CRC

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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 - 2021

Around 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 has evolved to meet the needs of this community, and currently includes four Automotive-focused Committees, an Aviation Committee, and a multitude of active Working Groups and Technical/Advisory Panels. In 2021, an expansion of the research program initiated the Sustainable Mobility Committee. This new Committee includes involvement from both the automotive and energy industries and is also open to membership from other companies, government agencies, and technical organizations in support of its vision.

CRC technical work during the 2020-2021 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.

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 (LCA) workshops, starting in 2009 at Argonne National Laboratory (ANL) near Chicago. Each were 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 workshop goals are to:

- Outline the technical needs arising out of policy actions and the 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 research priorities to narrow knowledge gaps.

The 2019 workshop sponsors included American Petroleum Institute (API), ANL, CARB, Canadian Fuels Association, Concawe, National Biodiesel Board, Renewable Fuels Association, USDA, Union of Concerned Scientists, EPA, Neste, and DOE.

Current Status and Future Program

Planned sessions for the 2021 workshop include Transportation Fuel Policy, Application of Models to Policy, Biofuels, Optimizing Biomass, Carbon Capture and Utilization, Electrification, Land Use Change, and Sustainable Farming. Liquid Petroleum Fuels, Recent Modeling of Crop-Based Biofuels, Examining Counterfactual Scenarios, Advanced Liquid Fuel Pathways, and Electrical Pathways. The 7th LCA workshop will meet virtually October 19-22, 2021.

EMISSIONS COMMITTEE

REAL WORLD VEHICLE EMISSIONS WORKSHOP

CRC Project No. E-110

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

Scope and Objective

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

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 topics 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

For the first time in its history, the 2020 Real World Workshop was cancelled as a result of the COVID-19 pandemic. The 2021 Workshop convened as the 30^{th} event and was held online from March 8-12, 2021 with 268 registered participants. A summary article has been submitted to *em Magazine*.

EMISSIONS COMMITTEE

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 U.S. 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 (O_3), and sulfur dioxide (SO_2). 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 (NH_3) and nitrogen dioxide. On-road vehicles continue to serve as one of the sources for atmospheric criteria pollutant emissions, contributing CO, volatile organic compounds (VOCs), NH_3 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.

Other than what has been used for many years, alternate remote sensing device (RSD) measurement systems may provide an opportunity for future data collection campaigns. The objective of Project E-119-3 is to evaluate other RSD systems' ability to measure on-road emissions (CO, CO_2, and HC, NO and NO_2, SO_2 and NH_3 and PM) over a five-day period, making real time comparisons to the Fuel Efficiency Automobile Test (FEAT) device, responsible for the historical CRC record of on-road emissions data for over three decades. Measurements will also capture evaporative emission 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 and data analysis is on-going.

EMISSIONS COMMITTEE

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

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

Leaders: M.B. Viola
P. Loeper

Scope and Objective

With Europe adopting the use of 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 different fuels with varying fuel 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 will continue at their facilities in San Antonio, Texas, and is expected to be completed in 2021.

EMISSIONS COMMITTEE

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

CRC Project No. E-123

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

Scope and Objective

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

Current Status and Future Program

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

As a continuation of earlier research, this project was awarded to Denver University (DU). The Final Reports for Tulsa (Fall 2017, Fall 2019); Denver (Winter 2017; Winter 2020), and Chicago (Fall 2018; Fall 2020) are available on the CRC website.

ALTERNATIVE OXYGENATES EFFECTS ON EMISSIONS PHASE II

CRC Project No. E-129-2

Leaders: E. Barrientos
J. Jetter
M.E. Moore

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 Project E-129 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, 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) has been 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 are being evaluated. The report is expected to be completed by the end of 2021.

EMISSIONS COMMITTEE

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. 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, which continues through 2021.

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 (E10) 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 Project E-133 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 vehicle(s) for testing, the same vehicles used in Project E-122-2.

In project E-133, the E-122-2 winter and summer market E10, low- and high-PMI fuels are each splash blended to E15. Testing is also completed on the E-122-2 Tier 3 Certification fuel. The same on-road and chassis-dynamometer drive cycle tests developed in the CRC Project E-122 are being used.

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. Project E-133 work is expected to follow the timeline of the E-122-2 work.

EMISSIONS COMMITTEE

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

CRC Project No. E-135

Leaders: E. Barrientos
M. Valentine

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 GDI engines. The expected vehicle technology trend is that as emissions regulations become more stringent, increased 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 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 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 Project E-135 is to improve understanding of fuel injection pressure impact as well as other technologies on tailpipe emissions from GDI engines. 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

Proposals received during the open bid are under evaluation, and a contractor selection is expected in 2021.

EMISSIONS COMMITTEE

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 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, Project E-136 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

Proposals received during the open solicitations will be reviewed. A contractor selection is expected in 2021.

EMISSIONS COMMITTEE

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

CRC Project No. RW-105

Leaders: R. Sager
D. DiCicco
S. Mason

Scope and Objective

The objective of Project RW-105 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.

The Project RW-105 contractor will co-locate and coordinate with three RSD systems at a single test site which are part of 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 Project E-119-3 are separately contracted by CRC. Co-location of all four vendors was successfully completed in Phoenix, AZ in April 2021.

ASSESSMENT OF ALTERNATE FORMULATIONS FOR THE PM INDEX

CRC Project No. RW-107-2

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

Scope and Objective

The EPA, Honda, and others have confirmed that the PM Index can reasonably predict the relative particulate-forming tendency of a gasoline. CRC Project RW-107 examined the performance of PMI and a number of other PM-indices for their ability to predict particle emissions from gasoline fuels using datasets representing a variety of technologies and fuel formulations. A chief issue was that none of the available PM indices were able to accurately predict PM emissions for fuel groups that contain both neat (E0) and E10 gasolines. In CRC Projects E-94-2 and E-94-3 and the EPAct studies, E10 and higher fuels were found to have consistently higher PM emissions than E0 gasolines of the same PMI values. PM emissions of E10 to E20 fuel blends were higher than indicated by PMI values while E0 emissions were lower. Improving the indices to remove the emissions bias with respect to ethanol was identified as a priority.

Project RW-107-2 will seek to:

- Optimize the mathematical form of the original PMI equation.
- Investigate potential adjustments for other fuel properties, such as net heating value, density, and various distillation parameters. If an ethanol bias remains after these steps, determine an appropriate adjustment factor.

Current Status and Future Program

Rincon Ranch Consulting was selected as the project contractor for this work. The Final Report was published on the CRC website in March 2021.

EMISSIONS COMMITTEE

VALIDATION OF THE NEW PM INDEX FORMULA

CRC Project No. RW-107-3/a

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

Scope and Objective

Project 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. CRC Project RW-107-3 seeks to 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 include 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 new form of the PMI equation developed within RW-107-2, referred to as PME.

Current Status and Future Program

SwRI was awarded this contract for vehicle testing which has been integrated into the E-122-2 and E-133 combined test matrix. PME validation with the data will be completed by Rincon Ranch Consultants.

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 March 2019, the EPA issued a final rule to extend the summertime 1 psi RVP waiver to gasoline-ethanol blends up to 15% ethanol. This action facilitates the 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. A report is under preparation.

EMISSIONS COMMITTEE

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 CO, VOCs, and NOx 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.

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, 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

Project RW-117 is expected to support 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, and a report is under preparation.

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 the research community, and that data have been featured in numerous publications.

Project RW-118 seeks to relocate the DU 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 for each application.

The database will be housed at the DU library with open access.

Current Status and Future Program

Project RW-118 will continue through 2021. The DU library will provide open access and continued maintenance of the database once the relocation is completed.

AVFL COMMITTEE

IMPROVED DIESEL SURROGATE FUELS FOR ENGINE TESTING AND KINETIC MODELING

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

Leaders: S. McConnell
B. Pitz

Scope and Objective

The objective of Projects AVFL-18 and AVFL-18a 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 market 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 on the CRC website, as the Final Report for the first phase of AVFL-18.

Research was extended under AVFL-18a to facilitate the development of second-generation surrogates with improved capabilities for matching market diesel fuels, blending engine research test quantities of surrogates, as well as single-cylinder engine and combustion vessel testing of selected surrogate fuels. Panel members worked to identify and obtain compounds of sufficient purity and sulfur content for blending surrogate fuels, using a variety of synthesis approaches. All four surrogates have been blended by Chevron for the selected surrogate formulations.

Researchers at the Army Research Laboratory, SNL, and National Research Council Canada 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 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 (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" as a NIST report.

The Panel directed the research conducted under CRC Contract No. 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 in 2021.

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.

