CRC

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COORDINATING RESEARCH COUNCIL, INC.

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COORDINATING RESEARCH COUNCIL
ANNUAL REPORT

September 2011

COORDINATING RESEARCH COUNCIL, INC.
3650 MANSELL ROAD • SUITE 140 • ALPHARETTA, GEORGIA 30022
TEL: 678-795-0506 • FAX: 678-795-0509 • WWW.CRCAO.ORG

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PART ONE

STATE OF THE COUNCIL

STATE OF THE COUNCIL: 2011

The Coordinating Research Council (CRC) provides the means for the automotive and energy industries to work together and with government to address mobility and environmental issues of national and international interest.

The technical programs in CRC have continued this year with broad cooperation from many supporting 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 2011 have included: The U.S. Department of Energy (DOE) and many of its national laboratories, the U.S. Department of Agriculture, the Health Effects Institute (HEI), the California Air Resources Board (CARB), the U.S. Environmental Protection Agency (EPA), the South Coast Air Quality Management District (SCAQMD), the Engine Manufacturers Association (EMA), the Renewable Fuels Association (RFA), the National Biodiesel Board (NBB), and many others. CRC has also continued coordination with research organizations worldwide, with Japanese, European and Canadian collaborations emphasized during the past year.

A waiver was approved this year by EPA to increase the allowable content of ethanol in gasoline from 10 volume percent (E10) up to 15 volume percent (E15) in newer light-duty vehicles. CRC has continued its assessment of the impact of such mid-level ethanol blends as a major research effort. It is essential to understand the impacts such a change may bring to fuel quality and performance in the current light-duty vehicle fleet. Several studies on the potential impacts of E15 and E20 were continued this year, including Performance Committee studies on engine durability (CM-136-09) and vehicle driveability (CM-138-09), Emissions Committee studies on impacts on OBD II systems (E-90) and evaporative emissions systems durability (E-91), the AVFL Committee study on fuel system compatibility (AVFL-15), and the Atmospheric Impacts Committee study on modeling expanded use of renewable fuels (A-73). CRC has coordinated its research program on mid-level ethanol blends with EPA, DOE, and many other stakeholders. CRC officers met with representatives of the U.S. General Accountability Office (GAO) to review our mid-level ethanol blend research program. GAO issued a report on this topic in June 2011 that references CRC's activities.

CRC completed Phase 1 of the Advanced Collaborative Emissions Study (ACES) in collaboration with the Health Effects Institute (HEI) in 2009 to provide an evaluation of the advanced diesel engine and aftertreatment systems meeting 2007 on-road heavy-duty diesel standards for particulate matter (PM). An article was published in the *Journal of Air and Waste Management Association* on the Phase 1 engine emissions test program. HEI commenced health effects testing at Lovelace Respiratory Research Institute (LRRI) in 2010. This year CRC coordinated development of the technical approach to be followed in Phase 2 to conduct an evaluation of engines meeting the much reduced 2010 oxides of nitrogen (NO_x) emissions standards.

CRC Emissions Committee projects conducted under E-77, in cooperation with EPA, achieved closure on the current work phase with release of Final Report No. E-77-2c. This program studied evaporative emissions from the in-use fleet. Test fuels evaluated in this study included E0, E10, and E20. This program included a detailed characterization of evaporative emissions to define canister emissions, permeation emissions, and emissions from fuel system leaks. One major accomplishment is demonstration of methods to identify on-road leaking vehicles using a new remote sensing technique and confirm leak levels with a simple mini-shed test that can be implemented in the field, but is also representative of laboratory measurements.

The Advanced Vehicle/Fuel/Lubricants (AVFL) Committee completed an investigation of biodiesel chemistry and carbon footprints under AVFL-17a. This study also included an assessment of regional fuel quality from various sources of biodiesel. The AVFL's Fuels for Advanced Combustion Engines (FACE) Working Group continues its broad collaborations with industry, government, and academic fuel experts.

The Diesel Performance Group of the CRC Performance Committee has formed three special sub-panels to evaluate field problems observed in modern diesel fuel injection systems. At least two types of fuel deposits have been documented in field operations of high pressure common rail fuel systems. Using an approach of collecting field problem data, developing bench tests, and confirming in engine demonstrations, the special CRC project teams are working with the EMA to define the issues, identify sources of the problems, and ultimately recommend possible solutions for correcting field problems.

The Octane Group of the Performance Committee continued its important test program to evaluate the relative contributions of motor octane number (MON) and research octane number (RON) in current light-duty engines and control systems. The first phase of testing was conducted by Chrysler, and the second phase was completed this year at General Motors. A final report comparing modern engine performance against octane number values was completed this year and published as CRC Report No. 660. In related work, a new octane study was initiated to assess the relationship of efficiency as a function of octane number in modern engines.

The Volatility Group of the CRC Performance Committee completed two studies during this program year evaluating the driveability performance of gasoline containing varying levels of ethanol and distillation properties. The first study was conducted in cooperation with ASTM to evaluate the influence of winter gasoline front-end volatility, mid-distillation temperature, and ethanol content on modern vehicles in warm temperature environments at low altitude and published as CRC Report No. 658. The second study was conducted to evaluate the effect the hot fuel handling performance of a set of 13 test fuels at high altitude. The test site was Pueblo, CO at an altitude of 5000 feet. The second study results were published as CRC Report No. 659.

The Atmospheric Impacts Committee is 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 Atmospheric Impacts Committee completed a new project as part 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 modeled the European domain with the CAM_x air quality grid model. Results from this U.S. developed model will be compared against several other European models.

The Atmospheric Impacts Committee continued its development of the CONCEPT model that will allow a straight forward adjustment of emissions factors based on fuel effects. This effort, now being conducted under the A-73 project series, provides a tool for assessing potential air quality impacts from the use of mid-level ethanol blends. Project A-76 is a new project evaluating light-duty vehicle emissions impacts from past, present, and future control scenarios.

Previous CRC projects resulted in the publication of three books by Oxford University Press: *Mechanisms of Atmospheric Oxidation of the Alkenes*, *The Mechanisms of Atmospheric Oxidation of Aromatic Hydrocarbons*, and *Mechanisms of Atmospheric Oxidation of the Alkanes*. A new book on *Mechanisms of Atmospheric Oxidation of the Oxygenates* was published this year by Oxford University Press.

The 5th Mobile Source Air Toxics Workshop was held in December 2010 in Sacramento, CA. This workshop, hosted by the California Air Resources Board, brought together key local, state, and federal government researchers, academic and industry researchers, and other stakeholders to discuss the state-of-the-art and future research needs. Proceedings from the workshop were released in early 2011.

The 21st CRC Real World Emissions Workshop was held March 21-23, 2010, in San Diego, California. Participants included representatives from government, universities, commercial organizations, and several international organizations. The 2011 keynote speaker was Dr. Robert Sawyer, Class of 1935 Professor of Energy Emeritus of UC-Berkeley and former chair of the California Air Resources Board, who shared his perspective on current important emission issues and related topics.

The second Life Cycle Analysis (LCA) Workshop on Biofuels was developed this year with broad support from an international organizing committee. The committee has invited world-renowned experts to present the latest information. Participants at this "invitation only" event are actively working on life cycle analysis techniques and applications. The workshop will be held again at Argonne National Laboratory, October 17-19, 2011. The workshop proceedings to be published in early 2012 will identify a consensus on the status of technology and uncertainties/gaps in the current data and procedures used in biofuel life cycle assessments. A related LCA overview study was published this year by the Emissions Committee as Final Report No. E-88.

Details on these and other CRC projects appear in Part Two of this Annual Report. 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 the Health Effects Institute (HEI) and the Coordinating Research Council (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 the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), the California Air Resources Board (CARB), the American Petroleum Institute (API), the Engine Manufacturers Association (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 has been performed. Emissions characterization results were used as the basis for selecting one HHDD engine/after treatment 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 will be performed on the 2010 HHDD engine technology.
- 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.

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Southwest Research Institute (SwRI) and Desert Research Institute (DRI) were selected to perform Phase 1. The Lovelace Respiratory Research Institute (LRRI) was selected to perform Phase 3. Four manufacturers (Caterpillar, Cummins, Detroit Diesel, and Volvo) supplied de-greened 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 the CRC Project E-55/59. The development of this engine cycle was performed 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 web site. An article on the Phase 1 engine emissions test program was published in the *Journal of Air and Waste Management Association* in April 2011.

CRC's technical panel continues to be apprised of developments in Phase 3 of ACES, which is ongoing.

