CRC

ANNUAL REPORT

2012

70th ANNIVERSARY

1942 - 2012

COORDINATING RESEARCH COUNCIL, INC.

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ANNUAL REPORT

September 2012

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PART ONE

STATE OF THE COUNCIL

STATE OF THE COUNCIL: 2012

The Coordinating Research Council (CRC) provides the means for the automotive and energy industries to work together and also with government and other stakeholders to address mobility and environmental issues of national and international interest. This year CRC celebrates a 70 year milestone since its official incorporation in 1942 in New York City.

The technical programs in CRC have continued again this year with broad cooperation from many partners on research projects and on other activities such as international technical workshops. This cooperation results in a finer focus on the important issues and leverage of both technical expertise and financial support to meet common goals. Partnerships in 2012 have included: The California Air Resources Board (CARB), Growth Energy, the Health Effects Institute (HEI), the National Biodiesel Board (NBB), the Renewable Fuels Association (RFA), the South Coast Air Quality Management District (SCAQMD), the Truck and Engine Manufacturers Association (EMA), the U.S. Department of Agriculture, the U.S. Department of Energy (DOE) and many of its national laboratories, the U.S. Environmental Protection Agency (EPA), and many others.

CRC has also continued coordination with research organizations worldwide, with Japanese, European, and Canadian collaborations emphasized during the past year. A CRC presentation on "Fuel Quality Issues and the U.S. Research Approach" was given in March 2012 at the Japan Auto Oil (JATOP) Conference in Tokyo.

CRC is nearing completion of its assessment of the impact of intermediate-level ethanol blends, a significant research program that has been generating results since 2006. It is essential to understand the impacts of changing fuel composition on vehicle performance in the current fleet. Several studies on gasoline blends of 15 and 20 volume percent ethanol (E15 and E20) were completed this year and others are nearing completion. Some of these include the Performance Committee study on engine durability (CM-136-09), Emissions Committee studies on impacts on OBD II systems (E-90) and evaporative emissions systems

durability (E-91), the AVFL Committee studies on fuel system compatibility (AVFL-15 and AVFL-15a), and the Atmospheric Impacts Committee study on modeling expanded use of renewable fuels (A-73). CRC has coordinated its research program on intermediate-level ethanol blends with EPA, DOE, and many of the other stakeholders.

An important highlight for 2012 is the start of Phase 2 of the Advanced Collaborative Emissions Study (ACES) in collaboration with the Health Effects Institute (HEI). This study will provide an evaluation of advanced diesel engine and aftertreatment systems meeting 2010 on-road heavy-duty diesel standards for particulate matter (PM) and oxides of nitrogen (NO_x). Engine testing is well underway in Phase 2. Meanwhile HEI is concluding health effects testing at Lovelace Respiratory Research Institute (LRRI) on 2007 technology engine exhaust and has released interim reports on their progress this year.

In addition to the ACES study, the CRC Emissions Committee has been active in several key areas of new research. Project E-83, "Effects of Olefin Content on Exhaust Emissions," was completed to show what impact olefin content in gasoline has on emissions of modern light-duty vehicles. Project E-88-2, "Transportation Fuel Life Cycle Analysis – A Review of Indirect Land Use Change and Agricultural N_2O Emissions," was completed this year presenting current understanding on key elements of life cycle analysis calculations. Studies on performance of on-board diagnostic (OBD) systems and evaporative emissions system durability (Projects E-90-2b and E-91) are nearing completion and results will be included in a comprehensive overview of the CRC Intermediate Ethanol Blend Research Program being prepared under Project E-97. The Emissions Committee started new studies on "Evaluation and Investigation of Gaseous and Particulate Emissions from SIDI In-Use Vehicles with Higher Ethanol Blend Fuels" (E-94-1), "Exhaust Emissions of Average Fuel Composition" (E-98), and "Very Low PM Mass Measurement" (E-99).

The Advanced Vehicle/Fuel/Lubricants (AVFL) Committee released their initial study on intermediate ethanol blend impacts on fuel system durability under Project AVFL-15. Additional investigations are continuing under Project AVFL-15a and publication of these results is expected later this year. The AVFL Committee also made significant progress in developing new diesel fuel surrogates formulations for research under Project AVFL-18 and published their work in the journal

Energy & Fuels. The committee is also actively pursuing advanced characterization methods and generating data under Project AVFL-19, "Characterization of Advanced Alternative and Renewable Fuels." A new investigation on "Biodiesel and Renewable Diesel Characterization and Testing in Modern LD Diesel Passenger Cars and Trucks" (AVFL-17b) was initiated to respond to data gaps in the existing literature. The AVFL's Fuels for Advanced Combustion Engines (FACE) Working Group continues its broad collaborations with industry and government fuel experts.

The Diesel Performance Group of the Performance Committee advanced their evaluation of field problems observed in modern diesel fuel injection systems where at least two types of fuel deposits have been documented in operations of high pressure common rail fuel systems. A new report documents industry progress on identifying sources of the problems. The goal is to establish detection methods and ultimately recommend possible solutions for correcting the field problems.

The Octane Group of the Performance Committee continued its timely evaluations of contributions of motor octane number (MON) and research octane number (RON) in current light-duty engines and control systems. A new octane study resulted in publication of an extensive literature survey, initiated to assess the relationship between efficiency and octane number in modern engines under Project CM-137-11-1, "Review to Determine the Benefits of Increasing Octane Number on Gasoline Engine Efficiency." Additional tasks have been completed and this will result in publication of enhanced data analysis with detailed input from industry and other experts on octane number impacts.

The Volatility Group of the Performance Committee completed a new study to evaluate the flammability of several ethanol-gasoline blend levels under Project CM-138-11-2 in cooperation with the Renewable Fuels Association and Growth Energy, Inc. The Volatility Group has also made extensive plans to conduct a new field study to determine E15 fuel blend correction factors to update the ASTM D4814 standard in full cooperation with industry stakeholders.

The Deposit Group of the Performance Committee released their report on Project CM-136-09-1B, "Engine Durability Study on Intermediate Ethanol Blends." This study was conducted by an experienced independent contractor, FEV. Results show durability performance characteristics of several popular vehicles operating on blends of E20 and E15 relative to an E0 baseline.

The Atmospheric Impacts Committee continued work examining future air quality scenarios through the use of air quality grid models. These models evaluate not only gaseous pollutant transport and reactions, but also directly emitted primary aerosols (PM) and secondary aerosols which are formed in the atmosphere. The committee completed its contribution to Phase 1 of the Air Quality Modeling Evaluation International Initiative (AQMEII) in cooperation with EPA and the Joint Research Centre (JRC) of Europe. The CRC contribution to this study under Project A-75 modeled the European domain with the CAMx air quality grid model. Results from this U.S. developed model were compared against several other European models and published as "Modeling Europe with CAMx for the Air Quality Model Evaluation International Initiative" in the journal *Atmospheric Environment*.

The Atmospheric Impacts Committee also completed Project A-76-1 in which light-duty vehicle emissions impacts from past, present, and future control scenarios were evaluated by applying several air quality modeling scenarios to compare relative improvements in ambient air quality as a function of vehicle emission standards that have been implemented and are now contemplated. The A-76-1 study results were published as "Effects of Light-Duty Gasoline Vehicle Emission Standards in the United States, Ozone and Particulate Matter" in the journal *Atmospheric Environment*. Also published in *Atmospheric Environment* this year are results from Project A-69, "Impact of Meteorology and Anthropogenic Emissions on the Local and Regional Ozone Weekend Effect in Midwestern U.S."

Previous CRC projects in the Atmospheric Impacts Committee resulted in the publication of four books by Oxford University Press: *Mechanisms of Atmospheric Oxidation of the Alkenes, Mechanisms of Atmospheric Oxidation of Aromatic Hydrocarbons, Mechanisms of Atmospheric Oxidation of the Alkanes,* and *Mechanisms of Atmospheric Oxidation of the Oxygenates*. A new project started this year will generate a manuscript for a fifth book on "Chemistry of Tropospheric Ozone Generation and the Influence of Trace Gases."

The 6th Mobile Source Air Toxics Workshop is scheduled for February 2013 to be held in Sacramento, CA. This workshop will be hosted by the California Air Resources Board and like previous events will bring together key local, state, and federal government researchers, academic and industry researchers, and other stakeholders to discuss current data and future research needs.

The 22st CRC Real World Emissions Workshop was held March 25-28, 2012, in San Diego, California. Participants included representatives from government, universities, commercial organizations, and several international organizations. The 2012 keynote speaker was Dr. John DeCicco of the University of Michigan Energy Institute who shared his perspective on "Clean Air Success and the Climate Challenge: Similarities, Differences and Research Needs." Proceedings of the workshop were published by CRC and a summary article, "Highlights from the 22nd Coordinating Research Council Real World Emissions Workshop," was published in the August 2012 issue of *EM Magazine* by the Air and Waste Management Association.

The second Life Cycle Analysis (LCA) Workshop on Biofuels was held at Argonne National Laboratory, October 17-19, 2011. An international organizing committee invited world-renowned experts to present the latest information on life cycle analysis techniques and uncertainties. Participation at this "invitation only" event was limited to individuals actively working in the field of life cycle analysis techniques and applications. The workshop proceedings identify a consensus position on the status of modeling technology and uncertainties/gaps in the current data and procedures used in biofuel life cycle assessments. The proceedings are published on the CRC website.

Details on these and other CRC projects appear in Part Two of this Annual Report. Final Reports issued since the last CRC Annual Report are listed in Part Three, and organization memberships comprise Part Four.

PART TWO

DETAILED REPORTS OF CRC PROJECTS

ADVANCED COLLABORATIVE EMISSIONS STUDY

CRC Project Nos. ACES, ACES-1, ACES-1a

Leaders: M. Natarajan
C. J. Tennant

Scope and Objective

The Advanced Collaborative Emissions Study (ACES) is a cooperative, multi-party effort to characterize the emissions and assess the possible health impacts of the new, advanced engine systems and fuels introduced into the market during the 2007–2010 time period.

Current Status and Future Programs

The ACES program is being carried out by HEI and CRC, using established emissions characterization and toxicological test methods to assess the overall health impacts of production-intent prototype engine and control technology combinations.

Funding for ACES is provided by DOE, EPA, CARB, API, EMA, and manufacturers of emissions control equipment.

ACES is divided into three phases:

- In Phase 1, extensive emissions characterization of four 2007 production heavy heavy-duty diesel (HHDD) engines was performed. Emissions characterization results were used as the basis for selecting one HHDD engine/aftertreatment system for health testing (Phase 3). In addition to the measurement of regulated pollutants, the exhaust gases were speciated to quantify nearly 700 compounds of interest.

- Phase 2 is analogous to Phase 1, but is being performed on 2010 HHDD engine technology. Additional measurements are being made to account for potential compounds from the NO_x aftertreatment technology, urea selective catalytic reduction systems (urea-SCR).

- In Phase 3, the selected 2007 engine has been installed in a specially designed emissions generation and animal exposure facility; it is being used in a chronic inhalation study with health measurements. HEI is leading this Phase, which is being performed by the Lovelace Respiratory Research Institute (LRRI).

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Southwest Research Institute (SwRI) and Desert Research Institute (DRI) were selected to perform Phase 1. Four manufacturers (Caterpillar, Cummins, Detroit Diesel, and Volvo) supplied degreened new 2007 engines for Phase 1 testing, using a common lubricant supplied by Lubrizol.

The Phase 1 evaluation was based on Federal certification test procedures (FTP) but also included testing on a new engine cycle based on a heavy-duty chassis dynamometer test cycle developed by CARB and employed extensively in CRC Project E-55/59. The engine cycle was developed by West Virginia University (WVU) under the ACES-1 project, funded by CARB. As a follow-on project to ACES-1, the ACES-1a project was performed by WVU with funding from HEI to create a 16-hour test schedule. The 16-hour test schedule is comprised of the FTP and portions of the CARB test cycles; it will be used for all engine characterization and exposure activities in the ACES Project.

The Final Reports for the ACES-1 and ACES-1a cycle development projects and the Phase 1 project Final Report have been released and are available on the CRC website. An article on the Phase 1 engine emissions test program was published in the *Journal of Air and Waste Management Association* in April 2011.

SwRI has been selected to perform Phase 2. Engines being tested in the Phase 2 project were degreened by their manufacturers (Cummins, Detroit Diesel, and Volvo) and delivered to SwRI. Testing began in June 2012 and will continue throughout the summer. Release of the final report for Phase 2 is expected in 2013.

NONROAD VEHICLE EMISSIONS

CRC Project No. E-70

Leaders: J. Koupal
M. Natarajan

Scope and Objective

The goal of this study is to collect data to quantify populations, usage, and emissions of diesel nonroad equipment in EPA Region 7. CRC cooperated with EPA and the State and Territorial Air Pollution Program Administrators/Association of Local Air Pollution Control Offices (STAPPA/ALAPCO) to conduct a systematic data collection designed to improve the methods and tools used by the EPA to estimate emissions from nonroad equipment. Data collected included populations, usage rates (activity), and "in-use" or "real-world" emission rates.