AVFL COMMITTEE

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

CRC Project No. AVFL-20 and AVFL-20a

Leaders: J. Anderson
A. Iqbal
S. Sluder

Scope and Objective

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

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

CRC and ORNL worked together to conduct both phases of engine testing and performance modeling for this project. The first phase was conducted on a Ford 1.6L turbocharged direct injection (DI) EcoBoost engine. Flint Hills Resources was a co-sponsor of both phases of this project. Gage Products prepared test fuels according to the matrix of 19 test fuels approved by the project panel members and the committee. Detailed Hydrocarbon Analysis (DHA) of the test fuels was performed by Chevron.

The test fuel matrix allowed exploration of a wide range of ethanol content (10 to 30 vol%), research octane number (91 to 102), and sensitivity (S=RON-MON) (6 to 7 and 10 to 12). ORNL completed the first stage of engine testing of all 19 fuels for knock resistance at a single compression ratio in the Ford EcoBoost engine. Subsequently, six of the test fuels were chosen for more detailed engine performance characterization at appropriately matched compression ratios. Using these data, vehicle-level modeling was used to estimate efficiency, fuel economy, and tailpipe CO2 emissions for these fuels in two vehicles. The Final Report for AVFL-20, "Effects of Octane Number, Sensitivity, Ethanol Content, and Engine Compression Ratio on GTDI Engine

Efficiency, Fuel Economy, and CO2 Emissions," was published on the CRC website in November 2017.

A naturally aspirated 1.4L test engine with port fuel injection (PFI) was provided by FCA for the companion Project AVFL-20a. Testing on the PFI engine was conducted by ORNL/DOE.

Current Status and Future Program

The Final Report was published as an Open Access SAE Paper in 2020.

AVFL COMMITTEE

HEAT OF VAPORIZATION MEASUREMENTS OF GASOLINE AND ETHANOL BLENDS

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

Leaders: M. Viola

Scope and Objective

Projects AVFL-27 and AVFL-27-2 evaluated methods for measurement of the heat of vaporization (HOV) for gasoline and ethanol/gasoline blends and explored alternate methods of determining the HOV as a function of boiling point and composition.

The University of Delaware (UDEL) and the National Renewable Energy Laboratory (NREL) were contracted to examine the selected test fuels in the first phase of the project. Three fuels from the FACE gasoline fuel set (Fuels A, D, and H) were selected by the project panel. Fuels A and H were tested at three ethanol blend levels (10%, 15%, and 30%). Iso-octane served as a reference compound for which the HOV is well known. Thermogravimetry with Differential Scanning Calorimetry (TGA/DSC) methods were used by both laboratories. In addition, a method based on Detailed Hydrocarbon Analysis (DHA) compositional data was explored at NREL.

The Final Report for Phase 1 of Project AVFL-27, "Heat of Vaporization Measurements of Gasoline and Ethanol Blends" was published on the CRC website in August 2016 and consists of a single document with both contractor reports (Parts A and B) and an Executive Summary prepared by the committee.

Current Status and Future Program

NREL has performed Phase Two of the project: "Full and Partial Heat of Vaporization Measurements of Gasoline and Ethanol/Gasoline Blends." The final report is in the form of an SAE Publication that was published in 2021; an executive summary for this research has been posted to the CRC website.

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
T. Kowalski

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 loads 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 project 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

AVFL COMMITTEE

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 Project 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 Project 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, Project AVFL-28-3, is being conducted by SwRI. Testing has been delayed but is expected to resume in Q3 2021.

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

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

Leaders: G. Gunter
J. Jetter

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 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 Project AVFL-29 was to develop an enhanced method for the speciation of gasoline.

The objective of Project AVFL-29-2 is 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 is to determine which components contribute most to PMI variability. The approach includes 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.

Project 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.

Current Status and Future Program

Project AVFL-29-2, "Effect of DHA Development on PMI Variability," has been awarded to Desert Research Institute (DRI) and is underway. Reporting is expected in late 2021.

AVFL COMMITTEE

AUTOIGNITION CHARACTERIZATION OF AVFL-20 TEST FUELS

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

Leaders: J. Anderson
A. Iqbal
S. McConnell

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

Modeling results to support the comparison research are being performed under Project AVFL-31c by Ford. Reporting is anticipated in late 2021.

EFFECTS OF BOOST PRESSURE AND FUEL COMPOSITION ON COMBUSTION KNOCK CHARACTERISTICS

CRC Project No. AVFL-32

Leaders: A. Iqbal
S. McConnell

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 AVFL-32 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, knock over-pressure (mean amplitude of pressure oscillations), and more.

AVFL-32 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.

AVFL COMMITTEE

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. Additional publications are in development for publication in 2021.

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

Project AVFl-33 is being performed by Oak Ridge National Laboratory. Reporting is expected in 2021.

AVFL COMMITTEE

ADVANCED CHARACTERIZATION OF E-117 DIESEL FUELS

CRC Project No. AVFL-34

Leaders: M. Viola

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 is anticipated in late 2021, in the form of an Open Access publication.

ADVANCED COMBUSTION LITERATURE SURVEY

CRC Project No. AVFL-35

Leaders: A. Ickes
J. Jetter

Scope and Objective

The goal of Project AVFL-35 was to obtain an understanding of (1) current, state-of-the-art advanced combustion concepts – approaches, limitations, and performance, (2) how fuel properties affect operation of the different concepts, and (3) the key supporting literature references.

This project consisted of a literature search along with a summary of findings and analysis of the specific combustion techniques. With the breadth of different concepts (and acronyms) falling into the advanced combustion area, concepts were curated and grouped as appropriate to highlight key trends.

Current Status and Future Program

This project was awarded to SwRI. The Final Report has been released on the CRC website.

AVFL COMMITTEE

IMPACT OF MON ON ENGINE PERFORMANCE

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

Leaders: V. Costanzo
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 wider 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 wider 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 emission regulations are driving the 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

Project AVFl-36/CM-137-19-1 has been awarded to FEV, and is underway. This work is being conducted in cooperation between the AVFL and Performance Committees. Reporting is expected in late 2021.

CRC "STOCHASTIC PRE-IGNITION" (SPI) WORKSHOP – 2020 & CRC "FUELS AND ENGINES: THE ROAD AHEAD" (FETRA) WORKSHOP – 2020

CRC Project No. AFEE-2020

Leaders: E. Chapman
V. Costanzo
R. McCormick

Scope and Objective

In planning the third Advanced Fuels and Engine Efficiency (AFEE) Workshop, the Organizing Committee decided to divide the content into two events, under new names, to best match the research topics with specialists in these fields.

The FETRA Workshop goal is to foster an open dialogue on the technical merits and challenges for engines and fuels for transportation, with a particular emphasis on practical pathways to reducing greenhouse gas and criteria pollutant emissions from transportation over the next thirty years.

The SPI Workshop has a particular emphasis on current status of stochastic pre-ignition, and discussion of next steps that the industry might take to improve the design threshold for downsized boosted engines through formulation and design changes in oils, fuels, and engines.

Current Status and Future Program

The SPI Workshop was held in September 2020. The FETRA Workshop was held in October 2020. The FETRA and SPI Workshop summaries have been released on the CRC website.

AVFL COMMITTEE

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. Project AVFL-37 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 it includes 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. Reporting is expected in late 2021.

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

CRC Project No. AVFL-38

Leaders: R. Lewis
M. Viola

Scope and Objective

Biogenic carbon is typically quantified using ^{14}C 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 ^{14}C 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.

Project AVFL-38 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. Development of a contract is in process.

FUELS FOR ADVANCED COMBUSTION ENGINES (FACE) WORKING GROUP

Leaders: E. Chapman
S. McConnell

Scope and Objective

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.

AVFL COMMITTEE

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 LUBRICANTS ADVISORY PANEL

Leaders: A. Ganghopadhyay
G. Gunter
T. Kowalski

Scope and Objective

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 and leading studies focused primarily on lubricant impacts as part of the AVFL Committee.

The completed Projects AVFL-28 and AVFL-28-2 and ongoing Projects AVFL-28-3 and AVFL-37 were developed by this Panel.

ATMOSPHERIC IMPACTS COMMITTEE

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

Project A-108 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
- 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 2021.

A perspective article that provides a general overview of gaps for improving atmospheric kinetic modeling was published in the *International Journal of Chemical Kinetics* (June 2018). A second journal article on the experimental database has been published in *Earth System Science Data* (June 2020).

ATMOSPHERIC IMPACTS COMMITTEE

THE INFLUENCE OF NOX ON SECONDARY ORGANIC AEROSOLS AND O3 FORMATION: CHAMBER STUDY

CRC Project No. A-113

Leaders: S. Gao
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 Project A-113, specifically designed novel environmental chamber experiments will elucidate the key roles of NO_x on SOA formation and investigate the role of peroxide chemistry. Large environmental 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 Programs

Project A-113 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 continues into 2021.

