Highlights from the Coordinating Research Council's

29th Real-World Emissions Workshop

by Susan Collet, Dominic DiCicco, Scott Mason, Megan Beardsley, Naveen Berry, Tom Long, Tao Huai, Matthew Thornton, Radha Purushothaman, Shirish Shimpi, and Seungju Yoon

The 29th Coordinating Research Council (CRC) Real-World Emissions Workshop was held on March 10–13, 2019, in Long Beach, CA. The workshop consisted of 56 presentations in 10 sessions, 54 posters, and 9 demonstrations of analytical and technical services by various vendors. More than 265 attendees helped set another record for the highest number of attendees. Session highlights follow.

Air Quality

Air quality research includes monitoring current ozone and projecting future ozone and particulate matter (PM) concentrations and determining the source apportionment, and is now expanding to decarbonizing scenarios. The 2016–2017 ozone increases in the Southern California Air Basin (see Figure 1) were primarily due to more frequent occurrence of meteorological conditions conducive to ozone formation. The fleet emission factor disparities between high- and low-socioeconomic status communities remain significant due to the different model-year distributions. Accurate source apportionment of PM emissions is needed for effective compliance with stringent regulations. A more accurate representation of secondary organic aerosol (SOA) chemistry in transport models is needed for developing efficient regulatory policies. Regarding options for decarbonizing the transportation sector, an analysis using current information found battery and fuel cell electric vehicles in California have a similar carbon dioxide (CO_2) intensity, and costs will depend on quantity sold.

Improving the Emissions Inventory

The emissions inventory can be improved by using updated in-use activity, and including volatile organic compound (VOC), nitrogen oxide (NOx), PM, and SOA emissions information. Emissions measurements from cargo-handling equipment during real-world operation revealed average in-use emissions were more than the certification standards, and the current inventory projections.

In Europe, emissions from vehicles with spark ignition engines with stop-start systems in urban traffic significantly exceeded limits for NOx and PM under real driving conditions. After treatment designs incorporating gasoline particulate filters can be used to mitigate PM emissions.

Updates to the heavy-duty vehicle activity is anticipated to significantly improve the understanding of emissions from the heavy-duty fleet. Results from a tailpipe NOx sensor study revealed the effectiveness of the after treatment system is dependent on the in-use duty cycle and is highly sensitive to operating temperatures. There is an ongoing assessment to determine a metric for a new paradigm of in-use NOx emissions compliance for heavy-duty on-highway engines. The goals are to cost effectively achieve additional NOx reductions and focus on in-use emissions, with consideration for sensor validation and durability.

Emissions Modeling

The U.S. Environmental Protection Agency (EPA) released the Motor Vehicle Emission Simulator (MOVES) version 2014b

