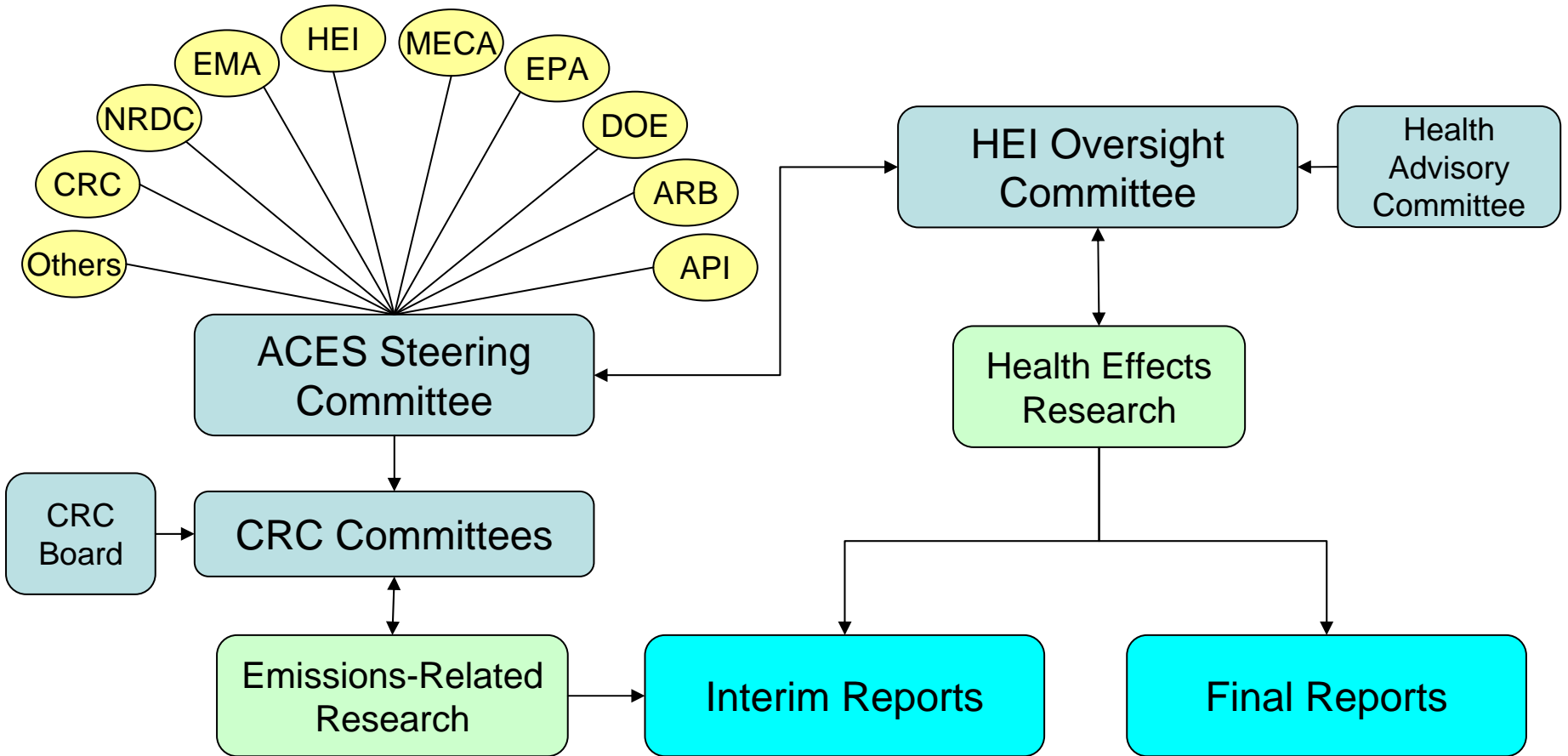
Aftertreatment Manufacturers

Coordinating Research Council (CRC)

Evaluating Emissions of Advanced Technology Diesels

- The combination of advanced-technology, compression-ignition engines, aftertreatment systems, reformulated fuels and reformulated oils developed to meet the 2007/2010 emission standards will result in substantially reduced emissions.
- Substantial public health benefits are expected from these reductions.
- With any new technology it is prudent to conduct research to ensure that there are no adverse impacts to public health and welfare.