ATMOSPHERIC IMPACTS COMMITTEE

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 in 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 Project A-114/RW-111 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 2021.

ATMOSPHERIC IMPACTS COMMITTEE

EMPIRICAL ANALYSIS OF HISTORICAL AIR QUALITY AND EMISSIONS INFORMATION TO DEVELOP OBSERVATIONALLY-BASED MODELS OF OZONE-VOC-NO_X RELATIONSHIPS IN SOUTHERN CALIFORNIA

CRC Project No. A-120

Leaders: S. Gao
T. French
S. Winkler

Scope and Objective

The South Coast Air Basin (SoCAB) of California has the highest peak ozone levels in the U.S. in spite of stringent controls. While significant ozone reductions have been realized, the recent trend has found a leveling off in the ozone design value (ODV), and have recently seen an increase. Multiple questions arise, including: How will ozone respond to proposed emissions changes? What is the most effective approach forward? How effective have past controls been in relationship to the advantages of NOx vs. VOC controls? What is the ultimate background ozone level? How well do chemical transport models (CTM), which are used to develop control strategies, capture ozone trends and, importantly, sensitivities to emissions?

The objective of Project A-120 is to conduct extensive and detailed modeling of SoCAB for a number of historical and future years, with uncertainty analysis, to understand how well the current CTMs capture ozone dynamics. While the focus is on ozone, the modeling will provide similar results for particulate matter. There will be three specific approaches to go beyond typical studies:

- Perform extensive sensitivity and uncertainty analysis,
- Use isopleths to provide a more direct, visual analysis tool, and
- Make direct comparisons of modeled sensitivities with empirically-derived sensitivities (including the use of isopleths).

Current Status and Future Programs

Project A-120 is being conducted by Georgia Tech, and meets several of the top research priority needs resulting from the 2018 CRC SCORES workshop, including addressing data gaps in the observational response of ozone to changes in NO_x and VOC. The Final Report is expected in 2021.

ATMOSPHERIC IMPACTS COMMITTEE

BIOGENIC VS. ANTHROPOGENIC VOC ANALYSIS DURING PEAK OZONE EVENTS IN THE SOUTH COAST AIR BASIN/ MEASUREMENT OF VOLATILE CONSUMER PRODUCTS

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

Leaders: T. Wallington
S. Gao
T. Kuwayama

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 mixtures, 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 is co-funded by California Air Resources Board. The contract for Project A-121 was awarded to UC-Davis in May 2019, and was extended in Project A-121-2 in January 2021 to encompass a full O_3 season. The campaign is being planned alongside the CARB efforts for summer 2021.

ATMOSPHERIC IMPACTS COMMITTEE

MOBILE SOURCE AIR TOXICS WORKSHOP 2021

CRC Project No. A-122

Leaders: S. Winkler
S. Yoon

Scope and Objective

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. The objective of the MSAT 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 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 at the Workshop, which was hosted by CARB at their headquarters. A summary article was published in July 2019 edition of *EM Magazine.*

Current Status and Future Programs

A 10th Workshop is being planned for 2022. It is expected that this workshop will relocate to Riverside, CA in February 2022 and will provide an opportunity to visit the new CARB facilities.

UNCERTAINTY IN OZONE CHANGES FROM CONTROL STRATEGY IMPLEMENTATION

CRC Project No. A-123

Leaders: M. Janssen
C. Rabideau
S. Winkler

Scope and Objective

Three-dimensional (3-D) chemical transport models (CTMs) are used to predict pollutant concentrations in future years and thus have an important role in developing State Implementation Plans (SIPs) for ozone (O_3) and particulate matter. CTMs require numerous inputs and parameters that are uncertain to various degrees. For example, current chemical mechanisms for O_3 formation have hundreds of rate constants and product stoichiometric coefficients, each with an associated uncertainty. Consequently, CTM predictions have uncertainty, and understanding this uncertainty is important to determining the significance of comparisons between predicted and observed O_3 concentrations, O_3 changes predicted in attainment demonstrations (SIPs), and modeled O_3 trends (dynamic evaluation).

A global uncertainty in the analysis of model predictions is a challenge due to the large number of inputs and parameters, the possibility of interactions among them, and the relatively long computer runtimes for 3-D models. A recently completed project for the Texas Air Quality Research Program (AQRP), showed uncertainty in O_3 concentrations in eastern Texas by the Comprehensive Air Quality Model with Extensions (CAMx). This uncertainty was due to uncertainties in the estimated chemistry, emissions, deposition velocities, and O_3 boundary concentrations.

The goal of this project is to extend the prior work to estimate the uncertainty in the O_3 change in eastern Texas in response to emission controls. The O_3 change from a base to future year could be smaller than the uncertainty in the O_3 concentration itself because errors for model inputs in the future year may be similar to those in the base year (correlation). Consequently, when taking the difference in the O_3 concentration between the base and future years, some of the errors in the O_3 concentrations for the two years may cancel, i.e., the O_3 concentration may tend to be greater than the correct value or less than the correct value in both years because some model input errors are in the same direction and have about the same magnitude in both years.

Current Status and Future Programs

Project A-123 meets the top research priority needs resulting from the 2018 CRC SCORES Workshop. The contract for Project A-123 was awarded to Ramboll. An Executive Summary was published on the CRC website in February 2021, and a journal article is in preparation.

EVALUATION OF OZONE PATTERNS AND TRENDS IN EIGHT MAJOR METROPOLITAN AREAS IN THE U.S.

CRC Project No. A-124

Leaders: G. Myers
S. Winkler

Scope and Objective

Ozone in the U.S. remains a persistent problem with more than 120 million people living in areas that do not meet the 2015 standard. While much progress in meeting the standard has been made over the past few decades, it has slowed since 2013 with some observed "back-sliding", as the mean and 90th percentile of all sites has increased. Regionally, the trends largely track the national pattern and have shown little change over the past 5 years.

Project A-124 seeks to improve our knowledge on O_3 processes by investigating possible causes for these trends in eight core based statistical areas (CBSAa) and to provide guidance to policy makers on future attainment strategies. Project A-124 builds on CRC Project A-118, which focused on the impact from smoke, NOx and climate change on O_3 in the South Coast Air Basin. In Project A-118, Generalized Additive Models (GAMs) were developed to explain trends in the Maximum Daily Average 8-hour (MDA8) for 6 sites in the South Coast region. The results show that NOx emissions are the largest drivers on long-term trends in MDA8 O_3 and that neither smoke nor climate change have had a significant influence on the long-term O_3 trends in this region, to date.

In Project A-124, the complex relationships between O_3, emissions and meteorology were examined and possible smoke impacts on O_3 at eight CBSAs were identified. One or more monitoring sites at each location were selected based on design value (DV).

Specific goals of Project A-124 were to:

- Evaluate the relationship between daily MDA8 O_3, temperature, NOx, and the presence or absence of smoke for eight large metropolitan areas in the US with high O_3 DVs.
- Develop GAMs to understand the relationship between daily MDA8 values and key meteorological predictors for each site.
- Examine patterns and trends in the GAM results to evaluate the causes for trends or lack of trends at each of the eight regions considered.

Current Status and Future Programs

University of Washington was contracted for Project A-124. Additional monitoring sites at two locations was supported through co-sponsorship. The Final Report was published March 2021 on the CRC website.

THE RISING IMPORTANCE OF NON-COMBUSTION EMISSIONS IN URBAN ATMOSPHERES

CRC Project No. A-125

Leaders: C. Rabideau
T. Wallington

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 goals of Project A-125 are 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 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

Project A-125 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.

ATMOSPHERIC IMPACTS COMMITTEE

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
G. Myers
S. Winkler

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 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 Project A-126 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. Project A-126 builds on 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

Project A-126 has been contracted with Ramboll. The one-year effort is expected to conclude in early 2022.

PERFORMANCE COMMITTEE

GASOLINE ENGINE DEPOSITS

CRC Project No. CM-136

Leader: J. Cruz
M. Sheehan

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 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 is the foundation for understanding the chemistry of the formation of sulfate salts and their ability to plug filters and vehicle fuel handling equipment.

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

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

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. The Final Report has been published on the CRC website.

PERFORMANCE COMMITTEE

VOLATILITY

CRC Project No. CM-138

Leader: R. Lewis
M. Valentine

Scope and Objective

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

Current Status and Future Program

Development of an Engine Based Test for Determining the Effect of Spark-Ignition Engine Fuel Properties on Combustion and Vehicle Driveability (CM-138-15-2 / 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” was used as the beginning test cycle with the instrumented vehicle on a chassis dynamometer. The test cycle was further developed as part of this research. 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 (2020).

