CRC

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2022

COORDINATING RESEARCH COUNCIL, INC.

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ANNUAL REPORT

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COORDINATING RESEARCH COUNCIL, INC.
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PART ONE

STATE OF THE COUNCIL

STATE OF THE COUNCIL - 2022

More than a century ago, a technical committee was formed for the purpose of cooperative research between the automotive and energy industries, government scientists, and academia. That Committee became the Coordinating Research Council (CRC) in 1942. CRC continues to provide a forum and process for 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. The operation of the Council continues to adapt to meet the needs of this community, and currently includes four automobile-focused Committees, an Aviation Committee, the Sustainable Mobility Committee, and a multitude of active Working Groups and Technical/Advisory Panels.

CRC technical work during the 2021-2022 research program year, as in years past, includes broad cooperation on research projects and in technical workshops. Current research partners span the stakeholder community, including: the U.S. Environmental Protection Agency (EPA), the California Air Resources Board (CARB), 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, multiple industry organizations, individual equipment, fuel, and additive manufacturers, and representatives of alternative/emerging fuels and technologies. The Sustainable Mobility Committee has experienced considerable growth with additional Members representing the heavy-duty and low-carbon fuels industries, and has established a Partner Member group with the involvement of the Department of Transportation, the Federal Highway Administration, EPA, DOE, the National Institute of Standards and Technology, and nine National Laboratories: Argonne, Brookhaven, Oak Ridge, Pacific Northwest, Sandia, Lawrence Livermore, Idaho, Lawrence Berkeley, and the National Renewable Energy Laboratory.

CRC technical reports are approved by the committees and research partners that oversee the research and are then made available on the CRC website, www.crcao.org. Select research projects conducted by CRC are also reported in the peer-reviewed literature. Workshop summaries and, if available, proceedings are also made available.

Details on these completed studies and ongoing CRC committee projects appear in Part Two of this Annual Report. Released Final Reports issued since the last CRC Annual Report are listed in Part Three. Organization and Membership 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-93-7

Leaders: R. De Kleine
H. Hamje
A. Levy

Scope and Objective

CRC has hosted six biennial, invitation-only Life Cycle Analysis of Transportation Fuels (LCA) Workshops, starting in 2009 at Argonne National Laboratory (ANL) near Chicago. Each workshop was attended by more than 100 LCA experts from government, industry, academia, and non-governmental organizations (NGOs). Past workshop summaries and proceedings are posted on the CRC website. The seventh workshop was held October 19-22, 2021. The goals of the workshop were to:

- Outline technical needs arising out of policy actions and ability of LCA to meet those needs.
- Identify recent research results and activities that have helped to close data gaps previously outlined as outstanding issues.
- Identify data gaps, areas of uncertainties, validation and verification, model transparency, and data quality issues.
- Establish priorities for directed research to narrow knowledge gaps.

Workshop sponsors included ANL, Canadian Fuels Association, National Biodiesel Board, Renewable Fuels Association presented by the Ohio Soybean Council, U.S. Department of Energy - Bioenergy Technologies Office, Union of Concerned Scientists, and the U.S. Environmental Protection Agency.

Current Status and Future Program

The 7th workshop was held virtually October 19-22, 2021. Thirty presentations were given over four days in sessions including Transportation Fuel Policy and Application of Models to Policy, Biofuels, Sustainable Farming, Carbon Capture and Utilization, Electrification, and Land Use Change. The open-invitation workshop hosted over 150 participants, a record number. A summary article of the presentations and discussion can be found on the CRC website.

The LCA panel and workshop will transition from the Real World Group to the Sustainable Mobility Committee (SMC), and future workshops will be planned by the SMC.

REAL WORLD VEHICLE EMISSIONS WORKSHOP

CRC Project No. E-110

Leaders: M. Viola
S.A. Mason

Scope and Objective

For three decades, CRC has held annual vehicle emissions workshops, gathering international experts in the field of vehicle/engine emissions to discuss the latest activities in modeling, measurement, and analysis.

The inaugural CRC Emissions Workshop convened as the "CRC-APRAC Vehicle Emissions Modeling Workshop" on October 30 and 31,1990. It was the first time that representatives from government agencies, universities, automotive and oil industries, and consulting and testing firms active in examining vehicle emissions inventories were assembled in one location with 117 participants engaging in discussions and twenty speakers presenting in four technical sessions including EMFAC7 and MOBILE4 Models, Model Evaluations, Laboratory Vehicle Emissions Studies, and On-Road Emissions Studies.

In three decades of annual events, the Real World Emissions Workshop has grown into an international event, hosting over 250 participants representing more than a dozen countries. Its 30-year history has spanned an era where the public has benefited from large reductions in vehicle tailpipe emissions, brought about by improvements in emissions control technologies and fuels, leading to demonstrable improvements in air quality. Program topic areas include novel and new research in:

- Air Quality
- Emissions Modeling
- Off-Road / Non-Road Emissions
- Emissions Measurement Methods
- Fuel Effects on Exhaust Emissions
- Improving the Emissions Inventory
- Particulate Emissions and Measurement
- Emissions Control Measures (I/M) and OBD
- In-Use Emissions for Light- and Heavy-Duty Vehicles

- Non-Tailpipe Emissions
- Sensors and New Technology

Current Status and Future Program

The 2022 Workshop was held March 13-16, 2022, at the Hyatt Mission Bay, San Diego, CA. The event marks the return to face-to-face workshops following the pandemic, and hosted 223 registrants, 197 of which were in-person attendees from 12 countries. A workshop summary is posted on the CRC website. The 2023 Workshop will return to the Renaissance Long Beach March 26-29, 2023.

EVALUATION AND STATISTICAL ANALYSIS OF REMOTE SENSING DEVICES AND TECHNOLOGY

CRC Project No. E-119-3/ E-119-3a

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

Scope and Objective

Since the early 1970's, many heavily populated US cities have violated the ever-changing National Air Quality Standards (NAAQS) established by the EPA pursuant to the requirements of the federal Clean Air Act. The NAAQS regulate emissions of six criteria pollutants: carbon monoxide (CO), nitrogen oxides (NOx), particulate matter (PM), lead, ground-level ozone (O3), and sulfur dioxide (SO2). Carbon monoxide (CO) levels are elevated primarily due to direct emission of the gas; and ground-level ozone, a major component of urban smog, is produced by the photochemical reaction of NOx and hydrocarbons (HC). Ambient levels of particulate emissions can result either from direct emissions of particles or semi-volatile species, or from secondary reactions between gaseous species, such as ammonia (NH3) and nitrogen dioxide (NO2). On-road vehicles continue to serve as one of the sources for atmospheric criteria pollutant emissions, contributing CO, volatile organic compounds (VOCs), NH3 and NOx to the national emission inventory. Ambient air measurements taken over the last three decades illustrate the dramatic emissions reductions from on-road sources achieved by the automotive and petroleum industries.

The Fuel Efficiency Automobile Test (FEAT) device is responsible for the historical CRC record of on-road emissions data for over three decades. Alternate remote sensing device (RSD) measurement systems may provide an opportunity for future data collection campaigns. The objective of Project E-119-3 was to evaluate other RSD systems' ability to measure on-road emissions (CO, CO2, and HC, NO and NO_2, SO_2 and NH_3 and PM) over a five-day period, making real time comparisons to the FEAT device. Measurements also captured evaporative and PM emissions when available to complement emissions measurements from the FEAT device. Under Project E-119-3a, statistical comparisons of the three RSD datasets will be done to compare and contrast each system's consistency or variability to measure and record data across a range of operating conditions.

Current Status and Future Program

Two contractors were selected to co-locate alternate RSD technologies alongside the Denver University FEAT system during a test campaign in Phoenix, AZ. Charles Blanchard has been contracted under Project E-119-3a to conduct statistical analysis of the three data sets. A successful testing campaign was completed April 12-16, 2021, in Phoenix, AZ. The state of Arizona provided plate matching services, and delivered data in late November 2021. Final Reports from each of the RSD vendors are completed and available on the CRC website. A statistical analysis of the combined data set is in progress.

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
P. Loeper

Scope and Objective

With Europe adopting the use of portable emissions measurement systems (PEMS) to determine light-duty emissions, there is a greater interest in the functionality and use of these systems.

The objective of Project E-122-2 is to understand PEMS performance in measuring changes during on-road and chassis-roll tests, using the on-road cycle developed in CRC Project E-122, which incorporates city, urban, and highway driving. Several engine technologies are represented in the four-vehicle test fleet, which are being tested with five fuels with varying properties to investigate how well PEMS can detect fuel property impacts on emissions. Summer and winter market fuels, each having a low and high Particulate Matter Index (PMI), as described by the Honda method, are being used for testing. Additionally, a Tier 3 certification fuel is used to ensure no vehicle shift in tailpipe emissions is encountered. Each fuel is tested multiple times in each vehicle to understand the variation in emissions that occur and how they change on the same route on a daily basis. A PEMS measures the tailpipe emissions for both the road and chassis testing, and results are compared to repeat chassis-dynamometer emissions testing. Specific goals of this project include determination of the following:

- Repeatability of the chassis roll testing to compare to the PEMS unit.
- Repeatability and accuracy of PEMS unit under real on-road driving conditions and changing ambient temperatures.
- Ability of the PEMS to measure differences in gaseous and PM emissions with respect to changes in PMI and/or Vapor Pressure (VP) of the fuel; and,
- The correlation of exhaust flow measurement of CO_2 from the individual PEMS system with direct vehicle exhaust

flow meter from the test cell and with constant volume sampling (CVS) bags.

To make certain the testing data collected would be suitable for statistical analysis, a statistician (CRC Project E-122-2a) developed the test matrix for this project, defining:

- Number and sequence of testing on each fuel and vehicle;
- Vehicles of each technology to test, (one hybrid or two of the same type, etc.); and,
- Market fuels to test and what fuel properties to investigate.

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 and will provide all of the analysis for the Final Report.

Current Status and Future Program

The contract for E-122-2 was awarded to Southwest Research Institute (SwRI) in April 2019. Experimental testing has completed, and a draft final report is under review.

ALTERNATIVE OXYGENATES EFFECTS ON EMISSIONS PHASE II

CRC Project No. E-129-2

Leaders: E. Barrientos
M. Moore
J. Jetter

Scope and Objective

CRC E-94 Projects were conducted to better understand the fuel effects on tailpipe emissions for gasoline direct injection (GDI). These studies observed an increase in particulate mass (PM) emission rate in GDI engines trending with an increasing ethanol content. However, the mechanism for increased PM formation remains unclear as ethanol itself is not thought to be a PM precursor. It has been theorized that the presence of ethanol contributes to a charge cooling effect in GDI engines, increasing PM formation from other fuel components. Other potential explanations include shifts in distillation characteristics, changes in volatility, and decreasing energy content. CRC Project E-129 was developed to determine whether the observed trend held for higher ethanol concentrations and to investigate potential mechanisms for PM formation with other oxygenates.

The purpose of this work is to extend the analysis of Project E-129 to additional oxygenates of interest and to add key information to explain the ethanol effects on SI PM emissions. The project will evaluate these fuels in a single cylinder engine (SCE), which offers more controllability of key parameters that are known to affect vehicle emissions and extend the analysis deeper into trends for NOx and THC related to fuel composition.

Current Status and Future Program

The National Renewable Energy Laboratory (NREL) was contracted to perform this work in their single-cylinder test set-up. Sixteen different oxygenated blends in high- and low- particulate matter index (PMI) base fuels were evaluated. The Final Report was shared on the CRC website November 2022.

PUBLICATION OF THE STORY OF THE (NEAR) ELIMINATION OF GASOLINE VEHICLE EMISSIONS

CRC Project No. E-130

Leaders: D.H. Lax
C.J. Tennant

Scope and Objective

Since the 1970's and earlier, the dramatic reductions of automotive pollution have contributed to significant improvements in air quality. CRC Project E-130 seeks to produce an easily understood historical story of how automotive emissions have been reduced to present-day levels and to educate a broad audience of the achievement of near-zero gasoline vehicle emissions accomplished over many years. Existing literature and accounts from industry and government agency participants directly involved in the research, investigations, and regulatory development that enabled this achievement will be included. The project is divided into three phases:

- Phase 1: Identify and acquire literature and conduct and document interviews of expert individuals working on emissions reductions technology during the period of focus.
- Phase 2: A technical publication writer will compile and distill all the information collected by the contractor in Phase 1. The deliverable will be a pamphlet or publication that presents the story to a broad, non-technical audience.
- Phase 3: Additional publications or reporting avenues will be explored.

Current Status and Future Program

Steve Welstand and Dr. Kent Hoekman, consultants, have been contracted for Phases 1 and 2 of this project. Five out of twelve draft chapters have been prepared, with a sixth underway. A journal article highlighting the early years (1940's-50's) was published in *Atmosphere* in November 2021. The completed work is expected to be published by SAE.

IMPACTS OF E15 ON NOX EMISSIONS

CRC Project No. E-133

Leaders: M.B. Viola
P. Loeper

Scope and Objective

The current fleet is using gasoline-ethanol blends of 90% gasoline and 10% ethanol in gasoline internal combustion engines. There are many vehicles that now accept E15 blends. However, E15 is still not the prevalent fuel in the market and there is much discussion on how the additional ethanol may impact NOx emissions.

The objective of this project is to conduct chassis dynamometer vehicle testing as well as PEMS emissions testing with E15 fuels to determine the impact additional ethanol may have on NOx emissions. Additional gaseous and PM emissions will also be measured to understand all criteria and particulate impacts. This testing uses newer Tier 3 certified vehicles for testing, the same vehicles used in Project E-122-2.

This work would be conducted using vehicles from Project E-122-2 as well as the PEMS units currently owned by CRC. There are two winter market E10 fuels: one low-PMI and one high-PMI fuel. These same fuels will be splash blended to E15. Additionally, two summer market E10 fuels, one low-PMI and one high-PMI fuel will also be splash blended to create E15 fuels. Testing will be conducted after E-122-2 Tier 3 Certification fuel at the end of Winter and Summer testing using the same on-road and chassis-dynamometer drive cycle as from CRC projects E-122 and E-122-2.

Current Status and Future Program

The contract for this work has been awarded to SwRI as an add-on project to CRC Project E-122-2. The data collection and experimentation phase of the project has concluded, and a draft final report is nearing completion.

LIGHT-DUTY PEMS PHASE 3: DESIGN OF EXPERIMENTS FOR ALTITUDE, GRADE, AND LOW TEMPERATURE IMPACTS ON PEMS PERFORMANCE TEST PROGRAM

CRC Project No. E-134-a

Leaders: M.B. Viola
P. Loeper

Scope and Objective

With Europe adopting the use of portable emissions measurement systems (PEMS) to determine light-duty real world emissions, there is a greater interest in PEMS functionality and use. The California Air Resources Board (CARB) and the Environmental Protection Agency (EPA) are also conducting tests in the United States with light-duty vehicles to determine PEMS viability to measure real world on-road emissions. This is in addition to the normal Federal Test Procedure (FTP-75), Highway Fuel Economy Test (HWFET), and US06 Supplemental Federal Test Procedures (SFTP) chassis dynamometer testing. There are several PEMS manufacturers producing these units and some studies have been conducted to understand how they perform compared to normal chassis dynamometer testing. This project investigates the use of multiple engine technologies and different fuel properties at altitude, steep grades and at low temperatures to determine PEMS performance in measuring emission changes during on-road and chassis roll tests.

The objective of Project E-134a is to use the on-road cycle, developed in the E-122 project which incorporates city, urban and highway driving. This study is to be conducted at altitude and use steep grades for the test cycle under Winter low temperature conditions. The same test cycle with grades should be conducted on a chassis roll. Emissions measurements should be taken at the tailpipe including all gaseous emissions and gravimetric particulate matter (PM) emissions. Simultaneously PEMS emissions should be taken. Measures are to be taken to make sure the vehicle exhaust system is kept at ambient pressure at the tailpipe at all times on the chassis roll during testing.

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. This test program could use two Winter fuels, a low and high Particulate Matter Index (PMI), as described by the Honda method. A third fuel Tier 3 Certification E10 may also be used in the program. A total of three fuels could be run on each of the four to six vehicles five times to understand the variation in emissions that occur and how they change on the same route on a daily basis. One PEMS unit will be used to measure the tailpipe emissions. Five repeats will be run on the chassis roll for repeatability and comparison to the PEMS unit. The PEMS unit will also measure emissions at the same time on the chassis roll for direct comparison.

Current Status and Future Program

The contract for statistical design of experiments and analytical support of the test program was awarded to SwRI. A future request for proposal (RFP) is expected for the full test program, based on the input from the statistician.

TIER 3 GDI VEHICLE TECHNOLOGIES EFFECTS ON PARTICLE EMISSIONS OPERATING WITH DIFFERENT FUELS

CRC Project No. E-135

Leaders: E. Barrientos
M. Viola

Scope and Objective

Different new vehicle technologies geared towards Tier 3 compliance such as increasing fuel injection pressure and atomization have shown potential significant benefits to reduce particle emissions from gasoline direct-injection (GDI) engines. The expected vehicle technology trend is that as emissions regulations become more stringent, more deployment of these technologies may be required. Furthermore, fuels containing a high proportion of heavy aromatics (C9+) compared to market average and certification fuels, characterized with a high particulate matter index (PMI), have been found to generate higher particulate emissions.

Moreover, CRC Projects E-94-2 and E-94-3 have indicated a potential link between an increase in particulate matter index (PMI) and ethanol content with increased PM emissions. Evaluation of interactions of fuel composition (i.e., PMI, aromatic content, and ethanol content) with different vehicle technologies used to meet Tier 3 emissions standards, such as higher injection pressure among others, and their effect on particulate, particle and gaseous emissions is of interest for future vehicle/fuel co-optimization to comply with upcoming emission regulations.

The purpose of this work is to improve understanding of fuel injection pressure impact as well as other technologies on tailpipe emissions from gasoline direct injected vehicles. The project will evaluate a specific fuel matrix comprised of fuels with low and high PMI, and different ethanol contents on vehicle(s) with different technology packages including different fuel injection pressures (e.g., 150-200 and 350+ bar).

Current Status and Future Program

The contract for this project has been awarded to SwRI. Testing has been completed and a Final Report is near completion.

ENGINE, AFTERTREATMENT, AND FUEL QUALITY ACHIEVEMENTS TO LOWER GASOLINE VEHICLE PM EMISSIONS: LITERATURE REVIEW AND FUTURE PROSPECTS

CRC Project No. E-136

Leaders: N. Kempema
S. McConnell

Scope and Objective

EPA's Tier 2 motor vehicle emissions standards and gasoline sulfur requirements, implemented starting in 2004, marked the beginning of a significant effort to limit light-duty vehicle emissions via a tandem approach involving more stringent vehicle standards as well as requirements on gasoline fuel sulfur content. The implementation of the California LEV III and EPA Federal Tier 3 programs is focusing further efforts on the control of light-duty vehicle particulate matter (PM). A 3 mg/mi FTP PM standard began in 2017 for both LEV III and Tier 3 and will be fully phased-in by 2021 for LEV III and by 2022 for Tier 3. The LEV III regulations will continue to tighten to a 1 mg/mi FTP standard beginning in 2025, with a 4-year phase-in across the fleet. Furthermore, to support the use of more advanced emissions controls and technologies, the EPA limited gasoline sulfur (a naturally occurring component in fuel that can adversely impact the effectiveness of aftertreatment technology) content to a maximum of 10 ppm as part of the Tier 3 program starting in 2017.

