Fighting for Air

Manufacturers enlist scientists to meet EPA regulations

BY CANDI S. CROSS

As the temperature staggers above 90 degrees, the last place anyone wants to be trapped is an automobile, particularly one that's being filled with the exhaust fumes of surrounding idle engines. In Atlanta, the skyline captures a summery sight to fixate on: thick rings of pollution made up of nitrogen oxide (NOx), particulate matter (dust, soot, fly ash, and diesel smoke), and ground-level ozone.

According to *USA Today,* travel on U.S. interstates and other federal highways increased 38 percent from 1990 to 2000 — from 600 billion annual vehicle miles to 839 billion nationwide. Not surprisingly, just-in-time manufacturing processes were cited as a major contributor to road congestion because of an increased reliability on components being trucked to factories as needed instead of being stocked in warehouses.

Besides the agonizing monotony associated with an everyday commute that's slower than a swamp turtle, the congestion brings fumes that offer more than an unpleasant smell. Scientists at the High Temperature Materials Laboratory (HTML) of Oak Ridge National Laboratory in Oak Ridge, Tenn., have analyzed the components of these fumes, exposing their ugly trail of health hazards.

Other researchers discovered long ago that air pollution from cars, factories, and power plants is a significant cause of asthma attacks — even in previously healthy people without respiratory problems. The Natural Resources Defense Council reports that 30 percent of childhood asthma is due to such environmental exposures, costing the United States $2 billion a year.

Air quality tests in multiple cities have revealed a severe number of particulates, which, if passed through the nose or throat, could get lodged in the lungs and cause irreversible damage and premature death. As a result, the Environmental Protection Agency established emissions control regulations to reduce diesel pollution from new heavy duty diesel trucks and buses. Based on preparations by engine parts manufacturers to meet a 2006 deadline, diesel fuel is proposed to contain 97 percent less sulfur. Simply put, this ultra-low sulfur diesel fuel in combination with advanced pollution control technology means that new trucks and buses rolling off the production lines should be up to 95 percent cleaner than previous models.

According to John Millett of EPA's press office, engines within the existing fleet will not be subject to the new regulations and may remain in operation for another 25 to 30 years. However, he expects that engine parts manufacturers have upgraded their testing labs and production lines considerably under the threat of serious consequences for falling short.

"The primary consequence would be if an engine were not certified for sale by the agency. Engines must be certified by EPA as meeting the new standards. It's important to note, however, that manufacturers have had a long lead-time — since early 2001 — to prepare for the new standards," says Millett. "Presumably there could be fines of as much as $32,500 per violation per day and any number of restrictions as the facts of a case merit, but the process of certification and recalls (in the case of faulty emissions systems) is built to avoid that as much as possible. That's not to say, however, that there haven't been enforcements actions in the past or that we would rule out such actions in the future if necessary."

The components of compliance

Companies such as Detroit Diesel, Freightliner LLC, and International Truck and Engine (which invented the Green Diesel Technology bus), dedicated gargantuan budgets and hours to meet the standards. In a succinct effort to minimize parts construction mistakes, specialized researchers helped determine the materials that would optimize the engine upgrades. For instance, HTML, a state-of-the-art facility of six distinct science centers, assessed hundreds of products for durability, heat and stress resistance, mechanical behavior, and thermal conductivity.

Created in 1985 to help the American automotive industry solve tough materials problems, HTML was originally called the Office of Transportation Materials. The organization accrued $70 million per year in project funds with the mission of developing high-efficiency diesel engines. According to HTML Director Arvid Pasto, the branch harbors 30 to 40 of the world's leading experts in chemistry and science at any given time, handling the intricacies of 70 to 100 projects per year.

"Companies can come to us with their problems and we help them using our expertise and technology. We study the microstructure and composition of materials down to atomic resolution if necessary, measuring the crystal structure and measuring the stresses in parts that have been manufactured, the mechanical properties of materials, how they fail," says Pasto, whose own niche education incorporates ceramic science. "All of these things play in composite breakdown. Things like aluminum or magnesium or high-strain steels to make cars more lightweight is also of interest to us. We deal with all materials that could be used in the transportation arena. ... We have a unique system that doesn't have a comparison."

Trucks and vehicles produced by Freightliner LLC and the Detroit Diesel Corp. undergo thousands of test hours in order to meet EPA emissions control standards.

