

Loop Holes for Air Pollution



Randall Guensler received his Ph.D. from UC Davis, where he worked as an ITS research engineer. Recently appointed assistant professor at Georgia Institute of Technology, he conducts research on vehicle emissions.

Scientists have underestimated how much motor vehicles pollute, primarily because laboratory tests don't capture the full range of vehicle emissions from a representative fleet.

By Randall Guensler

Many studies have shown that the amount of air pollution caused by motor vehicles is significantly underestimated. Although millions of vehicles have been tested for compliance with federal emissions standards over the past 20-plus years, many researchers are convinced that commonly used laboratory tests are not good indicators of how much a vehicle will pollute in real life. As a result, new research into vehicle emissions has focused on the role of so-called "high emitting" vehicles. Our questions: (1) Do a small number of vehicles – "superemitters" – cause a large percentage of air pollution? (2) Is there a small fraction of vehicle activity that causes vehicles to emit great quantities of pollutants ("superemissions")?

"Missing" Emissions

The simple answer to these questions is that superemitters exist, and so do superemissions. And recent research indicates that both superemitters and superemissions may be responsible for a large portion of the emissions that are "missing" from current emissions estimates.

It is common in research literature and the popular press to see estimates that 10% of the vehicle fleet accounts for 70% of all vehicle emissions. Yet legitimate studies conducted in recent years have come up with widely varying estimates of the emissions that should be attributed to superemitters. Various researchers have asserted that 5% of the fleet causes 25% of all emissions, that 15% of the fleet causes 43% of emissions and that 20% causes 60% of emissions.

Clearly there are emissions occurring during actual vehicle operation that are not captured by widely accepted laboratory tests. In particular, the federal test procedure puts vehicles through a fixed cycle of operation that never varies the pattern of acceleration, deceleration, cruise, and idle. However, we cannot reasonably presume that vehicles operate in the same manner on the road as they do on the test. For instance, rapid acceleration – believed to be one of the main causes of superemissions – simply does not occur during the federal test procedure (FTP). And because the parameters of the test cycle have been fixed for approximately 20 years, it is reasonable to believe that automakers can design their vehicles to obtain the best possible scores on the FTP test. Whether or not the auto industry produces designs specifically to meet the FTP, it is rea-

sonable to assume that manufacturers will select emission control configurations that reduce the risk of recalls.

Evidence of Superemitters

Superemitters – increasingly known in the popular press as "stinkers" – are often defined as those vehicles with the highest 1% of tested emission rates. The EPA has defined superemitters as those vehicles with emissions rates greater than five times the certification standard. Evidence that superemitters exist comes from three primary sources: 1) The federal test procedure emission testing database (FTM); 2) Data collected during the inspection and maintenance program (I&M) and roadside testing for validation of program results; and 3) Onroad remote sensing studies.

The FTP and I&M test databases are the most comprehensive sources of emission testing in terms of the number of vehicles tested. Thousands of vehicles are tested on the FTP and millions of vehicles are tested in the I&M program to determine whether they comply with in-use motor vehicle emission standards. These databases clearly indicate that a small percentage of vehicles have disproportionate emission rates. If

Large emission increases associated with high power and load conditions--such as rapid acceleration or high speed activities--are at the heart of the current emission research problem.

vehicles were operated on the FTP throughout their duty cycle, it would be reasonable to assume that a small percentage of vehicles would be responsible for a large percentage of on-road emissions. However, the FTP uses only one set of modal patterns—acceleration, deceleration, cruise and idle. It cannot be presumed that vehicles operate on the road as they do on the FTP test. While the FTP can detect the presence of vehicles that emit at least five times the certification standard, it cannot measure the full extent of the superemitters' output of carbon dioxide and hydrocarbons. This means that only limited conclusions can be drawn from the data.

Onroad emission tests also indicate that a small percentage of vehicles contribute to a large portion of onroad emissions. Remote sensing devices can accurately measure instantaneous emission concentrations in the exhaust plumes of vehicles as they pass by a roadside monitoring station. Using remote sensing data, the Desert Research Institute concluded that the dirtiest 25% of the fleet may be responsible for more than 84% of the carbon monoxide emissions. However, data collected by remote sensing devices are also limited. Such devices capture only a snapshot of vehicle emissions in time, and assumptions must be made to estimate emission rate information from measured emission concentrations.

Evidence of Superemissions

A small fraction of vehicle activities appear to be responsible for instantaneous puffs of superemissions, which

result when the air-fuel ratio drops and insufficient oxygen is present for complete combustion of the fuel. These low air-to-fuel ratios—known as “enrichment conditions”—tend to occur when drivers demand additional power from their vehicles. (For example, “enrichment” helps to improve engine performance during hard acceleration and high speed operations, or to operate accessories.) Enrichment conditions may also kick in to protect cylinders, valves, and catalysts from temperature damage during high RPM activity and to control engine knock.

The primary sources of evidence that superemissions come from a small fraction of vehicle operations are the onroad remote sensing studies and studies that use instrumented vehicles equipped with onboard emission monitors.