A follow-on project has been 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 is expected in mid-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. The objective of this project 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 volatility-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 is being conducted by SwRI.

"Driveability Index Relevance in Modern Gasolines and Vehicles" – CM-138-21-1

This project will conduct a literature review and other means as deemed appropriate to examine Driveability Index, including a history of how DI came into existence and its subsequent modifications. It will investigate how DI interacts with the other volatility limits established in ASTM D4814, how DI is impacted by ethanol blending, and if DI contributes to the specification or if there are enough controls in ASTM D4814 without DI. It will review gasoline specifications from around the world and identify/compare any specifications that would be considered similar to DI and/or control gasoline blending in a similar way to DI. It will investigate if modern engines need Driveability Index or other similar parameters from world gasoline specifications as part of the control limits for today's fuel. If it is unclear whether DI is necessary, it will make recommendations regarding what testing is required to make this determination.

A request for Proposals for this project has been posted to the CRC website.

PERFORMANCE COMMITTEE

GASOLINE COMBUSTION

CRC Project No. CM-137

Leaders: E. Chapman
V. Costanzo

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

CRC "Stochastic Pre-Ignition" (SPI) Workshop & CRC "Fuels and Engines: The Road Ahead" (FETRA) Workshop – 2020 Formerly Titled: "Advanced Fuel and Engine Efficiency" (AFEE) Workshop

These Workshops were supported equally by the Performance Committee Gasoline Combustion Group and AVFL, and are described in the AVFL Committee section under the project number AFEE-2020.

"Impact Of MON on Engine Performance"- CRC Project No. AVFL-36 / CM-137-19-1

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

DIESEL PERFORMANCE GROUP

CRC Project No. DP

Leaders: G. Gunter
S. Lopes

Scope and Objective

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

PERFORMANCE COMMITTEE

Current Status and Future Program

Cleanliness

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 have been generated by panel members and is under review for potential publication.

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 with the goal of informing the EPA and others in their current and future research on this topic (2014). 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 report is being prepared for publication.

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", June 2008 and CRC Report #656, "Biodiesel Blend Low-Temperature Performance Validation," 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/distributers, and OEMs in providing guidance on the best ways to keep diesel vehicles operating under most low temperature conditions. The guide was released on the CRC website in September 2016.

The Panel is conducting a project titled, "Low Temperature Filterability of Diesel Fuel at Retail Pumps," 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 late 2021.

Stability

This is a new Panel formed in 2020 to address issues related to diesel fuel stability. The Panel is currently considering 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: A. Carico
R. Juan

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 Thermal Stability 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.

WATER-SOLUBLE CONTAMINANTS IN JET FUEL

CRC Project AV-25-16

Leader: J.P. Belieres

Scope and Objectives

The source and mechanism of water-soluble deposits on engine hardware remains elusive. It is hoped that a systematic yearlong sampling program along with an array of analytical tests will provide sufficient information to correlate engine deposits with fuel component variations. This project is testing monthly samples from a maximum of ten selected airport locations for a period of one year. The results of these tests can be used to determine correlations between properties, fuel component deposits, and combustion events. A total of 95 regularly scheduled samples will be analyzed with provision for 5 additional "ad hoc" samples.

Measurements:

Fuel phase Analysis – "Organics"

- Measure total sulfur, nitrogen, and oxygen content
- Perform speciation and measure concentration of nitrogen, sulfur, and oxygen containing species.

Aqueous phase analysis:

- Sample pH
- Total Nitrogen concentration
- IC Analyses
- Measure concentration of Cu, Mg, Fe, S, Si, and P, in the sample's water phase by ICP-OES.
- ESI-TOFMS

Current Status and Future Program

This project was awarded to the University of Dayton Research Institute. The Final Report is being updated in response to final review, in preparation for publication.

AVIATION FUELS COMMITTEE

DEVELOPMENT OF INDUSTRY REFERENCE FLUIDS FOR ASTM D3241 TESTING

CRC Project No. AV-26-17

Leaders: E.A. Lodrigueza
J. Stolis

Scope and Objectives

The objective of Project AV-26-17 is to develop a reference fluid for standardization of ASTM D3241 testing - Standard Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels. The impact of project success would be immediate, due to significant variations in ASTM D3241 testing experienced across labs using different equipment and test consumables currently available in the field. Benefits would extend to the long-term by improving D3241 calibration and provide future standardization of new D3241 testing equipment and consumables.

A first reference fluid was designed to generate consistent D3241 tube deposit. This fluid underwent a known thermal oxidative chemistry pathway leading to consistent deposit thickness and profile on a D3241 heater tube at a test temperature falling within 250 to 300 °C. A second reference fluid was designed to generate consistent D3241 differential pressure response. This reference fluid underwent a known thermal oxidative chemistry pathway leading to consistent particulates and a differential pressure of 100 mm Hg within a 60 to 90 minutes time frame in a similar test temperature range as the deposit reference fluid.

Visual tube ratings and metrology (ellipsometry/interferometry) were used to evaluate the consistency of deposits produced by the fluids on a single JFTOT instrument (designated as the project standard instrument) using batch equivalent consumables (single production batch of tubes). The consistent performance of the fluid(s) over time on the project standard instrument is an important requirement that needs to be demonstrated.

Current Status and Future Program

Project AV-26-17 is being performed by the University of Dayton Research Institute. The Final Report was published on the CRC website in December 2020.

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 (vapor-to-liquid fuel ratio) 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, 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, enabling a more accurate mechanism to determine two phase flow conditions within the aircraft and engine fuel system during transient aircraft operation.

Current Status and Future Program

Project AV-27-18 is being performed by the University of Dayton Research Institute. Final reporting is expected in mid-2021.

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

CRC Project No. AV-28-19

Leaders: R. Gaughan
M. Rumizen

Scope and Objectives

The first goal of Project AV-28-19 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 more 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, 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.

AVIATION FUELS COMMITTEE

Research Questions to be Addressed:

- 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?
- How do modern cylinder pressure transducer-based measurements of IMEP (and their uncertainty) compare to the current BMEP and FMEP based IMEP calculation method?
- 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)?
- For how many of the combustion cycles can knock be observed from a cylinder pressure measurement during testing of the supercharge test method?
- How does the combustion and knocking characteristics compare between the supercharge method and the RON and MON test methods?

Current Status and Future Program

Project AV-29-19 is expected to be conducted by Argonne National Laboratory, and CFR Engines, Inc. Contractual arrangements are in progress.

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

Leader: A. Clark

Scope and Objectives

Project AV-29-20 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 featured. The review will cover aviation gas turbine fuels including standard kerosine grades Jet A/A-1, Military grades JP-8 and JP-5, and wide cut grades Jet B/JP-4. 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 alternatives 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.

- Interview key workers in current fuel database and property prediction research activities.
- Interview 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

Project AV-29-20 is being conducted by Chris Lewis Fuels Consultancy Ltd. Work is ongoing, with final reporting anticipated in late 2021.

JET FUEL & AVIATION GASOLINE HOV AND ENTHALPY DIAGRAM TESTING

CRC Project No. AV-20-20

Leader: A. Clark

Scope and Objectives

Project AV-20-20 is a continuation CRC Project AV-20-14, and will compare and characterize European produced Jet fuels relative to American produced Jet fuels. It will use HOV QI data to establish both average values and levels 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, Project AV-20-20 will produce Enthalpy Diagrams and Heat of Vaporization curves covering a range of aviation gasoline 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.

SUSTAINABLE MOBILITY COMMITTEE

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 Project SM-1 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 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 Project SM-1 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

Proposals were received from 7 bidders, with a decision expected in 2021.

SUSTAINABLE MOBILITY COMMITTEE

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

CRC Project SM-2

Leader: D. DiCicco

Scope and Objectives

Carbon dioxide and criteria emissions from the U.S. light duty vehicle fleet have declined over time even as vehicle numbers and miles travelled have increased. The trend should continue as sales of new vehicles with low tailpipe emissions replace older vehicles having higher emissions. In addition to tailpipe emissions, there are other local emission sources associated with the operation of vehicles, e.g., brake and tire wear; and emissions generated from facilities related to feedstock sources in the electric utility, petroleum and renewable energy sectors that are associated with supplying the energy used to power new electric and hybrid vehicles.

Project SM-2 will assess the trends in air quality (ozone, NO_2, PM_{10}, PM2.5, CO, CO_2) of several selected U.S. 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. The change in well-to-wheels CO_2 emissions associated with the same future scenarios will be modeled.

The goals of SM-1 are to:

- Determine and compare the incremental CO_2 and air quality impacts of high and low vehicle electrification scenarios, and 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.