Current Status and Future Programs

This data collection study by the Office of Transportation and Air Quality (OTAQ) in the Office of Air and Radiation (OAR) was performed as a work assignment under an EPA contract for National Portable Emissions Measurement Systems (PEMS)/Portable Activity Monitoring Systems (PAMS) research. In 2007, CRC and EPA initiated a Cooperative Research and Development Agreement (CRADA) to support an expansion of the testing.

Eastern Research Group (ERG), the prime contractor, worked with EPA to integrate statistical sampling techniques, the latest in-use activity and emissions measurement technology, and rigorous quality assurance and quality control methods to characterize in-use, real-world emissions from 52 non-road diesel engines. Prior to the fieldwork, representatives from 500 establishments were briefly interviewed regarding their equipment ownership and use.

During this pilot study, portable on-board instruments were used to measure exhaust emissions and usage of commercial non-road diesel engines in the construction sector. Statistical sampling was used to randomize the recruitment and screening of participants and the selection of equipment to be instrumented. Fieldwork for this study was conducted in EPA Region 7, which includes the states of Iowa, Nebraska, Kansas, and Missouri.

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Information gathered during the course of this study will be used to help refine methods and protocols for a larger-scale project to estimate the population, usage, and emissions of non-road equipment in various economic sectors. After undergoing analysis and quality assurance review, these data were stored in OTAQ's Mobile Source Observation Database, where they may help expand and improve the data currently used to support emission inventory modeling for non-road engines.

The project started in 2007, and CRC funded an expansion of this project through its CRADA with the EPA. The Final Report for this project was prepared for publication by EPA, and is posted to on the EPA and CRC websites.

EFFECTS OF OLEFINS CONTENT ON EXHAUST EMISSIONS

CRC Project No. E-83

Leaders: J. P. Uihlein
M. Valentine

Scope and Objective

The objective of this program is to evaluate the potential emissions impacts of different concentrations of fuel olefins on recent model light-duty gasoline vehicles. For this project, two gasoline fuels with differing olefin content (3% and 15%) were tested on a fleet of 15 modern gasoline-powered vehicles. Vehicles were tested over the LA92 cycle at least twice on each of the test fuels. Measurements included regulated emissions, fuel economy, and modal tailpipe emissions. Speciated emissions of mobile source toxics, including benzene, 1,3 butadiene, formaldehyde, and acetaldehyde were also measured. A comprehensive analysis of the resulting data, including statistical and other analyses of the trends in regulated emissions and toxics, was performed.

Current Status and Future Programs

The E-83 project was performed by the University of California-Riverside's Center for Environmental Research and Technology (CE-CERT). The Final Report was published in June 2012 and is available on the CRC website.

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E-85 / E-85-2 NATIONAL SURVEYS OF E85 FUEL QUALITY

CRC Projects No. E-85 and E-85-2

Leaders: K. J. Wright (ret.)
T. Alleman

Scope and Objective

NREL/DOE has partnered with CRC for these studies. The objectives of the studies were to compare the quality of E85 fuel currently sold in the U.S. with the ASTM D5798 quality specification and additionally to investigate other real or potential quality issues for this fuel.

Current Status and Future Programs

For the first study, the DOE Alternative Fuels Data Center E85 station database was used to select E85 public (both retail and fleet) and government fleet pumps for sampling. Locations were selected to cover the broadest possible U.S. continental geographic area. Sampling occurred at three times over the course of a year. The purpose of sampling at different times was to gather seasonally specific samples that would cover all volatility classes. Sampling times were selected to avoid transition classes. All fuel samples were tested for properties shown in D5798 and a short list of other fuel properties. A subset of samples was selected for more detailed characterization. Based on results from the Class 1 samples in the summer of 2008, an addendum of ten Class 1 samples collected in August 2009 was added to this project. The Final Report for Project E-85 was released on December 7, 2009.

The follow-on Project E-85-2, also in partnership with NREL, followed a similar approach. Sampling was performed on all three volatility classes throughout the year while avoiding transitional classes, testing all samples for only key properties of interest. Locations were selected to cover the broadest possible U.S. continental geographic area, focusing on urban areas where possible. Class 1 sampling began in July 2010. Class 3 sampling occurred in February 2011, and Class 2 sampling was conducted periodically throughout the project. The Final Report was published by NREL and CRC in January 2012.

MID-LEVEL ETHANOL BLENDS CATALYST DURABILITY STUDY

CRC Project Nos. E-87-1, E-87-2

Leaders: C. Jones
B. H. West

Scope and Objective

The purpose of these studies was to investigate the effects of ethanol-blended fuel on air-fuel ratio when operating in "open-loop" control conditions and associated catalyst and oxygen sensor temperatures. When a vehicle engine is operated at heavy loads, the control system will enrich the fuel-air mixture to cool the exhaust and protect the catalyst from overheating. A switching type oxygen sensor will not operate in this rich environment, and the control system will lose feedback from the sensor and go to "open-loop" operation. If the enrichment calculation does not take the possibility of higher ethanol fuel into account, then the calculation may be in error and the catalyst temperature protection could be compromised.

Project E-87-1 tested a small fleet of 25 U.S. and California-certified vehicles to determine if the fuel ethanol content affected the combustion stoichiometry and the catalyst and oxygen sensor temperatures when the vehicle was operated in catalyst protection mode. E-87-1 was a screening study to identify vehicle types (make, model, model year) of interest for the main study E-87-2.

The follow-up to the screening study was initially conceived as a collaboration with the DOE, who refers to the project in their research program as DOE V4. The objective of DOE V4 / E-87-2 was to determine the effects of intermediate-level ethanol blends on catalyst durability and exhaust emissions, using a larger selection of vehicles. Four fuels were used in the projects, defined here by their ethanol volume percent content: E0, E10, E15, and E20.

Current Status and Future Programs

The Transportation Research Center was selected as the contractor for the E-87-1 screening study through a competitive solicitation awarded by CRC. DOE/ORNL (Oak Ridge National Laboratory) and DOE/NREL (National Renewable Energy Laboratory) conducted their own pilot

studies in parallel to E-87-1. The E-87-1 Final Report was released in July 2009.

CRC Emissions Committee members were represented on an advisory panel for the DOE/ORNL contractor selection process for DOE V4 / E-87-2, "Catalyst Screening and Durability Study for Intermediate Ethanol Blends." SwRI was selected as the contractor for the main study through a competitive solicitation awarded by DOE/ORNL. Ten vehicle types or more (multiple vehicles of each type for different fuels) were aged for 50,000 miles or full useful life, whichever was greater, with emissions measurements performed every 25,000 miles.

CRC participation in DOE V4 was reduced in the latter stages of the project. DOE, working through ORNL and NREL, ran parallel testing projects at other laboratories without CRC participation. The Final Report, "Intermediate Ethanol Blends Catalyst Durability Program," was released in February 2012 by ORNL for DOE as Report ORNL/TM-2011/234. The Final Report, "Comparative Emissions Testing of Vehicles Aged on E0, E15 and E20 Fuels," was released by NREL for DOE as Report NREL/SR-5400-55778.

FOLLOW-ON STUDY OF TRANSPORTATION FUEL LIFE CYCLE ANALYSIS

CRC Project No. E-88-2

Leaders: P. L. Heirigs
D. M. DiCicco

Scope and Objective

The overall objective of this project was to investigate influential assumptions used in LCA modeling and those used to estimate the Greenhouse Gas (GHG) impacts of land use change (LUC). A primary deliverable from this work included identifying data gaps and making recommendations to improve the transparency of modeling methodologies. Particular focus was given to land-use databases and N_2O emissions estimates, with special attention paid to those methodologies utilized in policies such as EPA's RFS2 and CARB's LCFS.

Current Status and Future Programs

After a competitive bidding process, Desert Research Institute (DRI) was selected to conduct the work. Databases were acquired that were used to estimate global land use changes, as well as those to estimate emission factors from various land types (e.g., grasslands, forestlands, etc.). The database values were compared with other values from available literature sources to identify important differences and knowledge gaps. The project included tasks entitled 1) Review of Global Land Use Databases and 2) Review and Comparison of Data and Models Used to Estimate Agricultural N_2O and CH_4 Emissions.

The project scope included a database and literature review effort – no experimental modeling was performed. The literature previously reviewed under Projects AVFL-17 and AVFL-17a served as the starting point for this work. Computer-based search tools, including Web of Science, the Society of Automotive Engineers (SAE) literature search engine, the DOE citation database, trade literature, and patents were applied to update the information set.

In addition, DRI acquired emissions factor databases and other support documents used in both CARB and EPA policies, such as the Woods Hole and Winrock data, and compared these data to other published results.

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The Final Report for this project was released in January 2012.

CRC held invitation-only LCA Workshops in October 2009 and October 2011 at Argonne National Laboratory near Chicago. The workshop organizing committee included representatives from API, CARB, Conservation of Clean Air and Water in Europe (CONCAWE), U.S. DOE, Environmental Defense Fund (EDF), U.S. EPA, The National Biodiesel Board (NBB), Natural Resources Canada, USDA, Ford Motor Company, Chevron Global Downstream, RFA, Marathon Petroleum Company, ExxonMobil Research & Engineering, Argonne National Laboratory, and the South Coast Air Quality Management District (SCAQMD). Summaries from both workshops are posted on the CRC website.

A follow-on study designated E-88-3 is planned as a new start in 2012 based on results from E-88-2 and information needs identified in CRC Workshops on LCA.

EPAct/V2 LIGHT-DUTY VEHICLE FUEL EFFECTS

CRC Project No. E-89

Leaders: C. Hart
D. H. Lax
J. P. Uihlein

Scope and Objective

EPA initiated this study (referred to as EPAct) with CRC and DOE/NREL (referred to as V2). The study examined the effects of changes in fuel parameters on the exhaust emissions of late-model, light-duty vehicles.

- Phases 1 and 2 were run by EPA and DOE/NREL.
- Phase 3 includes fuels recommended by CRC and is intended to establish the effects of Reid Vapor Pressure (RVP), T50, T90, aromatics and ethanol content on exhaust emissions from Tier 2 vehicles.
- DOE/NREL is funding additional phases 4 and 5 that include emissions measurements at temperature extremes, and separately on high-emitting vehicles.

Current Status and Future Programs

CRC reviewed the test fuels matrix for Phase 3 and recommended expanding it with the inclusion of two additional fuels, supported by statistical analysis, to improve the value of the project. These two fuels enhance the understanding of the effect of the fuel distillation parameters.

EPA incorporated the recommended additional fuels for testing in the main program. The project was structured as follows:

- Phase 1:
  - Testing at 75°F over LA92
  - 3 ‘typical’ fuels E0, E10, and E15
  - 19 high sales volume Tier 2, 2 high-emitter and 1 high-mileage NLEV vehicles
- Phase 2: Repeat of Phase 1 except at 50°F
- Phase 3: Main Program

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- 27 fuels tested in 16 Tier 2 vehicles, E85 tested in FFVs that are included in the 16
- Fuel Matrix, 5 variables in matrix
- 2 levels of RVP, T90, aromatics
- 5 levels of T50
- 4 levels of ethanol (E0, E10, E15, E20) plus E85
- 2 additional fuels from CRC for resolving potential T90 non-linear effects
- Variables span the 5^{th} and 95^{th} percentiles of in-use fuel properties
- Measured emissions: PM, CO_2, NO_2, VOCs, ethanol, carbonyls, N_2O, NH_3 and HCN by FTIR, and SVOC speciation in Phases 1, 2, and 3

Fifteen of these vehicles were also used in Project E-83.

The Final Report documenting the testing procedures followed in the EPAct / V2 / E-89 project was reviewed by the CRC technical panel, and comments were provided to EPA. Additional reports on Phases 4 and 5, with no CRC involvement, on analyses performed by the sponsoring government agencies are also in development. EPA's schedule for release of the data and reports is indeterminate. The final deliverables will not be CRC publications.

IMPACT OF E15/E20 BLENDS ON OBDII SYSTEMS

CRC Project Nos. E-90, E-90-2a, and E-90-2b

Leaders: J. J. Jetter
P. L. Heirigs

Scope and Objective

The objectives of this study are to collect OBD and related data from in-use vehicles and analyze these data to determine the vehicles' potential to illuminate the Malfunction Indicator Lights (MIL) when fueled with intermediate ethanol blends (e.g., E15, E20). Target data include long-term fuel trim and any stored OBD diagnostic trouble codes (DTCs) related to enleanment.

Current Status and Future Programs

De la Torre Klausmeier Consulting, Inc. was chosen to perform the first phase of this project. To facilitate data interpretation, some vehicle data were collected in regions where E10 was marketed exclusively, and some in regions where E0 was marketed exclusively. Given that specific OBD threshold values for MIL illumination are considered confidential, the automotive Original Equipment Manufacturers (OEMs) provided general input during the data analysis phase.

Description of the study approach:

1. Obtain approval from states with Inspection/Maintenance (I/M) programs to conduct additional tests at inspection stations on a sample of high mileage vehicles.
2. Develop a plan for conducting these tests at inspection facilities.
3. Coordinate the collection and analysis of data.
4. Prepare draft and final reports.

This project was initiated in late 2008; a pilot study in the regions of Austin, TX, Dallas, TX and Chicago, IL, was completed in the spring of 2009. The Final Report for the pilot study was published on the CRC website.

