Highlights from the Coordinating Research

Session highlights from the 2013 MSATs workshop.

The Coordinating Research Council’s (CRC) 2013 Mobile Source Air Toxics (MSATs) Workshop was held February 5–6 at California Air Resources Board headquarters in Sacramento, CA. This workshop has been held every other year since 2002. The purpose of the workshop is to bring together researchers and practitioners to review the status and current knowledge regarding vehicle related mobile source air toxics. The overarching themes of the 2013 workshop were the ongoing trend of reduced vehicle emissions and improving air quality in urban areas in the United States. The following topics were organized into one plenary session and six technical sessions: regulatory aspects, air quality and exposure measurement, air quality and modeling, vehicle emissions and vehicle emissions modeling, atmospheric transformations, and trends and accountability. The workshop featured 35 oral presentations and 6 posters during two days with over 100 participants. The agenda, the workshop proceedings, and all presentations are available on the CRC Web site at www.crcao.org. The sessions are summarized below.

Plenary Session

**Trends in Toxics Emissions**

Efforts to control urban ozone over the past five decades have led to 30- to 50-fold decreases in toxic volatile organic compounds (VOCs), such as formaldehyde and acetaldehyde, in Los Angeles. Vehicle emission standards that reduce hydrocarbons, together with fuel benzene controls, have led to approximately a 65-fold reduction in benzene. It is likely that reductions of similar scale have occurred throughout the United States.

**Control of Diesel Emissions**

Historically, emissions from heavy-duty engines have been major contributors to local air pollution. However, in recent years, new technology diesel engines (NTDE) and stoichiometric natural gas engines have started to be introduced to the fleet. NTDE are equipped with advanced after-treatment, such as diesel particle filters and selective catalytic reduction. Stoichiometric natural gas engines are equipped with three-way catalysts. In addition to vehicle actions, ultra-low sulfur fuel has been introduced. The combination of vehicle and fuel actions has led to dramatic reductions in emissions of almost all exhaust components.

**Methods to Evaluate Toxicity**

To assess the relative toxicity of mobile source emissions the conceptual aspects of a screening methodology are being investigated. While human and animal studies provide highly relevant health effects information, a simple screening methodology would be useful for testing a large number of samples in a timely and cost-effective manner. Efforts to harmonize test methods and protocols, as well as attention to quality assurance/quality control measures, are being discussed in an attempt to make results more readily comparable across agencies and laboratories.

by Susan Collet, Timothy J. Wallington, Steve Japar, and Debra Kaden

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Regulatory Aspects

The U.S. Federal Highway Administration (FHWA) has developed an interim guidance explaining when and how to analyze MSATs for highway projects. This was done under the auspices of the National Environmental Policy Act. Additionally, the U.S. Environmental Protection Agency (EPA) released an improved on-road emissions model, Motor Vehicle Emission Simulator (MOVES2010b). National MSATs emission trends for vehicles operating on roadways for 2010–2050, as projected using MOVES2010b, are shown in Figure 1.

Air Quality and Exposure Measurements of MSATs

The relationship between near-road nitrogen dioxide (NO₂) concentrations and the factors determining those concentrations is currently not well understood. Factors controlling downwind NO₂ concentrations include wind direction, wind speed, proximity of the monitor to the roadway, traffic patterns, vehicle counts, fraction of heavy-duty vehicles, buildings and barriers, and urban background ozone and NO₂ emissions.

Near-source monitoring is a new aspect of the National Ambient Air Quality Standard process. This approach to air monitoring enables progress on reductions of regional and secondary pollutants to be tracked. New near-road monitoring stations located along major roads and arterials in large population centers are expected to provide micro-scale, high temporal resolution of vehicle-related multipollutant concentrations in urban areas.

Air Quality and Exposure Modeling of MSATs

To accelerate emission reductions from in-use diesel engines, the California Air Resources Board (CARB) implemented a series of regulations that require retrofit and/or replacement of older diesel engines in areas with high diesel traffic, such as ports. The initial phase of the emission control rule took effect in January 2010, and by June 2010, 50% reductions in black carbon emission factors and 40% reductions in nitrogen oxides (NOₓ) emission factors were observed in Oakland, compared to 2009 levels.

The increased use of ethanol in transportation fuels warrants an investigation of its consequences. An important component of such an investigation is the temperature dependence of ethanol and gasoline emissions on urban air pollution. Results were presented from a modeling study, which concluded that conversion of the entire South Coast Air Basin vehicle fleet to E85 in 2020 would slightly increase ozone, compared with gasoline, in the presence or absence of a fog under summer conditions. However, during winter conditions ethanol increases ozone relative to gasoline, although winter ozone is always lower than summer ozone.

A study comparing near-roadway air quality monitoring data observed in close proximity to the I-710

Figure 1. National MSATs emission trends for vehicles operating on roadways 2010–2050, as projected using MOVES2010b.

Source: EPA MOVES2010b model runs conducted during May-June 2012 by FHWA.
freeway with modeled concentrations was presented. Carbon monoxide (CO) concentrations were generally under-predicted for all time periods. NOx emissions were mostly associated with truck traffic for the I-710 freeway and were generally over-predicted in summer and under-predicted in winter.

