COORDINATING RESEARCH COUNCIL ANNUAL REPORT

September 2015

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PART ONE

STATE OF THE COUNCIL

STATE OF THE COUNCIL - 2015

The Coordinating Research Council (CRC) continues to maintain its original institutional scope and objectives established in 1942. These objectives are similar to those initially developed by the Cooperative Fuel Research Committee circa 1919. Following this long historical pattern, CRC provides the means for the automotive and energy industries to work together on joint research of mutual interest. CRC also encourages cooperative research with government and other stakeholders to address mobility and environmental issues of general interest. As a technical organization, CRC focuses on the fuel/hardware interface to maximize performance of transportation fuels and the equipment in which they operate.

CRC's scope covers fuel composition and quality of existing commercial fuels and fuels anticipated for future use. Research is conducted both in the laboratory and in the field to provide more realistic characterization of conditions and performance. Research goals include gathering data to understand fuel/hardware performance with respect to consumer satisfaction while at the same time meeting environmental requirements. Understanding larger scale impacts of changes in fuel and hardware and the performance of other vehicle fluids such as engine lubricants are also included in the scope of CRC operations.

The CRC technical programs in 2015 have again enjoyed broad cooperation from many research partners on projects and on other important collaborative activities such as technical workshops where current research results and other issues are discussed. This cooperation results in a high resolution focus and improved perspective on the important issues. Collaboration also leverages both technical expertise and financial support to meet common research goals under conditions of limited resources. Partnerships in 2015 have included: the California Air Resources Board (CARB), the Health Effects Institute (HEI), the National Biodiesel Board (NBB), the South Coast Air Quality Management District (SCAQMD), the Truck and Engine Manufacturers Association (EMA), the U.S. Department of Agriculture (USDA), the U.S. Department of Energy (DOE) and many of its national laboratories, the U.S. Environmental Protection Agency (EPA), and many others. CRC has also continued coordination efforts among research organizations worldwide, with European (Coordinating European

Council (CEC), and the Joint Research Centre, JRC) and Canadian collaborations (Natural Resources Canada, NRC) emphasized this year.

CRC technical reports are approved by the committees and research partners that oversee the research. Major accomplishments include the publication of research in Final Reports available on the CRC website, www.crcao.org. Some research projects conducted by CRC are also reported in the peer-reviewed literature and the technical committees have further emphasized this avenue for sharing results. CRC research programs are aimed at determining the impacts of changing fuel composition on vehicle performance in the current fleet. This research is intended to benefit associated industries, the government, and the consumer. The technical committees have enjoyed another productive year as evidenced by the number of important studies that have been completed and reported in the open literature.

The CRC Emissions Committee has continued its important studies of the effects of fuel quality on vehicle emissions. The second phase of engine testing in the "Advanced Collaborative Emissions Study" (ACES) was documented in the *Journal of Air and Waste Management* this year presenting a final summary of the research CRC conducted in collaboration with the Health Effects Institute (HEI). The Emissions Committee published results from two surveys conducted on the quality of commercially available fuel -- Project E-85-3 reported on the quality of ethanol flex fuel and Project E-112 reported results from a survey of biodiesel quality and composition. Project E-109 examined the impacts of vehicle performance as a function of natural gas composition as defined in an earlier survey of automotive natural gas refueling stations (PC-2-12). Projects E-94, E-96, and E-99 continued examinations of extremely low-level aerosol and particulate matter (PM) emissions with a goal of characterizing true emission rates and assessing downstream chemical and physical changes as a function of vehicle type. A literature survey of the impacts of organometallic gasoline additives was also conducted by the Emissions Committee and reported under Project E-114.

The Advanced Vehicle/Fuel/Lubricants (AVFL) Committee made significant progress in developing diesel fuel surrogates formulations under Project AVFL-18a by blending four advanced surrogate formulations and beginning engine combustion studies and combustion modeling. The Final Report on results from a study on "Biodiesel and Renewable Diesel Characterization and Testing in Modern LD Diesel Passenger Cars and Trucks" (AVFL-17b) was completed by the committee. The Final Report documented results from 8 light-duty diesel vehicles to meet the project goal of filling an existing gap in the literature. Additional vehicle testing and evaluation of diesel and biodiesel oxidation stability as a function of onboard storage and use conditions is being conducted under AVFL-17c. Significant progress was also made on project AVFL-20, "Gasoline-Ethanol Interactions & Effects on Engine Efficiency," with all Stage 1, 2, and 3 test fuel evaluations completed on an advanced SIDI engine test platform. The same fuels will also be tested under Project AVFL-20a in a more conventional PFI engine. A next generation engine configuration will be tested under Project AVFL-26, "Gasoline Fuel Properties Impacts on Future Engine Design." Projects AVFL-20, -20a, and -26 are being performed in cooperation with the U.S. Department of Energy at Oak Ridge National Laboratory (ORNL).

The AVFL's Fuels for Advanced Combustion Engines (FACE) Working Group continued its broad collaborations with industry and government fuel experts this year. The FACE Working Group plays a leading role in Project AVFL-23 designed to mine the data generated from extensive engine testing of the FACE diesel fuels and in Project AVFL-18a where diesel fuel surrogates are being blended and evaluated. The AVFL's Lubricants Advisory Panel has been productively engaged in 2015 preparing project plans for evaluating lubricant performance and impacts with advanced fuel and vehicle systems.

The Diesel Performance Group of the Performance Committee has remained very active this year with special focus meetings held by their Cetane, Corrosion, Cleanliness, Low-Temperature Operability, Diesel Deposit, and Biodiesel Panels to facilitate communications and foster progress on their respective research efforts. The Cleanliness Panel was responsible for producing CRC Report No. 667, "Diesel Fuel Storage and Handling Guide," now available on the CRC website and used by many interested parties including ASTM. Testing was completed under Project DP-05-12, "Effect of Wax Settling and Biodiesel Impurities on Light-Duty Diesel Performance." The Diesel Performance Group is also making further progress in other important areas by continuing their evaluation of field problems observed in modern diesel fuel under project DP-04, "Internal Diesel Injectors Deposits," and under Project DP-07, "ULSD Corrosion Study."

The Octane Group of the Performance Committee continued evaluations of performance contributions from motor octane number (MON) and research octane number (RON) on current light-duty engines and control systems. The Octane Group in collaboration with the Emissions Committee (E-108) published research on "Sub-Regular Grade (85 AKI) Octane Study." This study was conducted at Chrysler, Ford, and General Motors vehicle testing facilities using a standard set of test fuels designed to determine the effects of low octane gasoline used in some locations at low altitude.

The Volatility Group of the Performance Committee documented results of its field study under Project CM-138-13-1, "2014 CRC Hot-Fuel Handling (HFH) Vehicle Driveability Program." The Volatility Group's study CM-138-13-1, "Risk Analysis/Hazard Assessment of High Ethanol Content Fuels at the Service Station," was completed with the Final Report posted on the CRC website. This study estimated the incremental change in risk due to changes in fuel composition (at higher levels of ethanol). This project was conducted in cooperation with the U. S. Department of Energy through the National Renewable Energy Laboratory.

The Atmospheric Impacts Committee expanded its ongoing efforts to examine future air quality scenarios through development of improved data and through the use of photochemical air quality grid models. Air quality grid models evaluate not only gaseous pollutant transport and reactions, but also directly emitted primary organic aerosols (PM or POA) and secondary aerosols (SOA) which are formed in the atmosphere. The committee supported Phase 2 of the Air Quality Modeling Evaluation International Initiative (AQMEII) in cooperation with EPA and the Joint Research Centre (JRC) of Europe this year. CRC contributed funding under Project A-87 where coupled air quality and meteorology modeling evaluations of the European and North American domains were analyzed with guidance from the EPA/JRC program leaders.

The Atmospheric Impacts Committee completed the final aerosol grid modeling and inventory comparisons (Phase 4) of CRC Project A-74 conducted in collaboration with the Emissions Committee (Project E-96). The draft final report is now under review by the committee and other sponsors (CARB and EPA). The Atmospheric Impacts Committee continues its progress on reporting the effects of trends in fleet vehicle emissions and resulting impacts on ambient air quality along with studies of chemical mechanisms and demonstrations of new modeling techniques. A singular major accomplishment in 2015 was the publication by Oxford University Press of the book manuscript developed under Project A-78, *The Mechanisms of Reactions Influencing*

Atmospheric Ozone. The committee has also been very productive in other publications including Final Reports for Projects A-85, A-86, A-87-2, A-89, A-91, and A-92. Journal publications by the Atmospheric Impacts Committee this year include: Project A-76-3, “Emission Source Apportionment for Ozone and Particulate Matter in 2030,” (submitted to *JAWMA*); Project A-87, “A Comparison Between 2010 and 2006 Air Quality and Meteorological Conditions, and Emissions and Boundary Conditions Used in Simulations of the AQMEII-2 North American Domain,” (*AE*); Project A-89, “Incremental Ozone Apportionment (*AE*); and Project A-90, “Apportionment of Ozone,” (*ES&T*). A manuscript for Project A-91 has also been submitted to the *Journal of Air and Waste Management Association* and is anticipated to be published in the coming year. Projects A-89 and A-90 have resulted in exciting new advancements in understanding and defining ozone apportionment. For details on the committee’s new publications (18 total), see Part Three, Released Reports.

Special awards were presented to two members of the Atmospheric Impacts Committee by the CRC Board of Directors this year. Dr. Timothy Wallington, representing Ford, was recognized on the occasion of his co-authorship of the fifth book published by Oxford University Press documenting comprehensive information on atmospheric chemistry of mobile source related reactions (see Project No. A-78). Mr. Rory MacArthur was also recognized by the Board and the Committee for his leadership in directing atmospheric chemistry and modeling research during ten years of service as co-chair of the Committee.

The 25th CRC Real World Emissions Workshop was held in Long Beach, CA on March 22-25 with sponsorship from the California Air Resources Board (CARB), South Coast Air Quality Management District (SCAQMD), the National Renewable Energy Laboratory (NREL), and the US Environmental Protection Agency (EPA). A summary article presenting technical highlights from the workshop was prepared for publication in *EM* (Environmental Manager) a magazine of the Air and Waste Management Association.

The Atmospheric Impacts Committee held its seventh Mobile Source Air Toxics (MSAT) Workshop on February 17-19, 2015. The presentations reviewed the current state-of-knowledge regarding MSAT emission measurements, exposure, air quality and modeling, as well as the effectiveness of regulatory control measures. The MSAT Workshop was co-sponsored by CARB, HEI, EPA, SCAQMD, and Toyota. A summary article of the 2015 MSAT workshop was also published in *EM* Magazine.

Details on these and other CRC projects appear in Part Two of this Annual Report. Final Reports issued since the last CRC Annual Report are listed in Part Three. Organization and Memberships are presented in Part Four.

PART TWO

DETAILED REPORTS OF CRC PROJECTS

ACES, ACES-1, ACES-1A ADVANCED COLLABORATIVE EMISSIONS STUDY

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

Leader: C. J. Tennant

Scope and Objective

The Advanced Collaborative Emissions Study (ACES) was 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.

The ACES program was 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 new technology heavy-duty diesel engines and emissions controls.

Funding for ACES was 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 Truck and Engine Manufacturers Association (EMA), and a group of manufacturers of emissions control equipment.

The ACES program was divided into three phases:

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

• Phase 2 was analogous to Phase 1, but was performed on 2010 HHDD engine technology. Additional measurements were made to account for potential compounds from the NOx aftertreatment technology, urea selective catalytic reduction systems (UREA-SCR).

• In Phase 3, the selected 2007 engine was installed in a specially designed emissions generation and animal exposure facility; it was used in a chronic inhalation study (using rats and mice) with health measurements. HEI was the leader for this phase, which was performed by the Lovelace Respiratory Research Institute (LRRI).

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

Three manufacturers (Cummins, Detroit Diesel, and Volvo) supplied de-greened new 2010 engines for Phase 2 testing, using a common lubricant supplied by Lubrizol.

Southwest Research Institute (SwRI) and Desert Research Institute (DRI) performed both Phases 1 and 2.

Current Status and Future Program

The final reports for the ACES-1 and ACES-1a cycle development projects, the Phase 1 final report, and the Phase 2 final report have been released and are available on the CRC website. An article on the Phase 1 engine emissions test program was published in the Journal of Air and Waste Management in April 2011. HEI presented the final Phase 3 results at their annual meeting in May 2014, and the Phase 3 report was released by HEI at the beginning of 2015. An article authored by SwRI describing the results of Phase 2 was published by the Journal of Air and Waste Management in June 2015.

CRC/NREL NATIONWIDE SURVEY OF FUEL DISPENSED FROM FLEX FUEL SERVICE STATION PUMPS

CRC Project No. E-85-3

Leaders: T. Alleman
J. Y. Sigelko
K. D. Rose

Scope and Objective

The Coordinating Research Council (CRC) and the National Renewable Energy Laboratory (NREL) have undertaken market surveys of Ethanol Flex Fuel quality in the United States. This study is the third effort in recent years and the first survey since major modifications were made to ASTM Specification D5798 in 2011. These changes added a fourth class and reduced the minimum ethanol content to 51 vol% for all classes. The changes were made in an effort to provide more flexibility to blenders and to increase compliance with the specification. The methodology of this market survey was the collection of fuels from public flex fuel pumps that dispense ethanol/gasoline blends for use in flexible fuel vehicles. Ninety-one samples were collected and tested by ASTM test methods for vapor pressure, ethanol content, and water content and the results were compared to the appropriate class from Specification D5798-13a, the applicable standard when the samples were collected.

With support from NREL, the DOE Alternative Fuels Data Center was used to identify and confirm locations of flex fuel pumps throughout the United States. Locations were selected to cover the broadest geographic range possible, though flex fuel pumps are still located predominantly in the Midwestern US.

Vapor pressure, water content, and ethanol content results were compared to the requirements in ASTM Specification D5798-13a to determine if they met the specification for the appropriate class. Four samples collected from California were compared to the requirements in Title 13 of the California Code of Regulations (CCR), § 2292.4.

Current Status and Future Program

The final report was released by NREL in July 2015. A link to the report has been posted to the CRC website.

EMISSIONS

LCA WORKSHOPS

CRC Project No. E-93-4

Leader: J. Farenback-Brateman

Scope and Objective

CRC has hosted three invitation-only Life Cycle Analysis (LCA) workshops, starting in 2009. The 2009, 2011, and 2013 workshops held in October at Argonne National Laboratory near Chicago were each attended by more than 100 LCA experts from government, industry, academia, and NGOs. Workshop summaries are posted on the CRC website.

The 2015 workshop goals are to:

- Outline technical needs arising out of policy actions and ability of LCA analysis to meet those needs.
- Identify research results and activities that have come to light in the past two years that have helped to close data gaps previously outlined as outstanding issues.
- Identify data gaps, areas of uncertainties, validation/verification, model transparency, and data quality issues.
- Establish priorities for directed research to narrow knowledge gaps and gather experts' opinions on where scarce research dollars would best be spent.

The workshop organizing committee throughout the years has included representatives from API, CARB, Conservation of Clean Air and Water in Europe (CONCAWE), U.S. DOE, Environmental Defense Fund (EDF), U.S. EPA, National Biodiesel Board (NBB), Natural Resources Canada, U.S. Department of Agriculture (USDA), Ford Motor Company, Chevron Global Downstream, Renewable Fuels Association (RFA), Marathon Petroleum Company LP, ExxonMobil Research & Engineering, Argonne National Laboratory, the South Coast Air Quality Management District (SCAQMD), the University of Michigan, the University of Toronto, the European Joint Research Center's Institute for Environment and Sustainability, and the Union of Concerned Scientists.

Current Status and Future Program

The 2015 LCA workshop will be held on October 26-28, 2015 at the Argonne National Laboratory near Chicago. Preparations by the organizing committee are underway.

EMISSIONS

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

CRC Project No. E-94-1 / E-94-1a / E-94-2

Leaders: M. B. Viola
S. A. Mason

Scope and Objective

In the E-94-1 pilot study, vehicles with spark ignition direct injection (SIDI) engines were purchased and operated on fuels containing a range of ethanol concentrations (E0 to E20 or higher). Key objectives were to:

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

Three vehicles equipped with SIDI engines were used for the pilot phase of the program: one vehicle had a naturally-aspirated 4-cylinder engine, one had a turbo-charged 4-cylinder engine, and one had a naturally-aspirated V6 engine.