Following completion of the initial phase of the project (E-90), two additional elements were initiated: an analysis of existing data from I/M programs (E-90-2a) and an experimental program (E-90-2b). The E-90-2a project, "Evaluation of Inspection and Maintenance OBD II Data to

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Identify Vehicles that May be Sensitive to E10+ Blends," was performed by Sierra Research, and the Final Report was published on the CRC website.

Project E-90-2b, "Impact of Ethanol Blends on the OBDII System of In-Use Vehicles," was awarded to SwRI. Vehicle screening and testing are ongoing. This project has been extended to include varied ethanol percentage, ambient temperature, and geographic range for vehicle operation. An interim report is in development, with release anticipated in late 2012.

EVAPORATIVE EMISSIONS DURABILITY TESTING

CRC Project No. E-91

Leaders: J. Y. Sigelko
S. Bohr

Scope and Objective

The objectives of the evaporative emissions durability test program are to quantify effects of differing levels of ethanol and to document any detrimental effects of long-term ethanol exposure on the evaporative emissions and emissions durability of selected vehicles.

Current Status and Future Programs

Ten vehicle models which represent a variety of evaporative emission control strategies were tested. Two of each type of vehicle were tested on two test fuels: federal emissions test fuel (E0) and federal emissions test fuel blended with 20 percent ethanol by volume (E20). E0 served as the baseline fuel. Vehicles operating on E20 were compared to vehicles operating on E0 to determine the effects of increased ethanol levels in gasoline.

The approach consisted of: (a) conducting baseline evaporative emissions testing on the fleet of test vehicles, (b) exposing vehicles to a 3-month aging cycle of ambient diurnals, and (c) repeating this cycle four times by driving the vehicles over the course of a year.

The basic aging protocol consisted of driving the vehicle one EPA standard road cycle (SRC) twice per day, allowing the vehicle to cool completely between drives. The SRC is an EPA-devised test cycle of 25.9 miles duration at an average speed of 46.3 mph. Between drives, the vehicle was parked outside in ambient conditions.

All twenty vehicles were driven on road twice per day for 360 days, with eight hour minimum soak time between drives. The vehicles were parked outdoors during the aging period. At quarterly intervals, the vehicles were tested using two SHED procedures:

- The “Baseline Test” was similar to a two-day diurnal supplemental certification test sequence. The Baseline Test was always performed using ethanol-free certification gasoline. Results from this test provided information on how E20 fuel

substitution and vehicle aging may effect the vehicle's compliance with EPA evaporative emissions standards.

- The "Permeation Test" quantified the amount of permeation that contributed to evaporative emissions. Results from this test provided information on the possible sources of the permeation, vapor leaks and fuel pressure driven leaks, isolating each parameter to support emissions modeling. The Permeation Test procedure was adapted from CRC E-77.

Over 600 individual SHED tests were performed to assess the effect of aging and fuel exposure on permeation and evaporative emissions.

This project was conducted by ETC (now SGS) of Aurora, Colorado, with the sea-level work being performed by Chrysler as a subcontractor. The Final Report for this project was published on the CRC website.

EVALUATION AND INVESTIGATION OF GASEOUS AND PARTICULATE EMISSIONS ON SIDI IN-USE VEHICLES WITH HIGHER ETHANOL BLEND FUELS

CRC Project No. E-94-1

Leaders: M. B. Viola
J. P. Uihlein

Scope and Objective

In this pilot study, vehicles with spark ignition direct injection (SIDI) engines will be purchased and operated on fuels containing a range of ethanol concentrations; (E0 → E20 or higher). Key objectives are as follows:

- Determine gaseous and PM/PN (particle mass/particle number) emissions with E0 fuels as a baseline.
- Determine gaseous and PM/PN emissions with splash blended E10 and E20 fuels.
- Measure the effect of heavy aromatic compounds on the PM/PN emissions by utilizing two different base fuels.
- Characterize particulates from all testing.

Current Status and Future Programs

Vehicles

Three vehicles will be used for this pilot phase of the program. One vehicle will have a naturally-aspirated engine, one will have a turbo-charged engine, and one will have a V6 engine.

Fuels

Ethanol will be splash-blended to produce E10 and E20, with the potential to blend fuels higher than E20. Each fuel will be sampled and measured for RON, MON, sulfur, olefins, aromatics, oxygen, benzene, hydrogen, RVP, ethanol, and boiling point distribution. The use of two different base test fuels is being contemplated to evaluate the potential impact of heavy aromatic compounds on PM emissions from the test vehicles.

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Emissions Measurements

Using the LA92 test cycle (with an option to include the US06 test cycle), all tailpipe gaseous emissions will be collected along with instantaneous PN emissions. Fuel economy and GHG emissions (CO_2, N_2O and methane) will also to be collected. PM characterization will include:

a. For PM number (i.e., PN): Solid particles >23 nanometers in size.

b. For PM mass: Standard filter method using the EPA 1065 protocol.

c. Real-time Black Carbon or soot (mass-based): AVL Micro-Soot Sensor or equivalent

d. PM size distribution: EEPS or similar

e. Determine soot morphology using organic carbon / elemental carbon (OC/EC); also amount of sulfur contained in particulate.

This project was awarded to SwRI in May 2012. The approach to fuel formulation is being developed by the Committee prior to the start of work.

LINKING TAILPIPE AND AMBIENT PM

CRC Project No. E-96

Leaders: M. M. Maricq
H. Maldonado

Scope and Objective

The objective of this project is to define the relationship between semi-volatile organic compounds (SVOC) and other aerosols contained in vehicle exhaust and subsequent formation of secondary organic aerosols (SOA) and other compounds formed in the atmosphere via dilution and chemical reactions. The main project objective includes obtaining sufficient definition of the relationship between SVOC and SOA to model the behavior in the atmosphere. This project has application to both the Real World Group and the Atmospheric Impacts Committee and thus is a joint project, with the Atmospheric Impacts Committee referring to Project No. A-74.

Current Status and Future Programs

This project was awarded to Carnegie Mellon University (CMU). It leverages considerable additional funding provided through an EPA STAR grant and in-kind testing by CARB. The project consists of three test phases, and a fourth moedling phase. Phase 1 addressed light-duty vehicle emissions. Phase 1 testing was carried out in May 2010. Testing for Phase 2, aimed at heavy-duty diesel emissions, was completed in July 2011.

Phase 3 has two aims. The first was to revisit light-duty vehicles and address issues or questions that arose in the analysis of Phase 1 data. The second was to examine non-road engine emissions. Testing for Phase 3 was conducted in early 2012, and the CMU contract was modified to fund this work. Phase 4, proposed for 2012, will focus on incorporating Phase 1-3 results into improving atmospheric aerosol models.

Summary results from Phase 1 were presented at the 21st Real World Emissions Workshop in March 2011 and a follow-on presentation was given at the 22nd Workshop in 2012. An interim Phase 1 report has been completed and approved by the project panel and committees. Rather than release individual phase reports, the project team plans to release a comprehensive report at the conclusion of the project.

EMISSIONS

CRC MID-LEVEL BLEND RESEARCH

CRC Project No. E-97

Leaders: M. I. Watkins
M. Valentine

Scope and Objective

This study includes an overview of the entire CRC program on intermediate-level ethanol blends, as well as a summary of each research project. The study is organized to group together CRC projects addressing a single topic area such as: exhaust emissions, evaporative emissions, or driveability. The summary of each study and group of related studies includes both methodology and results. Implications for in-use emissions, performance and durability will be included where there are clear findings. The report will also cover studies by other groups that were closely related to the CRC program, but the project will not conduct a broad literature survey of mid-level blend impacts. Areas of uncertainty and limitations in the CRC program will also be described.

Current Status and Future Programs

After a competitive solicitation, this project was awarded to a team of consultants, Albert Hochhauser and Charles Schleyer. The project is ongoing, with reporting expected in late 2012.

EXHAUST EMISSIONS OF AVERAGE FUEL COMPOSITION

CRC Project No. E-98

Leaders: J. P. Uihlein
M. Valentine

Scope and Objective

The objective of this project is to measure exhaust emissions from a range of recent model light-duty gasoline vehicles operating on three fuels. One fuel will be a re-blend of one of the fuels from the EPAct/V2 program (a "tie" fuel); the other fuels will occupy the mid-space defined by the properties of all of the fuels tested in the EPAct/V2 program. Regulated emissions as well as speciated emissions will be measured using standard exhaust emission tests.

Current Status and Future Programs

Fifteen vehicles used in the EPAct/V2 program will be tested. Each vehicle-fuel combination will be tested using the LA-92 emissions test cycle, with the fuel order randomized for each vehicle.

Speciated emissions measurements will be carried out for the designated toxics benzene, 1,3-butadiene, formaldehyde, and acetaldehyde for all tests. Speciated emissions work is co-funded through CRC Project A-80. VOC speciation of the exhaust emissions for one test of one fuel for each vehicle for each bag is planned. Cumulative PM mass measurements will be made for each pair of back-to-back tests.

This project was awarded to SwRI. Testing is expected to occur in 2012, with a Final Report release in 2013.

EMISSIONS

VERY LOW PM MASS MEASUREMENT

CRC Project No. E-99

Leaders: H. Maldonado
M. M. Maricq

Scope and Objective

The objective is to examine modifications to gravimetric PM mass measurement that preserve the integrity of the method but decrease the variability and gaseous adsorption artifacts that limit the usability of this method at LEV III / Tier 3 emissions standards.

Current Status and Future Programs

Present motor vehicle PM emissions measurement regulations (CFR 40 Part 1065, 1066) require gravimetric determination of PM collected onto filter media from diluted exhaust. But with current sampling practices, the method is reaching its limit of detection at the proposed 3 mg/mi PM emissions standard. The combined effects of the more stringent PM standard and CFR minimum dilution requirements have reduced typical filter loading to 5 – 10 μg, depending on CVS tunnel flow. At the same time, a number of studies show that filters, including Teflon® membrane, are susceptible to gaseous adsorption artifacts that can contribute a 5 – 10 μg weight gain even in the absence of a test vehicle (i.e., tunnel and trip blanks). This artifact itself has high variability (~100%) and is susceptible to variation from facility to facility. The impacts on vehicle emissions testing are increased measurement uncertainty, and cost.

Tasks:

1. Identify hypothesized method modifications that will reduce variability of PM mass test results.
2. Prepare and submit the project test plan for CRC committee review and approval. The test plan should statistically demonstrate how method changes affect test measurement capability. The matrix includes test method, test engines/vehicles, test cycles, and fuels. Also included are parameters to measure environmental conditions, such as ambient outside air, ambient chamber air, ozone level, tunnel air, tunnel wind velocity, and dew point of diluted exhaust mixture, reporting frequency (e.g., 1 Hz), and the methods used to measure and calculate these parameters.

3. Perform testing according to test plan. Provide EC/OC data. Change plan as necessary to ensure a sufficient number of tests and repeatability. Provide a statistical assessment. Identify and quantify any ancillary impacts of the method modifications.
4. Analyze data set and produce final report.

A competitive procurement process for this project is ongoing, as well as the development of potential co-sponsorship.

EMISSIONS

ON-ROAD EMISSIONS MEASUREMENT VIA RSD

CRC Project No. E-106

Leaders: D. M. DiCicco
M. Natarajan

Scope and Objective

This project will be performed by Denver University (DU), following the general methodology of the E-23 project to use remote sensing devices to measure the emissions of in-use fleets. The researchers will make measurements in Chicago and Tulsa on an alternating two-year schedule. One measurement campaign will be conducted for one five-day week each year, alternating locations, between 2013-2016. The plan is to return to the E-23 Chicago site in early fall of 2013 and 2015, and to return to the Tulsa site in the early fall of 2014 and 2016. The equipment will be the same as was used in E-23, but with the new capability to monitor ammonia, sulfur dioxide, and nitrogen dioxide in real time from each passing vehicle. This project is expected to provide between 80,000 and 100,000 vehicle emissions readings over the course of the four year study.

Current Status and Future Programs

This project has been awarded to DU, and testing is expected to begin in 2013 with the first annual Final Report release in 2014.

DURABILITY OF AUTOMOTIVE FUEL SYSTEMS EXPOSED TO E20

CRC Project No. AVFL-15

Leaders: D. M. DiCicco
M. Foster
K. E. Knoll

Scope and Objective

The objective of Project AVFL-15 is to determine the durability of wetted fuel system components when exposed to gasoline containing 20% ethanol (E20). Functional testing of individual components is one metric that can be used to evaluate the impact on wear of fuel pumps and fuel injectors. Investigators gathered quantitative data on the impact of E20 on the performance of plastics and elastomers, including fuel system o-rings, hose materials, and fuel tank materials. The research focused on vehicles that were considered to be at risk for durability issues and represent a substantial fraction of the current in-use fleet.

Current Status and Future Programs

Testing for this project was conducted by the Transportation Research Center (TRC). New fuel system pairs were tested on respective test fuels (E0 and E20), focusing on components exhibiting the most susceptibility to ethanol content in the fuel. A pilot phase exposed fuel pump components to each of the test fuels. In addition to fuel pump and fuel injector testing, the program called for material testing of the complete fuel system after 11 months of aging at 105º F. The impact of wear on the fuel system components when exposed to E20 was measured.

