CRC

ANNUAL REPORT

2018

COORDINATING RESEARCH COUNCIL, INC.

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COORDINATING RESEARCH COUNCIL ANNUAL REPORT

September 2018

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PART ONE

STATE OF THE COUNCIL

STATE OF THE COUNCIL - 2018

The technical committee from the 1920s that became the Coordinating Research Council in 1942 would find much of the current CRC Committees familiar in structure and membership, despite the many decades of technical progress and expanded focus. CRC continues to provide the means for the automotive and energy industries to work together on joint research of mutual interest, and encourages cooperation and communication on research between industries, governments, and the scientific community at large.

CRC technical work during the 2018 research program year continues to enjoy broad cooperation on projects and technical workshops. Research partners in 2018 span the stakeholder community, including: the U.S. Environmental Protection Agency (EPA), the California Air Resources Board (CARB), the Health Effects Institute (HEI), the South Coast Air Quality Management District (SCAQMD), the Truck and Engine Manufacturers Association (EMA), the U.S. Department of Agriculture (USDA), many of the U.S. Department of Energy (DOE) National Laboratories, numerous researchers who participate in CRC workshops including those from academia, and others such as trade organizations interested in fuel effects.

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. Select research projects conducted by CRC are also reported in the peer-reviewed literature. Brief highlights from the technical committees are summarized below.

The Atmospheric Impacts Committee produced several reports this year documenting projects that improved knowledge of atmospheric chemistry relationships and modeling. This Committee and the EMA co-sponsored the Southern California Ozone Research Symposium (SCORES) on June 6-7, 2018 at the University of California, Riverside. Members of the Committee along with the Organizing Committee are currently planning the biennial Mobile Source Air Toxics (MSAT) Workshop for February 4-6, 2019 in Sacramento, CA hosted by CARB.

The Advanced Vehicle/Fuel/Lubricants (AVFL) Committee published the results of a study exploring new tests for engine wear relating to lubricants, an exploration of a new method for speciating gasoline, and the results of a project exploring the relationship between fuel properties, engine hardware and efficiency in a modern engine platform, performed in partnership with the DOE's Oak Ridge National Laboratory.

The CRC Emissions Committee continued its examination of fuel effects on emissions of modern engines, explored the relationship between laboratory testing and portable emissions measurement systems, and published a review of the effects of metal additives in fuels. The Committee's Real World Group reported on ongoing efforts to improve emissions measurements techniques, and explored new ways of modeling the impacts of biofuels on greenhouse gas inventories. Many reports were published by this Group from the multi-decade study of in-use vehicle fleet emissions levels, covering both ongoing data collection efforts and studies that used the large historical database to answer research questions about the effects of fuel changes and the distribution of emissions levels. This Group held the 28th Real World Emissions Workshop in Garden Grove, CA on March 18-21, 2018 with another attendance record, and continues to enjoy broad sponsorship from government and industry. The next event is being planned for March 10-13, 2019 in Long Beach, CA. The 5th 2017 CRC Life Cycle Analysis Workshop was held at Argonne National Laboratory on October 25-26, 2017, and planning is underway for the 6th Workshop at the same location on October 16-17, 2019.

The Performance Committee reported on a review of modern methods to evaluate vehicle performance & driveability, and explored the mechanisms involved with fuel system performance issues. From the Committee's Diesel Performance Group, another guide for the benefit of the public was produced, this time covering renewable hydrocarbon diesel fuel properties and performance.

The Aviation Committee published the results of studies examining fuel quality, fuel safety, and fuel/additive test methods in support of the flying public.

Details on these completed studies and ongoing CRC committee 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

CRC WORKSHOP ON LIFE CYCLE ANALYSIS OF TRANSPORTATION FUELS

CRC Project No. E-93-5

Leaders: J.H. Farenback-Brateman
A. Levy
R. De Kleine

Scope and Objective

CRC has hosted four invitation-only Life Cycle Analysis (LCA) workshops, starting in 2009. The 2009, 2011, 2013, and 2015 workshops held in October at Argonne National Laboratory (ANL) near Chicago were each attended by more than 100 LCA experts from government, industry, academia, and non-governmental organizations (NGOs). Workshop summaries are posted on the CRC website. The fifth workshop was held October 25-27, 2017 at ANL.

Current Status and Future Program

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, Phillips 66, Renewable Fuels Association (RFA), Marathon Petroleum Company LP, ExxonMobil Research & Engineering, ANL, SCAQMD, the University of Michigan, the University of Toronto, the European Joint Research Center's Institute for Environment and Sustainability, the Union of Concerned Scientists, and the International Council on Clean Transportation. The 2017 workshop sponsors included API, ANL, CARB, Canadian Fuels Association, Concawe, NBB, RFA, USDA, University of Michigan Energy Institute, and the Union of Concerned Scientists.

EMISSIONS COMMITTEE

The current workshop goals are to:

- Outline technical needs arising out of policy actions and ability of LCA 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 5th workshop addressed these goals through 18 invited technical presentations in 5 sessions including Retrospective Analysis and Implications for LCA, LCA Methodology, Soil Organic Carbon, Alternative Carbon Modeling Methods, and LCA of Emerging Technologies. The 2017 workshop hosted over 100 attendees, and a summary, authored by Kent Hoekman of Desert Research Institute, is available on the CRC website. A sixth workshop will be planned for 2019.

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 / E-94-2a / E-94-3

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

P. Loeper (E-94-3)
D.M. DiCicco (E-94-3)

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 particulate mass/particle number (PM/PN) 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.

Current Status and Future Programs

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 Research Octane Number (RON), Motor Octane Number (MON), sulfur, olefins, aromatics, oxygen, benzene, hydrogen, Reid Vapor Pressure (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 measured. PM/PN characterization included:

- PN: solid particles >23 nanometers in size.
- PM: standard filter method using the EPA 1065 protocol.
- Real-time black carbon or soot (mass-based): AVL Micro Soot Sensor.
- PM/PN size distribution: Engine Exhaust Particle Sizer (EEPS).
- Soot morphology using organic carbon / elemental carbon (OC/EC); also amount of sulfur contained in particulate.

Southwest Research Institute® (SwRI) performed the E-94-1 pilot study; the final report was published on the CRC website in June 2014.

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 emission measurements after a fuel change. The Final Report was published on the CRC website in December 2014.

Project E-94-2, "Fuel Effects on Gaseous and Particulate Emissions on SIDI In-use Vehicles," 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 incorporated the improved procedures validated in the E-94-1a study. SwRI performed the testing, Gage Products provided the fuel, and Robert Crawford of Rincon Ranch Consulting performed the statistical analysis under Project E-94-2a.

EMISSIONS COMMITTEE

The E-94-2 Final Report was published on the CRC website in March 2017.

In order to make the best use of leftover test fuels and the availability of a well-characterized test fleet, an additional study was developed: CRC Project E-94-3, "Fuel Effects On Gaseous And Particulate Emissions On SIDI In-Use Vehicles: Scoping Study For Splash Blending." The objectives were to collect information and evaluate differences in particulate emissions between match and splash blended E10 formulations. Four vehicles from Project CRC E-94-2 were selected. Specific goals of this research phase included:

- Determine gaseous and PM/PN emissions with E10 splash blended fuels.
- Determine fuels impacts on gaseous and PM/PN emissions and particulate morphology with turbocharged and naturally-aspirated engine technologies.
- Determine if there are any significant differences between the PM/PN emissions from splash blended and match blended E10 fuels.

The Final Report for E-94-3 was published on the CRC website in May 2018.

EMISSIONS COMMITTEE

REVIEW OF CRITICAL PARAMETERS FOR CORN ETHANOL AND SOYBEAN RENEWABLE DIESEL PATHWAYS

CRC Project No. E-102-2

Leader: A. Kapur

Scope and Objective

In 2013, CRC sponsored the E-102 study to better quantify sources of uncertainty and variability in selected Life Cycle Analysis (LCA) models that are being used to regulate fuels by conducting an in-depth evaluation of model inputs, and the associated uncertainties.

Current Status and Future Program

This follow-on project supports the uncertainty analysis from E-102 with published literature. The study assessed three LCA models used for regulation; namely, GREET, GHGenius, and BioGrace. The investigation focused on the well-to-wheel emissions of the following pathways:

- Petroleum gasoline/diesel
- Corn ethanol
- Soybean biodiesel/renewable diesel (RD)
- Sugarcane ethanol
- Cellulosic ethanol
- Natural gas

The objective was to find a range of values and/or parameter distributions outside of the default values for a specific pathway in GREET, GHGenius, or BioGrace. The work was divided into the following subtasks:

Task 1: Review of Literature for Corn Ethanol Pathway: The specific objective of this task is to review the literature for N_2O emissions and ethanol plant energy use for corn ethanol pathway.

Task 2: Review of Literature for Other E-102 Pathways: In addition to corn ethanol, other key parameters for petroleum and biofuel pathways listed were identified.

The specific objectives of these tasks were to:

1. Conduct a literature review of data published between 2010-2015 to determine a range of values for key parameters in GREET 2014, BioGrace v.4c and GHGenius v4.03a.

2. Determine if there are additional key parameters for these pathways.

3. Scan the literature to assess potential future trends for the key parameters.

$(S\&T)^2$ was selected to perform the research. Based upon LCA panel's feedback, the original scope of work was extended to include characterization of the influence of key parameters on the carbon intensity of each fuel pathway. During Phase II of the study, $(S\&T)^2$ generated sensitivity analysis results for each fuel pathway using the Monte Carlo method for all three LCA models and using the range of inputs generated in Phase I. The Final Report was posted to the CRC website in March 2018.

EMISSIONS COMMITTEE

REAL WORLD VEHICLE EMISSIONS WORKSHOP

CRC Project No. E-110

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

Scope and Objective

For nearly three decades, 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.

Current Status and Future Program

The 28th Real World Emissions Workshop, held March 18-22, 2018 in Garden Grove, CA, consisted of 50 presentations, 47 posters, and 8 demonstrations. In addition, two keynote presentations were made by Tahmid Mizan, Manager of Global Regulatory Affairs at Exxon Mobil Fuels and Lubricants Company, and Steven Cliff, Deputy Executive Officer at California Air Resources Board. The Workshop included a student poster competition with twelve entries. A record number of 252 participants from 12 countries attended. Co-sponsors for the Workshop were CARB, EPA, NREL/DOE, EMA, and SCAQMD.

A summary journal article on the research reported at the 27th Workshop authored by the Organizing Committee, was published in the October, 2017 edition of EM Magazine of the *Air and Waste Management Association,* and a link to the article is available on the CRC website. A similar summary article of this year's workshop is being prepared.

The 29th Real World Emissions Workshop will be held in Long Beach, CA on March 10-13, 2019.

COMBUSTION AND EMISSIONS CHARACTERISTICS OF A MEDIUM-DUTY VEHICLE OPERATING ON A HYDROGENATED VEGETABLE OIL RENEWABLE DIESEL

CRC Project No. E-117

Leaders: D.Z. Short
J. Cruz

Scope and Objective

Recently, renewable diesel fuel has been offered at 32 stations within California. This fuel has a much higher cetane number of 70-95 compared to the average Ultra Low Sulfur Diesel (ULSD) cetane number of 40-45. In addition, the fuel has a different energy density, distillation, hydrocarbon content, and viscosity compared to the average ULSD fuel in the U.S. market.

Hydrogenated vegetable oil (HVO) renewable diesel has been introduced into the market in response to Renewable Fuel Standard (RFS) and Low Carbon Fuel Standard (LCFS) requirements for more renewable fuels. There is a poor understanding of how this particular type of renewable fuel may influence a change in either the combustion process or the emissions from an engine relative to operation on a conventional petroleum-based ULSD fuel.

Current Status and Future Program

This study aims to determine the effects of a commercially available renewable diesel fuel on the engine-out gaseous and PM emissions of a medium-duty vehicle. In addition, the study will measure and analyze the engine combustion characteristics associated with the use of this renewable diesel fuel.

The project has been awarded to CE-CERT, and is in progress, with final reporting anticipated late 2018.

EMISSIONS COMMITTEE

HAGER ENVIRONMENTAL & ATMOSPHERIC TECHNOLOGIES (HEAT) AND DENVER UNIVERSITY (DU) REMOTE SENSING DEVICE (RSD) DATA MINING

CRC Project No. E-119-2

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

Scope and Objective

An on-road emission tailpipe survey was conducted by CRC participants using the HEAT emissions data and reporting (EDAR) system and the DU fuel efficiency automobile test (FEAT) system in Chicago during fall 2016. While these two systems differ greatly in how they operate, they measure the same pollutants. Performing data comparisons will provide further confidence to support the notion of low vehicle emissions across the fleet as well as provide an assessment of the two data sources.

Current Status and Future Program

Tailpipe emissions results for CO, CO_2, NO, and HC from HEAT (E-119) and DU (E-106 and E-119a) databases were analyzed to determine if they are statistically similar using a 95% confidence level. The DU dataset was truncated to contain data that was gathered only when EDAR was also gathering data. Tailpipe emissions were analyzed by comparing the matched EDAR and DU datasets as well as comparing individual vehicles that were measured multiple times by both systems. The results of the analyzed datasets were segmented by vehicle emissions certification levels (SULEV 30, Tier2Bin5, etc.) to explore the detection capabilities at varying emission rates. The contractor reported at what confidence level the comparison between EDAR and DU data is statistically similar. In addition to determining similarity, the contractor reported the mean, median, and standard deviation for each emission for each dataset.

In addition to the tailpipe emissions, the fraction of high emitting vehicles for 2005MY and newer vehicles were compared between the datasets, and the speed and acceleration data were analyzed to assess whether the differences were statistically significant.

Ultimately, the goal of this project was to compare as many areas in the list below between EDAR and FEAT as possible:

1. How well do the measured emissions and variabilities compare between the systems?
2. How well can the measurement systems detect classes of vehicles; such as high emitters?
3. How well can the systems measure at low levels? What is the limit of detection?
4. How well do the systems record vehicle speed and acceleration?
5. How effectively can the systems cover a range of vehicle specific power bins (as used in EPAs MOVES model)?

The contract was awarded to Charles Blanchard and began in the fourth quarter of 2017. The Final Report for this project was released on the CRC website in August 2018.

EMISSIONS COMMITTEE

LIGHT-DUTY PORTABLE EMISSIONS MEASUREMENT SYSTEM (PEMS) VALIDATION/CHASSIS DYNO CORRELATION

CRC Project No. E-122

Leaders: M.B. Viola
D.Z. Short

Scope and Objective

The objective of Project E-122 is to develop a better understanding of Portable Emissions Measurements Systems (PEMS) and how they perform compared to chassis roll dynamometer emissions results.

Current Status and Future Program

A drive cycle was developed and used for vehicle testing on the road and on a chassis dynamometer. This cycle incorporated city, urban, and highway driving to determine how well the PEMS measurements correlate to that of a chassis dynamometer emission test cell. The test is conducted several times to understand the variation in emissions that occur and how they change on the same route on a daily basis. Several PEMS units will be used, one at a time, to measure the tailpipe emissions. This will enable comparison of each PEMS unit under real-road driving conditions. An average of three to five drive cycles was used to program a chassis dynamometer in order to conduct chassis dynamometer emissions testing. The PEMS unit will also measure emissions at the same time on the chassis roll for direct comparison. Additionally, the same real world cycle is being conducted on a closed track to determine how repeatable the PEMS units are on the road without the variations one might encounter in real driving.

Specific goals include:

- Determine the repeatability of each PEMS unit with real road driving.
- Determine the repeatability of the chassis roll testing to compare to each of the PEMS units.
- Determine how driving on a closed track on the same real world driving impacts PEMS measurements.
- Conduct same testing on a rough road to determine if road roughness impacts PEMS emissions.
- Determine which exhaust flow measurement instrument from the individual PEMS system correlates best with the direct vehicle exhaust flow meter from the test cell and with the CVS bags based on CO_2.

ERG performed this project, completing testing using three different PEMS units. Real-world testing was completed on-road, and on smooth- and rough-surfaced test tracks. The Final Report was posted on the CRC website in June 2018.