Two different base test fuels, procured directly from fuel terminals, were selected to maximize the difference in the particulate matter index (PMI). Ethanol was splash-blended with the base fuels to produce E10 and E20 blends. Each fuel was analyzed for RON, MON, sulfur, olefins, aromatics, oxygen, benzene, hydrogen, RVP, ethanol, and boiling point distribution.

Using the LA92 test cycle, all tailpipe gaseous emissions were collected along with particulate matter (PM) and real-time particle number (PN) emissions. Fuel economy and Greenhouse Gas (GHG) emissions (CO_2, N_2O, and methane) were also collected. PM/PN characterization included:

A. PN: solid particles >23 nanometers in size.

B. PM: standard filter method using the EPA 1065 protocol.

C. Real-time black carbon or soot (mass-based): AVL Micro Soot Sensor.

D. PM/PN size distribution: Engine Exhaust Particle Sizer (EEPS).

E. Soot morphology using organic carbon / elemental carbon (OC/EC); also amount of sulfur contained in particulate.

Current Status and Future Programs

Southwest Research Institute® (SwRI) performed the E-94-1 pilot study; the final report is available on the CRC web site.

A follow-on study, E-94-1a, “Determination and Evaluation of New Prep Cycle on the Fuel Effects of Gaseous and Particulate Emissions on SIDI In-Use Vehicles,” was performed by SwRI. This study used the same vehicles as the pilot study, with similar fuels to evaluate the benefits of a more extensive vehicle preparatory (prep) procedure for stabilizing the emissions measurements after a fuel change. The final report is available on the CRC web site.

The main study, E-94-2 “Fuel Effects on Gaseous and Particulate Emissions on SIDI In-use Vehicles,” has expanded the SIDI fleet to 12 vehicles, using a matrix of eight specially-blended fuels to better understand the impact of varying fuel parameters on a range of SIDI engine technologies. This project incorporates the improved procedures validated in the E-94-1a study. SwRI is again performing the testing and Gage Products provided the fuel. The testing is in progress. The final report is expected in Q1 2016.

EMISSIONS

LINKING TAILPIPE AND AMBIENT PM

CRC Project No. E-96 (see also A-74)

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 the subsequent formation of secondary organic aerosols (SOA) and other compounds formed in the atmosphere via dilution and chemical reactions. The main project goal is to obtain sufficient definition of the relationship between SVOC and SOA to model the behavior in the atmosphere. This project is a joint effort by CRC's Real World Group (E-96) and the Atmospheric Impacts Committee (A-74).

Current Status and Future Program

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

Phase 3 had two objectives. The first was to revisit light-duty vehicle emissions and address questions that arose in the analysis of Phase 1 data. The second was to examine non-road engine emissions. Phase 3 testing was completed in early 2012.

Summary results from Phase 1 were presented at the 21st Real World Emissions Workshop in March 2011, and follow-on presentations were given at the 22nd and 23rd Workshops. Seven journal articles were published covering the research in the first three phases of this project. In addition to the journal articles, CRC has published an executive summary report on the CRC web site which refers to the journal articles.

EMISSIONS

Phase 4 which is in progress will examine PM emissions data and SOA information in connection with the CALNEX inventory, comparing these data against transport modeling (air quality grid modeling) results. The CRC Atmospheric Impacts Committee is taking the lead on the Phase 4 effort.

EMISSIONS

VERY LOW PM MASS MEASUREMENT

CRC Project No. E-99

Leaders: M. M. Maricq
H. Maldonado

Scope and Objective

The objective of this project is to examine possible changes to gravimetric PM filter measurements that would preserve the integrity of the method but reduce the variability and gaseous adsorption artifacts that limit the usability of this method at LEV III / Tier 3 emissions standards.

Current motor vehicle PM emissions measurement regulations (CFR 40 part 1065, 1066) require gravimetric determination of PM collected on filter media from diluted exhaust. However, the current gravimetric method is a challenge at the proposed 3 mg/mile PM emissions standard and is likely to reach its useful limit at the future 1 mg/mile emissions standard. The combined effects of the more stringent PM standard and CFR minimum dilution requirements have reduced typical filter loadings to about 20 µg at a tunnel flow of 350 CFM and a PM emissions rating of 1 mg/mile. At the same time, a number of studies show that filters, including Teflon™ membrane, are susceptible to gaseous adsorption artifacts that can contribute as much as a 3 – 7 µg weight gain, with outliers exceeding 10 µg, even when the procedure is run without a test vehicle (i.e., tunnel and trip blanks). This artifact itself can have a high variability (~100%) and can be different from one facility to another. The impacts on vehicle emissions testing are increased measurement uncertainty and cost.

Current Status and Future Program

This project was structured into the following tasks:

Task 1: Identify potential method modifications that will reduce variability of gravimetric PM test results.

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

Task 3: Perform testing according to test plan. Provide EC/OC data on the filtered PM emissions. Change plan as necessary to ensure a sufficient number of tests and repeatability. Provide a statistical assessment. Identify and quantify any ancillary impacts of the method modifications.

Task 4: Analyze data set and produce final report.

This project, co-sponsored by CARB, was awarded to the University of California at Riverside CE-CERT. After the project started in 2013, a process was initiated to broadly poll other laboratories measuring low PM levels to compare methods and aid in the final design of the experiments to be performed in this project. Experimental work has been completed and the final report has been reviewed. The final report was released on the CRC website in August 2015.

EMISSIONS

VERY LOW PM MASS MEASUREMENT PHASE 2: EVALUATION OF PARTIAL FLOW DILUTION

CRC Project No. E-99-2

Leaders: M. M. Maricq
H. Maldonado

Scope and Objective

The objective of E-99-2 is to compare commercially available partial flow diluters (PFDs), both unit-to-unit and against a full-flow constant volume sampling (CVS) tunnel, particularly for their ability to provide reproducible measurements at very low PM emission levels. This research focuses on evaluating the capabilities of commercial PFDs to meet LEV III / Tier 3 PM emission measurement requirements. The project is designed to address a number of issues for the application of PFDs for LDV exhaust emissions testing, including:

- exploring if PFDs can show equivalency to full flow (CVS) exhaust sampling,
- identifying the sources of error for PFD versus CVS sampling,
- defining what is needed to "condition" these sampling systems (PFD / CVS tunnel),
- establishing the sensitivity of the PFD performance for exhaust flow measurements,
- understanding the relative performance attributes and issues for individual PFD units,
- making recommendations for improvements to provide more efficient and accurate partial flow system performance in light-duty chassis dynamometer testing at Tier 3 PM standards, and
- developing a simple model that can predict the optimum exhaust extraction ratio based on readily available vehicle parameters, such as test cycle, engine displacement, and vehicle weight.

This project is structured into the following tasks:

1. Identify what testing is needed to answer the objectives of this project.
2. Prepare and submit the project test plan for CRC committee review and approval. The matrix will include test method,

vehicles, driving cycles, and fuels and will include a verification of the accuracies of the exhaust flow meters.

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

Current Status and Future Program

After a competitive solicitation, this project was awarded to the University of California at Riverside CE-CERT. The final report is anticipated to be released in the fall of 2016.

EMISSIONS

2014 MOVES REVIEW

CRC Project No. E-101

Leaders: D. M. DiCicco
D. H. Lax

Scope and Objective

The Real World Group is conducting an evaluation of the MOVES model (MOVES2014) that was released to the general public in mid-2014. MOVES is the EPA's MOtor Vehicle Emission Simulator (MOVES) that estimates emissions for mobile sources covering a broad range of pollutants.

Tasks included in this assessment include:

- Task 0: Scoping Assessment
- Task 1: Review and critically evaluate the methodologies and data used in MOVES2014 to estimate exhaust and evaporative emissions, particularly those related to fuel effects
- Task 2: Exercise the MOVES2014 Model
- Task 3: Provide recommendations

Current Status and Future Program

This project was awarded to Sierra Research. MOVES2014 was released at the end of July 2014, which allowed the assessment to begin mid-year. The project work plan and scope was revised in early 2015. The project analysis is nearly complete; several items of potential concern with the MOVE2014 model have been communicated to EPA, which is supporting the effort through their participation on the project panel. The final report is expected to be released in fall 2015.

ON-ROAD EMISSIONS MEASUREMENT VIA RSD

CRC Project No. E-106

Leaders: D. M. DiCicco
S. A. Mason

Scope and Objective

This project is being performed by the University of Denver (DU), following the general methodology of the previous E-23 project that used remote sensing devices (RSD) to measure the emissions of in-use vehicle fleets. The researchers are making measurements at specific roadway locations in Chicago and Tulsa on an alternating two-year schedule. Measurement campaigns are being conducted for one five-day week each year from 2013 to 2016. The previous E-23 Tulsa site will be retested in the early fall of 2015, while the Chicago site will be retested in the early fall of 2016. The equipment will be the same as was used in E-23, but with new capabilities to monitor ammonia, sulfur dioxide, and nitrogen dioxide in real time from each vehicle driving through the test location. This project is expected to provide between 80,000 and 100,000 vehicle emissions readings.

Current Status and Future Program

Testing commenced in 2013 for this project. Reports for a given city will be published each year with a final comprehensive report on all cities in the program at the end of the 4-year effort. The final report for the 2013 testing in Tulsa, OK was released in August 2014, and the final report for the 2014 testing in Chicago, IL was released in July 2015. Denver University is preparing to return to Tulsa for more testing in September 2015. CARB is separately funding similar measurements in California. CRC and CARB have agreed to share results with each other.

EMISSIONS

SUB-REGULAR GRADE (85 AKI) OCTANE STUDY

CRC Project No. E-108

Leaders: W. Studzinski
D. M. DiCicco

Scope and Objective

This study evaluated vehicle performance and emissions effects of an 85 AKI gasoline relative to an 87 AKI gasoline at two altitudes. AKI or Anti-Knock Index is the average of Research and Motor Octane (RON and MON). This project was conducted in coordination with the Octane Group of the Performance Committee.

- Test Locations:
  - Variable Altitude Chassis Dyno Emissions Chambers (Chrysler, Ford , and GM)
  - Two simulated altitudes: Low = 1,000 ft and High = 5,000 ft
- Measurements for evaluation:
  - Fuel economy
  - Emissions (CO_2, CO, NO_x, THC, NMOG)
  - Pre-catalyst inlet temperature
  - Spark retard/frequency of knock
  - Stoichiometry (relative air/fuel ratio)
- Test Vehicles
  - 10 various combinations of engine architectures, load factors, model years, manufacturers, and passenger cars and trucks.
- Test Fuels:
  - Matched E10 blends of 85 and 87 AKI fuel pairs
  - Equivalent properties including heating value, composition, (aromatics, olefins and sulfur), RVP, distillation (T50 and T90) and H/C ratio
- Test cycles:
  - 1×USFTP (cold) + 1×LA92 (hot) + 1×US06 (hot)
  - Half the tests were performed in an A-B-A format (85-87-85)
  - Half the tests were performed in a B-A-B format (87-85-87)

EMISSIONS

Current Status and Future Program

Testing for this project was conducted in the laboratories of GM, Ford, and Chrysler. Results from this study provided relevant data to ASTM and NCWM discussions regarding minimum AKI values in different US geographical regions. The Final Report was released in March 2015.

EMISSIONS

EFFECT OF FUEL COMPOSITION ON THE EMISSIONS AND PERFORMANCE OF MODERN, LIGHT-DUTY NATURAL GAS VEHICLES

CRC Project No. E-109

Leader: J. J. Jetter
K. D. Rose

Scope and Objective

The objective of this program was to gain an understanding of natural gas fuel quality effects upon modern light-duty natural gas vehicles (NGVs) which utilize "closed loop" engine control. Primary areas of interest:

- Tailpipe emissions
- Fuel economy
- Engine knock
- Basic driveability (startability, acceleration, etc.)

This project consisted of operating instrumented NGVs on a dynamometer over various driving cycles. Basic driveability performance was assessed during these dynamometer cycles, although this test configuration was designed primarily for emission evaluation.

NGVs currently marketed in the U.S. fall into two categories: dual-fuel and dedicated. Dual-fuel vehicles include a gasoline tank and can switch between NG and gasoline fuels, while dedicated vehicles are optimized for NG operation only. Two dedicated vehicles and one dual-fuel vehicle were selected for testing.

The results from the CRC Performance Committee Project PC-2-12, which surveyed the properties of market NG in different regions of the US, were used to design and blend the NG test fuels evaluated in this project.

Current Status and Future Program

This project was awarded to SGS after a competitive solicitation. The final report was released in May 2015.

E-110 REAL WORLD VEHICLE EMISSIONS WORKSHOP

CRC Project No. E-110

Leaders: D. M. DiCicco
S.A. Mason

Scope and Objective

For more than two decades, the Coordinating Research Council (CRC) has held an annual vehicle emissions workshop, gathering international experts in the field of vehicle/engine emissions to discuss the latest activities in modeling, measurement, and analysis. The 25th Real World Emissions Workshop, held March 22-25, 2015 in Long Beach, CA, consisted of 88 presentations, posters, and demonstrations. Two keynote presentations were also made by Alberto Ayala, Deputy Executive Officer of the California Air Resources Board, and Reuben Sarkar, US DOE's Deputy Assistant Secretary for Transportation. An expert panel discussed major issues for real-world emissions and overviews of all other CRC Committee research were presented. Two hundred twenty-one participants from 14 countries attended the 25th Workshop. Co-sponsors for the Workshop were CARB, EPA, NREL/DOE, and SCAQMD.

Current Status and Future Program

A summary journal article on the research reported at the 24th workshop in 2014 was published in the *EM* Magazine of the Air and Waste Management Association in November 2014. The summary article for the 2015 Workshop will be published in the same magazine this fall.

The 26th Real World Emissions Workshop will be held in Newport Beach, CA from March 13-16, 2016. Agenda and registration information will be published on the CRC website.

EMISSIONS

E-112 BIODIESEL (>B6) FUEL SURVEY

CRC Project No. E-112

Leaders: J. Y Sigelko
R. George

Scope and Objective

The State of Illinois recently created some tax incentives for fuel stations that sell diesel fuels blended with more than 11% biodiesel. The labeling regulation for pumps selling these blends requires only that the label list a biodiesel range from B6 to B20. Because fuel blends up to B5 do not require a label, the actual biodiesel content of the fuel may be anywhere from B0 to B20, which could be confusing to consumers. The objective of this project was to evaluate the biodiesel content and other properties of diesel fuel being sold in Illinois and Minnesota at a given point in time. Specific sampling locations were selected to cover the broadest geographic range possible in the States of interest.

Current Status and Future Program

The final report was released in May 2015.

E-114 EFFECTS OF ORGANOMETALLIC ADDITIVES ON GASOLINE VEHICLES: ANALYSIS OF EXISTING LITERATURE

CRC Project No. E-114

Leader: J. J. Jetter
K. D. Rose

Scope and Objective

An ASTM/NCWM Joint Task Force has been formed to evaluate publicly available information on the effects of organometallic additives on gasoline vehicles. Members of this Task Force have been asked to submit publications, documents and information pertinent to this topic to a comprehensive database maintained by the NCWM. The material was organized only by date of submission and an approximate list of the collected material is as follows:

- 15 studies
- 9 SAE papers
- 2 compilations
- 20 other documents and papers

The Joint Task Force asked CRC to perform this project, in which the database documents will be organized and summarized. The report is expected to provide overall conclusions on the impacts of organometallic additives on modern vehicles. The objective is to provide an independent and objective accounting of the publications and other material contained in the NCWM database. Following an initial screening of the database, additional documents have been added if relevant information was found to be missing.

The expected output from this project is a report that will include the following components, at a minimum:

- An organized list of the information contained in the NCWM database, including author and affiliation, subject, relevance, etc.
- A short summary of the key findings / points in each document.

The report will be made available to the ASTM and NCWM Task Forces. It was published on the CRC website in summer 2015.

EMISSIONS

Current Status and Future Program

A summary presentation was given at the 25th Real World Emissions Workshop in March 2015. The revised draft final report has been reviewed by the Emissions Committee, with release anticipated in fall 2015.