SwRI has been selected to perform Phase 2, and contracting is in process. Three heavy-duty diesel engines are expected to be tested in 2011 in the Phase 2 project.

EVALUATIONS OF THE MOVES MOBILE EMISSION FACTOR MODEL

CRC Project Nos. E-68, E-68a

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

Scope and Objective

The objective of these projects is to conduct assessments of EPA's new Motor Vehicle Emission Simulator (MOVES) emission factor model at appropriate levels of development. The first assessment (E-68) was applied to the general model outline and greenhouse gas (GHG) portion of the model. The second assessment (E-68a) was applied to the draft release of the complete model.

Current Status and Future Programs

EPA cooperated with CRC to facilitate these independent reviews of MOVES. The Final Report for the first assessment, E-68 "Analysis of EPA's Draft Plan for Emissions Modeling in MOVES and MOVES GHG," published in May 2004, is on the CRC website.

The follow-on project, E-68a, began in early 2009, when the draft version of the model was made available. This project was awarded to a team led by Air Improvement Resources, Inc.

Major tasks in the E-68a project were as follows:

Review and evaluate the methods used in MOVES2009 to estimate exhaust and evaporative emissions: The team reviewed, documented, and critically assessed the data and methods used to create the criteria pollutant emissions and toxics emissions for MOVES2009. The criteria pollutant emissions included HC (exhaust and evaporative), CO, NO_x, and PM (exhaust, brake and tire wear).

Exercise the MOVES2009 model: The team developed a protocol to exercise MOVES2009 and evaluated the ability of the model to represent real world emissions impacts associated with changes in the values of selected model parameters.

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Provide recommendations to CRC: The Final Report provided recommendations to EPA for future research and changes or updates regarding the MOVES model.

The E-68a Final Report was released on the CRC website this year.

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 nonroad diesel engines. Prior to the fieldwork, 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 nonroad 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 nonroad 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 nonroad engines.

The project started in 2007, and CRC funded an expansion of this project through the new CRADA with the EPA. Testing is complete. The Final Report for this project was prepared for publication by EPA.

ENHANCED EVAPORATIVE EMISSIONS VEHICLES

CRC Projects E-77, E-77-2, E-77-2b, E-77-2c, E-77-3

Leaders: K. J. Wright
C. Hart
K. E. Knoll

Scope and Objective

CRC, working with EPA, determined a need for an evaporative emissions test program to characterize real-world evaporative emission events for planning and inventory modeling purposes. The goals of this program are to characterize the aging fleet of enhanced evaporative emissions vehicles and to collect data on the newer technology vehicles. The effects of fuel vapor pressure and ethanol content in the fuel are being evaluated, along with the level of evaporative emissions control technology on the vehicle.

Current Status and Future Programs

The pilot program (E-77) focused on a fleet of ten vehicles of varying evaporative emissions control technologies and hydrocarbon-only fuels. The Final Report for this work was posted to the CRC website in 2007.

The first main study following the pilot was E-77-2.

The tested vehicles included:

- 4 Tier 2/Near Zero LEV
- 4 Enhanced 1996-2001
- One implanted leak (gas cap) vehicle in each vehicle category above.

The tested fuel was gasoline with the following ethanol content and vapor pressure (VP):

- Ethanol: 0% VP: 7 psi
- Ethanol: 0% VP: 9 psi
- Ethanol: 10% VP: 7 psi
- Ethanol: 10% VP: 10 psi
- Ethanol: 20% VP: 10 psi

EPA funded two follow-on projects to this work, E-77-2b and E-77-3. CRC's contributions to these projects were technical review assistance, vehicles, and fuels donation. E-77-2b began in 2008; it continued the E-77-2 test program, using the same test methods with additional cars. The Final Report has been published on the EPA website with a link provided on the CRC website.

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E-77-3 targeted the identification of potential fuel leaks in vehicles, and characterizes the emissions of found leaks. The project screened a high number of vehicles passing remote sensing devices (RSD). After identifying potential leaks in the RSD phase, temporary Sealed Housings for Evaporative Determination (SHEDs) were used to obtain data on emissions characterization. Two successful pilot studies for this project were completed in 2008. The EPA has continued related research in collaboration with the Colorado Department of Public Health and Environment.

E-77-2c was a direct follow-on project to E-77-2 and E-77-2b, to expand the database from this series of projects. One purpose of this particular study was to evaluate the effects of ethanol up to 20% volume on late model vehicle evaporative emissions. This was accomplished by expanding the work scope of Project E-77-2b to include fuels containing up to 20% ethanol, at two vapor pressures, 7 and 9 psi RVP. Eight new vehicles were tested using these two fuels, and vehicles from earlier phases of the research were tested with implanted fuel system leaks on a variety of fuels. The E-77-2c project was performed by Harold Haskew and Associates (HHA).

Final Reports have been released for the E-77 (pilot) and the E-77-2 projects. The E-77-2b report was released by EPA. The E-77-2c Final Report has been released by CRC. The E-77-3 report is in development; it is expected to be released in late 2011.

EXHAUST AND EVAPORATIVE EMISSIONS TESTING OF FLEXIBLE-FUEL VEHICLES

CRC Project No. E-80

Leaders: D. M. DiCicco
H. Maldonado

Scope and Objective

The objective of this project is to test a fleet of seven late model California-certified Flexible-Fueled Vehicles (FFVs) or their equivalent to determine the impact of varying ethanol-gasoline blends on their exhaust and evaporative emissions. Documenting the procedures, time, and mileage required to adjust engine fuel control systems is an important aspect of this testing, which will enhance understanding of the effect of switching fuels on emissions. Another project objective is the chemical speciation of exhaust and evaporative emissions of the test vehicles.

Current Status and Future Programs

The testing is outlined as follows:

- Pilot Program
  - Measure exhaust emissions (Unified Cycle) while vehicle learns new ethanol level
  - Transitions: E85 to E6, E6 to E85, E85 to 50/50 mix
- Main Program
  - After stabilizing fuel learning on four blends of gasoline and ethanol E6, E32, E59 and E85, measure tailpipe exhaust emissions on the following test cycles:
    -FTP
    -US06
    -Unified Cycle
  - After stabilizing fuel system (three week soak with weekly driving and one hour steady temperature SHED test), measure evaporative emissions over the following procedures:
    -FTP Running Loss
    -Unified Cycle Running Loss
    -Two-Day Diurnal

HHA completed testing for this project in early 2010. A statistical analysis was performed by the Committee. The Final Report was published by CRC in September 2011.

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EFFECTS OF OLEFINS CONTENT ON EXHAUST EMISSIONS

CRC Project No. E-83

Leader: J. P. Uihlein

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%) have been 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 is being performed.

Current Status and Future Programs

The E-83 project was awarded to the University of California-Riverside's Center for Environmental Research and Technology (CE-CERT). Testing is complete, and analysis is ongoing, with reporting expected later in 2011.

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

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

Leaders: K. J. Wright
T. Alleman

Scope and Objective

NREL/DOE has partnered with CRC for these studies. The objective of the studies is to compare the quality of E85 currently sold in the US 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 is to gather seasonally specific samples that cover all volatility grades. Locations 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 the E-85 project was released on December 7, 2009.

The follow-on project E-85-2, also in partnership with NREL, is following 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. Testing is complete, and analysis is ongoing. The Final Report for this project is anticipated to be released later in 2011.

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REAL-TIME PM MEASUREMENT WORKSHOPS

CRC Project No. E-86

Leaders: H. Maldonado
M. M Maricq

Scope and Objective

The area of PM emissions measurement is currently undergoing a number of concurrent and rapid changes. Regulatory changes include significant tightening of motor vehicle PM emissions and rule making in the areas of off-road, locomotive, marine engines, and stationary generators. Technology changes include new engine designs, development of diesel aftertreatment systems, and hybrid vehicles. There is also development of new PM sampling techniques and measurement instrumentation.

The CRC Real World Group PM Measurement Panel's objective is to explore the form that effective future PM measurement might take from a research and technology perspective. The panel's primary activity is to conduct focused, invitation-only workshops to gather expert information on the relative importance of various PM characteristics such as size, structure, and composition, in the context of measurement methods. This information is critical to a meaningful understanding of various PM measurement techniques applicable to the broad range of combustion sources.

Current Status and Future Programs

Two 2-day workshops were held: the first on the impact of transport and transformation between source and receptor, and the second on the evaluation of sampling and measurement methods. Each workshop was split into four half-day sessions; each session was devoted to a specific question. Two talks by invited experts led off each session. Those talks were followed by breakout sessions that provided opportunities for detailed discussion about current status and future directions of PM measurement.