NREL was a co-sponsor of this project. In early 2009, the contract was modified to increase the overall level of effort, adding fuel damper and fuel level sender testing in the process. In late 2009, this project was extended to include additional fuel pump durability soak testing, an extension of the fuel rig soak testing, and additional material analysis. In 2010, the project was extended twice, first to test additional fuel pumps, and again to test additional level senders. Project AVFL-15 is considered a pilot evaluation (not a comprehensive evaluation). The Final Report was reviewed by the Committee and Technical Panel and released in January 2012.

AVFL

DURABILITY OF AUTOMOTIVE FUEL SYSTEMS EXPOSED TO E15

CRC Project No. AVFL-15a

Leaders: S. W. Jorgensen
M. Foster

Scope and Objective

AVFL-15a was developed to examine durability of fuel pumps and fuel level senders during exposure to E15, drawing on the knowledge of potentially sensitive parts and using the test procedures developed in the parent AVFL-15 pilot project. Aggressive and non-aggressive fuel formulations of E15 test fuel are included in this continuation of the pilot project.

Current Status and Future Programs

After a competitive solicitation, the project was awarded to the Testing Services Group (TSG). Testing for the initial phase of AVFL-15a was completed in the first quarter of 2012. An interim draft data report was submitted to CRC, presenting results from the first phase of the test program. The committee elected to conduct supplemental testing to be completed by the third quarter of 2012. The committee will oversee data analysis for both phases of AVFL-15a. The Final Report is anticipated before the end of the calendar year and will include results and analyses of pump soak durability performance, pump endurance performance, and fuel level sensors exposed to E15 test fuels compared against E0 and E10 base fuels.

FUELS TO ENABLE LIGHT-DUTY DIESEL ADVANCED COMBUSTION REGIMES

CRC Project No. AVFL-16

Leaders: W. J. Cannella
C. S. Sluder

Scope and Objective

The objective of this project is to use the set of research diesel fuels developed by the FACE Working Group to determine the effects of diesel fuel properties and composition on the performance characteristics of a set of research test fuels in an advanced combustion light-duty (LD) diesel engine. The project included two main tasks:

Task 1 – Establish Engine Test Platform -- A research engine test platform was established capable of investigating fuel effects in advanced combustion regimes.

Task 2 – Investigate the Effect of Fuel Properties on Advanced Combustion Engine Operation -- This project investigated the impact of fuel properties, including cetane number, T90, and aromatic content in a matrix of test fuels. The FACE Working Group developed a matrix of nine test fuels which were used for this project.

Current Status and Future Programs

Advanced combustion operation with the fuels were defined in terms of quantitative metrics which included gaseous and particulate emissions, brake thermal efficiency, engine coefficient of variance (COV), cylinder pressure rise rate, and timing observed for achieving 50% fuel burn. Measured values include exhaust gas recirculation (EGR) level, emissions, combustion parameters, and engine performance parameters including torque, air consumption, and fuel consumption. Two operating modes were investigated: single injection and dual injection, to cover types of advanced combustion frequently investigated in recent research.

The Committee selected West Virginia University to perform this research. A significant amount of effort was devoted to the development of the engine test platform, including replacement of the original 2-valve-per cylinder engine with a 4-valve model enabling enhanced mixing and greater capability to achieve advanced combustion operation.

AVFL

Operation of the engine in an advanced combustion mode was demonstrated. The project was extended to include all of the FACE diesel fuels. Analysis in the draft final report was reviewed by the project panel and committee, and the Final Report was issued in August 2012.

BIODIESEL AND RENEWABLE DIESEL CHARACTERIZATION AND TESTING IN MODERN LD DIESEL PASSENGER CARS AND TRUCKS

CRC Project No. AVFL-17b

Leaders: M. Natarajan
S. W. Jorgensen

Scope and Objective

The objectives of the LD diesel biodiesel characterization and testing project are to: 1) Identify and procure high-quality biodiesel B100 from four different sources, 2) Develop B20 and RD20 blends with Ultra Low Sulfur Diesel (ULSD), 3) Develop a B20 blend with CARB Diesel, 4) Procure or lease suitable vehicles, and 5) Characterize the criteria and unregulated emissions from the vehicles using the LD FTP cycle.

Current Status and Future Programs

A competitive solicitation process for this project was conducted in the first quarter of 2012. The technical review panel selected CE-CERT to conduct the project, which started in June 2012.

Fuels: High quality B100 ASTM compliant biodiesel will be procured and blended with commercially available Federal ULSD. One CARB B20 blend will also be tested. The sources of biodiesel may be soy or other feedstocks that span the range of degree of saturation common in the marketplace. A Hydrogenated Vegetable Oil (HVO) and hydroprocessed animal fat will also be obtained. CRC Member laboratories will perform fuel analyses to determine their properties, including cetane. The fuels matrix will include 1) Federal ULSD baseline diesel, 2) Four B20 fuels blended with the Federal ULSD fuel (including one renewable diesel blend), 3) CARB baseline diesel, and 4) One B20 fuel blended with the CARB fuel for a total of seven test fuels.

Vehicles: In the current U.S. market, four LD diesel passenger cars are being sold. Manufacturers include Audi, BMW, Mercedes and VW. In addition, Ford, GM and Chrysler sell LD diesel trucks. The goal is to procure one car from each manufacturer for testing. The contractor will perform break-in, preconditioning, and engine/exhaust system monitoring, using protocols reviewed and agreed to by the project technical panel. A total of seven vehicles are planned for testing.

AVFL

Emissions to be measured include: 1) Regulated Emissions: HC, CO, NO_x, PM; 2) Unregulated emissions, including Carbonyls, PAH and NitroPAH. Optional measurements the committee hopes to include are 1) PM number, 2) EC/OC, 3) NMHC, 4) Fuel Economy, 5) NH_3 for SCR systems, 6) LNT regenerations emissions, and 7) DPF regenerations emissions. Tests will be done in duplicates. Allowing for repeats to meet criteria set by the project panel, it is expected that the total number of tests will be around 115.

SURROGATE FUELS FOR KINETIC MODELING

CRC Project No. AVFL-18

Leaders: C. J. Mueller
W. J. Cannella

Scope and Objective

The objective of this work is to establish and evaluate a methodology for formulating surrogates with compositional, ignition-quality, and volatility characteristics that are representative of diesel fuels produced from real-world refinery streams.

A surrogate fuel is a mixture of generally less than a dozen pure compounds that matches certain selected characteristics of a target fuel composed of many hundreds to thousands of compounds. Surrogate fuels are of interest because they can provide a better understanding of fundamental fuel composition and property effects on combustion and emissions-formation processes in internal-combustion engines. Ultimately, their application in numerical simulations with accurate vaporization, mixing, and combustion models could revolutionize future engine designs by enabling computational optimization for evolving real fuels. Dependable computational design would not only improve engine function, it would do so at significant cost savings relative to current optimization strategies, which rely on physical testing of hardware prototypes.

Current Status and Future Programs

The project team identified compounds representing the major hydrocarbon classes found in real diesel fuels to be included in surrogate fuel formulations. Surrogates have been formulated for two ultra-low-sulfur #2 diesel reference fuels. Analyses have been conducted to quantify the extent to which the surrogate fuels match the ignition-quality and volatility characteristics of their corresponding target fuels.

This project is being performed in collaboration with researchers at DOE's National Laboratories: Sandia (SNL), NREL, Lawrence Livermore (LLNL), Pacific Northwest (PNNL), ORNL and the Canadian National Lab, CANMET Energy. The National Institute of Standards and Technology (NIST) is assisting with fuel property measurements and regression optimization techniques to support surrogate formulation.

AVFL

Final evaluation of the first-generation surrogates was completed. A project report was reviewed and approved by the Project Panel and Committee for journal publication. The journal article describing the surrogate fuel formulation process was accepted for publication by *Energy & Fuels* and is currently available on their website, as well as on the CRC website. This article represents the Final Report for the first phase of AVFL-18.

Research was extended in 2012 to facilitate the development of second generation surrogates with improved capabilities for matching market diesel fuels, blending engine research test quantities of surrogates, as well as single-cylinder engine testing of both first and second generation surrogate fuels.

CHARACTERIZATION OF ADVANCED ALTERNATIVE AND RENEWABLE FUELS

CRC Project No. AVFL-19

Leaders: C. Fairbridge
W. J. Cannella
S. W. Jorgensen

Scope and Objective

The objective of this project is to characterize the physical and chemical properties of advanced alternative and renewable diesel fuels. This information is needed by OEMs, fuel producers, and combustion researchers to be able to predict the performance of these emerging fuel components in current and advanced combustion engines. The project team consists of fuel, engine, and combustion researchers from the energy companies, OEMs, and the U.S. and Canadian national laboratories. The current work builds on and complements the detailed characterization work that the team performed for the FACE Diesel Fuels (CRC Report "FACE-1 Chemical and Physical Properties of the Fuels for Advanced Combustion Engines (FACE) Research Diesel Fuels"). The advanced alternative and renewable fuels targeted for characterization include second generation bio-derived diesel fuels from non-food sources such as jatropha, algae, lignocellulose, and pyrolysis oils; "renewable" diesels from hydrogenated vegetable oils, animal fat and algae; Fischer-Tropsch type diesels from natural gas, coal, and biomass; oil shale; and oil sands. In addition, several conventional petroleum diesels have been characterized as references. Samples were obtained from commercial/semi-commercial producers of these fuels that were willing to provide samples for analysis and allow publication of the results in a blinded fashion (no assignment of producer name to the sample).

Current Status and Future Programs

The physical and chemical properties of each sample in the first round of testing have been characterized using standard ASTM-type analyses plus state-of-the-art advanced chemical composition techniques such as gas chromatography field ionization mass spectroscopy (GC-FIMS) and a two-dimensional method, 2DGCMS, that were used to characterize the FACE Research Diesel Fuels. Research partners at the National Labs and

AVFL

Natural Resources Canada/CANMET Energy are conducting the advanced characterization analyses in their laboratories, while standard tests have been performed at SwRI.

Standard ASTM testing on the samples include : 1) Cetane number by D613 engine test, 2) Cetane index by D976, 3) Distillation by D86 and D2887, 4) Specific gravity by D4052, 5) Kinematic viscosity by D445, 6) Cloud point by D2500, 7) Flash Point by D93, 8) Net heat of combustion by D240, 9) Lubricity by D6079, 10) Elemental Analysis by D5291, D5453, D5623, & D4629, 11) Hydrocarbon types by fluorescent indicator adsorption (FIA) D1319, 12) Hydrocarbons by D2545, 13) Aromatics by super critical fluid chromatography (SFC) D5186, 14) Bromine Number by D1159, and 15) Sulfur by D5453.

Advanced characterization tests include: 1) Ignition Quality Tester Derived Cetane Number by D6890 and Predictive Ignition Delay Time based on parametric ignition experiments, 2) GCMS analysis using one-dimensional (1D) GCMS, GCxGC-TOFMS (time of flight mass spectroscopy), GCxGC with flame ionization detection (FID), and GC-Field Ionization Mass Spectrometry (GC-FIMS) for components >200˚C, 3) Paraffins, Isoparaffins, Olefins, Naphthenes and Aromatics (PIONA) analysis for components <200˚C, 4) Saturates, Olefins, Aromatics, and Polar Compounds (SOAP), solid phase extraction for components >200˚C , 5) Detailed hydrocarbon analysis (DHA) for components <200˚C, and 6) ^{13}C and ^{1}H Nuclear Magnetic Resonance (NMR).

Fuel samples have been collected for the first round of testing, and reporting of analytical results is anticipated in the third quarter of 2012. Additional fuel samples will be analyzed under AVFL-19a as part of an extension of this work in 2012.

FUELS FOR ADVANCED COMBUSTION ENGINES (FACE) WORKING GROUP

Leaders: W. J. Cannella
R. M. Wagner
B. T. Zigler

Scope and Objective

The AVFL Committee formed the FACE Working Group to foster collaboration with DOE, NREL, ORNL, and other industry and government research laboratory experts. The mission statement for this group was approved by the CRC Board of Directors in 2005. The mission of the FACE Group is to recommend sets of test fuels well-suited for research so that researchers evaluating advanced combustion systems may compare results from different laboratories using the same set (or sets) of fuels.

The FACE Group is composed of volunteers from industry, government, and academia. Its membership includes researchers from the fuel industry, as well as members representing the engine, automobile and emission control technology manufacturers, academia, and U.S. DOE and Canadian National Laboratories. The activities of the group formally commenced in January 2006. The initial collaboration expanded to include scientists and engineers from other National Laboratories: SNL, LLNL, and PNNL, as well as Natural Resources Canada (NRCan), CANMET Energy, and private laboratories Battelle, Ricardo, and AVL.

Current Status and Future Programs

A key activity of this group has been developing two sets of fuels for research in advanced combustion in the diesel and gasoline ranges. The diesel fuel set, defined in 2007, is now commercially available from the Chevron Phillips Chemical Company, LLC (CPChem). Extensive characterization work has been performed by laboratories participating in the working group; a summary of standard analyses is available from the CRC website. The Final Report, “FACE-1 Chemical and Physical Properties of the Fuels for Advanced Combustion Engines (FACE) Research Diesel Fuels” has been published on the CRC website, and an accompanying conference paper was given at the 2009 SAE Fall Powertrains, Fuels, and Lubricants meeting. The group continues to

support the blender in decisions relating to blending new batches of the fuels, as there are periodic changes in the availability of blendstocks.

