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The Challenge of Ozone Pollution

Stephanie Berger, New York City Department of Transportation

Traffic on the Long Island Expressway. Automobiles are a major source of ozone pollution.

The Challenge of Ozone Pollution

Is it possible for a modern, affluent society to have a clean environment? Ozone pollution—commonly known as smog—is posing that question dramatically for this country. This issue of *EPA Journal* explores the situation.

The issue begins with an article by EPA Administrator Lee M. Thomas spelling out what he believes the nation's future ozone control strategy should be. In a *Journal* interview, J. Craig Potter, the Agency's Assistant Administrator for Air and Radiation, answers questions about the ozone pollution problem and discusses efforts to deal with it. Then, an article elaborates on the nature of ozone pollution and its effects, including its potential health consequences.

The fact that ozone pollution sources and conditions differ widely is explained in an article focusing on smog situations in such cities as Los Angeles, New York, Houston, and Atlanta. Another article introduces the array of technologies aimed at preventing or controlling this complex problem. The outlook for alternative fuels for motor vehicles, a potentially major smog control weapon, is presented next.

In a special forum, three leaders outside EPA with diverse viewpoints on the smog problem give their commentaries on how they feel it can best be solved. And an article explains the legal groundwork for EPA's actions under the Clean Air Act to deal with ozone pollution.

Two related articles report on air quality trends in the U.S. and on the results from EPA's phasedown of lead in gasoline. In a different vein, a bicycler explains why he enjoys this pollution-free transportation mode.

This issue of *EPA Journal* concludes with two regular features—Update and Appointments.

Editor's Note: In this issue of the magazine, "smog" and "ozone pollution" are used interchangeably, because smog has become a common term in American usage. However, the reader should understand that technically, smog includes more pollutants than just ozone, although ozone is the major component of what we normally think of as smog.

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EPA is charged by Congress to protect the nation's land, air, and water systems. Under a mandate of national environmental laws, the agency strives to formulate and implement actions which lead to a compatible balance between human activities and the ability of natural systems to support and nurture life.

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Front Cover: A view of Los Angeles, one of the U.S. cities with major smog problems. Photo by Rene Sheret, Folio, Inc.

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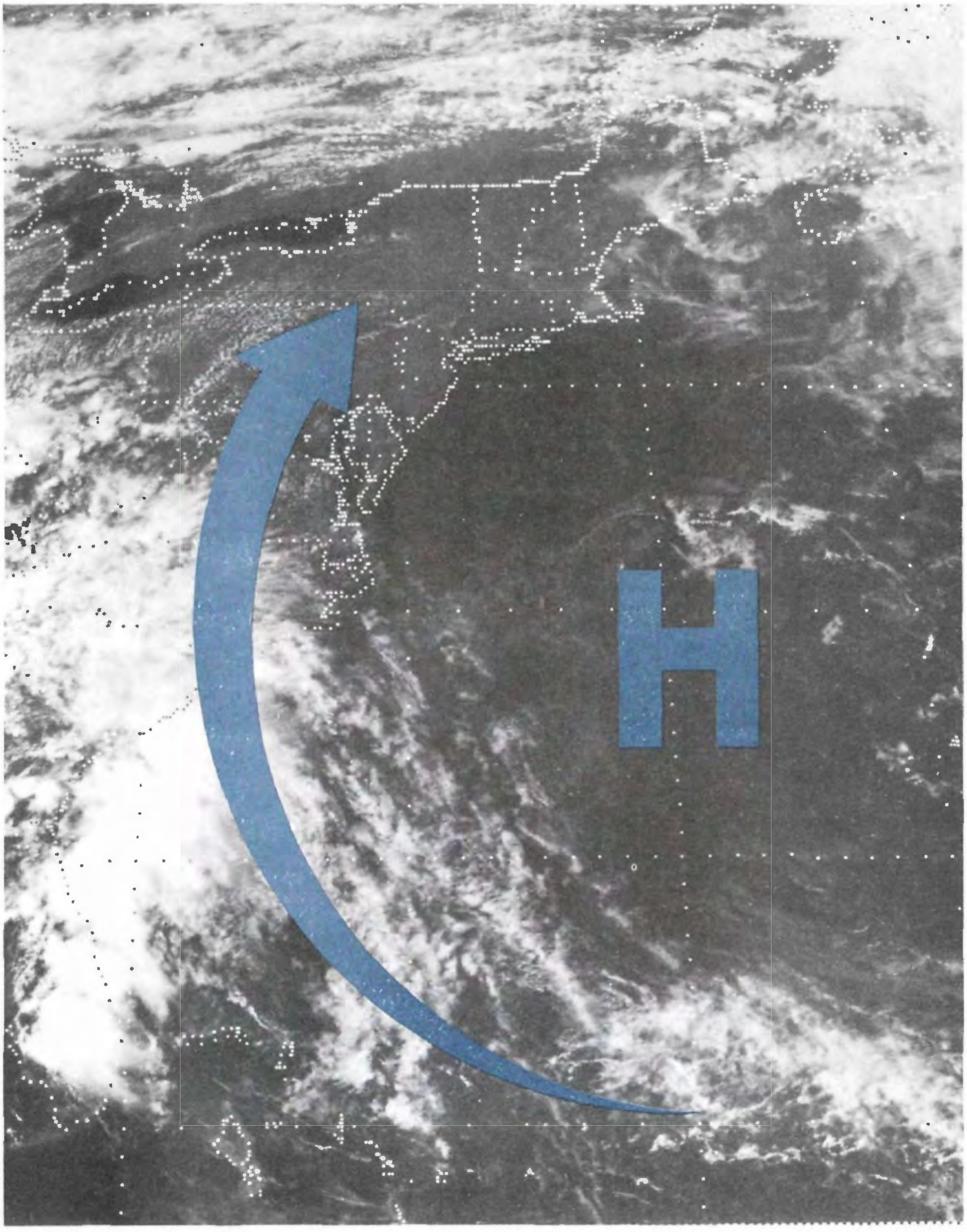
Next Steps in the Battle Against Smog