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

CRC Project No. AVFL-17b

Leaders: G. C. Gunter
S. W. Jorgensen

Scope and Objective

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

Current Status and Future Program

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

Fuels: High quality B100 ASTM compliant biodiesel was procured and blended with commercially available federal ULSD. One CARB B20 blend was also prepared. The sources of biodiesel included soy and other feedstocks that span the range of degree of saturation common in the marketplace. A renewable diesel, also known as hydrogenated vegetable oil (HVO), and a hydro-processed animal fat were also prepared and tested. A CRC member laboratory performed fuel analyses to determine properties. The fuels matrix included 1) Federal ULSD baseline diesel, 2) four B20 fuels blended with the Federal ULSD fuel (including one renewable diesel blend), 3) CARB baseline diesel, and 4) one B20 fuel blended with the CARB fuel, for a total of seven test fuels.

Vehicles: In the U.S. market, LD diesel passenger cars were available from manufacturers including Audi, BMW, GM, Mercedes, and VW. In addition, Ford, GM, and Chrysler sold LD diesel trucks. The goal was to procure a variety of vehicle types representing each manufacturer for testing. The contractor performed break-in, preconditioning, and engine/exhaust system monitoring, using protocols reviewed and agreed upon by the project technical panel. Eight vehicles were scheduled for testing.

Emissions measured included: 1) regulated emissions: HC, CO, NOx, PM; 2) unregulated emissions, including carbonyls, PAH and nitro-PAH. Optional measurements were 1) PM number, 2) EC/OC, 3) NMHC, 4) fuel economy, 5) NH_3 for SCR systems, and 6) DPF regenerations emissions. Tests were done in duplicate allowing for repeats to meet statistical criteria set by the project panel.

All test fuels were acquired by CE-CERT. In Phase 1, three vehicles completed testing on all fuels, and one vehicle completed regeneration emissions testing on selected fuels. Testing on a second vehicle included regeneration emissions testing on Federal ULSD and Federal-SME20 fuels in Phase 1.

An engine exhaust particle sizer (EEPS) spectrometer and a Dekati mass monitor (DMM) were added to the suite of instruments used to characterize particles. The EEPS provides real-time particle size distributions during transient operation, while the DMM measures real-time second-by-second PM mass. These instruments were beyond the original scope of the original test program and were given secondary priority in terms of completing the test matrix. These instruments were used in conjunction with testing if they were available and fully running at the time for any given test. The results of the special instrumentation were provided to CRC at no additional cost.

An interim Phase 1 draft report on regulated emissions, particle number and sizing, carbonyl compounds, NH_3, and EC/OC from the first three vehicles was submitted for review. A complete Phase 1 report was also prepared which included a full data set for all three vehicles, including EC/OC fraction and PAH/nitro-PAH emission results from one of the test vehicles.

Testing of the five vehicles in Phase 2 was completed in the second quarter of 2014. The Final Report, which includes a detailed statistical analysis of emission trends, was reviewed by the Committee and released in February 2015. A summary presentation was given at the 2015 Real World Emissions Workshop.

IN-VEHICLE BIODIESEL OXIDATION STABILITY

CRC Project No. AVFL-17c

Leaders: W. Woebkenberg
G. C. Gunter

Scope and Objective

The overall objective of this project is to investigate the effects of biodiesel and other baseline petroleum fuels from oxidation and thermal instability that may occur during onboard fuel storage and in-use vehicle operation.

The goals of Phase 1 of the study are to examine the impacts of various challenges to stability (temperature, pressure, oxidation, free radical formation, acid formation, etc.) on biodiesel blends during onboard vehicle use and storage conditions to:

1. More accurately capture and identify the environmental conditions and chemical processes which drive thermal and oxidative instability (literature search as it applies to onboard storage conditions)

2. Develop relationship between such processes and a measurable attribute of the fuel such as the onset/presence of free radicals, peroxide formation, acid number, induction period (IP), etc.

3. Develop a surrogate process or performance test to simulate those impacts and create oxidized biodiesel according to a given oxidation specification

4. Determine the statistical uncertainty in reaching a selected degree of oxidation of such a simulated process in the laboratory (repeatability)

5. Provide a project report with complete details of the project including the detailed final oxidation process and its repeatability analysis.

AVFL

Current Status and Future Program

The program consists of two phases, the first of which will develop a bench test methodology to replicate rapid oxidation induction period (IP) depletion in-vehicle. The second phase may involve aging fuels to various IP numbers and to various acid numbers. The effects on injectors and other components and their impacts on criteria and unregulated emissions may be observed to measure potential impacts from in-vehicle fuel stability issues. This project began in late CY2013 with a contract issued to Southwest Research Institute (SwRI).

High quality ASTM compliant B100 biodiesel was procured. B100 was blended with selected commercially available hydrocarbon diesel fuels comprised of high levels of hydrotreated and hydrocracked components, respectively. The hydrocarbon-only petroleum diesel fuels may also be evaluated separately for their stability performance. Sources of biodiesel were soy and palm oils that span a range of saturation and initial stability. CRC member laboratories performed fuel analyses to determine their properties.

The project panel identified modern diesel vehicle technologies and their generic fuel system conditions to serve as a minimum baseline to define in-use engine operation and onboard fuel storage conditions that can be more fully evaluated directly during vehicle onboard vehicle exposure operations. The baseline test conditions evaluated in this study included fuel tank breathing during diurnal storage, recirculation of fuel to the tank during operation, and exposure of fuel flowing in the pump/injection systems. Onboard vehicle conditions were also simulated in the laboratory to duplicate conditions that may be observed on a test track.

SwRI proposed analytical procedures to monitor fuel stability during simulated onboard vehicle storage and use to define any changes that may occur in fuel exposed to these conditions.

A literature review on biodiesel oxidation and thermal stability in vehicle systems was conducted. Mercedes-Benz provided a test vehicle for the project. The test fuels were chosen. The petroleum diesel fuel was ordered by SwRI. The National Biodiesel Board arranged delivery of the biodiesel to be used for this project to SwRI. SwRI conferred with the project panel members on vehicle instrumentation to monitor in-use fuel temperature and pressure conditions. These conditions were measured and applied to separate evaluations of fuels in the test matrix. After review of the initial testing results, the project panel elected to extend the project to include testing of B20 in a Chevy Silverado on a chassis dynamometer to provide a comparison against initial data collected on B0 and B5. B20 testing included replication of previous test conditions and a second test that incorporated air entrainment to simulate what is expected during on road vehicle use. B20 testing was completed.

AVFL

IMPROVED DIESEL SURROGATE FUELS FOR ENGINE TESTING AND KINETIC MODELING

CRC Project Nos. AVFL-18 and AVFL-18a

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

Scope and Objective

The objective of this work is to establish and evaluate a methodology for formulating surrogates with compositional, ignition-quality, volatility, and density characteristics that are representative of diesel fuels produced from real-world refinery streams. Such fuels will enable more valuable study of combustion in both experimental engines and computer simulations, which will help in the development of better fuels and engines.

Current Status and Future Program

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

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

This project is being performed in collaboration with researchers at several DOE national laboratories: Sandia (SNL), National Renewable Energy Laboratory (NREL), Lawrence Livermore (LLNL), Pacific Northwest (PNNL), and Oak Ridge (ORNL); as well as a Canadian federal laboratory (CanmetENERGY). The National Institute of Standards and Technology (NIST) is assisting with fuel property measurements and regression optimization techniques to support surrogate formulation.

Final evaluation of the first-generation surrogates was completed. A project report was reviewed and approved by the project panel and committee for journal publication. The journal article describing the surrogate fuel formulation process was published in 2012 by *Energy & Fuels.* This publication is currently available on the *Energy & Fuels* website, as well as on the CRC website. This journal article represents the final report for the first phase of AVFL-18.

Research was extended under AVFL-18a to facilitate the development of second generation surrogates with improved capabilities for matching market diesel fuels, blending engine research test quantities of surrogates, as well as single-cylinder engine and combustion vessel testing of selected surrogate fuels. Panel members have worked to identify and obtain compounds of sufficient purity and sulfur content for blending surrogate fuels, using a variety of synthesis approaches. All four surrogates have been blended by Chevron for the selected surrogate formulations. Sandia National Laboratories, along with two other laboratories, have begun single-cylinder engine and combustion vessel testing of the final surrogate fuels. Combustion modeling of engine performance is also being conducted in an independent fashion to predict the performance of the surrogate fuels in the selected engine test platforms. All engine and vessel testing should be complete by the summer of 2016. A series of publications are scheduled to document the development process of the new surrogate diesel fuels and the extensive testing and evaluation planned under this project.

AVFL

CHARACTERIZATION OF ADVANCED ALTERNATIVE AND RENEWABLE FUELS

CRC Project Nos. AVFL-19 and AVFL-19a

Leaders: W. J. Cannella
C. Fairbridge
S. W. Jorgensen
R. L. McCormick

Scope and Objective

The objective of these projects is to characterize the physical and chemical properties of advanced alternative and renewable fuels designed for use in diesel and spark-ignition engines. This information is needed by OEMs, fuel producers, and combustion researchers to predict the performance of emerging fuel components in current and advanced combustion engines.

Current Status and Future Program

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

The physical and chemical properties of each sample in the first round of testing (AVFL-19) were characterized using standard ASTM-type analyses plus state-of-the-art advanced chemical composition techniques that were used to characterize the FACE research diesel fuels. Research partners at the U.S. national laboratories and at Natural Resources Canada/CanmetENERGY conducted the advanced characterization analyses in their laboratories, while standard tests were performed at SwRI.

Standard ASTM testing on the samples under AVFL-19 included:
1) Cetane number by D613 engine test,
2) Cetane index by D976,
3) Distillation by D86 and D2887,
4) Specific gravity by D4052,
5) Kinematic viscosity by D445,
6) Cloud point by D2500,
7) Flash Point by D93,
8) Net heat of combustion by D240,
9) Lubricity by D6079,
10) Elemental Analysis by D5291, D5453, D5623, and D4629,
11) Hydrocarbon types by fluorescent indicator adsorption (FIA) D1319,
12) Hydrocarbons by D2545,
13) Aromatics by super critical fluid chromatography (SFC) D5186,
14) Bromine Number by D1159, and
15) Sulfur by D5453.

Advanced characterization tests included:

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

Standardized testing at SwRI and advanced characterization tests at partner laboratories were completed. The AVFL-19 project produced two final reports. The FACE Diesel Fuel Report was published as CRC Report AVFL-19-1. The Final Report for the analysis of the other renewable fuels was published as CRC Report AVFL-19-2 in May 2013.

AVFL

Additional renewable fuel samples were analyzed under AVFL-19a as part of an extension of this work in 2014 and 2015. AVFL-19a focuses on renewable gasoline-type components including samples of renewable naphtha, ethanol, butanol, and others. Samples of the test fuels were sent to the selected project test laboratories. SwRI performed standard ASTM testing. NREL, CanmetENERGY, PNNL, Phillips 66, GM, and Chevron provided additional testing of fuel samples under AVFL-19a. All results are being compiled into a report similar to the AVFL-19-2 Final Report. The draft final report is in panel review and is expected to be ready for Committee review in fall 2015.

OCTANE NUMBER ENGINE EFFICIENCY AND CO_2: FILLING LITERATURE GAPS

CRC Project Nos. AVFL-20 and 20a

Leaders: J. E. Anderson
W. J. Cannella
A. Iqbal
C.S. Sluder

Scope and Objective

This study investigates efficiency advantages for increased octane number fuel that may be available from ethanol or other blend components in modern light-duty vehicles.

Current Status and Future Program

The project consists of engine dynamometer testing on engines to evaluate the effects of fuel octane rating, sensitivity, and ethanol content on engine efficiency.

An agreement was established between CRC and ORNL to conduct both phases of engine testing and performance modeling for this study. The first phase is being conducted on a 1.6L Ford turbocharged DI EcoBoost engine. Flint Hills Resources is a co-sponsor of both phases of this project. Gage Products prepared test fuels according to the matrix of 19 test fuels approved by the project panel members and the committee. Samples of the test fuels went through detailed hydrocarbon analysis by Chevron.

The test fuel matrix allows exploration of a wide range of ethanol content (10 to 30 vol%), research octane number (91-102), and sensitivity (S=RON-MON) at two levels between 6-7 and 10-12. Engine and vehicle-level performance modeling are also included in the ORNL test plan. ORNL has completed the first stage of engine testing of all 19 fuels for knock resistance at a single compression ratio in the Ford EcoBoost engine. Subsequently, six of the test fuels were chosen for more detailed engine performance characterization at appropriately matched compression ratios; this testing is underway.

AVFL

The second phase of this project (AVFL-20a) is scheduled on a 1.4L FIRE naturally aspirated PFI engine provided by Fiat-Chrysler Automobiles (FCA US) as a current technology base line comparison with both the production configuration and with higher compression ratio. The FCA US PFI engine work will be conducted using the same six test fuels that were selected in Project AVFL-20. Project completion is expected in 2016.

DATA MINING OF FACE DIESEL FUELS

CRC Project No. AVFL-23

Leaders: W. J. Cannella
R. Gieleciak

Scope and Objective

This study is being conducted in cooperation with Natural Resources Canada (NRC). This project examines engine performance correlations based on various engine test programs conducted using FACE diesel fuels. A selection of performance parameters will be evaluated including those related to combustion efficiency.

Current Status and Future Program

This project is being conducted by NRCAN staff at their facilities. The project started in January 2014. The project is studying an extensive database on the chemical and physical properties of the FACE diesel fuels and available engine performance data, such as that collected by WVU in CRC Project AVFL-16 and other test programs where the FACE diesel fuel set was tested. Statistical analysis is being conducted to find new fuel property and engine performance relationships for the advanced combustion systems evaluated in the various test programs. NRCAN has developed several correlations associating fuel properties and composition with engine performance. An important tool in developing the correlations is principal component analysis (PCA) where collinear variables are eliminated to find the best parameters for characterizing performance. Specific modeling strategies include partial least squares regression (PLS), multilinear regression (MLR), and variable selection (VarSel) techniques. A draft final report from NRCAN is expected in the last quarter of 2015.

AVFL

GASOLINE FUEL PROPERTIES IMPACT ON FUTURE ENGINE DESIGN

CRC Project No. AVFL-26

Leaders: M. B. Viola
W. J. Cannella
C.S. Sluder

Scope and Objective

The technical scope for this the AVFL Committee includes evaluation of advanced fuels and advanced combustion systems. Within the Committee scope, sets of diesel and gasoline-based test fuels were developed by the Fuels for Advanced Combustion Engines (FACE) Working Group. With these tasks completed, the Committee investigated potential composition and property changes for the next generation of ground transportation fuels focusing on new developments for emerging gasoline properties and compositions. The objective of AVFL-26 is to evaluate the effects of a broad range of potential new gasoline properties and compositions on a next generation advanced engine platform aimed at maximizing fuel efficiency.

Current Status and Future Program

The AVFL Committee initiated a planning process to identify key factors that should be evaluated for the next generation of research test fuels. Surveys were conducted among government and industry members of the committee to identify the areas of further study needed to address developments seen on the horizon for new fuels and combustion systems. The outcome of this effort resulted in a proposed approach to examine the impact of gasoline fuel properties on future engine designs.

The fuel matrix in this study includes E0, E10, E30; high and low RON; and high and low distillation end point to represent potential impacts on particulate matter emissions. The test engine is a GM 2.0L I4 turbocharged LTG engine modified to create a possible next generation advanced technology configuration, reaching for a 25% improvement in fuel economy with a 2-stage turbo, 25% EGR, high energy ignition, and higher compression ratio.

An opportunity for co-funding was identified in a U.S. Department of Energy Funding Opportunity Announcement (FOA). The preliminary concept paper was approved by DOE, and a more detailed application was submitted. The FOA award announcement was made in August 2014, and the project is currently underway at ORNL testing facilities. The fuel test matrix has been defined, and Gage Products Company has been selected to prepare the blends. The test engine was prepared by GM and delivered to ORNL. A Cooperative Research and Development Agreement (CRADA) between ORNL and CRC has been executed for this jointly funded study. The project is expected to be completed by mid 2017.

AVFL

HEAT OF VAPORIZATION MEASUREMENTS OF GASOLINE AND ETHANOL BLENDS

CRC Project No. AVFL-27

Leaders: K. D. Rose
W. J. Cannella

Scope and Objective

This project will evaluate the accuracy of the heat of vaporization (HOV) measurement for up to 10 gasoline and ethanol/gasoline blends using a laboratory procedure and explore alternate methods of determining the HOV as a function of boiling point and composition. The results will be applied to assessment of engine operating efficiency potential.