At least four U.S. urban areas for which adequate underlying emissions inventory data exist to support air quality modeling will be used to construct base year and future scenarios. The well-to-wheel CO_2 emissions for EV and ICEV that are associated with these scenarios will be used to compare the incremental CO_2 and air quality impacts to meet climate objectives.

Current Status and Future Program

A Request for Proposals has been posted to the CRC website.

SUSTAINABLE MOBILITY COMMITTEE

EVALUATION OF A SAMPLE OF OFF-HIGHWAY REFUELING SITES FOR CURRENT AND POTENTIAL ELECTRICAL SERVICE TO SUPPORT LD AND HD EV CHARGING

CRC Project SM-3

Leader: C. Jones

Scope and Objectives

The objective Project SM-3 is to develop data on a sample of rural, near highway, convenience stores, truck stops or travel plazas. The data would include actual and potential electrical service, inclination to install DCFCs to service potential EV charging customers along with information on potential site locations for DCFCs.

The contractor will interview a selection of chains and develop a report summarizing the capability and inclination of the site to install DCFC stations.

Items to be captured include:

- The existing electrical service of the site (voltage, amperage, phase, etc.),
- The existing load of the site,
- Potential increases in load being considered (restaurant, car wash, …),
- Proprietor's goal for charging time and number of charge points
- The power supply would be traced to the high capacity source and the capacity and cost to extend to the store determined or estimated,
- Parking availability for DCFC sites and relationship to store , and
- Utility providing service (Note that follow up with the utility may be required to fully determine service).

Current Status and Future Program

A Request for Proposals has been posted to the CRC website.

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

CRC Project SM-4

Leader: C. Jones

Scope and Objectives

The objective of Project SM-4 is to model the battery life effects of V2G activity on top of ordinary vehicle driving cycles. The contractor should look at a variety of V2G strategies and develop possible strategies and recommendations for minimizing the V2G effects on battery life.

The contractor will research a variety of likely V2G duty cycles for use in the model. 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. The contractor will develop strategies and recommendations for minimizing the effects of V2G duty cycles on battery life. The report will also include an overview of V2G including the standards (there are at least two), and whose vehicles are or will be capable.

Current Status and Future Program

A Request for Proposals has been posted to the CRC website.

SUSTAINABLE MOBILITY COMMITTEE

RESEARCH IN SUPPORT OF FUTURE FUEL SPECIFICATIONS

CRC Project SM-5

Leader: D. Lax

Scope and Objectives

As the U.S. progresses along the path of a lower carbon future, it becomes more important to ensure that existing specifications governing the performance and properties of transportation fuels continue to be relevant for fuel/energy providers, vehicle/engine manufacturers, regulators, and consumers. CRC has a long history of conducting research designed to provide technical data and engineering insights on fuel/ vehicle interactions effects for use by organizations in support of initiatives by standards organizations such as ASTM.

The ultimate goal of Project SM-5 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 Request for Proposals has been posted to the CRC website.

EVALUATION OF HYDROGEN FUEL CELLS AS A POWER SOURCE FOR ELECTRIC VEHICLE CHARGING

CRC Project SM-6

Leaders: C. Jones

Scope and Objectives

As the number of battery electric vehicles (BEV) increases, the development of a non-residential charging infrastructure becomes more important. Charging away from home is more likely to require fast charging or charging of commercial vehicles. In some cases, the existing electric grid is unable to meet the power demand. Two of many possible scenarios are fast charging in areas remote from the high-capacity grid and commercial sites where a large number of vehicles need to recharged in a limited timeframe.

In the first case long distance travelers will want high power charging, typically supplied by Direct Current Fast Chargers (DCFC), to minimize the wait while their vehicle is recharged. It is very easy for DCFC units (which are typically at least 50 kW) to overwhelm the local grid capacity.

The second case could be a distribution center that uses electric delivery vans which drive around all day and return to recharge overnight. In this case having a hundred or more vans coupled with the power consumption of the building itself could again overwhelm the local grid capacity or trigger unsupportable demand charges.

One option for boosting available power is to install fuel cell systems. These systems can be resupplied with hydrogen and/or produce it themselves with an electrolyzer during periods of low electrical demand.

The objective of this project is to develop models of both potential sites. One is a rural charging station with limited electric service that uses fuel cells to supply DCFCs. The other is a distribution site that uses fuel cells to supply some, or all of the extra demand created when the fleet of delivery vehicles returns for recharge.

SUSTAINABLE MOBILITY COMMITTEE

The contractor will build a model of the two sites using the characteristics of current and near future fuel cells and vehicle charging equipment. The model will evaluate variations in customer density and demand, and the costs of fuel cells, chargers, grid electricity, hydrogen and the potential of making hydrogen on-site. The goal is to build a flexible model that will allow potential users to determine the lowest cost approach for their situation.

Current Status and Future Program

A Request for Proposals has been posted to the CRC website.

PART THREE

RELEASED REPORTS

RELEASED REPORTS – 2021

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	PENDING
*A-118	Role of Meteorology, Emissions and Smoke on O3 in the South Coast Air Basins	PENDING
*A-119	High-Resolution Inventory Data Extractor and Source Apportionments Regrouping Tool Developments	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
AVFL-20a	Potential Impacts of High-Octane Fuel Introduction in a Naturally Aspirated, Port Fuel-Injected Legacy Vehicle	SAE International; November 2020 ISSN: 0148-7191, e-ISSN: 2688-3627 DOI: https://doi.org/10.4271/2020-01-5117
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

RELEASED REPORTS – 2021

CRC Project No.	Title	Publication/NTIS Accession No.
AVFL-32 Phase1	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*, April 2021 DOI: https://doi.org/10.4271/2020-01-5117
AVFL-35	Advanced Combustion Literature Survey	PENDING
RW-107-2	An Improved Index for Particulate Matter Emissions (PME)	PENDING
E-123	On-Road Remote Sensing of Automobile Emissions in the Chicago Area: Fall 2020	PENDING
*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-131	Studying Capabilities and Limitations Of Vehicle Telematics Data	PENDING
*CRC Report No. 674	E15 Fuel Survey: July 2019	PENDING

AVIATION AND PERFORMANCE*

CRC Project No.	Title	Publication/NTIS Accession No.
AV-25-16	Fuel and Water Characterization in Support of the CRC Panel on Engine Component Deposits	PENDING
CM-136-18-2	Investigation of Sulfate Salt Solubilities in Ethanol and Gasoline-Ethanol Blends	PENDING
*CM-138-15-2	Development of an Engine Based Test for Determining the Effect of Spark Ignition Fuel Properties on Combustion and Vehicle Driveability	PENDING
*CM-138-18-1	CRC Driveability Workshop	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

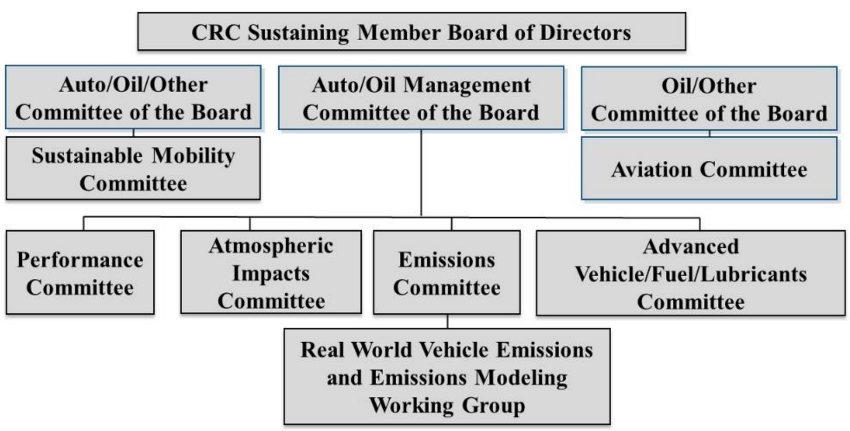
ORGANIZATION AND MEMBERSHIP

<u>ORGANIZATION – 2021</u>

The sustaining members of the CRC are the American Petroleum Institute (API) and a consortium of automobile manufacturers (Stellantis, Daimler, Ford, General Motors, Honda, Mitsubishi, Nissan, Toyota, and Volkswagen). For over 77 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.