by Lee M. Thomas

This satellite photo shows the eastern half of North America while a large "Bermuda high" hovers off the coast—a frequent summertime occurrence that can affect smog levels over a large area. Under these conditions, air currents drive clouds in a clockwise pattern, as shown, up the East Coast. Smog pollutants are forced up the coast in the same pattern, spread north and northeastward from their original sources by the prevailing winds.



NOAA World Weather Center

Over 60 major urban areas in every part of the country still do not attain the national health standard for ozone.

Since the Clean Air Act was passed in 1970, the United States has made impressive strides toward protecting and enhancing the quality of its air. Stringent air pollution controls are now required on most large new stationary facilities, like refineries and chemical plants. New cars and trucks must limit their air emissions to meet strict federal standards. Because of cooperative federal, state, and local efforts, effective air pollution controls are now in place on a host of smaller, widely dispersed sources such as printing shops and metal coating facilities.

This national investment in air pollution control has paid substantial dividends. The air in this country is measurably cleaner than in 1970. The improvement in air quality has improved the health and welfare of the American people, especially those living in urban areas.

However, one air quality problem has proven particularly intractable. That problem is ground-level ozone, or, as it is commonly described, "smog."

There is little doubt that human exposure to ozone concentrations at or above the national health standard is a serious concern. According to scientific studies, ozone concentrations that may occur during hot summer days in urban areas can impair lung functions in people with existing respiratory problems. People in good health can be affected as well. These effects include chest pain and shortness of breath. In addition, it is possible that permanent lung damage may result from repeated ozone exposures over a period of years.

These potential health problems are especially worrisome because they may be occurring in so many places. Over 60 major urban areas in every part of the country still do not attain the national health standard for ozone.

The widespread, intractable nature of the ozone problem has been recognized for some time. The Clean Air Act originally required that states develop plans to attain air quality standards by the mid to late 1970s. When it became apparent that the ozone standard would not be met in many areas by then, the Clean Air Act Amendments of 1977 called for new plans that would lead to attainment by December 31, 1982. Areas with especially serious problems were given an additional five years to attain. But now the final deadline—December 31, 1987—is fast approaching, and it is clear that many areas are still a long way from attaining the standard.

This widespread failure to attain an important national health standard—despite the deadline extensions—is causing concern among many members of Congress. They are beginning to look at ways to amend the act so that the ozone standard will in fact be attained nationwide at some future date.

We at EPA are very concerned about ozone nonattainment, too. For the last several months we have been asking ourselves why this particular air quality problem has been so difficult to solve. Why haven't we met the attainment deadlines set in the past? What actions would it take to meet any new deadlines set further in the future?