To understand how technology advances have helped reduce PM, this study will perform a literature review of publicly available articles, reports, and presentations of research in industry, academic, or government settings. Topics for review include:

- Fuels technologies: Impact of lowered fuel sulfur levels on effectiveness of emissions control systems, lubricant formulations, market fuel formulations, fuel additives, etc.
- Aftertreatment: Catalyst developments, impact of TWC on emissions profile and PM formation, gasoline particulate filters (GPFs), etc.

- Engine: Injection timing, high pressure fuel injection systems, dual DI/PFI combination fuel injection, spray guided DI, etc.
- Measurement: Discuss the ability of measurement technologies to resolve the emission levels associated with Tier 3/LEV III vehicles as needed.

The time period covered is that associated with the development and implementation of technologies and strategies designed to meet Tier 3/LEV III vehicle emissions control requirements. Documents published and not directly relating to Tier 3 /LEV III (e.g., relating to EU regulations and adopted technologies) may be included if they are considered exceptionally valuable either as a formative document or in discussing important research areas not included in the specified time period. In addition, technical interviews that provide insight into technology advancements are encouraged where appropriate.

Current Status and Future Program

The Final Report for Project E-136 was published on the CRC website in October, 2022.

LOW NOX AND NMOG MODELING

CRC Project No. E-140

Leaders: S. DeCarteret
M. Viola

Scope and Objective

Current emissions measurement capabilities may not be sensitive enough to measure very low NOx and NMOG (HC, CH4) emissions that will be required for future Light-Duty and Medium-Duty vehicles for certification at SULEV levels. One potential area of concern is the impact of test weight. With traditional CVS technology dilute volume increases as test mass increases requiring the instrumentation to measure lower concentrations. The uncertainty and limitations of the current sampling and analytical systems technology over the range of test weights need to be understood in order to identify potential areas for improvement.

The objective of this project is to develop a model to demonstrate and identify opportunities to reduce the uncertainty of the current technology used for chassis dyno LD and Medium Duty certification testing. The model developed shall incorporate the many variables which contribute to the measurement uncertainty. Analysis of the modeling results shall provide a sensitivity analysis identifying the contribution of each factor to the overall uncertainty. Based on the results, recommendations for areas of improvement and future study shall be included.

Current Status and Future Program

The project was awarded to SWRI and is expected to continue into early 2023.

LIQUID LEAKER TEST VEHICLE DETECTION IN E-119-3 RSD TEST CAMPAIGNS

CRC Project No. RW-105

Leaders: R. Sager
D. DiCicco

Scope and Objective

The objective of this project is to understand the capabilities of RSD systems to measure and interpret high evaporative emitters as well as PM emissions. Roadside measurements of PM will include installation of an on-board PEMS unit on test vehicles to serve as a reference measurement.

Under this project, the contractor will co-locate and coordinate with three RSD systems at a single test site under CRC Project E-119-3. During the test campaign, the contractor will operate test vehicles to drive through the RSD roadside location. The vehicles will be set up as liquid leakers to identify each system's capability of detecting evaporative emissions. Additionally, a vehicle with zero emissions is expected to drive through the test site several times per day releasing known levels of pollutants to serve as calibration points.

To detect PM emissions, a PEMS that has robust capability to measure particle mass will be installed on both of the test vehicles. Installation can be completed at the same time as the evaporative measurements if PEMS does not interfere with these test cases. PM and criteria pollutants will be measured during each test run.

Current Status and Future Program

Revecorp was selected as the contractor for RW-105. The three RSD systems for CRC Project E-119-3 are separately contracted by CRC. Co-location of all four vendors in Phoenix, AZ was successfully completed in Phoenix, AZ in April 2021. The contractors are preparing separate final reports.

VALIDATION OF THE NEW PM INDEX FORMULA

CRC Project No. RW-107-3/a

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

Scope and Objective

RW-107 revealed that the original PM Index exhibited an ethanol bias. A more robust PMI formulation was developed in RW-107-2, in which correlation with measured PM was improved, and the ethanol bias eliminated. The new formulation incorporates multiple enhancements. This third phase of the CRC RW-107 project series will validate the new form of the PM Index equation using a fresh dataset, including a range of PMI values, vehicle technologies, and fuel formulations.

The data required for the PMI validation consist of PM emission measurements from the first phase of a cold-start LA92 cycle, and analyses of the test fuels. Vehicle testing will be conducted to collect PM filter samples from the dilution tunnel during the LA92, and measure gaseous emissions (NOx / CO / HC / etc.) The LA92 cycle will be repeated as necessary to meet the validation requirements. The test fleet includes PFI vehicles and GDI vehicles. (The mathematical form of the vapor pressure term in the new equation is dependent upon engine technology, specifically GDI vs. PFI.) Test fuels include E0, E15, and E20 blends, all based on winter and summer market fuels. The E0 fuels are required to confirm that the ethanol bias has been removed in the new PMI formula.

Data collected will be used to validate the PME equation developed within RW-107-2.

Current Status and Future Program

SwRI was awarded this contract for vehicle testing which has been integrated into the Projects E-122-2 and E-133 combined test matrix. The testing at SWRI was completed, and data analysis is ongoing by Rincon Ranch Consultants to complete the PME validation.

E-15 FUEL SURVEY

CRC Project No. RW-115

Leaders: M. Moore
P. Loeper

Scope and Objective

Through two separate actions in 2010 and 2011, the EPA approved the use of E15 fuel in model year 2001 and newer light-duty vehicles. In 2019 and again in 2022, the EPA issued rules and emergency waivers to extend the summertime 1 psi RVP allowance to gasoline-ethanol blends up to 15% ethanol. These actions facilitated year-round sale of E15 in conventional gasoline areas. E15 is available today at more than 1,800 refueling stations in 30 states, and federal programs have offered funding designed to expand the infrastructure for renewable fuels via the installation of blender pumps.

Fuel properties, quality, dispenser configuration, and labeling are all important factors and are not well understood for E15. The objective of Project RW-115 is to analyze fuel properties of E15 fuel samples from a wide array of retail stations and document their labeling, naming, dispenser style, and configuration. This project seeks to improve the understanding of E15 fuel quality and how E15 is being marketed and dispensed.

Current Status and Future Program

A summary report and data from the 2019 Summer Survey, conducted by the Alliance of Automobile Manufacturers North American, are available on the CRC website as CRC Report No. 674. Additional fuel samples were collected as part of the Alliance of Auto Innovators Winter 2020 and Summer 2020 Fuel Surveys. The Final Report is available on the CRC website as of October 2021.

REMOTE SENSING MEASUREMENTS IN CENTRAL FRESNO, CALIFORNIA

CRC Project No. RW-117

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

Scope and Objective

Fresno, CA is a community of approximately 500,000 people located in California's central San Joaquin Valley. The Central Valley is an area in California that regularly exceeds National Ambient Air Quality Standards for PM and ozone. Mobile sources are one of many factors that contribute either with direct particulate emissions or indirectly with ozone pre-cursor emissions of carbon monoxide (CO), volatile organic compounds and oxides of nitrogen emissions to these air quality problems. Characterizing the Fresno area's light- and medium-duty vehicle fleet's emission distribution, and their changes over time, can be an important source of information in the community's efforts to improve the local air quality.

The University of Denver (DU) visited Fresno, CA in March of 2008 and collected seven days of measurements using DUs FEAT optical remote sensing unit. FEAT collects fuel specific gaseous emissions of CO, hydrocarbons (HC), nitric oxide (NO), nitrogen dioxide (NO_2, $NO_x \equiv NO + NO_2$), ammonia, and opacity. In Project RW-117, DU returns to the 2008 location to collect emissions measurements following the standard E-23 protocols that have been used in other CRC projects.

Current Status and Future Program

This project supports a larger effort by CARB to collect emissions measurements from at least ten disadvantaged communities throughout the State of California. Data collected by DU will be shared with CARB to support planning for their project. The Central Fresno field campaign was completed in June 2021. The Final Report is available on the CRC website as of November 2021.

REMOTE SENSING DEVICE DATABASE (FEAT)

CRC Project No. RW-118

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

Scope and Objective

Since 2000, the Stedman Group at the University of Denver (DU) has maintained a web server that contains a repository of all of the remote sensing emissions measurements collected by the group since the late 1980's. There are more than 100 emissions databases for light-duty cars and trucks from the U.S., and 23 data bases for heavy-duty trucks. The site also includes emissions measurements from planes, trains, automobiles, heavy-duty trucks, snowmobiles, snow coaches, and ocean-going ships. These data sets have provided important information for researchers outside the University of Denver and have been featured in numerous publications.

This project seeks to relocate the University of Denver Remote Sensing Device databases to a permanent website that will be maintained and accessible long after the retirement of any members of the Stedman Group. During data relocation efforts, some of the older databases will be reformatted to include additional (blank) fields and information matched to formats of newer (most recent 20-years), enhanced databases which include VIN decoding. Reformatting will result in like-formatted datasets that can be more easily incorporated into models without tedious reformatting.

The database will be housed at the University of Denver library with open access.

Current Status and Future Program

The Final Report for this database is available on the CRC website as of November 2021. The University of Denver library will provide open access and continued maintenance of the database once the relocation is completed. The database can be accessed at: https://digitalcommons.du.edu/feat

EVALUATION OF SHORT TERM FUEL IMPACTS ON LOW NOX ENGINE EMISSIONS

CRC Project No. RW-120

Leaders: E. Barrientos
S. McConnell
S. Berry

Scope and Objective

To investigate NOx reduction potential for establishing future emissions standards, SwRI, in partnership with EPA and CARB, evaluated different technologies and methods to lower NOx emissions from HD vehicles with minimal increase to CO2 emissions. Aftertreatment performance under various operating cycles and aging conditions was measured. Project RW-120 seeks to further evaluate and develop low NOx technologies with a focus on low load optimization and regulatory cycles. This SwRI project is being conducted, in part, to support EPA's Clean Trucks Plan rulemaking.

As a follow up to the current efforts underway at SwRI, it is of interest to understand potential fuel-related impacts on aftertreatment performance and durability. As performance demands for aftertreatment systems are expected to increase substantially in 2027+, it is imperative to understand the impact of alternative fuels on engine and aftertreatment performance. Fuels of interest include biofuels such as biodiesel and renewable diesel. The fuel blends will include B20 and B50 fuel blended with CARB diesel, as well as RD100 and blends of RD with biodiesel and CARB diesel. The testing will also include common market diesel fuels to assess sensitivity to specifications such as aromatics, cetane, and sulfur. Operating conditions will include low-load cycles and incorporate the aftertreatment system used in the CARB low NOx technology assessment. CRC Project RW-120 seeks to determine the impact of alternative fuels on system performance related to engine-out NOx and soot level and will be performed with the ongoing CARB and EPA low NOx programs at SwRI. Impact of fuel composition on emissions levels will be measured.

Current Status and Future Program

Two contracts have been executed for this work: SwRI will conduct the experimental work, and Gage Products will supply the fuels. All fuels have been blended and provided to SwRI. The project is ongoing, and the goal is to provide data for the EPA before final rule making in 2022.

IMPROVED DIESEL SURROGATE FUELS FOR ENGINE TESTING AND KINETIC MODELING

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

Leaders: S. McConnell
S. Wagnon

Scope and Objective

The objective of these projects 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.

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 enable 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. A literature review was performed in support of this research, and was published on the CRC website in December 2009.

The project team identified compounds representing the major hydrocarbon classes found in real diesel fuels to be included in surrogate fuel formulations. First-generation surrogates were 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 is being performed in collaboration with researchers at several DOE national laboratories: Sandia National Laboratory (SNL), National Renewable Energy Laboratory (NREL), Lawrence Livermore National Laboratory (LLNL), Pacific Northwest National Laboratory (PNNL), and Oak Ridge National Laboratory (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, as the Final Report for the first phase of AVFL-18.

Research was extended under Project 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 performed single-cylinder engine and combustion vessel testing of the surrogate fuels. Combustion modeling of engine performance is 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 second article under Project 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 a report describing 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 is available on the CRC website in June 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. A journal paper on the experimental apparatus designed to make these measurements was published in *Review of Scientific Instruments* (2020). NIST 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”.

The Panel directed the research conducted under CRC Project AVFL-18a-1, “Autoignition Study of CRC Diesel Surrogates in a Rapid Compression Machine (RCM),” at the University of Connecticut. The Final Report was published on the CRC website in October 2018. A journal article on the experimental RCM data and its simulation using a chemical kinetic model from Lawrence Livermore National Laboratory was published in Combustion and Flame (September 2020).

Sandia National Laboratory has performed Optical Engine measurements on the surrogate fuels; results from this research will be reported.

Current Status and Future Program

The Panel continues to meet regularly to review data and progress. Additional journal articles are anticipated to be published from this research, but have been delayed as a result of program direction at the participating National Laboratories.

GASOLINE TURBOCHARGED DIRECT INJECTION (GTDI) ENGINE WEAR TEST DEVELOPMENT

CRC Project No. AVFL-28, AVFL-28-2 and AVFL-28-3

Leaders: A. Gangopadhyay
G. Gunter

Scope and Objective

Gasoline turbocharged direct injection (GTDI) engines often produce more severe operating conditions than port fuel injection (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 represent current and future engine technologies.

The objective of this research 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.

The research is expected 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.

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. 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-28-2, SwRI evaluated GTDI engine wear performance using the same GTDI engine model, operating procedures, and test matrix as in AVFL-28, with a focus on different engine components to extend the work of the prior project. The Final Report for AVFL-28-2 was published on the CRC website in October 2019.

Current Status and Future Program

A third phase, AVFL-28-3, was conducted by SwRI to include balance shaft bearings, cam lobes, and tappets, fuel pump lobes, and top ring face. The Final Report for Phase 3 is available on the CRC website as of August 2022.

ENHANCED SPECIATION OF GASOLINE / EFFECT OF DHA DEVELOPMENT ON PMI VARIABILITY

CRC Project No. AVFL-29 and AVFL-29-2

Leaders: J. Jetter
G. Gunter

Scope and Objective

Most Detailed Hydrocarbon Analyses (DHAs) are performed with ASTM Methods D6729, D6730, or variations thereof. These are gas chromatography methods 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 a 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 AVFL-29 was to develop an enhanced method for the speciation of gasoline.

The objective of AVFL-29-2 was to determine the magnitude of variability of DHA and PMI results as measured by various test labs in practice for a set of gasoline samples covering a wide range of PMI. A secondary objective was to determine which components contribute most to PMI variability. The approach included analysis of several gasoline samples covering a range of PMI at various commercial and industry laboratories, using enhanced and standard DHA methods, and analysis of results.

Current Status and Future Program

AVFL-29 was performed by Separation Systems, Inc. The Final Report, "Enhanced Speciation of Gasoline," and Master Database were published on the CRC website in June 2018.

AVFL-29-2, "Effect of DHA Development on PMI Variability," was performed by DRI. The Final Report has been posted to the CRC website as of January 2022.

AUTOIGNITION CHARACTERIZATION OF AVFL-20 TEST FUELS

CRC Project No. AVFL-31a, AVFL-31b, and AVFL-31c

Scope and Objective

The objectives of Projects AVFL-31a, AVFL-31b, and AVFL-31c are 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.

Rapid Compression Machine (RCM) testing of AVFL-20 fuels has been performed by the Massachusetts Institute of Technology (MIT) [AVFL-31a], and additional testing has been conducted at Argonne National Laboratory (ANL) [AVFL-31b]. Different approaches for evaluating the RCM ignition delay data in conjunction with the engine test data were considered.

Current Status and Future Program

This project is on hold, as partners are currently unable to continue.

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 Project AVFL-32 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 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 Phase 1 of this research, several fuels of similar RON rating, but varied chemical composition, were analyzed under standard RON conditions on the instrumented CFR F1/F2 engine at Argonne National Laboratory. 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 is exploring how increased boost pressure on the CFR engine affects the knocking characteristics of several fuels with similar RON and varied chemical composition.

Current Status and Future Program

Project AVFL-32 is being conducted by Argonne National Laboratory. The paper, "Effects of Knock Intensity Measurement Technique and Fuel Chemical Composition on the Research Octane Number (RON) of FACE Gasolines: Part 1 - Lambda and Knock Characterization" was published in the journal *Fuel* in 2021. A Phase 2 Journal article is being prepared for Panel Review.

FUNDAMENTAL STOCHASTIC PRE-IGNITION (SPI) STUDY

CRC Project No. AVFL-33

Leaders: E. Chapman
G. Gunter

Scope and Objective

The goal of Project AVFL-33 is to characterize the impact of fuel properties on wall wetting and how this affects SPI frequency and severity in a Gasoline Turbocharged Direct Injection (GTDI) engine. Fuel properties of interest include composition (e.g., alcohols, aromatics, isoparaffins, olefins) and heavy-end volatility.

The approach is to perform dynamometer testing of a GTDI engine at SPI-prone conditions to determine fuel effects on SPI and influence of wall wetting. Wall wetting is being determined using real-time Fuel-in-Oil (FiL) analysis using a dry sump oil system and fuel dye fluorescence detection. The active cylinder is instrumented with pressure transducers to collect the SPI/LSPI event data. Wall wetting will be quantified while measuring SPI/LSPI count for each oil and fuel combination.

Current Status and Future Program

The project is being performed by Oak Ridge National Laboratory. Testing and analysis for Phase 1 are wrapping up and the draft final report is under preparation. Planning for Phase 2 is ongoing.

ADVANCED CHARACTERIZATION OF E-117 DIESEL FUELS

CRC Project No. AVFL-34

Leaders: M. Viola
R. Lewis

Scope and Objective

The goal of Project AVFL-34 is to use advanced characterization techniques to better understand differences in fuel composition that could help explain emissions differences observed in CRC Project E-117, "Combustion and Emissions Characteristics of a Medium-Duty Vehicle Operating on a Hydrogenated Vegetable Oil Renewable Diesel."

The Pacific Northwest National Laboratory (PNNL) and CanmetENERGY performed detailed fuel composition analyses on fuel samples provided from Project E-117.

Current Status and Future Program

Final reporting on Project AVFL-34 was delayed due to corrections needed in the Project E-117 data and report. A draft publication has been submitted to SAE for review.

AVFL COMMITTEE

IMPACT OF MON ON ENGINE PERFORMANCE

CRC Project No. AVFL-36 / CM-137-19-1

Leaders: A. Iqbal
S. McConnell

Scope and Objective

The primary objective of this study is to investigate the impact of fuel MON on engine anti-knock performance under a wide range of operating conditions, including those where the sensitivity weighting factor between RON and MON (K) may be positive (and potentially greater than 0.5). Testing under a wide range of operating conditions will help establish the relevance of fuel MON for modern engines, including from the perspective of durability and safe operation. To this end, the study will evaluate the impact of MON at multiple operating conditions including but not limited to:

- High speed high load (high power) operation with elevated air charge temperatures. This engine operation regime is representative of real-world driving conditions such as towing a trailer up a steep grade on a hot day. For future powertrains, this operating regime is expected to become even more challenging as criteria emissions regulations are driving elimination of enriched engine operation as a strategy for managing exhaust gas temperatures.
- Knock-limited part load operation which is relevant for drive cycle fuel economy. This operating regime is of interest for downsized boosted SI engines.