Millett asserts that manufacturers are now prepared to meet the new standards. He stands by the most recent EPA report that the emission reductions will prevent 8,300 premature deaths, more than 9,500 hospitalizations, and 1.5 million lost work days. "There are well-established methods for estimating the health effects of air pollution. At full implementation of the highway diesel regulations, by 2030 EPA estimates these benefits will be realized on an annual basis," he says.

BEYOND BORDERS

More than a half-million people die each year in Southeast Asia and the Pacific due to air pollution.

The World Health Organization released a report several years ago citing that seven of 10 cities with the worst pollution worldwide were in Asia. The result of smog and free-flying pollutants is that approximately 537,000 people in Southeast Asia and the Pacific die prematurely each year due to air pollution.

Why have governmental and commercial figures been so lax about the state of health in their communities? In conjunction with organizations such as the Korea Environment Institute and the United Nations Environment Programme, Dieter Schwela of the Stockholm Environment Institute investigated the conditions of 20 areas. The physicist and his research team found reasons for this startling complacency: "Lack of political will, lack of funding, little public and media awareness, lack of analyses of costs of health and environmental impacts versus costs of control measures," according to Schwela.

During site evaluations, cities were rated for their capabilities to manage air quality. Bangkok, Shanghai, Seoul, Singapore, Tokyo, and Taipei were identified as having thorough tools in place to control emissions. In contrast, Dhaka, Hanoi, Surabaya, and Kathmandu showed poor capabilities to manage air quality. "Based on their responses to a questionnaire, they do not implement a majority of tools usually applied in air quality management," says Schwela, whose prominent research centers on exposure and risk assessment of air pollutants. "Only few epidemiological studies exist. If we conclude from developed country studies cardio-respiratory ailments would be common consequences of exposure to air pollution."

Schwela strongly recommended active measures that Hong Kong and Tokyo have implemented for years: better inspection and source of emissions; adopting more stringent vehicle emission standards; using cleaner fuels for motor vehicles, industry and power plants; and taking a more strategic approach to managing air quality to include all aspects of the problem.

Considering the updated guidelines established by the EPA, could America's green customs blossom over the borders?

Patrick Charbonneau, vice president of government relations for International Truck and Engine, says: "There is a lot of dialogue between the CEOs of vehicle manufacturers in the United States, Japan, and Europe on how we can have countries like India or China take advantage of these low emissions technologies that are already developed if they have the capability to get low sulfur or ultra-low sulfur diesel fuel."

Based on International's track record in research, it's clear that the company has strongly supported consistent, stringent environmental standards worldwide. Beginning with the Sustainable Development Summit in Johannesburg in 2002, International was one of the first American companies to support the United Nations Partnership for Clean Fuels and Vehicles, a joint United Nations-EPA program to educate consumers and businesses in the developing world on the use of cleaner fuels and vehicles. Securing the support of its distributor in Guatemala, International's Tom Trueblood, director of public affairs, visited Guatemala City to demonstrate a Green Technology vehicle to the environmental and health ministries of seven Central American countries.

International also partnered with the Union of Concerned Scientists, the Natural Resources Defense Council, and multiple customer groups to advocate increased funding for the EPA's Clean School Bus USA program, which is based on a model that also engaged the needs of Canada and Mexico.

At the convergence of science and engineering, experts have maintained a two-tier feat: Improve the combustion coming from engines and minimize the particulates coming from the engine. Despite the complacency around pollution in the past, it's clear that toxic automobile systems can be controlled in various ways. Pasto says that companies have undergone a complicating and costly strategy to put catalysts in place to manage nitrous oxide, often termed "NOx traps." The devices are turbo chargers and exhaust gas recirculation systems made of ceramic. A large truck that is expected to tally approximately a million miles may include two of these high-temperature systems for the purpose of releasing gas through one while the other filters individual components. Metal could not withstand this process.

Freightliner LLC developed a Class 8 wind tunnel to conduct a two-year study on the impact of aerodynamics on fuel efficiency.

A collaboration between diesel engine maker Cummins and HTML helped summarize this conclusion for all manufacturers. As explained by Pasto, Cummins used HTML's X-ray electromicroscopy capabilities to understand the properties of materials used in an exhaust after-treatment system, a costly addition to many vehicles. Along with evaluating how such catalysts can be adversely affected by sulfur and other exhaust components, Cummins and HTML characterized the fatigue life of diesel soot filters, which remove more than 98 percent of particulate emissions from diesel exhausts.