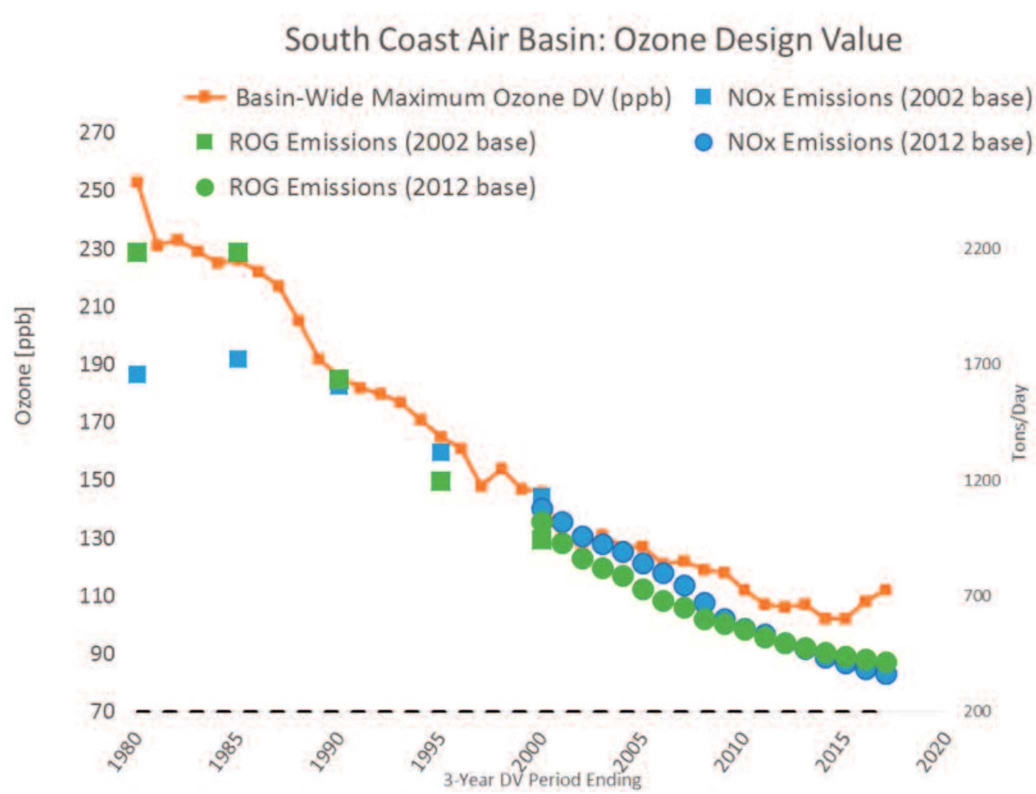

Figure 1. Southern California Air Basin ozone, reactive organic gas, and NOx trends, 1980–2017.

in August 2018; updating non-road engine and diesel fuel parameters. The next MOVES major version release is in 2020 at the earliest, and will incorporate new data on emission rates and vehicle activity estimates. To refine mobile source emission inventories in the emissions factors model (EMFAC), the California Air Resource Board (CARB) is using new techniques including automated license plate monitoring and on-board diagnostic scans.

Elsewhere around the world, portable emission monitor data from an urban route was compared to four different microscale modeling approaches to explore possible upgrades to Hong Kong's EMFAC-HK. In Mexico City, remote sensing device (RSD) emission results suggest the Mexico City light-duty vehicle evaporative emissions are significant. Artificial neural networks were able to predict fuel consumption for individual gasoline and diesel vehicles. With access to velocity estimates and ambient data, such models could help optimize routing for fuel consumption and/or tailpipe emissions.

Light-Duty Vehicle In-Use Emissions

Light-duty vehicle emission variations were studied. Real-world microscale vehicle activity and emissions show large variability in emission rates between road segments. Inter-road segment variability correlated with characteristics such as average grade and vehicle activity. After 29 years, on-road vehicle emission changes at two sites in a South Los Angeles neighborhood show tailpipe carbon monoxide emissions decreased by factors of 10 and 20 and hydrocarbon emissions decreased by a factor of 25 with unchanging fleet age (see Figure 2).

In Europe, 2018 model-year pre-real driving emissions gasoline and diesel vehicles are exceeding Euro 6 limits under real driving conditions. Diesel vehicles can meet Euro 6 limits under real driving conditions using a range of exhaust treatment technology. Soot mass (or black carbon), PM mass, and solid particulate number emissions were lower from vehicles equipped with gasoline particle filters (GPFs). CO_2 emissions were not impacted by GPFs.

Heavy-Duty Vehicle In-Use Emissions

Studying in-use heavy-duty vehicles is ongoing. Preliminary results of in-use emissions testing of heavy-duty vehicles using portable emission measurement systems (PEMS) reveal the effects of three-way catalysts aging on NOx emissions rate from older model-year stoichiometric natural gas engines. The current manufacturer heavy-duty in-use testing (HDIUT) program needs to be able to fully identify noncompliant engines.

CARB has started a first-of-a-kind heavy-duty surveillance program to verify the effectiveness of after treatment systems for in-use vehicles. Measurements on-road with PEMS and for chassis and engine dynamometer tests indicate that in a number of modes of operation NOx emissions from 0.2g/bhp-hr NOx vehicles will be greater than 0.2 g/bhp-hr. In addition, data may more realistically reflect real-world emissions if not-to-exceed boundaries are modified.

A study of heavy-duty diesel engine cold-start and idle NOx emissions showed not-to-exceed emission limit exceedances. Industry proposed a cost-effective paradigm shift from prescriptive laboratory-based to performance-based compliance programs, which utilizes on-board sensors, telematics, emissions data aggregation, etc.

Particulate Emissions and Measurement

Test equipment to measure diesel PM and vehicle hardware to control diesel PM is being evaluated. A comparison of PEMS with laboratory grade particulate number systems showed similar results. Low-cost particulate number measurements for the new European inspection maintenance regulations (Periodic Technical Inspection, PTI) showed condensation particle counters are acceptable for performance and operational demands. Another study found diesel particulate filters (DPFs) effectively control diesel PM emissions and reduces the solid fraction of PM. Control of crankcase particle emissions is being researched.