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AVFL-18a PANEL

S. McConnell, Co-Leader	Marathon Petroleum Corp.
W. J. Pitz, Co-Leader	LLNL

J. E.Anderson	Ford Motor Co.
J. T. Bays	PNNL
H. Dettman	CanmetENERGY
R. Gieleciak	CanmetENERGY
M. Kweon	U.S. Army Research Lab
A. Ickes	Chevron Energy Techn.
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-20/20a PANEL

J. E. Anderson, Co-Leader	Ford Motor Co.
A. Iqbal, Co-Leader	Stellantis
C. S. Sluder, Co-Leader	ORNL

E. M. Chapman	General Motors	R. P. Lewis	Marathon Petroleum Corp.
V. S. Costanzo	Aramco Services	G. K. Lilik	ExxonMobil
J. Cruz	Daimler	S. McConnell	Marathon Petroleum Corp.
D. M. DiCicco	Ford Motor Co.	J. Mengwasser	Shell Global Solutions
M. Foster	BP		
G. C. Gunter	Phillips 66	J. Y. Sigelko	Volkswagen of America
R. Hardy	Flint Hill Resources	J. J. Simnick	BP
D. H. Lax	API	M. Valentine	Toyota Motor N.A., Inc.
T. Leone	Ford Motor Co.	M. B. Viola	General Motor

AVFL-27-2 PANEL

S. McConnell, Co-Leader	Marathon Petroleum Corp.
M. B. Viola, Co-Leader	General Motors

J. E. Anderson	Ford Motor Co.	R. P. Lewis	Marathon Petroleum Corp.
E. M. Chapman	General Motors	G. K. Lilik	ExxonMobil
G. C. Gunter	Phillips 66	J. Y. Sigelko	Volkswagen of America
A. Ickes	Chevron Energy Techn.	M. Valentine	Toyota Motor N.A., Inc.
J. J. Jetter (ret.)	Honda R&D Am.		

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	J. Y. Sigelko	Volkswagen of America
D. H. Blossfeld	General Motors	R. Stockwell	Chevron
S. McConnell	Marathon Petroleum Corp.		

MEMBERSHIP

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
M. Valentine	Toyota Motor N.A., Inc.
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
V. S. Costanzo	Aramco Services
J. Cruz	Daimler
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.

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.	K. R. Kress	Phillips 66
		G. K. Lilik	ExxonMobil
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
V. S. Costanzo	Aramco Services	G. Parker	Lubrizol
J. Cruz	Daimler	J. Y. Sigelko	Volkswagen of America
A. Ickes	Chevron Energy Techn.	M. Valentine	Toyota Motor N.A., Inc.
		M. B. Viola	General Motors
A. Iqbal	Stellantis		

AVFL-35 PANEL

J. J. Jetter, Co-Leader	Honda R&D Am.
A. Ickes, Co-Leader	Chevron Energy Techn.

V. S. Costanzo	Aramco Services	G. K. Lilik	ExxonMobil
G. C. Gunter	Phillips 66	S. McConnell	Marathon Petroleum Corp.
A. Iqbal	Stellantis	J. Y. Sigelko	Volkswagen of America
D. H. Lax	API	M. Valentine	Toyota Motor N.A., Inc.
R. P. Lewis	Marathon Petroleum Corp		

MEMBERSHIP

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

V. S. Costanzo, Co-Leader	Aramco Services
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.	G. K. Lilik	ExxonMobil
A. Aradi	Shell	S. McConnell	Marathon Petroleum Corp.
E. M. Chapman	General Motors	L. McQuinn	Ford
S. R. Golisz	ExxonMobil	P. M.Najt	General Motors
G. C. Gunter	Phillips 66	B. Raney-Pablo	Ford Motor Co.
J. Holland	Phillips 66	J. Y. Sigelko	Volkswagen of America
M. Hussain	Phillips 66	J. J. Simnick	BP
A. Ickes	Chevron Energy Techn.	M. Valentine	Toyota Motor N.A., Inc.
C. Jones	General Motors		
D. H. Lax	API		

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

V. S. Costanzo, Co-Leader	Aramco Services
A. Iqbal, Co-Leader	Stellantis
S. McConnell, Co-Leader	Marathon Petroleum Corp.

E. M. Chapman	General Motors	T. Leone	Ford Motor Co.
A. Ickes	Chevron Energy Techn.	R. P. Lewis	Marathon Petroleum Corp.

MEMBERSHIP

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	R. P. Lewis	Marathon Petroleum Corp.
R. Gieleciak	CanmetENERGY	G. K. Lilik	ExxonMobil
G. C. Gunter	Phillips 66	L. Morrison	ExxonMobil
W.M. Kim	ExxonMobil	M. B. Viola	General Motors

MEMBERSHIP

EMISSIONS COMMITTEE

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

B. Alexander	BP	R. P. Lewis	Marathon Petroleum Corp.
T. Bera	Shell Global Solutions	A. Mabutol	Mitsubishi Mtrs R&D Am.
E. Barrientos	ExxonMobil	S. A. Mason	Phillips 66
H. Cheng	BP	M. Moore	Stellantis
V. Costanzo	Aramco Services	D. Nagashima	Honda R&D Co.
J. Cruz	Daimler	J. Y. Sigelko	Volkswagen of America
D. M. DiCicco	Ford Motor Co.	M. Valentine	Toyota Motor N.A., Inc.
F. Khan	Nissan Tech. Ctr. NA		

E-93-7 2021 LCA WORKSHOP ORGANIZNG COMMITTEE

	R. DeKleine, Co-Chair	Ford Motor Co.	
	H. Hamje, Co-Chair	ExxonMobil	
	A. Levy, Co-Chair	US EPA	

S. Ehsan	Concawe	D. Lax	API
B. Fayyaz	Chevron	J. Martin	UC USA
Z. Haq	DOE	A. Prabhu	CARB
X. He	Phillips66	T. Radich	USDA
M. Herman	Biodiesel	S. Richman	Ethanol RFA
K. Kline	ORNL	S. Searles	ICCT
S. Kuusisto	Neste	M. Wang	ANL

E-122-2 PANEL

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

B. Alexander	BP	S. A. Mason	Phillips 66
E. Barrientos	ExxonMobil	M. Moore	Stellantis
T. Bera	Shell Global Solutions	M. Olson	Mitsubishi Mtrs R&D Am.
J. Cruz	Daimler		
D. M. DiCicco	Ford Motor Co.	J. Y. Sigelko	Volkswagen of America
S. Decarteret	General Motors	J. Unsworth	Stellantis
O. Garcia	Volkswagen of America	M. Valentine	Toyota Motor N.A., Inc.
C. Jones	General Motors	Y. Xu	ExxonMobil
F. Khan	Nissan Tech. Ctr. NA	M. Yassine	Stellantis
A. S. Mabutol	Mitsubishi Mtrs R&D Am.		

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.

A. Bruce	BP	S. A. Mason	Phillips 66
C. Jones	General Motors	M. Moore	Stellantis
D. Lax	API	J. Y. Sigelko	Volkswagen of America
R. P. Lewis	Marathon Petroleum Corp.	M. Valentine	Toyota Motor N.A., Inc.
P. Loeper	Chevron Global Dnstrm.	M. B. Viola	General Motors

MEMBERSHIP

E-130 PANEL

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

M. McCarthy	Toyota		
S. A. Mason	Phillips 66	M. B. Viola	General Motors

REAL WORLD VEHICLE EMISSIONS & EMISSIONS MODELING GROUP

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

B. Alexander	BP	R. P. Lewis	Marathon Petrol. Corp.
R. Baldauf	US EPA	P. Loeper	Chevron Global Dnstrm.
N. J. Barsic	John Deere	J. E. Long	CARB
E. Barrientos	ExxonMobil	A. S. Mabutol	Mitsubishi Mtrs R&D Am.
M. Beardsley	US EPA	S. McConnell	Maraton Petroleum Corp.
T. Bera	Shell Global Solutions	M. E. Moore	Stellantis
E. Chapman	General Motors	D. Nagashima	Honda R&D Co.
V. Costanzo	Aramco Services	R. Nankee	Stellantis
J. Cruz	Daimler	R. Nine	DOE/NETL
A. Cullen	US EPA	M. Olechiw	US EPA
R. De Kleine	Ford Motor Co.	R. Purushothaman	Caterpillar
T. A. French	EMA	C. Ruehl	CARB
C. R. Fulper	US EPA	J. Y. Sigelko	Volkswagen of America
D. Ganss	Nissan Tech. Ctr. NA	M. R. Smith	Navistar
R. Giannelli	US EPA	D. Sonntag	US EPA
C. Hart	US EPA	R. Sutschek	Volkswagen of America
N. Kempema	Ford Motor Co.	M. Thornton	NREL
F. Khan	Nissan Tech. Ctr. NA	M. Valentine	Toyota Motor N.A., Inc.
Y. Khan	Cummins	A. Voice	Aramco
C. Laroo	EPA	M. K. Yassine	Stellantis
D. H. Lax	API	S. Yoon	CARB