"All of their [Cummins'] fuel injectors and their high-pressure fuel injectors have switched from a metal plunger to a ceramic plunger because if they put the metal plunger to higher and higher stress to try to get better combustion, they found that the metal sticks and as you push harder and harder, the metal expands out against the barrels, and the ceramic doesn't do that," says Pasto.

The cost of compliance

Modernizing products that potentially affect the health of millions of people holds challenges best highlighted in price and the amount of trial-and-error hours. "For our part, Detroit Diesel's EPA '07 program represents the most investment, the most resources, most testing, and most preparation we've ever placed on a launch," says Liane Bilicki, communications director of Detroit Diesel. "The Freightliner and Detroit Diesel engineering test teams have been crisscrossing the country from Portland to Detroit in test trucks in order to prove out the engines in all climates and environments and a variety of applications."

The vehicle manufacturing arm of Detroit Diesel Corp., Freightliner is the largest heavy duty truck manufacturer in North America and a leading manufacturer of medium-duty trucks and specialized commercial vehicles.

Joined by the U.S. Department of Energy, Freightliner first conducted a multimillion-dollar two-year study on the impact of aerodynamics on fuel efficiency. Using a custom-built wind tunnel, engineers sampled and finalized specific design guidelines to benefit existing and future heavy-duty trucks operating on highways. The guidebook will be implemented in Freightliner's newest manufacturing plant in Saltillo, Coahuila, Mexico, which is scheduled to produce more than 30,000 trucks annually starting in 2009.

"We built our Class 8 wind tunnel — the first and only of its kind — specifically for this type of research because it allows our engineers to replicate real-world aerodynamic scenarios in a controlled environment where we can precisely duplicate test conditions to evaluate even the slightest effects on aerodynamics," says Elmar Boeck, senior vice president of engineering and technology for Freightliner LLC. "The variables of driver influence, weather conditions, road surfaces, and traffic, to name a few, are overcome in the wind tunnel. The flexibility

provided by having the wind tunnel at our disposal enables us to evaluate many different scenarios in a very timely and cost-effective manner."

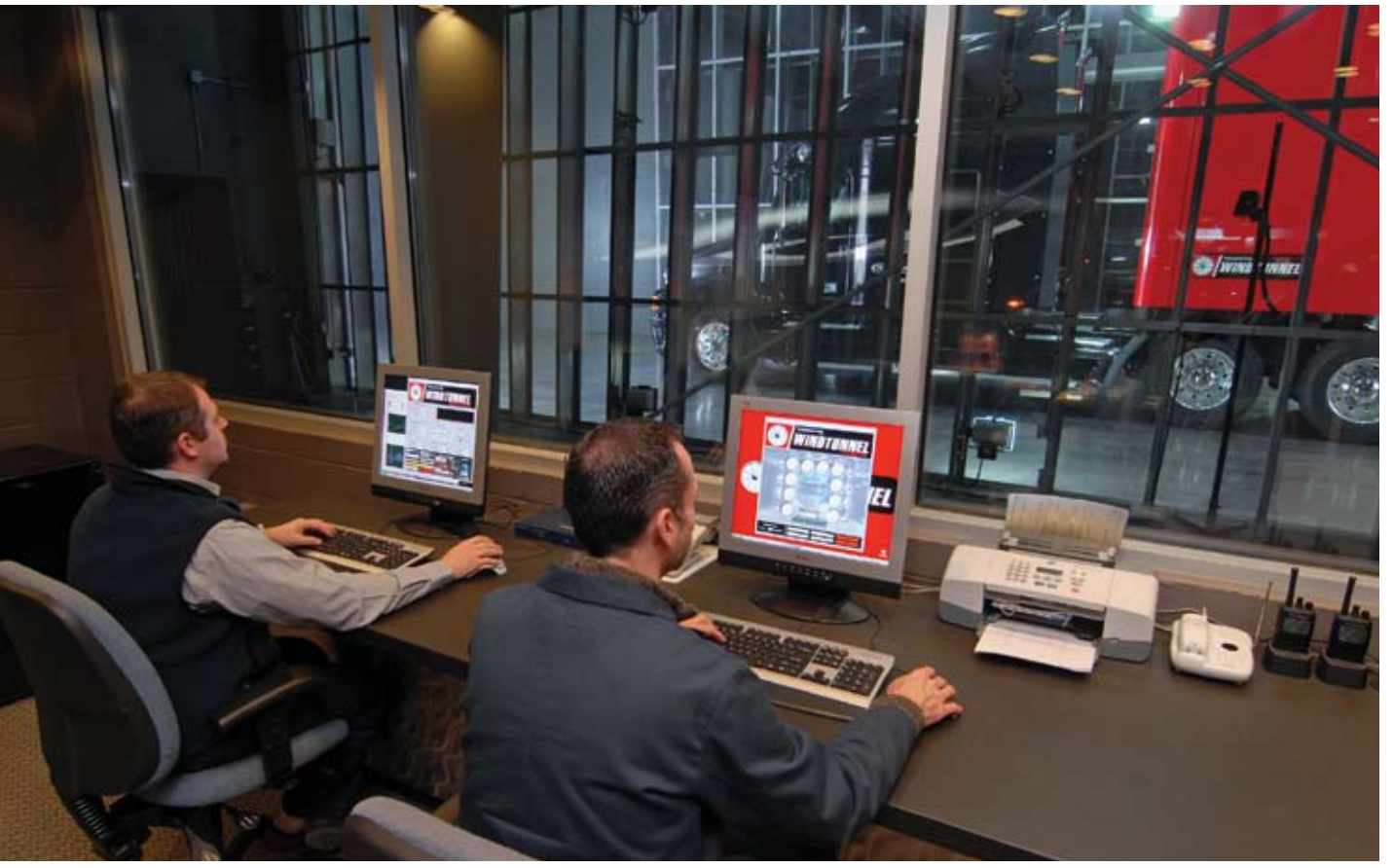
Freightliner engineers also learned key facts regarding water dispersion on glass and mirror surfaces in the wind tunnel. When rainy and windy conditions were simulated, engineers examined the effects of mirrors and mirror shape around the air flow of these surfaces. Forward and rearward visibility levels were determined for inclement weather.