The first workshop was held in Phoenix, Arizona, on December 4-5, 2008. The second workshop was held in San Diego, California, on March 19-20, 2009. A special issue of the *Journal of Air and Waste Management* (*JAWMA*) was published in October 2010, consisting of seven papers authored by the workshops' speakers and organizers (six from the invited experts, and one from the project leadership).

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 is to investigate the effects of ethanol-blended fuel on open loop air-fuel ratio and 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 in the fuel into account, then the calculation may be in error and the catalyst protection could be compromised.

The objective of E-87-1 was to test a small fleet of 25 U.S. and California-certified vehicles to determine if the fuel ethanol content affects the combustion stoichiometry and the catalyst and oxygen sensor temperatures when the vehicle is 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 Department of Energy, referring 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 and DOE/NREL conducted their own pilot studies in parallel to E-87-1. The E-87-1 Final Report was released in July 2009.

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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 is greater, with emissions measurements performed at every 25,000 miles.

CRC participation in DOE V4 has been reduced in the latter stages. DOE, ORNL, and NREL are also running parallel testing projects at other laboratories, without CRC participation.

DOE V4 testing is complete, with reporting anticipated in late 2011.

REVIEW OF TRANSPORTATION LIFE CYCLE ANALYSIS

CRC Project E-88

Leaders: C. H. Schleyer
P. L. Heirigs

Scope and Objective

There is increasing interest in energy consumption and GHG emissions from use of transportation fuels. A life-cycle analysis (LCA) or well-to-wheels analysis is required to get a comprehensive estimate of energy use and GHG emissions from use of various transportation fuels. This analysis consists of a well-to-tank (WTT) portion which covers the steps required to produce and deliver the finished fuel to the vehicle and the tank-to-wheels (TTW) portion which covers vehicle use of the fuel.

A number of models have been developed for conducting transportation fuel LCA analyses. The TTW portion of transportation also uses separate models to evaluate fuel and powertrain effects on vehicle fuel consumption and GHG emissions.

This project involves a broad review of the methodology, analytical tools, and models used in transportation fuel LCA, with a particular focus on biofuels. This review will identify gaps and provide recommendations for improvement in methodology, data, analysis tools, and models.

Current Status and Future Programs

After a competitive selection process, this project was awarded to Life Cycle Associates. The project began in late 2008 and the Final Report was released on the CRC website in early 2011.

CRC held an invitation-only LCA Workshop in October 2009 to present results from E-88 and other studies. The workshop organizing committee included representation 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, Renewable Fuels Association (RFA), Marathon Oil Company, ExxonMobil Research & Engineering, Argonne National Laboratory, and the South Coast Air Quality Management District (SCAQMD). Planning for another workshop in 2011 is underway.

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FOLLOW-ON STUDY OF TRANSPORTATION LIFE CYCLE ANALYSIS

CRC Project No. E-88-2

Leaders: C. H. Schleyer
P. L. Heirigs

Scope and Objective

The overall objective of this project is 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 is to identify data gaps and make recommendations to improve the transparency of modeling methodologies. Particular focus will be 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 have been 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 are being compared with other values from available literature sources to identify important differences and knowledge gaps. The project includes 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 includes a database and literature review effort – no experimental work of modeling is planned. The literature previously reviewed under Project AVFL-17 and AVFL-17a served as the starting point for this work. Computer-based search tools, including Web of Science, the SAE literature search engine, the DOE citation database, trade literature, and patents, are being applied to update the information set.

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

The project is underway, and is expected to be completed in late 2011.

EPAct 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 DOE V2). EPAct / V2 / E-89 is examining 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 agreed to partner with CRC and incorporated the recommended additional fuels for testing in the main program. The project is structured as follows:

- Phase 1:
  - Testing 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
  - 27 fuels tested in 16 Tier 2 vehicles, E85 tested in FFVs that are included in the 16
  - Fuel Matrix, 5 variables in matrix

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- 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 5th and 95th 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 are also being used in the E-83 project.

The final report documenting the testing performed in the EPAct / V2 / E-89 project (Phase 2 of the overall scope) is in review, and its release is expected in late 2011. Additional reports on Phases 4 and 5 with no CRC involvement or on analyses performed by the sponsoring government agencies, are also in development.

IMPACT OF E15/E20 BLENDS ON OBDII SYSTEMS

CRC Projects E-90, E-90-2a, and E-90-2b

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

Scope and Objective

The objectives of this study are to collect On-Board Diagnostics (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 (i.e., E15 or 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) are providing 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 has been released on the CRC website.

EMISSIONS

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 Identify Vehicles that May be Sensitive to E10+ Blends”, was awarded to Sierra Research after a competitive solicitation process. This project has been completed, and the Final Report has been released on the CRC website. Project E-90-2b, “Impact of Ethanol Blends on the OBDII System of In-Use Vehicles”, has been awarded to SwRI. Vehicle screening and testing is ongoing. This project is expected to continue into 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

This project is testing ten vehicle models representing a variety of evaporative emission control strategies. Two of each type of vehicle are being tested on two test fuels:, federal emissions test fuel (E0), and federal emissions test fuel blended with 20 percent ethanol by volume (E20). E0 is serving as the baseline fuel. Vehicles operating on E20 are being compared to vehicles operating on E0 to determine the effects of increased ethanol levels in gasoline.

The approach consists 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.

Intermediate testing (at the end of each 3-month aging cycle) and final testing using both federal certification fuel and the individual vehicle's ethanol evaluation fuel will document any deterioration in evaporative emissions performance. The testing with the federal certification fuel is using the EPA two-day cycle; these data will be used to compare the vehicle response to the in-use standards. The testing with the individual vehicle's ethanol evaluation fuel will use the procedure from the CRC E-77 pilot study.

EMISSIONS

The basic aging protocol consists 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 and a 46.3 mph average speed. Between drives, the vehicle is parked outside in ambient conditions. Each aging cycle lasts for 90 days.

The overall program is expected to last approximately 74 weeks. By performing the evaporative diurnal tests on the fuel that is used for aging, a real-world emissions measurement can be generated: a measurement that may be used to understand the real effects on air quality in urban areas. Further, using the E-77 Pilot Program test cycle allows the isolation of parameters for emissions modeling. These parameters are leaks, diurnal vapors, and permeation.

This project was awarded to ETC of Aurora, Colorado, with the sea-level work to be performed by Chrysler, working as a subcontractor. The project is ongoing, and is expected to continue through 2011, with a report in mid-2012.

BLENDER PUMP FUEL SURVEY

CRC Project No. E-95

Leaders: K. J. Wright
T. Alleman

Scope and Objective

The objective of the Blender Pump Fuel Survey was to follow the general approach of the E-85 and E-85-2 National Surveys of E85 Quality, but to focus specifically on blender pumps that are designed to allow the consumer to select the percentage of ethanol in the blend. Additional collection procedures were developed, such as how to ensure that the last fuel blend purchased did not carry over into the new sample, and the use of digital photos to verify the pump selection setting for comparison to the actual ethanol content of the sample. Samples were collected only from stations using a single hose to distribute gasoline and higher blended ethanol products. Stations that dispensed higher ethanol products and E85 out of a single hose were also allowed. Samples were collected only from stations with pre-set, discrete blends available (e.g., E30 and E50).

Current Status and Future Programs

NREL co-sponsored this project in a similar fashion to the E-85 and E-85-2 projects. The sampling was conducted in the summer of 2010. NREL released the final report on their website, and a link to the report has been posted to the CRC website.

EMISSIONS

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 phases, with plans to propose a fourth phase. Phase 1 addresses light-duty vehicle emissions. Testing was carried out in May 2010, and data analysis is ongoing. Phase 2 is aimed at heavy-duty diesel emissions, and was completed in July 2011. Phase 3 has two aims. The first is to revisit light-duty vehicles and address issues or questions that arise in the analysis of Phase 1 data. The second is to examine non-road engine emissions. Testing for Phase 3 is planned for late 2011 / early 2012. Phase 4, proposed for 2012, will focus on incorporating Phase 1-3 results into improving atmospheric aerosol models.