Current Status and Future Program

A competitive request for proposal was issued and proposals were reviewed by the project panel. The Committee approved for funding two laboratories. CRC has arranged agreements with the University of Delaware (UDEL) and the National Renewable Energy Laboratory (NREL) to examine the selected test fuels in the first phase of the project.

Three fuels from the FACE gasoline fuel set (Fuels A, D, and H) were selected by the project panel. It was decided that Fuels A and H would be tested at three ethanol blend levels (10%, 15%, and 30%). Iso-octane will serve as a reference for which the HOV is known. Aliquot samples of the test fuels were sent to UDEL and NREL. Testing has begun at both facilities and is expected to be complete by Fall 2015. Differential Scanning Calorimetry (DSC) methods will be used by both laboratories. In addition to direct measurements made by DSC, a calculation method based on Detailed Hydrocarbon Analysis (DHA) compositional data is also be explored.

The details for a second phase of the project will be developed following completion of Phase 1 testing.

FUELS FOR ADVANCED COMBUSTION ENGINES (FACE) WORKING GROUP

Leader: W. J. Cannella

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

The FACE group is composed of volunteers from industry, government, and academia. Its membership includes researchers from the fuel industry, as well as members representing the engine, automobile and emission control technology manufacturers, academia, and U.S. DOE and Canadian national laboratories. The activities of the group formally commenced in January 2006. The collaboration includes scientists and engineers from ANL, LLNL, NREL, ORNL, PNNL, and SNL as well as NRCAN/CanmetENERGY.

A key activity of this group has been developing two sets of fuels for research in advanced combustion in the diesel and gasoline ranges. The diesel fuel set, defined in 2007, is commercially available for purchase 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" was published on the CRC website, and an accompanying conference paper was given at the 2009 SAE Fall Powertrains, Fuels, And Lubricants Meeting. The group continues to support the blender in decisions relating to blending new batches of the fuels, as there are periodic changes in the availability of blendstocks.

The gasoline-range fuel set design was also finalized by the group. All ten fuels were blended in large batches and are commercially available for sale from CPCHEM. Detailed characterization of the gasoline fuel set is available on the CRC website in tabular form and further documented in CRC Final Report No. AVFL-24.

AVFL

Current and future activities include publishing a review of available data using the FACE fuels from combustion studies, along with recommendations for parameters to measure in the studies, outreach to the technical community to raise awareness of the availability of the test fuels, and ongoing discussions of how best to approach alternative fuels research when also working with the FACE fuel sets. Presentations have been made at: the SAE High Efficiency Engines Symposium, the AEC/HCCI consortia meetings, and the DOE Annual Merit Review Meeting. ORNL prepared a compilation paper for SAE in 2014 on engine test programs where the FACE diesel fuels were tested in advanced combustion engines. The group also serves in a support role for the AVFL projects that are employing FACE fuels in research.

The FACE Working Group has created a number of sub-teams to address various technical aspects of their work plan. Spin-off projects generated by ideas from this group include: AVFL-16, AVFL-18, AVFL-19, AVFL-24, and AVFL-26.

AVFL LUBRICANTS PANEL

Leaders: G. C. Gunter
T. Kowalski

The AVFL Committee technical scope includes evaluation of impacts of current lubricants on advanced vehicles and future lubricants on current or advanced vehicles. The AVFL Committee organized a panel of engine lubrication experts from industry that serve as a resource for Committee projects. The AVFL Lubricants Panel is also developing studies focused primarily on lubricant impacts for consideration by the full committee. The Lubricants Panel met twice in the last quarter of 2014 to review key issues impacting lubricant performance including discussion of potential impacts from biodiesel. A third meeting of the panel was held in February 2015 in Salt Lake City and a fourth meeting was held in May 2015 in Charlotte, NC.

ATMOSPHERIC IMPACTS

RELATIONSHIP BETWEEN SEMI-VOLATILE ORGANIC COMPOUNDS AND SECONDARY ORGANIC COMPOUNDS

CRC Project No. A-74

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

Scope and Objective

The objective of this project is to define the relationship between semi-volatile organic compounds (SVOC) contained in vehicle exhaust and subsequent formation of secondary organic aerosols (SOA) generated in the atmosphere via dilution and chemical reactions. The main project goal is to obtain sufficient definition of the relationship between SVOC and SOA to model the behavior in the atmosphere. The project is also sponsored by EPA and CARB. This project has application to both the Atmospheric Impacts Committee (AIC) and the CRC Real World Vehicle Emissions and Emissions Modeling Group (RWG). Therefore, a joint project was implemented in conjunction 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 also received in-kind support from CARB to conduct vehicle testing. The CMU proposal to CRC covered smog chamber experiments (approximately 5 gasoline vehicles and 2 diesel vehicles) to be conducted in connection with the vehicle test program (approximately 50 vehicles). This proposal was approved by the committee and the CRC RWG, leading to a contract negotiated with CMU in April 2010. A technical work plan was reviewed and approved by the project panel members. The project began with Phase 1 testing in May 2010 at the CARB El Monte, CA vehicle test laboratories. Summary results from Phase 1 were presented at the 21st Real World Emissions Workshop in March 2011.

A second phase of vehicle testing and smog chamber evaluations was conducted in June-July 2011 at the CARB/MTA heavy-duty chassis dynamometer facility. A third phase to add more vehicle and chamber testing to the project matrix was completed in mid-2012.

The Phase 1 final interim report was completed in May 2012. The Phase 2 final interim report was completed in November 2012. The Phase 3 final interim report was reviewed and approved by the project teams and committee members early in 2013.

Seven derivative journal articles were prepared and reviewed by the CRC committees for final documentation covering all work conducted through Phase 3 of the project. The journal articles were published in 2014.

Phase 4 was initiated by the project team and respective committee members to support modeling of SVOC primary emissions and their conversion to SOA based on data collected in the earlier phases. Photochemical grid modeling in Phase 4 will be compared to inventory data collected by EPA and other data collected during the CARB CALNEX field study. EPA provided the emissions inventory for Phase 4 and modeling was completed. CARB also provided an independent emissions inventory that was incorporated into the Phase 4 modeling assessments.

An Executive Summary of the Phase 1-3 effort was approved by the respective committees for publication in parallel with the seven journal articles. The Executive Summary with link references to the journal articles and the database appendices have been posted to the CRC website. The draft final report for Phase 4 was received in the third quarter of 2015 and is now under committee review.

ATMOSPHERIC IMPACTS

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

CRC Project Nos. A-76-1, A-76-2, and A-76-3

Leaders: S. Collet
R. S. MacArthur

Scope and Objective

The objective of this research program is to investigate the effect of historical, current, and future controls on LDV emissions outside California on ozone and PM in the U.S. LDV emissions standards in the U.S. have become increasingly stringent since the 1970s. Additional controls are planned, with the aim of improving ambient air quality. The incremental and cumulative air quality benefits of these emissions standards in the context of contributions from other mobile sources and other source categories are of primary interest. The projects require the use of MOVES and other emissions models coupled with regional 3D 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 studied under A-76-1 (in addition to a 2008 base case) included 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. Additional scenarios were selected for A-76-2 and A-76-3 including extending the modeling time frame to 2030.

Current Status and Future Programs

Emissions from on-road motor vehicles in the U.S. have decreased over the past four decades even with dramatic increases in traffic volume. Highway vehicle VOC emissions were reduced by approximately 75% from 1970 to 2005, and PM and NOx emissions were reduced by over 50%, while total vehicle miles traveled for highway vehicles increased more than twofold. These reductions have been due, in part, to the Federal Tier 0, Tier 1, and Tier 2 emission control programs.

ENVIRON was selected through a competitive bid process to conduct the initial study in this program using CAMx air quality modeling. EPA approves the use of CAMx for numerous ozone and PM state implementation plans throughout the U.S, and they have used it to evaluate regional mitigation strategies. CAMx was also used recently by EPA in its clean air transport rulemaking process.

The A-76-1 project was initiated in April 2011 and completed in January 2012. ENVIRON performed modeling for nominal periods of February and July in the Phase 1 study to represent a winter and summer month in the base year (2008) and in the future year (2022) scenarios. The geographic region of interest was the Eastern United States with focus on the four urban areas discussed in EPA's risk assessment analysis. These areas were Atlanta, Detroit, Philadelphia, and St. Louis. The air quality modeling domain proposed was the regional planning office (RPO) unified continental U.S. (CONUS) domain with 36 km horizontal resolution and an inner-nested domain with 12 km resolution over the eastern U.S. A journal article was published by *Atmospheric Environment* and is also available on the CRC website.

An extension to A-76-1 designated A-76-2, "Effects of Light-Duty Vehicle Emissions on Ozone and PM with Past, Present, and Future Controls, Phase 2," further examined ozone and PM levels and benefits from existing emissions controls and other possible future controls. The Phase 2 effort included a data analysis component in addition to emissions and air quality modeling. Phase 2 comprised an analysis of Atlanta air quality based on National Emissions Inventory (NEI) adjustments using new MOVES modeling scenarios of 100% Tier 0 for 2008 and 2022 on a 12 km grid using moves inputs, and reporting in the form of a CRC report and a journal article with all associated documentation. Project A-76-2 started in January 2012 and was completed in April 2013. The final report on Task 1 modeling of the effect of historic, current, and future controls on LDV emissions, ozone, and PM in the U.S. was published on the CRC website. ENVIRON also prepared a journal article on statistical analysis of trends in mobile emissions and air quality in Atlanta. The journal article on Task 2 statistical analysis was approved by *JAWMA* for publication. CRC has posted an open access link to article on the *JAWMA* website.

The committee elected to initiate the third phase (A-76-3) to extend the evaluation of the fleet more fully penetrated by LEV-III and to also identify source sectors with large contributions to future (2030) ambient ozone and PM in the U.S. The draft journal manuscript, "Emission Source Apportionment for Ozone and Particulate Matter in 2030," is under final revision for publication by *JAWMA.*

ATMOSPHERIC IMPACTS

CHEMISTRY OF TROPOSPHERIC OZONE GENERATION AND THE INFLUENCE OF TRACE GASES

CRC Project No. A-78

Leader: T. J. Wallington

Scope and Objective

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

Chapter I	Trace Gases in the Troposphere and the Chemistry of Their Interactions
Chapter II	Tropospheric Reactions of Ozone
Chapter III	Tropospheric Reactions of the Oxides of Nitrogen
Chapter IV	Tropospheric Reactions of OH Radicals with Hydrocarbons and Oxygenates
Chapter V	Tropospheric Reactions of Other Inorganic Trace Gases
Chapter VI	Photochemistry of the Oxygenates
Chapter VII	Effect of NOx, Hydrocarbons, and Other Trace gases on the Generation of Tropospheric Ozone

Current Status and Future Programs

The A-78 author team met in the first and second quarters of 2012 to refine the draft chapter outline above, develop details of the chapter contents, and make writing assignments. A third meeting of the writing group was held in September 2012. The draft final report in the form of a manuscript was prepared and reviewed by the committee near the end of the second quarter of 2013. The final manuscript was approved for publication by the Oxford University Press (OUP). The publication contract with OUP was approved by the authors and CRC. The new title is, "The Mechanisms of Reactions Influencing Atmospheric Ozone." The book was published in April 2015 and is available for purchase on the OUP website.

MODELING SENSITIVITY TO SPECIATION

CRC Project No. A-85

Leaders: R. S. MacArthur
S. Collet

Scope and Objective

The overall goal of this project is to improve LDV ozone and PM characterization by evaluating the impact from changing speciation profiles to determine the magnitude of such changes on model results. The evaluation will examine both exhaust and evaporative emission profile impacts.

Photochemical air quality models must represent differences in reactivity between individual Volatile Organic Compounds (VOCs). Condensed chemical mechanisms (e.g., CB05) use model species to represent the multitude of VOCs present in emissions. Some model species are explicit VOCs whereas others represent classes of VOCs. A "speciation profile" assigns total organic gas (TOG, which is VOC plus methane, ethane and acetone) emissions to model species. The TOG speciation profile influences photochemistry and consequently affects the predicted ozone concentrations. The speciation profile depends on the emissions source category and process and may be subject to considerable uncertainty and/or variability.

The Atmospheric Impacts Committee funded measurements of hydrocarbon speciation in the exhaust emissions of vehicles fueled with hydrocarbon-only gasoline (not containing ethanol) and with two levels of ethanol added as part of the CRC Emissions Committee Project E-98.

The specific objective of A-85 is to investigate the sensitivity of modeled ambient ozone concentrations to variability in vehicle exhaust TOG speciation in the E-98 data and the default EPA speciation profile used in a prior CRC study.

Current Status and Future Programs

Exhaust and evaporative VOC emissions differ in reactivity from fuel to fuel. The project evaluated the relative importance of differences in speciation profile reactivity on the ability to accurately model ozone or particulate matter. Since air quality models require VOC inputs and speciation profiles to represent those VOCs, it is important to get an accurate speciation profile. The relative impacts from different VOC speciation profiles have up to this point not been made clear. VOC speciation profiles appear to be less regarded during the model application process in some cases. Ad hoc research on the statewide level has probably been performed to investigate this, but widely distributed results were less abundant. Explicitly, VOC emissions factors for light-duty vehicle evaporative and exhaust emissions must be broken down into species for the air quality model chemistry to work appropriately because each specie has a unique reactivity. There is a difference between the aggregate reactivity of exhaust VOC compared with the aggregate reactivity of evaporative VOC.

It was proposed that a Southern California Air Basin (SoCAB) model application be examined where the mobile source speciation profile uncertainty is bracketed to investigate the magnitude of the change in ozone or PM. Various approaches describing uncertainty using statistical software packages were explored. The project was awarded to ENVIRON in January 2014. As a first step in the project, ENVIRON received the CRC Project E-98 speciation data from SwRI.

ENVIRON completed Tasks 1 and 2. Two gasoline vehicle exhaust VOC speciation profiles compiled and selected in Task 1 (Fuel 2 Bag 1 (start) and Fuel 2 Bag 3 (hot start)) were assigned to SPECIATE database species ID and subsequently used as input to the speciation tool to create CB05 mechanism profiles. The SMOKE processor was applied to develop CAMx-ready on-road mobile emissions using the two new profiles. These mobile emissions were then combined with emissions from other source categories from a prior CRC study to prepare four sets of CAMx-ready emissions files for July 2030: two profiles, each for two domains (36 km and 12 km). Task 3 modeling was then completed.

The draft final report was prepared and reviewed by the committee. ENVIRON then conducted an additional CAMx simulation and added the results to the report in response to comments received by the draft final report reviewers. The revised Final Report was received and published via the CRC website.

LOW CARBON FUEL STANDARD PROGRAM AIR QUALITY

CRC Project No. A-86

Leaders: R. S. MacArthur
S. Collet

Scope and Objective

The California Air Resources Board (ARB) approved the Low Carbon Fuel Standard (LCFS) regulation in 2009 to reduce GHG emissions by achieving a ten percent reduction in the carbon intensity of transportation fuels used in California by 2020. ARB approved some amendments to the LCFS in December 2011, which became effective on November 26, 2012, and were implemented by ARB on January 1, 2013. ARB expected to propose a comprehensive re-adoption of the LCFS regulation in the fall of 2014. ARB provided two sets of staff reports on the effects of LCFS and continued to conduct a series of public workshops in preparation for the re-adoption proposal.

Air quality benefits may accrue from LCFS regulation, but to date ARB has only provided its expectation of how emissions may be affected, where it is inferred, for example, that emissions reductions of some primary pollutants (e.g., sulfur dioxide and carbon monoxide) result in nearly proportional reductions in ambient concentrations. While precursor emissions (i.e., nitrogen oxides, volatile organic compounds) reductions do not always provide air quality benefits (i.e., NOx reductions can result in ozone increases—known as the NOx disbenefit), it is important to first understand potential emissions changes before evaluating air quality changes.

The project objective is to conduct a literature review that will include ARB's methods and results on the evaluation of the LCFS on air emissions and air quality and may also include information on other approaches for assessing air quality under the LCFS scenarios that may be followed.

ATMOSPHERIC IMPACTS

Current Status and Future Programs

Work began on A-86 in June 2014. ENVIRON reviewed the original ARB staff reports and other recent public materials including information presented at ARB meetings concerning the LCFS. The final report was approved by the committee in the last quarter of 2014 and is now available on the CRC website.