Motivated by competitive technologies vying for certification and a longstanding concern for the environment, International Truck and Engine also championed swift product upgrades. In 2004, the company entered into a cooperative research and development agreement with the EPA to evaluate the EPA's Clean Diesel Combustion in-cylinder technology for reducing NOx emissions. If successful, the technology could enable diesel engines to comply with tough federal and California 2010 standards for NOx without the need for costly after-treatment systems.

Forming a partnership with California's South Coast Air Quality Management district, whose original mission prompted school buses to make use of natural gas engines instead of diesel, International invested in sophisticated contrivances. According to Patrick Charbonneau, vice president of government relations, while the company focused on designing the Green Diesel Technology bus, engineers discovered that technologies in their lab could be used across all heavy duty diesel products. International presented its findings to the EPA and the California Resources Board, which catapulted researchers to the podium, where they were afforded the opportunity to help define the 2007 standards.

"That was done in 2000 and we had our demonstrator show that technology could work if we had ultra-low sulfur fuel available. It was a combination of certain regulators focusing on eliminating diesel because they thought it was dirty and us having technology in the lab," says Charbonneau, who served as vice president of engineering during this time. "If we had clean fuel available, we knew we could have near-zero emissions so that's how it started in California."

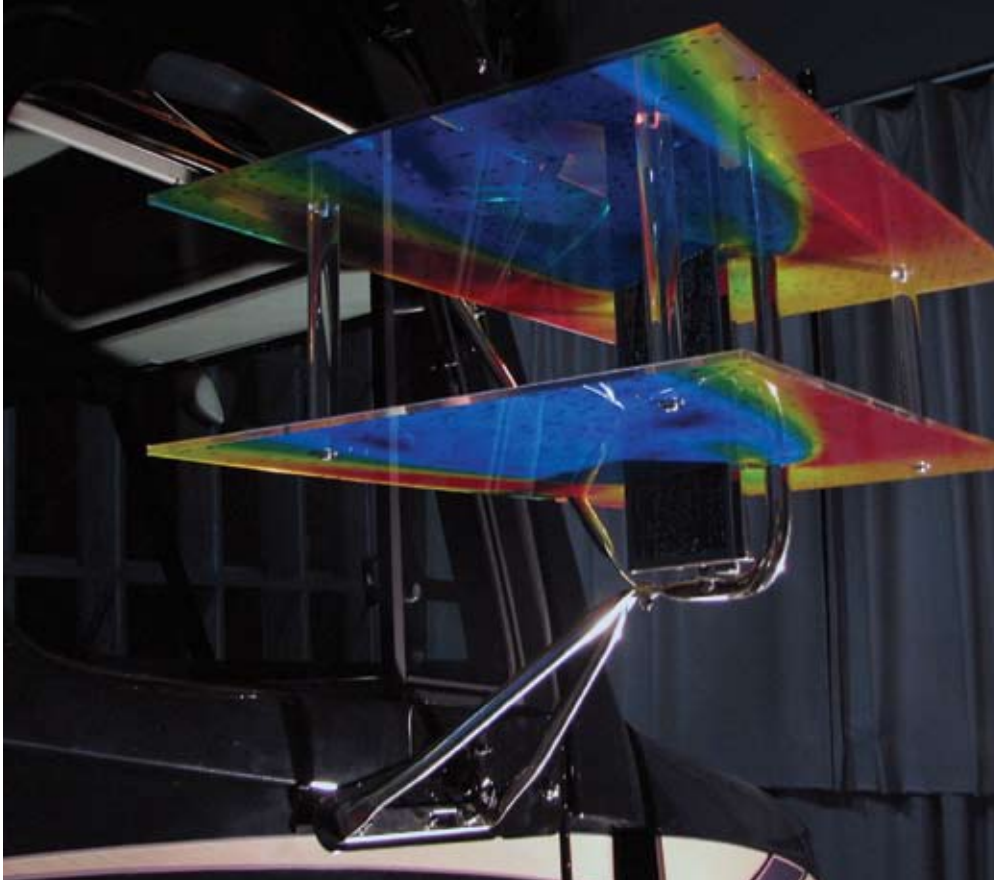
The vehicles that include particulate filters and component changes that achieve a 50 percent reduction in NOx add $5,000 to $9,000 to the price tag of each vehicle, depending on the size