Probably the most obvious reason for our past inability to attain the ozone standard is the nature of the ozone problem itself. Unlike most other air quality problems, ozone is caused by emissions of an air pollutant—volatile organic compounds (VOCs)—from a very wide range of sources. VOCs are emitted by large stationary sources, like refineries, and by small stationary sources, like corner gas stations and neighborhood dry cleaners. They are emitted by millions of individual cars and trucks, and they are emitted when people use products like paints and cleaning solvents in and around their homes. In short, our modern society emits VOCs at work and at play, at home and on the job, and the enormous diversity of VOC sources enormously complicates our efforts to control them.

For example, because VOC sources are so diverse, no single control technology can be applied to more than a small part of the problem. In fact, much of the ozone problem is not amenable to traditional "end-of-pipe" controls at all. Depending on the source, a number of different techniques may be used to control emissions. Production processes may have to be altered, or substitutes may have to be found for process materials like adhesives and solvents, or people may have to change their driving habits. In a typical nonattainment area, some combination of all these steps—and more—may be needed to reach attainment.

To make matters worse, no two nonattainment areas are exactly alike. Emissions inventories, source characteristics, meteorology, and geography all vary from area to area, and those factors will have an effect on local ozone concentrations. Thus different techniques have to be developed to control emissions from different sources, and different combinations of techniques have to be

A new deadline is necessary, but that new deadline should be realistic and tailored to the circumstances of individual nonattainment areas.

developed to attain the standard in different areas.

Because VOC emissions are associated with so many facets of our economic life, our past progress toward attainment has been complicated by the economic growth we have enjoyed. Since 1970, the national economy has grown by 44 percent. Over the same period, the U.S. population has grown by only 18 percent, but the total vehicle miles travelled nationwide has climbed by an astounding 58 percent.

What happened to VOC emissions since 1970? As a result of EPA and state controls on both mobile and stationary sources, VOC emissions dropped by 22 percent between 1970 and 1985. Had no VOC controls been imposed, EPA estimates that total nationwide VOC emissions would have grown by 32 percent.

This is an impressive achievement. VOCs have been controlled without impeding the economic growth essential to the well-being of the United States. Anticipated future economic growth, of course, will have to be factored in to any plan that attempts to attain the ozone standard by some future date.

Our past efforts to attain the standard sometimes failed because we simply did not realize all the different kinds of VOC sources that had to be controlled. For example, only recently have sewage treatment plants been recognized as a significant source of VOCs, and only recently have they begun to be controlled. Similarly, hazardous waste treatment, storage, and disposal facilities often were not included in local lists of VOC sources subject to control. Over the past few years we have learned a great deal about the sources of VOCs, and that knowledge should help us do a better job planning for and reaching attainment in the future.

Ground-level ozone is similar, in some respects, to the acid rain problem. That is, the pollutant of concern is the product of atmospheric processes, and the areas of concern may be affected by pollutant sources miles away. The uncertainties associated with atmospheric transformation and transportation have complicated past ozone control efforts in two ways. First, from a technical perspective, they have made it very difficult to define with any precision how much pollution from what set of sources has to be controlled to attain the standard in a particular area. Second, from a political perspective, they have made it more difficult to reach a consensus on the actions needed to solve the problem.

Our review of past national efforts to control ozone has been a valuable exercise, because it has taught us not only the root causes of our past failings, but the necessary ingredients of our future success. Based on our past experience implementing the Clean Air Act, I believe that any future ozone control strategy should include several basic components. For example, I believe a new deadline is necessary, but that new deadline should be realistic and tailored to the circumstances of individual nonattainment areas. Furthermore, the strategy should ensure that the states make steady and measurable progress toward the overall goal of attainment.

The national ozone control strategy also should contain explicit assurances that the standard not only will be attained, but that it will be maintained in the face of future economic growth. And the strategy should incorporate mechanisms for addressing regional ozone problems when and where they occur.

