Automobile carbon monoxide emission

ARTICLE *in* ENVIRONMENTAL SCIENCE AND TECHNOLOGY · FEBRUARY 1989

Impact Factor: 5.33 · DOI: 10.1021/es00179a002

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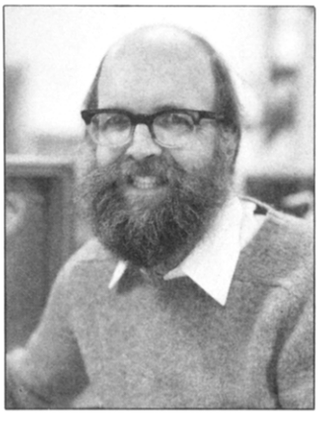
Automobile carbon monoxide emission

By Donald H. Stedman

It is amazing what can be seen in the infrared region of the spectrum. With a light source on one side of a highway on-ramp, and infrared detectors and a PC on the other, we are able to determine remotely the percentage of CO in the exhaust of passing cars in less than one second per vehicle. Briefly, the remote sensor measures the increase in IR absorption by CO and CO_2, compared with the air in front of the car. If these observed increases of CO and CO_2 are well correlated, the computer determines their ratio and calculates the percent CO equivalent to a tailpipe measurement of CO at that instant. The system is calibrated from the computer by means of a half-second puff of a certified gas calibration mixture.

With a data base of 10,000 percent-CO snapshot readings for each week of operation, we have examined our data to categorize the emissions of the fleet we observe. We find that 10% of the vehicles produce more than 50% of the CO. These few gross polluters are not new and not well maintained. On the rare occasions when we were on site, calibrating the instrument, we observed some of the gross polluters passing by, including taxis, mobile wreckers, and even state highway vehicles.

In light of these experiments, we have looked in detail at all the programs currently in place in the state of Colorado that purport to control mobile source CO emissions. These include Inspection and Maintenance (I/M), Oxygenated Fuels, and a Better Air Campaign featuring voluntary no-drive days. The following comments discuss why these programs don't work as well as was hoped, or as well as their proponents claim. Although several of the currently proposed Clean Air Act amendments fulfill the need to "do something" politically, they may not achieve the desired CO reduction goals either.



Donald H. Stedman

Inspection and maintenance

There is wide variation among I/M programs: centralized and decentralized, with and without tampering inspections (some predicated on whether or not the vehicle passed its test), with windshield tags and with tags required for registration, with large and with small waiver dollar amounts, and so forth. A common denominator is annual (or biennial), idle (usually) or fast idle testing. The major problem with these programs is that they are infrequent. A responsible, concerned citizen whose vehicle goes into one of the gross failure modes detectable by an idle test will drive an average of six months before that failure is detected. Mechanically inclined owners, and all fleet owners, certainly know how to adjust their vehicles to pass the test and to adjust them back afterwards. The hope is that an annual test would remind the general public of a 12-month commitment to keep the air clean. Unfortunately some people regard it as an annual obstacle to be overcome, just as they regard the April 15 tax payment deadline.

A study of the idle-speed emissions of more than 600 vehicles in Colorado showed no correlation between emissions and how recently the I/M sticker had been obtained (*1*). A study in Michigan showed that of 600 vehicles that had failed their annual test, the process of driving around the block and retesting them allowed more than 200 to pass (*2*). The other problem aspect of most I/M programs is that vehicles are not tested under load. This makes it impossible to obtain useful NO_x emissions data. Even hydrocarbon and CO emissions of on-road vehicles are quite different from those of idling or fast-idling vehicles.

Testing by remote sensing measures in-use emissions without imposing on the vehicle owner. Remote sensing samples vehicles approximately in proportion to their mileage, that is, in proportion to how much pollution they cause. The vehicle emission remote sensing technology the University of Denver has developed can identify the 10% of the gross polluters that are responsible for 50% of the CO pollution.