EMISSIONS COMMITTEE

LIGHT-DUTY PORTABLE EMISSIONS MEASUREMENT SYSTEM (PEMS) PURCHASE AND STATISTICAL ANALYSIS PROJECT DEVELOPMENT

CRC Project No. E-122-2/ E-122-2a/ E-122-2b/ E-122-2c

Leaders: M.B. Viola
D.Z. Short

Scope and Objective

With Europe adopting the use of PEMS to determine light duty real world emissions, there is a greater interest in their functionality and use. Both CARB and EPA have been conducting tests here in the United States with light duty vehicles to determine their viability to measure real world on-road emissions

This project aims to investigate the use of multiple engine technologies and different fuel properties to determine PEMS performance in measuring emission changes during on road and chassis roll tests.

The objective of Project E-122-2 is to use the on-road cycle developed in CRC Project E-122 which incorporates city, urban and highway driving. Several engine technologies will be used for testing along with different fuel properties to investigate how well PEMS can detect fuel property impacts on emissions. Summer and Winter fuels, each having a low and high Particulate Matter Index (PMI), as described by the Honda method, will be used for testing. A total of four fuels will be run on each of four vehicles multiple times to understand the variation in emissions that occur and how they change on the same route on a daily basis. A CRC-owned PEMS unit purchased under Projects E-122-2b and E-122-2c will be used to measure the tailpipe emissions. Repeat testing will be conducted on a chassis-dynamometer for comparison to the PEMS unit, which will also measure emissions at the same time on the chassis roll for direct comparison. Specific goals of this project include to determine:

- the repeatability of the chassis roll testing to compare to the PEMS unit;
- the repeatability and accuracy of PEMS unit under real on road driving conditions and changing ambient temperatures;
- if the PEMS unit can measure differences in gaseous and PM emissions with respect to changes in PMI and/or Reid Vapor Pressure (RVP) of the fuel;
- and, how exhaust flow measurement from the individual PEMS system correlates with the direct vehicle exhaust flow meter from the test cell and with the CVS bags based on CO_2.

To make certain the testing data collected would be suitable for statistical analysis, a statistician contracted through E-122-2a to help develop the test matrix for this project and define:

- how many tests would be conducted on each fuel and vehicle as well as order of testing;
- how many vehicles would be used of each technology for testing, (one hybrid or two of the same type);
- and, how many market fuels will be used for testing and what fuel properties will be investigated;

The statistician will be involved throughout the project on regular project calls to help guide decisions and conduct all the statistical analysis on the project data at the end of testing. They will provide all of the analysis as well as support write up for the Final Report.

Current Status and Future Program

A demonstration of a PEMS unit was completed at Southwest Research Institute in May 2018. The purchase of the PEMS unit is expected to occur in late 2018. A statistician is under contract to support the development of a statistically sound testing matrix and to support the test-phase data analysis.

The statement of work for this project has been approved and is expected to be released on the CRC website.

EMISSIONS COMMITTEE

CONTINUED MONITORING OF E-23/E-106 SITE EMISSIONS

CRC Project No. E-123

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

Scope and Objective

Project E-23 achieved historically significant on-road emission measurements from six cities, Chicago, Denver, Los Angeles, Phoenix, Omaha, and Tulsa using consistent equipment and calibration methods between 1997 and 2006. Project E-106 and a companion California Air Resources Board contract extended those measurements beginning in 2013 in Chicago, Denver, Los Angeles, and Tulsa. The longer the historical record is, the more that can be learned, because the effect of age on fleet emissions can be observed without the confusion caused by the effect of changing model years.

Current Status and Future Program

Project E-123 will repeat the E-106 schedule and return to Tulsa, Denver, and Chicago on an alternating two-year schedule. There will be one measurement campaign (one five-day week) each year, alternating locations starting in 2017. The plan is to return to the E-106 Tulsa site in the early fall of 2017 and 2019, Denver in the winter of 2018 and 2020, and the Chicago site in the early fall of 2018 and 2020. The equipment that will be used is the same equipment used in E-23 and E-106; it can monitor CO, HC's, NO, NH_3 and NO_2 in real time from each passing vehicle. Typically, each test campaign yields 20,000 to 25,000 valid emissions readings. Project E-123 is therefore expected to provide between 120,000 and 140,000 vehicle emissions readings.

As a continuation of earlier research, this project was awarded to Denver University. Testing in Tulsa was completed in September 2017, and the Final Report was added to the website in March 2018. A draft report for testing completed in Denver 2017 is under review. Testing was completed in Chicago this fall, and work is expected to continue into 2020.

EVALUATION OF REFORMULATED GASOLINE (RFG) FOR RFG AREAS

CRC Project No. E-123-2

Leaders: D.M. DiCicco
S.K. Berkhous

Scope and Objective

The definition and use of federal reformulated gasoline (RFG) were first stipulated under the Clean Air Act Amendments (CAAA) of 1990. Full implementation of Phase I RFG regulations began in 1995; Phase II RFG was implemented in 2000. The primary purpose of RFG regulations is to address high concentrations of pollutant ozone. In 1998, the EPA "Complex Model" replaced the Simple Model for determining compliance with the Phase I RFG emissions reduction requirements. The emissions reduction requirements for RFG were originally established relative to the 1990 in-use vehicle fleet. The Simple and Complex models were based upon results from experimental studies meant to represent that fleet. To determine compliance with the emissions reduction requirements of RFG, the properties of a candidate fuel are inserted into the Complex Model, and a new set of fleet-wide emission values are calculated (for both exhaust and non-exhaust pollutants). Comparison of the predicted emissions with the baseline emissions is used to demonstrate attainment of the required reductions.

Current Status and Future Program

This project was conducted in two phases: Phase I of this project consisted entirely of literature work, with no experimental component and was conducted by the Desert Research Institute. The two main objectives of Phase I were:

(1) Determine and summarize evaluations of RFG's effectiveness that had already been conducted.

(2) Using available information about gasoline composition in RFG and non-RFG areas, assess emissions impacts of RFG over the period of 2000 to 2015. By inserting fuel compositional data into

the Complex Model spreadsheet, the emissions reduction of both RFG and non-RFG compared to the same baseline were estimated.

Phase II included on-road remote sensing of RFG vs. non-RFG automobile emissions. Phase II was carried out by the University of Denver by conducting a vehicle emissions data analysis comparing RFG areas with non-RFG areas 2000 – 2015 with an emphasis on 2012 – 2015.

The project was awarded to a team of Denver University and Desert Research Institute. The Final Report was completed in April 2018 and is available on the CRC website. A publication of this work is anticipated.

RSD MEASUREMENTS IN LYNWOOD, CA

CRC Project No. E-124

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

Scope and Objective

In 1989, Denver University (DU) visited Los Angeles, California with their first FEAT instrument that was only capable of measuring carbon monoxide and carbon dioxide and collected measurements in a number of locations. One of the sites visited was Lynwood, CA. In 1991, DU revisited Lynwood with a newer FEAT instrument that also included hydrocarbon capabilities and again collected emission measurements. In 1989, vehicle fleets on Long Beach Blvd. averaged 8.7 years old while fleets surveyed at the other locations ranged from 5 to 7 years old. When DU returned in 1991, the Long Beach Blvd. fleet had increased in age to almost 11 years old, which is still the oldest fleet that DU has ever sampled. The fleet ages were a reflection at that time of the economic conditions found in the Lynwood area.

Current Status and Future Program

In Project E-124, DU will return to the Lynwood area and collect measurements using the latest FEAT instrument and collect measurements at both the Long Beach Blvd. and I-710/Imperial Highway locations. These measurements will be compared with the 1989 and 1991 Lynwood measurements along with more recent data sets collected at the West Los Angeles and other E-23/E-106 sites.

This project was awarded to DU in mid-2017, who completed RSD measurements at the Lynwood site in early May. The Final Report is expected in late 2018.

EMISSIONS COMMITTEE

DETAILED HYDROCARBON ANALYSIS (DHA) AND PARTICULATE MATTER (PM) EMISSIONS DATA MINING

CRC Project No. E-127-1

Leaders: D.M. DiCicco
P. Loeper

Scope and Objective

Analyze DHAs for the 12 fuels used in Projects E-94-2 and E-94-3 to better understand which hydrocarbons or group of hydrocarbons correlate with PM emissions from the E-94 program.

Current Status and Future Program

There will be two contractors for this project. The first contractor will reprocess the chromatograms from the DHAs for the 12 fuels used in the E-94 project by following the method described in CRC Project AVFL-29. The intention is for the contractor to identify all hydrocarbons.

The second contractor will study and analyze the DHAs from the first contractor and tailpipe PM emissions values from Project E-94 to identify individual hydrocarbons that correlate with increasing PM formation tendency. Any values in the DHAs described as "unknown" will be ignored for the analysis. Any hydrocarbon that is not present in at least 4 of the fuels will also be ignored for the analysis. The PM emissions results for the Mercedes-Benz GLK350 from Project E-94 will not be considered in the analysis. CRC is open to suggestions from the contractor regarding what defines a correlation between hydrocarbons and increasing PM formatting tendency.

The contractor will look at each vehicles PM emissions individually, determine hydrocarbons that correlate with the vehicles PM emissions, and repeat for all other valid vehicles. Upon completing this task, the list of hydrocarbons for each vehicle will be compared to each other and those hydrocarbons that correlate to PM emissions for multiple vehicles will be noted.

EMISSIONS COMMITTEE

Enhanced DHA results from nineteen different fuels that were delivered to the contract laboratory are undergoing further analysis and investigation.

EMISSIONS COMMITTEE

ALTERNATIVE OXYGENATE EFFECTS ON EMISSIONS

CRC Project No. E-129/ E-129a

Leaders: S.K. Berkhous
M. Valentine

Scope and Objective

The objective of this study is to evaluate the impact of oxygenated blendstocks on tailpipe emissions, in particular PM emissions, from current in-use SIDI vehicles.
Four SIDI vehicles from Project CRC E-94-2 were used for this testing program.

Seven different fuels, including a base hydrocarbon fuel and six oxygenate blends were evaluated over the same test protocols established in Project E-94. The oxygenated blends included:

Ethanol
- 10% Volume Ethanol
- 15% Volume Ethanol

Isobutanol
- 16% Volume Isobutanol
- 24% Volume Isobutanol

Ether
- 19% Volume MTBE
- 29% Volume MTBE

Current Status and Future Program

The competitive solicitation was awarded to SGS, which has a newly acquired testing facility located at Sea Level in Columbus, IN. Work is ongoing, and is expected to be completed near the end of 2018.

Robert Crawford of Rincon Ranch Consulting was awarded the contract for E-129a to provide statistical support of the data collected during the project.

LITERATURE REVIEW TO ASSESS THE USE OF STOCK AND FLOW MODELS COMPARED TO OTHER GHG METHODOLOGIES TO MODEL BIOFUEL GHGS

CRC Project No. RW-104

Leaders: W. Chernicoff
A. Kapur
D.Z. Short
L. Verduzco

Scope and Objective

Attributional lifecycle assessment (LCA) models have been used by researchers and policymakers for a number of years. Due to their limitations in addressing certain aspects of the lifecycle of biofuels, the scientific literature from researchers and LCA practitioners has put their effectiveness into question. As the practice of GHG assessment has expanded, new approaches have emerged, providing better definition and answering new questions. Although LCA models have continued to update and become more complex, their underlying methodologies are limited.

Current Status and Future Program

This project is expected to be a comprehensive review of existing literature and a study of the strengths and weaknesses of stock and flow models compared to other methodologies such as the more traditional attributional and consequential LCAs used by policy makers. Literature and models will cover approaches to measuring GHG values, sustainability, and ecosystem service effects of biomass and plant-based fuels from seed to consumer use.

The literature review should:

- Be comprehensive in scope, and seek out peer reviewed literature and studies that have a sufficiently broad scope and cover the breadth of modeling and analysis approaches, are process-based, whether empirical or theory-based.

EMISSIONS COMMITTEE

- Provide a description of the carbon stocks and flows methodology and explain data requirements to develop a carbon cycle budget.
- Explain the advantage of applying the carbon stocks and flow methodology over other types of carbon assessments.
- Include critiques, strengths, weaknesses, and limitations of the methodologies/models found in the literature.
- Explain the uncertainty of the results and how the models can be validated.
- Explain whether other types of modeling approaches such as LCA can be used to estimate carbon flows.
- Include a section on knowledge and research gaps.
- Avoid recommending specific values or models for policymaking.
- Describe the current status of stock and flow models, as well as potential improvements and data needs to use this approach as a tool for measuring greenhouse gas flows.

The project was awarded to Savant Technical Consultants, and the Final Report was released on the CRC website in July 2018.

ASSESSMENT OF THE RELATIVE ACCURACY OF THE PM INDEX AND RELATED METHODS

CRC Project No. RW-107

Leaders: J.J. Jetter
R.P. Lewis

Scope and Objective

The EPA, Honda, and others have confirmed that the PM Index (PMI) can reasonably predict the relative particulate-forming tendency of a gasoline. The only fuel analysis required to calculate a PM Index is a DHA (detailed hydrocarbon analysis). However, performing the high-quality DHA required for PM Index determination may be beyond the capability of some laboratories. This has led to the search for potential alternatives to the original PM Index that do not require a DHA. For example, Ford has developed an Oxygen Extended Sooting Index (OESI), which incorporates fuel smoke point measurements and various fuel volatility metrics. GM has developed the Particulate Evaluation Index (PEI) which is based on fuel aromatic content, and also the Particle and Soot Correlation Equation (PASCE), which uses E170 and the C/H ration of the fuel. JAMA has proposed a Simplified PM Index that uses only the volatility parameters of the fuel; one version of the equation uses E130 and E170, and another version uses only E150.

These variations of the PM Index have all been developed using different vehicles and fuel matrices. The objective of this project is to compare the performance of PM Index alternatives to the original PM Index, using datasets representing a variety of vehicle technologies and fuel formulations. The proposed metric would be the correlation coefficient resulting from a comparison of the PM Index alternative to actual (measured) particulate mass and particulate number. The contractor will choose the appropriate correlation coefficient—or other metric(s)—for this task. (Note that PM Indices do not predict PM or PN emissions; rather, they indicate the relative propensity of the fuel to form particulates. The slope of the trend line is related to the sensitivity of the vehicle to fuel formulation.)

A second objective is to compare the performance of an enhanced PM Index to the original PM Index, where the enhanced Index is calculated using the results of the new DHA developed in AVFL-29.

Current Status and Future Program

Project RW-107 was awarded to Rincon Ranch Consulting, and began in the second quarter of 2018. Work is ongoing.

IMPROVED DIESEL SURROGATE FUELS FOR ENGINE TESTING AND KINETIC MODELING

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

Leaders: W. J. Cannella
J. E. Anderson

Scope and Objective

The objective of this work is to establish and evaluate a methodology for formulating surrogate fuels 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 could enable improved engine function 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.

Project AVFL-18 was 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) and the Army Research Laboratory. The National Institute of Standards and Technology (NIST) assisted 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 May 2012 in *Energy & Fuels* and is currently available on their 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 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.

Researchers at the Army Research Laboratory, SNL, and National Research Council Canada are performing single-cylinder engine and combustion vessel testing of the 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. Publications are in development by the individual participating laboratories to document the testing and evaluation of the surrogate diesel fuels, and links will be posted to the CRC website when they are available.

The first article under AVFL-18a was published in *Energy & Fuels* (January 2016) covering creation of the surrogate fuels in sufficient quantities for engine and combustion-vessel testing, as well as subsequent physical and chemical property measurements.

CanmetENERGY provided CRC with an report decribing work conducted under AVFL-18a on GCxGC analysis of surrogate component purity, titled: "GC×GC Studies of Palette Compounds Used In the Next Generation of Diesel Fuel Surrogate Blends." This report has been posted on the CRC website following review and approval by the committee in December 2016.

Freezing point evaluations at elevated pressures have been conducted at Pacific Northwest National Laboratory on the surrogate test fuels to determine phase change conditions that may impact laboratory combustor and engine operations. NIST has again supported the project with additional surrogate fuel property analyses. NIST published their most recent work in January 2017, "Preliminary Models for Viscosity, Thermal Conductivity, and Surface Tension of Pure Fluid Constituents of Selected Diesel Surrogate Fuels" as a NIST report.

The Panel is overseeing the research conducted under CRC Contract No. AVL-18a-1, "Autoignition Study of CRC Diesel Surrogates in a Rapid Compression Machine," at the University of Connecticut. Final reporting is anticipated in fall of 2018.

The AVFL-18 Panel continues to hold regular conference calls to share results from Panel Members and Laboratory Partners for this ongoing research program.