Current Status and Future Program

This Project was awarded to FEV in 2020, but faced numerous delays. Testing on engines one and two was completed. The project panel decided not to pursue testing of the third engine as it would have incurred a delay of at least one year at FEV or would have required a change in vendors. A Final Report is currently being drafted.

THERMAL AND ELECTRICAL PROPERTIES OF LUBRICANTS FOR HEV/EV APPLICATIONS

CRC Project No. AVFL-37

Leaders: A. Gangopadhyay
G. Gunter

Scope and Objective

The objective of Project AVFL-37 is to develop a database of thermal and electrical properties of base oils from Group I to Group V. These data will enable better understanding of base oil chemistry to help meet the performance requirements of next generation automatic transmission fluid for future hybrid and all-electric vehicles.

Several different base oils were selected from Group I to Group V based on recommendations from oil/additives companies employing their knowledge and experience in formulation and availability. The project emphasizes Group V oils including monoesters, diesters, polyol esters, aromatic esters, phosphate esters, polyalkylene glycols, silicones, synthetics and variants thereof, etc. Group V oils are emphasized because they include a wide variety of chemical types, producing greater differences in properties, and they are not as well characterized as the oils from the other Groups.

Current Status and Future Program

SwRI is performing this research. The Draft Final Report has completed the panel review; anomalous data points were observed, so additional testing was added to investigate these points. The Final Report was posted on the CRC website in May 2022.

USING SEPARATION-ENHANCED ISOTOPE RATIO MASS SPECTROMETRY TO ENABLE INCREASED RENEWABLE CARBON CONTENT IN TRANSPORTATION FUELS

CRC Project No. AVFL-38

Leaders: M. Viola
R. Lewis

Scope and Objective

Biogenic carbon is typically quantified using 14C analysis by accelerator mass spectrometry (AMS), ASTM D6866 Method B, which is available at a limited number of commercial labs because of stringent requirements for labs also handling 14C tracers. Project AVFL-38 will demonstrate the ability to use chemical separations in combination with stable isotope analysis to track the distribution of biogenic carbon across co-processed fuel streams, by compound, chemical class, or boiling point range, while obtaining a biogenic carbon balance for representative refinery conditions.

This work will apply chemical separation approaches as part of the isotope ratio mass spectrometry (IRMS) analyses, enabling biogenic carbon tracking in fuel product streams by boiling point (BP) range, by chemical class, or even by compound. Focusing on subclasses of compounds within the sample increases sensitivity to shifts in isotope value within that subclass, which would otherwise be obscured by sample complexity when using bulk IRMS (or AMS) analysis. This improved resolution will provide greater insight into the chemical processes that are occurring when co-processing bio- and fossil-derived feeds. Results from each separated fraction will be compared with bulk analysis to determine if detection limits, accuracy, or precision are improved.

Sample sets from industry (fossil and renewable feeds, and each liquid product stream) will be tested using bulk IRMS, and a separation approach (typically gas chromatography (GC)) followed by IRMS. By focusing on fuel fractions rather than analysis of all carbon atoms in the sample, differences in stable isotope distributions can be used to provide advanced quantification of the persistence of biogenic feeds through a refining process. These measurements can be used for process optimization, and the refiner, having additional process information, can obtain a renewable carbon balance.

Current Status and Future Program

DOE awarded this project to the team in May 2021. Project team participants include Pacific Northwest National Laboratory, Natural Resources Canada, CanMet Energy, and Argonne National Laboratories. The project continues until September 2023.

LUBE EFFECT ON CATALYST AND GASOLINE PARTICULATE FILTER AGING – LITERATURE REVIEW

CRC Project No. AVFL-39

Leaders: G. Gunter
A. Gangopadhyay

Scope and Objective

Under CRC Project AVFL-39, literature review of publicly-available articles or reports of research in industry, academic, or government settings will be performed. Topics for review include:

- Effect of lube oil formulation and phosphorous level on catalyst/GPF efficiency.
- Effect of lube additives on ash accumulation in the GPF, the effect of ash on pressure drop across the GPF, and the effect of pressure drop on fuel economy.
- A comparison of various test methods for lube additive effects on catalyst and GPF.
- Combination of the effects of engine operating mode and lube additive effect on catalyst/GPF efficiency.
- Effect of soot level, soot deposition rate, and soot morphology on ash deposition in catalyst and GPF.

Literature will include publications from 2013 to present.

Current Status and Future Program

SwRI was selected as the contractor, and the project is underway with expected completion in 2022.

DEVELOPMENT OF ADVANCED COMPRESSION IGNITION GASOLINE RATING METHODS ON A VARIABLE COMPRESSION RATION CFR ENGINE

CRC Project No. AVFL-40

Leaders: S. McConnell
J. Waldman

Scope and Objective

The scientists, engineers, and analysts of the Co-Optimization of Fuels & Engines (Co-Optima) initiative are investigating fuels and engines as dynamic design variables that can work together to boost efficiency and performance, while minimizing emissions. Potential benefits include dramatic improvements in vehicle fuel economy and increases in the use of domestically sourced fuel for transportation.

This project explores the possibility of a modified CFR F1/F2 octane rating engine to rate fuels for Advanced Compression Ignition (ACI) engines using a set of homogeneous charge compression ignition (HCCI) test conditions. After upgrading the CFR engine at Argonne National Laboratory (ANL) to operate over a wider range of fuel properties, air/fuel ratio, thermodynamic, and temporal test conditions, a detailed characterization of at least 15 gasoline blends with bio-fuel blend stocks will be evaluated. This data will be correlated to that from ACI engines in the Co-Optima program to identify a down-select of key HCCI fuel rating conditions and fuel properties for ACI engines.

The purpose of this project is to obtain a better understanding how a homogeneous charge compression ignition (HCCI) fuel rating metric on the variable compression ratio (CR) CFR F1/F2 octane test engine is affected by a wider range of fuel properties, engine speed, lambda, and thermodynamic conditions than currently operable on the carbureted CFR engine at Argonne National Laboratory (ANL).

Current Status and Future Program

CRC has executed a CRADA with DOE and ANL for this project. In-kind contributions will be provided by CRC for this work.

FUELS FOR ADVANCED COMBUSTION ENGINES (FACE) WORKING GROUP

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 developed in 2005 and updated 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.

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 FACE 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 in 2010, after an accompanying conference paper was given at the 2009 SAE Fall Powertrains, Fuels, and Lubricants Meeting.

A gasoline-range fuel set design was also developed by the FACE Working 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 AVFL-24, "FACE Gasolines and Blends with Ethanol: Detailed Characterization of Physical and Chemical Properties." (2014)

The FACE Working Group has generated a number of projects conducted by the AVFL Committee: AVFL-16, AVFL-18, AVFL-19, AVFL-23, AVFL-24, AVFL-26, AVFL-31, AVFL-32, and AVFL-38.

The Group meets regularly throughout the year to review project status, share results from various Member research projects in support of the Group's mission, and to develop ideas for future research projects.

AVFL COMMITTEE

AVFL LUBRICANTS ADVISORY PANEL

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 CRC Committees and Project Panels to consult on matters involving lubricants. The AVFL Lubricants Panel is also developing studies focused primarily on lubricant impacts for consideration by the full Committee.

The Panel meets periodically to develop project ideas for consideration by the AVFL Committee. The recently completed Projects AVFL-28 and AVFL-28-2, and ongoing Projects AVFL-28-3 and AVFL-37 were developed by this Panel.

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

This project brings 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.

The expert panel consists of “full active participants” as well as “observers” who occasionally weigh in with their expertise. The panel members assembled into various working groups to organize the efforts, 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
- 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

ATMOSPHERIC IMPACTS COMMITTEE

- Chemical Mechanism Working Group
- Thermochemistry Working Group
- Mechanism Generation Working Group

Current Status and Future Programs

A multi-year contract was awarded to UC Riverside in April 2017 and has been extended through 2022.

A perspective article that provides a general overview of gaps for improving atmospheric kinetic modeling was published in the *International Journal of Chemical Kinetics.* A second journal article on the experimental database has been published in *Earth System Science Data* (June, 2020).

THE INFLUENCE OF NO_X ON SECONDARY ORGANIC AEROSOLS AND O_3 FORMATION: CHAMBER STUDY

CRC Project No. A-113

Leader: T.J. Wallington

Scope and Objective

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. As stringent NOx controls continue to reduce ambient NOx levels, 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.

Within this project, specifically designed novel environmental chamber experiments will elucidate the key roles of NO_x on SOA formation and investigate the role of peroxide chemistry. These large chambers are designed to study atmospheric chemistry at low NOx concentrations (atmospherically relevant NOx loadings).

Primary objectives of Project A-113 are to:

- Design new experimental methods using environmental chambers to elucidate the interplay of NOx with select anthropogenic and biogenic precursors at atmospherically relevant (current and projected) oxidant levels;
- Identify SOA formation potential of select VOC precursors within these well-controlled environments;
- Evaluate ozone prediction under these scenarios; and,
- Provide guidance to regional air quality models on how to implement improvements to SOA predictive models.

Current Status and Future Program

This study directly addresses one of the Research Needs (Influence of NOx on SOA Formation and Ozone) from the CRC Air Quality Modeling Research Needs (AQMRN) Workshop held in February 2016.

The multi-year project began in January 2018 with UC Riverside and has been extended in 2022.

CHARACTERIZING PRIMARY ORGANIC AEROSOL EMISSIONS FROM IN-USE MOTOR VEHICLES

CRC Project No. A-114/ RW-111

Leader: M.E. Moore

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 the pollutant particle concentrations, for example. 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.

Current Status and Future Program

The goal of this project is to quantify the volatility profile and particle concentration in exhaust emissions. Measurements focus on physical properties of exhaust, both particulate and gas-phase concentrations.

Results from this study will be used to:

- Confirm that varying dilution leads to organic evaporation behavior that is consistent with published volatility profiles and partitioning theory,
- Better understand the interpretation of existing emissions datasets where particle concentration and volatility information does not exist,
- Determine the accuracy and limitation of using dilution factor to quantify the volatility profile of individual vehicles during standard emissions measurement efforts, and
- Add to the growing body of data documenting the volatility profiles of individual vehicles by tier, model, and model year, etc.

West Virginia University was awarded the contract for this project in February 2019, which continues into 2022.

BIOGENIC VS. ANTHROPOGENIC VOC ANALYSIS DURING PEAK OZONE EVENTS IN THE SOUTH COAST AIR BASIN/ MEASUREMENT OF VOLATILE CHEMICAL PRODUCTS (VCPS) IN LOS ANGELES

CRC Project No. A-121/ A-121-2

Leaders: T. Wallington
T. Kuwayama
C. Rabideau

Scope and Objective

The combined results from past studies using photochemical grid models and indicator species suggest that NO_x emission controls provide an efficient method to reduce surface ozone concentrations in California, but recent increases in ambient ozone concentrations in Los Angeles highlight the need for additional air pollution mitigation strategies. Direct measurements of the change in ozone per unit change in precursor species in the atmosphere would build confidence in the model prediction. In 2014, the SCAQMD funded a pilot project to measure the sensitivity of ozone formation to NOx and VOC using smog chambers deployed at sites across the SoCAB.

The University of California, Davis, in collaboration with CARB and CRC, will directly measure ozone response to NOx and VOC perturbations. Three parallel smog chambers equipped with UV lights are filled with ambient air at approximately 11a.m. each day. One chamber is used as a control for comparison to nearby monitors to verify that the system represents the real atmospheric behavior. The second and third chambers are perturbed by either NO_2 or VOC mixture, and ozone formation is compared between the three chambers after irradiation by UV lights.

Volatile consumer products (VCPs) have been identified as a source that could potentially contribute significantly to O_3 and SOA formation. In Project A-121, VCP measurements will be taken alongside ambient ozone perturbation experiments at four sites in Los Angeles over 26 days to improve our understanding of the factors that contribute to ozone formation. Project A-121-2 expands the measurement program to 90 days to cover a full O_3 season.

The relative contributions from biogenic vs. different anthropogenic sources such as VCPs and mobile sources will be identified through a statistical analysis of the measured concentrations.

Current Status and Future Programs

Projects A-121 and A-121-2 meet the top research priority needs resulting from the 2018 CRC SCORES workshop to observe response of ozone to changes in NO_x and VOCs. The project was co-funded by California Air Resources Board. The campaign was conducted alongside the CARB efforts in summer 2021. Project A-121-2 expanded the measurement program to 90 days to cover a full O_3 season. The Final Report for both phases of work was published on the CRC website in October 2022.

MOBILE SOURCE AIR TOXICS WORKSHOP 2021

CRC Project No. A-122

Leaders: S. Winkler
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, 2017, and 2019 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 was held in Sacramento, CA on February 4-6, 2019, with co-sponsors including CARB, API, HEI and SCAQMD. There were 30 technical presentations and over 120 attendees of the Workshop, which was hosted by CARB at their headquarters. Dr. Kent Hoekman was selected again to support organization of the 2019 MSAT Workshop with the aid of organizing committee participants. A summary article was published in July 2019 edition of *EM Magazine.*

A 10th workshop was held virtually February 7-10, 2022. A summary article is available on the CRC website.

ATMOSPHERIC IMPACTS COMMITTEE

THE RISING IMPORTANCE OF NON-COMBUSTION EMISSIONS IN URBAN ATMOSPHERES

CRC Project No. A-125

Leaders: T. Wallington
C. Rabideau

Scope and Objective

The urban atmosphere is complex and rapidly changing. The long-term trend is that emissions of VOCs, IVOCs, SVOCs, and NOx from combustion sources, primarily traffic, are decreasing. I/S/VOC emissions from non-combustion sources may be stable or even increasing. Furthermore, non-combustion sources emit a wide range of organic compounds not typically found in traffic emissions such as organic nitrogen and sulfur compounds. Sub-daily spatial-temporal variations in emission mean that the source mix and possibly the chemical regime (e.g., VOC/ NOx) changes rapidly both in time and space at the intra-urban scale.

The goal of this project is to improve the understanding of how anthropogenic emissions from multiple source sectors vary spatially and temporally in dense urban areas, and how emissions of both organic species and NO_x from these sources impact $PM_{2.5}$ and O_3 formation at the urban scale.

A mobile laboratory will collect measurements from a series of quasi-stationary sites in Pittsburgh and New York City in different macroenvironments, distributed across space and time. Collected measurements will constrain primary anthropogenic emissions and quantify secondary $PM_{2.5}$ and O_3 production potential.

Current Status and Future Programs

This project meets the primary objectives of the SCORES and AQRN Workshops. The multi-year effort was awarded to Carnegie Mellon University in 2021, and is expected to continue through 2024.

ABILITY OF PHOTOCHEMICAL MODELS TO PREDICT OBSERVED OZONE CHANGES IN THE SOUTH COAST AIR BASIN DUE TO EMISSIONS REDUCTIONS FROM COVID-19

CRC Project No. A-126

Leaders: T. French
S. Winkler
G. Myers

Scope and Objective

In response to the COVID-19 pandemic, there have been substantial reductions to many activities (e.g., driving, manufacturing, goods movement) that generate ozone and fine particulate matter ($PM_{2.5}$) precursor emissions across the world. This has resulted in a real-world experiment of a sudden reduction in emissions.

Despite the reductions in emissions due to the pandemic, 2020 ozone concentrations in the SoCAB were some of the highest and most persistent seen in decades. In 2020, there were 157 days that the Maximum Daily Average 8-hour (MDA8) ozone concentrations exceeded 70 ppb; the next closest year that had more exceedance days was 1997 (174 days), over two decades ago. The SCAQMD has cited the following possible reasons:

- Summer of 2020 had extremely high temperatures.
- There were more stagnant days with limited mixing.
- There were record wildfires and smoke emission impacts in 2020.
- Possible changes in emissions due to COVID-19 response, with NOx reductions in spring and early-summer that became more typical by August and potentially more VOC emissions from increased disinfecting.

The purpose of the proposed work is to better understand the effects of the 2020 emission reductions on ozone concentrations in the SoCAB and evaluate whether the photochemical modeling systems used to demonstrate attainment of the ozone NAAQS in the SoCAB can reproduce the 2020 ozone changes in response to the COVID emission changes. In particular, it is important to isolate the changes in ozone due to (1) meteorological conditions; and (2) emission changes caused by the response to the COVID pandemic. This work will build off preliminary data analysis and modeling conducted by Ramboll to analyze the 2020 and other recent year meteorological and emissions conditions and preliminary top-down broad-brush modeling of 2019 and 2020 that are described next. This top-down analysis was used to help design and form a foundation for the proposed detailed bottom-up modeling analysis in this proposal.

Current Status and Future Programs

This project has been contracted with Ramboll. The Final Report is available on the CRC website as of March, 2022.

AIR QUALITY RESEARCH NEEDS WORKSHOP II

CRC Project No. A-127

Leaders: S. Winkler
C. Rabideau

Scope and Objective

CRC AIC committee sponsored an Air Quality Research Needs (AQRN) workshop in 2016. This AQRN workshop was a successful collaborative event that resulted in recommendations of five key focus areas for future AQ research. These results have been guiding AIC's project solicitation and funding prioritization since 2017. With the rapidly evolving energy and regulatory landscape, the AQRN Workshop II will identify emerging research needs that could bridge scientific gaps for development of efficient control strategies and sound regulatory policies.

It is expected that the two-day workshop will include participants from industry, government, and academia to make recommendations for future air quality (including greenhouse gas) research needs that could help oil/auto industries stay in a better position in a changing regulatory landscape. Health research is not part of the scope of this workshop. The research needs identified will help guide AIC project selection.

Current Status and Future Programs

The workshop was held November 8-9, 2022, at UC Davis, California. Approximately 70 attendees convened to review relevant topic materials and brainstorm research needs. Priority voting of the topics identified the top research needs, which will be compiled in a Summary article that is expeted to be finalized in the first quarter of 2023.

ATMOSPHERIC IMPACTS COMMITTEE

QUANTIFYING THE EFFECTS OF VOC/NO_X CHEMISTRY ON TROPOSPHERIC OZONE PRODUCTION: YIELDS OF ORGANIC NITRATES FROM REACTION OF SUBSTITUTED ORGANIC PEROXY RADICALS WITH NO.

CRC Project No. A-128

Leaders: T. Wallington

Scope and Objective

The formation of atmospheric secondary pollutants, including ozone and secondary organic aerosol (SOA), is driven by non-linear chemistry involving volatile organic compounds (VOCs) and oxides of nitrogen (NOx). Direct control on ozone formation occurs via the reaction of organic peroxy radicals with NO. The peroxy radicals (RO_2), generated following reaction of OH with a VOC compound (RH), react with NO via two pathways, the first major channel generating ozone (via NO_2 photolysis) and the second limiting ozone formation via organic nitrate ($RONO_2$) production.

Thus, quantification of the organic nitrate formation yield for the full range of temperature and pressure conditions and VOCs encountered in the troposphere is of critical importance in constraining model uncertainty regarding tropospheric ozone production, and determining the efficacy of NOx vs VOC controls on ozone production. Detailed chemical models (e.g., Leeds MCM; GECKO-A; UC-Riverside MechGen) would employ the data obtained directly; more condensed mechanisms (e.g., SAPRC, Mozart, GEOS-Chem, RACM, …, and variants) would employ the data through the 'lumping' that occurs for complex VOC chemistry.