The gasoline-range fuel set design has been finalized by the group. Five of the ten fuels have been blended in large batches and are commercially available for sale. These fuels are expected to be available from CPChem. Blending of the remaining five fuels is in progress. Plans for characterization of the gasoline fuel set are in development.

Current and future activities include publishing a review of available data using the FACE fuels from combustion studies, along with recommendations for parameters to measure in the studies, outreach to the technical community to raise awareness of the availability of the test fuels, and ongoing discussions of how best to approach alternative fuels research when also working with the FACE fuel sets. Presentations have been made at: the SAE High Efficiency Engines Symposium, the AEC/HCCI consortia meetings, and the DOE Annual Merit Review meeting. This year ORNL prepared a compilation paper for SAE on engine test programs where the FACE diesel fuels were tested in advanced combustion engines. The group also serves in a support role for the AVFL projects that are employing FACE fuels in research.

The FACE Working Group has created a number of sub-teams to address various technical aspects of their work plan. Spin-off projects generated by ideas from this group include: AVFL-16, AVFL-18 and AVFL-19.

AIR TOXICS WORKSHOP

CRC Project No. A-45

Leaders: S. Japar
R. S. MacArthur

Scope and Objectives

The objective of this project is to bring together key individuals and organizations working on current issues of mobile source air toxics for in-depth technical discussions in a workshop format.

Current Status and Future Programs

The Atmospheric Impacts Committee, in conjunction with CARB, hosted the 2010 CRC Mobile Source Air Toxics (MSAT) Workshop in Sacramento following the previous workshops held in Houston in 2002, Scottsdale in 2004, and Phoenix in 2006 and 2008. As with the previous events, the 2010 workshop brought together key government, academic and industry researchers, and stakeholders working in this area. The technical sessions were held at Cal-EPA Headquarters. Technical sessions included a plenary session with prominent speakers representing CARB, EPA, Lovelace Respiratory Research Institute, a former CARB chairman, and UC Davis Institute of Transportation Studies. Other technical sessions covered topics on needs of the regulators, air quality and exposure measurement of MSATs, vehicle emissions and vehicle emissions modeling, uncertainties, and accountability. A summary of the workshop technical content was prepared and included in the Final Proceedings released in CD format March 2011.

Preparation for the next workshop is underway. A contract was issued to Dr. Steven Japar to help organize the new workshop with the aid of the previous organizing committee participants. Dr. Japar and the organizing committee have developed the technical program and identified speakers. The new workshop will be held February 2013 in Sacramento, CA following the format of the 2010 workshop.

ATMOSPHERIC IMPACTS

CONCEPT/CAMx MODELING OF EXPANDED USE OF RENEWABLE FUELS

CRC Project No. A-73-1/2/3

Leaders: R. S. MacArthur
A. M. Dunker
S. Collet

Scope and Objectives

The committee proposed a new approach for performing air quality modeling of intermediate level ethanol blends using emissions data from other CRC and related studies by applying a method initially demonstrated in Project A-67. This modeling approach is application of the emissions modification model CONCEPT integrated with CAMx as the grid modeling tool (CONCEPT/CAMx).

Current Status and Future Programs

The committee approved a work statement for the project in 2009. The Mobile6.2 emissions factor model was replaced by MOVES and some script recoding was written to achieve faster computation speed. Initial plans to incorporate the MOVES model under CONCEPT have been reassessed due to remaining complexities of this tool.

The project was divided into two main efforts to be developed in parallel to meet the overall project objectives of demonstrating the CONCEPT/CAMx modeling tool:

1. A-73-1, "Protocol for Analyzing Data and Developing Inputs to the CONCEPT Emission Model for Representing Ethanol Blends."
2. A-73-2, "Perform CONCEPT/CAMx Modeling of Expanded Use of Renewable Fuels."

The Committee and Working Group selected contractors to work on each project – Sierra Research Associates for Project A-73-1 and Alpine Geophysics for Project A-73-2. Sierra Research completed its survey of emissions data for A-73-1 and delivered the Task 1 Literature Survey. A project work plan for A-73-2 by Alpine Geophysics was approved by the committee. A-73-1 and A-73-2 continued through 2011 due to a delay in release of important data on the impacts of intermediate-level ethanol blends on new vehicle emissions. CRC and committee leadership

continue to work with the providers of these data to obtain permission for use in the projects.

Regular teleconference coordination meetings were held with Sierra Research and Alpine Geophysics to aid progress and assist in final data collection. It was determined that the SMOKE model would be required to complete all the contemplated modeling work scope. The modeling suite for the project therefore now is CAMx/SMOKE. Fuel adjustment factors (FAF) and final speciated emissions data for E10 and E20 blends updated with CB5 chemistry were provided by Sierra Research to Alpine Geophysics.

The A-73-1 Final Report has been approved by the Committee but will not be released until the A-73-2 report is completed. Additional delays in A-73-2 are now pointing towards modeling completion sometime during the third quarter of 2012. The Final Report for A-73-2 is expected towards the end of 2012.

A new phase for the A-73 program was developed to extend intermediate-level ethanol blend air quality modeling under A-73-3. ENVIRON was selected to conduct the new phase after a competitive solicitation process. Depending on results achieved in the A-73-2 project, the extension would evaluate ozone and PM2.5 air quality impacts in an extensive region including Atlanta, Chicago, and Detroit using the EPA predictive model in a comparison of related modeling results to be reported under A-73-2.

ATMOSPHERIC IMPACTS

RELATIONSHIP BETWEEN SEMI-VOLATILE ORGANIC COMPOUNDS AND SECONDARY ORGANIC COMPOUNDS

CRC Project No. A-74

Leaders: T. J. Wallington
R. S. MacArthur

Scope and Objectives

The objective of this project is to define the relationship between semi-volatile organic compounds (SVOC) contained in vehicle exhaust and subsequent formation of secondary organic compounds (SOA) generated in the atmosphere via dilution and chemical reactions. The main project objective includes obtaining sufficient definition of the relationship between SVOC and SOA to model the behavior in the atmosphere. The project is also sponsored by EPA and CARB. This project has application to both the Atmospheric Impacts Committee and the CRC Real World Vehicle Emissions and Emissions Modeling Group (RWG). Therefore, a joint project was proposed in connection with CRC Project No. E-96.

Current Status and Future Programs

A proposal was submitted to CRC by Dr. Allen Robinson of Carnegie Mellon University (CMU) entitled, "Linking Tailpipe to Ambient: A Proposal to the CRC RWG and AIC to Add Characterization of Emissions Aging to the Planned CMU/CARB/EPA Vehicle Testing." CMU was previously awarded a grant from EPA and is also receiving in-kind support from CARB to conduct vehicle testing. The CMU proposal to CRC is for smog chamber experiments (approximately 5 gasoline vehicles and 2 diesel vehicles) to be conducted in connection with the vehicle test program (approximately 50 vehicles). This proposal was approved by the committee and the CRC RWG, leading to a contract negotiated with CMU in April 2010. A technical work plan was reviewed and approved by the project panel members. The project began with Phase 1 testing in May 2010 at the CARB El Monte, CA vehicle test laboratories. Summary results from Phase 1 were presented at the 21st Real World Emissions Workshop in March 2011.

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A second phase of vehicle testing and smog chamber evaluations was conducted in June-July 2011 at the CARB/MTA heavy-duty chassis dynamometer facility. A third phase to add more vehicle and chamber testing to the project matrix was completed in mid-2012. The Phase 1 Final Interim Report was completed in May 2012. A fourth phase is now planned by the committee to support modeling of SVOC primary emissions and their conversion to SOA based on data collected in the earlier phases.

ATMOSPHERIC IMPACTS

AIR QUALITY MODEL EVALUATION INTERNATIONAL INITIATIVE (AQMEII)

CRC Project No. A-75-1

Leaders: T. J. Wallington
P. Roberts
C. H. Schleyer

Scope and Objectives

The objective of the AQMEII program is to evaluate the performance of several types of air quality models in North American and European domains. The U.S. EPA approached the committee inviting their participation in this program by supporting modeling of the European Continent with the CAMx air quality grid model used in many other CRC research studies. Emissions inventories, meteorology data sets, and data repository tools were assembled by the AQMEII international organizing committee to evaluate the performance of several models using a 2005 full calendar year data set. This initial phase of AQMEII was jointly hosted by U.S. EPA (S.T. Rao) and the European Union Joint Research Centre (Stefano Galmarini).

Current Status and Future Programs

The committee requested a proposal from ENVIRON to perform the 2005 CAMx European model simulations for AQMEII. This proposal was approved by the committee and resulted in a project start in April 2010. CRC arranged for Peter Roberts of Europe's CONCAWE organization to support the project. The ENVIRON proposal included other European scientists well-positioned to support the inventory and meteorology for the European domain. ENVIRON was selected because of their extensive experience developing and applying the CAMx model in other CRC programs. ENVIRON was also selected in a separate contract action to model the North American domain using CAMx by the Electric Power Research Institute (EPRI) as part of the same international initiative. The A-75-1 modeling results report was submitted and approved by the committee. This CRC Final Report is posted on the CRC website and also presented in a journal article published *Atmospheric Environment* (see A-75-2).

EVALUATION OF CAMx RESULTS FROM AQMEII

CRC Project No. A-75-2

Leaders: T. J. Wallington
R. S. MacArthur

Scope and Objectives

The objective of this project is to investigate and demonstrate the influence of input data, assumptions and uncertainties on model performance for the European domain studied in the AQMEII program.

Current Status and Future Programs

Multiple model inter-comparisons were conducted to identify possible key roles played by different input data. Sensitivity analyses were performed for the selected inputs using the base case CAMx model developed under Project A-75-1. In addition, this study demonstrated how advanced probing tools available in CAMx (HDDM and Process Analysis) can be used for model performance evaluations.

Four tasks were conducted:

- Compare results from CAMx European modeling study with results from other models available on the AQMEII Ensemble performance evaluation system hosted by JRC.
- Perform sensitivity analysis to demonstrate how model performance depends upon input data and assumptions. (Revised annual run resubmitted to JRC for performance evaluation).
- Demonstrate the use of advanced probing tools (Higher Order Direct Decoupled Method/HDDM and Process Analysis/PA) to understand ozone sensitivity to precursors (VOC and NOx) and/or source sectors.

ATMOSPHERIC IMPACTS

- Publish a journal article focusing on model sensitivity to input data in the AQMEII special journal edition and participate in the AQMEII workshop held in North Carolina in fall 2011.

ENVIRON was selected to conduct this project for the committee. Work started in fall 2010 and a draft final report was prepared in the form of a draft journal article. The CRC Final Report for A-73-2 is now available on the CRC website. The journal article was submitted to *Atmospheric Environment* on May 31, 2011 and published December 2011.

EFFECTS OF LIGHT-DUTY VEHICLE EMISSIONS ON OZONE AND PM WITH PAST, PRESENT, AND FUTURE CONTROLS

CRC Project No. A-76-1/2

Leaders: S. Collet
R. S. MacArthur

Scope and Objectives

The objective of this new study is to investigate the effect of historical, current, and future controls on LDV emissions outside California on ozone and PM in the U.S. LDV emissions standards in the U.S. have become increasingly stringent since the 1970s. Additional controls are planned, with the aim of improving ambient air quality. It is of interest to study the incremental and cumulative air quality benefits of these emissions standards in the context of contributions from other mobile sources and other source categories. The project requires the use of MOVES and other emissions models coupled with regional 3-D air quality modeling to estimate the absolute and relative contributions of LDV emissions to ozone and PM under various emission control scenarios for a representative month in winter and summer. Scenarios to be studied (in addition to a 2008 base case) include Tier 1, Tier 2, California LEV III nationwide, and a zero-out of LDV emissions, all for a 2022 future year, with emphasis on four urban areas outside California.

Current Status and Future Programs

Emissions from on-road motor vehicles in the U.S. have decreased over the past four decades even with increases in traffic volume. Highway vehicle VOC emissions were reduced by approximately 75% from 1970 to 2005, and PM and NOx emissions were reduced by over 50%, while total VMT for highway vehicles increased more than twofold. These reductions have been due, in part, to the Federal Tier 0, Tier 1, and Tier 2 emission control programs. The Tier 0 program instituted standards for THC, CO, NOx, and PM for 1981-1993 model year vehicles. Tier 1 applied to 1994-2003 model year vehicles for the same pollutants with a phase-in for the early years. Tier 2 applied to model years 2004 onwards and phased in completely in 2009. Proposed California LEV III standards will phase in from 2014 to 2022. The fleet average NMOG + NO_x for passenger cars and trucks (PC/LDT1 and LDT2) both decrease

by approximately 60% from 2010 to 2020. CARB issued a final Initial Statement of Reasons and final regulatory language for the LEV III standards in September 2011.