Most important of all, the national strategy should allow the states substantial latitude in designing attainment plans that are efficient, effective, and politically acceptable. We at EPA are committed to the attainment of the ozone standard nationwide. But we recognize that, in some areas, achieving that goal could require extraordinary control actions that may be costly, socially disruptive, and politically unpopular. Depending on the area in question, an ozone control plan may limit the use of automobiles, or require the use of alternative, cleaner-burning fuels, or require the development of a mass transit system. It may restrict the use of certain consumer products, or it may add to the cost of basic goods such as bread and gasoline. Virtually everyone living in an ozone nonattainment area contributes directly to the problem in some way, and virtually everyone will be affected directly by the solution.

Thus it is essential that the people of this country understand the health and environmental values at stake, and that through their local and state governments they participate in the process of defining local control plans. In general, the people most directly affected by local problems are usually most capable of formulating effective solutions. I believe that principle is especially applicable to the ozone problem. If people living in urban areas all across the country participate in the planning and cooperate in the implementation of local control programs, I am confident that we will move steadily toward our overall goal: nationwide attainment of the ozone health standard. □

(Thomas is Administrator of EPA.)

Answers about Ozone Pollution

An Interview with J. Craig Potter

Ozone is not only harmful to human lungs, but can have an adverse effect on cash crops. Shown is a soybean field in Kansas.

To get answers to questions the public is asking about ozone pollution and actions to deal with it, EPA Journal interviewed J. Craig Potter, EPA's Assistant Administrator for Air and Radiation. The text of the interview follows:

Q **We've been hearing a lot about ozone lately, in the upper atmosphere and at ground level. What is it?**

A Chemically, ozone is simply a form of oxygen with three oxygen atoms, instead of the two found in regular oxygen. This composition makes it very reactive, or unstable, so that it combines with practically every material it comes in contact with. And it's this reactivity that is giving us problems because it tends to break down substances, not just materials, but biological substances such as tissues and cells as well.

This isn't a problem if the ozone reactions stay in equilibrium. But what we've discovered is that in the upper atmosphere, where we need ozone to protect us from ultraviolet radiation, the ozone is being destroyed by manmade chemicals called chlorofluorocarbons.

U.S. Dept. of Agriculture

And at ground level, where it can be a harmful pollutant, too much ozone is being produced by human activities.

Q Is there any difference between naturally occurring ozone and manmade ozone?

A No, at least not in the sense that we can tell where they come from. Chemically, they are the same. Lightning discharges create some ozone, but both natural and manmade ozone are the result of sunlight acting on gases in the atmosphere. And in fact, the amount of ozone that occurs naturally is about the same as the amount of ozone that occurs from man's activities.

So where is the problem? The problem is where the ozone is concentrated. Manmade ozone is essentially an urban phenomenon, and cities are where most of the population is. People will look at a map of ozone nonattainment areas and they see southern California, they see the East Coast, they see Chicago and Texas and other places, and they say "What's the big deal? Most of the country doesn't have a problem." The point is that where there is a problem, that's where the people are.

Q Specifically, what are the health concerns for ozone?

A Well, as I mentioned earlier, ozone is highly reactive, meaning that it chemically combines and recombines with substances. That reactivity causes measurable, physical damage. We've known for a long time that it directly affects the lungs, not only the mechanical functioning, but also the mucous membranes leading to the lungs. We know, too, that ozone causes tissue damage. And these effects occur not only to sensitive individuals, but to healthy people as well.

We're also seeing evidence that chronic exposure to ozone also produces effects. It may interfere with the autoimmune system. It may accelerate aging.

I think we tend to forget just how biologically vulnerable human beings are. It sounds dramatic, but you could say that we totter on the edge of disaster all the time just by virtue of the fact that our bodies run on air, air that may contain harmful substances. Ozone is one of those substances. But our vulnerability to the air we breathe is one the reasons that EPA is so concerned about air pollution in general.

Q Are there ozone effects other than on human health?

A There are. We have good evidence that it affects trees and vegetation. Certainly, we've seen that cash crops like soybeans have been affected. Ozone also seems to accelerate the aging of many materials, again as a result of its chemically reactive nature. For example, it causes rubber cracking, dye fading, paint erosion. Generally, it has a tendency to accelerate effects on other substances.

Q How is ozone different from other major air pollutants that EPA deals with?

A In one basic respect, it's totally different. Ozone is what we call a secondary pollutant. Unlike sulfur dioxide or nitrogen oxide or particulate matter, ozone is not emitted directly from a source. Instead, it's formed primarily as a result of the interaction between hydrocarbons and nitrogen dioxide in sunlight.