Oxygenated fuels

According to Hollman (*3*), the world's first mandated oxygenated fuels program, which took place in Colorado for two months in early 1988, ". . .resulted in an 8–11% reduction in ambient carbon monoxide levels." According to his slides, this reduction was actually modeled. From Colorado Department of Health (CDH) data reports, (*4*) it can be determined that the basis is Federal Test Procedure (FTP) measurements of 156 vehicles and Mobile3 modeling of the results, which predicted a 12–16% improvement of the mobile source term. Hollman did not mention that the results of Mobile3 CO emissions modeling have been shown to be wrong by a factor of more than two in recent studies (*5, 6*) and that the particular model used for the oxygenated fuels program depends critically on the slopes of two lines that claim to be related to the fuel-dependent increase in CO emissions with vehicle age (deterioration rate). The deterioration rate data are shown in a CDH report (*7*). The two least-squares lines are

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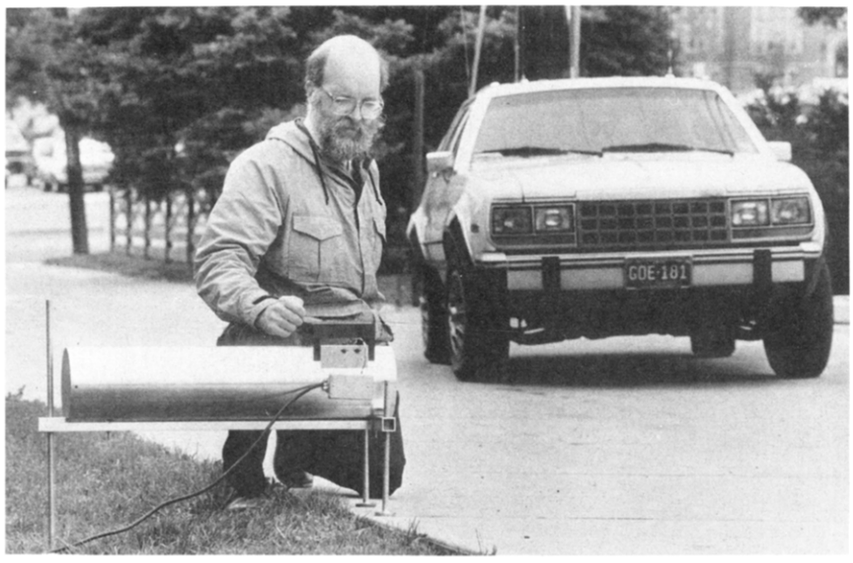
plotted; however, when the standard deviations are plotted, they overlap each other and most of the rest of the data. These arguments leave the reliability of the model in considerable doubt.

With the remote sensing system at a single on-ramp we obtained 20,000 CO emissions measurements during the 1988 oxygenated fuels programs and 20,000 measurements after its termination. The results showed a $6 \pm 2\%$ CO improvement, possibly arising from the fuel switch. The results would be scaled downward by any loss in average gas mileage. The cost to the public of the two-month program was estimated at $3 million–14 million (*4*, *8*). According to Hollman (*3*), "Due to the success of Colorado's Oxygenated Fuels program other states are now following our lead and implementing oxygenated fuels programs. These include Arizona, New Mexico, and Nevada." It is an interesting situation when the state agency that mandates a program also gets to evaluate it and to set its own criteria for success.