INTERCOMPARISON AND EVALUATION OF COUPLED METEOROLOGY/CHEMISTRY MODELS OVER NORTH AMERICA AS PART OF PHASE 2 OF AQMEII

CRC Project No. A-87

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

Scope and Objective

The overall goal of the Air Quality Modeling Evaluation International Initiative (AQMEII) Phase 2 is to assess how well the current generation of coupled regional-scale air quality models can simulate the observed spatio-temporal variability in the optical and radiative characteristics of atmospheric aerosols and associated feedbacks among aerosols, radiation, clouds, and precipitation. Modeling is being conducted in the European and North American domains. This will help establish the state-of-the-science in regional-scale modeling using coupled modeling systems.

Current Status and Future Programs

CRC continued participation in AQMEII Phase 2 with EPA and the Joint Research Centre (JRC). ENVIRON was selected to assist in evaluating modeling results from AQMEII Phase 2 in conjunction with the overall analysis and assessment effort led by JRC. ENVIRON gathered the necessary data and began processing the data in coordination with other AQMEII participating groups.

ENVIRON submitted their draft final manuscript on the North American domain review to the committee. The manuscript was submitted in May 2014 for publication in a special AQMEII issue of Atmospheric Environment along with results from other Phase 2 program participants. The first manuscript was been published in July 2015 by Atmospheric Environment. An additional effort covering simulation results from the North American domain called dynamic evaluation of 2006–2010 ozone trends in AQMEII-2 was also documented as CRC Report No. A-87-2 published on the CRC website in March 2015.

ATMOSPHERIC IMPACTS

STATE SUPPORTED MOVES INPUTS IMPROVEMENTS

CRC Project No. A-88

Leaders: S. Collet
M. Janssen

Scope and Objective

The ultimate goal of this project is to provide to state and local air agencies and U.S. EPA more accurate input for the MOVES model. There are many parameters and many inputs for those parameters, but this project intends to focus its efforts on a limited number of parameters identified as critical in previous studies (see CRC Project No. A-84). To achieve the ultimate goal, this project provided improved data for the database of on-road mobile inputs used to create emissions for the 2011-amended National Emissions Inventory (NEI), with particular focus on obtaining default data following EPA best practices. The objective of the project is to provide improved default inputs that are state specific and reflect any known differences between various areas of the state. This is to be provided either as county-by-county data, or data grouped by the existing county groups in the most recent version of NEI inputs or differences between urban and rural areas of the state. These inputs are especially important to provide data for states that do not provide inputs to EPA for the NEI.

Current Status and Future Programs

The project was awarded to ERG and work began in January 2014. The project panel was comprised of a wide range of state and regional air quality planning office (RPO) representatives along with members of EPA to provide additional oversight and technical input to the project. The Task 1 deliverables (“Evaluation of Data Sources for Improving NEI Inputs” and associated databases) were approved and posted to the CRC website. Task 2 deliverables were completed and approved by the committee and an expanded panel. The Task 2 effort included state-by-state details on vehicle age and population distributions. The project panel also developed a method for estimating vehicle populations for vehicles over 30 years old where data were not already specified. The Task 2 deliverables also included detailed information on estimating long-haul truck vehicle miles travelled (VMT). A manuscript was accepted as a presentation by Transportation Research Board (TRB) and the CRC Final Report was posted to the CRC website in October 2014.

USING UNCERTAIN REGIONAL AIR QUALITY MODEL OUTPUTS FOR OZONE SOURCE APPORTIONMENT

CRC Project No. A-89

Leaders: S. Collet
R. S. MacArthur

Scope and Objective

The objective of this project is to obtain modeling verification of ozone apportionment techniques from a long history of modeling runs. Techniques for estimating ozone response in photochemical models to changes in model emissions already exist (i.e., brute force, DDM and OSAT). These source apportionment experiments predict future changes in air quality at a particular location given changes to selected emission sources. Results from this type of experiment cannot be verified in the real-world because there is no corresponding set of observations. The proposed research will use an 18-year simulation study to cross-validate results, permitting quantitative assessment of model input uncertainties and their impact on apportionment results.

Current Status and Future Programs

This project was awarded to Porter-Gego and began in November 2013. Supporting Porter-Gego in this study are principle investigators from the AQMEII, S.T. Rao (EPA, retired) and Stefano Galmarini (JRC). The concept and preliminary modeling results were presented at the 9th International Conference on Air Quality – Science and Application in Garmisch-Partenkirchen, Germany, on March 24-28, 2014. A manuscript based on the Garmisch presentation was completed and submitted to *Atmospheric Environment*. The *AE* article, “Methods for Reducing Biases and Errors in Regional Photochemical Model Outputs for Use in Emission Reduction and Exposure Assessments,” was in press April 2015.

ATMOSPHERIC IMPACTS

The committee approved a series of other deliverable reports during two phases of the project. More recently a CRC report titled, "Ozone Metamodel for the Continental US: Model Inputs, Development and Performance," is in review and a related journal article is in preparation. This report describes the methodology of creating the metamodel from multi-model ensembles using unbiased model outputs and temporal components. The project is scheduled for completion in 2015 with a final journal article expected to be published in 2016.

APPORTIONMENT OF OZONE ABOVE THE BACKGROUND CONCENTRATION TO EMISSION SOURCES

CRC Project No. A-90

Leaders: S. Collet
R. S. MacArthur

Scope and Objective

The objectives of this project are to (1) demonstrate a new source allocation method (Path Integral Method, "PIM") to an existing modeling data set and (2) determine the contributions of light-duty vehicles (LDV's) and other major sources to anthropogenic ozone. A secondary objective is to display and place greater focus on the uncontrollable ozone background concentration.

Current Status and Future Programs

This project was awarded to Dr. Alan Dunker and ENVIRON; work began May 2014. Task 1 of the project, "Develop and Test the Numerical Procedure for Integrating the Sensitivity Coefficients," was completed after developing and testing the numerical procedure. Task 2, "Apportion the Anthropogenic Ozone Increment for the Full Month of July," was also completed. ENVIRON and Dr. Dunker completed the sensitivity simulations for the alternate integration paths and analyzing the impact on the PIM source contributions. A draft final report was approved by the committee and submitted to the journal, *Environmental Science and Technology (ES&T)*. The journal manuscript for A-90 was accepted and published by the *Environmental Science & Technology*. An Executive Summary for this report and the link to the journal article has been posted to the CRC website.

ATMOSPHERIC IMPACTS

FUTURE MOBILE SOURCE EMISSION CONTROLS AND OZONE TRENDS IN THE SOUTH COAST AIR BASIN

CRC Project No. A-91

Leaders: S. Collet
T.A. French
R. S. MacArthur

Scope and Objective

The objective of this study is to assess and demonstrate an optimized approach for reducing mobile source NOx emissions in California's South Coast Air Basin that minimizes the potential increases in ozone levels that could result from a NOx-focused control strategy (i.e., NOx disbenefit).

Current Status and Future Programs

This project was awarded to Desert Research Institute (DRI) with funding co-sponsorship by the Truck and Engine Manufacturers Association (EMA). DRI planned to assess and demonstrate the effects of lowering on-road NOx emissions on ambient ozone and PM2.5 levels in the California South Coast Air Basin (SoCAB) using a series of base and sensitivity air quality model simulations. All CMAQ-ready emissions and meteorological inputs were obtained from the South Coast Air Quality Management District (SCAQMD) for the 2008 base year, 2023 and 2030. Appropriate adjustment factors were applied to the mobile source NOx emissions in the future year inventories. DRI planned to also demonstrate the effect of concomitant adjustments in the mobile source hydrocarbon emissions that address potential underestimations indicated by the recent 2010 Van Nuys Tunnel Study (Fujita et al, 2012) and an updated reconciliation of ambient and emission inventory data.

Work began in January 2014. Task 1 Reconciliation of Ambient and Emission Inventory Data, Task 2, "CMAQ Modeling" and Task 3, "Box Model Calculations," was completed. The project was extended to include an additional modeling episode. A summary presentation was given at the 2015 Real World Emissions Workshop and at the AIC Annual Meeting. The Final Report for this project was approved for release in April 2015 and a related journal article is being reviewed by *JAWMA.*

AIR TOXICS WORKSHOP

Project No. A-92

Leaders: S. Collet
E. McCauley

Scope and Objective

The objective of this workshop 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. The Atmospheric Impacts Committee, in conjunction with CARB, hosted the 2010 and 2013 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. Each of these events brought together key government, academic and industry researchers, and stakeholders working in this area.

Current Status and Future Programs

Dr. Kent Hoekman was selected to support organization of the 2015 MSAT workshop with the aid of new organizing committee participants. Dr. Hoekman and the organizing committee developed the technical program and identified speakers. The 2015 workshop offered speakers an opportunity to have their paper published in a special MSAT issue of the *Journal of the Air & Waste Management Association (JAWMA)*. A student poster competition was held in conjunction with the workshop in 2015 and winners were Mary Cameron from Stanford University and Diep Vu from University of California at Riverside (CE-CERT). The MSAT Workshop was held again at CARB headquarters in Sacramento, CA on February 17-19, 2015. A workshop summary was prepared by Dr. Hoekman, and included in the workshop proceedings. The summary has also been reviewed and approved by the workshop chairs and committee for distribution. The summary is now available on the CRC website. Another summary overview of the 2015 MSAT Workshop was published in JAWMA's *EM* magazine in July 2015.

ATMOSPHERIC IMPACTS

AQMEII/HTAP2 MODELING ACTIVITY - PHASE 3

Project No. A-95

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

Scope and Objective

The objective of Phase 3 of the Air Quality Modeling Evaluation International Initiative (AQMEII-3) organized by the U.S. EPA and the European Commission's Joint Research Centre (JRC) will focus on applying regional scale atmospheric models in coordination with global modeling being performed by the Task Force on Hemispheric Transport of Air Pollution (TF-HTAP) to examine the contribution of inter-continental transport to regional air quality, the sensitivity of regional air quality to changes in emissions in key source regions world-wide, and to develop inter-comparisons of the performance of global and regional-scale models.

Current Status and Future Program

A proposal for the A-95 project was reviewed and approved by the committee. This project was awarded to ENVIRON International Corporation and is currently underway. The base case simulation was scheduled to start in the second quarter of 2015. The next step will be a performance model evaluation followed by uploading the results to ENSEMBLE, completing sensitivity scenarios and drafting the final report. The draft final report is expected at the end of October 2015.

PM2.5 DATA ANALYSIS AND MODELING IN THE SAN FRANCISCO BAY AREA

Project No. A-96

Leader: R. S. MacArthur
S. Collet

R. MacArthur

Scope and Objective

The objective of this project is to increase confidence in research tools and minimize uncertainty by analyzing and modeling PM2.5 for the San Francisco Bay Area and make recommendations on using modeling and analysis tools for air quality decision making.

Current Status and Future Programs

The project was awarded to UC Davis in April 2015. Task 1 to obtain meteorological model (WRF) outputs and emissions inventory for 2012 from the District has been completed. The base case and sensitivity simulations for Task 2 are currently underway. A related contract was awarded to UC Davis by the Bay Area Air Quality Management District (BAAQMD) that will supplement the A-96 technical program. The project is scheduled to conclude in the summer of 2016.

ATMOSPHERIC IMPACTS

ASSESSING AND IMPROVING THE ISOPRENE OXIDATION MECHANISM

Project No. A-97

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

Scope and Objective

The objective of this project is to implement new versions of the Carbon Bond and Statewide Air Pollution Research Center (SAPRC) chemical mechanisms in the Comprehensive Air Quality Model with Extensions (CAMx). The new versions will have the most recent isoprene chemistry from the developers of the mechanisms. A sensitivity tool will then be used with a simplified configuration of CAMx to screen the isoprene chemistry for the important oxidation pathways. The most important pathways will be investigated further with 3-D CAMx simulations. Finally, the sensitivity of urban and rural ozone to anthropogenic VOC, CO, and NOx emissions and isoprene emissions in 3-D CAMx simulations will be determined.

Current Status and Future Programs

This project was awarded to ENVIRON International Corporation. The scope of the work plan has been revised to use the latest version of CMAQv5.1 for 3-D model simulations, implement chemistry updates in the CMAQ code and evaluate ozone model performance. The comparison with MCM v3.3 shows that CB6r2 and SAPRC07TIC include key elements of a "modern" isoprene mechanism. The next steps for this project are to update the isoprene chemistry in the CB6r2 and conduct a sensitivity analysis that will determine the relative importance of isoprene products in CB6r2/CB6r3/SAPRC07TIC. A 3-D model analysis will be done following the sensitivity analysis. This project is on schedule for completion at the end of 2015.

AIR QUALITY MODELING RESEARCH NEEDS WORKSHOP

Project No. A-98

Leaders: S. Collet
S. McConnell

Scope and Objective

The objective of this workshop is to provide sound science research plans for assessing the impacts of vehicle emissions on air quality for the external technical community. This will be accomplished through a two day workshop which will discuss approaches to improve the ability to predict the effect of emissions on air quality, by improving inventories, air chemistry, air quality modeling, and predicting the importance of emerging data

Current Status and Future Programs

This workshop has been approved by the Atmospheric Impacts Committee and the CRC Board. An organizing committee has been formed and planning is underway. The organizing committee plans to extend invitations to experts working in the field to assist in developing a research needs plan early in 2016.

ATMOSPHERIC IMPACTS

DOCUMENTING A METHOD FOR CLOUD-BASED MODELING OF MOVES

Project No. A-103

Leaders: S. Collet
M. Janssen

Scope and Objective

The objective of this project is to provide documentation of a method developed by ERG to conduct MOVES emission factor modeling with the aid of cloud resources. ERG had conducted earlier work in this area and demonstrated significant efficiency increases thus saving computing time required to run the MOVES model.

Current Status and Future Programs

An agreement was established with ERG in July 2015 to provide a brief report documenting their efficient approach for processing MOVES runs using available Cloud resources. The final report is expected prior to the end of 2015.

NATURAL GAS FUEL SURVEY

Project No. PC-2-12

Leader: J. J. Jetter

Scope and Objective

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

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

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

Specific Tasks included:

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

Current Status and Future Programs

This project was performed by SwRI. The American Gas Association (AGA) provided co-funding and technical participation. The final report was published to the CRC web site. The results of this study were instrumental in the design of the test matrix for Project E-109, "Effect Of Fuel Composition On The Emissions And Performance Of Modern, Light-Duty Natural Gas Vehicles," conducted by the CRC Emissions Committee. The E-109 Project Final Report was released in May 2015.

PERFORMANCE

GASOLINE ENGINE DEPOSITS

CRC Project No. CM-136

Leader: J. Axelrod

Scope and Objectives

The current 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 in PFI and Direct Injected (DI) vehicles.
- Determine the extent of SI fuel injector fouling and intake valve deposits and assess the adequacy of current deposit control additive dosages to prevent deposit formation.

Current Status and Future Program

Gasoline Engine Intake Valve Deposit Testing

ASTM D5500 is the test recognized by EPA for certifying additives to protect against Intake Valve Deposits. CARB has a separate test and there is also a private program Top Tier certification test. The CRC Gasoline Deposit Group is considering a re-evaluation of the test procedures to possibly update the vehicles and the fuels. The ASTM standard was implemented in 1994. Since that time there have been changes in fuel properties, engine technologies, changes in ethanol usage rates, and new performance requirements. The composition of the fuel has changed and will change again in 2017 with Tier III with respect to sulfur content and possibly ethanol content. Refining changes have been made and crude oil content has shifted with more heavy and oil Syncrude being used. Changes in engine technology include hybrids, FFVs, DISI, turbo boost, downsizing, and VVT. The extent of ethanol use has also dramatically changed. The current engine test platforms, which include BMW 318i and Ford 2.3L (ASTM D6201), are now nearly obsolete. The certification fuel requirements are also not relevant to today's fuel composition.

The American Chemistry Council (ACC) is proactively working to develop a new PFI-based test. There are many challenges with this effort. Determining lowest additive concentration (LAC) for the newer

150,000 mile certification requirements is a completely new situation. Today, the level requirements are not well known (overtreated, undertreated, tolerance, etc.) but there appears to be little or no field problems reported at the present time. However, representatives from the OEM's and additive companies pointed out that formation of excessive IVD is still a major potential problem. The ACC has proposed that once they complete the initial test development, CRC is to assume responsibility for the test development so a consensus can be reached on key test parameters.