So there are no ozone emissions per se. What is actually emitted are the hydrocarbons and the nitrogen oxides and these combine with other substances in the atmosphere and the whole mixture stews in the sun to produce ozone.

Q Is this what makes ozone so difficult to manage?

A Yes, among other reasons. With sulfur dioxide, for example, we use what we call Gaussian modeling, where we actually measure plumes and predict how they will disperse in the atmosphere. Well, we can't do that with ozone. We have great difficulty in modeling ozone concentrations and predicting where it will appear because it's so dependent on weather conditions and because hydrocarbon emissions come from so many sources. Ozone levels are not so much the result of emissions from stacks, as they are the result of things that happen after those emissions occur.

So all this casts a lot of uncertainty into measurements and predictions, and calls for much more sophisticated modeling techniques.

Q Is it possible for EPA to regulate ozone effectively, given these basic problems?

A Well, basically what we have to work with is the ambient standard itself, which the Clean Air Act requires us to set at levels protective of human health. Right now, that standard is set at 0.12 parts per million, but some studies suggest that it may not be protective enough.

One of the things to realize here is that ozone is regulated under the same categories we have for all air pollution—that is, stationary sources and mobile sources. But because ozone is not emitted directly, we've had to develop some pretty complicated mechanisms for getting at it, such as requiring inspection and maintenance for automobiles, or establishing emissions controls on certain industrial processes, or even as a last resort, prohibiting construction of new facilities that would emit hydrocarbons.

There's no question that what we've done so far has been effective. In places like California, exposures are much less than they used to be. The way the law works, though, is that if you have any levels above the ambient standard, then you are in violation of the law. And in certain instances—Los Angeles, for example—we have serious reservations that they will ever be able to meet the standard.

So the real question is not how effective we are, but whether this approach is working. Do we need to consider the possibility that we ought to be dealing with this air pollutant differently than the others? In other words, is the ambient standard really the way to go?

As we begin to understand ozone better, I think we're going to realize that the nature of this stuff is such that we will never meet the standard totally in some places. We may also find that we have problems in areas where we never expected it. Ozone moves around the atmosphere in funny ways, so that it can show up in places where there aren't even any hydrocarbons being emitted. The name of that headache is ozone transport, and it's a real issue, particularly on the East Coast, where weather conditions routinely push ozone north along the coastline. A lot of places in New England end up coping

Jon Riley, Folio, Inc.

with an ozone problem that isn't even theirs, that may have come from as far away as Washington or Baltimore. But the law says that they are the ones out of compliance. How do we deal with this?

Q Right now, we depend on regulations and technology to control ozone. How much further can we go along that route?

A Well, our proposal to require equipment on cars to control gasoline vapors—the so-called onboard vapor controls—goes pretty far. It's certainly the biggest jump we can make right now to deal with the problem of emissions from refueling. We estimate that onboard controls and other volatility regulations, along with normal vehicle turnover, will get us a nationwide ozone reduction of 10 to 12 percent over the next 10 years or so.

And I think there is still room for some technological "fixes." For example, we're very interested in alternative fuels like methanol, ethanol, and compressed natural gas because they've already shown they contribute substantially less to ozone formation than conventional gasoline fuels. And that's when they're used in engines really designed to run on gasoline. In engines designed specifically for them, the clean air benefits would be enormous. Methanol is especially attractive because it can be produced from coal, natural gas, and even biomass materials, and all the alternative fuels could be readily available. Not only that, but they have the potential to reduce carbon monoxide and particulate emissions as well.

Aside from improving fuels, of course, we can also work on other engineering aspects of automobile technology. And there are major improvements we can make in mass transit technology and convenience, too.

But I think you are right to ask how far we can go with technology. There's probably always a little more we can do with automobiles, but we have to ask ourselves what we're gaining for the cost involved. That's really the question we're dealing with.

The billows of smoke and steam rising from this oil refinery may look like smog in the making, but the real culprit in smog formation is volatile organic compounds (VOCs), which are invisible. Controls are helping to reduce the pollution, including VOCs, from refineries, chemical plants, and other sources.

Q What other controls are we talking about? Will future reductions depend on changes in lifestyle or personal habits?

A Yes, I think ultimately we will be talking about lifestyle issues. That's a part of our dilemma here. People who are concerned about air quality and environmental problems in general frequently cite the desire of the American people to have a cleaner environment. True, they do. But the American people also want to have cars.