LONGITUDINAL EMISSIONS STUDY (PILOT)

CRC Project No. E-100a

Leaders: M. B. Viola
C. Hart
D. R. Lawson

Scope and Objective

The US Environmental Protection Agency (EPA) has developed an inventory model, MOVES, which has replaced MOBILE6.2. The modal structure of MOVES requires continuous rather than aggregate measurements. Currently the light-duty emissions in MOVES are based primarily on Inspection and Maintenance (I/M) data. As I/M programs discontinue tailpipe testing, less of these data will be available in the future. The FACA MOVES Review Workgroup recommended that EPA develop a long-term systematic data collection plan to support MOVES.

The long-term program currently under development by EPA will be designed to measure exhaust emissions from current vehicle technologies using portable instruments (PEMS/PAMS). The scope of this project covers remote sensing measurements for purposes of the pilot program, and delivery of those data to EPA. EPA will use the pilot measurements to develop, test and refine screening methods for purposes of vehicle sampling and recruitment.

Current Status and Future Programs

A pilot program was initiated during 2010 in the Detroit Metropolitan Statistical Area. The objectives of the pilot study were to develop, test and refine one or more screening indices for exhaust emissions and to develop and field-test methods for sampling, recruitment and measurement. The three project tasks were:

Task 1: A work plan and standard operating procedures were developed. The remote sensing system was verified. Suitable sample sites were selected within the Detroit urban area for the follow-up field measurements.

EMISSIONS

Task 2*:* Road-side remote sensing measurements were performed with the objective to obtain at least 30,000 valid measurements. Data were processed, analyzed and reviewed. License plate images were read and matched to the measurements.

Task 3: Progress, results, system performance and data quality were summarized in scheduled reports. A complete database will be delivered for future use.

The project was performed by Michigan Technological University (MTU). Sampling was completed in the summer of 2010. The final report was released in August 2011.

INVESTIGATION OF THE ROLE OF LUBRICATING OIL ON PARTICULATE MATTER EMISSIONS FROM VEHICLES

CRC Project AVFL-14

Leaders: C. H. Schleyer
D. R. Lawson

Scope and Objective

The objective of this project is the evaluation of PM emissions in eight types of vehicles using conventional and advanced lubricants. The emissions were tracked by each vehicle/lubricant combination. Testing was conducted at cold operating conditions (30° F) and at normal operating conditions (72° F) on two lubricant formulations. The impact of ethanol at a 10% blend level was studied in light-duty (LD) vehicles, and the impact of biodiesel at a 20% blend level was studied in the medium-duty (MD) vehicles. Natural gas-fueled MD vehicles were also evaluated.

Current Status and Future Programs

Study vehicles included the following:

- Normal-emitting gasoline vehicle – Model year 2002 or newer gasoline-powered LD vehicle with fewer than 75,000 miles.
- High-emitting gasoline vehicle – LD, gasoline-powered vehicle with known PM emissions rate of greater than 200 mg/mile over the Unified Driving Cycle and whose emissions were consistently high with high lubrication oil consumption, and/or had visible smoke related to lubrication oil.
- Normal-emitting diesel vehicle – HD vehicle with a diesel engine displacement of at least 7.2 liters and a minimum rated torque of 660 ft-lbs. Engine model year 2002 or newer with fewer than 270,000 miles. No PM control technology (filter, trap, oxidation catalyst).
- High-emitting diesel vehicle – HD vehicle with a diesel engine displacement of at least 7.2 liters and a minimum rated torque of 660 ft-lbs. Engine/vehicle model year 1996 or older and known to emit high levels of PM. High lubrication oil consumption, and/or visible smoke related to lubrication oil.

AVFL

- Normal-emitting natural gas vehicle – modern CNG- or LNG-fueled transit bus or school bus of model year 2002 or newer with fewer than 270,000 miles. Displacement of at least 7.6 liters and a minimum rated torque of 660 ft-lbs.
- High-emitting natural gas vehicle – high-mileage CNG- or LNG-fueled transit bus or school bus, known to emit measurable levels of PM. High lubrication oil consumption, and/or visible smoke related to lubrication oil.
- Normal-emitting MD diesel vehicle – a MD pickup truck with a diesel engine. Model year 2002 or newer with fewer than 30,000-75,000 miles on the odometer.
- High-emitting MD diesel vehicle – a pickup truck with a diesel engine. Model year 1996 or older and known to emit high levels of PM, has high lubrication oil consumption, and/or visible smoke related to lubrication oil.

This project, also known as the Collaborative Lubricating Oil Study on Emissions (CLOSE) Project, includes the participation of co-sponsors DOE/NREL, SCAQMD, and CARB. The American Chemistry Council (ACC) joined the project after its inception, providing technical expertise and test lubricants, including the used oils from other ongoing ACC programs.

In 2008, CRC and other sponsors expanded the study to include some repeat testing, in the interest of better separating fuel and lubricant effects from testing variances.

Vehicle testing has been completed, and analysis is complete. The final report was released by the project sponsors (including CRC) in September 2011.

E20/E15 DURABILITY STUDIES

CRC Project AVFL-15 / 15a

Leaders (15): D. M. DiCicco
M. Foster
K. E. Knoll

Leaders (15a): S. W. Jorgensen
M. Foster

Scope and Objective

The objective of the AVFL-15 project 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 are gathering 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 focuses on older (late 1990s) vehicles that are at risk for durability issues and represent a substantial fraction of the current in-use fleet.

Current Status and Future Programs

New fuel system pairs (E0 and E20) are being tested, focusing on components exhibiting the most susceptibility to ethanol content in the fuel. A pilot phase exposed fuel pump components to each of the fuels. Besides fuel pump and fuel injector testing, the program calls for material testing of the complete fuel system after 11 months of aging at 105^{o} F. The impact of wear on the fuel system components when exposed to E20 will be measured.

DOE/NREL is a co-sponsor of the AVFL-15 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. The AVFL-15 project is still considered a pilot evaluation, and additional testing is likely to be needed. The testing is ongoing and reporting is anticipated in late 2011.

AVFL

Follow-on Research

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 the test procedures of the AVFL-15 project. An aggressive and a non-aggressive formulation of the E-15 blend have been included in this project. After a competitive solicitation, the project was awarded to TSG. The project is ongoing, and is expected to be completed by the end of 2011.

FUELS TO ENABLE LIGHT-DUTY DIESEL ADVANCED COMBUSTION REGIMES

CRC Project AVFL-16

Leaders: W. J. Cannella
C. S. Sluder
R. M. Wagner

Scope and Objective

The objective of this effort is to identify the characteristics of advanced fuels that affect the achievable advanced combustion operating range of light-duty (LD) diesel engines. The project includes two main tasks:

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

Task 2 – Investigate the Effect of Fuel Properties on Advanced Combustion Engine Operation -- This project will investigate the impact of cetane number, T90, and aromatic content in a matrix of test fuels. The Fuels for Advanced Combustion Engines (FACE) Working Group has developed a matrix of nine test fuels which will be used for this project.

Current Status and Future Programs

Advanced combustion operation with the fuels has been defined in terms of quantitative metrics which will include gaseous and particulate emissions, engine Coefficient of Variance (COV), cylinder pressure rise rate, and timing for 50% 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 will be investigated: single injection and dual injection, to cover types of advanced combustion frequently investigated in recent research.

AVFL

The Committee selected West Virginia University to perform this research. A significant amount of effort has been devoted to the development of the engine test platform, including the replacement of the original 2-valve-per cylinder engine with a 4-valve model. The operation of the engine in an advanced combustion mode has been demonstrated. The project is expected to continue through the end of 2011.

INVESTIGATION OF BIODIESEL CHEMISTRY, CARBON FOOTPRINT, AND REGIONAL FUEL QUALITY

CRC Project AVFL-17a

Leader: M. Natarajan

Scope and Objective

This project, conceived as the second stage of the research performed in Project AVFL-17, consisted of three tasks:

Task 1 - To investigate and evaluate the fatty acid methyl esters (FAME) in terms of their chemistry and composition and their influence on the emission characteristics. For example, the carbon chain length, the location, and the number of double bonds in the FAME structure were considered in how they influence the FAME properties and emissions. Significant information in this area was already collected in AVFL-17. This task was more focused - for example, examining the location of the double bonds in the FAME structure and their influence on the fuel-relevant properties such as cold flow, cloud point, cetane number, oxidation stability, density and emissions.

Task 2 - To investigate the carbon footprint of the various biodiesels. Literature data were collected on life cycle analysis of the various biodiesels using different models. A critical evaluation of the various studies which are most complete and based on sound science was required in this Task. An attempt was made to explain the various assumptions associated with land use change, including international scenarios.