Organic nitrate yields from the oxidation of alkanes have been reasonably well studied, and demonstrate the inherent complexity – nitrate yields depend on the size and structure of the peroxy radical, as well as on temperature and total pressure. To date however, only limited/no information is available regarding nitrate yields from the chemistry of oxygenated VOCs, including alcohols, carbonyls, ethers and multifunctional species. Thus, we propose here environmental chamber studies aimed at quantifying organic nitrate yields in the chemistry of these oxygenated VOCs, with the broad goal of improving the representation of VOC/NOx chemistry in air quality models.

The objective of the project is to improve the state of knowledge regarding the yields of organic nitrates in VOC oxidation, and thus to further constrain model representation of the effects of VOC/NOx chemistry on ozone and secondary organic aerosol production. Nitrate yield determinations in the reactions of organic peroxy radicals with NO will focus on radicals derived from oxygenated VOCs, including ketones, alcohols, ethers and multi-functional species, for which very little information is available. Through studies of compounds of variable size and structure, and over ranges of temperature and pressure (in some cases), a set of ‘rules’ will be developed that can be used by air quality modelers to describe organic nitrate (and hence ozone) production for the wide variety of VOC encountered in the troposphere, particularly in urban areas. The classes of compounds under investigation have been identified as products of standard VOC chemistry, ‘volatile chemical products’ emissions, as well as (in some cases) potential alternative fuels.

Current Status and Future Program

The project began in April, 2022 and will continue until February, 2024.

ATMOSPHERIC IMPACTS COMMITTEE

OBSERVATION-BASED QUANTIFICATION OF BACKGROUND CONTRIBUTIONS TO MAXIMUM US O3 CONCENTRATIONS

CRC Project No. A-129

Leaders: S. Winkler
C. Rabideau

Scope and Objective

Since at least the 1940s, urban areas of the United States have suffered from degraded air quality, one main indicator of which is elevated ozone concentrations. Through large reductions of anthropogenic emissions of photochemical ozone precursors, great improvement has been made, but several areas of the country still exceed the 2015 National Ambient Air Quality Standard (NAAQS) for ozone. The NAAQS requires that the Ozone Design Value (ODV) not exceed 70 parts-per-billion (ppb, defined as nmole ozone/mole air). The ODV is defined as the 3-year average of the annual fourth highest daily maximum 8-hour average (MDA8) ozone concentration; it thus represents ~98th percentile of MDA8 values observed in the warm half of the year, when those four highest values generally occur. A time series of ODVs observed at a particular monitoring station is thus a smoothed measure of the temporal evolution of the maximum ozone concentrations impacting that location.

The purpose of this project is to examine the existing record of ozone concentrations measured in the southwest US, including the interior portions of southern California and the states of Nevada, Utah, New Mexico and Texas. Routine ozone monitoring began in the US in the early 1970s and continues to the present. The accumulated data set provides the basis for an observational-based quantification of ozone air quality improvement over 4 to 5 decades, the relative contributions of background ozone transported into the US and that produced domestically, and the relative importance of domestic contributions from industrial and urban emissions, agricultural emissions, and wildfire emissions. Although this approach could be applied to any percentile of the measured surface ozone distribution, this project will focus on ODVs based on the 2015 ozone NAAQS. Since the four highest MDA8 O_3 concentrations are generally recorded in the warmer half of the year (i.e., the ozone season) the ODV corresponds to ~ 98th percentile of MDA8 values recorded at a site during the ozone season. This focus is chosen to maximize the policy relevance of the results, since it is the maximum ozone concentrations that are associated with the strongest health, crop and ecosystem impacts, and is hence the statistic upon which the NAAQS is based. The purpose of this project is to examine this ozone measurement record in a particularly relevant region of the US – the southwest, which is recognized to have the largest impacts from transported background ozone.

Current Status and Future Program

Dr. David Parrish, consultant, has been selected as the contractor and the project is underway with journal article submitted and another planned to be completed in late 2022.

PERFORMANCE COMMITTEE BACKGROUND & PROJECTS

The Performance Committee's history can be traced to the beginning of the Council with the formation of the Cooperative Fuels Research (CFR) Committee of the Society of Automotive Engineers (SAE). Inspired by a spirit of cooperation and a desire for technological progress that arose in the aftermath of the first World War, the Committee included manufacturers of equipment such as vehicles and engines, producers of fuels and lubricants, government researchers, and academics. In the earliest years, the National Bureau of Standards provided laboratory facilities, but as the industries supported by the Committee developed their own technical acumen, they began to take on more of the testing within their own companies to support the collective effort. The CFR Committee developed a process for cooperative research that remains with us today.

The second World War, requiring an extraordinary effort of industries in support of the Allied cause, motivated the incorporation of the Coordinating Research Council in 1942. The focus of this new company was to increase the performance and reliability of the military equipment being used to prosecute the war. Today the emphasis is on supporting all equipment, and the work is no longer labeled "Top Secret," but the principle of providing a forum for industries to work together in the interest of the public good has not varied.

The modern Performance Committee of the Council is organized as a main committee that serves in an executive capacity and 4 topical working groups that develop and execute research projects: Deposits, Diesel Performance, Gasoline Combustion, and Volatility. The working groups have a diverse membership that connects the research to a broad swath of companies and research institutions. The research plans are driven by technical needs of ever-changing industries and standard-setting entities such as ASTM. Research studies are conducted by the Members or by contractors funded through the Committee's budget as provided by the CRC Members.

GASOLINE ENGINE DEPOSITS

CRC Project No. CM-136

Leader: M. Sheehan
I. Tibavinsky

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

Gasoline Engine Intake Valve Deposit Testing

ASTM D5500 is the test recognized by EPA for certifying additives to protect against Intake Valve Deposits. CARB has a separate test, and there is also a private program Top Tier certification test. The CRC Gasoline Deposit Group is considering a re-evaluation of the test procedures to possibly update the vehicles/engine 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, 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. A project panel has been formed to plan CRC research on this topic.

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

Port Fuel Injection (PFI) Intake Valve Deposit (IVD) Test Development (CM-136-18-1)

This project will develop a new engine-based test method suitable to replace existing ASTM D5500 test method for demonstrating effectiveness of gasoline detergent additives. It will conduct an engine test program to develop a final test fuel specification, test parameters, operating conditions, engine hardware requirements, and recommendations for pass / fail criteria. The work will result in an ASTM test methodology for IVD measurement and be acceptable to the EPA and potentially CARB for use in their Lowest Additive Concentration (LAC) certification test programs. This work will be completed in the Prove-out Phase of the CRC test development project. There will be a follow up Precision Phase of the project to define the repeatability and reproducibility of the test method once the Prove-out Phase is complete. The overall development project is expected to consist of three Prove-Out phases and one Precision phase.

- Phase 1 – Prove-Out Test Cycle
- Phase 2 – Prove-Out Test Fuel
- Phase 3 – Prove-Out Detergent
- Phase 4 – Precision

The project team has formed around five workstreams: Engine Test Development, Data Analysis, Test Fuel, Additives, and EPA / CARB Engagement.

The project has been awarded to Intertek and is underway.

Investigation into Filter Plugging Due to Sulfate Salt Contamination of Ethanol, Gasoline, and Gasoline-Ethanol Blends (CM-136-15-1 / CM-136-18-2)

The objective of the first project (CM-136-15-1) 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 first project consisted of two phases:

Phase One was a literature search of the published 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.

Phase Two 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 work 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 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.

RFA and Flint Hills Resources co-sponsored this 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.

The objectives of the follow-on work are to address a narrower range of solubility issue, and the researchers are focused on investigations of sodium sulfate, sodium bisulfite and sodium metabisulfite in ethanol. "Investigation of Sulfate Salt Solubilities in Ethanol and Gasoline-Ethanol Fuel Blends" was conducted by DRI (Desert Research Institute). The Final Report has been published on the CRC website.

<u>Study of Modern Gasoline Oxidation Stability with Correlations and Precision Updates to ASTM Stability Tests CM-136-20)</u>

This project's objectives are to:

- Develop a robust statistical design of experiments using ASTM D6300 for an Interlaboratory Study (ILS) on the current gasoline oxidation stability tests ASTM D525 Pressurized Cylinder Induction Period test and the ASTM D7525 Rapid Small-Scale Oxidation Test (RSSOT).
- Execute a statistically robust ILS with participating external laboratories from the CRC project participants.
- Develop the data for updated precision statements for both tests.
- Develop a statistically robust correlation between the pressurized cylinder test and the RSSOT. Perform this task with North American fuels to develop a robust correlation useful in multiple jurisdictions.

This project is being conducted by SwRI.

VOLATILITY

CRC Project No. CM-138

Leader: L. Gremillion
S. Kirby

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 / CM-138-19)

The objective of Project CM-138 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 performed the testing. RFA co-sponsored this research. The Final Report has been released (2014).

A follow-on project was developed to test an additional vehicle equipped with in-cylinder and spark-plug transducer pressure sensors, to assess the ability of the latter sensor type to be used for this type of research. The Final Report has been released on the CRC website as of October 2021.

"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". Concerns were expressed in the industry that the original "Doner Report" information may be outdated. The objective of this project was 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 were done in a manner similar to that of the original "Doner Report" but with computer-generated isothermal maps. The new study included data covering 1996 through 2016 (twenty-one years, which is similar to that from the "Doner Report"), and Hawaii (left out of the original study). State temperature data (excluding Panama Canal which was part of the original report) were analyzed in multi-geographic regions when appropriate as was done for the prior study.

DRI performed this project. The Final Report was published on the CRC website in December 2018. In late 2019, it was discovered that updates to a table in the report were needed, and the proposed revision (addendum) to the Final Report was posted to the CRC website in March 2020.

“Driveability Workshop to Train and Calibrate Raters Using the CRC Trick Car” (CM-138-18-1)

CRC has used trained raters for many years to assess the driveability vehicle performance for test programs. The existing driveability rater pool consist of retirees or from testing facilities. Therefore, CRC sees the need to establish new trained raters for future volatility projects. CRC has not conducted a rater workshop to train and calibrate driveability raters since 2002, where a ‘trick car’ (Driveability on Demand Training Vehicle) was used to train and calibrate driveability raters by subjecting them on demand to various driveability malfunctions at different intensities. Calibrating raters will improve test result precision. CRC has a new ‘trick car’ which was developed under CRC Project CM-138-17-1. This project's objective is to meet at a common test site to train novice and inexperienced personnel to be driveability raters and to calibrate experienced driveability raters using the CRC Driveability on Demand Training Vehicle.

This Workshop was conducted by SwRI in September 2019. The Final Report has been released on the CRC website.

“Development of Automated Driveability Rating System Using Trick Car” (CM-138-20)

The primary objective of this project is to develop an Automated Driveability Rating System (ADRS) for Light Duty (LD) vehicles capable of identifying and rating fuel-related driveability events including hesitation, stumble, surge, stall, and idle quality at trace, moderate, and heavy severities. The project is using the vehicle developed in CRC Project CM-138-17-1 and used in the training Workshop in CRC Project CM-138-18-1. This project includes selection of sensors, a data processing and control unit, collection of data, and development of software to process, analyze and identify driveability issues. This project was conducted by SwRI; the Final Report has been released on the CRC web site.

PERFORMANCE COMMITTEE

GASOLINE COMBUSTION

CRC Project No. CM-137

Leader: B. Alexander
E. Chapman

Scope and Objective

In 2020, the name of this Working Group was changed from the Octane Group to the Gasoline Combustion Group. The objectives of this group are to conduct surveys of the combustion-related requirements of current production automotive vehicles, to develop methods for quantifying combustion-related fuel requirements of vehicles, and to determine effects of variables such as mileage accumulation and altitude on combustion-related fuel requirements.

Current Status and Future Program

"Impact Of MON On Engine Performance" (AVFL-36 / CM-137-19-1)

This Project is supported equally by the Performance Committee Gasoline Combustion Group and AVFL and described in the AVFL Committee section.

"Alternative to Tetraethyl Lead (TEL) in ASTM D2699 and D2700" (CM-137-21)

Both ASTM D2699 and D2700 require tetraethyl lead (TEL) blends with isooctane as reference fuels to rate gasolines with ON > 100. There is a desire to develop an alternative to TEL blends for the rating of gasolines with ON > 100. Both CRC and ASTM agree that the best way forward is to identify and evaluate an alternative to TEL. The proposed literature study includes evaluating toxicity, material compatibility, availability, and cost of candidate compounds to use as an alternative to TEL. The laboratory study proceeds in two phases, including a precursor study at one lab which would run in parallel with the literature study, and a full ARV (Accepted Reference Value) study completed after the precursor study. The Statement of Work (SOW) for this project is being developed by the CRC Project Panel in coordination with an ASTM task force and CRC Aviation Committee members.

DIESEL PERFORMANCE GROUP

CRC Project No. DP

Leader: G. Gunter
S. Lopes

Scope and Objective

The objective of the Diesel Performance Group (DPG) 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, the International Organization for Standardization (ISO), and the National Conference on Weights and Measures (NCWM). Much of the knowledge gained is common to other diesel applications such as heavy-duty diesel (HDD). This Group works closely with industry stakeholders and benefits from their contributions.

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

Active Panels:

- Cleanliness
- Corrosion
- Deposit
- Low Temperature Operability
- Stability

Inactive Panels:

- Biodiesel & Renewable Diesel
- Cetane Number
- Lubricity

Current Status and Future Program

<u>Cleanliness</u>

The objective of the Cleanliness 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.

The Panel generated a CRC guide to compile best available current knowledge and practice regarding cleanliness of diesel fuel. CRC Report No. 667, "Diesel Fuel Storage and Handling Guide," was published on the CRC website in September 2014. ASTM periodically holds workshops on this topic and distributes the guide to participants.

The Panel 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.

The Panel meets periodically. Data on fuel haze measurements was generated and analyzed by the Panel under Project No. DP-06-20, resulting in the publication of CRC Report No. 675, “Evaluation of Diesel Fuel Haze Resulting from Water Content,” now published on the CRC website as of January 2022.

Corrosion

Accelerated corrosion has been observed in some retail underground tanks storing and dispensing ultra-low sulfur diesel (ULSD) since 2007. In addition, corrosion is affecting 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 in 2014 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 of 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 USTs that are in ULSD 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 performed the testing in this project, with significant interaction and support from CRC Panel Members. Fred Passman was contracted as a consultant to complete the Final Report. The Final Report has been released on the CRC web site as of July 2021.

“Fuel Research Using the Internal Diesel Injector Deposit (IDID) Rig” (DP-04-22)

The objective of the proposed work is to determine precision of the new test system to evaluate internal diesel injector deposits which is described in the previous CRC Project No. DP-04-17 report. The test now known as the CRC Internal Diesel Injector Deposit (IDID) Test, uses a combination of an injector deposition rig and a novel application of a spectroscopic instrument (Variable Angle Spectroscopic Ellipsometer, VASE) to measure deposit thickness. The intention is to conduct research as per the design of experiment test matrix designed by the CRC Diesel Deposit Panel to establish repeatability/reproducibility and sensitivity of the test rig. This project is being conducted by SwRI.

Deposit

The objective of the Deposit 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.

Experts on the Deposit Panel wrote a review of potential causes of internal diesel injector deposits which was published as CRC Report #665, “Internal Diesel Injector Deposits,” October 2013.

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 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, titled "Fuel Research Using the Internal Diesel Injector Deposit (IDID) Rig" (CRC DP-04-17), was performed by SwRI. The Final Report was released on the CRC website in September 2019.

The Deposit Panel is planning additional research to build upon the recent publications.

Low Temperature Operability

The Panel conducted a study in which various test methods used to characterize fuel low temperature operability were evaluated for their ability to predict whether test vehicles experienced fuel-related operability problems in low temperature test conditions. Results were documented in CRC Report #649, "Evaluation of Low Temperature Operability Performance of Light-Duty Diesel Vehicles for North America," November 2007.

The Panel conducted a study of the effect of biodiesel blendstock properties on cold flow properties of biodiesel blends. Results were documented in two reports: CRC Report #650, "Biodiesel Blend Low-Temperature Performance Validation," in June 2008 and CRC

Report #656, "Biodiesel Blend Low-Temperature Performance Validation," in June 2010.

The Panel has utilized members' expertise to generate CRC Report No. 671, "Diesel Fuel Low Temperature Operability Guide." The guide was written for general use by end users, fuel producers / distributors, 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," using resources provided by Panel members. A test rig 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. Reporting on this research is expected in 2023.

Stability

This Panel formed in 2020 to address issues related to diesel fuel stability. The Panel considered potential project ideas related to 1) improving viability of engine-based stability tests which are based on dated technology and 2) investigating whether current ASTM fuel stability specification limits (Rancimat) are sufficient to protect modern fuel injection systems.

AVIATION FUELS COMMITTEE

THERMAL STABILITY PANEL

CRC Project No. AV-24-16

Leaders: R. Juan
A. Carico

Scope and Objectives

There has been an increased number of incidences of jet fuels that do not meet the ASTM D1655 requirements for D3241 ("JFTOT") thermal stability at pre-airfield terminals or airport depots. The product in question does meet certification at the production point, but fails after moving through the fungible distribution system. The number and severity of these failures have caused supply chain and end user issues. The Project Panel will be investigating a number of failure mechanisms and the factors possibly involved in causing those failures.

Current Status and Future Program

The Panel has been meeting periodically since its formation, with the frequency varied according to the occurrences of observed issues with fuel stability. Samples have been procured and testing performed to inform potential future research in this area.

DEVELOPMENT OF FUEL V/L RATIOS FOR APPLICATION TO SYSTEM 'SUCTION' CAPABILITY DETERMINATION

CRC Project No. AV-27-18

Leaders: J. P. Belieres
R. Kamin

Scope and Objectives

The objective of Project AV-27-18 is to generate the appropriate data needed to update the SAE documents dealing with V/L and gases solubility, as well as updating CRC and ASTM publications. These publications determine the ability of a fuel pump to operate when presented with a fuel and gas (V/L, vapor-to-liquid fuel ratio), or minimum required inlet pressure (fuel only): with testing performed for stabilized operating conditions and idealized test conditions, and with practices stating that testing should not be used to establish transient performance for the aircraft installation since they are not intended to establish altitude, climb rate or other transient performance of the system.

In addition, under failure conditions, there is a need for the integrated aircraft and engine fuel system to operate, when the aircraft pumps are non-operational, in a "suction" or "gravity" feed mode. Under these conditions it is critical that air evolution from the fuel does not result in a "vapor lock" condition. This project is investigating:

- Air solubility (and other critical properties) of various fuel types, including biofuels, to support determination of test conditions for contemporary fuels.
- Capability to estimate influence of aircraft rate of climb, and the corresponding reduction in ambient pressure experienced by the fuel, on the derived V/L ratio, enabling a more accurate mechanism to determine two phase flow conditions within the aircraft and engine fuel system during transient aircraft operation.

AVIATION FUELS COMMITTEE

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Current Status and Future Program

Project AV-27-18 was performed by the University of Dayton Research Institute. The Final Report has been released on the CRC website as of March 2022.