One of the things we have be honest about is that Americans tend to want to drive around in automobiles—alone. Now we can control cars, and we have controlled them to a very high degree. But we are going to reach a point where we can't control them anymore on a vehicle-by-vehicle basis, and the fact is that the actual vehicle miles traveled in this country are increasing at a substantial rate. And the question then will be: How do we regulate or deal with that?

Places like southern California rely absolutely on the automobile. They also get ozone buildup simply from the fact that it gets trapped by the Santa Monica Mountains in Los Angeles. It's the classical situation of land breezes during the night, sea breezes during the day. The air moves off the coast at night, comes back in during the day, and this happens day after day after day. It's always happened in Los Angeles, whether people were there or not. There's only so much we can do with direct controls. Ultimately, we're going to have to turn to adjustments in the way people live their lives.

I suspect that the same Americans who want environmental protection—from ozone, among other things—are not going to like the notion that they may have to carpool, or even put up with nondriving days. And those are the kinds of things we're talking about, the so-called draconian measures we may have to take to meet the ozone standard. In my view, these will have to be decided at the local and state levels, not by the federal government. We need to create a certain amount of flexibility to adjust the program to local circumstances.

Q How many areas are expected not to attain the standards by the December 31 deadline?

A It varies. This is because some areas were extension areas and some were not. But there are over 60. Let me explain that we measure attainment status basically by calculating a three-year average of exceedances. So right now, we are working on the basis of data from 1984 through 1986. You may have heard people talk about 1983 being a terrible year for ozone, and as result of averaging the next three years instead, we've seen several areas go back into attainment.

The point to recognize, though, is that the original deadline for attainment was 1975, 12 years ago. That was extended to 1977. Then the standard was reset, actually raised, in 1979, at which point the attainment deadline became 1982. Some of the areas did not attain in 1982, either, and they were given five-year extensions. The 1987 deadline is not the first deadline we've come up against. Many of these areas have been extended two or three times. So what we're saying is that it's not simply a matter of not having met the standards, it's a matter of not having met them in some cases for 12 years.

Q What will EPA do about areas not meeting the December compliance date?

A Well, we want to encourage compliance as much as we can. The problem is, most of the large stationary sources are already controlled and now we're facing controls on smaller sources, including places like auto body shops, dry cleaners, even bakeries. Pollution controls for these sources will be very, very expensive. And also, a significant amount of hydrocarbons are emitted just from everyday consumer products—things like paints, deodorants, household cleaners.

As far as mobile sources, we talked before about equipment controls for cars. There may be other things we can do, such as establish some general standard to enhance inspection and maintenance (I/M) programs. Basically, though, if we want to attain the ozone standard by the deadline, it's going to require drastic measures in many urban areas. Under the Clean Air Act, this could include banning new construction and cutting off funds for highway and sewage treatment plant construction. The most extreme action we could take would be to step in and impose our own transportation controls at the local level. We can guess how popular that would be.

To answer your question specifically, though, right now we are in the process of developing what we call a "post-87" strategy. A lot of it will involve state implementation plan (SIP) procedures because those are the mechanisms that govern our interactions with states and local communities. For example, we've already notified certain areas that, because they have not implemented their SIPs in a timely fashion, we may have to disapprove them.

These disapprovals and sanctions are something EPA will have to deal with, whether or not Congress takes any action. And Congress is part of it, too. We are talking with them about how we might change or adjust the law to deal more effectively with ozone.

Q Somebody could look at this history of extensions you've recited and conclude that EPA is not really serious about attaining the ozone standard. How would you answer that?

A It's very much a misinterpretation of what has happened to say that we're not serious. Bill Ruckelshaus used to warn us not to set ourselves up for failure in this business. And to some extent, I think that's the question we're asking here. Have we set ourselves up to fail with a standard that we can't meet? Not because of any efforts we make or don't make, but simply because there are circumstances beyond our control?

Los Angeles, again, is my example. The Indians for years called it the "Valley of Ten Thousand Smokes." Smoke and smog have always collected there because of its natural conditions, because of the tendency for inversion layers to form.