AVFL COMMITTEE

OCTANE NUMBER, ENGINE EFFICIENCY, AND CO2: FILLING LITERATURE GAPS

CRC Project No. 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 fuels 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 was conducted on a Ford 1.6L turbocharged direct injection (DI) EcoBoost engine. Flint Hills Resources was 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. Detailed Hydrocarbon Analysis (DHA) of the test fuels was performed by Chevron.

The test fuel matrix allowed exploration of a wide range of ethanol content (10 to 30 vol%), research octane number (91 to 102), and sensitivity (S=RON-MON) (6 to 7 and 10 to 12). ORNL 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. Using these data, vehicle-level modeling was used to estimate efficiency, fuel economy, and tailpipe CO2 emissions for these fuels in two vehicles with this engine. The Final

Report for AVFL-20, "Effects of Octane Number, Sensitivity, Ethanol Content, and Engine Compression Ratio on GTDI Engine Efficiency, Fuel Economy, and CO2 Emissions," was published on the CRC website in November 2017.

A naturally aspirated 1.4L test engine with port fuel injection (PFI) was provided by FCA for the companion AVFL-20a project. Testing on the PFI engine (AVFL-20a) has been transferred to ORNL/DOE. ORNL continues to consult with the AVFL Committee for the technical oversight of this activity in an informal capacity. Testing is expected to occur in the fall of 2018. Engine and vehicle-level performance modeling are also planned by ORNL.

AVFL COMMITTEE

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 objective of AVFL-26 is to evaluate the effects of a range of other combinations of gasoline properties and compositions on a next-generation advanced engine platform aimed at maximizing fuel efficiency.

Current Status and Future Program

The fuel matrix in this study includes E0, E10, E30; high and low RON; and high and low distillation end point to represent possible impacts on particulate matter (PM) 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.

Gage Products Company has prepared the fuels. The engine was provided and set up by GM at IAV. CRC is supporting the testing, which is ongoing. Final reporting is anticipated in early 2019.

HEAT OF VAPORIZATION MEASUREMENTS OF GASOLINE AND ETHANOL BLENDS

CRC Project No. AVFL-27 and AVFL-27 Phase 2

Leaders: M. B. Viola
W. J. Cannella

Scope and Objective

These projects are evaluating methods for measurement of the heat of vaporization (HOV) for gasoline and ethanol/gasoline blends using laboratory procedures, and is exploring alternate methods of determining the HOV as a function of boiling point and composition.

Current Status and Future Program

A competitive request for proposal (RFP) was issued and proposals were reviewed by the project panel. The committee approved funding for two laboratories. CRC 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. Fuels A and H would be tested at three ethanol blend levels (10%, 15%, and 30%). Iso-octane served as a reference compound for which the HOV is well known. Samples of the test fuels were sent to UDEL and NREL. Thermogravimetry with Differential Scanning Calorimetry (TGA/DSC) methods were used by both laboratories. In addition to direct measurements made by TGA/DSC, a calculation method based on Detailed Hydrocarbon Analysis (DHA) compositional data was explored at NREL. Testing at both laboratories was completed in 2015.

AVFL COMMITTEE

Results from both laboratories were reviewed by the project panel and documented in final reports submitted by NREL and UDEL. The Final Report for Phase 1 of the project, "Heat of Vaporization Measurements of Gasoline and Ethanol Blends" was published in August 2016 and consists of a single document with both contractor reports (Parts A and B) and an Executive Summary prepared by the committee. Phase two of the project is in development.

GASOLINE TURBOCHARGED DIRECT INJECTION (GTDI) ENGINE WEAR TEST DEVELOPMENT

CRC Project No. AVFL-28 and AVFL-28 Phase 2

Leaders: G. C. Gunter
T. Kowalski

Scope and Objective

Gasoline Turbocharged Direct Injection (GTDI) engines often produce more severe operating conditions than PFI engines. GTDI engines operate at higher temperature, higher cylinder pressure, and higher specific torque. GTDI engines are often downsized, causing them to operate at higher load for a larger fraction of operating time. Some modern engines also use alternative combustion cycles (Miller/Atkinson, for example) or stop/start technology which subjects the engine and lubricant to new types of stress compared to conventional PFI engines. Some GTDI engines use certain lubricated components not represented in current wear tests based on PFI engines; for example, turbocharger bearings, polymer-coated bearings, and aluminum alloy bearings. For these reasons, a new test for GTDI engines is needed to be representative of current and future engine technologies.

The project objective is to develop a procedure for testing wear performance of engine lubricant (motor oil) for use in GTDI engines operating in high-fuel-economy duty cycles. Elements of this test protocol include:

- Test engine candidates
- Test engine configuration and component selection
- Test engine operating conditions
- Test methods and criteria to measure engine wear
- Criteria to rate lubricant performance

CRC does not establish lubricant specifications or define certification procedures. Data generated from CRC research can be used by lubricant standards-setting organizations that may develop lubricant specifications and engine wear tests as they see fit.

AVFL COMMITTEE

The purpose of this project is to determine general sensitivities of GTDI engine technology and to develop appropriate operating conditions to test those sensitivities. The purpose is not to point out the sensitivities or weaknesses of any particular engine model.

Current Status and Future Program

In AVFL-28, a series of in-field operating conditions were selected, and the engine operated at these conditions using both a SAE 5W-30 oil and a SAE 0W-16 oil with the same additive package. Engine components were examined using Radionuclide Tracer (RNT) techniques to identify sensitive engine parts and performance conditions.

The Final Report for AVFL-28, "Gasoline Direct Injection (GDI) Engine Wear Test Development" was published on the CRC website in January 2018. In AVFL-28 Phase 2, SwRI is evaluating the wear performance of the same GTDI engine using the same engine and operating procedures and test matrix as in AVFL-28, with a focus on different engine components to extend the work of the prior project. Final reporting for AVFL-28 Phase 2 is expected in late 2018.

ENHANCED SPECIATION OF GASOLINE

CRC Project No. AVFL-29

Leaders: J. J. Jetter
W.J. Cannella

Scope and Objective

Most Detailed Hydrocarbon Analyses (DHAs) are performed with ASTM Method D6730, or a variation thereof. This is a gas chromatography method in which many species are left unidentified. Labs can leave ≥5% of the species listed as unidentified, typically for species eluting late in the chromatogram which have comparatively strong effect on the particulate matter index (PMI). Unidentified or misidentified peaks in this region can result in an inaccurate PMI determination and can misrepresent the composition of a given sample.

The objective of this project was to develop an enhanced method for the speciation of gasoline. Desired attributes of the method were:

- Capable of being used on a routine basis by a typical chemical analysis laboratory.
- Easy to perform qualitative and quantitative calibration. A detector with a linear response to pure hydrocarbons is preferred to minimize the number of species in the calibrant.
- Provides accurate quantification of oxygenated species.
- Resolves, identifies, and quantifies species to the greatest reasonable extent. Identifies specific isomers whenever possible; compound class and carbon number are the minimum identification requirements for species > C9.
- Capable of quantifying species with a boiling point up to 280°C at a minimum; 350°C is the preferred target.

AVFL COMMITTEE

Current Status and Future Program

This project was awarded to Separation Systems, Inc. EPA participated on the project technical panel. The Final Report, "Enhanced Speciation of Gasoline," and Master Database were published on the CRC website in June 2018.

AUTOIGNITION CHARACTERIZATION OF AVFL-20 TEST FUELS
CRC Project No. AVFL-31

Leaders: A. Iqbal
S. McConnell

Scope and Objective

The objective of this project is to evaluate combustion properties of the AVFL-20 test fuel set using laboratory autoignition characterization methods to develop correlations between fuel properties, composition, and autoignition characteristics.

Current Status and Future Program

Rapid Compression Machine (RCM) testing of AVFL-20 fuels has been performed by the Massachusetts Institute of Technology (MIT) and additional testing is being conducted at Argonne National Laboratory (ANL). Different approaches for evaluating the RCM ignition delay data in conjunction with the engine test data have been discussed with MIT, ANL, and Oak Ridge National Laboratory (ORNL). Future direction of this collaborative research project is being planned.

AVFL COMMITTEE

EFFECTS OF BOOST PRESSURE AND FUEL COMPOSITION ON COMBUSTION KNOCK CHARACTERISTICS

CRC Project No. AVFL-32

Leaders: S. McConnell
A. Iqbal

Scope and Objective

The main objective of this project is to learn how boosting affects the knock characteristics of fuels with varied levels of important hydrocarbon classes found in modern commercial gasolines. A secondary objective is to investigate how boosting affects the operation of the standard Research Octane Number (RON) Cooperative Fuel Research (CFR) test engine and what further information would be required to propose modifications to the octane test method to improve the correlation between octane number and knock propensity in modern SI engines.

During the first year (Phase 1), several fuels of similar RON rating, but varied chemical composition, will be analyzed under standard RON conditions on the instrumented CFR F1/F2 engine at Argonne National Laboratory. Previous work on this test engine has identified important differences in the engine operating conditions and the combustion and knock characteristics among fuels with either increased aromatic or ethanol content. Important parameters affected by fuel composition during RON testing, despite constant RON level, include indicated mean effective pressure (IMEP), lambda, onset of auto-ignition, peak rate of heat release during auto-ignition, and knock over-pressure (mean amplitude of pressure oscillations), and more.

Phase 2 will explore how increased boost pressure on the CFR engine affects the knocking characteristics of several fuels with the similar RON and varied chemical composition.

Current Status and Future Program

Project AVFL-32 is being conducted by Argonne National Laboratory, with reporting anticipated in 2019.

FUELS FOR ADVANCED COMBUSTION ENGINES (FACE) WORKING GROUP

Leaders: J. E. Anderson
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, and updated and approved again in 2015. The original mission of the FACE group was to recommend sets of test fuels well-suited for research so that researchers evaluating advanced combustion systems can 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 collaboration includes scientists and engineers from ANL, LLNL, NREL, ORNL, PNNL, SNL and NRCAN/CanmetENERGY. The activities of the Working Group formally commenced in January 2006.

An initial key activity of this group was developing two sets of fuels for research in advanced combustion in the diesel and gasoline ranges. The diesel fuel set, defined in 2007, became commercially available for purchase from Chevron Phillips Chemical Company, LLC (CPCHEM). Extensive characterization work has been performed by laboratories participating in the working group; a summary of standard analyses of these fuels 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.

AVFL COMMITTEE

A gasoline-range fuel set design was also developed by the FACE group. All ten fuels were blended in large batches and became 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, "FACE Gasolines and Blends with Ethanol: Detailed Characterization of Physical and Chemical Properties."

Current and future activities may 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 published a 2014 SAE paper summarizing advanced combustion engine test programs utilizing the FACE diesel fuels. The latest publication (2016) is the Final Report on AVFL-23, "Data Mining of FACE Diesel Engine Fuels," produced by NRCAN that identified a number of correlations between advanced engine performance parameters and test fuel properties. 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-23, AVFL-24, AVFL-26, AVFL-31, and AVFL-32.

AVFL COMMITTEE

AVFL LUBRICANTS ADVISORY 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 serves 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 Advisory Panel has been meeting regularly over the past several years discussing new project initiatives. The Panel meets periodically to develop project ideas for consideration by the AVFL Committee. The recently completed Project AVFL-28 and the ongoing Project AVFL-28 Phase 2 were developed by this Panel.

INFLUENCE OF NOX ON SECONDARY ORGANIC AEROSOL (SOA) AND OZONE

CRC Project No. A-105

Leaders: D.C. Baker
M. E. Moore

Scope and Objective

In CRC Project A-90, a new source apportionment approach called the Path-Integral Method (PIM) was implemented to rigorously apportion the anthropogenic increment to ozone; and, in a subsequent demonstration task, to evaluate PIM for source contributions to US ozone from light-duty vehicles and other major anthropogenic sources. PIM can be extended to SOA and account rigorously for both direct and indirect effects of NOx on SOA as well as ozone. NOx emissions are changing and the emission inventories are uncertain, so it is important to evaluate how the source contributions depend upon NOx emission levels. This can be accomplished by applying PIM to a reduced NOx emission scenario. This study directly addresses one of the Research Needs (Influence of NOx on SOA Formation and Ozone) from CRC's Air Quality Modeling Research Needs Workshop held in February 2016.

The objectives of Project A-105 were to determine the contributions of US anthropogenic sources to SOA in the Houston regions and to evaluate how the concentrations of SOA and ozone and the source contributions depend on NO_x emissions. This was accomplished through the following tasks: (1) run base case and provide model performance evaluation (MPE); (2) implement PIM for SOA to provide rigorous source contributions for SOA; (3) determine contributions of US anthropogenic source sectors to SOA and ozone using PIM; (4) evaluate how concentrations and source sector contributions depend upon NOx emissions; (5) publish the new methods (1) and the results (2&3) in a peer-reviewed journal.

ATMOSPHERIC IMPACTS COMMITTEE

Current Status and Future Programs

Ramboll Environ, Inc. was selected as the contractor for this project. The project was authorized in March 2017. Ramboll Environ applied the Comprehensive Air-Quality Model with Extensions (CAMx) to simulate formation of ozone and SOA in the Houston area during NASA's DISCOVER-AQ study period. The base case simulation included emissions from all (anthropogenic and natural) sources and was run with two different OA modeling schemes available in CAMx. The OA scheme used for the subsequent source apportionment analysis was selected based on the base case model performances results. A numerical procedure was developed for PIM source apportionment of SOA. The anthropogenic increments to ozone and SOA (the differences between the base case and the background case without US anthropogenic emissions) were then apportioned to various US anthropogenic source groups using PIM.

The Executive Summary of this work was posted on the CRC website in May 2018. A journal article has been submitted to *Atmospheric Environment.*

EVALUATE THE SENSITIVITY OF MOVES2014A TO LOCAL DATA ON START ACTIVITY

CRC Project No. A-106

Leaders: S. Collet
S. McConnell

Scope and Objective

The ultimate goal of this research program was to provide states and local air agencies and US EPA more accurate input for the MOVES (Motor Vehicle Emission System) model. This project focused on a limited number of parameters that previous studies have identified as critical. The previous studies include CRC Project A-88 titled "MOVES Input Improvements for the 2011 NEI" and CRC Project A-84 (see also TRB Paper No. 14-2898) titled "Study of MOVES Information for the National Emissions Inventory." The focus of this work was to provide information for improving on-road inputs at the local level for use in a wide range of air pollution emission inventory efforts.

To help achieve these goals, the objective of this project was to understand currently unexploited data that are potentially available to state and county modelers regarding light-duty car and truck start locations and timing, and the emission implications of using such data as compared to current MOVES defaults.

Current Status and Future Programs

Eastern Research Group (ERG) was selected as the contractor for this project, which started in March 2017. ERG approached the project in four executable tasks, plus a fifth reporting task. Under Task 1, ERG provided a review of telematics data sources with respect to their applicability for producing start-related inputs for MOVES. StreetLight was selected as the data provider. Under Task 2, the StreetLight telematics data were analyzed and aggregated to populate MOVES start-related inputs for the same three counties used in A-100 pilot analysis (Cook County, IL; Fulton County, GA; Clark County, NV). Under Task 3, these StreetLight-derived

MOVES inputs were compared to MOVES defaults and other independent sources of trip data. Under Task 4, ERG conducted an emissions sensitivity analysis to quantify the impact the telematics data have on MOVES emissions relative to default values. Finally, under Task 5, ERG produced documentation and other deliverables. The Final Report and supplemental data were published on the CRC website in December 2017.

ATMOSPHERIC IMPACTS OF VOC EMISSIONS: FORMATION YIELDS OF ORGANIC NITRATES IN REACTIONS OF ORGANIC PEROXY RADICALS WITH NO

CRC Project No. A-107

Leaders: D.C. Baker
T.J. Wallington

Scope and Objective

The main goal of the work is to determine the overall air quality impact of four- to six-carbon (C4-C6) alkanes and their atmospheric by-products, particularly in areas impacted by oil and/or natural gas (O/NG) extraction.

The specific objectives are to obtain yields of organic nitrates from oxidation of the alkanes, as a function of the structure and size of the alkane, and also as a function of temperature. This collective dataset can be made available for incorporation into process- and regional-scale models, so that more accurate predictions of ozone production can be obtained on urban / regional scales, and in areas impacted by O/NG extraction.