The 2011 National Air Toxics Assessment (NATA) is scheduled to be released in 2014. Airports and heliports, as well as shipping ports and shipping lanes, will be added to this NATA as point sources. The mobile source component will use MOVES-2010b and NONROAD2008. The new NATA version will also model secondary formation of formaldehyde, acetaldehyde, and acrolein, and account for transformation of 1,3-butadiene.

Emission Factors 2011 (EMFAC2011) was released by CARB in September 2011, replacing the previous EMFAC2007 version. Predictions made by the two versions were compared for Los Angeles County in the year 2035. Average diesel particulate matter (PM) emission factors projected by EMFAC2011 were 79% lower than projected by EMFAC2007. Brake-wear PM emissions were predicted to dominate over exhaust PM emissions for all vehicle categories.

Vehicle Emissions Modeling
Idling of heavy-duty trucks, particularly for long periods such as overnight at truck stops, has been shown to degrade local air quality. In combination with inversion layers typical of the early morning hours, these areas become “pollution hot spots” for PM and air toxics. However, newer trucks emit much lower amounts of pollutants than older trucks (see Figure 2). Thus, as newer trucks penetrate the fleet to a greater degree, the impact of truck idling will become less detrimental to air quality.

The simultaneous demands to increase fuel economy and reduce emissions are a challenge. Gasoline direct injection was introduced as a technology to increase gasoline engine fuel economy, but now faces considerable development demands to meet the more stringent PM emissions standards. Increasing ethanol content in gasoline fuel adds another variable. Low-level ethanol blends were found to have only a small impact on PM emissions, with blends using 20% ethanol (E20) resulting in a slight decrease in PM emissions.

Emissions from increasing use of emerging renewable oxygenates such as iso-butanol are not well understood. Observations indicate butanols are more reactive than ethanol during combustion and/or while transiting the three-way catalyst producing more carbonyls than ethanol. Benzene emissions appeared to decrease with increasing volumetric concentration of blending alcohol, while emissions of 1,3-butadiene were unaffected by alcohol blending.

Atmospheric Transformations
Some motor vehicle emissions are emitted as PM (referred to as primary PM), but the majority are emitted as gas. Some of the organic gases undergo gas-to-particle conversion in the atmosphere (referred to as secondary organic aerosol [SOA] formation). SOA formation from vehicle exhaust was addressed in using a photochemical smog chamber. Extrapolating chamber data to conditions in real urban air masses is complex and the fractional contribution from gasoline and diesel exhaust emissions to ambient SOA in urban environments remains poorly known.
Understanding Today’s
Clean Air Act Permit Programs

Get up-to-date on the latest rules impacting NSR and Title V permitting: the Greenhouse Gas Tailoring Rule; the New Ozone, NO2 and PM2.5 NAAQSs; modeling; NEPA issues; CAFO sources, and more.

This two-day workshop will cover permitting changes presented by both national and regional leaders in the field.

Workshop Faculty Include:
Colin Campbell, Principal, RTP Environmental
Gale Hoffnagle, Senior Vice President and Technical Director, TRC Environmental Corporation
Dave Jordan, Program Director, ERM
Mark Smith, Chief of Air Permits and Compliance Branch, U.S. EPA, Region 7

Sponsorship and exhibit opportunities are available.

Trends and Accountability
Studies of airborne VOCs show decreases in VOC emissions. The sources of these VOCs are predominantly on-road vehicle emissions, and include several air toxics (including benzene, 1,3-butadiene, formaldehyde, and acetaldehyde), as well as various reactive hydrocarbons that efficiently form SOA and ozone. The mixing ratios of VOCs and CO in ambient air in Los Angeles have decreased approximately 50-fold during the past 50 years, at an average annual rate of 7.5%.

Malfunctioning vehicles are a disproportionate source of emissions in the total fleet, and their contribution has been increasing as overall emissions decrease. For example, the proportion of emissions from malfunctioning vehicles increased from 16% to 32% 1995–2003, even though the percentage of malfunctioning vehicles in the fleet decreased from 10% to 5% over that same time period. Most malfunctioning vehicles are at least 10 years old and generally have higher acetylene emission rate ratios. The effective identification and control of these malfunctioning vehicles will become increasingly important for improving mobile source emission estimates as well as reducing future tailpipe emissions.

Summary
There is an ongoing trend of reduced vehicle emissions and improving air quality in urban areas in the United States. Even as vehicle miles traveled have increased, there has been a large decrease in toxic VOCs. New diesel technology engines with ultra-low sulfur fuel have led to reductions in exhaust emissions. Identifying and controlling malfunctioning vehicles is important to improve emission estimates and reduce tailpipe emissions. Further research is needed on cost-effective methods for mobile source emissions toxicity screening, the relationship between vehicle emissions and near-road NO2 concentrations, changes in emissions associated increasing use of ethanol, and gas-to-particle conversion (SOA formation) in the atmosphere.

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