CRC's role is to provide data on performance but does not recommend what limits or variables should be set for standards or regulatory performance.

PERFORMANCE

VOLATILITY

CRC Project No. CM-138

Leader: L. M. Gibbs

Scope and Objective

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

Current Status and Future Program

<u>2013 Intermediate Temperature E15 Cold-Start and Warmup Driveability Program</u>

The objective of this project was to determine an accurate ethanol offset for the Driveability Index equation in ASTM D4814, "Specification for Automotive Spark-Ignition Engine Fuel" including ethanol content of 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) were evaluated in a group of late-model fuel-injected (including direct injection) vehicles selected through a screening process to represent sensitive vehicles. The program was conducted at a test track test site. An ancillary program was conducted to evaluate the AVL-DRIVE™ System for automated driveability ratings, and will be reported separately.

Ethanol manufacturers' trade associations Growth Energy and Renewable Fuels Association (RFA) provided funding for this project. Testing was performed in February and March of 2013. The final report was released as CRC Report No. 666 in April 2014.

2014 CRC Hot-Fuel Handling (HFH) Vehicle Driveability Program testing Maximum ASTM D4814 Volatility Class Gasoline Blends (Max. RVP, Min. T50, Min. TVL20)

The objective of this program was to evaluate HFH Vehicle Driveability Performance of a fleet of conventional test vehicles, MYs 1998 – 2014 using a summer through winter test fuel matrix that included D4814 volatility class maximums for Vapor Pressure limits, and Vapor Pressure limits plus 1 PSI, along with T50 and TVL20 parameters set to their minimums. The program included 3 Vapor Pressure levels at each ambient test temperature window in order to assess potential non-linear driveability effects, evaluated E15 blends relative to E10 blends, and utilized a variety of vehicle hardware content, fuel system designs, and model years.

Recent CRC Performance Committee reports (No. 658 and 659) detail the effects of D4814 Class D and E gasoline T50, TVL20, and ethanol content effects on vehicle hot-fuel handling (HFH) driveability, both at Sea Level and Altitude. To further understand volatility effects on modern vehicle HFH performance for all D4814 volatility classes, this study set the VP (DVPE) parameter of a series of carefully designed test fuels to its maximum limit, while simultaneously setting the blend's T50 and TVL20 parameters to their minimum D4814 limits or lower. All other test fuel parameters were held as constant as reasonably possibly from blend to blend and consistent with the U.S. gasoline market. This program accounted for all volatility classes (AA through E) and investigated potential non-linear effects in each temperature range.

Flint Hills Resources co-sponsored this field study. The final report has been released as CRC Report No. 668.

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

The objective of this project was to determine the incremental change in risk due to a change in fuel composition for transport delivery and customer refueling with higher levels of ethanol fuels.

The benchmark was the currently accepted public safety level of the terminal blender making an E10 blend (10 vol% ethanol blended into a base gasoline where the resulting vapor pressure is appropriate for the season and geographic location). The analysis included the tanker truck driver loading/blending/delivering higher ethanol blends such as E51, E83, and E98 and, ultimately the consumer dispensing E10 compared to these higher ethanol blends into personal vehicles at self-serve refueling stations. The U. S. Department of Energy supports efforts to increase the use of ethanol-rich transportation fuels such as "E85." The Renewable Fuel Standards requirements to vastly increase the amount of ethanol containing fuels into the marketplace will rapidly increase the opportunity for these fuels to be present in the marketplace. A risk analysis/hazard assessment is required to fully judge the safety implications, if any, of the introduction of these new fuel blends into the hands of the public.

The subcontractor was engaged to survey the literature to determine what gasoline-ethanol blends can create a flammable mixture in the vapor space above the liquid in a tank. The subcontractor worked with the Risk Assessment/Hazard Analysis (RA/HA) team to define possible fuel delivery, service station storage, and retail dispensing accident scenarios, and then narrow the choices to approximately six for further analysis by covering a range of possibilities. A consequence vs. frequency risk matrix was developed to facilitate a semi-quantitative risk analysis. The analysis can be used to determine the adequacy of existing safeguards on current fuel handling/dispensing systems.

This analysis did not consider materials compatibility per se, unless directly related to a failure mode that would cause or allow a spark of sufficient energy to enter the headspace above ethanol gasoline blends. Toxicity and environmental impacts such as groundwater or air quality were also not considered.

AcuTech performed this project. NREL provided co-funding. The final report was posted on the CRC web site in Summer 2014.

2015 Development of a Thermodynamics-Based Fundamental Model for Prediction of Gasoline-Ethanol Blend Properties and Vehicle Driveability

This project's objective is to take a more fundamental approach toward describing the effects of blending ethanol into gasoline, on the blend distillation properties and the driveability of vehicles using gasoline-ethanol blends. Such an approach perhaps could be based more on the non-linear thermodynamic relationships between gasoline hydrocarbon components and ethanol, rather than the brute-force regression approach used today in the ASTM gasoline standard D4814.

Specifically the objectives for the project are:

1. Develop a thermodynamics-based approach to predicting the distillation properties of blends of hydrocarbon gasoline and fuel-grade ethanol based on commonly measured properties of gasoline and ethanol.

2. Review past CRC and any other studies on the driveability performance of vehicles with gasoline and gasoline-ethanol blends and develop a better model for predicting driveability index of gasoline ethanol blended fuels.

This new approach should use readily and commonly measured properties for gasoline, fuel blending ethanol, and gasoline-ethanol blends to be useful. For example, a correlation based on detailed hydrocarbon analysis (DHA) and ethanol component analysis may be the most fundamental approach but practically not useful, since such information is hardly ever available on a regular inspection test of gasoline.

The project will not involve the creation of new test data for gasoline or vehicles. Rather, existing CRC and any other publically-available driveability data and fuels' inspections will be used to develop this new model. It is envisioned that this project can be completed within six months or less time.

The Volatility Group has formed a technical panel and awarded the project to Evap Consulting, Inc., after a competitive solicitation. The contract is in place and the project is underway, with final reporting expected in late 2015.

PERFORMANCE

OCTANE

CRC Project No. CM-137

Leader: W. Woebkenberg

Scope and Objective

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 Program

<u>Literature Review of Octane Number versus Engine/Vehicle Performance</u>

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. Funding was also supplemented by USCAR. Literature sources from the previous 20 years were evaluated to develop a searchable database to identify currently known relationships and to identify potential gaps in our current understanding.

The project started in June 2011 and focused on liquid gasoline fuels (primarily hydrocarbon and ethanol-containing fuels) and on hardware that is currently in-use or may be in use in the near future. The Task 1 Final Report and the Tasks 2-5 Final Report have been released on the CRC website in December 2011 and September 2012, respectively.

Development of a work plan for future Octane work is ongoing, through coordination with related projects in the Emissions and AVFL Committees.

<u>Advanced Fuel and Engine Efficiency Workshop</u>

The Octane Group of the Performance Committee worked with the AVFL committee to organize an international workshop held in Baltimore, MD on February 25-26, 2014. The workshop was designed to address advanced fuels and methods for improving engine efficiency, focusing on light-duty engine technology and associated fuel effects, and included discussion of octane research (past and potential for the future).

The workshop was co-sponsored by DOE and API with in-kind support contributed by MIT. This was the first workshop to be conducted by CRC on this topic. Proceedings of the workshop were published on the CRC website.

Sub-Regular Grade (85 AKI) Octane Study (See also E-108)

In coordination with the Emissions Committee, this study is evaluating vehicle performance and emissions effects of an 85 AKI gasoline relative to an 87 AKI gasoline at two altitudes. Results from this study will provide relevant data to ASTM and NCWM discussions regarding minimum AKI values in different US geographical regions. The final report was released in March 2015.

PERFORMANCE

DIESEL PERFORMANCE GROUP

CRC Project No. DP

Leader: M. Nikanjam

Scope and Objective

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 International 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
- Corrosion

Current Status and Future Program

Low Temperature Operability

The Low Temperature Operability Panel is developing a guide along the lines of the document produced by the Cleanliness Panel, also under the Diesel Performance Group. Regularly scheduled conference calls are being held to develop the outline and assign sections of the report. The guide is expected to be published in late 2015.

Biodiesel/Low Temperature Operability

A joint Biodiesel/Low Temperature Operability Panel program on "The Effect of Wax Settling and Biodiesel Impurities on Low Temperature Light-Duty Diesel Performance" has completed testing. The program objective is to determine if newer fuel blending streams (FT, HVO, severely hydro-processed, etc.) and/or Biodiesel impurities impact vehicle low temperature operability performance during extended periods of non-operation of LD diesel vehicles. Weekend shut-down is an example of extended non-operation. Conventional diesel, B5, and B20, as well as cold flow additives are being evaluated. The program is being run in two phases. Phase 1 is laboratory bench testing to simulate weekend cool-down and warmup cycles to determine visually and through standard cold flow laboratory testing if this has a significant impact on estimated vehicle performance as measured by Cloud Point, Pour Point, Cold Filter Plugging Point (CFPP), Simulated Filter Plugging Point (SFPP), and Low Temperature Flow Test (LTFT). Fuels include blend components representing: Biodiesel, Gas-to-Liquids (GTL), Biomass-to-Liquids (BTL)/ Hydro-treated Vegetable Oil (HVO), Hydro-cracked and severely Hydro-processed streams. This laboratory phase has been completed. The draft report is in development.

Phase 2 duplicated the laboratory experience in LD vehicles to verify any issues identified in the laboratory test work. Similar fuels were used. Tests were performed with simulated overnight and weekend heating/cooling cycles to compare results.

Mahle-Behr conducted the Phase 2 vehicle testing. Testing and data analysis are complete, and the draft final report is in development, with release anticipated in the second half of 2015.

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 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.

The draft work plan for the scoping study, titled "Performance Evaluation Protocol for Diesel Vehicles – Effect of Fuel Cetane Number on Low Temperature on Vehicle Performance" is currently in review by the Diesel Performance Group and the Performance Committee.

Diesel Deposits

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

PERFORMANCE

1. Data Analysis and Recommendations
2. Bench/Rig/Engine Investigation; Na-Soap Deposits
3. Engine Investigation

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

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

Internal diesel injector deposits were categorized as metal soap, amide lacquer, and carbonaceous. Metal-soap deposit is the more significant issue currently in the U.S. HD application. It also is a concern globally and in LD applications. The data analysis sub-panel prepared CRC Report No. 665, "Internal Diesel Injector Deposits," for CRC Project DP-04-13a, which was released on the CRC website in October 2013.

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

An initial scoping study consisted of a program to conduct a limited screening program using two in-house tests to determine if fuels which are expected to cause internal injector deposits can be differentiated from those that are not expected to form such deposits.

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

Unfortunately results from this scoping study did not confirm that either one of these rigs, in their present state, could discriminate among deposit forming or not deposit forming fuels. The Diesel Performance Group released a final report for CRC Project DP-04, "Scoping Study to Evaluate Two Rig Tests for Internal Injector Sticking," on the CRC website in July 2012.

Sub-panel 2 planned and evaluated a new rig offered by Delphi UK. Tests were conducted in the later part of 2012. Results were more encouraging. Details of the Delphi rig evaluation were reviewed in late March 2013. The final report CRC DP-04-13b, "Internal Injector

Deposits: A Scoping Study to Evaluate the Delphi Test Rig," was published on the CRC website in August 2013. With the accomplishment of the task by the Data Analysis Panel and combination of the rig and engine evaluation, the panel will continue as one group without subpanels.

The ultimate goal of this effort is to establish an industry-standard tool that can evaluate and discriminate among fuels and additives for diesel injector fouling. One approach is the use of an engine on a test stand, similar to what is being pursued in Europe by the CEC. The CRC panel is following that progress but hopes to establish a simpler and quicker test rig. With in-kind participation from members of the Truck and Engine Manufacturers Association (EMA), correlation testing is complete for the Bench/Rig/Engine Investigation; analysis for this project is in process, with reporting to follow.

Fuel Cleanliness

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

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

The initial goal was to generate a single CRC guide to compile best available current knowledge and practice regarding cleanliness of diesel fuel. The CRC document has the following outline:

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

Experts in each area are working within this panel to provide technical details. CRC Report No. 667, "Diesel Fuel Storage and Guide" has been published on the CRC website. ASTM held a workshop with over 160 attendees based on this report in June 2015.

Corrosion

The Corrosion Panel was formed under the DPG, and held an inaugural meeting in Houston, TX in February 2014.

Severe and rapid corrosion has been observed in some retail systems storing and dispensing ultra-low sulfur diesel (ULSD) since 2007. In addition, the corrosion is coating the majority of metallic equipment in both the wetted and un-wetted portions of some ULSD underground storage tanks (USTs). To investigate this issue, multiple stakeholders in the diesel, vehicle, regulatory, and truck stop industries, through the Clean Diesel Fuel Alliance, sponsored a research study by Battelle Memorial Institute (hereafter termed "Battelle study").

The objective of the CRC effort is to field test clean sites containing fiberglass UST systems following the same test procedures (fuel, vapor, water, scrapings, etc.) that were used in the Battelle study of contaminated sites. The results from this effort will be directly compared directly with those from the Battelle study to determine differences. They also will be used (as part of a subsequent effort) to facilitate development of an appropriate laboratory bench test that replicates the processes and factors determining the corrosion observed in the field.

The panel developed a protocol for selecting sites with ULSD systems determined to have severe corrosion. This was posted to the CRC web site and is expected to inform EPA and others in their current research on this topic. EPA has completed a test program and has provided the draft report to the panel for an opportunity to provide comments. CRC Panel members reviewed the draft report and forwarded comments to EPA for consideration, and are considering future research plans.

PART THREE

RELEASED REPORTS

RELEASED REPORTS - 2015

AIR POLLUTION & ADVANCED TECHNOLOGY*

CRC Project No.	Title	Publication/NTIS Accession No.
ACES Phase 2	Regulated and Unregulated Emissions from Modern 2010 Emissions-Compliant Heavy-Duty On-Highway Diesel Engines	*Journal of the Air & Waste Management Association* Vol. 65, Issue 8 (2015) p. 987-1001
A-76-3	Emission Source Apportionment for Ozone and Particulate Matter in 2030	*Journal of the Air & Waste Management Association* PENDING
A-78	The Mechanisms of Reactions Influencing Atmospheric Ozone	*Oxford University Press 2015*
A-83	Sensitivity of Atmospheric Models to Rate Terms within Complex Chemical Mechanisms	*Atmospheric Environment* Vol. 98, (2014) p. 224–230
A-84	Motor Vehicle Emissions Simulator Input Data Evaluation and Sensitivity Analysis of Data Submitted for 2011 National Emissions Inventory	*TRB: Journal of Transportation Research Board*, No. 2427, (2014) p. 63-72
A-85	Ozone Modeling Predictions Sensitivity to Speciation of Exhaust VOC Emissions	PB2015-105123
A-86	Low Carbon Fuel Standard Program Air Emissions Effects	PB2015-101215
A-87	A comparison between 2010 and 2006 air quality and meteorological conditions, and emissions and boundary conditions used in simulations of the AQMEII-2 North American domain	*Atmospheric Environment* Vol. 115, (2015) p. 389-403
A-87-2	Dynamic Evaluation of 2006 – 2010 Ozone Trends in AQMEII-2 North American Domain Simulations	PB2015-104203
A-88	CRC A-88 Task 2: Age Distribution and Vehicle Population	PB2015-105651