Current Status and Future Programs

University Corporation for Atmospheric Research (UCAR) member entity National Center for Atmospheric Research (NCAR) was selected as the contractor for this project initiated in March 2017. NCAR is investigating the OH-initiated oxidation of a suite of C4-C6 alkanes, and determining the organic nitrate yield from the reactions of relevant peroxy radical with NO, using end-product analysis. The work is being done in environmental chambers at NCAR. The temperature of the chamber can be regulated between roughly 240 and 340 K by flowing a suitable fluid through a jacket surrounding the chamber. Hydroxyl radicals are generated by the photolysis of isopropyl nitrite in the presence of NO, which produces a suite of alkyl peroxy radicals (RO_2) depending on the number of unique sites of attack available in the hydrocarbon.

ATMOSPHERIC IMPACTS COMMITTEE

The alkoxy (RO) radical reacts further to produce a carbonyl compound, which can typically be detected by the GC-FID. The relative proportion of the different sites of attack are estimated from the rules given in the literature, with additional information about the relative abundance of peroxy radicals coming from the GC-FID measurements of the carbonyl products. Authentic standards are available for most of these nitrates and carbonyls, which are used for identification and quantification.

Additional experiments are planned in a 10 m^3 Teflon chamber, equipped with basic instrumentation for monitoring NOx and O_3, and Proton-Transfer Reaction–Mass Spectrometer (PTR-MS) and GC-MS systems for further characterization of reaction products. These studies will provide the opportunity to identify and quantify some of the less volatile nitrates that may not be amenable to analysis by GC-FID. Use of the two chambers, with very different surface-to-volume ratios, will also give added confidence in the results. The project will continue through 2018.

Better understanding of the chemistry and surface-to-volume considerations in chambers were both high priorities from CRC's Air Quality Modeling Research Needs Workshop held in February 2016.

DEVELOPMENT AND EVALUATION OF DATABASES AND ESTIMATION METHODS FOR PREDICTING AIR QUALITY IMPACTS OF EMITTED ORGANIC COMPOUNDS

CRC Project No. A-108

Leaders: C.G. Rabideau
T.J. Wallington

Scope and Objective

The objectives of this project are to bring together an expert panel to evaluate the structure-reactivity and other estimation methods needed to develop complete detailed mechanisms, and make recommendations for approaches judged to be the most consistent with available knowledge. This is analogous to the work of the International Union of Pure and Applied Chemistry (IUPAC) or NASA kinetic data panels, or the books on atmospheric mechanisms by Calvert and co-workers, but it is focused on compiling and evaluating estimation methods rather than the underlying experimental data themselves. As with these other efforts, this project has significant in-kind and ongoing support with periodic updates as new data and methods become available.

Current Status and Future Programs

A proposal from Dr. William Carter at UC Riverside was reviewed and approved by the Committee. A contract was awarded to UC Riverside in April 2017.

Prior to the initiation of this project, a group of experts (participants) were assembled in various areas related to this project and were in communication via email and teleconferences concerning the work to be carried out. It was decided to form various working groups to organize the efforts, and the objectives, tasks, and current status of the work of each group.

The working groups include the following:

- Project Coordination and Leadership
- Preparation of a Perspective Article

ATMOSPHERIC IMPACTS COMMITTEE

- MAGNIFY/EUROCHAMP-2020/MCM Coordination
- Experimental Data Collection
- Quantum Calculation Data Collection
- Organic SAR Group/ Estimates for Reactions of Organic Compounds
- Radical SAR Group/ Estimates for Reactions of Organic Radicals
- Estimates for Photolysis
- Chemical Mechanism Working Group
- Thermochemistry Working Group
- Mechanism Generation Working Group

The groups consist of “full active participants” as well as “observers” who have expressed an interest and will, on occasion, weigh in with their expertise. Project documents and teleconference minutes are stored and shared on a Google Drive. A perspective article that provides a general overview of gaps for improving atmospheric kinetic modeling was reviewed by the committee and published in the *International Journal of Chemical Kinetics.* The project continues into 2019.

AIR QUALITY MODELING OF THE RELATIONSHIP BETWEEN SIMULATED $PM_{2.5}$ IN RESPONSE TO VARYING REDUCTIONS OF AMMONIA EMISSIONS OVER THE SOUTH COAST AIR BASIN

CRC Project No. A-109

Leaders: D.C. Baker
C.G. Rabideau
T.A. French

Scope and Objective

The objective of this project was to make a limited assessment of the effects of changes in ammonia emissions on secondary PM2.5 concentrations in the South Coast Air Basin (SoCAB). Ammonia reacts with nitric acid to form ammonium nitrate and with sulfuric acid to form ammonium bisulfate and ammonium sulfate; all of these are components of secondary PM2.5. Under CRC Project A-91, the Community Multi-scale Air Quality Model (CMAQ) was used to examine the effects of NOx and reactive organic gases (ROG) emission reductions on ozone concentrations. Under CRC Project A-101 CMAQ was used to examine the effects of NOx and ROG emission reductions on secondary PM2.5 concentrations. Under CRC Project A-109, three additional simulations for the future year 2030 with different levels of ammonia emissions were evaluated.

This ammonia assessment builds on CRC Projects A-91 and A-101 and the new simulation results support further publication and presentation of CRC Projects A-91, A-101 and A-109. This project was designed to provide a mechanism to address additional questions that have been identified under Project A-101.

Current Status and Future Programs

The project was awarded to Dr. William Stockwell and the project started in July 2017. The project was completed in two tasks followed by reporting to the committee.

ATMOSPHERIC IMPACTS COMMITTEE

Task 1: CMAQ PM2.5 Modeling - Use CMAQ to Perform Additional Sensitivity Tests of Modeled PM2.5 to Variations in Ammonia Emissions for the Future Year 2030. In Task 1, three simulations with variations in the ammonia emissions inventory were performed. The base case, simulated previously in CRC Project A-101, is future year 2030 with the target NOx and ROG emissions with a ROG/NOx ratio equal to 5.1. Ammonia emissions were then adjusted by factors 1.5, 0.75 and 0.50 and sensitivity simulations were performed with CMAQ.

Task 2: Analyze CMAQ Ammonia Sensitivity Simulations to Determine Effects on PM2.5 Concentrations. In Task 2, analysis of the response of modeled PM2.5 to variations in ammonia emissions for the future year 2030 were performed. The analysis methods included basin-wide color contour plots of 24-hour PM2.5 concentrations for the simulated variations on ammonia emissions. For selected sites, 24-hour PM2.5 concentrations and time series were examined.

A journal article that includes the results of A-109 and A-101 has been submitted to the *Journal of Air and Waste Management*. An Executive Summary of this project was posted on the CRC website in May 2018.

SCOPING STUDY FOR REWRITE OF MOVES FOR EFFICIENCY

CRC Project No. A-110

Leaders: S. Collet
M. Janssen

Scope and Objective

The overall goal of this project was to make it quicker for state and local air agencies and US EPA to obtain their MOVES (Motor Vehicle Emission System) results. This project focused on the architecture MOVES uses to calculate results.

Current Status and Future Programs

ERG was awarded the project**,** which consisted of four tasks, structured around three approaches plus development of a scoping plan. Under Task 1, an evaluation of the potential to recode the model was conducted. Under Task 2, a Runspec Execution Utility was described that could be used to execute any arbitrary MOVES runspec(s) in the cloud and also a Runspec Creation Utility that would facilitate the batch creation of runspecs. Task 2 also included a Worker Cloud Gateway that, with some changes to the MOVES architecture, would enable the deployment of large numbers of workers in the cloud to process bundles generated by a local master. Under Task 3, an evaluation was conducted on the potential for automated application of Advanced Performance Features to eliminate redundant processing through storage and re-use of common intermediate and "core model input" tables (CMITs). Finally, Task 4 is a scoping document which includes the results of Tasks 1-3 along with a scoping plan.

By design, each of the elements developed in Tasks 1-3 can be pursued independently of the others. For short term improvements, Tasks (2) and (3) could be pursued without changes to the current MOVES 2014a model, with the exception of the Worker Cloud Gateway (meant to optimize cloud application of a MOVES version that adopted the recoding recommendations of Task 1). This approach would provide more flexibility for EPA and the user community to begin implementing performance improvements that do not immediately require the EPA to modify the code. Ultimately, the vision is that all three approaches could be implemented in parallel to maximize the speed of the model.

The Final Report was published on the CRC website in August 2017.

IMPROVING WEST COAST OZONE BOUNDARY CONDITIONS (BCS) FOR REGIONAL AIR QUALITY MODELS

CRC Project No. A-111

Leaders: D.C. Baker
S. Tanrikulu
T.J. Wallington

Scope and Objective

The objective of this project is to develop a methodology, which can be codified into a distributed software tool and associated database, to adjust western ozone boundary conditions derived from global model output using observational data along the US west coast. The project will be conducted in two phases: (A) tool development and evaluation with existing 2012 observational data and Bay Area Air Quality Management District (BAAQMD) regional simulation results; and (B) testing, evaluation, and refinement of the tool with 2016 observation data from the California Baseline Ozone Transport Study (CABOTS) and new BAAQMD regional simulation results.

Current Status and Future Programs

This project will be conducted in cooperation with technical leaders, panel members, and co-sponsorship from CRC, BAAQMD, and CARB (the project team). CRC has contracted with Ramboll Environ Inc.

The project team will evaluate a software tool that estimates monthly/seasonal ozone bias in global models over the Eastern Pacific Ocean and adjusts MOZART-simulated ozone to remove monthly/seasonal ozone bias over the Eastern Pacific Ocean in each of the three vertical zones. The inputs to the tool will include raw MOZART output data and the compilation of statistical results as well as possibly meteorological and precursor species measurements. The team will develop a five-year (2012-2016) standardized observational database to support the tool.

ATMOSPHERIC IMPACTS COMMITTEE

The project team will test the tool on the 6-hourly 2012 MOZART output, from which boundary conditions will be developed for the BAAQMD's 2012 Central California CMAQ modeling application. The team will systematically test CMAQ with original and adjusted boundary conditions and evaluate CMAQ results against coastal ozone measurement data to assess and verify any improvements in simulated coastal ozone patterns. The team will document results from this work, the computer code, and its operation in a final report and make recommendations on the use of the method developed.

In the CRC portion of the project, the Contractor will test and evaluate the software tool against data collected during the 2016 CABOTS, which includes measurements via aircraft, ozonesondes at Bodega Bay and Half Moon Bay, and ozone lidar. The 2016 MOZART data will be used to develop boundary conditions for the BAAQMD's 2016 CMAQ modeling application. The BAAQMD will systematically test CMAQ with original and adjusted boundary conditions, and the contractor will evaluate CMAQ results against both routine and CABOTS data, particularly the ozonesonde data, to assess and verify any ozone performance improvements. CABOTS measurements will be used strictly as a separate and independent evaluation database, not to be included in the standard measurement database that supports the tool.

This project is underway and is expected to be completed at the end of 2018.

RELATIVE REDUCTION FACTORS USING ANTHROPOGENIC OZONE INCREMENTS

CRC Project No. A-112

Leaders: S. Winkler
C.G. Rabideau

Scope and Objective

Current attainment status for the National Ambient Air Quality Standard (NAAQS) for ozone is determined by measured ambient ozone expressed as the design value (DV). US EPA guidance for demonstrating future attainment of the ozone NAAQS recommends using photochemical grid model results analyzed by Relative Reduction Factors (RRFs). The RRF is the ratio of the simulated concentration in a future year with emission reductions in place to the simulated concentration in the base year.

Many sources contribute to ground level ozone in a non-attainment area and can be categorized as:

- US Background (USB) ozone originating from all sources except US anthropogenic emissions, including stratospheric ozone, ozone transported from foreign countries, and ozone from natural emissions within the US.
- Local ozone increment from anthropogenic emissions within the non-attainment area; these sources are the particular focus of local air quality management activities.
- Regional ozone increment from US anthropogenic emissions outside of the non-attainment area; these sources are typically reduced by national strategies such as mobile source or power plant programs.

Current Status and Future Programs

With the current RRF methodology, categories that may have individual contributions to ground level ozone are combined in the RRF (and the DV), which obscures individual contributions and generates errors. The overall objective of this project is to develop improved RRF procedures that focus on the US anthropogenic increments to ozone that are influenced by air quality management activities.

This project is supported by co-sponsorship from API and Houston O_3 Coalition. This work will be accomplished through three tasks:

1. Establish alternative methodologies that separate the effects of changing local, regional and US background concentrations to ozone. A technical memorandum will be the deliverable.
2. Perform simulations with the CAMx regional model for Houston and analyze results.
3. Reporting.

The technical memorandum to identify alternative RRF approaches was completed in February 2018. The simulation work is ongoing, and is expected to continue through the third-quarter of 2018.

THE INFLUENCE OF NO_X ON SECONDARY ORGANIC AEROSOLS AND OZONE FORMATION: CHAMBER STUDY

CRC Project No. A-113

Leaders: T.J. Wallington
S. Gao

Scope and Objective

This study directly addresses one of the Research Needs (Influence of NOx on SOA Formation and Ozone) from CRC's Air Quality Modeling Research Needs Workshop held in February 2016. The complex interplay of VOCs and NOx on atmospheric ozone formation (e.g., the ozone isopleth) requires a detailed, mechanistic understanding of the underlying chemical processes leading to its formation. Similarly, it has become readily apparent that condensable species formed in peroxide rich (low-NO) environments and organic nitrate formation in higher NOx environments both contribute significantly to enhanced aerosol formation. Classic environmental chamber experiments using VOC and NO/NO_2 mixtures may miss important SOA formation pathways leading to errors in atmospheric predictive models. It is critical that secondary pollutant formation be evaluated under such peroxide rich (low NOx) environments to greatly improve prediction of secondary pollutants under future environmental situations as stringent NOx controls continue to reduce ambient NOx levels.

The project objectives are to conduct novel environmental chamber experiments to elucidate the key roles of NO_x on SOA formation by performing experiments specifically designed to investigate the role of peroxide chemistry. Primary objectives are: 1) design new experimental methods using environmental chambers to best elucidate the interplay of NOx with select anthropogenic and biogenic precursors at atmospherically relevant (current and projected) oxidant levels; 2) identify SOA formation potential of select VOC precursors within these well-controlled environments; 3) evaluate ozone prediction under these scenarios; and 4) provide guidance to regional air quality models on how to implement improvements to SOA predictive models.

Current Status and Future Programs

The committee reviewed and approved a proposal from David Cocker at UC Riverside, and the project began in January 2018. The investigation of NOx effects on SOA formation will be conducted through a minimum of 100 defined chamber experiments over the course of 3 years, which will be guided by SAPRC model predictions of oxidant and gas-phase species including measurement of ozone, NOx, hydrocarbon decay, aerosol number and volume time traces along with aerosol density, volatility (at 100°C), and bulk chemical composition (bulk chemical composition derived from aerosol mass spectrometer).

The experiments will be conducted in large, state-of-the-art environmental chambers at UC Riverside designed specifically to study atmospheric chemistry at low NOx concentrations (atmospherically relevant NOx loadings). The program will perform in-depth analysis of select aerosol precursor compounds aimed at a deeper mechanistic understanding of the processes influencing SOA formation.

This three-year project kicked off at the beginning of 2018 and is expected to continue into 2020.

ATMOSPHERIC IMPACTS COMMITTEE

CHARACTERIZING PRIMARY ORGANIC AEROSOL EMISSIONS FROM IN-USE MOTOR VEHICLES

CRC Project No. A-114/ RW-111

Leaders: M.E. Moore
S. McConnell
J. Geidosch

Scope and Objective

It has been shown that primary organic aerosol (POA) mass from combustion emissions evaporates as it is diluted to ambient conditions. The semi-volatile partitioning of a large fleet of gasoline vehicles has been demonstrated on a chassis dynamometer and the volatility profiles have been quantified using a combination of thermodenuder and mass spectrometer analysis. Large scale model studies have also shown that treating POA compounds as semi-volatile has a significant impact on the average magnitude of emissions from combustion sources as well as on the spatiotemporal variability of organic aerosol (OA) concentrations, particularly in urban areas and close to sources. Although many chemical transport models (CTMs) now include POA semi-volatile partitioning, standard emissions measurements procedures do not collect the information needed to inform gas/particle partitioning calculations.