Off Road/Non-Road Emissions

EPA is working to improve the non-road emissions model by collecting and analyzing real-world activity data from a variety of non-road vehicles and equipment. CARB's future off-road inventories are likely to include more idling time and load bins. Brake-specific emissions using a broad spectrum of organic compounds were analyzed from non-road diesel engines with various after treatment configurations.

Fuel Effects on Emissions and Fuel Economy

The effect of different fuel types on emissions were studied. Using premium fuel in a premium-fuel-recommended vehicle may result in increased fuel economy and increased performance. The ethanol blending effects on vehicle emissions showed predictions from a model must account for ethanol composition and properties. A decrease in test temperature has a greater impact on PM emissions for light-duty gasoline direct injection vehicles than a change to the gasoline properties T50 and RVP. Hot-running emissions from a natural gas engine were below the 0.02 g/bhp-hr heavy-duty vehicle criteria pollutant standard. Fuel blends influence exhaust and in-cylinder concentrations of polycyclic aromatic hydrocarbons. Engine-out emissions from a light-duty diesel vehicle operating on hydrogenated vegetable oil were lower than its emissions while operating on ultra-low sulfur diesel fuel.

Figure 2. On-road vehicle emissions test site in Lynwood, CA, at I-710 and, Imperial Highway; top is from December 1989, bottom is May 2018.

Emission Measurement Methods

Various approaches are available to measure the emissions from vehicles and more are being explored. PEMS provides real-world emissions data by measuring vehicle emissions while the vehicle is operating under real driving conditions. Other emission measurement methods are remote sensing, and use of chassis and engine dynamometers. A European process incorporated a data collection system for "comparative" testing rather than "compliance" testing. A CARB project explored the abilities and limitations of on-road PEMS testing and measurement uncertainties. A "road-to-lab" study will be conducted to compare vehicle emissions results between PEMS and chassis dynamometer data. Other studies being conducted are projects involving on-board monitoring; control of after treatment systems using radio frequency sensors; the sensitivity of radio frequency measurements in detecting changes in engine-out conditions; and the capability of low-cost PEMS to find high concentrations of test vehicle emissions and ambient air.

Emissions Control Measures

Characterizing heavy-duty diesel vehicle emissions and their engine after treatment operation characteristics could further assist in controlling real-world emissions and in developing effective emission control measures. Heavy-duty diesel vehicles equipped with DPFs at the Port of Los Angeles showed increases in PM emissions over time due to DPF deterioration. However, fleet-wide PM emissions decreased as older non-DPF-equipped trucks were retired and replaced by newer DPF-equipped trucks.

Most DPF-equipped trucks emit black carbon emissions near or below their PM certification standards. About 4% of the trucks in the on-road fleet emit 50% of black carbon emission. However, NOx emission factors from selective catalytic reduction (SCR)-equipped trucks could be three to four times higher than their certification standards. For the SCR-equipped trucks, the first 10 minutes of operation could contribute a disproportionally high percentage of NOx emissions due to low-load and low-temperature operations.

An approach for a comprehensive heavy-duty vehicle inspection and maintenance program that could be implemented in California is being explored. One study suggests significant reductions in NOx and PM opacity after repairing a vehicle's faulty emission control components.

Next Workshop

The 30th Real-World Emissions Workshop is scheduled for March 15–18, 2020, in San Diego, CA. **em**

Susan Collet is an executive engineer at Toyota Motor North America Inc.; **Dominic DiCicco** is an environmental and energy manager at Ford Motor Company; **Scott Mason** is a fuels specialist at Phillips 66 Company; **Megan Beardsley** is an environmental scientist at the U.S. Environmental Protection Agency (EPA); **Naveen Berry** is an assistant deputy executive officer at South Coast Air Quality Management District (SCAQMD); **Tom Long** is a mechanical engineer at EPA; **Tao Huai** is a branch chief at California Air Resources Board (CARB); **Matthew Thornton** is a principal research engineer at the U.S. National Renewable Energy Laboratory (NREL); **Radha Purushothaman** is an engineering specialist at Caterpillar Inc.; **Shirish Shimpi** is a director of emissions development, at Cummins Inc.; and **Seungju Yoon** is a manager at CARB.

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