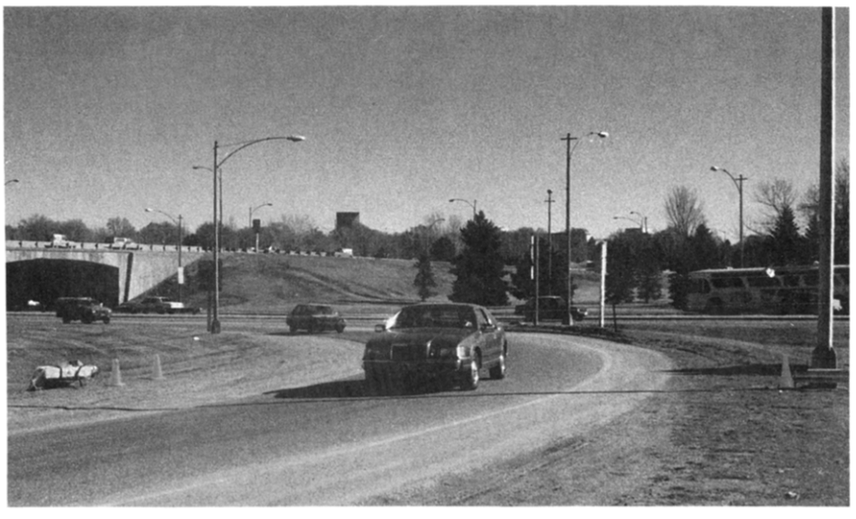


Checking instrument: *Stedman observes real-time emissions data*

Better air campaigns

This year is the fifth year of a Better Air Campaign in the front range region, the urbanized strip of Colorado just east of the Continental Divide. The "No Drive Days" aspect of the campaign is designed to reduce CO by persuading citizens to reduce their total vehicle miles traveled (VMT). The success of the program is evaluated by telephone surveys, which have indicated that public awareness is widespread, and by a VMT study. The VMT study uses data from 29 highway traffic counters run by the Colorado State Highway Department. The count data are modeled by the highway department to obtain VMT estimates. These VMT estimates are then compared with the VMT in the year preceding the first better air campaign, using a complex statistical package resulting in a modeled VMT reduction from the year's campaign.

Last year the 9% reduction in VMT was then translated into a 13% reduction in CO emissions. This last step is the most questionable of all. It includes a modeled reduction in emissions from the 91% of remaining vehicles because of reduced congestion. This congestion effect in the model is not supported by the data (*6*). Furthermore, a 9% reduction in VMT would cause a 9% reduction in vehicle emissions only if it were applied randomly to all vehicles regardless of emissions. Since the distribution of emissions is so skewed toward a few gross polluters causing the problem, it would appear that the VMT reduction would affect the median vehicle emissions, rather than the mean. The ratio of mean to median emissions in CDH FTP data is 0.2, similar to our remote sensing data of 0.13. With the 0.2 estimate, a 9% reduction in VMT should be credited with less than a 2% reduction in CO emissions.



Motorists beware: *Remote sensing devices may be checking your emissions*

Clean Air Act

The state of Alaska has been pushing for Cold Temperature New Car Certification (CTNCC) based on the argument that most CO violations occur at temperatures colder than that of the FTP certification test, and that CTNCC would solve this problem. This legislation is very expensive. It will not be very effective because of the confusion in distribution functions discussed earlier and because new cars are not a CO emission problem anywhere, even when cold. Furthermore, although most cars run dirtier when cold, the few gross polluters pollute so much that they dominate the emissions problem even when their engines are hot. If the gross polluters are also high mileage vehicles, then their importance to the problem is even greater.

The same argument applies to all other amendments seeking to clean the air by further decreasing new car standards. New cars in Colorado are supposed to meet a 3.4 g/mile standard. Since the average car in Denver emits 50 g/mile, it is apparent that further "Detroit bashing" simply isn't going to achieve the clean air goals.

There are a few gross polluters on the roads; we have the technology to identify those vehicles and determine how much they pollute in proportion to how much they drive. It is a long road from identification to enforcement (*9*). I invite readers to consider how they might devise enforcement strategies, given our new high-technology remote sensing identification capability.

Other Clean Air Act programs

Stage two (California-style gasoline pumps) and on-board hydrocarbon

emissions control measures are claimed by EPA to reduce hydrocarbon emission by only 2%, at very high cost. Surely an innovative legislator can devise a way to use the much more cost-effective remote sensing of hydrocarbon polluters. An excellent review of the problems of motor vehicle emissions, which discusses the past 10 years but not the solutions made possible by the inception of remote sensing, has been prepared by Walsh (*10*).

Acknowledgments

Thanks to the Colorado Office of Energy Conservation, the National Science Foundation (grant number ATM-8620365), the American Petroleum Institute, and Ken Barr for funding. Thanks also to Gary Bishop and others in the research group, without whom this program could not have been carried out.