Current vehicle emissions measurements report total hydrocarbons, non-methane organic compounds, and particulate mass. However, in order to calculate OA partitioning, one needs to know how the emissions themselves respond to swings in, for example, the pollutant particle concentrations. Without this information, many CTMs have relied on ambient OA measurements to constrain the total OA mass emitted from combustion sources like vehicles, and parameters vary widely depending on the model and application. While there has been extensive recent work on the detailed measurement of POA volatility and composition, these scientific findings need to be connected to standard measurements and methods that are the most common source of data for emissions inventories and models like CMAQ.

ATMOSPHERIC IMPACTS COMMITTEE

Current Status and Future Program

The goal of this project is to quantify the volatility profile and particle concentration in exhaust emissions. Measurements will focus on exhaust physical properties and particulate and gas-phase concentrations. Results from this study will be used to 1) confirm that varying dilution leads to organic evaporation behavior that is consistent with published volatility profiles and partitioning theory, 2) better understand the interpretation of existing emissions datasets where particle concentration and volatility information does not exist, 3) determine the accuracy and limitation of using dilution factor to quantify the volatility profile of individual vehicles during standard emissions measurement efforts, and 4) add to the growing body of data documenting the volatility profiles of individual vehicles by tier, model, and model year, etc.

A solicitation for this project is available on the CRC website, and bids are being collected.

DEVELOPING IMPROVED VEHICLE POPULATION INPUTS FOR 2017 NATIONAL EMISSIONS INVENTORY (NEI)

CRC Project No. A-115

Leaders: S. Collet
M. Janssen
M. Beardsley

Scope and Objective

While data are sometimes provided by state and local air quality agencies as part of the NEI process, many states are unable to provide such data. Thus, significant additional efforts are needed to augment the efforts of air agencies to further improve the MOVES inputs. Previous CRC projects, including CRC A-88 and CRC A-100, have provided states and local areas with detailed vehicle activity information to improve their vehicle emission inventory inputs to their air quality analysis. Project A-115 builds on that progress by developing vehicle population inputs needed for the next round of EPA's NEI for calendar year 2017 with the goal of providing states and local air agencies with up-to-date activity information for their air quality estimates.

Current Status and Future Program

The objective of this project is to provide state and local air agencies and US EPA with more accurate county-level vehicle population inputs for the MOVES model and the SMOKE modeling system. The primary outcome would include county- and regional-specific estimates of age distributions and vehicle counts for the 2017 calendar year. This information could be used for the 2017 NEI and for state and EPA's broader inventory and air quality efforts. The use of these data in a consistent and enhanced manner will be a significant improvement over using national default age distributions and can have a meaningful effect on emissions. As demonstrated in CRC A-84, vehicle age distributions are one of the most important factors in determination of fleet emissions.

ATMOSPHERIC IMPACTS COMMITTEE

An important secondary outcome will be the ability to compare vehicle age distributions and counts in calendar year 2017 with previous work by EPA for calendar year 2014 and the previous work in CRC A-88 for calendar year 2011. This will allow trends analysis across years and facilitate EPA calculation of national and county-specific vehicle scrappage rates. Scrappage rates are an important factor in generating estimates of future year vehicle age distributions for use in air quality projection use to demonstrate attainment of air quality goals.

The project team for this work consists of many contributors from states and agencies collaborating to identify the vehicle data needed. Phase 1 of this project is currently underway through in-kind contribution from the contributing team members. ERG has been identified to contract for Phase 2 of the work, and will utilize the results of Phase 1 to provide any correction methodology to the data provider's information, update age distributions and vehicle populations, QA the results and identify anomalous data, use the detailed age distributions and counts in calendar year 2017 to compare to previous work to describe national and regional trends in vehicle populations and age distributions.

Phase 2 of this work is pending the completion of Phase 1.

SOUTHERN CALIFORNIA OZONE RESEARCH SYMPOSIUM (SCORES)

CRC Project No. A-116

Leaders: S. Collet
D.C. Baker
T.A. French

Scope and Objective

This symposium aimed to bring together researchers to assess the state of the science as it relates to the mechanisms for ozone and particulate matter (PM) formation and the modeling of future ozone and PM levels. The specific framework for this symposium was the emerging ozone and PM trend in the South Coast Air Basin (SoCAB). More specifically, the rate of decline in ambient ozone levels in the SoCAB has been flattening out or even reversing despite continuing significant reductions in the ambient levels of precursor emissions, specifically NO_x. In addition, the results generated by current ozone modeling tools, including CMAQ, for the SoCAB have under-predicted past rates of ozone decline and appear not to be tracking the more recent trends.

These issues suggest that our understandings of the mechanisms for ozone formation, for the means of achieving reductions in ozone formation, and for the modeling of future ozone levels, particularly in the SoCAB, need to be reassessed and updated. Changes to these also affect PM, To that end, this symposium convened leading experts in the relevant fields of atmospheric chemistry, ozone science, and air quality modeling to evaluate whether the core assumptions regarding the formation, mitigation and modeling of ground-level ozone still hold, and whether there are additional research programs that need to be initiated to address any significant data gaps or unanswered questions.

ATMOSPHERIC IMPACTS COMMITTEE

Current Status and Future Programs

The symposium was held June 6 and 7, 2018 at U.C Riverside. EMA co-sponsored the event. The workshop organizers consisted of participants from South Coast Air Quality Management District, California Air Resources Board, U.S. Environmental Protection Agency, Truck and Engine Manufacturers Association, Caterpillar, Inc., Toyota Motor North America, Phillips 66, Chevron, Volkswagen, and Ford. Dr. Ted Russell of Georgia Tech was selected to support the organization and planning of the workshop. An article summarizing the workshop activities and outcome has been submitted to *EM Magazine.*

MOBILE SOURCE AIR TOXICS WORKSHOP 2019

CRC Project No. A-117

Leaders: S. Collet
S. Yoon

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, 2013, 2015 and 2017 CRC Mobile Source Air Toxics (MSAT) workshops 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

The 9th MSAT Workshop is being planned for 2019. Dr. Kent Hoekman was selected again to support organization of the 2019 MSAT Workshop with the aid of organizing committee participants. The workshop will again by hosted by CARB in Sacramento, CA on February 4-6, 2019.

PERFORMANCE COMMITTEE

GASOLINE ENGINE DEPOSITS

CRC Project No. CM-136

Leader: J. Axelrod
J. Cruz

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 Port Fuel Injection (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

<u>Gasoline Engine Intake Valve Deposit Testing</u>

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 used to assess deposit levels and the impact of 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 sold at retail today has changed, with Tier III regulations reducing sulfur content. Since 1994, refining changes have been made and crude oil type has shifted with changing crude slates. Changes in engine technology include hybrids, FFVs (Flex Fuel Vehicle), DISI (Direct Injection Spark Ignition), turbo boost, downsizing, and VVT (Variable Valve Timing). The extent of ethanol use has also dramatically changed. The current engine test platforms, which include dated BMW 318i and Ford 2.3L (ASTM D6201), do not represent the majority of the current vehicle population. The certification fuel requirements are also quite different from today's fuel composition.

Additive companies of the American Chemistry Council (ACC) are working to develop a new PFI-based intake valve test. The primary goal is to replace the existing tests, in particular the BMW test required by EPA and the Ford 2.3L required by CARB, with a more modern test. The ACC has proposed that once they complete the initial test development, CRC assumes responsibility for the test confirmation 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 COMMITTEE

Investigation into Filter Plugging Due to Sulfate Salt Contamination of Ethanol, Gasoline, and Gasoline-Ethanol Blends (CM-136-15-1)

The objective of this project was to develop a thorough understanding of the formation of particulate sulfate salts in ethanol, gasoline, and fuels containing ethanol, including the impacts of water and ethanol concentration, the level of sulfates and cations, and the influence of temperature, gasoline aromatic content and detergent additives on fuel-borne particulate formation and filterability. Based on filterability experiments, the goal was to determine the relative maximum levels of cations and sulfate anions in ethanol and in fuel blends containing ethanol with current levels of detergent additives that will result in filter plugging and vehicle performance problems.

The program consisted of two phases:

The first phase was a literature search of the published and publically presented information on the possible sources of the cations and sulfate anions, the solubility of various sulfate salts in alcohols, hydrocarbons, and their blends, filter plugging due to sulfate salts, potential interactions between fuel additives and sulfate salts and automotive performance problems associated with sulfate salts in gasoline and gasoline-ethanol blends. This information was categorized and summarized to guide the next phase.

The second phase consisted of laboratory work to determine the solubility and filterability of sulfate/sulfite salts in ethanol, gasoline and gasoline-ethanol blends and higher amounts of gasoline detergent additives. This is the foundation for understanding the chemistry of the formation of sulfate salts and their ability to plug filters and vehicle fuel handling equipment.

In the laboratory experimental phase, the variables were determined based on the literature search. The first set of lab experiments looked at the solubility of sulfate salts in denatured fuel ethanol. The variables included temperature, water content, cation (ammonium, sodium), and sulfate anion level. The second set of lab experiments studied the solubility of sulfate salts in gasoline. The variables considered include temperature, water content, cation (ammonium or sodium), aromatic content, detergent level, and sulfate anion level. The third set of experiments studied the solubility of sulfate salts in gasoline-ethanol blends and focused on the variables that were determined to be important in sets 1 and 2.

Testing involved preparing the required solutions and heating/cooling them to test temperature. The solutions were then filtered using an appropriate ASTM test procedure. The amount and composition of precipitate were determined and compared with the initial dosage.

The Desert Research Institute (DRI) performed this research. RFA and Flint Hills Resources co-sponsored the project. The Final Report, "Investigation into Filter Plugging Due to Sulfate Salt Contamination of Ethanol, Gasoline, and Gasoline-Ethanol Blends" was published on the CRC website in January 2018.

Additional research on this topic is being planned to take place in the Fall/Winter of 2018.

PERFORMANCE COMMITTEE

VOLATILITY

CRC Project No. CM-138

Leader: L. M. Gibbs
R. Lewis
M. Valentine

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

Development of an Engine Based Test for Determining the Effect of Spark-Ignition Engine Fuel Properties on Combustion and Vehicle Driveability (CM-138-15-2)

The objective of this project is to take a more fundamental approach toward measuring the in-cylinder combustion instability that is the root cause of poor vehicle operability. CRC would like to determine whether fuels of differing compositions and physical characteristics (e.g. Driveability Index) can be distinguished from vehicle performance differences using an instrumented engine in a vehicle on an all-weather chassis dynamometer. In addition, CRC would like to identify the measurements that are most effective at differentiating the physical and compositional characteristics between fuels. Finally, CRC would like to establish the resolution and repeatability of the measurements.

The test program consists of testing instrumented whole vehicles on a chassis dynamometer. The vehicles are being tested one at a time with time between each vehicle for the evaluation of the data and potential test program adjustment to apply the learnings from the last test to the next test. The engines in these vehicles are instrumented with cylinder pressure indication on each cylinder, Engine Control Unit (ECU) taps of the primary engine controls parameters, as well as temperature and pressure instrumentation of all major intake and exhaust components. All data are being captured using various measurement equipment (crank angle resolved and time based) and will be merged into one combined dataset which will be used for assessment. The driving pattern applied in CRC Report No. 666, "2013 CRC Intermediate-Temperature E15 Cold-Start and Warm-Up Vehicle Driveability Program" is being replicated with the instrumented vehicle on a chassis dynamometer. Test fuels are a series of hydrocarbon and hydrocarbon-ethanol blends of differing compositional and physical properties with the goal of determining discrimination sensitivity. FEV is performing the testing. RFA is co-sponsoring this research. Testing is in progress; the test procedures are being revised for the current and future cars tested to reflect knowledge gained during the work so far.

Literature Review and OEM/Test House Interviews on Alternatives for Determining Demerits of Vehicle Performance (CM-138-16-1)

The objective of this project was to develop a thorough literature review and understanding of current technology available to determine vehicle driveability performance demerits using alternatives to human trained raters.

CRC has used trained raters for many years to assess the driveability vehicle performance for test programs. These test programs have often either tested the driveability of hot-start maneuvers or cold-start and warm-up maneuvers associated with fuel test programs. There is no current established program to develop trained raters and most of these trained raters are past normal retirement age. The Performance Committee is seeking alternatives to human trained raters to measure vehicle performance in view of this situation. The technology status of these methods needs to be understood and assessed to undertake an effective replacement for trained raters, if possible.

The program consisted of three phases. The first phase was a domestic and international literature search of the published and publically presented information on current vehicle performance testing techniques to determine and quantify vehicle malfunctions during performance driveability rating. This literature was summarized to guide the second phase which was interviews of the OEMs and vehicle testing laboratories to document current and upcoming technology and test practices used for vehicle performance driveability rating. The third phase was to report the literature study and results from the interviews to give CRC a state of the art assessment on vehicle driveability testing options.

FEV performed this project. The Final Report "Literature Review and OEM/Test House Interviews on Alternatives for Determining Demerits of Vehicle Performance" was published on the CRC website in December 2017.

Comparison of Ambient Temperatures from 'Doner Report' To Modern Day Ambient Temperatures for the Same Geographic Areas (CM-138-16-2)

Table 4 Schedule of U. S. Seasonal and Geographical Volatility Classes in ASTM D4814 Standard Specification for Automotive Spark-Ignition Engine Fuel was generated from state ambient temperatures obtained by the U.S. Army during the 1970s, known as the "Doner Report". Recent ASTM ballot activity on volatility limits has generated concerns by some that the "Doner Report" information is outdated. The objective of this project is to conduct a review of modern day ambient temperatures for the geographic regions in ASTM D4814 Table 4 with the new data then compared to that in the "Doner Report". The report and data review are to be done in a manner similar to that of the original "Doner Report" but with computer-generated isothermal maps. The new study will include data covering from 1996 through 2016 (twenty-one years, which is similar to that from the "Doner Report"), and is to include Hawaii (left out of the original study). State temperature data (excluding Panama Canal which was part of the original report) will be analyzed in multi-geographic regions when appropriate as was done for the prior study. Ambient temperatures recorded for this project will not be altitude compensation corrected since the original

"Doner Report" did not correct for altitude. Once the modern data are produced, these will be statistically compared to those from the "Doner Report."

DRI is performing this project. The Final Report is expected to be published in fall 2018.

Computer Controlled Poor Driveability on Demand Training Vehicle (CM-138-17-1)

Numerous projects over the years have been performed in order to refine and better understand the relationship between gasoline and gasoline-ethanol blended fuels with driveability issues drivers experience in their vehicles. In carrying out these projects, the CRC developed a system and nomenclature to better discriminate between the types of driveability events and their severity. The task of scoring these events utilizes trained operators called raters. The raters perform a pre-set series of maneuvers on a test vehicle and determine if a potential driveability event the vehicle experienced is either a hesitation, a stumble, or a surge. The rater then assigns a severity score of high, medium, or low to the driveability event. Once the current trained raters retire, the knowledge and methodology will retire along with them. A solution is to develop a means where the driveability events can be created, controlled, and be reproducible. This way, newer raters can be trained to identify and rate the events. Additionally, using a dedicated vehicle where the driveability events can be created could offer a different level of versatility in the types of driveability projects. Instead of leaving projects to the unknown characteristics of vehicles in the field to create driveability problems, the projects can be designed around the dedicated vehicle. Utilizing a Driveability on Demand Training Vehicle will also result in not having to develop and source high Drivability Index (DI) test fuels that may or may not result in a poor driveability event for some future correlation from Road to Lab test programs.

PERFORMANCE COMMITTEE

The project objective was to develop ECM calibration software and hardware to control driveability events through an easy to use user interface system in a dedicated, CRC-owned vehicle. The contractor must develop a means to create any driveability events at any severity. These events must be repeatable and not affect the vehicle's normal operation, outside of initiation of a driveability event. The driveability events require easy user input and interface. The project will result in a vehicle with the means for an operator to easily and reproducibly cause hesitation, stumble, surge, stall, and/or poor idle quality driveability events. These events should be able to vary in intensity (high, medium, and low), also at the discretion of the operator.

This project is being performed by SwRI. The Final Report anticipated in fall 2018.

PERFORMANCE COMMITTEE

OCTANE

CRC Project No. CM-137

Leader: W. Woebkenberg
M. Winston-Galant

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

Advanced Fuel And Engine Efficiency Workshop

The Octane Group of the Performance Committee worked with the CRC AVFL Committee to organize the "Advanced Fuels and Engine Efficiency Workshop" 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. The 2nd Advanced Fuels and Engine Efficiency Workshop was conducted in late 2016 and again co-sponsored by the CRC AVFL and Performance Committees. Proceedings of both Workshops are published on the CRC website.