Task 3 - To collect literature data on the regional and national biodiesel fuel quality specifications and measurement methods used in the various regions of the world and how they are enforced.

Current Status and Future Programs

This project was awarded to Desert Research Institute. The Final Report was released by CRC.

AVFL

SURROGATE FUELS FOR KINETIC MODELING

CRC Project No. AVFL-18

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

Scope and Objective

A surrogate fuel is a mixture of generally less than a dozen pure compounds that matches certain characteristics of a target fuel composed of tens 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 that rely on physical testing of hardware prototypes. 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.

Current Status and Future Programs

This project has identified compounds representing the major hydrocarbon classes found in real diesel fuels that will be included in the surrogate fuels. 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, NREL, Lawrence Livermore, and ORNL. The National Institute of Standards and Technology (NIST) is assisting with data collection and optimization techniques to support surrogate formulation. Final evaluation of the first-generation surrogates is underway. Reporting on this project is expected in late 2011.

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 Fuels for Advanced Combustion Engines (FACE) Working Group to foster collaboration with DOE, NREL, and ORNL. 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. Department of Energy National Laboratories. The activities of the group formally commenced in January 2006. The initial collaboration has expanded to include scientists and engineers from other National Laboratories: Sandia, Lawrence Livermore, and Pacific Northwest, as well as Canada's National Centre for Upgrading Technology (NCUT), and private laboratories: Battelle, Ricardo, and AVL.

Current Status and Future Programs

The group has been working on recommending two sets of fuels for research in advanced combustion in the diesel and gasoline ranges. The diesel fuel set, defined in 2007, is 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.

AVFL

The gasoline-range fuel set design has been finalized by the group. These fuels are expected to be available from CPChem; blending of the fuels is ongoing, with some offered for sale now. 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. 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; currently the most active team is dedicated to issues relating to Advanced Alternative & Renewable Fuels (AARF). This team, which is currently being led by Craig Fairbridge of NCUT, is working to obtain samples of those fuels which will be fully characterized, similar to what was done for the FACE Diesel Fuels.

AIR TOXICS WORKSHOP

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, this workshop brought together key government, academic, and industry researchers, and stakeholders working in this area.

The 2010 workshop (A-45c) was held December 1-2, 2010 in Sacramento, CA. The organizing committee representing a broad range of interests developed the final program content and nominated speakers for each session as done in previous workshops. The technical sessions were held at Cal-EPA Headquarters with a welcome reception held at the nearby Citizen Hotel on November 30, 2010. 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.

ATMOSPHERIC IMPACTS

THE MECHANISMS OF ATMOSPHERIC OXIDATION OF THE OXYGENATES

Project No. A-68

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

Scope and Objectives

The objective of this project is to prepare a comprehensive inventory of fundamental data and information on the atmospheric reactions of oxygenates in a format suitable for publication as a reference textbook.

Current Status and Future Programs

In recent years, a major interest has developed in alternative fuels such as ethanol, butanol, fatty acid methyl esters, and other biofuels that are largely oxygenates. The effects of these fuels and their oxidation products on the atmospheric chemistry of the urban, rural, and "free" atmospheres are of increasing interest. The development of the three previous books supported by CRC dealt with the atmospheric chemistry of the three major classes of hydrocarbons: the alkenes, the aromatic hydrocarbons, and the alkanes, including the halo-alkanes. In each of these books, some of the oxidation products of these hydrocarbons were discussed, but the accent in each book was on the hydrocarbons themselves. This textbook is related directly to the atmospheric chemistry of the many oxygenates.

Discussions of the alcohols, aldehydes, and ketones from the three previous books were drawn on, updated, and included in the new "Oxygenates" book, but the new book also includes discussion related to ethers and other classes of oxygenates, e.g., the esters which are major components of biodiesel fuels. The development of a realistic outline of a book on Oxygenates required discussion and planning by the authors. This project is completed and the following chapter topics were included in this book:

- The Oxygenates: Their Properties, Sources, and Uses as Alternative Fuels
- The Rate Coefficients and Mechanisms for the Atmospheric Oxidation of the Alcohols (sections on acyclic, cyclic, aromatic alcohols, and halo-alcohols).

- The Rate Coefficients and Mechanisms for the Atmospheric Oxidation of the Ethers (sections on acyclic, cyclic, aromatic ethers, and halo-ethers).
- The Rate Coefficients and Mechanisms for the Atmospheric Oxidation of Aldehydes (sections on acyclic, cyclic, aromatic aldehydes, and halo-aldehydes).
- The Rate Coefficients and Mechanisms for the Atmospheric Oxidation of the Ketones (sections on acyclic, cyclic, aromatic, hydroxy ketones, and halo-ketones).

An author team led by Jack Calvert and including Tim Wallington, Michael Pilling, Abdelwahid Mellouki, and John Orlando was assembled, and the project started in September 2007. The authors held a coordination meeting at the start of the project, and met again in April 2008, August 2008, and December 2008.

In March 2009, discovery of a large amount of literature not previously anticipated was reported. The significance of the new literature warranted a delay in the final product to ensure a more comprehensive report. The draft manuscript was delivered to CRC in fall 2009 and submitted separately for technical editor and technical content review. Reviewer comments were addressed by the author team, and the revised Final Manuscript was delivered to CRC and accepted as the final contract deliverable. The authors negotiated a contract through CRC with *Oxford University Press (OUP)* in March 2010 whereupon the final manuscript was submitted to the book publisher including author and subject indices. *OUP* published the book in August 2011.

A follow-on project is in committee planning under Project No. A-78 for a new effort entitled “Critical Review of Hydrocarbon Atmospheric Chemistry” to be conducted by a similar author team.

ATMOSPHERIC IMPACTS

REGIONAL MODELING OF WEEKEND/WEEKDAY EMISSIONS CHANGES

Project No. A-69

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

Scope and Objectives

The main objectives of this study are to improve regional emission inventories, models, and control strategies by simulating the impact of weekday/weekend emission changes. The objectives encompass three steps: 1) Review and improve the weekend emission inventory in the eastern U.S., 2) Test the ability of a regional model to simulate the impact of weekday/weekend emission changes on O_3, and 3) Determine to what extent the emission changes in upwind cities affect downwind cities and rural areas.

Current Status and Future Programs

CRC funded two previous projects on modeling the impact of weekday/weekend emission changes in Los Angeles. Project A-36 focused on simulation of an episode during the Southern California Ozone Study (SCOS) in 1997. In Project A-56, Los Angeles emissions were projected to 2010, and the simulated weekday/weekend ozone changes in 2010 were compared to those obtained with emissions for 1997. NREL funded a modeling study of a weekday/weekend ozone episode in southeast Michigan in 2002. Although the modeling domain was larger than southeast Michigan, the review of the weekend emission inventory and the updates to the inventory were confined to southeast Michigan.

There had been little or no modeling study of weekday/weekend ozone (and PM) changes over a large regional domain using a consistent set of weekend emission changes for the entire domain. Simulating a weekday/weekend episode provides a more stringent test of a regional model (and the associated emission inventory) than simulating a weekday episode. Because the weekend emission reductions are substantial, a weekday/weekend episode can test the model's ability to simulate the effects of emission reductions. Modeling a regional weekday/weekend episode is also of interest because the emission changes in one urban area may impact ozone concentrations in a downwind urban area, delayed by the time required for atmospheric transport. Thus, the weekday/weekend ozone changes in a large region

may be different or more complicated than those seen in Los Angeles, which has no large urban area upwind.

An ozone episode in the Midwestern U.S. containing at least one weekend was chosen. The modeling domain covered most of the eastern U.S. with fine grids over the major urban areas. The weekend emission inventory for the entire region was reviewed and adjustments made as necessary to apply a consistent set of assumptions and to use the latest information on weekend activity data. A regional model (CAMx) was used to simulate the episode. Model predictions for ozone (and other pollutants) were compared to ambient measurements within and downwind of urban areas. Analyses of model results, sensitivity tests, and applications of probing tools were also used as appropriate to determine the impact of weekend emission changes in large urban areas on downwind urban and rural areas.

Project deliverables included a regional emission inventory updated for weekday/weekend changes, quarterly reports, and a Final Report, part of which is a draft journal article with recommended improvements in modeling longer ozone and PM episodes that include weekends. The report documents improvements to the weekend regional emission inventory for on-road and off-road vehicles.