In the wind tunnel control room, Freightliner engineers are able to evaluate data collected in real time from both interior and exterior vehicle running tests.

of the model. "That's basically an industry-wide cost impact," says Charbonneau. "We actually worked with a coalition of vehicle manufacturers and customers about a year and a half ago to get congressional support for a bill that would provide a tax benefit for 2007 vehicle customers. It was actually very well supported but what did happen though is that we had three hurricanes in a row and when that happened, the ability for the federal government to fund tax incentives really went by the wayside. Again, we had good support, but the hurricanes drove a nail in the coffin."

With the computerized engineering techniques and analyses involved as background work before products accumulate real road testing hours, the hike in price is well accounted for. The emissions change affects every engine in every vehicle that undergoes production; from a design standpoint, each component either breathes life into the engine model or deadens it through failure. Like those of Detroit Diesel and Freightliner, International's engines first receive thousands of test hours in a sophisticated laboratory. Once multiple systems are approved for road testing, entire vehicles run on durability tracks around the clock. High-altitude testing is executed in the Colorado Mountains followed by cold-start testing in Alaska. Finally, heating and cooling tests are preformed in Death Valley. All data collected from the tests are downloaded via cellular technology, which enables engineers to monitor results in real time.



As rainy and windy conditions are simulated in a mirror test, engineers determine visibility during inclement weather conditions.

As these approved vehicles begin to traverse roadways this year and blend in with the older, environmentally lax models, other innovations will be aimed at healing air quality woes. For instance, International, UPS, Eaton Corp., and the U.S. Army National Automotive Center are working with the EPA to build the world's first full hydraulic hybrid urban delivery vehicle with reduced emissions and significantly improved fuel economy. Additionally, International and Eaton were selected to manufacture diesel-electric hybrid trucks for a U.S. Defense Department-funded pilot program serving the U.S. utility industry. The program aims to achieve up to a 60 percent improvement in fuel economy in medium-duty utility trucks, providing a comparable reduction in greenhouse gas emissions while further improving exhaust emissions.

The profit gain or loss associated with continual upgrades or product failures may ultimately sneak up on engine parts manufacturers once vehicles accrue enough driver miles in a few years. However, the quest for cleaner air demands wide and sweeping changes, and the health of 300 million Americans does not carry a price tag.

"I'm not at liberty to say what the companies think, but what we see is that there are some fairly severe challenges on durability and lifetime. Right now that's an unknown," says Pasto. "Until you have lots and lots of vehicles on the road and have accumulated lots and lots of miles and experiences, you really don't know what's actually going to happen."

ON THE WEB

SMOKE ON THE WATER STILL?

Thales of Miletus said it: Water sustains all. It's also a vessel for more than 10 million marine engines operating in the United States. The EPA's eight-year emissions control phase-in span for cleaner boat engines ended in 2006. Indmar Marine Engines led the way in green manufacturing. Read about the company's commitment to improve air quality and pioneer new technologies.

www.iienet.org/magazine/feb07/water