ENVIRON was selected through a competitive bid process to conduct this study and used CAMx for air quality modeling. EPA has approved the use of CAMx for numerous ozone and PM State Implementation Plans throughout the U.S, and they have used it to evaluate regional mitigation strategies. CAMx was also used recently by EPA in its Clean Air Transport rulemaking process.

ENVIRON performed modeling for February and July to represent a winter and summer month in the base year (2008) and in the future year (2022) scenarios. The geographic region of interest was the eastern United States with focus on the four urban areas discussed in EPA's Risk Assessment analysis. These areas were Atlanta, Detroit, Philadelphia, and St. Louis. The air quality modeling domain proposed was the regional planning office (RPO) unified continental U.S. (CONUS) domain with 36 km horizontal resolution with an inner-nested domain with 12 km resolution over the eastern U.S. The project was initiated in April 2011 and completed in January 2012. A draft journal article was submitted to *Atmospheric Environment* and ENVIRON posted the draft article on their CAMx Model website. The final approved A-76 article has been published and is now available on the CRC and *Atmospheric Environment* websites.

An extension to A-76 was funded through the 2012 committee budget. The extension is called A-76-2, "Effects of Light-Duty Vehicle Emissions on Ozone and PM with Past, Present, and Future Controls, Phase 2." This continuation will further determine ozone and PM levels and benefits from existing emissions controls and examine other possible future controls. The Phase 2 effort includes a data analysis component in addition to emissions and air quality modeling. Tasks will include analysis of Atlanta based on National Emissions Inventory (NEI) adjustments using MOVES, new modeling scenarios of 100% Tier 0 for 2008 and 2022 on a 12 km grid using MOVES inputs, and reporting to include a journal article and all associated documentation. Project A-76-2 started in January 2012. ENVIRON is on schedule for completing the project by the end of 2012.

CHEMISTRY OF TROPOSPHERIC OZONE GENERATION AND THE INFLUENCE OF TRACE GASES

CRC Project No. A-78

Leader: T. Wallington

Scope and Objectives

CRC arranged contracts with Jack Calvert, John Orlando, Robert Stockwell, and Timothy Wallington to prepare a new manuscript to update and add to the Oxford University Press books previously published through committee sponsorship. The title of the new work is "Chemistry of Tropospheric Ozone Generation and the Influence of Trace Gases." The focus in the new manuscript includes:

Chapter I Trace Gases in the Troposphere and the Chemistry of Their Interactions

Chapter II Tropospheric Reactions of Ozone

Chapter III Tropospheric Reactions of the Oxides of Nitrogen

Chapter IV Tropospheric Reactions of OH Radicals with Hydrocarbons and Oxygenates

Chapter V Tropospheric Reactions of Other Inorganic Trace Gases

Chapter VI Photochemistry of the Oxygenates

Chapter VII Effect of NO_x, Hydrocarbons, and Other Trace gases on the Generation of Tropospheric Ozone

Current Status and Future Programs

The A-78 author team met in the first and second quarters of 2012 to develop details of the above chapters and to make writing assignments. A third meeting of the writing group will commence in September 2012. Final Report for Project A-78 is expected towards the end of 2012.

ATMOSPHERIC IMPACTS

ASSESSMENT OF NEAR-ROADWAY NO_2 CONCENTRATIONS

CRC Project No. A-79

Leaders: S. Collet
M. Koerber

Scope and Objectives

The objective of this study is to establish a baseline dataset from two year-long studies that can be used by federal, regional, and state agencies to understand the range of concentrations of NO_2 emissions near roadways as a function of traffic load and weather conditions.

Current Status and Future Programs

A new project was started in 2012 under A-79 to evaluate data collected in recent near road air quality studies to document the levels of NO_2. A contract was established with Sonoma Technology (STI) to report on data available from studies in Las Vegas and Los Angeles. The Los Angeles dataset was provided by SCAQMD. The Las Vegas dataset for this project is also immediately available and may be supplemented with additional observations derived from a larger dataset generated by FHWA and EPA if released in time. Preliminary conclusions were presented to the committee and working group members at the summer 2012 committee meeting. STI is scheduled to complete the study by the end of 2012.

SPECIATION OF EPACT TEST FLEET EXHAUST EMISSIONS

CRC Project No. A-80

Leader: R. S. MacArthur

Scope and Objectives

The project objective is to obtain complete speciation exhaust emissions data for several average property gasolines selected by the CRC Emissions Committee as part of Project E-98 and compare new speciation data results against data reported in EPA's SPECIATE4.3 database.

The project approach includes adding appropriate tasks to the Emissions Committee project to collect detailed intermediate ethanol blend speciation data. All testing will be conducted using the same vehicle fleet used in the EPAct Fuel Effects Study for a direct comparison of results.

Current Status and Future Programs

The committee worked with the E-98 Project panel to select SwRI as the contractor to conduct this work. A contract was established to conduct both standard exhaust emissions testing and speciation analysis of the exhaust. Project A-80, "Speciation of EPAct Test Fleet Exhaust Emissions," was started in May 2012. The EPA test fleet will be used to evaluate emissions performance of a "tie" fuel from the original study and two new "mid-point" fuels to assess model performance.

PERFORMANCE

NATURAL GAS FUEL SURVEY

CRC Project No. PC-2-12

Leader: J. J. Jetter

Scope and Objectives

The objective of this program is to gain an understanding of natural gas quality in the following locations along the distribution line:

- Large-scale transmission pipelines
- Local Distribution Company(LDC) pipelines
- Vehicle refueling nozzle at station

Resulting data will be used to (1) form a basis for the development of a Natural Gas Vehicle (NGV) fuel specification through a consensus organization such as ASTM, and (2) inform NGV developers regarding the range of natural gas fuel properties that can be expected in the U.S. market.

Specific Tasks

- Search for existing data
- Preparation of equipment for sampling and analysis
- Arrangements with CNG stations
- Site visits and on-site analyses
- Off-site sample analysis

Current Status and Future Programs

A Request for Proposal was issued by CRC for this project. An award is anticipated in 2012.

GASOLINE ENGINE DEPOSITS

CRC Project No. CM-136

Leader: J. Axelrod

Scope and Objectives

The objectives of this group are to:

- Develop test procedures for the objective evaluation of spark-ignition (SI) engine fuel and fuel additive contributions to combustion chamber deposits (CCD), intake valve deposits, and injector deposits.
- Determine the extent of SI fuel injector fouling and adequacy of current deposit control additive dosages to prevent injector fouling.
- Establish the relationship of SI vehicle fuel level sensor failures and concentrations of corrosive sulfur gasoline species.
- Identify characteristics of SI engine durability with the use of mid-level ethanol blends in non-flexible fuel vehicles.

Current Status and Future Programs

Port Fueling Injector Fouling Survey

In 2004, two auto companies reported deposit-related Port Fuel Injector (PFI) plugging problems in cars, with a high incidence rate in Florida. The Deposit Group formed a panel to determine the extent of fuel injector fouling in this region of the U.S. and the adequacy of current deposit control additive dosages to prevent injector fouling.

The program approach was to sample gasoline from 10 major marketers in Tampa and Miami, analyze the fuel composition, assess PFI fouling tendencies with the CRC PFI bench rig using ASTM D6421, and compare fouling tendency of Honda and GM injectors with standard Chrysler rig injectors. GM provided injectors from Florida that were known to cause fouling problems. Twenty commercial fuels were collected in Florida, analyzed, and tested in the PFI bench rig. Six of the twenty fuels were shown to be deposit-prone. There appeared to be no correlation between apparent deposit severity and fuel properties or additive dosage. This raised the question of whether the PFI bench test is representative or too severe.

PERFORMANCE

In a second phase of the program, the tendency of Original Equipment Manufacturers (OEM) and ASTM injectors to foul was compared. All showed fouling in the PFI bench rig. The effectiveness of several detergents and dosage was also evaluated and varying degrees of effectiveness were observed in the PFI bench rig.

The Panel then compared the bench rig with the Chrysler PFI fouling vehicle test. CRC Report No. 646, "Port Fuel Injector Fouling Using PFI Bench Rig Evaluation of Florida Gasoline, OEM Injectors and Deposit Control Additives," was issued in September 2005. The panel placed the project on hold in February 2007 because of several issues; rig injectors did not foul to the same levels observed previous to December 2006, and rigs showed poor reproducibility. The test development is continuing as non-CRC funded work at SwRI, but SwRI has not identified enough fouling injectors to conduct precision studies. Only when the PFI Panel and the Deposits Group feel that a reproducible test procedure and proper equipment is in place will this CRC work be restarted. The Deposit Group and committee members have worked with Bosch to select new injectors for future PFI evaluations since the supply of the existing injectors is limited and dwindling. A replacement PFI model has not been identified. Recommendations have been made to focus on new technology hardware to evaluate direct injector fouling performance. SwRI is investigating possible solutions without committee financial support.

Engine Durability for Intermediate Ethanol Blends

A Request for Proposal was released by CRC in February 2009 for a new study to evaluate the potential effect of mid-level ethanol blends in the U.S. LD vehicle fleet. Objectives of the test program are to determine engine durability effect of mid-level ethanol blends (e.g., E20, E15) on a group of engines from vehicles that may be considered sensitive to the effects of mid-level ethanol blends. Test fleet selection was determined cooperatively by CRC member companies and OEMs.

The approach consisted of laboratory testing of eight vehicles, using an engine test cycle used by an original equipment manufacturer (OEM) member of CRC to test for engine durability in an accelerated manner. Accelerated testing is standard practice in the automotive industry, and is used to reduce test time and reveal possible failures. Severity of the cycle reduced test time and compensated for the inherently small sample size associated with these tests. FEV performed this project. The Final Report was posted on the CRC website in May 2012.

VOLATILITY

CRC Project No. CM-138

Leader: L. M. Gibbs

Scope and Objectives

The objective of the CRC Volatility Group is to investigate the relationship between vehicle driveability performance and fuel volatility characteristics.

Current Status and Future Programs

2009/2010 CRC/ASTM TVL20, T50 EtOH Volatility

This project was conducted in cooperation with ASTM to determine, under two cool ambient temperature conditions below 5,000 feet altitude, the effect on hot-fuel-handling driveability performance of these fuel variables:

- the front-end volatility parameter involving the temperature for a vapor-liquid ratio of 20 (TVL20),
- the 50% evaporated distillation point,
- the ethanol content.

The study was conducted on a large group of late model vehicles equipped with fuel injection systems. Testing was conducted at SwRI in fall 2009, but due to delays caused by weather conditions was not completed at that time. Steps were taken by one of the project sponsors to cost-effectively maintain the current fleet throughout the project delay. Funding to complete the first phase in spring 2010 was obtained, and testing was reinitiated at SwRI in April 2010 and completed in June 2010. Data analysis was completed and results were published in CRC Report No. 658. The second phase to test summer fuel blends under hot ambient conditions is under development for consideration by CRC.

2009/2010 Low T50 High Altitude Hot-Fuel Handling

This study determined the effects of TVL20, 50% evaporated distillation point (T50), and ethanol content up to 20 vol % on hot-fuel-handling driveability performance at high altitude (5000+ft.) under hot ambient temperature conditions in a fleet of 20 late model vehicles. This was a follow-on program to the 2006 CRC Hot-Fuel-Handling Program (CRC

Report No. 648). The test site for this program was Pueblo, CO at the Transportation Technology Center, Inc. (TTCI) facility. Testing was conducted in July-August 2010. The test fuel matrix for this program was approved in 2009, and invitations for participation were issued to interested parties. Several contractors were hired to assist in conducting the field program.

The project was supported with supplemental funding from NREL, RFA, and Suncor. Primary support contractors for the project included TTCI (test facility in Pueblo) and Gage Products (for test fuels). The Final Report was released for publication as CRC Report No. 659 and is available on the CRC website.

2011/2012 Intermediate Temperature E15 Cold-Start and Warmup Driveability Program

The objective of this new project is to determine an accurate ethanol offset for the Driveability Index equation in ASTM D4814, "Specification for Automotive Spark-Ignition Engine Fuel" covering ethanol contents from 10 to 15 volume percent.

The U.S. EPA has issued a partial waiver for ethanol blends containing up to 15 volume percent. The waiver only applies to 2001 and later model LD vehicles, but does not apply to HD vehicles, marine, motorcycles, and small engines. The current Driveability Index (DI) has an ethanol offset as a function of ethanol content, but is limited to a maximum ethanol content of 10 volume percent (E10). One issue in updating ASTM D4814 to make it applicable to 15 volume percent ethanol blends (E15) is to determine the ethanol offset for this higher ethanol concentration.

Hydrocarbon-only fuels and various concentrations of ethanol blends up to 20 volume percent having a range in DI (splash blends, matched DI to splash blends, and constant DI) will be evaluated in a group of 27 late-model fuel-injected (including direct injection) vehicles selected through a screening process to represent sensitive vehicles. The program will be conducted at a test track test site. Final details of the program are still being worked out. Fuel blending proposals have been received by CRC to support this study.

Sponsorship for this test program is being provided by Growth Energy and the Renewable Fuels Association, with a project start anticipated in February 2013.