	MOVES Input Improvements for the 2011 NEI	PB2015-101261
A-89	Methods for Reducing Biases and Errors in Regional Photochemical Model Outputs for Use in Emission Reduction and Exposure Assessments	*Atmospheric Environment* Vol. 112, (2015) p. 178–188
A-89-1	Methods for Adjusting Biases in Ozone Model Outputs for Use in Attainment Demonstrations and Exposure Assessments Deliverable 1B	PB2015-105648
A-89-2	Using Uncertain Regional Air Quality Model Outputs for Ozone Source Apportionment Deliverable 1C	PB2015-105649
A-89-3	Metamodel Demonstration: Effects of Mobile Source Reductions on Ozone Trends in the Northeast US Deliverable 1E	PB2015-105650
A-90	Apportionment of Ozone Above the Background Concentration to Emissions Sources: Executive Summary	PB2015-105125
	Source Apportionment of the Anthropogenic Increment to Ozone, Formaldehyde, and Nitrogen Dioxide by the Path-Integral Method in a 3D Model	*Environmental Science & Technology* Vol. 49, Issue 11, (2015) p. 6751–6759
A-91	Projected Ozone Trends and Changes in the Ozone-Precursor Relationship in the South Coast Air Basin in Response to Varying Reductions of Precursor Emissions	PB2015-104109
	Projected Ozone Trends and Changes in the Ozone-Precursor Relationship in the South Coast Air Basin in Response to Varying Reductions of Precursor Emissions	*Journal of the Air & Waste Management Association* PENDING
A-92	Highlights from the Coordinating Research Council 2015 Mobile Source Air Toxics Workshop	*EM* Magazine (July 2015), p. 28-32
AVFL-17b	Biodiesel and Renewable Diesel Characterization and Testing in Modern LD Diesel Passenger Cars and Trucks	PB2015-103727

E-94-1a	Determination and Evaluation of New Prep Cycle on the Fuel Effects of Gaseous Emissions on SIDI In-Use Vehicles	PB2015-103732
E-85-3	Survey of Flex Fuel in 2014	NREL TP-5400-63503
E-99	Very Low PM Mass Measurements	PENDING
E-103	Evaluation of N_2O Measurement Instruments with Light-Duty Vehicles	PB2015-101216
E-106	On-Road Remote Sensing of Automobile Emissions in the Tulsa Area: Fall 2013	PB2014-109130
	On-Road Remote Sensing of Automobile Emissions in the Chicago Area: Fall 2014	PB2015-105128
24th RWE Workshop	Highlights from the Coordinating Research Council 24th Real World Emissions Workshop	*EM* Magazine (November 2014) p. 26-31
25th RWE Workshop	Highlights from the Coordinating Research Council 25th Real World Emissions Workshop in Long Beach, California	*EM* Magazine PENDING
E-108	Effects of 85 and 87 Anti-knock Index (AKI) Gasoline Ethanol Blends on U.S. Light-Duty Vehicle Emissions, Fuel Economy, and Performance at Two Elevations (1,000 ft. and 5,000 ft.) (CRC 669)	PB2015-104110
E-109	Effect of Fuel Composition on the Emissions and Performance of Modern, Light-Duty Natural Gas Vehicles	PENDING
E-112	Survey of Biodiesel Content at Retail Diesel Fuel Outlets in Illinois and Minnesota	PB2015-105124
E-114	Effects of Organometallic Additives on Gasoline Vehicles: Analysis of Existing Literature	PENDING

*The primary source for CRC Air Pollution and Advanced Technology 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.

RELEASED REPORTS - 2015

AVIATION & PERFORMANCE**

CRC Project No.	Title	Publication/NTIS Accession No.
AV-14-11	Aviation Turbine Fuel Lubricity - A Review	PB2015-101262
DP-06-13	Diesel Fuel Storage and Handling Guide (CRC 667)	PB2015-101214
CM-138-13-1	2014 CRC Hot-Fuel-Handling Program (CRC 668)	PB2015-104108

**The primary source for CRC Performance and Aviation reports is:
National Technical Information Service, U.S. Department of Commerce
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When ordering a report, be certain to include the NTIS Accession Number.

PART FOUR

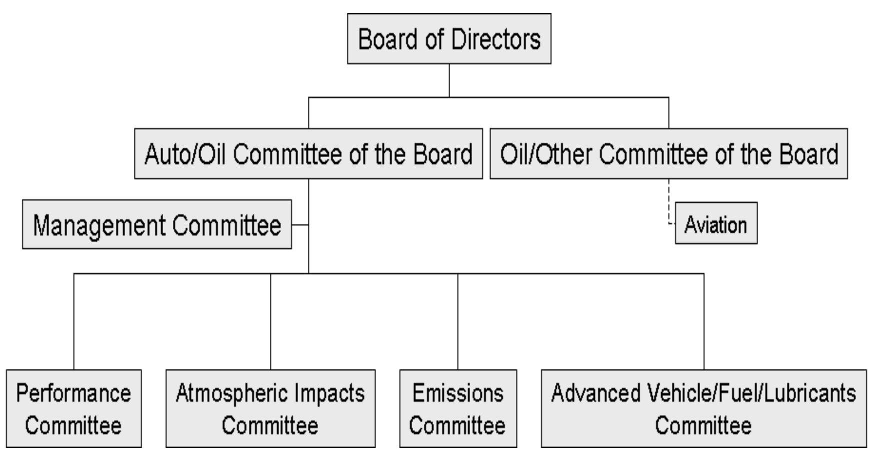
ORGANIZATION AND MEMBERSHIP

ORGANIZATION – 2015

The sustaining members of the CRC are the American Petroleum Institute (API) and a consortium of automobile manufacturers (Chrysler, Daimler, Ford, General Motors, Honda, Mitsubishi, Nissan, Toyota, and Volkswagen). For over 73 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 in setting standards. CRC has only one real mandate, and that is to add to the scientific base that may be useful in technology coordination and appropriate regulation. CRC information is made publicly available and is used by industry to help ensure optimum compatibility and customer satisfaction with its products and by industry, government, and the public to enhance joint achievement of clean air.

CRC has two basic types of research programs:

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

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

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

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

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S. W. Jorgensen	General Motors	J. Silvas	Flint Hills Resources
D. H. Lax	API	J. J. Simnick	BP
T. Leone	Ford Motor Co.	M. Valentine	Toyota Tech. Ctr. N.A.
R. P. Lewis	Marathon Petroleum Co.	L. Webster	Nissan Tech. Ctr. N.A.
S. Mason	Phillips 66	W. Woebkenberg	Aramco Services

MEMBERSHIP

AVFL-23 PANEL

W. J. Cannella, Co-Leader	Chevron Energy Technology
R. Gieleciak, Co-Leader	CanmetENERGY

J. T. Bays	PNNL	C. J. Mueller	SNL
N. Killingsworth	LLNL	K. D. Rose	ExxonMobil
S. McConnell	Marathon Petroleum Co.		

AVFL-26 PANEL

M. B. Viola, Leader	General Motors
W. J. Cannella, Co-Leader	Chevron Energy Tech.
C. S. Sluder, Co-Leader	ORNL

J. Anderson	Ford Motor Co.	S.W.Jorgensen	General Motors
J. Cruz	Daimler	S. McConnell	Marathon Petroleum Co.
G. C. Gunter	Phillips 66	K. D. Rose	ExxonMobil
A. Iqbal	Fiat Chrysler Automobiles	W.Woebkenberg	Aramco Services
J. J. Jetter	Honda R&D Am.		

AVFL-27 PANEL

M. B. Viola, Leader	General Motors
K. D. Rose, Co-Leader	ExxonMobil

J. Anderson	Ford Motor Co.	A. Iqbal	Fiat Chrysler Automobiles
J. T. Bays	PNNL	S.W.Jorgensen	General Motors
W. J. Cannella	Chevron Energy Tech.	S. McConnell	Marathon Petroleum Co.
G. C. Gunter	Phillips 66	C. S. Sluder	ORNL

EMISSIONS COMMITTEE

K. D. Rose, Co-Chair	ExxonMobil
M. Valentine, Co-Chair	Toyota Tech. Ctr. N.A.

J. Cruz	Daimler	S. A. Mason	Phillips 66
D. M. DiCicco	Ford Motor Co.	J. Mengwasser	Shell Global Solutions
R. George	BP	D. Patterson	Mitsubishi Motors R&D Am.
J. J. Jetter	Honda R&D Am.	D. Z. Short	Marathon Petroleum Co.
S. I. Johnson	Volkswagen of America	N. L. Simon	Fiat Chrysler Automobiles
F. Khan	Nissan Tech. Ctr. NA	M. B. Viola	General Motors
P. Loeper	Chevron Global Dnstrm	W. Woebkenberg	Aramco Services

E-94 PANEL

M. B. Viola, Co-Leader	General Motors
S. A. Mason, Co-Leader	Phillips 66

E. J. Blash	Fiat Chrysler Automobiles	R. P. Lewis	Marathon Petroleum Co.
V. R. Burns	Fiat Chrysler Automobiles	P. Loeper	Chevron Global Dnstrm
J. Cruz	Daimler	J. Mengwasser	Shell Global Solutions
D. M. DiCicco	Ford Motor Co.	D. Patterson	Mitsubishi Motors R&D Am.
R. George	BP	K. D. Rose	ExxonMobil
J. J. Jetter	Honda R&D Am.	D. Z. Short	Marathon Petroleum Co.
C. Jones	General Motors	J. Y. Sigelko	Volkswagen of America
F. Khan	Nissan Tech. Ctr. N.A.	M. Valentine	Toyota Tech. Ctr. N.A.
D. H. Lax	API	W. Woebkenberg	Aramco Services

MEMBERSHIP

E-108 PANEL

W. Studzinski, Co-Leader — General Motors
D. M. DiCicco, Co-Leader — Ford Motor Co

E. J. Blash	Fiat Chrysler Automobiles	K. Mitchell	Shell
V. R. Burns	Fiat Chrysler Automobiles	K. D. Rose	ExxonMobil
J. Farenback-Brateman	ExxonMobil	J. Rutherford	Chevron
R. George	BP	J. Y. Sigelko	Volkswagen of America
J. Horn	Chevron		
A. Iqbal	Fiat Chrysler Automobiles	J. J. Simnick	BP
D. H. Lax	API	M. Valentine	Toyota Tech. Ctr. N.A.
S. A. Mason	Phillips 66		
J. Mengwasser	Shell Global Solutions	M. Winston-Galant	General Motors

E-109 PANEL

J. J. Jetter, Co-Leader — Honda R&D America
K. D. Rose, Co-Leader — ExxonMobil

D. Bowerson	Fiat Chrysler Automobiles	A. Schlenker	ANL
R. George	BP	D. Z. Short	Marathon Petroleum Co.
S. I. Johnson	Volkswagen of America	J. Y. Sigelko	Volkswagen of America
D. H. Lax	API	N. L. Simon	Fiat Chrysler Automobiles
R. P. Lewis	Marathon Petroleum Co.	K. Stutenberg	ANL
P. Loeper	Chevron Global Dnstrm	M. Valentine	Toyota Tech. Ctr. N.A.
S. A. Mason	Phillips 66	M. B. Viola	General Motors
J. Mengwasser	Shell Global Solutions	T. Wallner	ANL
M. Nikanjam	Chevron Products Co.		

E-112 PANEL

J. Y. Sigelko, Co-Leader — Volkswagen of America
R. George, Co-Leader — BP

J. Cruz	Daimler	K. D. Rose	ExxonMobil
D. M. DiCicco	Ford Motor Co.	D. Z. Short	Marathon Petroleum Co.
D. H. Lax	API	M. Valentine	Toyota Tech. Ctr. N.A.
R. P. Lewis	Marathon Petroleum Co.	M. B. Viola	General Motors
P. Loeper	Chevron Global Dnstrm	L. Webster	Nissan Tech. Ctr. N.A.
S. A. Mason	Phillips 66	W. Woebkenberg	Aramco Services
J. Mengwasser	Shell Global Solutions		

REAL WORLD VEHICLE EMISSIONS & EMISSIONS MODELING GROUP

D. M. DiCicco, Co-Chair	Ford Motor Co.
S. A. Mason, Co-Chair	Phillips 66

J. R. Agama	Caterpillar
C. Bailey	US EPA
R. Baldauf	US EPA
N. J. Barsic	John Deere
M. Beardsley	US EPA
K. N. Black	FHWA
V. Burns	Fiat Chrysler Automobiles
J. Cruz	Daimler
A. Cullen	US EPA
T. A. French	EMA
C. R. Fulper	US EPA
R. George	BP
R. Giannelli	US EPA
C. Hart	US EPA
K. Helmer	US EPA
H. Hogo	SCAQMD
J. J. Jetter	Honda R&D Am.
F. Khan	Nissan Tech. Ctr. NA
F. A. Krich	Fiat Chrysler Automobiles
D. H. Lax	API
R. P. Lewis	Marathon Petroleum Co.
P. Loeper	Chevron Global Dnstrm
J. E. Long	CARB
T. R. Long	US EPA
A. S. Mabutol	Mitsubishi MtrsR&DAm.
H. Maldonado	CARB
M. M. Maricq	Ford Motor Co.
E. McCauley	CARB
J. Mengwasser	Shell Global Solutions
R. S. Monroe	Fiat Chrysler Automobiles
E. K. Nam	US EPA
R. Nankee	Fiat Chrysler Automobiles
R. Nine	DOE/NETL
M. Olechiw	US EPA
F. Parsinejad	Chevron Oronite
D. Patterson	Mitsubishi Mtrs R&D Am.
R. Purushothaman	Caterpillar
K. D. Rose	ExxonMobil
S. A. Shimpi	Cummins
D. Z. Short	Marathon Petroleum
J. Y. Sigelko	Volkswagen of America
M. R. Smith	US EPA
D. Sonntag	US EPA
M. Spears	US EPA
M. Thornton	NREL
M. Valentine	Toyota Tech. Ctr. N.A.
W. Vance	CARB
M. B. Viola	General Motors
L. Webster	Nissan Tech. Ctr. NA
W. Woebkenberg	Aramco Services
M. K. Yassine	Fiat Chrysler Automobiles

MEMBERSHIP

LIFE CYCLE ANALYSIS PANEL

D. Z. Short, Chair — Marathon Petroleum Co

R. Bromiley	Shell Projects & Tech.	R. P. Lewis	Marathon Petroleum Co.
V. Burns	Fiat Chrysler Automobiles	A. S. Mabutol	Mitsubishi Mtrs R&D Am.
V. Camobreco	US EPA	S. A. Mason	Phillips 66
R. De Kleine	Ford Motor Co.	N. L. Simon	Fiat Chrysler Automobiles
J. Farenback-Brateman	ExxonMobil	K. D. Rose	ExxonMobil
A. Kapur	Phillips 66	M. Valentine	Toyota Tech. Ctr. N.A.
C. Kim	Ford Motor Co.	L. Verduzco	Chevron
R. Larson	US EPA	M. B. Viola	General Motors
D. H. Lax	API		

LCA WORKSHOP ORGANIZING COMMITTEE

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V. Camobreco, Co-Chair — US EPA

J. Anderson	Ford	D. H. Lax	API
G. Cooper	RFA	L. Marelli	JRC
R. De Kleine	Ford Motor Co.	J. I. Martin	U. of Concerned Sci.
J. DeCicco	University of Michigan	D. O'Grady	NRC
J. Duffield	USDA	D. Scott	NBB
H. Hamje	CONCAWE	D. Z. Short	Marathon Petroleum Co.
H. Hogo	SCAQMD	L. Verduzco	Chevron
A. Kapur	Phillips 66	M. Q. Wang	ANL
R. Larson	US EPA		

E-99 PANEL

H. Maldonado, Co-Chair	CARB
M. M. Maricq, Co-Chair	Ford Motor Co.

N. J. Barsic	John Deere	R. S. Monroe	Fiat Chrysler Automobiles
S. Collet	Toyota Technical Ctr. N.A.	D. B. Nagy	General Motors
R. R. Graze	Consultant	R. Purushothaman	Caterpillar, Inc.
H. Hogo	SCAQMD	K. D. Rose	ExxonMobil
C. Laroo	US EPA	S. A. Shimpi	Cummins, Inc.
P. Loeper	Chevron Global Dnstrm	D. Z. Short	Marathon Petroleum Co.
S. A. Mason	Phillips 66	M. K. Yassine	Fiat Chrysler Automobiles

MEMBERSHIP

ATMOSPHERIC IMPACTS COMMITTEE

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S. Collet, Co-Chair	Toyota Technical Ctr. N.A.