So I don't think it's accurate to say we haven't tried to meet the requirements of the law. I do think there are more things we can do. There's always more you can do. But to translate that into saying we really have not made an effort is wrong. With ozone, we're dealing with something we're going to have to face with every other pollutant, too. We're trying to balance the need for environmental protection against the need for some kind of economic growth. The standards set 15 years ago never considered how we would deal with growth. So the issue in this generation of pollution problems is: "How can we have it both ways? How can we protect the environment, while enjoying the economic growth we depend on?"

Q We've talked about institutional and government changes. What can individuals do? How are they involved in the ozone problem?

A First of all, I think people need to be aware of what the cause of the problem is. It's in large part these hydrocarbon emissions. And putting gas in your lawnmower, or painting your house with oil-based paint, or stripping a piece of furniture—those simple, everyday operations have the potential to create ozone because they involve the evaporation of volatile organic compounds into the air. But you have some substitutes. You can use water-based paints, for example. People can minimize their contributions to ozone. I wouldn't want to overstate it, of course, but they can do something.

But the biggest contribution is to improve the way we use automobiles. If you can use a car to go somewhere with six people in it, presumably that removes five cars from the road. That's five cars that would have been emitting hydrocarbons, carbon monoxide, and particulates. Carpooling and using cars more efficiently is bound to have an impact on the ozone problem. But you can see that we're talking about planning our lives to minimize pollution, we're talking about major lifestyle changes.

Q But do you think people will change? Is it possible that we will just have to live with ozone?

A In some areas, I think that may be the case. But there may be ways to get around it. Our basic responsibility at EPA is to protect health. That means we want to limit people's exposure to ozone. It's important to realize that ozone is not a year-round problem. For the most part, it's a five-month, summer phenomenon. It occurs during the period when people are more likely to be outside. Well, maybe people will be willing to live with temporary inconveniences. Maybe we can adjust living patterns so that people won't be exposed to ozone during the worst times. There's a lot people can do. □

Smog: Its Nature and Effects

by Bob Burke

Ozone or "smog" is just one of six major air pollutants that EPA regulates, but it is by far the most complex, intractable, and pervasive. It is also an extremely difficult pollutant to regulate effectively.

Many more Americans live in areas that suffer unhealthy levels of ozone than are affected by any other air pollutant. Adverse health effects have been observed in test animals and in humans even at exposure levels only slightly higher than federal health standards for ozone. In fact, concentrations of the pollutant are often far higher than federal standards in many urban areas of the country. Permanent damage to respiratory systems and other adverse health effects are known to occur from repeated exposure to ozone at such high levels.

Ozone is difficult to control because of the extremely large number of individual sources that can contribute to its formation, and because much of the pollution these sources produce may be transported to areas long distances away.

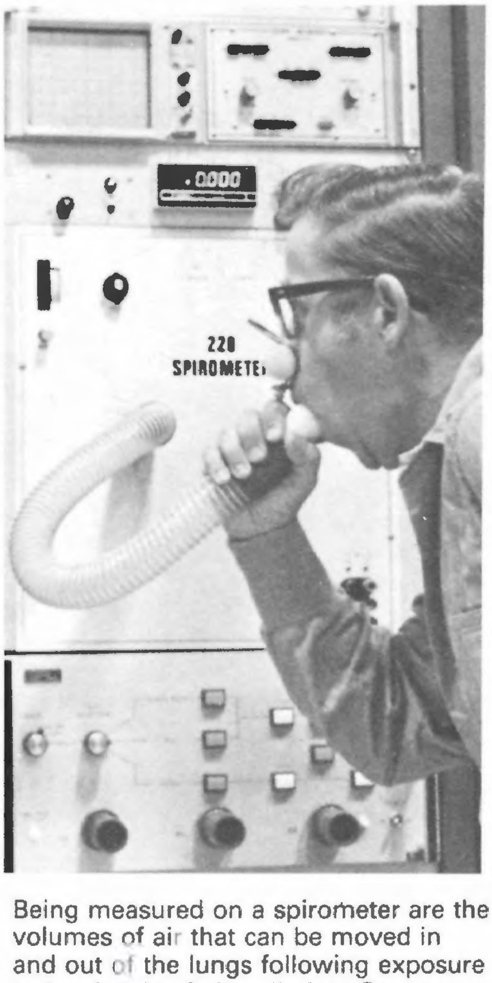
Ozone is Pervasive

One way to put the unique problems of ozone into perspective is by comparing the number of Americans experiencing unhealthy levels of the major air pollutants