Review of LSPI Or Low Speed Pre-Ignition (AKA Stochastic Pre-Ignition, SPI) – (CM-137-17-1)

Abnormal ignition, especially low speed/stochastic preignition (LSPI/SPI), in gasoline engines has been reported in the literature for many decades, going back to at least the 1920s. This phenomenon was something initially noted by the CRC in 1954, and a document was created so that a common set of terms were used to discuss and communicate the nuances of normal and abnormal combustion. At that time, engine manufacturers were testing designs that included both higher compression ratio and evaluating the use of turbochargers and superchargers for improved performance and economy. In the last 14 years, another abnormal combustion issue, low speed/stochastic preignition, has been observed and documented. This low speed/stochastic preignition issue has again shown up in the industry in response to the need for improved fuel economy as engine design change towards downsized, higher compression ratios and turbocharged engines, and manifested by way of changes in engine hardware, oil properties and fuel properties similar to changes since the 1950s. Quick resolution of the current low speed/stochastic preignition issue is required to minimize risk of engine hardware damage and enable utilization of advanced technologies to significantly improve vehicle fuel economy. Therefore, all aspects that can yield improvement need to be understood.

The objectives of this project are to:

- Investigate, through reviews of the academic, commercial and government literature and interviews with OEMs and suppliers, the factors associated with the onset and/or severity of LSPI/SPI as related to current market fuels and engine design/hardware and engine lubricating oil.
- Identify critical technology gaps in understanding LSPI/SPI and suggest R&D efforts where CRC could contribute with possible future programs.

This project has been awarded to FEV, with reporting anticipated in fall 2018.

DIESEL PERFORMANCE GROUP

CRC Project No. DP

Leader: M. Nikanjam
S. Lopes

Scope and Objective

The objective of the Diesel Performance Group is to help to define the minimum diesel fuel requirements for light-duty diesel vehicles in North America. This will be achieved by providing supporting technical data for diesel performance issues that are needed by the fuel, engine, equipment, and additive industries and can be used by technical groups such as ASTM International and the International Organization for Standardization (ISO). Much of the knowledge gained is common to other diesel applications such as heavy-duty diesel (HDD). We work closely with interested parties and benefit from their contributions.

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

- Biodiesel & Renewable Diesel
- Cleanliness
- Corrosion
- Deposit
- Low Temperature Operability

Current Status and Future Program

Biodiesel & Renewable Diesel

In 2017, the Biodiesel Panel was expanded to include renewable diesel and the panel name updated to reflect the change. The panel has utilized the expertise of its members over the last year to develop a guidance document, entitled, "Review of the Properties and Performance of Hydrocarbon Renewable Diesel Fuel." The Guide was published on the CRC website in September 2018. This document will be a guide to many users and also will surface potential areas that may require a more focused CRC study; the panel will review potential topics for future research during fall 2018.

Cleanliness

The objective of this panel is to address, to investigate, and to 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 (refinery to vehicle fuel tank). Modern high-pressure common-rail injection systems require much cleaner diesel fuel.

As a first major project, the panel generated a 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

CRC Report No. 667, "Diesel Fuel Storage and Handling Guide," was published on the CRC website in September 2014. ASTM held a workshop with over 160 attendees based on this report in June 2015.

The Panel then developed a summary one-sheet guide targeted to benefit fuel station operators. CRC Report No. 672, “Preventive Maintenance Guide for Diesel Storage and Dispensing Systems,” was published on the CRC website in July 2016.

Corrosion

Accelerated corrosion has been observed in some retail underground tanks storing and dispensing ultra-low sulfur diesel (ULSD) since 2007. In addition, the corrosion is affecting many of metallic equipment in both the wetted and un-wetted portions of some ULSD underground storage tanks (USTs). To identify the root cause of accelerated corrosion, multiple stakeholders in the diesel, vehicle, regulatory, and truck stop industries, through the Clean Diesel Fuel Alliance, sponsored a field research study by Battelle Memorial Institute in 2012.

The CRC Panel developed a protocol for selecting sites with diesel fuel systems that had severe corrosion. This was posted to the CRC website with the goal of informing the EPA and others in their current and future research on this topic. Using the CRC protocol, the EPA, in consultation with the CRC Panel, conducted a survey USTs in the field.

To identify possible root causes of the excessive corrosion, the CRC Panel developed a laboratory test program titled:

Identification of Potential Parameters Causing Corrosion of Metallic Components in Diesel Underground Storage Tanks (DP-07-16-1)

The project objective is to identify parameters that directly contribute to accelerated corrosion of metal parts and tank equipment in underground storage tank systems that are in ultra-low sulfur diesel service, including retail sales, fleet suppliers, and fuel storage for emergency power generation. The parameters being evaluated were generated by identifying all major changes that took place related or independent of the introduction of ULSD.

Battelle is performing this project. Reporting is anticipated in early 2019. This general screening may rule out some of the 11 parameters and identify those having the potential to increase the corrosion rate. A more focused study of important factors may be the next project.

PERFORMANCE COMMITTEE

Deposit

The objective of this Panel is to identify or develop a laboratory bench top or test rig for evaluating diesel fuel's tendency to cause internal injector deposits in diesel engines and to use a tool to evaluate possible effects by fuels, impurities, and additives.

An initial scoping study of limited screening used three 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. The Delphi rig was identified as one that had the potential for this application. Results of these studies are in two CRC reports on the CRC website:

CRC Project DP-04, "Scoping Study to Evaluate Two Rig Tests for Internal Injector Sticking," July 2012.

CRC Project DP-04-13b, "Internal Injector Deposits: A Scoping Study to Evaluate the Delphi Test Rig," August 2013.

A comprehensive rig/engine test program was conducted to verify correlation between the Delphi rig and actual engines. Results were positive and have been documented in CRC Report DP-04-10 "Internal Injector Deposits; Correlation of the Delphi Test Rig with Production Engines," published March 2016 on the CRC website.

The Deposit Panel has designed a program to set up and use the test rig at a U.S. research facility to begin evaluation of fuels, additives, and impurities. The project is titled "Fuel Research Using the Internal Diesel Injector Deposit (IDID) Rig" (CRC DP-04-17) and is being performed by SwRI. The first phase has been completed, including setting up the new rig, repeating fuels from the previous program to ensure that the rig is similar in performance to the one used at Delphi, and testing the new VASE capability for deposit evaluation. VASE capability provides quantitative data and differentiates among fuels. Additional tests were performed to evaluate seven-hour tests as a replacement for 21-hour tests.

The next Phase of the research is conducting tests to identify potential factors responsible for injector sticking. Testing is in process. The complete report is anticipated in 2019.

Low Temperature Operability

The panel has utilized members' expertise to generate CRC Report No. 671, "Diesel Fuel Low Temperature Operability Guide."

The intent was to develop a guide similar to that published by CRC for Diesel Cleanliness. The guide was written for general use by end users, fuel producers/distributers, and OEMs in providing guidance on the best ways to keep diesel vehicles operating under most low temperature conditions.

The guide was released on the CRC website in September 2016.

The Panel is conducting a project titled, "Low Temperature Filterability of Diesel Fuel at Retail Pumps." A test rig developed at Innospec is being used to determine limitations in dispenser filters in operation in cold temperature. This test rig may be able to evaluate any relationship between filter pore size and operational issues at low temperatures.

PART THREE

RELEASED REPORTS

RELEASED REPORTS - 2018

AIR POLLUTION & ADVANCED TECHNOLOGY*

CRC Project No.	Title	Publication/NTIS Accession No.
A-105	Influence of NOx on Secondary Organic Aerosol and Ozone Executive Summary	PB2018-101255
A-106	Evaluating the Sensitivity of MOVES2014a to Local Start Activity Data	PB2018-100478
A-108	Perspective on Mechanism Development and Structure-Activity Relationships for Gas-Phase Atmospheric Chemistry	*International Journal of Chemical Kinetics* Volume 50, Issue 6 June 2018, Pgs 435-469 https://doi.org/10.1002/kin.21172
A-109	Air Quality Modeling of the Relationship Between Simulated PM2.5 in Response to Varying Reductions of Ammonia Emissions over the South Coast Air Basin: Executive Summary	PB2018-101221
	Projected Changes in Particulate Matter Concentrations in the South Coast Air Basin Due to Basin-Wide Reductions in Nitrogen Oxides, Volatile Organic Compounds and Ammonia Emissions	*Journal of the Air & Waste Management Association* PENDING*
A-110	Scoping Study for Rewrite of MOVES for Efficiency	PB2017-102618
AVFL-20	Effects of Octane Number, Sensitivity, Ethanol Content, and Engine Compression Ratio on GTDI Engine Efficiency, Fuel Economy, and CO2 Emissions	PB2018-100225
AVFL-28	Gasoline Direct Injection (GDI) Engine Wear Test Development	PB2018-100570
AVFL-29	Enhanced Speciation of Gasoline	PB2018-101330

E-94-2	Relationship Among Various Particle Characterization Metrics Using GDI Engine Based Light-Duty Vehicles	*SAE Technical Paper* 2018-01-0353, 2018, https://doi.org/10.4271/2018-01-0353
E-94-3	Impacts of Splash-Blending on Particulate Emissions for SIDI Engines	PB2018-101084
E-99	Very Low Particle Matter Mass Measurements from Light-Duty Vehicles	*Journal of Aerosol Science* Vol. 117, March 2018, Pgs 1-10 https://doi.org/10.1016/j.jaerosci.2017.12.006
	Uncertainty in Gravimetric Analysis Required for LEV III Light-Duty Vehicle PM Emission Measurements	SAE Int. J. Engines 11(3):2018, doi:10.4271/03-11-03-0024
E-102-2	Review of Critical Parameters for Transportation Fuel Pathways	PB2018-100910
E-106	The Story of Ever Diminishing Vehicle Tailpipe Emissions as Observed in the Chicago, Illinois Area	*Environmental Science & Technology* 52 (13), May 18, 2018, Pgs 7587–7593 DOI: 10.1021/acs.est.8b00926
E-110-27	Highlights from the Coordinating Research Council's 27th Real World Emissions Workshop	*EM Magazine* October, 2017
E-114-2	Literature Review on the Effects of Organometallic Fuel Additives in Gasoline and Diesel Fuels	*SAE Int.J. Fuels Lubr.* 11(1):2018, doi:10.4271/04-11-01-0005
E-119	Remote Sensing of Automobiles Emissions in Rolling Meadows: Fall 2016	PB2017-102620
E-119a	Fall 2016 On-Road Emissions Measurements in the Chicago Area: Comparison of two University of Denver Remote Sensing Datasets	PENDING*

E-119-2	Hager Environmental and Atmospheric Technologies (HEAT) and Denver University (DU) Remote Sensing Device (RSD) Data Mining	PB2018-101634
E-122	Light Duty PEMS Validations / Chassis Dynamometer Correlation	PB2018-101254
E-123	On-Road Remote Sensing Of Automobile Emissions in The Tulsa Area: Fall 2017	PB2018-101303
	On-Road Remote Sensing of Automobile Emissions in the Denver Area: Winter 2017	PB2018-101636
E-123-2	Evaluation of Emissions Benefits of Federal Reformulated Gasoline versus Conventional Gasoline	PB2018-101083
E-123-3	Analyze Existing West LA Data set for On-Road Evaporative Emissions	PB2018-101637
RW-104	Literature Review to Assess the Use of Stock and Flow Models Compared to Other GHG Methodologies to Model Biofuel GHGS	PB2018-101372

RELEASED REPORTS (Cont.) - 2018

AVIATION & PERFORMANCE*

CRC Project No.	Title	Publication/NTIS Accession No.
AV-18-17	The Quality of Aviation Fuel Available in the United Kingdom Annual Survey 2014	PB2018-100990
AV-22-15	Charge generation and dissipation in aviation fuel handling with filter monitors	PB2018-100226
AV-23-15/17	Review of Existing Test Methods Used for Aviation Jet Fuel and Additive Property Evaluations with Respect to Alternative Fuel Compositions	PB2018-101329
CM-138-16-1	Literature Review and OEM/Test House Interviews on Alternatives for Determining Demerits of Vehicle Performance	PB2018-100479
CM-136-15-1	Investigation into Filter Plugging Due to Sulfate Salt Contamination of Ethanol, Gasoline, and Gasoline-Ethanol Blends	PB2018-100663
DP-08-18 (CRC Report No. 673)	Renewable Hydrocarbon Diesel Fuel Properties and Performance Review	PB2018-101635

The primary source for CRC 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.

*"PENDING" reports are available now on CRC website, www.crcao.org.

PART FOUR

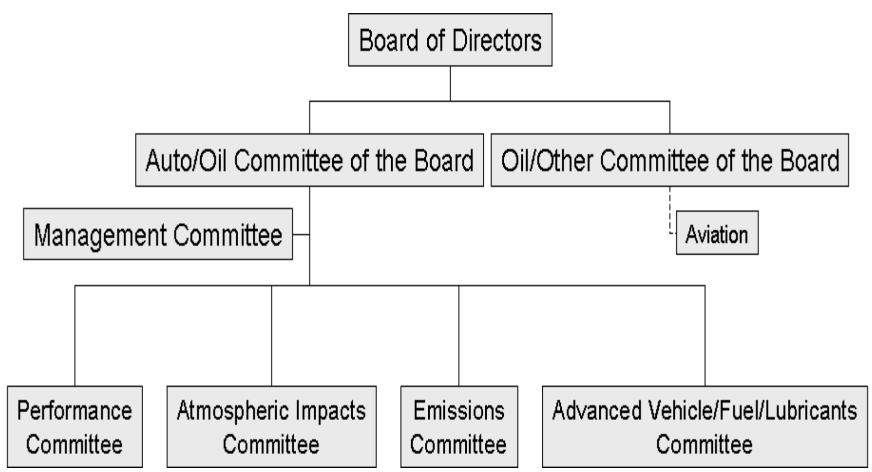
ORGANIZATION AND MEMBERSHIP

ORGANIZATION – 2018

The sustaining members of the CRC are the American Petroleum Institute (API) and a consortium of automobile manufacturers [Fiat Chrysler Automobiles (FCA), Daimler, Ford, General Motors, Honda, Mitsubishi, Nissan, Toyota, and Volkswagen]. For over 76 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 on the CRC website.

CRC's Auto/Oil Committee of the Board of Directors oversees the cooperative research summarized in this report. Board membership is comprised of seven representatives from the petroleum industry and nine 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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D.M.DiCicco	Ford Motor Co.	S. McConnell	Marathon Petroleum Co.
J. Farenback-Brateman	ExxonMobil	J.Mengwasser	Shell Global Solutions
M. Foster	BP	B. Reed	Mitsubishi Mtrs. R&D Am.
D. Ganss	Nissan Tech. Ctr. NA		
G. C. Gunter	Phillips 66	J. Y. Sigelko	Volkswagen of America
A. Ickes	Chevron Energy Techn.	R. Sutschek	Volkwagen of America
A. Iqbal	FCA USA LLC.	M. Valentine	Toyota Tech. Ctr. N.A.
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J. Cruz	Daimler	B. Reed	Mitsubishi Mtrs R&D Am.
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M. Block	Mitsubishi Mtrs R&D Am.	P. Loeper	Chevron Global Dnstrm
		S. A. Mason	Phillips 66
J. Cruz	Daimler	M. Moore	FCA USA LLC.
D. M. DiCicco	Ford Motor Co.	J. Y. Sigelko	Volkswagen of America
R. George	BP	M. Valentine	Toyota Tech. Ctr. N.A.
J. J. Jetter	Honda R&D Am.		