ENVIRON and Sonoma Technology, Inc. (STI) conducted this work under Contracts A-69-1 and A-69-2 respectively. A final report (A-69-2) containing data analyses necessary for modeling the weekend effects was received by the committee in May 2009 from STI. ENVIRON used these data and other data from LADCO to conduct their modeling activities. The Final Report for A-69-1 was published by CRC in May 2011.

ATMOSPHERIC IMPACTS

CONCEPT/CAMx MODELING OF EXPANDED USE OF RENEWABLE FUELS

Project No. A-73

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

Scope and Objectives

The committee proposed a new focus on performing air quality modeling of mid-level ethanol blends using emissions data from other CRC and related studies as an extension and application of the approach demonstrated in Project No. A-67. The modeling approach selected is development of the new emissions inventory model CONCEPT suite with CAMx (CONCEPT/CAMx) for possible application in the Lake Michigan area in cooperation with Lake Michigan Air Directors Consortium (LADCO). To bracket air quality predictions from ethanol emissions changes, the application of CONCEPT/CAMx in additional domains will also be accomplished. The additional domains may include the Northeast, Atlanta, or Dallas. The Northeast would be important for representation of effects for a major urban complex, Atlanta would help in characterizing changes in a biogenics-VOC-dominated airshed, and Dallas would be an extension of work done previously in the Auto/Oil program.

Current Status and Future Programs

The committee developed a final statement for the project in 2009. The original Mobile6.2 emissions factor model has been replaced and some script recoding has resulted in faster computation. Initial plans to incorporate the MOVES model under CONCEPT are being reassessed due to the complexity of this application. Competitive solicitations for this project were conducted during the final quarter of 2009. 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

ATMOSPHERIC IMPACTS

The committee and working group reviewed proposals submitted to CRC and 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 has been received from Alpine Geophysics and approved by the committee. A-73-1 and A-73-2 continued work into 2011 due to a delay in release of important new data on the impacts of mid-level blends on new vehicle emissions. CRC and committee leadership are working with the providers of these new data to obtain permission for use in these projects. Regular coordination meetings are being held via teleconference with Sierra Research and Alpine Geophysics to aid progress and assist in final data collection. Additional modeling is planned in 2011 under Project No. A-73-3 to follow work in the initial two phases.

ATMOSPHERIC IMPACTS

RELATIONSHIP BETWEEN SEMI-VOLATILE ORGANIC COMPOUNDS AND SECONDARY ORGANIC COMPOUNDS

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) and other aerosols contained in vehicle exhaust and subsequent formation of secondary organic compounds (SOA) and other aerosols 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 supported by EPA and CARB. This project has application to both the 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 on this topic. The CMU proposal to CRC is for atmospheric 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.

ATMOSPHERIC IMPACTS

A second phase of vehicle testing and chamber evaluations was conducted in June-July 2011 at the CARB/MTA heavy-duty chassis dynamometer facility. A third phase is planned for later in 2011 or early 2012 to add more vehicle and chamber testing to the project matrix. Completion of Phase 1-3 work including preparation of the Final Report is expected in 2012. A fourth phase is also under consideration by the committee to support modeling of SVOC primary emissions and their conversion to SOA.

ATMOSPHERIC IMPACTS

AIR QUALITY MODEL EVALUATION INTERNATIONAL INITIATIVE (AQMEII)

Project No. A-75-1

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

Scope and Objectives

The objective of this project is to evaluate the performance of several types of air quality models in North America and Europe domains. The U.S. E.P.A. approached the committee inviting their participation in this program by supporting modeling of the European Continent using 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. AQMEII is 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 model simulations. 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 EPRI separately under the same international initiative. The A-75-1 modeling results report was submitted and approved. This report will be released to the public following acceptance of the journal article by *Atmospheric Environment* if there are no copyright issues identified.

EVALUATION OF CAMx RESULTS FROM AQMEII

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 key inputs using the base case CAMx model developed for project A-75 to demonstrate how model performance depends upon input data and assumptions. In addition, this study demonstrated how advanced probing tools available in CAMx (HDDM and Process Analysis) can be used for model performance evaluation.

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 Joint Research Center (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 to be held in North Carolina in fall 2011 (anticipated to coincide with the 2011 CMAS conference.)

As contractor for the A-75 study, 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 journal article was submitted to *Atmospheric Environment* on May 31, 2011.

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

Project No. A-76

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 US. LDV emissions standards in the US have become increasingly strict since the 1970s and 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 US 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% though total VMT for highway vehicles increased more than two-fold. 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 light-duty trucks (PC/LDT1 and LDT2) both decrease by approximately 60% from 2010 to 2020. ARB is planning to

issue final Initial Statement of Reasons and final regulatory language for the LEV III standards later in 2011.

ENVIRON was selected through a competitive bid process to conduct this study and will use 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 has used it to evaluate regional mitigation strategies. CAMx was also used recently by EPA in its Clean Air Transport rulemaking process.

ENVIRON will perform 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 is the eastern United States with focus on the four urban areas discussed in EPA's Risk Assessment analysis. These areas are Atlanta, Detroit, Philadelphia, and St. Louis. The air quality modeling domain proposed is the Regional Planning Offices (RPO) unified Continental United States (CONUS) domain with 36 km horizontal resolution with an inner nested domain with 12 km resolution over the eastern US. The project was initiated in April 2011 and is scheduled for completion in December 2011.

REVIEW GLOBAL MOBILE SOURCE GHG AND CLIMATE MODELING

Project No. A-77

Leaders: R. S. MacArthur
T. Wallington

Scope and Objectives

The objective of this new study is to conduct a review of information reported in the literature on world-wide mobile source greenhouse gases (GHG) and how the information is used in current climate modeling applications.

Current Status and Future Programs

This project is in committee planning. The work statement will be prepared by the project leadership team and approved by the committee. It is expected that CRC will conduct a competitive solicitation to identify an appropriate independent contractor to complete the study.

PERFORMANCE

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.

In a second phase of the program, the tendency of 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. The rig injectors do not foul to the same level previous to December 2006. The rigs have shown poor reproducibility. The test development work is continuing as non-CRC funded work at SwRI. 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. The 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. The test fleet selection was determined cooperatively by CRC member companies and OEMs. The test vehicles were selected from among those that are more likely to exhibit some issues with mid-level ethanol blends

The approach consists of laboratory testing up to 14 engines using an engine durability cycle adapted for use on whole vehicles. The test procedure calls for accelerated testing to reduce test time and reveal possible failures. Accelerated testing is standard practice in the automotive industry. The severity helps reduce test time and compensate for the inherently small sample size associated with these tests.

PERFORMANCE

A number of companies responded to a competitive solicitation, and FEV was selected as the contractor. Testing is underway and monthly status reports are being submitted. The project achieved successful completion of Phases 1 -7 and now Phase 8 is underway. Preliminary results are regularly reported on the CRC website. A new summary update was posted on the CRC website in August 2011. Testing is proceeding on vehicles showing sensitivities on E20 at E15 followed by E0 gasolines depending on failure results reported in prior testing. Additional failures have been reported under Phases 2-8. Funding to support E15 and E0 testing of up to six more vehicle-fuel tests was identified in the first quarter of 2011. The FEV contract was modified to allow more fuel-vehicle tests with options for additional testing as needed. The project panel recommended authorization to test up to four more vehicles tests as the Final Report is being prepared with an expected release time near the end of 2011.

This the highest priority project in the Performance Committee.

VOLATILITY

CRC Project No. CM-138

Leaders: 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

2008 Cool Ambient Cold Start and Warm-up E85 and E15/20 Volatility Study

There were two parts to this volatility program: 1) Determine the effect of vapor pressure of E85 Ethanol Fuel on cold-start and warm-up driveability performance under cool ambient conditions in a large group of late model, flexible-fuel vehicles equipped with fuel injection systems, and 2) Determine the effect of E15 and E20 on cold-start and warm-up driveability performance under cool ambient conditions in a moderate size group of late model and older conventional vehicles.

The minimum vapor pressure required for the two warmer ambient conditions of the three volatility classes in ASTM Specification D5798 (Classes 1 and 2) for acceptable cold-start and warm-up driveability were determined. A follow-on program was required to investigate E85 properties for the coldest Class 3 fuels. The cold-start and warm-up performance of E20 versus gasoline with similar vapor pressures was also determined. This program was conducted in January and February 2008. The Renewable Fuels Association (RFA) and NREL contributed funding and manpower support to the project, and Lubrizol contributed some test vehicles. The report was approved by the committee and published as CRC Report No. 652. A follow-on program investigated E85 properties for Class 3 (i.e., winter E85) fuels and was conducted in a low temperature chassis dynamometer facility as described below.