Project Organization



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

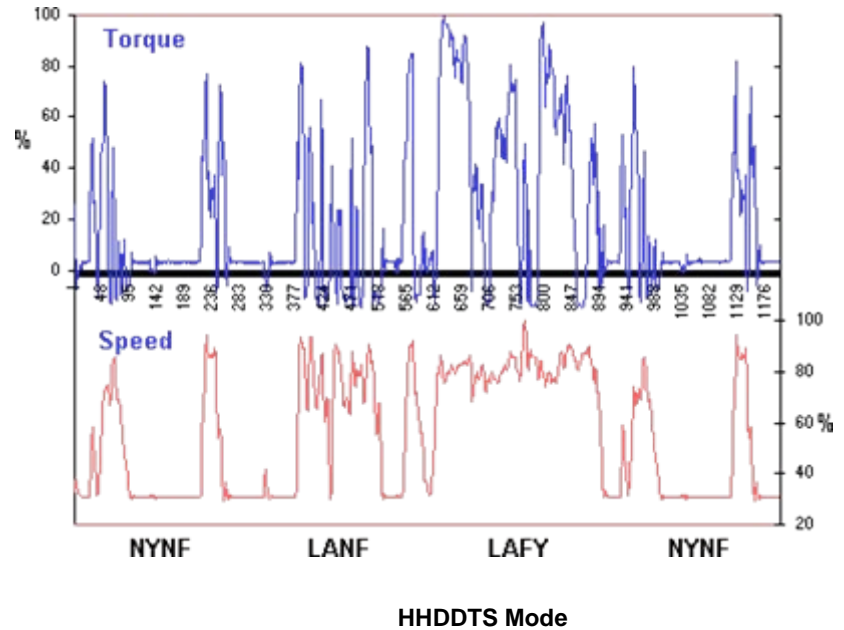
	2007				2008				2009				2010				2011				2012			
Phase 1: Testing																								
Phase 1: Analysis & Reporting																								
Phase 2: Testing																								
Phase 2: Analysis & Reporting																								
Phase 3: Facilities Development																								
Phase 3: Animal Biological Screening and Health Testing																								
Phase 3: Analysis & Reporting																								



Phase 1 Approach: Test Cycles

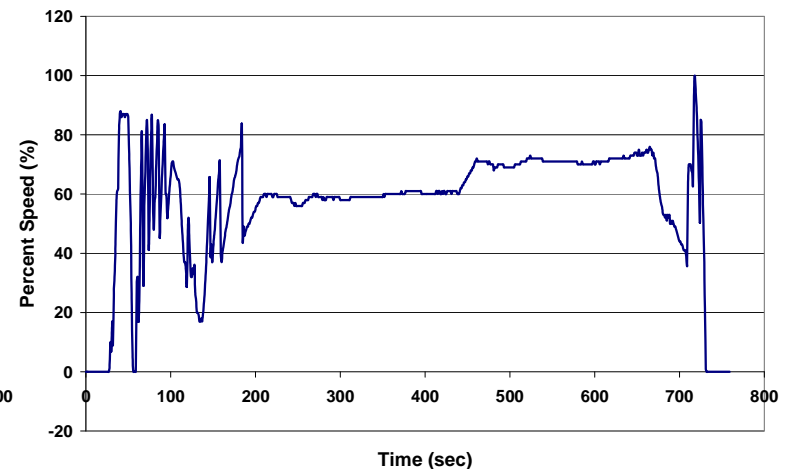
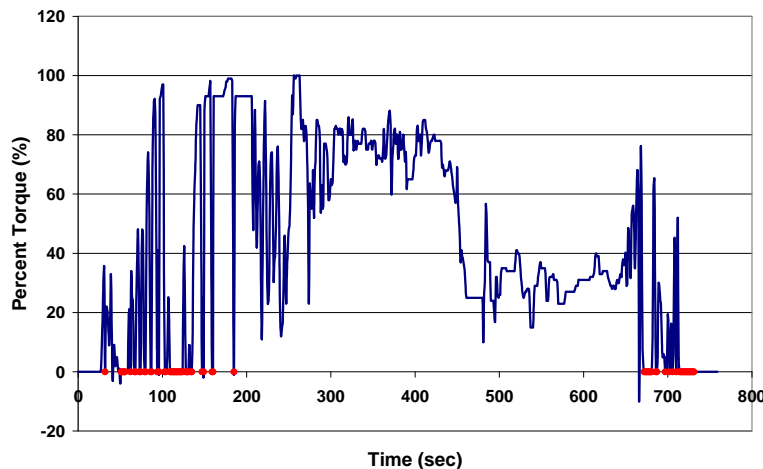
FTP