E-117 PANEL

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R. George	BP	M. Moore	FCA USA LLC.
G. Gunter	Phillips 66	M. Valentine	Toyota Tech. Ctr. N.A.
J. J. Jetter	Honda R&D Am.	M. B. Viola	General Motors
F. Khan	Nissan Tech. Ctr. N.A.	W. Woebkenberg	Aramco Services
J. Lee	Aramco Services		
P. Loeper	Chevron Global Dnstrm		

E-122 PANEL

D. Z. Short, Co-Leader	Marathon Petroleum Co.
M. B. Viola, Co-Leader	General Motors

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S. Berkhous	ExxonMobil
M. Block	Mitsubishi Mtrs R&D Am.
J. Cruz	Daimler
D. M. DiCicco	Ford Motor Co.
R. George	BP
J. J. Jetter	Honda R&D Am.
F. Khan	Nissan Tech. Ctr. NA
J. Lee	Aramco Services
P. Loeper	Chevron Global Dnstrm.
A. S. Mabutol	Mitsubishi Mtrs R&D Am.
S. A. Mason	Phillips 66
J. Mengwasser	Shell Global Solutions
M. Moore	FCA USA LLC.
M. Olson	Mitsubishi Mtrs R&D Am.
J. Y. Sigelko	Volkswagen of America
J. Unsworth	FCA USA LLC.
M. Valentine	Toyota Tech. Ctr. N.A.
D. Vu	Ford Motor Co.
W. Woebkenberg	Aramco Services
M. Yassine	FCA USA LLC.

E-127-1 PANEL

D. M. DiCicco, Co-Leader	Ford Motor Co.
P. Loeper, Co-Leader	Chevron Global Dnstrm.
D. Z. Short, Co-Leader	Marathon Petroleum Co.

J. Anderson	Ford Motor Co.
T. Bera	Shell Global Solutions
S. Berkhous	ExxonMobil
M. Block	Mitsubishi Mtrs. R&D Am.
J. Cruz	Daimler
R. George	BP
J. J. Jetter	Honda R&D Am.
F. Khan	Nissan Tech. Ctr. NA
J. Lee	Aramco Services
A. S. Mabutol	Mitsubishi Mtrs. R&D Am.
S. A. Mason	Phillips 66
J. Mengwasser	Shell Global Solutions
M. Moore	FCA USA LLC.
J. Y. Sigelko	Volkswagen of America
M. Valentine	Toyota Tech. Ctr. N.A.
M. B. Viola	General Motors
W. Woebkenberg	Aramco Services

MEMBERSHIP

E-129 PANEL

S. Berkhous, Co-Leader	ExxonMobil
M. Valentine, Co-Leader	Toyota Tech. Ctr. N.A.

A. Carreon	Ford Motor Co.	S. A. Mason	Phillips 66
S. Decarteret	General Motors	J. Mengwasser	Shell
D. M. DiCicco	Ford Motor Co.	M. Moore	FCA USA LLC.
J. Glodich	Ford Motor Co.	D. Z. Short	Marathon Petroleum Co.
D. Lax	API	J. Y. Sigelko	Volkswagen of America
R. P. Lewis	Marathon Petroleum Co.	M. B. Viola	General Motors
P. Loeper	Chevron Global Dnstrm		

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
R. Baldauf	US EPA
N. J. Barsic	John Deere
M. Beardsley	US EPA
T. Bera	Shell Global Solutions
S. Berkhous	ExxonMobil
K. N. Black	FHWA
K. Borgert	US EPA
A. Carreon	Ford Motor Co.
J. Cruz	Daimler
A. Cullen	US EPA
R. DeKleine	Ford Motor Co.
J. Farenback-Brateman	ExxonMobil
T. A. French	EMA
C. R. Fulper	US EPA
D. Ganss	Nissan Tech. Ctr. NA
R. George	BP
R. Giannelli	US EPA
C. Hart	US EPA
K. Helmer	US EPA
J. J. Jetter	Honda R&D Am.
F. Khan	Nissan Tech. Ctr. NA
F. A. Krich	FCA USA LLC.
C. Laroo	EPA
D. H. Lax	API
J. Lee	Aramco Services
R. P. Lewis	Marathon Petrol. Co.
P. Loeper	Chevron Global Dnstrm.
J. E. Long	CARB
T. R. Long	US EPA
F. Minassian	SCAQMD
A. S. Mabutol	Mitsubishi Mtrs R&D Am.
M. M. Maricq	Ford Motor Co.
M. E. Moore	FCA USA LLC.
J. Mengwasser	Shell Global Solutions
R. Nankee	FCA USA LLC.
R. Nine	DOE/NETL
M. Olechiw	US EPA
F. Parsinejad	Chevron Oronite
R. Purushothaman	Caterpillar
C. Ruehl	CARB
S. A. Shimpi	Cummins
D. Z. Short	Marathon Petroleum Co.
J. Y. Sigelko	Volkswagen of America
M. R. Smith	Navistar
D. Sonntag	US EPA
R. Sutschek	Volkwagen of America
M. Valentine	Toyota Tech. Ctr. N.A.
W. Vance	CARB
M. B. Viola	General Motors
D. Vu	Ford Motor Co.
W. Woebkenberg	Aramco Services
M. K. Yassine	FCA USA LLC.
S. Yoon	CARB

MEMBERSHIP

E-119-2 PANEL

	D. M. DiCicco, Leader	Ford Motor Co.	
N. J. Barsic	John Deere	P. Loeper	Chevron Global Dnstrm.
S. Berkhous	ExxonMobil	M. M. Maricq	Ford Motor Co.
K. N. Black	FHWA	S. A. Mason	Phillips 66
A. Carreon	Ford Motor Co.	M. E. Moore	FCA USA LLC.
T. A. French	EMA	R. Purushothaman	Caterpillar
C. Hart	US EPA	C. Ruehl	CARB
D. H. Lax	API	D. Sonntag	US EPA
R. P. Lewis	Marathon Petroleum Co.	M. B. Viola	General Motors

28TH REAL WORLD EMISSIONS WORKSHOP ORGANIZING COMMITTEE

	D. M. DiCicco, Co-Chair	Ford Motor Co.	
	S. A. Mason, Co-Chair	Phillips 66	
M. Beardsley	US EPA	F. Minassian	SCAQMD
K. N. Black	FHWA	R. Purushothaman	Caterpillar
S. Collet	Toyota Technical Ctr. N.A.	S. A. Shimpi	Cummins
T. Huai	CARB	M. Thornton	NREL
T. R. Long	US EPA	S. Yoon	CARB

E-123-2 PANEL

	D. M. DiCicco, Co-Leader	Ford Motor Co.	
	S. Berkhous, Co-Leader	ExxonMobil	
N. J. Barsic	John Deere	S. Mason	Phillips 66
K. N. Black	FHWA	M. E. Moore	FCA USA LLC.
K. Borgert	US EPA	J. Mengwasser	Shell Global Solutions
D. H. Lax	API		

MEMBERSHIP

RW-104 PANEL

D. Z. Short, Co-Leader	Marathon Petroleum Co.
A. Kapur, Co-Leader	Phillips 66
L. Verduzco, Co-Leader	Chevron
W. Chernicoff, Co-Leader	Toyota Tech. Ctr. N.A

K. N. Black	FHWA
R. Bromiley	Shell Projects & Tech.
R. De Kleine	Ford Motor Co.
J. Farenback-Brateman	ExxonMobil
A. Kapur	Phillips 66
L. Rafelski	US EPA
D. H. Lax	API
R. P. Lewis	Marathon Petroleum Co.
A. Levy	US EPA
C. Lohmann	Flint Hills Research
M. Moore	FCA USA LLC.
J. Y. Sigelko	Volkswagen of America
M. R. Smith	Navistar
M. Valentine	Toyota Tech. Ctr. N.A.

MEMBERSHIP

RW-107 PANEL

J. J. Jetter, Co-Leader	Honda R&D Am.
R. P. Lewis Co-Leader	Marathon Petroleum Co.

J. R. Agama	Caterpillar
J. Anderson	Ford Motor Co.
C. Bailey	US EPA
R. Baldauf	US EPA
N. J. Barsic	John Deere
M. Beardsley	US EPA
S. Berkhous	ExxonMobil
K. N. Black	FHWA
V. Burns	FCA USA LLC.
A. Butler	US EPA
K. Borgert	US EPA
J. Cruz	Daimler
A. Cullen	US EPA
D. M. DiCicco	Ford Motor Co.
J. Farenback-Brateman	ExxonMobil
T. A. French	EMA
C. R. Fulper	US EPA
R. George	BP
R. Giannelli	US EPA
C. Hart	US EPA
K. Helmer	US EPA
F. Khan	Nissan Tech. Ctr. NA
F. A. Krich	FCA USA LLC.
C. Laroo	EPA
D. H. Lax	API
J. Lee	Aramco Services
P. Loeper	Chevron Global Dnstrm.
J. E. Long	CARB
T. R. Long	US EPA
F. Minassian	SCAQMD
A. S. Mabutol	Mitsubishi Mtrs. R&D Am.
M. M. Maricq	Ford Motor Co.
S. A. Mason	Phillips 66
J. Mengwasser	Shell Global Solutions
M. Moore	FCA USA LLC.
R. Nankee	FCA USA LLC.
R. Nine	DOE/NETL
M. Olechiw	US EPA
F. Parsinejad	Chevron Oronite
R. Purushothaman	Caterpillar
C. Ruehl	CARB
S. A. Shimpi	Cummins
D. Z. Short	Marathon Petroleum Co.
J. Y. Sigelko	Volkswagen of America
M. R. Smith	Navistar
R. Sobotowski	US EPA
D. Sonntag	US EPA
M. Valentine	Toyota Tech. Ctr. N.A.
W. Vance	CARB
M. B. Viola	General Motors
W. Woebkenberg	Aramco Services
M. K. Yassine	FCA USA LLC.

LIFE CYCLE ANALYSIS PANEL

R. De Kleine, Co-Leader	Ford Motor Co.
J. Farenback-Brateman, Co-Leader	ExxonMobil
D. Z. Short, Co-Leader	Marathon Petroleum Co.

R. Bromiley	Shell Projects & Tech.	C. Lohmann	Flint Hills Research
V. R. Burns	FCA USA LLC.	A. S. Mabutol	Mitsubishi Mtrs. R&D Am.
J. Han	ExxonMobil	S. A. Mason	Phillips 66
A. Kapur	Phillips 66	S. Popp	FCA USA LLC.
C. Kim	Ford Motor Co.	L. Rafelski	US EPA
D. H. Lax	API	L. Verduzco	Chevron
R. P. Lewis	Marathon Petroleum Co.	M. B. Viola	General Motors
A. Levy	US EPA		

MEMBERSHIP

ATMOSPHERIC IMPACTS COMMITTEE

D. C. Baker, Co-Chair	API Consultant
S. Collet, Co-Chair	Toyota Technical Ctr. N.A.

D. Ganss	Nissan Tech. Ctr. NA	B. Postel	BP America
C. Jones	General Motors	C. Rabideau	Chevron
A. S. Mabutol	Mitsubishi Mtrs. R&D Am.	J. Y. Sigelko	Volkswagen of America
		R. Sutschek	Volkswagen of America
S. A. Mason	Phillips 66	T. J. Wallington	Ford Motor Co.
M. E. Moore	FCA USA LLC.	S. Winkler	Ford Motor Co.
G. F. Myers	Marathon Petroleum Co.	K. Wrigley	ExxonMobil

ATMOSPHERIC IMPACTS WORKING GROUP

D. C. Baker, Co-Chair	API Consultant
S. Collet, Co-Chair	Toyota Technical Ctr. N.A.

Z. Adelman	LADCO	T. Kuwayama	CARB
M. Beardsley	US EPA	C. Lawson	Shell
D. Choi	US EPA	D. H. Lax	API
B. E. Croes	CARB	S. M. Lee	SCAQMD
D. M. DiCicco	Ford Motor Co.	M. M. Maricq	Ford Motor Co.
H. J. Feldman	API	R. Mathur	US EPA
T. A. French	EMA	J. Price	TX Comm. on EQ
S. Gao	Phillips 66	K. Sargeant	US EPA
J. Geidosch	US EPA	J. Smith	TX Comm. on EQ
M. L. Gupta	FAA	S. Tanrikulu	BAAQMD
M. Janssen	LADCO	B. Timin	US EPA
C. Kalisz	API	C. Yanca	US EPA
D. M. Kenski	LADCO	J. Zietsman	TX A&M Trans. Inst.
M. Koerber	US EPA		

MEMBERSHIP

A-110 PANEL

S. Collet, Co-Leader	Toyota Technical Ctr. N.A.
M. Janssen, Co-Leader	LADCO

D. C. Baker	Shell Global Solutions	C. G. Rabideau	Chevron
D. Choi	US EPA	J. Y. Sigelko	Volkswagen of America
S. McConnell	Marathon Petroleum Co.	S. Winkler	Ford Motor Co.

A-112 PANEL

C. G. Rabideau, Co-Leader	Chevron
S. Winkler, Co-Leader	Ford Motor Co.

D. C. Baker	API Consultant	E. Hendler	Houston Ozone SIP Coalition
D. Choi	US EPA	C. Kalisz	API
S. Collet	Toyota Technical Ctr. N.A.	S. M. Lee	SCAQMD
S. W. Hampton	ExxonMobil	A. S. Mabutol	Mitsubishi Mtrs. R&D Am.

2018 SOUTHERN CALIFORNIA OZONE RESEARCH SYMPOSIUM (Project No. A-116)

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

J. R. Agama	Caterpillar	M. Spears	EMA
S. Gao	Phillips 66	M. C. Sospedra	SCAQMD
S. M. Lee	SCAQMD	J. Y. Sigelko	Volkswagen of America
R. Mathur	US EPA	W. Vance	CARB
C. G. Rabideau	Chevron	S. Winkler	Ford Motor Co.
A. G. Russell	GA Tech		

MEMBERSHIP

2019 MSAT ORGANIZING COMMITTEE
(Project No. A-117)

D. C. Baker, Co-Chair	API Consultant
S. Collet, Co-Chair	Toyota Technical Ctr. N.A.

S. K. Hoekman	DRI	C. Ruehl	CARB
G. F. Meyers	Marathon Petroleum Co.	J. Y. Sigelko	Volkswagen of America
T. Kuwayama	CARB	T. J. Wallington	Ford Motor Co.
		S. Yoon	CARB

MEMBERSHIP

PERFORMANCE COMMITTEE

A. Iqbal, Co-Chair	FCA USA LLC.
J. J. Simnick, Co-Chair	BP

R. Adams	Mitsubishi Mtrs. R&D Am.
J. Axelrod	ExxonMobil
J. Cruz	Daimler
D. Ganss	Nissan Tech. Ctr. NA
G. C. Gunter	Phillips 66
J. Jetter	Honda
R. P. Lewis	Marathon Petroleum Co.
S. Lopes	General Motors
M. E. Moore	FCA USA LLC.
M. Nikanjam	Chevron
B. Raney-Pablo	Ford Motor Co.
J. Russo	Shell
J. Y. Sigelko	Volkswagen of America
W. Studzinski	General Motors
M. Valentine	Toyota Tech. Ctr. N.A.
M. Winston-Galant	General Motors
W. Woebkenberg	Aramco Services

GASOLINE DEPOSIT GROUP
(Project No. CM-136)

J. Axelrod, Chair	ExxonMobil
J. Cruz	Daimler

B. Alexander	BP
D. Bohn	Flint Hills
K. Brunner	SwRI
R. Chapman	Innospec
J. Draper	Motiva
B. Evans	Evans Research
T. Frank	Lubrizol Corp.
I. Gabrel	FCA USA LLC.
L. M. Gibbs	Consultant
G. C. Gunter	Phillips 66
C. Huang	ITW
J. J. Jetter	Honda R&D Am.
A. M. Kulinowski	Afton Chemical
D. H. Lax	API
R. P. Lewis	Marathon Petroleum Co.
P. Loeper	Chevron
M. Lynch	ExxonMobil
I. Mathur	Haltermann
M. Miller	Sunoco Inc.
K. Mitchell	Shell Canada Ltd.
R. Monroe	General Motors
C. L. Muth	Nalco Energy Services
F. Parsinejad	Chevron Oronite Co.
C. M. Pyburn	Pytertech Intl.
B. Raney-Pablo	Ford Motor Co.
J. Russo	Shell
D. Schoppe	Intertek
D. Z. Short	Marathon Petroleum Co.
J. Y. Sigelko	Volkswagen of America
W. Studzinski	General Motors
W. Y. Su	Huntsman Corp.
R. D. Tharby	Tharby & Associates
M. Valentine	Toyota Tech. Ctr. N.A.
M. Winston-Galant	General Motors
W. Woebkenberg	Aramco Services
H. Zhao	Huntsman Adv Tech.