2008 Cold Ambient E85 Class 3 Volatility Study

This study, started in summer 2008, evaluated 20 flexible fuel vehicles on 8 fuels with varying vapor pressure and hydrocarbon content. The target test temperature levels were -10°F and -30°F, but these targets were modified to 0ºF and -20ºF due to operational difficulties observed at -30ºF. Limited testing was done at 0°F. The all-weather chassis dynamometer (AWCD) facility of Imperial Oil in Sarnia, Canada was used to complete the study at

the end of 2008. Raters from previous CRC programs evaluated the performance of the test fuels. Slight differences were expected between road and dynamometer testing, but trained raters were able to obtain consistent ratings on the dynamometer.

The Sarnia program was completed in December 2008 after 66 test days (20 vehicles, 3 temperatures). The final data report was received and approved by the project leaders. RFA provided cost sharing and participation on data analysis to support the project. The project analysis panel met in May 2009 to prepare the draft report. The Final Report was published as CRC Report No. 654.

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 of fuel front-end volatility (i.e., TVL20), 50% evaporated distillation point, and ethanol content on hot-fuel-handling driveability performance in 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 data analysis and draft report were reviewed by the project panel and the Final Report was released for publication as CRC Report No. 659 and is now 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 light-duty vehicles. It does not apply to heavy-duty 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 may be conducted in an all-weather chassis dynamometer or at a test track test site. Final details of the program are still being worked out.

The results are urgently needed by ASTM, but the project currently has no funding.

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 Driveability Index 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 Driveability Index. This information may be used to guide future gasoline volatility regulations and specifications.

PERFORMANCE

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. 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 no funding.

2011 Mathematical Prediction of Flammability of Ethanol-Containing Fuels

This contract program will predict 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 are E10, E15, E20, E30, E40, E50, E85, and E100. Equations and/or nomographs will be developed for estimating the flammability temperatures of ethanol-gasoline blends as a function of vapor pressure.

Funding for this contract study has been provided by Growth Energy and the Renewable Fuels Association. A draft summary report is currently under review.

OCTANE

CRC Project No. CM-137

Leaders: 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

Determining Octane Number Requirements

In October 2005, the Octane Group published CRC Report No. 643 in which results from an acceleration octane test round-robin program were recorded. The report included a brief description of the work done within CRC with the Octane Acceleration Technique, the difficulties encountered with the data analysis of the CRC Interlaboratory study, the variability among laboratories in conducting the testing, and specific recommendations for a future improved test procedure. CRC Report No. 643 is available on the CRC website.

Importance of RON vs. MON

The objective of this program is to assess the relative importance of Research Octane Number (RON) and Motor Octane Number (MON) in current and future fleets. Given these results, it may be possible to ascertain whether the arithmetic average of RON and MON, (R+M)/2, is still the best way to determine the Antiknock Index (AKI).

Shell Oil data indicate that recent production European and Japanese vehicles are more responsive to RON than MON for avoidance of spark knock. They found that for a given RON, a fuel of lower MON had better road octane performance and gave better power and acceleration. All vehicles were equipped with knock sensors and 93% were equipped with manual transmissions.

PERFORMANCE

Experimental work at MIT under Professor John Heywood has corroborated the work at Shell. The MIT study on a single cylinder engine also showed that RON was a better predictor of engine power and performance compared to MON. MIT used CRC historical octane survey data in their assessment.

This RON sensitivity differs from historical U.S. data, which showed a pronounced sensitivity to MON. The CRC Octane Group developed a program that verifies and expands on the Shell and MIT research, testing vehicles representative of the current and future U.S. fleet.

CRC sought OEM support for a test program emphasizing the fuel economy potential that could accrue from changes in RON and fuel sensitivity (RON-MON). A letter was issued to the CRC OEM members of the Performance Committee requesting statements of interest in participating by testing engines at their respective laboratories and reporting summary data back to the committee to assess the RON vs. MON octane response of their engines. The Octane Group of the Performance Committee organized a panel to identify the test fuel set for the study and agreed to begin the project with even a limited number of participating laboratories.

A detailed program plan was reviewed and approved by the panel. A request for proposal for test fuel blending was issued by CRC and awarded to Haltermann Products. Hand blends and larger drum quantities of the test fuels were approved by the project group and shipped to Chrysler. Testing was started in 2008 on a 5.7-liter Hemi engine at Chrysler's laboratories. At the October 2008 meeting, the group approved using a GM boosted smaller displacement engine (DISI) in place of the naturally-aspirated small engine proposed by Chrysler. Chrysler reported preliminary results from their engine testing at the November 2009 group meeting. GM received the test fuels and completed testing on the second engine in early 2010. GM reported results to the committee at the April 27-28, 2010 meeting in Denver. The Final Report on the results of the Chrysler and GM engine studies dated May 2011 was approved for publication and is posted on the CRC website as CRC Report No. 660. Additional literature review and analysis of relative RON and MON contributions is planned by the committee.

Literature Review of Octane Number Versus Engine/Vehicle Performance

The objective of this program is to conduct a broad literature review of public and private reports and to 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 will be 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 project is slated for completion in 2011.

PERFORMANCE

DIESEL PERFORMANCE GROUP

CRC Project No. DP

Leaders: M. Nikanjam

Scope and Objectives

The objective of the Diesel Performance Group is to help define the minimum requirements to make light-duty diesel 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 proposal has been drafted jointly by both panels to study the effect of wax settling and biodiesel impurities on light-duty diesel performance. Details were presented by John Chandler.

This program will address cases in which light-duty vehicles do not operate for an extended period. Weekend shut downs will be an example. Conventional diesel, B5, and B20, as well as cold flow additives will be evaluated.

Two phases are proposed. Phase 1 consists of laboratory bench testing. Weekend cool down and warm up cycles will be simulated. Significant impact on vehicle operations will be estimated by standard tests such as cloud point and CFPP. Operating range of -10°C to -35°C will be considered.

Trace biodiesel components will be analyzed to evaluate their effect on vehicle operation at low temperature.

Phase 2 consists of duplicating the laboratory experience in LDD vehicles. The group may discuss and choose to include some HD vehicles, if the EMA members or other parties supplement CRC funding. Low temperature operability limits will be evaluated for various fuel/vehicle combinations and for overnight and weekend shut down cycles.

Work on Phase 1 has initiated by Infineum and NREL at no cost to CRC. Phase 2, however, has to wait for CRC funds to become available. It is assumed that Phase 1 alone can generate useful information in the absence of Phase 2, so commencing Phase 1 is not contingent upon funding assurance for Phase 2.

Cetane Number Program

The initial objective of this panel was to determine the limit of acceptable operation of North American light-duty 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 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 North American light-duty diesel vehicles at low temperature was the original deliverable for this project.

PERFORMANCE

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:

- Two US LDD vehicles
- Three fuels:
  - -20°F cloud point with a 40 cetane number
  - Above fuel additized with cetane number improve to reach a 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

Jacobs Engineering in Detroit has a cold chassis dynamometer capable of reaching -40°F. It also has cold soak facilities.

This program is awaiting CRC funding to commence the scoping study.

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. Sub panels are as follows:

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

PERFORMANCE

The Data Analysis panel solicits and compiles data related to test methods and engine testing. A user survey was drafted and sent to the CRC and the EMA members. The survey requested the following:

- Injector failure date and location
- Vehicle information
- Poor performance / OBD code
- Cold after long shutdown / Hot engine
- What was replaced
- Application and service type
- Fuel; additive, biodiesel, …
- Fuel; mixed source or single supplier
- Any analysis performed on failed injector
- Willing to provide failed injectors

The Bench/Rig/Engine Investigation sub panel's Phase 1 is a limited scoping and 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.

Caterpillar and Innospec have volunteered to evaluate several fuels in their in-house test rigs. These rigs provide indirect measure of the sticking tendency of the fuel but require less fuel than actual engines would.

Seven fuels had been selected to cover a range of applications and deposit forming tendencies.
To keep the initial scoping program simple, factors such as impurities, additives, and biodiesel are not included. If we conclude that one or both of these rigs have the ability to differentiate deposit forming vs. not deposit forming fuels, a larger program to include more factors can be designed.

The Engine Investigation sub panel is investigating options to develop an industry-standard engine test to evaluate fuels and additives for their tendency to cause internal injector deposits and capabilities to prevent such deposits.

Initial thoughts for a possible engine test have been proposed. PSA DW10 that is used widely in industry for injector nozzle tip coking was proposed if a different cycle is used.