FEASIBILITY ANALYSIS: ALTERNATIVE APPROACHES TO THE REPLACEMENT OF ASTM D909 SUPERCHARGE RATING

CRC Project No. AV-28-19

Leaders: M. Rumizen
R. Gaughan

Scope and Objectives

The first goal of the project is to summarize the conditions, requirements, and rationale of the current ASTM D909 Supercharge Octane Rating test method. A great deal of information about the engine setup and test requirements can be found in the ASTM D909 test method and the CFR Engines F-4 manual. More information likely exists in the CFR Engines Inc. archives that could provide better detailed information about the rationale of the supercharge test method. However, there is a lack of fundamental understanding regarding the actual cylinder thermodynamic conditions of the D909 test method. In the case of the RON and MON tests, there has already been some highly impactful research on instrumented RON and MON test engines [8,10-23], but there is a lack of detailed combustion measurements and analyses of the F-4 supercharge rating engine.

After a detailed literature review of previous measurements (and rationale) of the F-4 supercharge method test engine, the next step will be to instrument the F-4 engine installed at CFR Engines, Inc. and combine measurements and modeling of the engine operating conditions, cylinder conditions, and combustion and knocking characteristics. Common aviation gasolines, such as 100LL aviation gasoline and reference fuels, will be tested. This will provide the needed fundamental information about the cylinder thermodynamic conditions the test fuels are exposed to during the current supercharge test method. A Three Pressure Analysis (TPA) GT-Power model of the RON and MON engines has been developed. The GT-Power model uses measurements from actual engine experiments to provide some of the boundary conditions for the model to improve its accuracy.

Research Questions to be Addressed:

1. What are the cylinder thermodynamic conditions (or range of conditions) the fuel is exposed to during the current F-4 supercharge test method over the typical range of performance numbers?
2. How do modern cylinder pressure transducer-based measurements of IMEP (and their uncertainty) compare to the current BMEP and FMEP based IMEP calculation method?
3. In a blind test, how well does the operator-based human ear detection of "light knock" compare with a cylinder pressure transducer-based knock intensity measurement, such as the maximum amplitude of pressure oscillations (MAPO), as demonstrated for a RON test of isooctane in Figure 6?
4. From how many of the combustion cycles can knock be observed from a cylinder pressure measurement during testing of the supercharge test method?
5. How does the combustion and knocking characteristics compare between the supercharge method and the RON and MON test methods?

Current Status and Future Program

A new Cooperative Research and Development Agreement (CRADA) between CRC and Argonne National Laboratory has been signed, and this project is under way.

A REVIEW OF CURRENT EXPERIMENTAL AND CORRELATION METHODS TO DETERMINE THE CALORIFIC ENERGY CONTENT OF LIQUID FUELS. PHASE 1 – LITERATURE REVIEW OF CALORIFIC INSTRUMENTS, METHODS AND CORRELATIONS.

CRC Project No. AV-29-20

Leaders: A. Clark

Scope and Objectives

This is a study to review and critique current measurement and estimated energy density methods, how the data they produce is used, and their relevance to today's applications. Alternative estimation and measurement methods will also be covered. The review will cover aviation gas turbine fuels including standard kerosene grades Jet A/A-1 (JP8), High Flash Point (JP5), and wide cut grades Jet B/JP4. The review will also cover aviation gasoline grades.

Methodology employed to gather, collate and review information will include the following:

- Obtain latest versions of aviation fuel and associated energy density test/estimation methodologies. (equipment and procedures).
- Acquire, collate and review all data, information from Research Reports pertaining to the above methods (where available).
- Contact ASTM groups that own these methods (if active).
- Carry out an academic database literature search in relevant areas.
- Complete equipment manufacturer searches to identify status of currently in-use apparatus and potential alternative either off the shelf, requiring modification or in development by internet searches and discussion with equipment vendors.
- Search information on the use of alternative methods in other industries/fuel types, etc., literature / internet searches and discussion with key workers.
- Have discussion with key workers in current fuel database and property prediction research activities.

- Have telecon or internet-based interviews with subject matter experts, and energy density data producers and users including key stakeholders such as test house, fuel producers, OEMs, Carriers, test equipment manufacturers and workers in relevant fuel property measurement and prediction development.

Current Status and Future Program

The project was conducted by Chris Lewis Fuels Consultancy Ltd. The Final Report has been released on the CRC web site December 2021.

JET FUEL & AVIATION GASOLINE HOV AND ENTHALPY DIAGRAM TESTING

CRC Project No. AV-20-20

Leaders: A. Clark

Scope and Objectives

This work is a continuation of the work done and reported in CRC Project AV-20-14, and will characterize European produced Jet fuels relative to American produced Jet fuels. It will use HOV QI data to establish both average value and level of variation with regard to a jet fuel type, and investigate if there is a significant difference between two similar fuel types that (essentially) meet the same specification, but are manufactured in different regions of the world.

Additionally, it will produce Enthalpy Diagrams and Heat of Vaporization curves to a range of Avgas samples for inclusion in the CRC Aviation Fuel Property Handbook.

Current Status and Future Program

The project has been awarded to the University of Delaware, and is in progress.

UPDATE OF AVIATION GASOLINE PROPERTIES USING 100LL COFAS FROM PRODUCERS, SAMPLES ANALYSES BY AFETF, AND NEG DATA

CRC Project No. AV-30-22

Leaders: R. Gaughan
D. Atwood

Scope and Objectives

Project AV-30-22 partners with the FAA, and collects a new set of CoA's from producers, the AFETF data, and NEG data starting in 2011. Evaluate the current maximum lead content, graph the relationships between the properties, specifically, lead vs MON/D909, lead vs aromatic content, and variability in measured physical properties. Data should be reported by region and if possible, by blinded refinery.

The data should be reported as a continuation of the original data sets, or the original data sets should be incorporated into this report.

Note 1: The original referenced work was based only on US (United States) refineries. There is interest in including fuels produced at European and other refineries in the rest of the world. The data outside of the US (United States). would not be available from the FAA data sources. The proposer should provide information on the ability to include non-US reviews and a separate cost estimate if this work is also proposed.

Note 2: An interest has been expressed to try to collect data related to the viability of refiners to specifically produce 100 VLL aviation gasoline to help reduce atmospheric lead emissions. Because of US (United States). anti-trust laws and proprietary business data, it is recognized that this will make accessing such data difficult. It has been suggested that the proposer work with EAA and API through CRC to collect data related to the viability of producing the fuel, separate from an individual company's intention. The proposer should provide information on the ability to address this data collection and submit a separate cost estimate if this work is also proposed.

Current Status and Future Program

A competitive solicitation is in progress.

MICROBIAL TEST KIT EVALUATION

CRC Project No. AV-31-22

Leaders: M. Vaughan

Scope and Objectives

This project's objective is to conduct an independent laboratory study to confirm the technical performance and reliability of proposed and existing IATA (International Air Transport Association) recommended methods for microbiological contamination in aviation fuel tanks.

Evaluate current and proposed IATA recommended Microbiological Test Kits and compare to reference test methods.

Test Methods to Include in Study:

- FuelStat® Resinae Plus (ASTM D8070)
- MicrobMonitor®2 (ASTM D7978)
- HY-LiTE® (ASTM D7463)
- Aidian: Easicult TTC and Easicult®M
- San-Ai Biochecker FC
- LuminUltra® ATP (ASTM D7687) (Not currently IATA recommended but proposed and in use by some airlines with their own internally developed action levels)
- IP385/ASTM D6974 (current laboratory reference method)
- qPCR ASTM method in development (as a possible reference technology)

Test evaluation will be carried out in accordance with the protocol developed by the IATA Microbiological Contamination Panel with input from IATA member airlines, Airbus, Boeing, Embraer, US Air Force, Microbiological Experts (Echa Microbiology, FQS, Merck, Conidia Bioscience, Aidian, San-Ai Biochecker)

Simulations of fuel tanks containing contaminated fuel and water, at various levels of contamination, will be developed and then tested with each of the methods.

Current Status and Future Program

A competitive solicitation is in progress.

INVESTIGATE JP-5 VAPOR PRESSURE VALUES IN FIGURE 2-12 OF CRC FUEL HANDBOOK

CRC Project No. AV-32-22

Leaders: M. Thom
A. Clark

Scope and Objectives

Project AV-32-22 aims to identify the source of the data used in CRC Fuels Handbook for JP-5 vapor pressure and determine if it was the same as JP-7 for some reason or has always been incorrect. Another objective is to determine what contemporary JP-5 vapor pressure data indicates or determine whether there is no vapor pressure data available.

The plan is to research the potential source of the original CRC Fuel Handbook vapor pressure data. This may include DOD research reports published before or contemporary to the original publication of the CRC handbook. Sources identified shall be provided.

If this data can be located, the proposer is to perform a comparison of the data between JP-5 and JP-7 specifically, and across any other fuel data identified during Step 1.

Research contemporary data on fuel vapor pressure and determine what data indicates in comparison to the existing CRC Handbook data.

It is recognized that if no data is found, a subsequent research proposal may be submitted for developing data.

Current Status and Future Program

This project has been awarded to UDRI.

EVALUATE THE POTENTIAL FOR SIGNIFICANT GREENHOUSE GAS EMISSION REDUCTIONS FROM INTERNAL COMBUSTION ENGINES OPERATED ON LIQUID FUELS OVER THE 2021-2030 TIME PERIOD: LITERATURE REVIEW AND FUTURE PROSPECTS

CRC Project SM-1

Leaders: D. DiCicco
H. Hamje

Scope and Objectives

The objective of this literature review is to evaluate and determine the total greenhouse gas (GHG) emissions reductions that are achievable now and in 2030 from liquid fuel-based light-duty vehicles. Phase 1 of the study will focus upon the GHG reduction opportunities on a Well-To-Wheel (WTW) basis for liquid fuels/ICEV and electric grid/PEVs operation. To capture the overall lifecycle performance of a light-duty vehicle (including manufacturing and disposal) and the liquid fuel used to operate its internal combustion engine (ICE) and provide a holistic perspective, Phase II of the study will incorporate the elements of vehicle manufacturing and end of life disposal.

The goal of Phase I is to:

- Define those pathways that come closest to representing a net GHG neutral (net-zero) scenario for light-duty vehicles equipped with internal combustion engines operating with liquid-based fuels,
- Evaluate, for each pathway now and in 2030, the relative contributions to net GHG emissions that result from vehicle-related improvements in engine/energy efficiency and changes in the carbon intensity of the liquid fuels used for vehicle operation, and
- Compare with plug-in electric vehicle (PEV) performance utilizing a WTW (electricity generation + vehicle efficiency) approach.

The objective questions of utmost interest are: Is there a pathway to 2030 for significant WTW GHG reductions for ICE-equipped light-duty vehicles operated on liquid fuels? How does the pathway compare to PEVs using a similar WTW approach (energy production + vehicle operation)? Can the transportation sector achieve a goal of net-zero carbon given the technologies and processes available today and that are conceivably expected to be available in the near-term for the ICE-equipped LDV, the liquid fuel on which it operates, and, in the case of PEVs, the US electricity grid carbon footprint?

Current Status and Future Program

This project has been awarded to E4Tech and AVL and is in progress.

EVALUATION OF THE USE OF EVS FOR TRANSIENT GRID STORAGE (V2G) ON BATTERY LIFE

CRC Project SM-E-4/8

Leaders: E. Chapman
C. Brooks
I. Tibavinsky

Scope and Objectives

The objective of this project is to model the battery life effects of V2G activity on top of ordinary EV battery usage such as mobility related discharge, slow and fast charging, and calendar aging. A variety of V2G strategies are possible and their effects on battery life can be modeled. The model would include the effects of various ordinary uses as described above. The end product should be the identification of V2G cycles that, when coupled with certain mobility and charging usages, result in a battery deteriorating below the warranty requirement and identification of the salient modes of deterioration.

The contractor will research a variety of likely V2G duty cycles for use in the model; these may include full grid load leveling, peak shaving as well as V2Building. The contractor will have an up-to-date battery use and life model and will layer the V2G duty cycles on a variety of existing vehicle use and charging scenarios based upon Level 2 and higher power DC Fast Charging . The model will simulate up to 8 years of use and if possible, include calendar aging.

The battery model will be of the Newman 2PD type with variables populated from the characteristics of a real cell. It will model carbon anode and higher nickel NMC or NCA/NMCA cathode batteries and have multiple degradation modes. The modeled battery will have 75kWh of capacity and the failure threshold is 70% performance. The maximum rate of V2G discharge is 10 kW. Knowing there are many possible use case scenarios, it is expected that the contractor and CRC will decide upon a design of experiments matrix that is achievable for the time of performance.

Current Status and Future Program

This project is being conducted by the University of Michigan.

CARBON RETURN ON INVESTMENT FOR ELECTRIFIED VEHICLES

CRC Project SM-E-20

Leaders: M. Przybylo
X. He

Scope and Objectives

The objective of this project is to evaluate the carbon return on investment (CROI) for a variety of battery sizes in the different vehicle electrification strategies.

The contractor will model the carbon intensity for producing batteries based on size and battery technology (i.e.. mineral content) using real world data from a variety of vehicle models. This data will be combined with an in-use average driving calculation to determine the actual carbon return on investment (CROI). The project will include PHEV and BEV (Battery Electric Vehicles) vehicle configurations, with models from a selection of automobile manufacturers. The size of the battery and driving habits of the average driver will help to determine the true potential CO2 benefit.

Current Status and Future Program

This project is being conducted by the National Renewable Energy Laboratory.

V2X REQUIREMENTS TO SUPPORT THE SAE J1634 SHORT MULTI-CYCLE TEST AND SETTING INITIAL SOC FOR PLUG-IN HYBRID ELECTRIC VEHICLES

CRC Project SM-E-18 / E-142

Leaders: E. Chapman
S. Decarteret
M. Yassine
M. Al-Hadrasi

Scope and Objectives

Evaluate potential industry standard V2X communication protocols (such as ISO 15118-20 and SAE J2836). Provide a comparison of protocol options and identify a recommended protocol. Develop guidelines, procedure, quality checks and best practices to perform the SAE J1634 (April 2021) EV battery discharge utilizing the recommended V2X protocol. This shall include requirements for the vehicle battery discharge control, communication between vehicle and battery cycler, and battery cycler control.

Identify methods for "SOC conditioning" (charging or discharging battery to a setpoint) to address a host of situations for both BEVs and PHEVs. Manual methods currently exist using a chassis dyno (SAE J2908 and or SAE J1711) and/or standard charging equipment. Include what is possible with manual methods, a combination of manual and automatic, and fully automatic methods. Describe what procedures, equipment or new features are needed for each with the preferred goal of providing safe, unsupervised charging or discharging to a pre-determined SOC set-point with automatic termination of power flow when the target SOC is reached."

Current Status and Future Program

A competitive solicitation is in process.

CHARGING PLAZA LOAD ANALYSIS AND FORECAST

CRC Project SM-E-16

Leaders: E. Chapman
I. Tibavinsky
V. Raj-Mohan

Scope and Objectives

This project will explore how the growing diversity of vehicle charging capabilities, charging behavior, or 'styles', impacts load shape and peak demand and thus, the site host utility bill. Further, the research will explore different approaches to optimizing operational costs through on-site storage, customer pricing signals (demand response, throttling, or rewards programs), or other to-be-determined methods. Using scenario-based Excel models to estimate the frequency and duration of a charging station reaching its nameplate capacity, the research will evaluate the practical feasibility and estimated cost-effectiveness of different approaches (e.g., storage vs managed charging). Insights from this modeling effort can be used to inform system design and pricing strategies.

The modeling will also allow for the exploration of site level utilization and how utilization may change over time with increasing levels of EV's (Electric Vehicles) and EV charging. The model can be used to evaluate the profitability of different charging stations based on defined scenarios (e.g., monthly utilization, when / how they are used). Results from the scenario analysis will provide guidance on how a retail charging plaza could mature / evolve over time as utilization increases or remains low depending on its scenario (e.g., urban vs rural, remote, etc..). Finally, insights from the utilization modeling exercises will inform the viability of rural and remote DDCFC (DC Fast Charging) stations and identify the potential need for supportive subsidy or other incentives (state, local, or federal).

The contractor will build an Excel based model to 'simulate' plaza level charging station use, load shape, peak demand, and utility bills. If available, the model will be informed based on real-world data, statistical models, and empirical assumptions. The contractor will build several scenarios of future charging plaza operations based on vehicle charging characteristics and different charging styles.

The model will produce results that include:

- Typical and outlier load shapes for different charging scenarios
- Presentation of different future scenarios for plaza level utilization
- Utility bills based on utility tariffs
- Quantitative and qualitative considerations for different approaches to mitigating peak demand events (e.g., storage, price signals, throttling, curtailing, etc.)

Current Status and Future Program

This project is being performed by the Smart Electric Power Alliance (SEPA).

RESEARCH IN SUPPORT OF FUTURE FUEL SPECIFICATIONS

CRC Project SM-F-5

Leaders: M. Sheehan

Scope and Objectives

The ultimate goal of this assessment is to maintain and/or broaden the scope for liquid fuels in a lower carbon future.

This effort will examine opportunities to alter current specifications for transportation fuels to enable lower fuel carbon intensity while remaining relevant to modern/future vehicles. It is intended to explore both: (a) those properties could be changed to enable increased use of renewables, and (b) those parameters that could be limiting changes in petroleum (and renewable) fuel manufacturing processes and process efficiency improvements that might also reduce carbon intensity. This effort will be undertaken from a holistic perspective, i.e., one that explores those property and performance specifications deemed necessary to support incremental changes in engine, vehicle, and fuel requirements that increase total energy efficiency/reduce total carbon intensity evaluated on a wells-to-wheels system-wide basis.

Current Status and Future Program

A competitive solicitation is in process.

SUSTAINABILITY AND LOCAL AIR QUALITY IMPACTS OF FUTURE ELECTRIFICATION AND NEW VEHICLE EMISSION REGULATION SCENARIOS IN THE U.S.

CRC Project SM-F-2 / A-134

Leaders: J. Anderson
S. Winkler
H. Hamje

Scope and Objectives

Assess the trends in air quality (ozone, NO_2, PM_{10}, PM2.5, CO, CO_2) of several selected US urban areas and regions for various scenarios (2030-2035) involving different assumptions regarding: (a) the future penetration of electrified vehicles in the on-road light-duty vehicle fleet), (b) the mix of fuels (i.e., gasoline/diesel, biodiesel, ethanol) needed to operate internal combustion engine-equipped vehicles (ICEVs) and generate electricity for electrified vehicles; and (c) emissions levels for future light-duty ICEVs. Model the change in well-to-wheels CO_2 emissions associated with the same future scenarios. Determine and compare the incremental CO_2 and air quality impacts of high and low vehicle electrification scenarios. Consider CO_2, PM2.5, PM10, NOx, ozone, CO, non-methane hydrocarbons, methane, oxygenates, etc. Compare cases to each other and/or to air quality and climate objectives, or other metrics.

- Identify and select at least 4 US urban areas and/or regions for which adequate underlying emissions inventory (and other) data exist to support air quality modeling and:
    - Construct a base year scenario.
    - Construct at least 3 alternative future year scenarios that will serve as a reference case, a high vehicle electrification case and a low vehicle electrification case.
- For each of the locales/regions selected:
    - Model the well-to-wheels CO2 emissions for EV and ICEV associated with each scenario described above.
    - Determine and compare the incremental CO_2 and air quality impacts related to the future scenarios and to the base year.

  - Compare cases to each other and to air quality and climate objectives.

Current Status and Future Program

This project is being performed by the University of Houston.