- Foundation: HD-FTP
- CRC Project ACES-1
 - Conversion of CARB Chassis Cycles using E-55/59 data
 - Creep, Transient, 2 Cruise Cycles
- CRC Project ACES-1a
 - 16-hour test schedule based on HD-FTP & ACES-1/CARB Engine Cycles



HHDDTS Mode

HHDDTS Mode



Regulated Emissions

- Relative to EPA 2007 regulated emissions limits, and based on the average FTP cycle emissions from all engines:
 - PM: 89 percent below the 0.01g/hp-hr limit
 - CO: 98 percent below the 15.5 g/hp-hr limit
 - NMHC: 95 percent below the 0.14 g/hp-hr limit
 - NOx: 10 percent below the 1.2 g/hp-hr average limit



Unregulated Emissions

On a g/hr emission rate basis, the great majority of unregulated emission species were below the level observed with 2004 engine technology used in CRC E55/59.

Compounds	% Lower Than 2004 Engine Technology	
	16-Hour Cycle	CARBx-ICT
Single Ring Aromatics	82%	69%
PAH	79%	26%
Nitro-PAH	81%	49%
Alkanes	85%	84%
Polar	81%	12%
Hopanes/Steranes	99%	99%
Carbonyls	98%	78%
Inorganic Ions	38%	100%
Metals and Elements	98%	90%
Organic Carbon	96%	78%
Elemental Carbon	99%	100%
Dioxins/Furans ^a	99%	N/A

^a Relative to 1998 Engine Technology

In general, the low exhaust temperature cycle CARBx-ICT showed less reduction for the hydrocarbon-based compounds, compared to the 16-Hour Cycle