PERFORMANCE

Fuel Cleanliness

This panel continues to monitor field issues related to fuel cleanliness in general as well as updates on recent ASTM activities.

Diesel cleanliness has become a more important issue for newer injection equipment. The sub panel has been populated formally and is in the process of defining projects.

One example is metal carboxylates deposits on filters in vehicles and in dispensing units. This is related to the work of the Deposit Panel and a potential cause for injector sticking as well.

Fuel storage tank equipment corrosion and whether it is related to S15 diesel is another potential project.

PART THREE

RELEASED REPORTS

RELEASED REPORTS - 2011

AIR POLLUTION*

CRC Project No.	Title	NTIS Accession No.
AVFL-17a	Investigation of Biodiesel Chemistry, Carbon Footprint and Regional Fuel Quality	PB2011-113889
E-68a	Review of the 2009 Draft Motor Vehicle Emissions Simulator (MOVES) Model	PB2011-113886
E-77-2c	Study to Determine Evaporative Emission Breakdown, including Permeation Effects and Diurnal Emissions, Using E20 Fuels on Aging Enhanced Evaporative Emissions Certified Vehicles	PB2011-113888
E-88	Review of Transportation Fuel Life Cycle Analysis	PB2011-113887
E-90-2a	Evaluation of Inspection and Maintenance OBD II Data to Identify Vehicles That May Be Sensitive to E10+ Blends	PB2011-113885
E-95	Blender Pump Fuel Survey	PB2011-113884
A-69-1	Regional Modeling of Weekday/Weekend Ozone Changes in the Midwestern US	PB2011-110660
A-75	Evaluation of CAMx Results from AQMEII: Sensitivity Analysis and Comparison with Other Models	Pending
A-75-2	Modeling Europe with CAMx for Phase II of the AQMEII	Pending
E-70	Populations, Activity and Emissions of Diesel Nonroad Equipment in EPA Region 7	Pending
E-80	Exhaust and Evaporative Emissions Testing of Flexible-Fuel Vehicles	Pending
E-100a	Remote Sensing Measurements for the E-100 Longitudinal Emission Pilot Study	Pending
AVFL-14	Collaborative Lubricating Oil Study on Emissions	Pending

RELEASED REPORTS - 2011

AVIATION & PERFORMANCE*

CRC Project No.	Title	NTIS Accession No.
AV-09-09	Initial Development of an Advanced Test Method for Jet Fuel Identification and Characterization, Phase 1	PB2011-108195
AV-11-09	Develop an Aviation Fuel Cold Flowability Test to Replace Freezing Point Measurement	PB2011-108194
CM-138-09-1	2010 CRC Altitude Hot-Fuel-Handling Program (CRC 659)	PB2011-108193
CM-138-09-2	2009-2010 CRC/ASTM Hot-Fuel Handling Program (For Classes D-4 and E-5 Gasoline) (CRC 658)	PB2011-103322
CRC Report No. 657	Investigation of Reduced Tel Content in Commercial 100LL AVGAS	PB2011-110653
CRC Report No. 660	Fuel Antiknock Quality – Engine Response to RON versus MON - Scoping Tests	PB2011-111870

*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

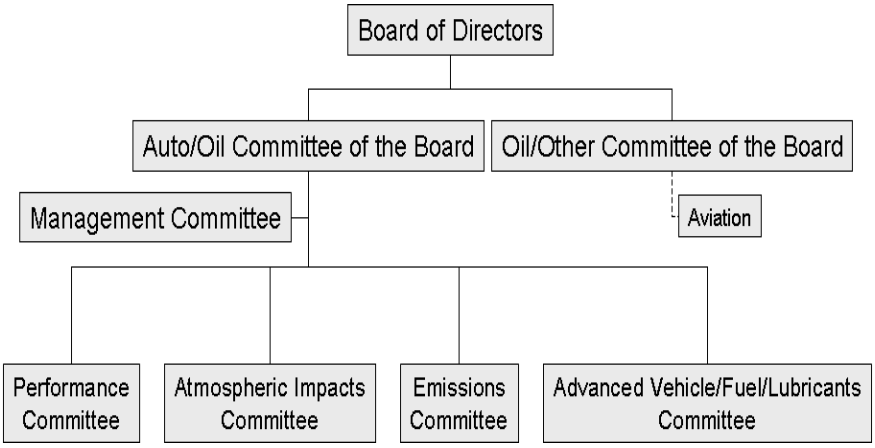
ORGANIZATION AND MEMBERSHIP

ORGANIZATION - 2011

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 69 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 published and made publicly available.

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 published and made publicly available.

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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(Project No. CM-136)

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(Project No. CM-137)

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(Project No. CM-138)

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D. H. Lax	API
R. P. Lewis	Marathon Petroleum Co.
E. A. Lodrigueza	ConocoPhillips
K. Mitchell	Shell Canada Ltd.
K. Moore	Renewable Fuels
R. Osman	Flint Hills Resources
W. J. Piel	Lyondell Chemical Co.
J. Porco	Gage Products
C. M. Pyburn	Pybertech Intl.
R. Reynolds	Downstream Alternatives
C. Richardson	Ford Motor Co.
D. Schoppe	Intertek
A. Schuettenberg	ConocoPhillips
M. Valentine	Toyota Technical Ctr.
L. Webster	Nissan Tech. Ctr. NA
J. P. Wick	Marathon Petroleum Co.

MEMBERSHIP

DIESEL PERFORMANCE GROUP

(Project No. DP)

M. Nikanjam, Ldr. Chevron

D. Altermatt	Chrysler	R. Leisenring	Sunoco Inc.
D. Arters	Lubrizol	R. P. Lewis	Marathon Petroleum Co.
J. Axelrod	ExxonMobil	T. Livingston	Robert Bosch
D. Berman	ChevronPhillips	H. Martin	Fleetguard/Cummins
P. Biggerstaff	Baker Petrolite	R.L. McCormick	NREL
J. E. Carter	Haltermann Products	A. A. Millard	Infineum USA
A. Cayabyab	CARB	R. Mills	Chevron
R. Chapman	Innospec Fuel Spec.	K. Mitchell	Shell Canada
D. A. Daniels	Innospec Fuel Spec.	M. Natarajan	Marathon Petroleum Co.
D. R. Forester	Power Service Products	R. Osman	Flint Hills Resources
M. Foster	BP	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	ConocoPhillips	W. Studzinski	General Motors
C. Hamer	PCS Instruments	J. T. Talbert	Shell Global Solutions
E. Izor	Denso	R. D. Tharby	Tharby & Associates
J. J. Jetter	Honda R&D Am.	M. Valentine	Toyota Technical Ctr.
S. R. Kirby	Navistar, Inc.	G. Webster	AET
A. Kulinowski	Afton Chemical	L. Webster	Nissan Tech. Ctr. NA
P. Lacey	Delphi Diesel Sys.	S. A. Westbrook	SwRI
D. H. Lax	API	P. Yon-Hin	Nalco Co.

DP - LOW TEMPERATURE OPERABILITY PANEL

(Project No. DP-02)

J. Chandler, Ldr. Infineum

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

DP - BIODIESEL PANEL

(Project No. DP-02a)

R. McCormick, Ldr. NREL

D. Arters	Lubrizol	S. Howell	National Biodiesel Board
R. Baranescu	Int'l. Truck & Eng.	J. J. Jetter	Honda R&D Am.
A. Buczynsky	GM Powertrain	T. Livingston	Robert Bosch
J. Chandler	Infineum	R. Mills	Chevron
D. R. Forester	Power Service Prods.	K. Mitchell	Shell Canada Products
R. Gault	EMA	H. K. Nanjundaswamy	FEV
P. Henderson	GM Powertrain	M. Nikanjam	Chevron Products Co.

DP - CETANE NUMBER PANEL

(Project No. DP-3)

A. M. Kulinowski, Ldr. Afton Chemical

J. Axelrod	ExxonMobil	J. J. Jetter	Honda R&D Am.
A. Buczynsky	GM Powertrain	S. Johnson	Volkswagen of America
F. J. Cornforth	ConocoPhillips	T. Livingston	Robert Bosch
D. R. Forester	Power Service Prods.	K. Mitchell	Shell Canada
M. Foster	BP	M. Nikanjam	Chevron Products Co.
K. Freund	Volkswagen of America	J. T. Talbert	Shell Global Solutions

MEMBERSHIP

DP - DEPOSIT PANEL

(Project No. DP-4)

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

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