LITERATURE REVIEW OF MODELS USED FOR BIOFUELS GHG EMISSIONS MODELING AND COMPARISON OF RESULTS ON SOME COMMONLY AVAILABLE FUELS

CRC Project SM-LCA-17

Leaders: R. De Kleine
X. He

Scope and Objectives

The objective of this project would be to review various commonly used available models/approaches, identify sources of uncertainty and attempt to understand differences in results produced by these models for some common fuels and feedstocks.

This work would be in the form of a literature review which would contrast and compare the features of various models in use by different organizations and highlight model differences. It would also compare results generated by these models for several fuel pathways selected to represent commonly available fuels (e.g., renewable diesels and gasolines, biodiesels, alcohols etc.) derived primarily from various agricultural feedstocks (e.g., corn, soybean, canola, rapeseed) as well as one or two pathways selected to represent fuels derived from non-agricultural feedstocks (e.g., lignocellulosic sources, used cooking oils, animal fats, etc.). The study would attempt to identify and explain the sources of differences in the results.

Current Status and Future Program

This project is being performed by Trinity Consultants.

SUSTAINABLE MOBILITY COMMITTEE

SUSTAINABLE MOBILITY WORKSHOP

Leaders: H. Hamje
E. Chapman

Scope and Objectives

The 1st Sustainable Mobility Workshop was held December 13-15, 2022, hosted by the National Renewable Energy Laboratory. (NREL) There were 144 Attendees from 16 countries, with 32 speakers over the course of the event. Supporters of the Workshop included NREL, Afton, Aramco, Deutz, the National Institute of Standards and Technology, and the Southwest Research Institute.

The Workshop featured these Sessions/Panels:

- Life Cycle Analysis
- MD/HD/Offroad/Marine
- Electrification - Policy Updates and Infrastructure
- Electrification- EV Fluids / Battery Recycling / Supply Chain
- Electrification-Battery Modeling / Durability & Safety / Security
- Novel Carbon Reduction Strategies
- Fuels

Current Status and Future Program

The next event is being planned in cooperation the Society of Automotive Engineers International and their Energy and Propulsion Conference & Exhibition in November 2023.

PART THREE

RELEASED REPORTS

RELEASED REPORTS – 2022

AIR POLLUTION AND ADVANCED TECHNOLOGY*

CRC Project No.	Title	Publication/NTIS Accession No.
*A-107	Atmospheric Impacts of VOC Emissions: Formation Yields of Organic Nitrates in Reactions of Organic Peroxy Radicals with NO	PB2021100656
*A-118	Role of Meteorology, Emissions and Smoke on O3 in the South Coast Air Basins	PB2021100657
*A-119	High-Resolution Inventory Data Extractor and Source Apportionments Regrouping Tool Developments	PB2021100672
A-120	Empirical Analysis of Historical Air Quality and Emissions Information to Develop Observationally Based Models of Ozone-VOC-NOx Relationships in Southern California	PENDING
A-121-1 and 2	Measurement of Volatile Chemical Products (VCPs) in Los Angeles and Biogenic vs. Anthropogenic VOC Analysis During Peak Ozone Events in the SoCAB	PENDING
A-123	Uncertainty in Ozone Changes from Control Strategy Implementation	PENDING
A-124	Evaluation of O3 Patterns and Trends in 8 Major Metropolitan Areas in the U.S.	PENDING
A-126	Ability of Models to Reproduce the Observed Changes in Ozone in the SoCAB due to Emissions Reductions from COVID-19	PENDING

RELEASED REPORTS – 2022

CRC Project No.	Title	Publication/NTIS Accession No.
A-129	Maximum Ozone Concentrations in Inland California: Contributions from Background Ozone, Urban Ozone Transport, Agriculture and Wildfires	PENDING
AVFL-26	Future Gasoline Engine Technologies and High Octane Fuels for Reducing Fuel Consumption and GHG Emissions, Parts A & B	PENDING
*AVFL-27-2	Improved Method for the Measurement of Full and Partial Heat of Vaporization of Gasoline and Ethanol/Gasoline Blends Executive Summary	PENDING
AVFL-29-2	Effect of Detailed Hydrocarbon Analysis (DHA) Development on Particulate Matter Index (PMI) Variability	PENDING
AVFL-32 Phase 1	Effects of Knock Intensity Measurement Technique and Fuel Chemical Composition on the Research Octane Number (RON) of FACE Gasolines: Part 1 – Lambda and Knock Characterization	*Fuel* Volume 304, 15 November 2021, 120722 https://doi.org/10.1016/j.fuel.2021.120722
AVFL-35	Advanced Combustion Literature Survey	PENDING
AVFL-37	Thermal and Electrical Properties of Lubricants for HEV/EV Applications	PENDING
RW-107-2	An Improved Index for Particulate Matter Emissions (PME)	PENDING
RW-115	E-15 Fuel Survey January and July 2020	PENDING
RW-117	On-Road Remote Sensing of Automobile Emissions in the Fresno, CA Area: Spring 2021	PENDING

RELEASED REPORTS – 2022

CRC Project No.	Title	Publication/NTIS Accession No.
RW-118	Re-locating the FEAT data Repository to the University of Denver Library	PENDING
E-119-3 HEAT	On-Road Remote Sensing of Automobile Emissions in the Phoenix Area: Spring 2021	PENDING
E-119-3 OPUS	On-Road Remote Sensing of Automobile Emissions in the Phoenix Area: Spring 2021	PENDING
E-123	On-Road Remote Sensing of Automobile Emissions in the Chicago Area: Fall 2020	PB2021100674
*E-123	On-Road Remote Sensing of Automobile Emissions In The Tulsa Area: Fall 2019	PENDING
*E-123	On-Road Remote Sensing of Automobile Emissions in The Denver Area: Winter 2020	PENDING
*E-123-4	Revisit Inspection and Maintenance Evaluation using Historical U.S. Remote Sensing Measurements	PENDING
*E-127-1	Analysis and Review of DHA Methods used in CRC Oxygenated Gasoline Emissions Projects E-94-2, E-94-3, and E-129	PENDING
E-129-2	Alternative Oxygenate Effects on Emissions	PENDING
E-130	Vehicle Emissions and Air Quality: The Early Years (1940s–1950s). Atmosphere 2021, 12(10), 1354	*Atmosphere* 2021, 12(10), 1354; https://doi.org/10.3390/atmos12101354

RELEASED REPORTS – 2022

CRC Project No.	Title	Publication/NTIS Accession No.
*E-131	Studying Capabilities and Limitations of Vehicle Telematics Data	PENDING
E-136	Engine, Aftertreatment, and Fuel Quality Achievements to Lower Gasoline Vehicle PM Emissions: Literature Review and Future Prospects	PENDING
*CRC Report No. 674	E15 Fuel Survey: July 2019	PB2021100660

RELEASED REPORTS – 2022

AVIATION AND PERFORMANCE*

CRC Project No.	Title	Publication/NTIS Accession No.
AV-18-18	The Quality of Aviation Fuel Available in the United Kingdom – Annual Survey 2015	PENDING
AV-25-16	Fuel and Water Characterization in Support of the CRC Panel on Engine Component Deposits	PB2021100669
AV-26-17	Development of Industry Reference Fluids for ASTM D3241 Testing	PB2021100676
AV-27-18	Measurement of Aviation Fuel Properties Relevant for the Estimation of V/L Ratio Parameter Calculation	PENDING
AV-29-20	A Review of Current Experimental and Correlation Methods to Determine the Calorific Energy Content of Liquid Fuels	PENDING
CM-136-18-2	Investigation of Sulfate Salt Solubilities in Ethanol and Gasoline-Ethanol Blends	PB2021100658
*CM-138-15-2	Development of an Engine Based Test for Determining the Effect of Spark Ignition Fuel Properties on Combustion and Vehicle Driveability	PB2021100673
*CM-138-18-1	CRC Driveability Workshop	PB2021100670
CM-138-19	Development of a Revised Engine Based Test for Determining the Effect of Spark Ignition Fuel Properties on Combustion and Vehicle Driveability	PENDING

RELEASED REPORTS – 2022

CM-138-20	Development of Automated Driveability Rating System Using Trick Car and User's Guide	PENDING
DP-06-20	Evaluation of Diesel Fuel Haze Resulting from Water Content	PENDING
DP-07-16-01	Identification of Potential Parameters Causing Corrosion of Metallic Components in Diesel Fuel Underground Storage Tanks	PENDING

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.

*These reports were completed and submitted to NTIS for an Accession Number in 2020 as listed in the 2020 CRC Annual Report. Due to COVID-19 related delays, the NTIS Accession numbers are still PENDING.

PART FOUR

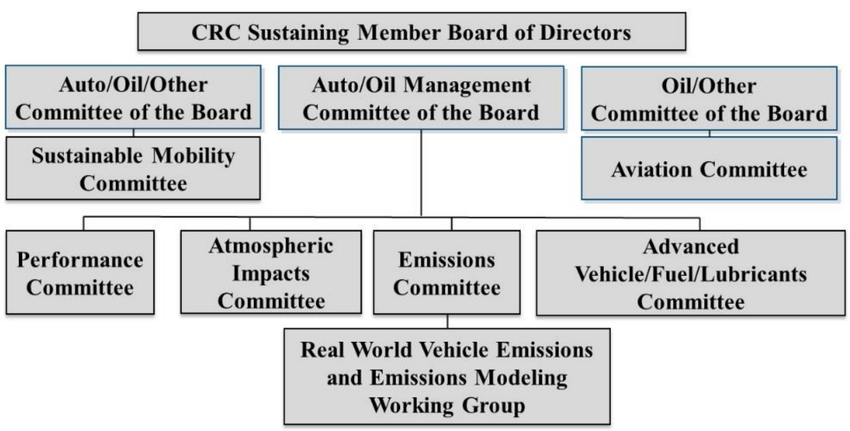
ORGANIZATION AND MEMBERSHIP

ORGANIZATION – 2022

The sustaining members of the CRC are the American Petroleum Institute (API) and a consortium of automobile manufacturers (Stellantis, Mercedes Benz, Ford, General Motors, Honda, Mitsubishi, Nissan, Toyota, and Volkswagen). For over 78 years, CRC has provided the means for the automotive and petroleum industries to study problems of mutual interest. The objective of CRC, 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.



ORGANIZATION

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 final reports are made publicly available and are 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.

ORGANIZATION

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.

MEMBERSHIP

COORDINATING RESEARCH COUNCIL, INC.

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E. Hillawi	Nissan Tech. Ctr. N.A.	R. Sutschek	Volkswagen of America
K. Johnson	Shell Global Solutions	I. Tibavinsky	Mercedes-Benz
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A.B. Leland, Assistant Secretary	CRC

CRC OFFICERS & STAFF

C. J. Tennant	Executive Director
A. B. Leland	Deputy Director
R. A. Kang	Committee Coordinator
B. L. Carter	Project Coordinator
D. J. Jenkins	Accountant
J. R. Tucker	Senior Committee Coordinator

ADVANCED VEHICLE/FUEL/LUBRICANTS COMMITTEE

E. M. Chapman, Co-Chair	General Motors
S. McConnell, Co-Chair	Marathon Petroleum Corp.

R. Adams	Mitsubishi Mtrs. R&D Am.
J. E. Anderson	Ford Motor Co.
A. A. Aradi	Shell Global Solutions
D.M.DiCicco	Ford Motor Co.
M. Foster	BP
D. Ganss	Nissan Tech. Ctr. N.A.
C. Gerhard	BP
G. C. Gunter	Phillips 66
M. Henderson	Honda R&D Am.
E. Hillawi	Nissan Tech. Ctr. N.A.
A. Ickes	Chevron Energy Techn.
A. Iqbal	Stellantis
J. J. Jetter	Honda R&D Am.
D. H. Lax	API
R. P. Lewis	Marathon Petroleum Corp.
G. K. Lilik	ExxonMobil
A. S. Mabutol	Mitsubishi Mtrs R&D Am.
J.Mengwasser	Shell Global Solutions
D. Nagashima	Honda R&D Am.
M. Przybylo	Toyota Motor N.A., Inc.
B. Raney-Pablo	Ford Motor Co.
J. Y. Sigelko	Volkswagen of America
R. Sutschek	Volkwagen of America
I. Tibavinsky	Mercedes-Benz
M. B. Viola	General Motors
N. Yanikov	Honda R&D Am.
X. Yu	Aramco Americas

FUEL FOR ADVANCED COMBUSTION ENGINES (FACE) WORKING GROUP

E. M. Chapman, Co-Chair	General Motors
S. McConnell, Co-Chair	Marathon Petroleum Corp.

A. A. Aradi	Shell Global Solutions
J. E. Anderson	Ford Motor Co.
J. T. Bays	PNNL
D. M. DiCicco	Ford Motor Co.
M. Foster	BP
A. Gangopadhyay	Ford Motor Co.
R. Gieleciak	CanmetENERGY
S. Goldsborough	ANL
G. C. Gunter	Phillips 66
E. Hillawi	Nissan Tech. Ctr. N.A.
A. Ickes	Chevron Energy Techn.
A. Iqbal	Stellantis
N. Killingsworth	LLNL
D. H. Lax	API
R. P. Lewis	Marathon Petroleum Corp.
G. K. Lilik	ExxonMobil
M. E. Moore	Stellantis
C. J. Mueller	SNL
M. Ratcliff	NREL
J. Y. Sigelko	Volkswagen of America
C. S. Sluder	ORNL
D. Splitter	ORNL
M. B. Viola	General Motors
S. Wagnon	LLNL
X. Yu	Aramco Americas

MEMBERSHIP

AVFL LUBRICANTS ADVISORY PANEL

A. K. Gangopadhyay, Co-Leader	Ford Motor Co.
G. C. Gunter, Co-Leader	Phillips 66
T. D. Kowalski, Co-Leader	Toyota

D. H. Blossfeld	General Motors
M. L. Blumenfeld	ExxonMobil
C. Cao	Phillips 66
E. M. Chapman	General Motors
F. Cooney	General Motors
T. Cushing	General Motors
D. M. DiCicco	Ford Motor Co.
J. Evans	Infineum
D. Ganss	Nissan Tech. Ctr. NA
A. Gauer	General Motors
H. Hahn	Chevron
C. Laufer	Infineum USA LP
J. Maynes	ExxonMobil
S. McConnell	Marathon Petroleum Corp.
M. P. Raney	General Motors
D. Schildcrout	Ford Motor Co.
J. Y. Sigelko	Volkswagen of America
R. Sutschek	Volkwagen of America
H. Tang	Stellantis
J. S. Vilardo	Phillips 66
A. Zack	General Motors
K. Zreik	General Motors

AVFL-18a PANEL

S. McConnell, Co-Leader	Marathon Petroleum Corp.
S. Wagnon, Co-Leader	LLNL

J. E.Anderson	Ford Motor Co.
J. T. Bays	PNNL
E. M. Chapman	General Motors
H. Dettman	CanmetENERGY
R. Gieleciak	CanmetENERGY
A. Ickes	Chevron Energy Techn.
M. Kweon	U.S. Army Research Lab
C. J. Mueller	SNL
S. Neill	NRC Canada
M. Ratcliff	NREL
J. E. Temme	U.S. Army Research Lab
M. B. Viola	General Motors

MEMBERSHIP

AVFL-28-3 QUICK RESPONSE PANEL

A. K. Gangopadhyay, Co-Leader	Ford Motor Co.
G. C. Gunter, Co-Leader	Phillips 66

B. Anderson	Afton Chemical	S. McConnell	Marathon Petroleum Corp.
D. H. Blossfeld	General Motors	J. Y. Sigelko	Volkswagen of America

AVFL-29-2 PANEL

G. C. Gunter, Co-Leader	Phillips 66
J. J. Jetter (ret.), Co-Leader	Honda R&D Am.

J. E. Anderson	Ford Motor Co.
E. M. Chapman	General Motors
A. Ickes	Chevron Energy Techn.
D. H. Lax	API
R. P. Lewis	Marathon Petroleum Corp.
G. K. Lilik	ExxonMobil
S. McConnell	Marathon Petroleum Corp.
J. Mengwasser	Shell Global Solutions
M. E. Moore	Stellantis
J. Y. Sigelko	Volkswagen of America
A. K. Voice	Aramco Services

AVFL-32 PANEL

A. Iqbal, Co-Leader	Stellantis
S. McConnell, Co-Leader	Marathon Petroleum Corp.

J. E. Anderson	Ford Motor Co.
E. M. Chapman	General Motors
D.M.DiCicco	Ford Motor Co.
M. Foster	BP
D. Ganss	Nissan Tech. Ctr. NA
G. C. Gunter	Phillips 66
E. Hillawi	Nissan Tech. Ctr. N.A
J. Holland	Phillips 66
M. Hussain	Phillips 66
A. Ickes	Chevron Energy Techn
S. Mabutol	Mitsubishi Mtrs R&D Am.
D. Nagashima	Honda R&D Am.
J. Mengwasser	Shell Global Solutions
J. Y. Sigelko	Volkswagen of America
C. S. Sluder	ORNL
R. Sutschek	Volkwagen of America
M. B. Viola	General Motors
J. Wellhousen	Phillips 66

MEMBERSHIP

AVFL-33 PANEL

E. M. Chapman, Co-Leader	General Motors
G. C. Gunter, Co-Leader	Phillips 66

R. Adams	Mitsubishi Mtrs. R&D Am.	G. K. Lilik	ExxonMobil
		P. Loeper	Chevron
J. E. Anderson	Ford Motor Co.	M. McCarthy	Toyota
S. Bartley	Lubrizol	S. McConnell	Marathon Petroleum Corp.
D. Boese	Infineum	J. Mengwasser	Shell Global Solutions
B. Chinta	General Motors	M. E. Moore	Stellantis
M. Henderson	Honda R&D Am.	G. Parker	Lubrizol
A. Ickes	Chevron Energy Techn.	J. Y. Sigelko	Volkswagen of America
		I. Tibavinsky	Mercedes-Benz
A. Iqbal	Stellantis	M. B. Viola	General Motors
K. R. Kress	Phillips 66	X. Yu	Aramco Americas

AVFL-36/ CM-137-19-1 PANEL

A. Iqbal, Co-Leader	Stellantis
S. McConnell, Co-Leader	Marathon Petroleum Corp.

B. Alexander	BP	T. Leone	Ford Motor Co.
J. E. Anderson	Ford Motor Co.	R. P. Lewis	Marathon Petroleun Corp.
A. Aradi	Shell		
E. M. Chapman	General Motors	G. K. Lilik	ExxonMobil
S. R. Golisz	ExxonMobil	S. McConnell	Marathon Petroleum Corp.
G. C. Gunter	Phillips 66	L. McQuinn	Ford
J. Holland	Phillips 66	P. M.Najt	General Motors
M. Hussain	Phillips 66	M. Przybylo	Toyota Motor N.A., Inc.
A. Ickes	Chevron Energy Techn.	B. Raney-Pablo	Ford Motor Co.
C. Jones	General Motors	J. Y. Sigelko	Volkswagen of America
D. H. Lax	API	X. Yu	Aramco Americas

MEMBERSHIP

AVFL-36/ CM-137-19-1 QUICK RESPONSE PANEL

A. Iqbal, Co-Leader	Stellantis
S. McConnell, Co-Leader	Marathon Petroleum Corp.

E. M. Chapman	General Motors	R. P. Lewis	Marathon Petroleum Corp.
A. Ickes	Chevron Energy Techn.	M. Przybylo	Toyota Motor N.A., Inc.
T. Leone	Ford Motor Co.	X. Yu	Aramco Americas

AVFL-37 PANEL

A. K. Gangopadhyay, Co-Leader	Ford Motor Co.
G. C. Gunter, Co-Leader	Phillips 66

J. E. Anderson	Ford Motor Co.	D. H. Lax	API
A. Aradi	Shell	G. K. Lilik	ExxonMobil
J. Barstad	Infineum	S. McConnell	Marathon Petroleum Corp.
C. Cao	Phillips 66	J. Y. Sigelko	Volkswagen of America
E. Hillawi	Nissan Tech. Ctr. N.A	R. Stockwell	Chevron
T. D. Kowalski	Toyota	M. B. Viola	General Motors

AVFL-38 PANEL

J. E. Anderson, Co-Leader	Ford Motor Co.
S. McConnell, Co-Leader	Marathon Petroleum Corp.

J. T. Bays	PNNL	Z. Li	LANL
R. Gieleciak	CanmetENERGY	G. K. Lilik	ExxonMobil
G. C. Gunter	Phillips 66	M. Przybylo	Toyota Motor N.A., Inc
W.M. Kim	ExxonMobil	J. Moran	PNNL
D. H. Lax	API	L. Morrison	ExxonMobil
S. Lehmann	PNNL	M. B. Viola	General Motors
R. P. Lewis	Marathon Petroleum Corp.		

