



Advanced Collaborative Emissions Study (ACES) Phase 2 Status Report

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

US Department of Energy (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)

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					█	█



Status, Phase 1 & 2

Phase 1:

- Complete

Phase 2:

- Work start pending sponsor approval
- 3 manufacturers participating:
 - Cummins, DDC, Volvo
- Basis of testing: 16-hour cycle and FTP cycles
- Phase 1 elements dropped: CARB cycle testing, blow-by differential, excess tunnel blanks
- Fuel procurement from same (commercial) source as Phase 3



Phase 1 Reporting

- Cycle Development: ACES-1 & ACES-1a - 2007
- Final Report - 2009
- Database - 2010
- Additional Reporting:
 - A&WMA 102nd Annual Conference & Exhibition: 2009 – Special Session
 - Diesel Technology Forum Webinar: “Heavy-Duty Diesel Engine Emissions Research” – September 2009
 - “Regulated and Unregulated Emissions from Highway Heavy-Duty Diesel Engines Complying with U.S. Environmental Protection Agency 2007 Emissions Standards” - Journal of the Air & Waste Management Association – April 2011

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Phase 1 Results: Regulated Emissions Relative to EPA 2007 Standard Based on FTP Transient Cycle

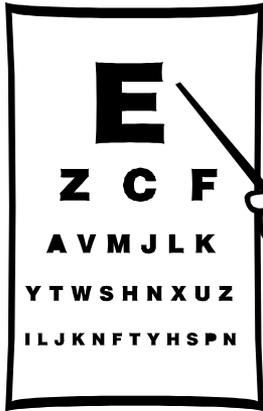
	2007 EPA Standard (g/hp-hr)	Average ACES Engine Emissions (g/hp-hr)	ACES Emissions % Reduction Relative to the 2007 Certification Standard
CO	15.5	0.33	98
NMHC	0.14	0.0064	95
PM	0.01	0.0011	89
NO _x	1.2 ^a	1.075	10

^a Average value between 2007 and 2009, with full enforcement in 2010 at 0.20 g/hp-hr

Source: <http://www.dieselforum.org/multimedia/webinars/eavy-duty-diesel-engine-emissions-research-webinar>