MEMBERSHIP

GASOLINE DEPOSIT SULFATE PANEL
(Project No. CM-136-15-1)

R. P. Lewis, Co-Leader	Marathon Petroleum Co.
C. Jones, Co-Leader	General Motors

B. Alexander	BP
J. Axelrod	ExxonMobil
J. Cruz	Daimler
K. Davis	RFA
I. Gabrel	FCA USA LLC.
L. Gibbs	Consultant
G. C. Gunter	Phillips 66
R. Hardy	Flint Hills Resources
A.M. Kulinowski	Afton Chemical
D. H. Lax	API
M. Lynch	ExxonMobil
A. McKnight	Innospec
B. Raney-Pablo	Ford Motor Co.
J. Russo	Shell
D. Z. Short	Marathon Petroleum Co.
M. Valentine	Toyota Tech. Ctr. N.A.
M. Winston-Galant	General Motors

OCTANE GROUP
(Project No. CM-137)

M. Winston-Galant, Co-Leader	Ford Motor Co.
W. Woebkenberg, Co-Leader	Aramco Services

B. Alexander	BP
T.Briggs	SwRI
K. Brunner	SwRI
E. Chapman	General Motors
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.
G. C. Gunter	Phillips 66
A. Iqbal	FCA USA LLC.
J. J. Jetter	Honda R&D Am.
C. Jewitt	Consultant
F. Khan	Nissan Tech. Ctr. NA
D. H. Lax	API
R. P. Lewis	Marathon Petroleum Co.
P. Loeper	Chevron
M. Lynch	ExxonMobil
J. Mengwasser	Shell
M. Miller	Sunoco Inc.
K. Mitchell	Consultant
P. J. Morgan	SwRI
C. M. Pyburn	Pybertech International
B. Raney-Pablo	Ford Motor Co.
J. Russo	Shell
D. Schoppe	Intertek
D. Z. Short	Marathon Petroleum Co.
J. Y. Sigelko	Volkswagen of America
J. J. Simnick	BP
R. A. Sobotowski	US EPA
W. Studzinski	General Motors
A. Swarts	SwRI
M. Valentine	Toyota Tech. Ctr. N.A.

OCTANE GROUP – LSPI PROJECT PANEL
(Project No. CM-137-17-1)

W. Woebkenberg, Co-Leader — Aramco Services
E. Chapman, Co-Leader — General Motors

B. Alexander	BP
J. Anderson	Ford Motor Co.
V. Costanzo	Aramco Services
J. Cruz	Daimler
R. Davis	General Motors
D. M. DiCicco	Ford Motor Co.
J. Farenback-Brateman	ExxonMobil
G. C. Gunter	Phillips 66
A. Iqbal	FCA USA LLC.
J. J. Jetter	Honda R&D Am.
F. Khan	Nissan Tech. Ctr. NA
D. H. Lax	API
R. P. Lewis	Marathon Petroleum Co.
M. Lynch	ExxonMobil
J. Mengwasser	Shell
B. Raney-Pablo	Ford Motor Co.
J. Russo	Shell
D. Z. Short	Marathon Petroleum Co.
J. Y. Sigelko	Volkswagen of America
J. J. Simnick	BP
W. Studzinski	General Motors
M. Valentine	Toyota Tech. Ctr. N.A.
M. Winston-Galant	General Motors

MEMBERSHIP

VOLATILITY GROUP
(Project No. CM-138)

L. M. Gibbs, Co-Leader	Consultant
M. Valentine, Co-Leader	Toyota Tech Ctr. N.A.
R. P. Lewis, Co-Leader	Marathon Petroleum Co.

B. Alexander	BP
K. Brunner	SwRI
J. Cruz	Daimler
K. Davis	RFA
H. Doherty	Sunoco
J. Draper	Motiva
B. Evans	Evans Research
J. Farenback-Brateman	ExxonMobil
T. Frank	Lubrizol Corp.
I. Gabrel	FCA USA LLC.
G. C. Gunter	Phillips 66
R. Hardy	Flint Hills Resources
G. Herwick	Trans. Fuels Consult.
A. Iqbal	FCA USA LLC.
J. J. Jetter	Honda R&D Am.
C. Jones	General Motors
F. Khan	Nissan Tech. Ctr. NA
D. H. Lax	API
P. Loeper	Chevron
M. Lynch	ExxonMobil
K. Mitchell	Consultant
B. Raney-Pablo	Ford Motor Co.
J. Russo	Shell
D. Schoppe	Intertek
D. Z. Short	Marathon Petroleum Co.
J. Y. Sigelko	Volkswagen of America
W. Studzinski	General Motors
M. Valentine	Toyota Tech. Ctr. N.A.
S. Van Hulzen	POET
M.Winston-Galant	General Motors
W. Woebkenberg	Aramco Services

DEVELOPMENT OF AN ENGINE BASED TEST FOR DETERMINING THE EFFECT OF SPARK IGNITION FUEL PROPERTIES ON COMBUSTION AND VEHICLE DRIVEABILITY PROJECT PANEL
(Project No. CM-138-15-2)

C. Jones, Leader — General Motors

K. Davis	RFA	D. H. Lax	API
L. M. Gibbs	Consultant	J. Y. Sigelko	Volkswagen of America
G. C. Gunter	Phillips 66	J. J. Simnick	BP
G. Herwick	Trans. Fuels Consult.	M. Valentine	Toyota Tech. Ctr. N.A.
A. Iqbal	FCA USA LLC.	M.Winston-Galant	General Motors
J. J. Jetter	Honda R&D Am.	W. Woebkenberg	Aramco Services

MEMBERSHIP

LITERATURE REVIEW AND OEM/TEST HOUSE INTERVIEWS ON ALTERNATIVES FOR DETERMINING DEMERITS OF VEHICLE PERFORMANCE PROJECT PANEL (PROJECT NO. CM-138-16-1)

J. J. Simnick, Leader BP

J. Cruz	Diamler	K. Mitchell	Shell Canada Ltd.
L. M. Gibbs	Consultant	C. Richardson	Ford Motor Co.
G. C. Gunter	Phillips 66	J. Y. Sigelko	Volkswagen of America
A. Iqbal	FCA USA LLC.		
J. J. Jetter	Honda R&D Am.	M. Valentine	Toyota Tech. Ctr. N.A.
R. P. Lewis	Marathon Petroleum Co.	M.Winston-Galant	General Motors

COMPARISON OF AMBIENT TEMPERATURES FROM 'DONER REPORT' TO MODERN DAY AMBIENT TEMPERATURES FOR THE SAME GEOGRAPHIC AREAS PROJECT PANEL (PROJECT NO. CM-138-16-2)

R. P. Lewis, Co-Leader Marathon Petroleum
M.Winston-Galant, Co-Leader General Motors

B. Alexander	BP	M. Lynch	ExxonMobil
K. Davis	RFA	B. Raney-Pablo	Ford Motor Co.
H. Doherty	Sunoco	J. Russo	Shell
J. Farenback-Brateman	ExxonMobil	D. Z. Short	Marathon Petroleum Co.
L. M. Gibbs	Consultant		
G. C. Gunter	Phillips 66	M. Valentine	Toyota Tech. Ctr. N.A.
F. Khan	Nissan Tech. Ctr. NA		
D. Lax	API		

MEMBERSHIP

COMPUTER CONTROLLED POOR DRIVEABILITY ON DEMAND TRAINING VEHICLE PROJECT PANEL (PROJECT NO. CM-138-17-1)

M.Winston-Galant, Leader — General Motors

B. Alexander	BP
J. Farenback-Brateman	ExxonMobil
L. M. Gibbs	Consultant
G. C. Gunter	Phillips 66
A. Iqbal	FCA USA LLC.
J. Jetter	Honda
D. Lax	API
R. P. Lewis	Marathon Petroleum
M. Lynch	ExxonMobil
K. Mitchell	Consultant
J. Russo	Shell
D. Z. Short	Marathon Petroleum Co.
J. J. Simnick	BP
J. Y. Sigelko	Volkswagen of America
J. Simnick	BP

MEMBERSHIP

DIESEL PERFORMANCE GROUP
(Project No. DP)

S. Lopes, Co-Leader	General Motors
M. Nikanjam, Co-Leader	Chevron

H. Ahari	FCA USA LLC.	P. Lacey	Delphi Diesel Systems
A. Aradi	Shell	D. H. Lax	API
J. Axelrod	ExxonMobil	R. Leisenring	Consultant
P. Biggerstaff	Baker Petrolite	R. P. Lewis	Marathon Petroleum Co.
D. Bohn	Flint Hills Resources	T. Livingston	Robert Bosch
L. Cattani	FCA USA LLC.	R. Long	PEI
A. Cayabyab	CARB	R. L. McCormick	NREL
R. Chapman	Consultant	R. Mills	Chevron
J. Cruz	Daimler	K. Mitchell	Consultant
D. A. Daniels	Innospec Fuel Spec.	A. G. Morin	Eurenco
J. Draper	Motiva	J. Porco	Gage Products
E. English	Fuel Quality Services	B. Raney-Pablo	Ford Motor Co.
D. Forester	Fuel Quality Services	S.B.Rubin-Pitel	ExxonMobil
T. Frank	Lubrizol Corp.	J.A.Rutherford	Chevron Oronite
I. Gabriel	FCA USA LLC.	D. Schoppe	Intertek
R. Gault	EMA	P. Searles	API
R. George	BP	D. Z. Short	Marathon Petroleum Co.
G. C. Gunter	Phillips 66	J. Y. Sigelko	Volkswagen of America
C. Hamer	PCS Instruments	W. Studzinski	General Motors
D. Hess	Infineum	A. Swarts	SwRI
C. Huang	Cummins	R. D. Tharby	Tharby & Associates
J. J. Jetter	Honda R&D Am.	M. Valentine	Toyota Tech. Ctr.N.A.
F. Khan	Nissan Tech. Ctr. NA	J. VanScoyoc	Chevron Phillips Chem Co.
D. Kozub	Daimler	G. Webster	AET
A. Kulinowski	Afton Chemical	S.A.Westbrook	SwRI
E. Kurtz	Ford Motor Co.	W.Woebkenberg	Aramco Services

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

S. Broughton, Leader   Marathon Petroleum Co.

J. Axelrod	ExxonMobil	R. P. Lewis	Marathon Petroleum Co.
J. Chandler	Consultant	S. Lopes	General Motors
D. A. Daniels	Innospec Fuel	H. Martin	Cummins / Fleetguard
T. Frank	Lubrizol Corp.	K. Mitchell	Consultant
R. Gault	EMA	M. Nikanjam	Chevron Products Co.
G.C. Gunter	Phillips 66	S.B. Rubin-Pitel	ExxonMobil
D. Hess	Infineum	P. Searles	AP
C. Hodge	Consultant	W. Studzinski	General Motors
J. J. Jetter	Honda R&D Am.	M. Valentine	Toyota Tech. Ctr.N.A.
A.M.Kulinowski	Afton Chemical		

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

A. M. Kulinowski, Leader   Afton Chemical

R. Andra	FCA USA LLC.	T. Livingston	Robert Bosch
A. Aradi	Shell	S. Lopes	General Motors
J. Axelrod	ExxonMobil	K. Mitchell	Consultant
A. L. Boehman	Univ of MI	A.G. Morin	Eurenco
K. Brogan	General Motors	M. Nikanjam	Chevron Products Co.
T. Frank	Lubrizol Corp	S. B. Rubin-Pitel	ExxonMobil
R. Gault	EMA	J. Y. Sigelko	Volkswagen of America
R. George	BP	W. Studzinski	General Motors
G.C. Gunter	Phillips 66	M. Valentine	Toyota Tech. Ctr.N.A.
J. J. Jetter	Honda R&D Am.	W. Woebkenberg	Aramco Services

MEMBERSHIP

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

J. Axelrod, Co-Leader.	ExxonMobil
M. Nikanjam, Co-Leader	Chevron

D. Abdallah	ExxonMobil
H. Abi-Akar	Caterpillar
M. Ahmadi	Oronite Additive
A. Aradi	Shell
P. Biggerstaff	Baker Petrolite
D. Bohn	Flint Hills Resources
C. Burbrink	Cummins
R. Chapman	Consultant
J. Draper	Motiva
T. Frank	Lubrizol Corp.
R. Gault	EMA
R. George	BP
B. E. Goodrich	John Deere
G. C. Gunter	Phillips 66
H. Huang	Cummins
J. J. Jetter	Honda R&D Am.
A. Kulinowski	Afton Chemical
P. Lacey	Delphi Diesel Systems
D. H. Lax	API
T. Livingston	Robert Bosch
S. Lopes	General Motors
J. Martinez	Chevron
K. Mitchell	Consultant
M. Valentine	Toyota Tech. Ctr. N.A.
S.A.Westbrook	SwRI

DP - DEPOSIT PROJECT PANEL
(Project No. DP-04-17)

J. Axelrod, Co-Leader	ExxonMobil
M. Nikanjam, Co-Leader	Chevron Products Co

D. Abdallah	ExxonMobil
A. Aradi	Shell
R. Chapman	Consultant
J. Draper	Motiva
R. Gault	EMA
G. C. Gunter	Phillips 66
A. Kulinowski	Afton Chemical
P. Lacey	Delphi Diesel Systems
T. Livingston	Robert Bosch
S. Lopes	General Motors
J. Martinez	Chevron

MEMBERSHIP

DP – FUEL CLEANLINESS PANEL
(Project No. DP-06-16-1)

R. Chapman, Leader — Consultant

C. Burbrink	Cummins	J. Martinez	Chevron
J. Eichberger	Fuels Institute	M. Nikanjam	Chevron
E. W. English	Fuel Quality Services	F. Passman	BCA Inc.
R. Gault	EMA	S. Pollock	Steel Tank Institute
G. C. Gunter	Phillips 66	S. Rubin-Pitel	ExxonMobil
R. Haerer	US EPA	P. Searles	API
R. Leisenring	Consultant	D. Z. Short	Marathon Petroleum Co.
R. P. Lewis	Marathon Petroleum Co.	M. Valentine	Toyota Tech. Ctr.N.A.
T. Livingston	Robert Bosch	S. A. Westbrook	SwRI
S. Lopes	General Motors		

DP – FUEL CORROSION PANEL
(PROJECT NO. DP-07-16)

D. H. Lax, Leader. — API

A. Aradi	Shell	R. Long	PEI
R. Chapman	Consultant	J. Martinez	Chevron
T. Covert	Ford	R. McNutt	Sigma
J. Eckstrom	BP	K. Moriarty	NREL
J. Eichberger	Fuels Institute	M. Nikanjam	Chevron
E. W. English	Fuel Quality Services	F. Passman	Biodeterioration Cntrl Assoc.
S. Fenwick	Nat. Biodiesel Brd.	S. Pollock	Steel Tank Institute
R. Gault	EMA	B. Renkes	Fiberglass Tank & Pipe
L. Gerber	US EPA	P. Searles	API
G. C. Gunter	Phillips 66	D. Z. Short	Marathon Petroleum Co.
R. Haerer	US EPA		
S. Hernandez	Chevron	K. Spiker	Quiktrip
S. Howell	Nat. Biodiesel Brd.	M. Valentine	Toyota Tech. Ctr.N.A.
M. Kass	ORNL	S. A. Westbrook	SwRI
R.P. Lewis	Marathon Petroleum Co.		

MEMBERSHIP

DP – BIODIESEL AND RENEWABLE DIESEL PANEL
(Project No. DP-08)

R. L. McCormick, Leader NREL

A. Aradi	Shell	S. Howell	Nat. Biodiesel Brd.
D. Bohn	Flint Hills Resources	J. J. Jetter	Honda R&D Am.
J. Chandler	Consultant	D. Lax	API
R. Chapman	Innospec	R. Lewis	Marathon Petroleum Co.
J. Cruz	Daimler		
D. Daniels	Innospec	T. Livingston	Robert Bosch
E. W. English	FQS	K. Mitchell	Consultant
S. Fenwick	Nat. Biodiesel Brd.	H. Nanjundaswamy	FEV
T. Frank	Lubrizol Corp.	M. Nikanjam	Chevron
R. Gault	EMA	S.B. Rubin-Pitel	ExxonMobil
R. George	BP	D. Z. Short	Marathon Petroleum Co.
B. Goodrich	John Deere		
G.C. Gunter	Phillips 66	J. Y. Sigelko	Volkswagen of America
P. Henderson	GM Powertrain	W. Studzinski	General Motors
D. Hess	Infineum	M. Valentine	Toyota Tech. Ctr.N.A.
C. Hodge	Consultant	S. Westbrook	SwRI

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