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UTC Spotlight

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Vermont's TAQLab Works to Close Knowledge Gaps in Vehicle Tailpipe Emissions

On-road, real-world data on how second-by-second driving style, hybrid vehicles, climate, and topography affect vehicle tailpipe emissions are scarce. The University of Vermont (UVM) Transportation Air Quality Laboratory (TAQLab), which opened in May 2009, was designed as a research hub for efforts aimed at filling such data gaps. Although researchers who work directly in the lab are predominantly engineers, the Vermont University Transportation Center (UTC) paired the group with social scientists to study public understanding of factors affecting tailpipe emissions as well as to design programs to advance public knowledge.

Andy Duback

Transportation Air Quality Lab Research Vehicle – 2010 Hybrid Toyota Camry used to compare Hybrid to Nonhybrid emissions.

The on-campus TAQLab research facility houses instrumentation used to collect real-world, onboard, and lab-based emissions from light-duty gasoline vehicles and diesel engines running on biodiesel fuels. Unique to this laboratory are instruments capable of collecting high temporal resolution (in some cases sub-second) data on vehicle and engine operation as well as exhaust gas and particle emissions. The TAQLab team studies carbon emissions, which have global impacts, as well as ultrafine particle emissions that create local public health challenges. The team investigates substances regulated by the Environmental Protection Agency (EPA) as well as unregulated particle number and air toxics.

Andy Duback

Tailpipe Adapter for the Total On-Board Tailpipe Exhaust Measurement System (TOTEMS)

In a large multiyear USDOT UTC grant, TAQLab researchers comparing emissions from hybrid and nonhybrid vehicles have discovered surprising results. It is widely acknowledged that greenhouse gas (GHG) tailpipe emissions vary with fuel efficiency and thus fuel efficient hybrids offer a benefit. Knowing that vehicle acceleration generally results in the highest emission rates, researchers originally hypothesized that hybrids might offer a reduction in particle number and air toxics emissions due to the combined power of the electric and conventional motors during acceleration. However, initial findings presented at two conferences in the last year indicated that while driving the same route, the cumulative emissions were always higher from the hybrid. Researchers suspect that the continuous restarting of the internal combustion engine (ICE), as the hybrid switches from electric motor to ICE propulsion, contributed to increased particle number emissions even though overall fuel efficiency was improved and carbon emissions were reduced.

Vehicles with onboard test equipment are driven on a route that includes city, rural, and Interstate roads, on both flat and hilly terrain. Instruments, typically used in the laboratory, were securely placed in the vehicle so that vibrations and movement would not affect real-world measurements. A tailpipe adapter, built by the research group, feeds particles to a heated sample line that ensures the ultrafine particles do not change composition before being counted by the instrument in the vehicle.

The TAQLab team tracks vehicles and second-by-second driving styles using Global Positioning Systems, roof-mounted accelerometers, and an onboard diagnostics device that logs vehicle speed. Knowing the location, velocity, and acceleration of the vehicle allows the group to compare emissions by road type, at intersections, and on grades. Data have demonstrated that speed, acceleration, and road grade are associated with emissions, but the relative relationships are a function of the driver. To document driving styles, the team's first experiment is designed to compare drivers more than 70 years old with drivers aged 21 to 35 years. Results thus far indicate statistically significant differences in age-related driving styles. The same equipment is now being deployed in a UTC VTrans partnership to study idling behavior and how it varies throughout the seasons in Vermont's northern climate.

In an interdisciplinary effort, UVM social scientists are studying how citizens can participate in tailpipe emission solutions. A series of focus groups have demonstrated that people generally have little knowledge about tailpipe emissions or how to decrease them. In an effort to bring scientific research studies to the public, the Vermont Clean Cities Coalition, a major component of the U.S. Department of Energy and hosted by the Transportation Research Center (TRC) at UVM, is actively campaigning eco-driving educational workshops. These workshops are a simple, low-tech way to reduce fuel consumption and GHG emissions while saving consumers money by promoting energy-reduction strategies that encourage fuel-efficient driving. Target audiences for eco-driving workshops include public and private fleets, driver education programs, and the general public.

Andy Duback

Eco-Driving provides hands-on energy-reduction strategies for communities and businesses.

About This Project

The TAQLab is a joint venture of the UVM TRC and the School of Engineering in CEMS. The research is funded by the US DOT's UTC program, and is part of the TRC project, "Emissions and Performance of Alternative Vehicles in Northern Climates," led by School of Engineering Associate Professor and TAQLab Director Britt Holmén. Graduate students Karen Sentoff and Mitchell Robinson collected the on-road particle data. UVM UTC Director Dr. Aultman-Hall (laultman@uvm.edu), Professor of Engineering together with Ph.D. candidate Nathan Belz are conducting the driving style experiments. The UTC VTrans partnership studying idling is led by Jim Sullivan. Focus groups have been led by Drs. Richard Watts and Thomas Macias. The Vermont Clean Cities Coordinator is Tom McGrath.