The Problem and the Solution

The first indications that enrichment conditions were probably causing a large portion of vehicle emissions not captured by FTP test conditions were reported initially for single vehicles, and later for a small instrumented fleet of vehicles. Large emission increases associated with high power and load conditions, such as rapid acceleration or high speed activities, are at the heart of the current emission research problem. Carbon monoxide emission rates under enrichment conditions can soar as high as 2,500 times the emission rate noted when air and fuel are perfectly balanced. Although most vehicles spend less than 2% of their total driving time in severe enrichment, this can account for up to 40% of total carbon monoxide emissions.

New testing and modeling methods can capture the high emissions associated with both superemitters and

(Continued on back page)

A Look at Georgia Tech's Emission Research Program

Research over the past several years has suggested that existing mobile-source emission models are limited in accurately estimating emissions from highway vehicles. Not only has this research shown discrepancies between estimated and measured emission levels, but some researchers have even called into question the very structure of existing models.

To help rectify these discrepancies and improve the accuracy of measuring mobile source emissions, the Georgia Institute of Technology in Atlanta has formed a unique research entity called the Georgia Tech Research Partnership, a collaboration among public and private enterprises. The Partnership is a multi-million dollar program with a majority of funding provided by the Environmental Protection Agency.

Automakers Involved

While two professors from Georgia Tech's Department of Civil and Environmental Engineering, along with eight principal researchers, oversee the new emission program, the partnership is drawing on the expertise and resources of eleven other organizations, including three automobile manufacturers, which individually and in combination have unique capabilities.

One of the principal investigators in the Partnership's research program is Randall Guensler, who received his Ph.D. in civil engineering from UC Davis, where he also worked as a research engineer at the Institute of Transportation Studies. Guensler said the Partnership is unique in emission research for two reasons—first, because of the involvement of automakers, who will be contributing vehicles as well as staff, and second, because of the comprehensive and integrated approach to the emissions research.

“This is the first time that each emission component, such as fuel type

(Continued on back page)



INSTITUTE OF TRANSPORTATION STUDIES
 University of California
 Berkeley, California
 94720-1720

Nonprofit Org.
 U.S. Postage
 PAID
 Berkeley, CA
 Permit No. 1

ADDRESS CORRECTION REQUESTED

LOOP HOLES

(Continued from page 3)

superemissions. Studies indicate that we should sample a more representative vehicle fleet (one that includes more superemitters) and model emissions as a function of varied acceleration, deceleration, cruise, and idle activities.

Obstacle to New Models

It will not be easy to develop new models. Our analysis of vehicles tested on a variety of testing cycles demonstrates substantial variability in vehicle emissions in response to changes in emission testing cycles. The variability indicates that the effects of changes in operating conditions may be more difficult to model than the recent limited evidence has indicated. Specifically, from one test cycle with one set of characteristics to another cycle with another set of characteristics, some emissions will increase while others will decrease. To address uncertainty about vehicle emissions behavior, a great deal of additional data need to be collected, disseminated and analyzed. Defining the role of high emitting vehicles and enrichment conditions in the new emissions modeling regime will be a critical component of this process.

GEORGIA'S RESEARCH PARTNERSHIP

(Continued from page 3)

and vehicle activity—has not been thought of as being independent. The program will be looking at inter-correlations that haven't been accounted for in the past," Guensler said. He also noted that the Georgia program will be more advanced because of the substantial level of "real world" testing of vehicles—that is, testing the emissions of vehicles on the road instead of in the laboratory.

Diverse Resources from Partners

Members of the Partnership include the Atlanta Gas Light Co., Ford Motor Co., General Motors Research Laboratories, the Georgia Department of Natural Resources, the Georgia Department of Transportation, Toyota Motor Co., the U.S. Environmental Protection Agency, the Georgia Research Alliance, NGV Development Co., NGV Southeast and Systems Applications International, a consulting firm with extensive experience in emissions modelling. The Partnership intends to include other major auto manufacturers at a later date.

Atlanta Gas Light Co., NGV Development Co. (a consortium of companies developing natural gas vehicles) and NGV Southeast (a division of NGV Development) are providing research capabilities in the area of alternative fuels, while

the government agencies are contributing skills in data collection, analysis and quality assurance. Georgia Tech, the lead organization in the Partnership, brings transportation and air quality expertise to the research program. As an example of the cooperation among the partners, the Atlanta Gas Light Co. and NGV Development Co. have agreed to incorporate Georgia Tech laboratory space into the design of NGV Southeast's new alternative fuel dynamometer test facility in Atlanta, where alternative fuels such as compressed and liquefied natural gas, methanol, ethanol, hydrogen, and reformulated gasoline will be tested on light and medium duty vehicles and city buses.

Further information about the Georgia Tech Research Partnership can be obtained by contacting Dr. Michael Meyer (404-853-3094) or Dr. Randall Guensler (404-894-0404).

- By David Rompf

ITS REVIEW

Published four times a year by the
 Institute of Transportation Studies
 FAX (510) 642-1246
 David Rompf, Guest Editor
 Lyn Long, News Coordinator-Irvine
 Carol Earls, News Coordinator-Davis
 ISSN 0192 3994

PATH photos courtesy of the California Department of Transportation. Page 2 photo of Randall Guensler courtesy of Morris Semiatin.