References

(1) Wolff, B. Ph.D. Thesis, Colorado State University, 1987.
(2) Berens, D. Presented at the panel discussion on Inspection and Maintenance Programs, SAE Government/Industry Meeting, Washington, DC, 1988.
(3) Hollman, T. *Abstracts of Papers*, First Interdisciplinary Conference on Urban Air Quality, Boulder, CO, 1988.
(4) Final Report to the Colorado Air Quality Control Commission, 1988 Oxygenated Fuels Program. Colorado Department of Health, Air Pollution Control Division: Denver, CO, 1988.
(5) Hlavlinka, M. W.; Ballin, J. A. *J. Air Pollut. Control Assoc.* **1988,** *38,* 1035-39.
(6) Zweidlinger, R. B. et al. *Environ. Sci. Technol.*, **1988,** *22,* 956.
(7) Air Pollution Control Division "Ethanol Blended Fuel as a CO Reduction Strategy at High Altitude"; technical report. Colorado Department of Health, Air Pollution Control Division: Denver, CO, 1985.
(8) Levine, J.L. Testimony to the Colorado Air Quality Control Commission. Amoco Oil Co., Chicago, IL, 1988.
(9) Ashby, H. A. Presented at the 12th North American Motor Vehicle Emissions Control Conference, Louisville, KY, 1988.
(10) Walsh, M. P. "Critical Analysis of the Federal Motor Vehicle Control Program"; Northeast States for Coordinated Air Use Management, Albany, NY, 1988.

Donald H. Stedman received his B.A. and M.A. degrees from Cambridge University. He received his Ph.D. from the University of East Anglia. He is Brainerd Phillipson professor of chemistry at the University of Denver. His research career started with studies of the chemical kinetics of atom reactions. His studies at the Kansas State University led to the discovery of a rich chemistry of argon, krypton, and xenon metastable atoms and to a new system to produce metastable nitrogen. After two years as a researcher at the Ford Motor Co., Stedman started his academic career at the University of Michigan.

Energy efficiency: A futuristic goal

By Stanton S. Miller

The United States is a different energy nation in terms of energy use now than it was earlier, but it still faces a challenge. The best energy news in 15 years, after the 1973 oil embargo and the onset of our first energy crisis, is that energy efficiency has improved 35%. But what is more significant is that this energy efficiency was achieved during a period when the economy grew 40%.

The worst energy news is that of the world's 10 largest economies, the United States is seventh in terms of national energy intensity. "National energy intensity" means energy consumption per dollar of gross national product. U.S. energy efficiency is better than that of only China, India, and Canada. The United States uses twice as much energy as Japan does to produce a dollar of gross national product, and the United States is half as efficient as western Europe.

Such are the findings in *World Resources 1988-89,* the third edition of a global report on environmental conditions and trends. This report is published by the World Resources Institute and the International Institute for Environment and Development in collaboration with the United Nations Environment Programme.

Building on earlier volumes, this third report gives special attention to environmental conditions and trends in Asia and devotes a chapter to rehabilitating degraded lands in developing countries. The report's regular features include more than 50 data tables covering 146 countries and 11 chapters on conditions and trends in population and health, human settlements, food and agriculture, forests and rangelands, wildlife and habitat, energy (my focus here), fresh water, oceans and coasts, atmosphere and climate, global systems and cycles, and policies and institutions.

The past eight years

What happened during the Reagan administration specifically in terms of energy is the subject of the Department of Energy publication DOE/S-0068, *United States Energy Policy 1980–1988.* The report concludes that the dynamics of world energy have changed, reducing the potential for manipulation of the energy market. As former Secretary of Energy John S. Herrington said in the foreword of the report, "We [the United States] are producing 21% more goods and services with less than 1% increase in energy use."

The years ahead

The energy issues facing agency heads in the Bush administration were detailed in the transition series of GAO reports published in November 1988. The report "Energy Issues" included seven issues, some new but most long-standing. One long-standing issue was reducing U.S. vulnerability to oil disruptions. Transportation accounts for two-thirds of all oil used in this country. Not only is this sector 97% dependent on oil, it is the only sector of the economy in which oil consumption has continued to increase over the past decade.

Commercializing clean coal technologies is another issue the Bush administration will face. The United States is seeking to develop cost-effective ways to burn coal more cleanly, to control acid rain, and to improve our energy security by reducing dependence on imported oil and gas. Although 20 bills to control acid rain have been introduced in Congress since January 1987, the clean coal technology will not be available commercially until the mid-1990s, according to the report. Other impending energy issues include modernizing and safely operating our nuclear energy industry and developing a program for disposing of nuclear waste.

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