MEMBERSHIP

30TH REAL WORLD EMISSIONS WORKSHOP ORGANIZING COMMITTEE

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

R. Baldauf	US EPA	J. Martin	US EPA
D. Choi	US EPA	R. Purushothaman	Caterpillar
S. Gao	Phillips 66	M. Thornton	NREL
T. Huai	CARB	D. Vu	Marthon Petroleum Corp.
J. Impullitti	SCAQMD	S. Yoon	CARB
Y. Khan	Cummins		

RW-105 PANEL

D. DiCicco, Co-Chair	Ford Motor Co.
S. Mason, Co-chair	Phillips 66
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	J. E. Long	CARB
S. Bohr	Ford Motor Co.	M. E. Moore	Stellantis
J. Cruz	Daimler	J. Y. Sigelko	Volkswagen of America
A. Cullen	US EPA	M. Valentine	Toyota Motor N.A., Inc.
C. R. Fulper	US EPA	M. B. Viola	General Motors
M. Grote	Stellantis	S. Yoon	CARB
C. Hart	US EPA		

MEMBERSHIP

RW-107-2 PANEL

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

B. Alexander	BP		
J. E. Anderson	Ford Motor Co.	S. A. Mason	Phillips 66
R. Baldauf	US EPA	J. Mengwasser	Shell Global Solutions
N. J. Barsic	John Deere	M. Moore	Stellantis
M. Beardsley	US EPA	R. Nankee	Stellantis
E. Barrientos	ExxonMobil	R. Nine	DOE/NETL
E. Chapman	General Motors	M. Olechiw	US EPA
J. Cruz	Daimler	F. Parsinejad	Chevron Oronite
A. Cullen	US EPA	R. Purushothaman	Caterpillar
D. M. DiCicco	Ford Motor Co.	C. Ruehl	CARB
T. A. French	EMA	S. A. Shimpi	Cummins
C. R. Fulper	US EPA	J. Y. Sigelko	Volkswagen of America
R. Giannelli	US EPA	M. R. Smith	Navistar
C. Hart	US EPA	R. Sobotowski	US EPA
F. Khan	Nissan Tech. Ctr. NA	D. Sonntag	US EPA
D. H. Lax	API	M. Thornton	NREL
P. Loeper	Chevron Global Dnstrm.	M. Valentine	Toyota Motor N.A., Inc.
J. E. Long	CARB	M. B. Viola	General Motors
A. S. Mabutol	Mitsubishi Mtrs. R&D	M. K. Yassine	Stellantis

MEMBERSHIP

ATMOSPHERIC IMPACTS COMMITTEE

S. Gao, Co-Chair	Phillips 66
S. Winkler, Co-Chair	Ford Motor Co.

P. Gangopadhyay	Toyota	J. I. Moutinho	ExxonMobil
E. Hillawi	Nissan Tech. Ctr. N.A.	G. F. Myers	Marathon Petroleum Corp.
D. Johnson	BP	D. Nagashima	Honda R&D Am.
C. Jones	General Motors	C. Rabideau	Chevron
A. S. Mabutol	Mitsubishi Mtrs. R&D Am.	J. Y. Sigelko	Volkswagen of America
		R. Sutschek	Volkswagen of America
M. E. Moore	Stellantis	T. J. Wallington	Ford Motor Co.

ATMOSPHERIC IMPACTS WORKING GROUP

S. Gao, Co-Chair	Phillips 66
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	C. Lawson	Shell
D. M. DiCicco	Ford Motor Co.	D. H. Lax	API
H. J. Feldman	API	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
S. A. Mason	Phillips 66	D. Vu	Marthon Petroleum Corp
B. Murphy	US EPA		

A-120 PANEL

T. A. French, Co-Chair — EMA
S. Gao, Co-Chair — Phillips 66

T. Kuwayama	CARB	T. J. Wallington	Ford Motor Co.
C. Rabideau	Chevron	S. Winkler	Ford Motor Co.
J. Y. Sigelko	Volkswagen of America		

A-121 PANEL

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

T. A. French	EMA	S. M. Lee	SCAQMD
S. Gao	Phillips 66	J. I. Moutinho	ExxonMobil
M. Janssen	LADCO	C. Rabideau	Chevron
C. Jones	General Motors	J. Y. Sigelko	Volkswagen of America

MEMBERSHIP

A-123 PANEL

C. Rabideau, Co-Leader	Chevron
M. Janssen, Co-Leader	LADCO
S.Winkler, Co-Leader	Ford Motor Co.

T. A. French	EMA	S. Reid	BAAQMD
B. Koo	BAAQMD	J. Y. Sigelko	Volkswagen of America
S. M. Lee	SCAQMD	S. Tanrikulu	BAAQMD
R. Mathur	US EPA	T. J. Wallington	Ford Motor Co.
M. E. Moore	Stellantis		
J. I. Moutinho	ExxonMobil		

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.		

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		

MEMBERSHIP

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		
J. I. Moutinho	ExxonMobil	T.J. Wallington	Ford Motor Co.

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

MEMBERSHIP

PERFORMANCE COMMITTEE

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

E. Chapman	General Motors	A. Mabutol	Mitsubishi Mtrs. R&D Am.
V. Constanzo	Aramco Services	M. E. Moore	Stellantis
J. Cruz	Daimler	D. Nagashima	Honda R&D Am.
D. Ganss	Nissan Tech. Ctr. NA	B. Raney-Pablo	Ford Motor Co.
R. George	BP	M. Sheehan	Chevron
S. Golisz	ExxonMobil	J. Y. Sigelko	Volkswagen of America
G. C. Gunter	Phillips 66	W. Studzinski	General Motors
E. Hillawi	Nissan Tech Ctr. NA	M. Valentine	Toyota Motor N.A., Inc.
K. Johnson	Shell	Y. Xu	ExxonMobil
S. Lopes	General Motors		

GASOLINE DEPOSIT GROUP
(Project No. CM-136)

J. Cruz, Co-Leader	Daimler
M. Sheehan, Co-Leader	Chevron

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

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

M. Sheehan, Co-Leader	Chevron
J. Cruz, Co-Leader	Daimler

B. Alexander	BP	R. Monroe	General Motors
E. Chapman	General Motors	A. Moravec	General Motors
G. C. Gunter	Phillips 66	B. Raney-Pablo	Ford Motor Co.
K. Johnson	Shell	R. Smocha	Chevron
R. P. Lewis	Marathon Petroleum Corp.	M. Valentine	Toyota Motor N.A., Inc.
J. Martinez	Chevron	Y. Xu	ExxonMobil

GASOLINE DEPOSIT SULFATE PANEL
(Project No. CM-136-18-2)

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

B. Alexander	BP	D. H. Lax	API
J. Cruz	Daimler	M. Lynch	ExxonMobil
K. Davis	RFA	A. McKnight	Innospec
L. Gibbs	Consultant	B. Raney-Pablo	Ford Motor Co.
G. C. Gunter	Phillips 66	M. Sheehan	Chevron
A. Iqbal	Stellantis	R. Smocha	Chevron
K. Johnson	Shell	M. Valentine	Toyota Motor N.A., Inc.
A.M. Kulinowski	Afton Chemical		

MEMBERSHIP

Project No. CM-136-20 PANEL

J. C. Eckstrom, Co-Leader	BP
E. English, Co-Leader	FQS, Inc.

J. Ayala	Ayalytical
D. Chu	Panair Labs
V. Colantuoni	Koehler Instruments
O. Costenoble	NEN
J. Cruz	Daimler
C. Edinger	Anton-Paar
D. Forester	Consultant
A. Gallonzelli	CAMCOM
E. Gaouyat	Total
M. Garg	Reliance Industries Ltd
R. Gil	Energy Institute
S. Golisz	ExxonMobil
G. C. Gunter	Phillips 66
A. Iqbal	Stellantis
C. Jones	General Motors
T. King	Halterman
S. Kirby	General Motors
K. Kuenzel	Ford Motor Co.
D. Lax	API
R.Lewis	Marathon Petroleum
M. Moore	FCA
B. Morlan	Chevron
B. Raney-Pablo	Ford Motor Co.
G. Rickard	Intertek
S. Ryzyi	Ford Motor Co.
R. Shah	Koehler Instrument
M. Sheehan	Chevron
Y. Xu	ExxonMobil

GASOLINE COMBUSTION GROUP

(formerly Octane Group)

(Project No. CM-137)