C. Jones	General Motors	K. D. Rose	ExxonMobil
R. S. MacArthur	Chevron Products Co.	J. Y. Sigelko	Volkswagen of America
S. A. Mason	Phillips 66	N. L. Simon	Fiat Chrysler Automobiles
S. McConnell	Marathon Petroleum Co.	T. J. Wallington	Ford Motor Co.
D. Patterson	Mitsubishi Mtrs.R&D Am.	L. Webster	Nissan Tech. Ctr. NA
B. Postel	BP America		

ATMOSPHERIC IMPACTS WORKING GROUP

D. C. Baker, Co-Chair	Shell Global Solutions
S. Collet, Co-Chair	Toyota Technical Ctr. N.A.

J. Cassmassi	SCAQMD	R. P. Lewis	Marathon Petroleum Co.
B. E. Croes	CARB	M. M. Maricq	Ford Motor Co.
D. M. DiCicco	Ford Motor Co.	R. Mathur	US EPA
H. J. Feldman	API	E. McCauley	CARB
T. A. French	EMA	E. Nam	US EPA
S. Gao	Phillips 66	J. Price	TX Comm. on EQ
M. L. Gupta	FAA	K. Sargeant	US EPA
M. Janssen	LADCO	J. Smith	TX Comm. on EQ
R. Kaleel	LADCO	S. Tanrikulu	BAAQMD
C. Kalisz	API	B. Timin	US EPA
D. M. Kenski	LADCO	W. Vance	CARB
M. Koerber	US EPA	C. Yanca	US EPA
C. Lawson	Shell	J. Zietsman	TX A&M Trans. Inst.
D. H. Lax	API		

MEMBERSHIP

A-74/E-96 PANEL

R. S. MacArthur,Co-Ldr.	Chevron Products Co.
H. Maldonado, Co-Ldr.	CARB
M. M. Maricq, Co-Ldr.	Ford Motor Co.
T. J. Wallington, Co-Ldr.	Ford Motor Co.

J. R. Agama	Caterpillar, Inc.	M. L. Gupta	FAA
N. J. Barsic	John Deere	R. P. Lewis	Marathon Petroleum Co.
D. M. DiCicco	Ford Motor Co.	S. McConnell	Marathon Petroleum Co.
T. A. French	EMA	S. A. Mason	Phillips 66
R. Giannelli	US EPA		

2015 MSAT ORGANIZING COMMITTEE

(Project No. A-92)

S. Collet, Co-Chair	Toyota Technical Ctr. N.A.
E. McCauley, Co-Chair	CARB

J. Collins	CARB	R. S. MacArthur	Chevron Products Co.
S. K. Hoekman	DRI	T. J. Wallington	Ford Motor Co.

2016 AIR QUALITY MODELING RESEARCH NEEDS ORGANIZING COMMITTEE

(Project No. A-98)

S. Collet, Chair	Toyota Technical Ctr. N.A.

M. Beardsley	US EPA	K. Sargeant	US EPA
R. Guensler	GA Tech	J. Xu	CARB
R. Mathur	US EPA	J. Zietsman	TX A&M Trans. Inst.
S. McConnell	Marathon Petro. Co.		

MEMBERSHIP

PERFORMANCE COMMITTEE

J. J. Jetter, Co-Chair	Honda R&D Am.
J. J. Simnick, Co-Chair	BP

J. Axelrod	ExxonMobil	D. Patterson	Mitsubishi Mtrs R&D Am.
J. Cruz	Daimler	C. Richardson	Ford Motor Co.
G. C. Gunter	Phillips 66	J. Russo	Shell
S. I. Johnson	Volkswagen of America	W. Studzinski	General Motors
R. P. Lewis	Marathon Petroleum Co.	M. Valentine	Toyota Tech. Ctr. N.A.
R. Monroe	Fiat Chrysler Auto.	L. Webster	Nissan Tech. Ctr. N.A.
M. Nikanjam	Chevron	W. Woebkenberg	Aramco Services

GASOLINE DEPOSIT GROUP

(Project No. CM-136)

J. Axelrod, Ldr.	ExxonMobil

B. Alexander	BP	K. Mitchell	Shell Canada Ltd.
K. Brunner	SwRI	R.Munroe	Fiat Chrysler Automobiles
W. J. Cannella	Chevron Energy Tech.	W. J. Most	Fuel Tech. Assoc.
R. Chapman	Innospec	C. L. Muth	Nalco Energy Services
J. Cruz	Daimler	F. Parsinejad	Chevron Oronite Co.
J. Draper	Nalco	C. M. Pyburn	Pytertech Intl.
B. Evans	Evans Research	C. Richardson	Ford Motor Co.
T. Frank	Lubrizol Corp.	J. Russo	Shell
I. Gabrel	Fiat Chrysler Automobiles	D. Schoppe	Intertek
L. M. Gibbs	Consultant	D. Z. Short	Marathon Petroleum Co.
G. C. Gunter	Phillips 66	J. Sigelko	Volkswagen of America
T. E. Hayden	BASF	J. Silvas	Flint Hills Resources
J. J. Jetter	Honda R&D Am.	W. Studzinski	General Motors
A. K. Jung	BASF Corp.	W. Y. Su	Huntsman Corp.
A. M. Kulinowski	Afton Chemical	R. D. Tharby	Tharby & Associates
D. H. Lax	API	M. Valentine	Toyota Tech. Ctr. N.A.
R. P. Lewis	Marathon Petroleum Co.	L. Webster	Nissan Tech. Ctr. N.A.
I. MacMillan	Innospec Fuel Spec.	M. Winston-Galant	General Motors
M. Miller	Sunoco Inc.	H. Zhao	Huntsman Adv Tech.

OCTANE GROUP
(Project No. CM-137)

W. Woebkenberg, Ldr. — Aramco Services

B. Alexander	BP
T. Briggs	SwRI
K. Brunner	SwRI
W. J. Cannella	Chevron Energy Tech.
R. Chapman	Innospec Fuel Spec.
J. Cruz	Daimler
D. M. DiCicco	Ford Motor Co.
B. Evans	Evans Research
J. Farenback-Brateman	ExxonMobil
T. Frank	Lubrizol Corp.
P. Geng	General Motors
G. C. Gunter	Phillips 66
A. Iqbal	Fiat Chrysler Automobiles
J. J. Jetter	Honda R&D Am.
C. Jewitt	Consultant
K. Knapp	Chevron Phillips Chem
D. H. Lax	API
R. P. Lewis	Marathon Petroleum Co.
M. Miller	Sunoco Inc.
K. Mitchell	Shell Canada
P. J. Morgan	SwRI
C. M. Pyburn	Pybertech International
R. Reynolds	Downstream Alternatives
C. Richardson	Ford Motor Co.
J. Russo	Shell
D. Schoppe	Intertek
D. Z. Short	Marathon Petroleum Co.
J. Silvas	Flint Hills Resources
J. Sigelko	Volkswagen of America
J. J. Simnick	BP
R. A. Sobotowski	US EPA
W. Studzinski	General Motors
M. Valentine	Toyota Tech. Ctr. N.A.
L. Webster	Nissan Tech. Ctr. N.A.
M. Winston-Galant	General Motors

MEMBERSHIP

VOLATILITY GROUP
(Project No. CM-138)

L. M. Gibbs, Ldr. Consultant

B. Alexander	BP
K. Brunner	SwRI
W. J. Cannella	Chevron Energy Tech
J. Cruz	Daimler
H. Doherty	Sunoco
B. Evans	Evans Research
J. Farenback-Brateman	ExxonMobil
T. Frank	Lubrizol Corp.
I. Gabrel	Fiat Chrysler Automobiles
G. C. Gunter	Phillips 66
P. Geng	General Motors
R. Hardy	Flint Hills Resources
G. Herwick	Trans. Fuels Consult.
J. J. Jetter	Honda R&D Am.
D. H. Lax	API
R. P. Lewis	Marathon Petroleum Co.
M. Lynch	ExxonMobil
K. Mitchell	Shell Canada Ltd.
R. S. Monroe	Fiat Chrysler Automobiles
W. J. Piel	Lyondell Chemical
J. Porco	Gage Products
C. M. Pyburn	Pybertech Intl.
C. Richardson	Ford Motor Co.
J. Russo	Shell
D. Schoppe	Intertek
D. Z. Short	Marathon Petroleum Co.
J. Sigelko	Volkswagen of America
J. Silvas	Flint Hills Resources
W. Studzinski	General Motors
M. Valentine	Toyota Tech. Ctr. N.A.
S. Van Hulzen	POET
L. Webster	Nissan Tech. Ctr. N.A.
J. P. Wick	Marathon Petroleum Co.
M.Winston-Galant	General Motors
W. Woebkenberg	Aramco Services

DEVELOPMENT OF A THERMODYNAMICS-BASED FUNDAMENTAL MODEL FOR PREDICTION OF GASOLINE-ETHANOL BLEND PROPERTIES AND VEHICLE DRIVEABILITY PANEL
(Project CM-138-15-1)

J. J. Simnick, Ldr. BP

J. Cruz	Daimler	R. Monroe	Fiat Chrysler Automobiles
L.M. Gibbs	Consultant	D. Z. Short	Marathon Petroleum Co.
S. VanderGriend	ICM, Inc	J. Sigelko	Volkswagen of America
G. Herwick	Trans. Fuels Consult.	J. Silvas	Flint Hills Resources
D. Lax	API	W. Studzinski	General Motors
M. Lynch	ExxonMobil	M. Winston-Galant	General Motors

2014 HOT-FUEL HANDLING DATA ANALYSIS PANEL
(Project CM-138-13-1)

R. P. Lewis, Ldr. Marathon Petroleum Co.

L. M. Gibbs	Consultant	D. Z. Short	Marathon Petroleum Co.
J. Horn	Chevron	J. J. Simnick	BP
J. J. Jetter	Honda R&D Am.	W. Studzinski	General Motors

MEMBERSHIP

DIESEL PERFORMANCE GROUP
(Project No. DP)

M. Nikanjam, Ldr. Chevron

H. Ahari	Fiat Chrysler Auto.	R. P. Lewis	Marathon Petroleum Co.
A. Aradi	Shell	T. Livingston	Robert Bosch
J. Axelrod	ExxonMobil	S. Lopes	General Motors
P. Biggerstaff	Baker Petrolite	H. Martin	Fleetguard / Cummins
L. Cattani	Fiat Chrysler Auto.	R. L. McCormick	NREL
A. Cayabyab	CARB	R. Mills	Chevron
R. Chapman	Innospec Fuel Spec.	K. Mitchell	Shell Canada
J. Cruz	Daimler	R. S. Monroe	Fiat Chrysler Automobiles
D. A. Daniels	Innospec Fuel Spec.		
J. Draper	Nalco	J. Porco	Gage Products
E. English	Fuel Quality Services	C. Richardson	Ford Motor Co.
D. Forester	Fuel Quality Services	S.B.Rubin-Pitel	ExxonMobil
T. Frank	Lubrizol Corp.	J.A.Rutherford	Chevron Oronite
I. Gabriel	Fiat Chrysler Auto.	D. Schoppe	Intertek
R. Gault	EMA	D. Z. Short	Marathon Petroleum Co.
R. George	BP	J. Sigelko	Volkswagen of America
G. C. Gunter	Phillips 66	J. Silvas	Flint Hills Resources
C. Hamer	PCS Instruments	W. Studzinski	General Motors
D. Hess	Infineum	A. Swarts	Sasol
J. J. Jetter	Honda R&D Am.	R. D. Tharby	Tharby & Associates
S. R. Kirby	Navistar, Inc.	M. Valentine	Toyota Tech. Ctr.N.A.
A. Kulinowski	Afton Chemical	G. Webster	AET
N. Kuzhiyi	GE	L. Webster	Nissan Tech. Ctr.N.A.
P. Lacey	Delphi Diesel Systems	S.A.Westbrook	SwRI
D. H. Lax	API	W.Woebkenberg	Aramco Services
R. Leisenring	xfTech		

DP - LOW TEMPERATURE OPERABILITY PANEL
(Project No. DP-02)

J. Chandler, Ldr. Consultant

J. Axelrod	ExxonMobil	S. Lopes	General Motors
D. A. Daniels	Innospec Fuel	H. Martin	Cummins / Fleetguard
T. Frank	Lubrizol Corp.	K. Mitchell	Shell Canada Products
R. Gault	Truck & EMA	M. Nikanjam	Chevron Products Co.
G.C. Gunter	Phillips 66	S.B. Rubin-Pitel	ExxonMobil
D. Hess	Infineum	W. Studzinski	General Motors
J. J. Jetter	Honda R&D Am.		
A.M. Kulinowski	Afton Chemical		

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

R. L. McCormick, Ldr. NREL

R. Baranescu	U. of IL at Chicago	S. Howell	National Biodiesel Bd.
J. Chandler	Consultant	J. J. Jetter	Honda R&D Am.
T. Frank	Lubrizol Corp.	T. Livingston	Robert Bosch
R. Gault	EMA	K. Mitchell	Shell Canada Products
G.C. Gunter	Phillips 66	H. Nanjundaswamy	FEV
P. Henderson	GM Powertrain	M. Nikanjam	Chevron Products Co.
D. Hess	Infineum	S.B. Rubin-Pitel	ExxonMobil
		W. Studzinski	General Motors

MEMBERSHIP

DP - CETANE NUMBER PANEL
(Project No. DP-03)

A. M. Kulinowski, Ldr. Afton Chemical

R. Andra	Fiat Chrysler Automobiles	S.I. Johnson	Volkswagen of America
A, Aradi	Shell	T. Livingston	Robert Bosch
J. Axelrod	ExxonMobil	S. Lopes	General Motors
A. L. Boehman	Univ of MI	K. Mitchell	Shell Canada Products
T. Frank	Lubrizol Corp	M. Nikanjam	Chevron Products Co.
R. Gault	Truck & EMA	S. B. Rubin-Pitel	ExxonMobil
R. George	BP	J. Y. Sigelko	Volkswagen of America
G.C. Gunter	Phillips 66	W. Studzinski	General Motors
J. J. Jetter	Honda R&D Am.	W. Woebkenberg	Aramco Services

DP - DEPOSIT PANEL
(Project No. DP-04)

J. Axelrod, Co-Ldr. ExxonMobil

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

DP – LOW TEMPERATURE OPERABILITY BIODIESEL PROJECT PANEL
(Project No. DP-05-12)

D.A. Daniels, Ldr. Innospec Fuel Spec.

J. Axelrod	ExxonMobil	T. Livingston	Robert Bosch
R. Baranescu	U. of IL at Chicago	S. Lopes	General Motors
J. Chandler	Consultant	R. L. McCormick	NREL
T. Frank	Lubrizol Corp.	H. Martin	Cummins / Fleetguard
R. Gault	EMA	K. Mitchell	Shell Canada Products
G.C. Gunter	Phillips 66	H. Nanjundaswamy	FEV
P. Henderson	GM Powertrain	M. Nikanjam	Chevron Products Co.
D. Hess	Infineum	S.B. Rubin-Pitel	ExxonMobil
S. Howell	National Biodiesel Bd.	W. Studzinski	General Motors
J. J. Jetter	Honda R&D Am.	A. Swarts	Sasol
A.Kulinowski	Afton Chemical		

DP – FUEL CLEANLINESS PANEL
(Project No. DP-06-13)

R. Chapman, Ldr. Innospec Fuel Spec.

N. C. Blizard	Cummins Engine Tech	S. Lopes	General Motors
E. W. English	Fuel Quality Services	M. Nikanjam	Chevron Products Co.
R. Gault	EMA	F. Passman	BCA Inc.
G. C. Gunter	Phillips 66	S. Rubin-Pitel	ExxonMobil
R. Leisenring	KIOR	D. Z. Short	Marathon Petroleum Co.
R. P. Lewis	Marathon Petroleum Co.	S. A. Westbrook	SwRI
T. Livingston	Robert Bosch		

MEMBERSHIP

DP – FUEL CORROSION PANEL
(PROJECT NO. DP-07-13)

D. Lax, Ldr. — API

R. Chapman	Innospec	J. Eichberger	NACS
T. Covert	Ford	M. Kass	ORNL
S. Curran	Fiberglass Tank & Pipe Inst.	R.P. Lewis	Marathon Petroleum Co.
J. Eckstrom	BP	P. Miller	US EPA
E. W. English	Fuel Quality Services	K. Moriarty	NREL
R. Gault	Truck & EMA	M. Nikanjam	Chevron Products Co.
L. Gerber	US EPA	B. Renkes	PEI
L. Grainawi	Steel Tank Inst.	P. Searles	API
A.M. Gregg	Battelle	D. Z. Short	Marathon Petroleum Co.
G. C. Gunter	Phillips 66	K. Spiker	Quiktrip
R. Haerer	US EPA	S. A. Westbrook	SwRI