MEMBERSHIP

AVFL-39 PANEL

A. K. Gangopadhyay, Co-Leader	Ford Motor Co.
G. C. Gunter, Co-Leader	Phillips 66

D. H. Blossfeld	General Motors
E. M. Chapman	General Motors
M. Deegan	Ford Motor Co.
M. Henderson	Honda R&D Am.
A. Ickes	Chevron Energy Techn.
R. I. Johnson	General Motors
C. Lambert	Ford Motor Co.
C. Laufer	Infineum
D. H. Lax	API
S. Li	General Motors
G. K. Lilik	ExxonMobil
P. Loeper	Chevron
J. J. Maynes	ExxonMobil
S. McConnell	Marathon Petroleum Corp.
M. Patel	Chevron
J. Y. Sigelko	Volkswagen of America
P. Szymkowicz	General Motors
C. Thomas	General Motors
M. B. Viola	General Motors
M. Zumbaugh	General Motors

AVFL-40 PANEL

S. McConnell, Co-Leader	Marathon Petroleum Corp.
J. Waldman, Co-Leader	General Motors

E. M. Chapman	General Motors
G. C. Gunter	Phillips 66
J. Holland	Phillips 66
A. Hoth	ANL
A. Ickes	Chevron Energy Techn.
R. Sinur	CFR Engines
M. B. Viola	General Motors

MEMBERSHIP

AVFL-40 PANEL

E. M. Chapman, Co-Leader	General Motors
S. McConnell, Co-Leader	Marathon Petroleum Corp.

K. Baumgard	SNL	G. K. Lilik	ExxonMobil
N. Cho	John Deere	J. D. Martinez	SNL
D. Dou	John Deere	P. Miles	SNL
S. Fenwick	Clean Fuels	C. J. Mueller	SNL
B. Geisick	John Deere	R. Proctor	SNL
C. Gerhard	BP	M. Przybylo	Toyota Motor N.A., Inc
M. Gonzalez	General Motors	B. Raney-Pablo	Ford Motor Co.
G. C. Gunter	Phillips 66	T. Shipp	Cummins
M. Henderson	Honda R&D Am.	J. Y. Sigelko	Volkswagen of America
S. Howell	MarcIV	I. Tibavinsky	Mercedes-Benz
A. Ickes	Chevron	R. T. Wilson	SNL
J. Kodavasal	Cummins	X. Yu	Aramco Americas
R. P. Lewis	Marathon Petroleum Corp.		

MEMBERSHIP

EMISSIONS COMMITTEE

P. Loeper, Co-Chair	Chevron Global Downstream
M. B. Viola, Co-Chair	General Motors

B. Alexander	BP	A. Mabutol	Mitsubishi Mtrs R&D Am.
T. Bera	Shell Global Solutions	M. Moore	Stellantis
E. Barrientos	ExxonMobil	M. Przybylo	Toyota Motor N.A., Inc.
D. M. DiCicco	Ford Motor Co.	J. Y. Sigelko	Volkswagen of America
G. Gunter	Phillips 66	I. Tibavinsky	Mercedes-Benz
M. Henderson	Honda R&D Co.	A. Voice	Aramco
F. Khan	Nissan Tech. Ctr. NA		
R. P. Lewis	Marathon Petroleum Corp.		

E-122-2 PANEL

P. Loeper, Co-Leader	Chevron Global Dnstrm.
M. B. Viola, Co-Leader	General Motors

B. Alexander	BP	A. Mabutol	Mitsubishi Mtrs R&D Am.
T. Bera	Shell Global Solutions	S. McConnell	Marathon Peroleum Corp.
E. Barrientos	ExxonMobil	M. Moore	Stellantis
S. Decarteret	General Motors	M. Olson	Mitsibishi Mtrs R&D Am.
D. M. DiCicco	Ford Motor Co.	M. Przybylo	Toyota Motor N.A., Inc.
O. Garcia	Volkswagen of America	J. Y. Sigelko	Volkswagen of America
G. Gunter	Phillips 66	I. Tibavinsky	Mercedes-Benz
M. Henderson	Honda R&D Co.	A. Voice	Aramco
F. Khan	Nissan Tech. Ctr. NA	Y. Xu	ExxonMobil
R. P. Lewis	Marathon Petroleum Corp.		

MEMBERSHIP

E-129-2 PANEL

E. Barrientos, Co-Leader	ExxonMobil
J.J. Jetter, Co-Leader	Honda R&D Am. (Retired)
R. Lewis, Co-Leader	Marathon Petroleum Corp.

B. Alexander	BP	M. Moore	Stellantis
E. Chapman	General Motors	J. Y. Sigelko	Volkswagen of America
D. Lax	API	M. Valentine	Toyota Motor N.A., Inc.
R. P. Lewis	Marathon Petroleum Corp.	M. B. Viola	General Motors
P. Loeper	Chevron Global Dnstrm.	A. Voice	Aramco

E-130 PANEL

D. Lax, Co-Leader	API
C. Tennant, Co-Leader	Coordinating Research Council

M. Henderson	Honda R&D Am.	M. B. Viola	General Motors
M. McCarthy	Toyota		
S. McConnell	Marathon Petroleum Corp.		

MEMBERSHIP

E-135 PANEL

E. Barrientos, Co-Leader — ExxonMobil
M. B. Viola, Co-Leader — General Motors

B. Alexander	BP	M. Henderson	Honda R&D Am.
D. Lax	API	M. Moore	Stellantis
P. Loeper	Chevron	A. Voice	Aramco
O. Garcia	Volkswagen of America		

E-136 PANEL

N. Kempema, Co-Leader — Ford Motor Co.
R. Lewis, Co-Leader — Marathon Peroleum Corp.

B. Alexander	BP	S. McConnell	Marathon Petroleum Corp.
E. Barrientos	Exxonmobil	M. Moore	Stellantis
E. Chapman	General Motors	L. Rubino	Stellantis
M. Henderson	Honda R&D Am.	P. Szymkowicz	General Motors
R. Johnson	General Motors	C. Thomas	General Motors
C. Lambert	Ford Motor Co	A. Voice	Aramco
D. Lax	API	M. Zumbaugh	General Motors
S. Li	General Motors		
P. Loeper	Chevron		

E-140 PANEL

S. Decarteret, Co-Leader — General Motors
M. B. Viola , Temporary Co-Leader — General Motors

J. Baustian	BP	D. McBryde	US EPA
G. Gunter	Phillips 66	M. Moore	Stellantis
M. Henderson	Honda R&D Am.	J. Sigelko	Volkswagen of America
D. Lax	API	I. Tibavinsky	Mercedes-Benz
P. Loeper	Chevron	M. Yassine	Stellantis
Y. Ma	CARB		

MEMBERSHIP

REAL WORLD VEHICLE EMISSIONS & EMISSIONS MODELING GROUP

M. B. Viola, Co-Chair	General Motors
J. Baustian, Co-Chair	BP

B. Alexander	BP
N. J. Barsic	John Deere
E. Barrientos	ExxonMobil
M. Beardsley	US EPA
T. Bera	Shell Global Solutions
K. Borgert	US EPA
E. Chapman	General Motors
A. Cullen	US EPA
D. DiCicco	Ford Motor Co.
T. A. French	EMA
C. R. Fulper	US EPA
D. Ganss	Nissan Tech. Ctr. NA
R. Giannelli	US EPA
G. Gunter	Phillips 66
M. Henderson	Honda R&D Am.
J. Jetter	Honda R&D Am.
N. Kempema	Ford Motor Co.
F. Khan	Nissan Tech. Ctr. NA
Y. Khan	Cummins
A. Klinkenberger	Daimler
A. Kotz	NREL
C. Laroo	US EPA
D. H. Lax	API
R. P. Lewis	Marathon Petrol. Corp.
P. Loeper	Chevron Global Dnstrm.
A. S. Mabutol	Mitsubishi Mtrs R&D Am.
M. McCarthy	Toyota Motor NA, Inc
S. McConnell	Maraton Petroleum Corp.
M. E. Moore	Stellantis
D. Nagashima	Honda R&D Co.
R. Nine	DOE/NETL
M. Olechiw	US EPA
R. Purushothaman	Caterpillar
M. Przybylo	Toyota Motor NA, Inc
C. Ruehl	CARB
J. Y. Sigelko	Volkswagen of America
M. R. Smith	Navistar
R. Sutschek	Volkswagen of America
I. Tibavinsky	Mercedes-Benz
A. Voice	Aramco
H. Vreeland	US EPA
S. Wright	Volkswagen of America
M. K. Yassine	Stellantis
S. Yoon	CARB
J. Zhang	CARB

MEMBERSHIP

32ND REAL WORLD EMISSIONS WORKSHOP ORGANIZING COMMITTEE

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

S. Cao	SCAQMD	J. Martin	US EPA
D. Choi	US EPA	R. Purushothaman	Caterpillar
T. Huai	CARB	A. Voice	Aramco
A. Katzenstein	SCAQMD	H. Vreeland	US EPA
Y. Khan	Cummins	S. Yoon	CARB
A. Kotz	NREL		

RW-105 PANEL

M. B. Viola, Co-Chair	General Motors
R. Sager, Co-Chair	Stellantis

B. Alexander	BP	D. H. Lax	API
J. Andrzewski	General Motors	P. Loeper	Chevron Global Dnstrm.
N. J. Barsic	John Deere	M. E. Moore	Stellantis
S. Bohr	Ford Motor Co.	J. Y. Sigelko	Volkswagen of America
A. Cullen	US EPA	M. B. Viola	General Motors
C. R. Fulper	US EPA	S. Yoon	CARB
M. Grote	Stellantis		

RW-107-3 PANEL

J. Jetter, Co-Chair	Honda R&D Am. (Retired)
M. E. Moore , Co-Chair	Stellantis
R. P. Lewis, Co-Chair	Marathon Petroleum Corp.

B. Alexander	BP
N. J. Barsic	John Deere
E. Barrientos	ExxonMobil
J. Baustian	BP
M. Beardsley	US EPA
T. Bera	Shell Global Solutions
K. Borgert	US EPA
E. Chapman	General Motors
A. Cullen	US EPA
D. DiCicco	Ford Motor Co.
T. A. French	EMA
C. R. Fulper	US EPA
D. Ganss	Nissan Tech. Ctr. NA
R. Giannelli	US EPA
G. Gunter	Phillips 66
M. Henderson	Honda R&D Am.
N. Kempema	Ford Motor Co.
F. Khan	Nissan Tech. Ctr. NA
Y. Khan	Cummins
A. Klinkenberger	Daimler
A. Kotz	NREL
C. Laroo	US EPA
D. H. Lax	API
P. Loeper	Chevron Global Dnstrm.
A. S. Mabutol	Mitsubishi Mtrs R&D Am.
M. McCarthy	Toyota Motor NA, Inc
S. McConnell	Maraton Petroleum Corp.
D. Nagashima	Honda R&D Co.
R. Nine	DOE/NETL
M. Olechiw	US EPA
R. Purushothaman	Caterpillar
M. Przybylo	Toyota Motor NA, Inc
C. Ruehl	CARB
J. Y. Sigelko	Volkswagen of America
M. R. Smith	Navistar
R. Sutschek	Volkswagen of America
I. Tibavinsky	Mercedes-Benz
M. B. Viola	General Motors
A. Voice	Aramco
H. Vreeland	US EPA
S. Wright	Volkswagen of America
M. K. Yassine	Stellantis
S. Yoon	CARB
J. Zhang	CARB

MEMBERSHIP

RW-120 PANEL

E. Barrientos, Co-Chair	ExxonMobil
S. Berry , Co-Chair	EMA
S. McConnell, Co-Chair	Marathon Petroleum Corp.

B. Alexander	BP	D. H. Lax	API
N. J. Barsic	John Deere	P. Loeper	Chevron Global Dnstrm.
J. Baustian	BP	S. Lopes	General Motors
E. Chapman	General Motors	S. McConnell	Maraton Petroleum Corp.
D. DiCicco	Ford Motor Co.	M. E. Moore	Stellantis
T. A. French	EMA	T. Sutton	EMA
C. R. Fulper	US EPA	M. B. Viola	General Motors
Y. Khan	Cummins	S. Yoon	CARB
R. P. Lewis	Marathon Petroleum Corp.		

MEMBERSHIP

ATMOSPHERIC IMPACTS COMMITTEE

C. Rabideau, Co-Chair	Chevron
S. Winkler, Co-Chair	Ford Motor Co.

P. Gangopadhyay	Toyota	M. E. Moore	Stellantis
B. Ghosh	Phillips 66	G. F. Myers	Marathon Petroleum Corp.
H. Hamje	ExxonMobil	D. Nagashima	Honda R&D Am.
E. Hillawi	Nissan Tech. Ctr. N.A.	J. Y. Sigelko	Volkswagen of America
A. S. Mabutol	Mitsubishi Mtrs. R&D Am.	R. Sutschek	Volkswagen of America
		T. J. Wallington	Ford Motor Co.

ATMOSPHERIC IMPACTS WORKING GROUP

C. Rabideau, Co-Chair	Chevron
S. Winkler, Co-Chair	Ford Motor Co.

Z. Adelman	LADCO	M. Koerber	US EPA
M. Beardsley	US EPA	T. Kuwayama	CARB
D. Choi	US EPA	D. H. Lax	API
D. M. DiCicco	Ford Motor Co.	S. M. Lee	SCAQMD
T. A. French	EMA	R. Mathur	US EPA
J. Geidosch	US EPA	K. Sargeant	US EPA
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.

MEMBERSHIP

A-114/RW-111 PANEL

M. E. Moore, Co-Leader — Stellantis

J. Geidosch	US EPA	G. F. Myers	Marathon Petroleum Corp.
M. Hays	US EPA	R. Purushothaman	Caterpillar
T. Kuwayama	CARB	J. Y. Sigelko	Volkswagen of America
P. Loeper	Chevron	M. R. Smith	Navistar
B. Murphy	US EPA	D. Vu	Marthon Petroleum Corp

A-121 PANEL

T. Kuwayama, Co-Leader — CARB
T. J. Wallington, Co-Leader — Ford Motor Co.

T. A. French	EMA	S. M. Lee	SCAQMD
M. Janssen	LADCO	C. Rabideau	Chevron
C. Jones	General Motors	J. Y. Sigelko	Volkswagen of America

A-124 PANEL

G. F. Myers, Co-Chair — Marathon Petroleum Corp.
S.Winkler, Co-Chair — Ford Motor Co.

Z. Adelman	LADCO	J. Esker	Utah Mining Association
R. Agnew	Chevron	D. Greco	Michigan Manufacturers Assoc.
J. W. Beasley	Marathon Petroleum Corp.	B. Koo	BAAQMD
M. D.Bujdoso	Marathon Petroleum Corp.	S. M. Lee	SCAQMD
R. H. Browning	Utah Petroleum Org.		

MEMBERSHIP

A-125 PANEL

C. Rabideau, Co-Chair	Chevron
T.J. Wallington, Co-Chair	Ford Motor Co.

T. A. French	EMA	E. Praske	SCAQMD
S. Gao	Phillips 66	J. Y. Sigelko	Volkswagen of America
M. Janssen	LADCO	S. Winkler	Ford Motor Co.
T. Kuwayama	CARB	R. Zhang	SCAQMD
D. H. Lax	API		
J. I. Moutinho	ExxonMobil		

A-126 PANEL

T. A. French, Co-Chair	EMA
G.F. Myers, Co-Chair	Marathon Petroleum Co.
S. Winkler, Co-Chair	Ford Motor Co.

S. Gao	Phillips 66	C. Rabideau	Chevron
T. Kuwayama	CARB	J. Y. Sigelko	Volkswagen of America
S. M. Lee	SCAQMD	T.J. Wallington	Ford Motor Co.
J. I. Moutinho	ExxonMobil		

A-127 PANEL AIR QUALITY RESEARCH NEEDS II WORKSHOP

C. Rabideau, Co-Chair	Chevron
S. Winkler, Co-Chair	Ford Motor Co.

T. Fox	US EPA	R. Mathur	US EPA
T.A. French	EMA	C. Rabideau	Chevron
N. Kumar	DRI	J. Y. Sigelko	Volkswagen of America
T. Kuwayama	CARB	R. Wayland	US EPA
S. M. Lee	SCAQMD		

MEMBERSHIP

2022 CRC MOBILE SOURCE AIR TOXICS WORKSHOP ORGANIZING COMMITTEE

S. Winkler, Co-Chair	Ford Motor Co.
S. Yoon, Co-Chair	CARB.

C. Bailey	US EPA	M. M. Maricq	Consultant
T. A. French	EMA	C. Rabideau	Chevron
S. M. Lee	SCAQMD	J. Y. Sigelko	Volkswagen of America

A-128 PANEL

G.F. Myers, Co-Chair	Marathon Petroleum Co.
T.J. Wallington, Co-Chair	Ford Motor Co.

T. A. French	EMA	C. Rabideau	Chevron
M. Janssen	LADCO	J. Y. Sigelko	Volkswagen of America
T. Kuwayama	CARB	S. Winkler	Ford Motor Co.