E. Chapman, Co-Leader	General Motors
V. Constanzo, Co-Leader	Aramco Services

B. Alexander	BP	A. McKnight	Innospec
S. Bartley	Lubrizol	J. Mengwasser	Shell
T.Briggs	SwRI	M. Miller	Sunoco Inc.
S. Broughton	Marathon Petroleum Corp.	K. Mitchell	Consultant
K. Brunner	SwRI	P. J. Morgan	SwRI
R. Chapman	Innospec Fuel Spec.	C. M. Pyburn	Pybertech International
J. Cruz	Daimler	B. Raney-Pablo	Ford Motor Co.
D. M. DiCicco	Ford Motor Co.	D. Schoppe	Intertek
S. Golisz	ExxonMobil	M. Sheehan	Chevron
G. C. Gunter	Phillips 66	J. Y. Sigelko	Volkswagen of America
A. Iqbal	Stellantis	R. A. Sobotowski	US EPA
J. J. Jetter	Honda R&D Am.	W. Studzinski	General Motors
F. Khan	Nissan Tech. Ctr. NA	A. Swarts	SwRI
D. H. Lax	API	M. Valentine	Toyota Motor N.A., Inc.
R. P. Lewis	Marathon Petroleum Corp.	Y. Xu	ExxonMobil
M. Lynch	ExxonMobil		

Project No. CM-137-21 PANEL

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

J. Bizub	Consultant	G. C. Gunter	Phillips 66
L. Campbell	Marathon Petroleum Corp.	J. Holland	Phillips 66
E. Chapman	General Motors	M. Hussain	Phillips 66
V.S. Constanzo	Aramco	R. P. Lewis	Marathon Petroleum Corp.
R. Durrett	General Motors		

MEMBERSHIP

VOLATILITY GROUP
(Project No. CM-138)

M. Valentine, Co-Leader	Toyota Motor N.A., Inc.
R. P. Lewis, Co-Leader	Marathon Petroleum Corp.

B. Alexander	BP	K. Johnson	Shell
S. Bartley	Lubrizol	C. Jones	General Motors
S. Broughton	Marathon Petroleum Corp.	F. Khan	Nissan Tech. Ctr. NA
K. Brunner	SwRI		
E. Chapman	General Motors	D. H. Lax	API
J. Cruz	Daimler	M. Lynch	ExxonMobil
K. Davis	RFA	K. Mitchell	Consultant
J. Draper	Motiva	B. Raney-Pablo	Ford Motor Co.
I. Gabrel	Stellantis	D. Schoppe	Intertek
L.M. Gibbs	Consultant	M. Sheehan	Chevron
S. Golisz	ExxonMobil	J. Y. Sigelko	Volkswagen of America
G. C. Gunter	Phillips 66		
G. Herwick	Trans. Fuels Consult.	W. Studzinski	General Motors
A. Iqbal	Stellantis	S. Van Hulzen	POET

Project No. CM-138-19-1 PANEL

C. Jones, Co-Leader	General Motors
S. Golisz, Co-Leader	ExxonMobil

E. Chapman	General Motors	R. P. Lewis	Marathon Petroleum
V. Constanzo	Aramco	M. Sheehan	Chevron
L.M. Gibbs	Consultant	J. Y. Sigelko	Volkswagen of America
G. C. Gunter	Phillips 66		
A. Iqbal	Stellantis	M. Valentine	Toyota Motor N.A., Inc.
D. H. Lax	API		

MEMBERSHIP

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	J. Russo	Shell
S. Golisz	ExxonMobil	M. Sheehan	Chevron
A. Iqbal	Stellantis	M. Valentine	Toyota Motor N.A., Inc.
R. P. Lewis	Marathon Petroleum Corp.		

MEMBERSHIP

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

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

S. Broughton, Leader Marathon Petroleum Corp.

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

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

G. C. Gunter, Leader Phillips 66

D. Abdallah	ExxonMobil	P. Henderson	Consultant
H. Abi-Akar	Caterpillar	H. Huang	Cummins
M. Ahmadi	Oronite Additive	A. Kulinowski	Afton Chemical
A. Aradi	Shell	P. Lacey	Delphi Diesel Systems
T. Bera	Shell	D. H. Lax	API
D. Bohn	Flint Hills Resources	S. Lopes	General Motors
S. Broughton	Marathon Petroleum Corp.	J. Martinez	Chevron
		K. Mitchell	Consultant
C. Burbrink	Cummins	N. Mukkada	Chevron
R. Chapman	Consultant	K. Salem	Lubrizol
J. Draper	Motiva	M. Sheehan	Chevron
S. Fenwick	National Biodiesel Bd	T. Sutton	EMA
R. George	BP	M. Valentine	Toyota Motor N.A., Inc.
B. E. Goodrich	John Deere	Y. Xu	ExxonMobil

MEMBERSHIP

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

R. Chapman, Leader — Consultant

D.Bohn	Flint Hills Resources	C. Huang	Cummins
S. Broughton	Marathon Petroleum Corp.	R. Leisenring	Consultant
		R. P. Lewis	Marathon Petroleum Corp.
C. Burbrink	Cummins	S. Lopes	General Motors
J. Eichberger	Fuels Institute	N. Mukkada	Chevron
E. W. English	Fuel Quality Services	F. Passman	BCA Inc.
S. Fenwick	Nat. Biodiesel Board	S. Pollock	Steel Tank Institute
S. Golisz	ExxonMobil	S. Rubin-Pitel	ExxonMobil
G. C. Gunter	Phillips 66	K. Salem	Lubrizol
R. Haerer	US EPA	P. Searles	API
J. Hove	Fuels Institute	T. Sutton	EMA

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

D. H. Lax, Leader API

R. Bennick	BP
T. Bera	Shell
P. Beu	Wawa
S. Broughton	Marathon Petroleum Corp.
R. Chapman	Consultant
J. Eckstrom	BP
J. Eichberger	Fuels Institute
E. W. English	Fuel Quality Services
S. Fenwick	Nat. Biodiesel Brd.
S. Golisz	Chevron
G. C. Gunter	Phillips 66
R. Haerer	US EPA
S. Hernandez	Chevron
J. Hove	Fuels Institute
C. Huang	Cummins
M. Kass	ORNL
R.P. Lewis	Marathon Petroleum Corp.
R. Long	PEI
J. Martinez	Chevron
R. McNutt	Sigma
K. Moriarty	NREL
N. Mukkada	Chevron
F. Passman	Biodeterioration Cntrl Assoc.
S. Pollock	Steel Tank Institute
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

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

R. L. McCormick, Leader NREL

T. Alleman	NREL	S. Kirby	Navistar
T. Bera	Shell	D. Lax	API
D. Bohn	Flint Hills Resources	R. Lewis	Marathon Petroleum Corp.
J. Chandler	Consultant	K. Mitchell	Consultant
R. Chapman	Innospec	H. Nanjundaswamy	FEV
J. Cruz	Daimler	M. Nikanjam	Chevron
E. W. English	FQS	S.B. Rubin-Pitel	ExxonMobil
S. Fenwick	Nat. Biodiesel Brd.	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	M. Valentine	Toyota Motor N.A., Inc.
C. Hodge	Consultant		
C. Huang	Cummins		

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J. Burgazli	Innospec
C. Chang	NASA
A. Clark	BP
E. Corporan	US Air Force
B. Culbertson	Honeywell
D. Cyr	Chevron
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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
C. Lewis	Chris Lewis Fuels Consultancy Ltd.
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
G. Valentich	Shell
M. Vaughn	IATA
P. Wilkins	DLA Energy
P. Wrzesinski	US Air Force
S. Zabarnick	UDRI

MEMBERSHIP

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D. M. DiCicco, Co-Leader	Ford Motor Company
H. Hamje, Co-Leader	ExxonMobil

H. Abedrabo	Toyota	D. Lax	API
R. Bennick	BP	S. A. Mason	Phillips 66
V. S. Constanzo	Aramco	M. Moore	Stellantis
J. Cruz	Daimler	V.R. Raj Mohan	Shell
A. Iqbal	Stellantis.	M. Sheehan	Chevron
C. Jones	General Motors	J. Y. Sigelko	Volkswagen of America
M. Kevnick	Volkswagen of America	F. Walas	Marathon Petroleum Corp
J. Kliesch	Honda R&D Am.		

Project No. SM-1 PANEL

D. M. DiCicco, Co-Leader	Ford Motor Company
H. Hamje, Co-Leader	ExxonMobil

H. Abedrabo	Toyota	D. Lax	API
R. Bennick	BP	S. A. Mason	Phillips 66
V. S. Constanzo	Aramco	M. Moore	Stellantis
J. Cruz	Daimler	V.R. Raj Mohan	Shell
R. De Kleine	Ford Motor Company	M. Sheehan	Chevron
A. Iqbal	Stellantis.	J. Y. Sigelko	Volkswagen of America
C. Jones	General Motors	M. Traver	Aramco
M. Kevnick	Volkswagen of America	F. Walas	Marathon Petroleum Corp
J. Kliesch	Honda R&D Am.		