2012+ Cold-Start and Warmup Low Vapor Pressure Driveability

The objective of this new project is to determine the effects of very low vapor pressure, ethanol content, and DI on cold-start and warm-up driveability performance under cool ambient conditions in late-model vehicles equipped with fuel injection systems. The deliverables for the project will include technical information on the effect of very low vapor pressure gasolines on cold-start and warm-up driveability performance as a function of ethanol content and DI. This information may be used to guide future gasoline volatility regulations and specifications.

The U.S. EPA complex model valid ranges for conventional and reformulated gasoline sets the minimum vapor pressure at 6.4 psi. The state of California and several county and city areas in other states have set a maximum vapor pressure for gasoline in the summertime of 7.0 psi. In the spring when transitioning to meet a low vapor pressure requirement, even lower vapor pressure gasoline may have to be used to blend down existing gasoline in terminal and service station storage tanks. The September 2004 CRC Project No. E-65 report, "Fuel Permeation from Automotive Systems," states that, under the test conditions investigated, the average permeation emissions of the ethanol blend increased 65% and 45% over the MTBE and hydrocarbon-only reference fuels, respectively. It has been suggested that one approach to compensate for this increase is to lower the vapor pressure of ethanol blends.

Hydrocarbon-only fuels and various concentrations of ethanol blends with typical and very low vapor pressures and ASTM maximum and low DI will be evaluated in a group of 27 late-model fuel-injected vehicles selected through a screening process to represent sensitive vehicles. When funded, this program will be conducted in March and April to coincide with the lower ambient temperatures present when the 7.0 psi rules first come into effect. The test fuel design involves ten fuels at three vapor pressure levels (5, 6.5, and 8 psi), two DI levels (1100 and 1250), and three ethanol levels (0, 5.7, and 10 volume percent). The fuels are to be made using refinery gasoline components covering a full range of carbon number hydrocarbons and types of hydrocarbons.

This project has been planned, but funding is not yet available.

PERFORMANCE

2011 Mathematical Prediction of Flammability of Ethanol-Containing Fuels

This contract program predicted the vapor flammability of various ethanol-gasoline blends using well validate modeling techniques. With the increased interest in mid-level ethanol blends and the introduction of blending pumps, concern has been raised about the safe handling, distribution, and storage of such blends. The blends covered in the study included E10, E15, E20, E30, E40, E50, E85, and E100. Equations and/or nomographs were developed for estimating the flammability temperatures of ethanol-gasoline blends as a function of vapor pressure.

Funding for this contract study was provided by Growth Energy and the Renewable Fuels Association. The Final Report, released in September 2011 as CRC Report No. 661, is available on the CRC website.

2012 Risk Analysis/Hazard Assessment of High Ethanol Content Fuels at the Service Station

Using risk analysis/hazard assessment, the objective of this new project is to determine the incremental change in risk due to a change in fuel composition (higher levels of ethanol). The benchmark will be the currently accepted public safety level of the terminal blender making an E10 blend (10 vol % ethanol blended into a base gasoline where the resulting vapor pressure is appropriate for the season and geographic location). The analysis will include the tanker truck driver loading/blending/delivering the blend and, ultimately the consumer dispensing E10 into personal vehicles at self-serve refueling stations. The U. S. Department of Energy supports efforts to increase the use of ethanol-rich transportation fuels such as “E85”. The Renewable Fuel Standards requirements to vastly increase the amount of ethanol-containing fuels into the marketplace will rapidly increase the opportunity for an unintended consequence (e.g., a fire) to occur. A risk analysis/hazard assessment is required to fully judge the safety implications, if any, of the introduction of these new fuel blends into the hands of the public.

PERFORMANCE

A subcontractor will be engaged to survey the literature to determine what gasoline-ethanol blends can create and hold sufficient static during product transfers activities which promote static generation. The subcontractor will work with the Risk Assessment/Hazard Analysis (RA/HA) team to define possible service station accident scenarios, and then narrow the choices to approximately six for further analysis by covering a range of possibilities. A consequence vs. frequency risk matrix will be developed that can be used to facilitate a semi-quantitative risk analysis. The analysis will be used to determine the adequacy of any existing safeguards on current fuel handling/dispensing systems.

After a competitive solicitation, a contractor was selected, and is on hold until fully funded. DOE is providing part of the funding.

PERFORMANCE

OCTANE

CRC Project No. CM-137

Leader: J. J. Simnick

Scope and Objectives

The objectives of the CRC Octane Group are to conduct surveys of the octane number requirements of current production automotive vehicles, to develop methods for measuring vehicle octane number requirement, and to determine effects on octane number requirement of variables such as mileage accumulation and altitude.

Current Status and Future Programs

Literature Review of Octane Number Versus Engine/Vehicle Performance

This program will conduct a broad literature review of public and private reports and interview knowledgeable experts to identify the potential benefits of octane number on improved engine efficiency. A competitive solicitation by CRC resulted in selection of HD-Systems to conduct the study under CRC Project No. CM-137-11-1. Initial funding was made available from USCAR. Literature sources from the previous 20 years were evaluated to develop a searchable database to identify currently known relationships and to identify potential gaps in our current understanding.

The project started in June 2011 and focuses on liquid gasoline fuels (primarily hydrocarbon and ethanol-containing fuels) and on hardware that is currently in-use or may be in use in the near future. The Task 1 Final Report has been released on the CRC website. The Final Report on the Task 2-5 effort was published on the CRC website.

DIESEL PERFORMANCE GROUP

CRC Project No. DP

Leader: M. Nikanjam

Scope and Objectives

The objective of the Diesel Performance Group is to help to define the minimum requirements to make LD diesel vehicles in North America a success. This will be achieved by providing supporting technical data for diesel performance issues that are needed by the fuel, engine, equipment, and additive industries that can be used by technical groups such as ASTM and the International Organization for Standardization (ISO).

The Diesel Performance Group currently has the following active panels and will adjust and add new ones as needed:

- Low Temperature Operability
- Cetane Number
- Biodiesel
- Deposit
- Fuel Cleanliness

Current Status and Future Programs

Biodiesel/Low Temperature Operability

A joint Biodiesel/Low Temperature Operability Panels' program: "The Effect of Wax Settling and Biodiesel Impurities on Low Temperature Light-Duty Diesel Performance" is in progress.

The program objective is to determine if newer fuel blending streams (F-T, HVO, severely hydro-processed, etc.) and/or Biodiesel impurities impact vehicle low temperature operability performance during extended periods of non-operation of LD diesel vehicles. Weekend shut-down is an example. Conventional diesel, B5, and B20, as well as cold flow additives are being evaluated. The program is being run in two phases. Phase 1 is laboratory testing to simulate weekend cool-down and warm-up cycles to determine visually and through standard cold flow laboratory testing if this has a significant impact on estimated vehicle performance as measured by Cloud Point, Pour Point, Cold Filter Plugging Point (CFPP), Simulated Filter Plugging Point (SFPP), and Low Temperature Flow Test (LTFT). Fuels include blend components

representing: Biodiesel, Gas-to-Liquids (GTL), Biomass-to-Liquids (BTL)/ Hydrotreated Vegetable Oil (HVO), Hydro-cracked and severely Hydro-processed streams.

Phase 2 has been funded by the CRC and will duplicate the laboratory experience in LD (and perhaps some HD) vehicles to verify any issues identified in the laboratory test work. The same or similar fuels would be used.

Low temperature operability limits would be determined for the fuel/vehicle combinations. Tests then would be repeated with simulated overnight and weekend heating/cooling cycles to compare results.

Cetane Number Program

The initial objective of this panel was to determine the limit of acceptable operation of North American LD diesel vehicles as a function of temperature and fuel cetane number quality.

Following a previous CRC AVFL project, this panel had outlined a larger North American (NA) program to test appropriate NA vehicles at lower operating temperatures with a more statistical approach. A lower-cost scoping study was discussed later to determine if test tools and facilities are fit for this purpose. Performance data regarding the effect of fuel cetane number on the operation of NA LD diesel vehicles at low temperature was the original deliverable for this project.

In addition to startability and performance at low temperature, the group decided to broaden the objective to include:

- Power
- Driveability/noise
- Fuel economy
- *Emissions (outside performance committee)*

The panel proposed a simple scoping program as follows:

- Three U.S. LD diesel vehicles
- Three fuels:
  - -20°F cloud point with a 40 cetane number
  - Above fuel additized with cetane number improved to reach 50 cetane number
  - A fuel with a natural cetane number of 45.
- Combined cycles to evaluate startability and low temperature driveability.
  - CEC M-11-T-91 cold weather start ability

        - Based on time to start, time for engine speed rise, number of start attempts, number of stalls, idle speed
    - CEC M-08-T-83 cold weather driveability
        - Evaluates malfunctions over a 104-second driving cycle repeated 12 times
- Ambient and one low temperature, preferably -30°F

This scoping program has received CRC funding. The panel hopes to conduct testing during the fourth quarter of 2012.

Diesel Deposits

This panel has three sub-panels to address the current issue of internal injector sticking reported in a number of common rail systems in certain geographic locations in the U.S. The sub-panels are as follows:

- Data Analysis and Recommendations
- Bench/Rig/Engine Investigation; Na-Soap Deposits
- Engine Investigation

The data analysis sub-panel's goal is to:

- Consolidate existing data on suspected causes
- Identify consistencies and inconsistencies in available literature
- Provide conclusions based on "highly likely," "likely," "possible," "unlikely"

Internal diesel injector deposits were categorized as metal soap, amide lacquer, and carbonaceous. Metal-soap deposit is the more significant issue currently in the U.S. HD application. It also is a concern globally and in LD applications.

Sub-panel 2 is charged with identifying or developing a laboratory bench top or test rig for evaluating fuel's tendency to cause internal injector deposits as well as additives effectiveness to avoid such deposit formation.

An initial scoping study at no cost to CRC consisted of a program to conduct a limited screening program using two in-house tests to determine if fuels which are expected to cause internal injector deposits can be differentiated from those that are not expected to form such deposits.

PERFORMANCE

Seven fuels were tested to cover a range of applications and deposit forming tendencies. Fuels included EPA deposit-forming and EPA non-deposit-forming diesel, CARB diesel assumed not to form deposits, and an EPA diesel that was formulated to cause deposits.

Results from this scoping study did not confirm that either one of these rigs, in their present state, could discriminate among deposit forming or not deposit forming fuels.

Sub-panel 2 plans to evaluate a new rig offered by Delphi. Tests are planned for the later part of 2012.

The engine investigation sub-panel is evaluating paths to identify and develop an industry-standard practical engine/cycle to evaluate fuels/additives and their tendency to form internal injector deposit.

Engines with large displacement for HD application can be used initially as part of a study to correlate with smaller laboratory rigs but cannot be used routinely for long-term evaluation of fuels and additives.

Smaller passenger vehicle engines similar to Peugeot DW10 are more practical. The EMA has agreed to support the development of a global test if the outcome can predict the performance of larger engines.

Pending results of the Delphi rig evaluation and CEC progress, this sub panel will define a path forward.

Fuel Cleanliness

Based on the recommendation by the Diesel Performance Group that diesel fuel cleanliness has become a more important issue for newer injection equipment, this panel has become more active.

The objective of this panel is to address, investigate, and provide information for general housekeeping and other issues, as related to fuel cleanliness, that are outside the defined fuel properties in existing CRC DPG panels and that have relevance from the point of diesel production to the point of customer use.

PERFORMANCE

The ultimate goal is to generate a single CRC guide to compile best available current knowledge regarding cleanliness of diesel fuel. The proposed CRC document will have the following outline:

1. Introduction / background
2. Scope /what is the supply chain/storage system
3. Types, sizes, and sources of contamination
4. Microbial growth
5. Corrosion and corrosion products
6. Filters and filtration
7. Additives
8. Storage tank design
9. Housekeeping guidelines

Experts in each area are working within this panel to provide technical details. This effort has been on a volunteer basis so far with no CRC funding.