A-129 PANEL

C. Rabideau, Co-Chair	Chevron
S. Winkler, Co-Chair	Ford Motor Co.

P. Gangopadhyay	Toyota	M. E. Moore	Stellantis
H. D. Hamje	ExxonMobil	T. J. Wallington	Ford Motor Co.

PERFORMANCE COMMITTEE

A. Iqbal, Co-Chair	Stellantis
R.P. Lewis, Co-Chair	Marathon Petroleum Corp.

B. Alexander	BP
E. Chapman	General Motors
D. Ganss	Nissan Tech. Ctr. NA
L. Gremillion	Motiva
G. C. Gunter	Phillips 66
E. Hillawi	Nissan Tech Ctr. NA
K. Johnson	Shell
S. Kirby	General Motors
D. H. Lax	API
S. Lopes	General Motors
A. Mabutol	Mitsubishi Mtrs. R&D
M. E. Moore	Stellantis
D. Nagashima	Honda R&D Am.
M. Przybylo	Toyota
B. Raney-Pablo	Ford Motor Co.
M. Sheehan	Chevron
J. Y. Sigelko	Volkswagen of America
W. Studzinski	General Motors
I. Tibavinsky	Mercedes-Benz
Y. Xu	ExxonMobil
X.Yu	Aramco

GASOLINE DEPOSIT GROUP
(Project No. CM-136)

M. Sheehan, Co-Leader	Chevron
I. Tibavinsky, Co-Leader	Mercedes-Benz

B. Alexander	BP
S. Bartley	Lubrizol
S. Broughton	Marathon Petroleum Corp.
K. Brunner	SwRI
R. Chapman	Innospec
J. Draper	Motiva
I. Gabrel	Stellantis
L. M. Gibbs	Consultant
G. C. Gunter	Phillips 66
C. Huang	ITW
K. Johnson	Shell
A. M. Kulinowski	Afton Chemical
D. H. Lax	API
R. P. Lewis	Marathon Petroleum Corp.
M. Lynch	ExxonMobil
I. Mathur	Haltermann
A. McKnight	Innospec
M. Miller	Sunoco Inc.
K. Mitchell	Shell Canada Ltd.
F. Parsinejad	Chevron Oronite Co.
M. Przybylo	Toyota
C. M. Pyburn	Pytertech Intl.
B. Raney-Pablo	Ford Motor Co.
S. Rubin-Pitel	ExxonMobil
D. Schoppe	Intertek
J. Y. Sigelko	Volkswagen of America
J. Simnick	Consultant
R. Smocha	Chevron
W. Studzinski	General Motors
W. Y. Su	Huntsman Corp.
Y. Xu	ExxonMobil
H. Zhao	Huntsman Adv Tech.

MEMBERSHIP

GASOLINE DEPOSIT PFI IVD TEST DEVELOPMENT TEAM
(Project No. CM-136-18-1)

M. Sheehan, Co-Leader	Chevron
B. Alexander	BP

W. Chong	Chevron	A. Moravec	General Motors
J. Ciaravino	GM	B. Raney-Pablo	Ford Motor Co.
G. C. Gunter	Phillips 66	R. Smocha	Chevron
K. Johnson	Shell	I. Tibanvinsky	Mercedes-Benz
R. P. Lewis	Marathon Petroleum Corp.	Y. Xu	ExxonMobil
J. Martinez	Chevron		

FUEL DEGRADATION IN STORAGE (ASTM D525 vs D7525)
(Project No. CM-136-20 PANEL)

J. C. Eckstrom, Co-Leader	BP
E. English, Co-Leader	FQS, Inc.
R. Lewis	Marathon Petroleum

B. Alexander	BP	B. Raney-Pablo	Ford Motor Co.
G. C. Gunter	Phillips 66	S. Rubin-Pitel	ExxonMobil
A. Iqbal	Stellantis	M. Sheehan	Chevron
S. Kirby	General Motors	J. Simnick	Consultant
D. Lax	API	I. Tibavinsky	Mercedes-Benz
M. Moore	FCA	Y. Xu	ExxonMobil
B. Morlan	Chevron		

GASOLINE COMBUSTION GROUP
(Project No. CM-137)

B. Raney Pablo, Co-Leader	Ford Motor Co.
B. Alexander, Co-Leader	BP

S. Bartley	Lubrizol	A. McKnight	Innospec
T.Briggs	SwRI	J. Mengwasser	Shell
S. Broughton	Marathon Petroleum Corp.	M. Miller	Sunoco Inc.
K. Brunner	SwRI	K. Mitchell	Consultant
E. Chapman	General Motors	P. J. Morgan	SwRI
R. Chapman	Innospec Fuel Spec.	M. Przybylo	Toyota
D. M. DiCicco	Ford Motor Co.	C. M. Pyburn	Pybertech International
I. Gabrel	HCS Group	S. Rubin-Pitel	ExxonMobil
R. George	BP	D. Schoppe	Intertek
L. Gremillion	Motiva	M. Sheehan	Chevron
G. C. Gunter	Phillips 66	J. Y. Sigelko	Volkswagen of America
A. Iqbal	Stellantis	J. Simnick	Consultant
F. Khan	Nissan Tech. Ctr. NA	W. Studzinski	General Motors
D. H. Lax	API	A. Swarts	SwRI
R. P. Lewis	Marathon Petroleum Corp.	Y. Xu	ExxonMobil
M. Lynch	ExxonMobil	X. Yu	Aramco

ALTERNATIVE TO HIGH OCTANE TEL
Project No. CM-137-21 PANEL

B. Raney-Pablo, Co-Leader	Ford Motor Co.
S. Rubin-Pitel, Co-Leader	ExxonMobil

D. Atwood	FAA	R. Gill	Energy Institute
G. Bell-Eunice	Phillips 66	G. C. Gunter	Phillips 66
J. Bizub	Consultant	J. Holland	Phillips 66
L. Campbell	Marathon Petroleum Corp.	D. Kadlecek	ExxonMobil
		R. Legg	SwRI
E. Chapman	General Motors	R. Lewis	Marathon Petroleum
A. Clark	BP	E. Lodrigueza	Phillips 66
R. Durrett	General Motors	B. Logan	Phillips 66
D. Faedo	Milan Monza	R. Terschek	ROFA Germany
R. Gaughan	Consultant	M. Rumizen	FAA

MEMBERSHIP

VOLATILITY GROUP
(Project No. CM-138)

S. Kirby, Co-Leader	General Motors
L. Gremillion, Co-Leader	Motiva
G. Gunter	Phillips 66

S. Bartley	Lubrizol	R. Lewis	Marathon Petroleum
S. Broughton	Marathon Petroleum Corp.	M. Lynch	ExxonMobil
K. Brunner	SwRI	K. Mitchell	Consultant
E. Chapman	General Motors	M. Przybylo	Toyota
K. Davis	RFA	B. Raney-Pablo	Ford Motor Co
J. Draper	Motiva	S. Rubin-Patel	ExxonMobil
I. Gabrel	Stellantis	D. Schoppe	Intertek
L.M. Gibbs	Consultant	M. Sheehan	Chevron
A. Iqbal	Stellantis	J. Y. Sigelko	Volkswagen of America
C. Jones	General Motors	J. Simnick	Consultant
F. Khan	Nissan Tech. Ctr. NA	W. Studzinski	General Motors
D. H. Lax	API		

PROJECT NO. CM-138-20 PANEL

G. C. Gunter, Co-Leader	Phillips 66
J. Y. Sigelko, Co-Leader	Volkswagen of America

B. Alexander	BP	B. Raney-Pablo	Ford Motor Co.
S. Broughton	Marathon Petroleum	S. Rubin-Patel	ExxonMobil
A. Iqbal	Stellantis	M. Sheehan	Chevron
K. Johnson	Shell		
R. P. Lewis	Marathon Petroleum		

DIESEL PERFORMANCE GROUP
(Project No. DP)

G. C. Gunter, Co-Leader	Phillips 66
S. Lopes, Co-Leader	General Motors

H. Ahari	Stellantis	R. P. Lewis	Marathon Petroleum Corp.
B. Alexander	BP	R. Long	PEI
T. Bera	Shell	R. L. McCormick	NREL
S. Broughton	Marathon Petroleum Corp.	A. McKnight	Innospec
A. Cayabyab	CARB	K. Mitchell	Consultant
R. Chapman	Consultant	A. G. Morin	Eurenco
J. Draper	Motiva	J. Morris	Navistar
E. English	Fuel Quality Services	N. Mukkada	Chevron
I. Gabrel	Stellantis	J. Porco	Gage Products
R. George	BP	M. Przybylo	Toyota
B. Goodrich	John Deere	B. Raney-Pablo	Ford Motor Co.
C. Hamer	PCS Instruments	K. Salem	Lubrizol
D. Hess	Infineum	D. Schoppe	Intertek
C. Huang	ITW Global	P. Searles	API
R. Jennings	Consultant	M. Sheehan	Chevron
I. Johnson	Daimler Truck	J. Y. Sigelko	Volkswagen of America
K. Johnson	Shell	J. Simnick	Consultant
F. Khan	Nissan Tech. Ctr. N.A.	W. Studzinski	General Motors
D. Kozub	Daimler	L. Super	Daimler Truck
A. Kulinowski	Afton Chemical	T. Sutton	EMA
E. Kurtz	Ford Motor Co.	A. Swarts	SwRI
D. H. Lax	API	V. Tran	Infineum
R. Leisenring	Consultant	J. VanScoyoc	Chevron Phillips Chem Co.

MEMBERSHIP

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

S. Broughton, Leader   Marathon Petroleum Corp.

J. Chandler	Consultant	S. Lopes	General Motors
G.C. Gunter	Phillips 66	K. Mitchell	Consultant
D. Hess	Infineum	N. Mukkada	Chevron
C. Hodge	Consultant	S.B. Rubin-Pitel	ExxonMobil
A.M. Kulinowski	Afton Chemical	P. Searles	AP
R. P. Lewis	Marathon Petroleum	W. Studzinski	General Motors
	Corp.	V. Tran	Infineum

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

G. C. Gunter, Leader   Phillips 66

D. Abdallah	ExxonMobil	B. E. Goodrich	John Deere
H. Abi-Akar	Caterpillar		
M. Ahmadi	Oronite Additive	A. Kulinowski	Afton Chemical
A. Aradi	Shell	D. H. Lax	API
T. Bera	Shell	S. Lopes	General Motors
S. Broughton	Marathon Petroleum	K. Mitchell	Consultant
	Corp.	N. Mukkada	Chevron
C. Burbrink	Cummins	K. Salem	Lubrizol
R. Chapman	Consultant	M. Sheehan	Chevron
J. Draper	Motiva	T. Sutton	EMA
S. Fenwick	Clean Fuels Alliance	Y. Xu	ExxonMobil
R. George	BP		

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

G. C. Gunter, Leader Phillips 66 S. Lopes General Motors, Leader

S. Broughton	Marathon Petroleum Corp.	R. P. Lewis	Marathon Petroleum Corp.
		R. Morgan	Choice Analytical
C. Burbrink	Cummins	N. Mukkada	Chevron
J. Eichberger	Fuels Institute	F. Passman	BCA Inc.
E. W. English	Fuel Quality Services	S. Pollock	Steel Tank Institute
S. Fenwick	Clean Fuels Alliance Am	S. Rubin-Pitel	ExxonMobil
R. Haerer	US EPA	K. Salem	Lubrizol
J. Hove	Fuels Institute	P. Searles	API
R. Leisenring	Consultant	T. Sutton	EMA

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

D. H. Lax, Leader API

R. Bennick	BP	J. Hove	Fuels Institute
T. Bera	Shell	M. Kass	ORNL
P. Beu	Wawa	R.P. Lewis	Marathon Petroleum Corp.
S. Broughton	Marathon Petroleum Corp.	R. Long	PEI
J. Eckstrom	BP	J. Martinez	Chevron
J. Eichberger	Fuels Institute	R. McNutt	Sigma
E. W. English	Fuel Quality Services	K. Moriarty	NREL
S. Fenwick	Clean Fuels Alliance Am	N. Mukkada	Chevron
G. C. Gunter	Phillips 66	F. Passman	Biodeterioration Cntrl Assoc.
R. Haerer	US EPA	S. Pollock	Steel Tank Institute
S. Hernandez	Chevron	B. Raney-Pablo	Ford Motor Co.
		B. Renkes	Fiberglass Tank & Pipe
		S. M. Ryzyi	Ford Motor Co.
		P. Searles	API
		K. Spiker	Quiktrip
		T. Sutton	EMA

MEMBERSHIP

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

R. L. McCormick, Leader — NREL

T. Bera	Shell	R. Lewis	Marathon Petroleum Corp.
J. Chandler	Consultant	K. Mitchell	Consultant
R. Chapman	Innospec	H. Nanjundaswamy	FEV
E. W. English	FQS	S.B. Rubin-Pitel	ExxonMobil
S. Fenwick	Clean Fuels Alliance Am	K. Salem	Lubrizol
R. George	BP	M. Sheehan	Chevron
B. Goodrich	John Deere	J. Y. Sigelko	Volkswagen of America
G.C. Gunter	Phillips 66	W. Studzinski	General Motors
P. Henderson	Consultant	T. Sutton	EMA
D. Hess	Infineum		
C. Hodge	Consultant		
D. Lax	API		

MEMBERSHIP

AVIATION FUELS COMMITTEE
STEERING COMMITTEE

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A. Carico, Vice-Chair	Airlines for America

D. Atwood	FAA
D. Baniszewski	DLA Energy
J. Bauldreay	Bauldreay Jet Fuel Consulting Ltd
J.P. Belieres	Boeing
J. Burgazli	Innospec
A. Clark	BP
E. Corporan	US Air Force
B. Culbertson	Honeywell
D. Cyr	Chevron
C. Doucet	Total
A. Dye	FACET Filtration
J. Gammon	Gammon Technical
T. Gleaves	MOD UK
J. Godoy	API
J. Green	Citgo
A. Hobday	Rolls-Royce
M. Hunnybun	Energy Institute
R. Juan	Marathon Petroleum
R. Kamin	US Navy
J. Kinder	Boeing
J. Klettlinger	NASA
E. Lodrigueza	Phillips 66
T. Loegel	US Navy
R. Midgley	Shell
M. Rumizen	FAA
J. Sheridan	Marathon Petroleum
J. Silvas	Citgo
J. Stolis	Flint Hills Resources
M. Thom	Baere Aerospace
M. Vaughn	IATA
P. Wilkins	DLA Energy
P. Wrzesinski	US Air Force
S. Zabarnick	UDRI

MEMBERSHIP

SUSTAINABLE MOBILITY COMMITTEE (SMC)

E. Chapman, Co-Leader	General Motors
H. Hamje, Co-Leader	ExxonMobil

J. Anderson	Ford Motor Co.	M. Leuck	Neste
R. Bennick	BP	S. Lopes	General Motors
J. Bouchard	Aramco Americas	M. McCarthy	Toyota
M. Bradley	Volkswagen of America	S. McConnell	Marathon Petroleum Corp.
R. Brezny	MECA	M. Moore	Stellantis
C. Brooks	Honda R&D Am.	S. Pansare	Phillips 66
J. Burgazli	Innospec	M. Przybylo	Toyota
R. DeKleine	Ford Motor Co.	V.R. Raj Mohan	Shell
D. DiCicco	Ford Motor Co.	R. Sallinen	Neste
M. Geller	MECA	M. Sheehan	Chevron
E. Hillawi	Nissan	J. Y. Sigelko	Volkswagen of America
A. Iqbal	Stellantis	G. Stobbs	Marathon Petroleum Corp.
C. Jones	General Motors		
M. Kevnick	Volkswagen of America	I. Tibavinsky	Mercedes-Benz
S. Kirby	General Motors	M. Traver	Aramco Americas
J. Kliesch	Honda R&D Am.	A. Triana-Padilla	WABTEC
D. Lax	API	C. Trobaugh	Cummins

MEMBERSHIP

SUSTAINABLE MOBILITY COMMITTEE (SMC-CR)
NOVEL CARBON REDUCTION WORKING GROUP

S. M. McConnell, Co-Leader	Marathon Petroleum
M. Traver, Co-Leader	Aramco Americas

R. Brezny	MECA	S. Pansare	Phillips 66
C. Brooks	Honda R&D Am.	M. Przybylo	Toyota
J. Burgazli	Innospec	V.R. Raj Mohan	Shell
D. DiCicco	Ford Motor Co.	M. Salata	BP
M. Geller	MECA	M. Sheehan	Chevron
H. Hamje	ExxonMobil	J. Y. Sigelko	Volkswagen of America
E. Hillawi	Nissan	G. Stobbs	Marathon Petroleum Corp.
C. Jones	General Motors	I. Tibavinsky	Mercedes-Benz
R. LagoSari	Aramco Americas	M. Traver	Aramco Americas
D. Lax	API		
M. Moore	Stellantis		

SUSTAINABLE MOBILITY COMMITTEE (SMC-E)
ELECTRIFICAITON WORKING GROUP

C. Brooks, Co-Leader	Honda R&D Am.
E. Chapman, Co-Leader	General Motors
I. Tibavinsky, Co-Leader	Mercedes-Benz

J. Burgazli	Innospec	S. Kirby	General Motors
D. Cun	Honda R&D Am.	D. Lax	API
T. Garrick	General Motors	S. Lopes	General Motors
C. Gerhard	BP	S. McConnell	Marathon Petroleum Corp.
H. Hamje	ExxonMobil	S. Panainete	Mercedes-Benz
X. He	Aramco	S. Pansare	Phillips 66
E. Hillawi	Nissan	M. Przybylo	Toyota
A. Iqbal	Stellantis	V.R. Raj Mohan	Shell
C. Jones	General Motors	M. Sheehan	Chevron
K. Kar	ExxonMobil	J. Y. Sigelko	Volkswagen of America
M. Kevnick	Volkswagen of America		

MEMBERSHIP

SUSTAINABLE MOBILITY COMMITTEE (SMC-F) FUELS WORKING GROUP

S. Kirby, Co-Leader	General Motors
S. McConnell, Co-Leader	Marathon Petroleum Corp.

J. Anderson	Ford Motor Co.	S. Pansare	Phillips 66
R. Bennick	BP	Y. Pei	Aramco Americas
R. Brezny	MECA	M. Przybylo	Toyota
J. Burgazli	Innospec	V.R. Raj Mohan	Shell
D. DiCicco	Ford Motor Co.	B. Raney-Pablo	Ford Motor Co.
M. Geller	MECA	M. Sheehan	Chevron
H. Hamje	ExxonMobil	J. Y. Sigelko	Volkswagen of America
E. Hillawi	Nissan		
C. Jones	General Motors	G. Stobbs	Marathon Petroleum Corp.
R. SariLago	Aramco Americas		
D. Lax	API	I. Tibavinsky	Mercedes-Benz
M. Moore	Stellantis	M. Traver	Aramco Americas

MEMBERSHIP

SUSTAINABLE MOBILITY COMMITTEE (SMC-LCA)
LIFE CYCLE ANALYSIS WORKING GROUP

H. Hamje, Co-Leader	ExxonMobil
R. De Kleine	Ford Motor Co.

J. Bouchard	Aramco Americas	R. Lewis	Marathon Petroleum
B. Fayyaz-Najafi	Chevron	S. Lopes	General Motors
M. Fulton	Fedex	A. Mabutol	Mitsubishi Motors
H.. Hamje	ExxonMobil	S. McConnell	Marathon Petroleum Corp.
X. He	Aramco Americas	M. Moore	Stellantis
X. He	Phillips 66	S. Pansare	Phillips 66
E. Hillawi	Nissan	L. Rafelski	US EPA
A. Iqbal	Stellantis	J. Y. Sigelko	Volkswagen of America
K. Johnson	Shell	G. Stobbs	Marathon Petroleum Corp.
C. Jones	General Motors		
C. Kim	Ford Motor Co.	I. Tibavinsky	Mercedes-Benz
J. Kliesch	Honda R&D Am.	S. Torkamani	ExxonMobil
D. Lax	API	M. B. Viola	General Motors
A. Levy	US EPA	D. Vu	Marathon Petroleum