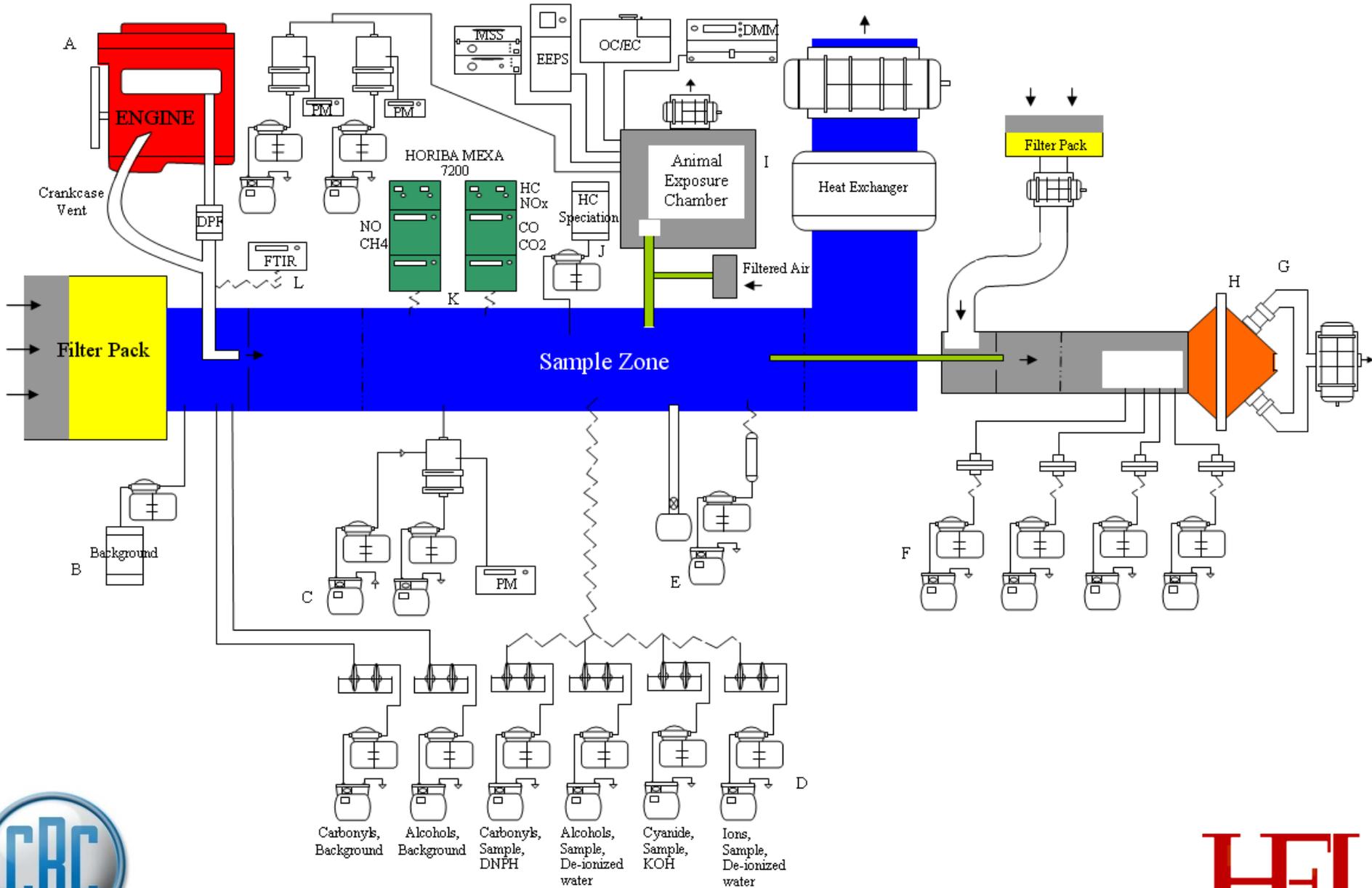
Phase 2 Measurements



Analyte Class	Notes	Method
Regulated Emissions	NO _x , NMHC, CO, PM, CH ₄ , CO ₂ , N ₂ O	CFR Part 1065
N ₂ O, NH ₃ , isocyanic acid and methyl isocyanate	Real Time, Raw Exhaust	FTIR
NO _x , NO, NO ₂	Real Time Dilute	Cchemi. (NO ₂ by difference)
Ions	Water Impinger (4 slpm), 47 mm TX-40 filter (28 slpm)	IC
Fuel/Oil PM Contribution	47 mm TX-40 filter, selected samples only, 28 slpm	DFI/GC
Hydrogen Ion	H ⁺ , water impinger, 4 slpm	Titration
Cyanide Ion	Impinger, 4 slpm	IC
VOC (C ₁ – C ₁₂)	Tedlar ® bag	GC/FID
Carbonyl compounds	DNPH impingers, 4 slpm	HPLC
Alcohols	DI water impinger, 4 slpm	GC/FID
Selected VOCs	Solid sorbent, 1 slpm (nitromethane, nitropropane, hydrogen sulfide, carbonyl sulfide)	GC/MS
Dioxins/Furans	One sample per engine, on 16-hr integrated sample, gas- and particle-phase extracts analyzed together, 1700 slpm	GC/MS
Real Time Total PM	1Hz, 10 slpm	DMM-230
Real Time Soot	1Hz, 2 slpm	MSS
Real Time PM Size and Number	1Hz, 10 slpm	EEPS
Metals and Elements	47 mm Teflo [®] filter, 28 slpm	ICP/MS, ICP, EDXRF
PAH	Gas- and particle-phase extracts analyzed together, except 16-Hour integrated sample, 1700 slpm	GC/MS
Nitro-PAH	Gas- and particle-phase extracts analyzed together, except 16-Hour integrated sample, 1700 slpm	GC/MS
Hopanes, Steranes	Gas- and particle-phase extracts analyzed together, except 16-Hour integrated sample, 1700 slpm	GC/MS
Polar compounds	Gas- and particle-phase extracts analyzed together, except 16-Hour integrated sample, 1700 slpm	GC/MS
Other SVOC (C ₁₄ -C ₄₀)	Gas- and particle-phase extracts analyzed together, except 16-Hour integrated sample, 1700 slpm	GC/MS
Nitrosamines	Thermosorb N®, 1 slpm	GC/MS
OC/EC	Quartz filters, 58 slpm	TOR and TOT
Particle-Phase Urea Compounds	TX-40 filter, 90 mm, ~336 slpm	ESI-MS



Phase 2 Sampling



New for Phase 2: Urea Compounds

- Dr. John Storey (Oak Ridge National Laboratory)
- Particulate-phase urea compounds
 - Large (90 mm) filter
 - Sampling over entire 16 hour aging cycle
 - Atmospheric Pressure Chemical Ionization Mass Spec (APCI-MS)
 - ammeline, ammeline, biuret, cyanuric acid, melamine, triuret, and urea
- FTIR
 - Continuous sampling
 - Raw exhaust
 - Detection limit: 1-2 ppm
 - Isocyanic acid, hydrogen cyanide, and methylisocyanate



CRC ACES Panel

Reynaldo Agama	Caterpillar	Mani Natarajan	Marathon Petroleum Company LP
Nicholas Barsic	John Deere	Ralph Nine / Carl Maronde	US Department of Energy / National Energy Technology Laboratory
Steve Berry	Volvo	Shirish Shimpi	Cummins
Maria Costantini / Rashid Shaikh	Health Effects Institute	Joseph Somers	US Environmental Protection Agency
Timothy French	Engine Manufacturers Association	Jeff Shaffer	Volvo
Thomas Hesterberg	International	John Storey	ORNL
Donald Keski-Hynnala	Detroit Diesel	Chris Tennant	CRC
Dan Kieffer	PACCAR	Steve Trevitz	Volvo
Chris Laroo	US Environmental Protection Agency	Tim Wallington	Ford Motor Company
<i>TBD</i>	National Renewable Energy Laboratory	Urban Wass	Volvo
Hector Maldonado	California Air Resources Board	Matt Watkins	ExxonMobil
M. Matti Maricq	Ford Motor Company	Ken Wright	ConocoPhillips



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