PART THREE

RELEASED REPORTS

RELEASED REPORTS - 2012

AIR POLLUTION & ADVANCED TECHNOLOGY*

CRC Project No.	Title	NTIS Accession No.
A-69-1	Impact of meteorology and anthropogenic emissions on the local and regional ozone weekend effect in Midwestern US	*Atmospheric Environment* Vol. 57 (2012) p. 13-21
A-75-1	Evaluation of CAMx Results from AQMEII: Sensitivity Analysis and Comparison with Other Models	PB2012-105227
A-75-2	Modeling Europe with CAMx for Phase II of the AQMEII	PB2012-105228
A-75-2	Modeling Europe with CAMx for the Air Quality Model Evaluation International Initiative (AQMEII)	*Atmospheric Environment* Vol. 53, (2012) p. 177–185
A-76-1	Effects of Light-duty Vehicle Emissions on Ozone and PM with Past, Present, and Future Controls	PB2012-113427
A-76-1	Effects of Light Duty Gasoline Vehicle Emission Standards in the United States on Ozone and Particulate Matter	*Atmospheric Environment* Vol. 60 (2012) p. 109–120
AVFL-14	Collaborative Lubricating Oil Study on Emissions	PB2012-105328
AVFL-15/ CRC 662	Durability of Automotive Fuel System Components Exposed to E20	PB2012-105329
AVFL-15/ CRC 662	Appendices	PB2012-105340
AVFL-16	Fuels to Enable Light-Duty Diesel Advanced Combustion Regimes	Pending
AVFL-18	Methodology for Formulating Diesel Surrogate Fuels with Accurate Compositional, Ignition-Quality, and Volatility Characteristics	*Energy & Fuels* 2012, 26, 3284−3303

RELEASED REPORTS - 2012

AIR POLLUTION & ADVANCED TECHNOLOGY (Continued)*

CRC Project No.	Title	NTIS Accession No.
E-70	Populations, Activity and Emissions of Diesel Nonroad Equipment in EPA Region 7	EPA Report # EPA-420-R-12-009
E-80	Exhaust and Evaporative Emissions Testing of Flexible-Fuel Vehicles	PB2011-114911
E-83	Effects of Olefins Content on Exhaust Emissions	Pending
E-85-2	National 2010–2011 Survey of "E85"	PB2012-105295
E-88-2	Transportation Fuel Life Cycle Analysis, A Review of Indirect Land Use Change and Agricultural N_2O Emissions	PB2012-105230
E-100a	Remote Sensing Measurements for the E-100 Longitudinal Emission Pilot Study	PB2011-114912

RELEASED REPORTS - 2012

AVIATION & PERFORMANCE*

CRC Project No.	Title	NTIS Accession No.
AV-03-04	Diesel Lubricity Additive and Fatty Acid Methyl Ester Effect on Jet Fuel Thermal Oxidative Stability	PB2011-114910
AV-10-09	Jet Fuel "Aromatics Effects" and "Distillation Slope" Research Survey	PB2012-110240
AV-12-10	Properties of Russian Jet Fuels	PB2012-105229
CM-136-09-1B	Intermediate-Level Ethanol Blends Engine Durability Study	PB2012-110776
CM-137-11-1	Review to Determine the Benefits of Increasing Octane Number on Gasoline Engine Efficiency	PB2012-105823
CM-137-11-1b	Review to Determine the Benefits of Increasing Octane Number on Gasoline Engine Efficiency: Analysis and Recommendations	Pending
CRC Report No. 661	Mathematical Prediction of Flammability of Ethanol-Containing Fuels	PB2011-114909

*The primary source for the CRC Air Pollution, Performance and Aviation reports is:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
www.ntis.gov
Phone: 800-553-6847

When ordering a report, be certain to include the NTIS Accession Number.

PART FOUR

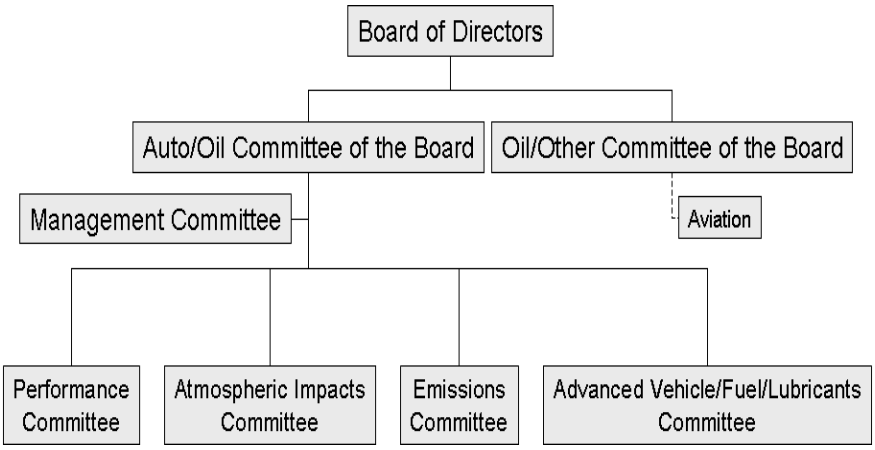
ORGANIZATION AND MEMBERSHIP

ORGANIZATION - 2012

The sustaining members of the CRC are the American Petroleum Institute (API) and a consortium of automobile manufacturers (Chrysler, Ford, General Motors, Honda, Mitsubishi, Nissan, Toyota, and Volkswagen). For over 70 years, CRC has provided the means for the automotive and petroleum industries to study problems of mutual interest. CRC's objective, as stated in our charter, is:

> To encourage and promote the arts and sciences by directing scientific cooperative research in developing the best possible combinations of fuels, lubricants, and the equipment in which they are used, and to afford means of cooperation with the Government on matters of national interest within this field.

CRC manages a range of technical projects designed to keep pace with today's rapidly-changing technology. Industry sponsors support approved projects by equal contributions from the industries directly concerned. Industry and the Government develop projects through committees comprised of their engineers and scientists.



Technical direction in each subject area is handled by an appropriate committee that closely supervises the progress of groups under its jurisdiction. The CRC Board of Directors is responsible for general policy and operation, including providing financial support, manpower, and laboratory facilities.

The diversity of the organizations participating in the various CRC committee activities can be seen in the remainder of this section. Committees and their working groups are made up of professionals of the highest technical competence in their areas.

CRC is not involved in regulation, hardware or fuel development, nor setting standards. CRC has only one real mandate, and that is to add to the scientific base that underlies regulation and technology. All CRC information is made publicly available and is used by industry to ensure optimum compatibility and customer satisfaction with its products and by industry, government, and the public to enhance joint achievement of clean air.

CRC has two basic types of research programs:

Cooperative research programs -- where scientists from various organizations come together to conduct cooperative research. This method utilizes the expertise from industry, government, and academia to develop and conduct experimental research programs. The results of these programs are made publicly available through written technical publications.

Contract research programs – where CRC conducts research by contract with independent research laboratories. Requests for proposal are issued to leading research organizations and universities to carry out specific research programs. Committees composed of industry and government representatives design these programs. The committees evaluate the proposals, and the research is carried out under the monitorship of the committees. Once again, reports that document the results of the study are made publicly available through written technical publications.

CRC's Auto/Oil Committee of the Board of Directors oversees the cooperative research summarized in this report. Board membership is comprised of six representatives from the petroleum industry and eight representatives from the automobile companies. Each industry has one vote on this committee, and each side must agree on matters concerning research priorities and funding before a project goes forward.

This organizational structure ensures research programs that are relevant to both industries as they change their products to comply with the provisions in the U.S. Clean Air Act Amendments or other regulations that affect the industries. Industry believes that making improvements in air quality can best be achieved through a sound understanding of the scientific issues. Industry working together with involvement from appropriate Government agencies is an effective approach to obtain technical information needed to achieve environmental and other vehicle performance goals.

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GASOLINE DEPOSIT GROUP

(Project No. CM-136)

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W. L. Clark	NREL	M. Miller	Sunoco Inc.
F. J. Cornforth	Phillips 66	K. Mitchell	Shell Canada Ltd.
K. D. Eng	Shell Global Solutions	W. J. Most	Fuel Tech. Assoc.
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(Project No. CM-136-09-1B)

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K. Freund	Volkswagen of America	J. Mount	Phillips 66
J. Frusti	Chrysler	W. J. Most	Fuel Tech. Assoc.
L. M. Gibbs	Consultant	C. L. Muth	Nalco Energy Services
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J. Horn	Chevron	C. Richardson	Ford Motor Co.
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H. Kleeberg	FEV	J. Szewczyk	Chrysler
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D. Lancaster	General Motors	M. Watkins	ExxonMobil
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S. Lindholm	Shell	J. Williams	API

OCTANE GROUP

(Project No. CM-137)

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B. Evans	Evans Research	C. Richardson	Ford Motor Co.
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(Project No. CM-137-11-1)

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P. Geng	General Motors	R. Osman	Flint Hills Resources
G. Gunter	Phillips 66	R. Reynolds	Downstream Alternatives
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(Project No. CM-138)

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F. J. Cornforth	Phillips 66	K. Moore	Renewable Fuels
H. Doherty	Sunoco	R. Osman	Flint Hills Resources
K. D. Eng	Shell Global Solutions	W. J. Piel	Lyondell Chemical Co.
B. Evans	Evans Research	J. Porco	Gage Products
J. Farenback-Brateman	ExxonMobil	C. M. Pyburn	Pybertech Intl.
J. M. Frusti	Chrysler	R. Reynolds	Downstream Alternatives
P. Geng	General Motors	C. Richardson	Ford Motor Co.
R. Hardy	Flint Hills Resources	D. Schoppe	Intertek
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		W. Studzinski	General Motors
E. Holthusen	Saudi Aramco	M. Valentine	Toyota Technical Ctr.
J. Horn	Chevron	L. Webster	Nissan Tech. Ctr. NA
J. J. Jetter	Honda R&D Am.	J. P. Wick	Marathon Petroleum Co.

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(Project No. DP)

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P. Biggerstaff	Baker Petrolite	A. A. Millard	Infineum USA
J. E. Carter	Haltermann Products	R. Mills	Chevron
A. Cayabyab	CARB	K. Mitchell	Shell Canada
R. Chapman	Innospec Fuel Spec.	M. Natarajan	Marathon Petroleum Co.
D. A. Daniels	Innospec Fuel Spec.	R. Osman	Flint Hills Resources
D. R. Forester	Power Service Products	J. Porco	Gage Products
K. Freund	Volkswagen of America	C. Richardson	Ford Motor Co.
R. George	BP	J. A. Rutherford	Chevron Oronite
G. C. Gunter	Phillips 66	D. Schoppe	Intertek
C. Hamer	PCS Instruments	R. Spence	Denso Intl. America
E. Holthusen	Saudi Aramco	W. Studzinski	General Motors
E. Izor	Denso	J. T. Talbert	Shell Global Solutions
J. J. Jetter	Honda R&D Am.	R. D. Tharby	Tharby & Associates
S. R. Kirby	Navistar, Inc.	M. Valentine	Toyota Technical Ctr.
A. Kulinowski	Afton Chemical	G. Webster	AET
P. Lacey	Delphi Diesel Sys.	L. Webster	Nissan Tech. Ctr. NA
D. H. Lax	API	S. A. Westbrook	SwRI
R. Leisenring	Sunoco Inc.	P. Yon-Hin	Nalco Co.

DP - LOW TEMPERATURE OPERABILITY PANEL

(Project No. DP-02)

J. Chandler, Ldr. (ret.) Infineum

D. Arters	Lubrizol	G.C. Gunter	Phillips 66
J. Axelrod	ExxonMobil	J. J. Jetter	Honda R&D Am.
A. Buczynsky	GM Powertrain	H. Martin	Cummins/Fleetguard
D. A. Daniels	Innospec Fuel	K. Mitchell	Shell Canada Products
R. Davidson	Afton Chemical Corp.	M. Nikanjam	Chevron Products Co.

MEMBERSHIP

DP - BIODIESEL PANEL
(Project No. DP-02a)

R. McCormick, Ldr. NREL

D. Arters	Lubrizol	J. J. Jetter	Honda R&D Am.
R. Baranescu	Int'l. Truck & Eng.	T. Livingston	Robert Bosch
D. R. Forester	Power Service Prods.	R. L. McCormick	NREL
R. Gault	EMA	A. Millard	Infineum
G.C. Gunter	Phillips 66	K. Mitchell	Shell Canada Products
P. Henderson	GM Powertrain	M. Nikanjam	Chevron Products Co.
S. Howell	National Biodiesel Bd	W. Studzinski	General Motors

DP - CETANE NUMBER PANEL
(Project No. DP-3)

A. M. Kulinowski, Ldr. Afton Chemical

J. Axelrod	ExxonMobil	T. Livingston	Robert Bosch
F. J. Cornforth	Phillips 66	K. Mitchell	Shell Canada
D. R. Forester	Power Service Prods.	M. Nikanjam	Chevron Products Co.
R. George	BP	J. Y. Sigelko	Volkswagen of America
G.C. Gunter	Phillips 66	W. Studzinski	General Motors
J. J. Jetter	Honda R&D Am.	J. T. Talbert	Shell Global Solutions
S. Johnson	Volkswagen of America	W. Woebkenberg	Daimler

DP - DEPOSIT PANEL

(Project No. DP-4)

J. Axelrod, Co-Ldr.	ExxonMobil
D. Arters, Co-Ldr	Lubrizol

M. Ahmadi	Oronite Additive Co.	D. H. Lax	API
J. Anderson	Paccar Inc.	T. Livingston	Robert Bosch
P. Biggerstaff	Baker Petrolite	I. MacMillin	Octel-Starreon
N. C. Blizard	Cummins Engine Tech.	A. Millard	Infineum
R. Chapman	Innospec Fuel Spec.	R. Mills	Chevron
H. DeBaun	Navistar	M. Nikanjam	Chevron Products Co.
D. R. Forester	Power Service Prods.	R. Osman	Flint Hills Resources
R. Gault	Engine Manufacturers	J. D. Parsons	Caterpillar
R. George	BP	J. Rutherford	Chevron
B. E. Goodrich	John Deere	W. Studzinski	General Motors
G.C. Gunter	Phillips 66	T. Talbert	Shell
J. J. Jetter	Honda R&D Am.	C. Trobaugh	Cummins
S. R. Kirby	Navistar, Inc.	M. Valentine	Toyota Technical Ctr.
A. Kulinowski	Afton Chemical	L. Webster	Nissan Tech. Ctr. NA
P. Lacey	Delphi Diesel Systems	W. Westbrook	SwRI