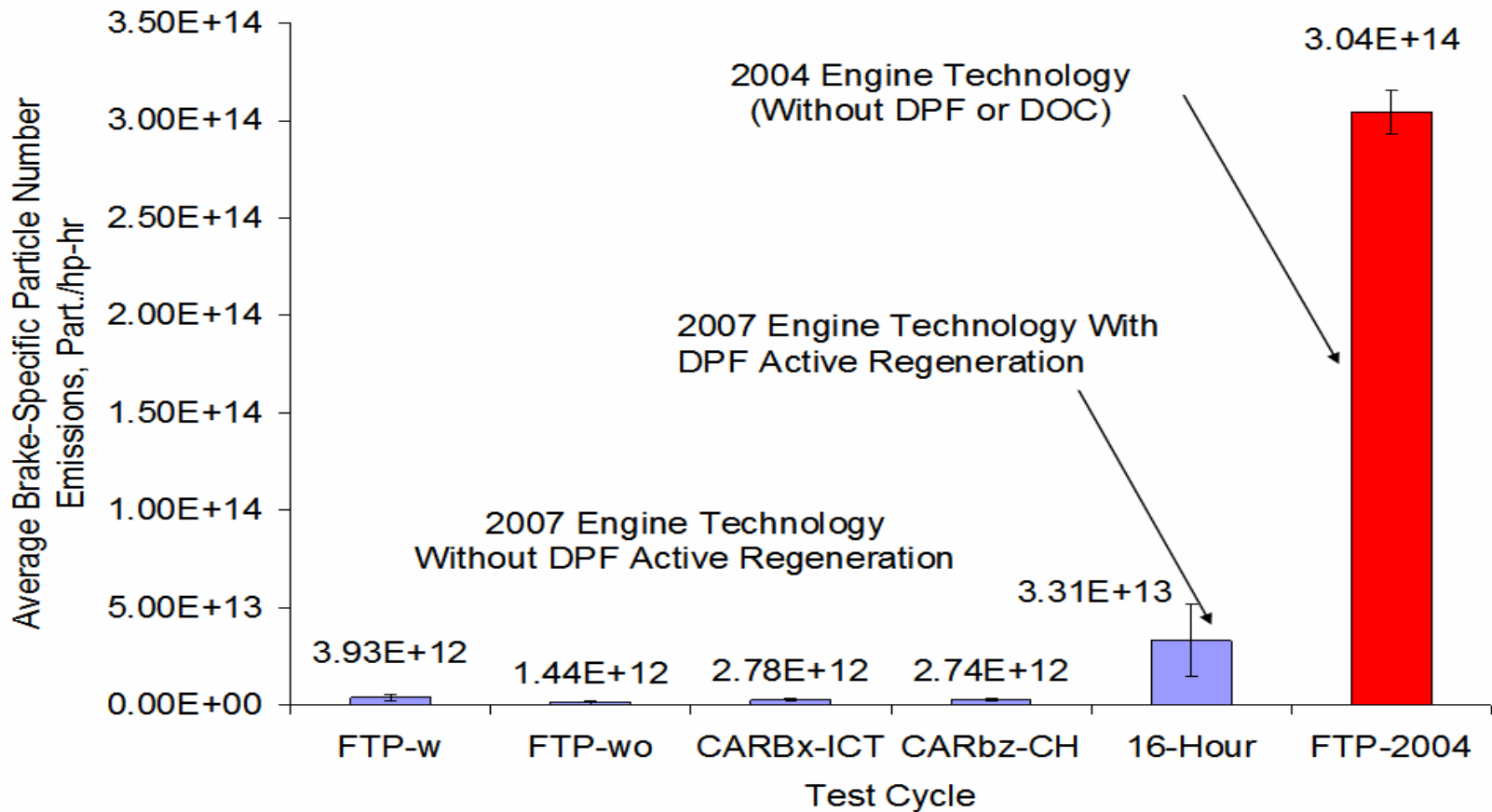


NO₂ Emissions

- The NO₂ to NO_x ratios determined for the ACES engines (~68%) were higher than typical ratios (4% to 15%) for 2004 technology engines
- Due to the catalyzed DOC/DPF or catalyzed DPF without DOC, the ACES engines emit 7 to 2 times higher NO₂, compared to a 2004 engine technology (2.4 g/hp-hr NO_x limit) emitting NO₂ in the range from 0.096 to 0.36 g/hp-hr
- 2010 NO_x emissions limit of 0.20 g/hp-hr will eliminate this temporary increase in NO₂



Average Particle Number Emissions



Without DPF regeneration, the particle number emissions average was 99 percent lower than the level emitted by a 2004 engine technology, and **with regeneration** it was **90 percent lower**



Summary – Phase 1 Results

- Regulated PM, CO, and NMHC emissions were at least 90% below the 2007 standard, and NO_x was 10% below standard
- Most unregulated emissions were at least 90% below 2004 technology engines
- Average NO₂ emission of 0.68 g/hp-hr was 2 to 7 times higher than the emissions from 2004 engines
 - However, 2010 engine technology NO_x limit of 0.20 g/hp-hr will force NO₂ emissions to be substantially lower than both 2007 and 2004 technology engines
- Particle number emissions average was at least 90% below 2004 technology engines, even when DPF regeneration occurred
- The final report is under review by the CRC ACES Panel, and expected to be available by June 30, 2009



CRC ACES Panel

Reynaldo Agama	Caterpillar	M. Matti Maricq	Ford Motor Company
James Ball	Independent Advisor	Mani Natarajan	Marathon Petroleum Company LLC
Nicholas Barsic	John Deere	Ralph Nine / Carl Maronde	US Department of Energy / National Energy Technology Laboratory
Steve Berry	Volvo	Robert Okamoto	California Air Resources Board
Steven Cadle	General Motors R&D Center	Charles Schleyer	ExxonMobil
Timothy French	Engine Manufacturers Association	Shirish Shimpi	Cummins
Thomas Hesterberg	International	Joseph Somers	US Environmental Protection Agency
Donald Keski-Hyynila	Detroit Diesel	Chris Tennant	CRC
Chris Laroo	US Environmental Protection Agency	Steve Trevitz	Volvo
Douglas Lawson	National Renewable Energy Laboratory	Urban Wass	Volvo
Hector Maldonado	California Air Resources Board	Jane Warren / Rashid Shaikh	Health Effects Institute



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