Metropolitan Area Populations Subject to Air Pollution Levels above Federal Health Standards in 1985

Ozone	76.4 million
Particulate matter	47.5 million
Carbon monoxide	39.6 million
Nitrogen dioxide	7.5 million
Lead	4.5 million
Sulfur dioxide	2.2 million

While these comparative figures are important indicators of the magnitude of ozone pollution, they actually understate the relative public health impact of ozone. Some of the pollutants (such as lead and carbon monoxide) are highly localized. For example, they tend to concentrate only along roadways, as a consequence of motor vehicle traffic, or near other specific sources that emit them. Therefore, if the standards for these pollutants are exceeded in a county containing a million or more people, the number of county residents who actually experience such excess exposure levels may be only a fraction of this total population.



Being measured on a spirometer are the volumes of air that can be moved in and out of the lungs following exposure to low levels of air pollution. Ozone pollution impairs normal lung functioning and reduces the ability to perform physical exercise.

By comparison, if ozone standards are exceeded in the same county, it is likely that all, or almost all, county residents will experience significant ozone exposure. High concentrations of ozone tend to pervade an entire county or region, and may extend to areas far beyond.

Ozone is Elusive

Unlike the other major air pollutants, ozone is not emitted directly by specific sources. Instead, it is formed in the air by chemical reactions from nitrogen oxides and volatile organic compounds (VOCs). In each area, the sources of ozone may consist of literally thousands of large and small stationary sources in addition to motor vehicles—the major mobile source contributor. Sources of VOCs include (1) products of combustion from motor vehicle engines and other machinery; (2) vapors of gasoline emitted by motor vehicles, service station pumps, gasoline refineries and petroleum storage tanks; and (3) chemical solvent vapors emitted by a host of commercial and industrial sources such as dry cleaning establishments, solid waste facilities, and metal surface paints.

Ozone Transport

Effective controls are also hampered by the phenomenon of ozone transport. This also accounts for much of the pollutant's pervasiveness and presents a range of practical difficulties to regulators.

Scientists in EPA's laboratory in Corvallis, Oregon, inspect pine seedlings for ozone damage.

Most of the other pollutants that EPA regulates tend to concentrate in the air in some proximity to the sources that emit them. Not so with ozone. Emissions of VOCs are, in fact, often carried distances of hundreds of miles from these sources, resulting in high concentrations over large regions.

The Effects of Sunlight

The reactions that form ozone are stimulated by sunlight, so that ozone reaches peak levels in most of the country during the summer months—particularly when air is stagnant for extended periods. This type of pollution first gained public attention in the 1940s as Los Angeles "smog." The highest concentrations have long been found in that city, but very high concentrations also began to develop in other areas as motor vehicle travel increased following World War II. Ozone generally affects all areas that have extended periods of abundant sunlight coupled with high emissions from motor vehicles—a major source of both VOCs and nitrogen oxides.

Health Effects

Ozone severely irritates the mucous membranes of the nose and throat, impairs normal functioning of the lungs, and reduces the ability to perform physical exercise. In general, the pollutant's adverse health effects depend on a combination of factors: the amount of ozone in the air, and the frequency and duration of exposure. However, the effects of ozone at any concentration are felt most by people with asthma, chronic obstructive lung disease (such as emphysema), or allergies, and by persons who regularly perform strenuous exercise outdoors. Sensitive individuals may experience adverse health effects from even relatively low concentrations of the pollutant. It also appears that ozone in combination with other pollutants presents greater potential respiratory effects than any single air pollutant alone.

The health effects of ozone have been confirmed in closely controlled and monitored laboratory testing programs and in epidemiological surveys of population groups that are routinely exposed to high concentrations of the pollutant. When ozone levels are up,

Adverse health effects have been observed in test animals and in humans even at exposure levels only slightly higher than federal health standards for ozone.

hospital admissions go up, there is more sickness generally, and physical activity becomes difficult even for healthy individuals. The most vulnerable suffer extreme discomfort and distress.

Under closely monitored exposure conditions, people with perfectly healthy respiratory systems have been found to suffer adverse effects and reduced physical capacities in response to even relatively low concentrations of ozone. Chest pains, coughing, wheezing, pulmonary and nasal congestion, labored breathing, sore throat, nausea, and other disfunctions begin to occur when ozone reaches higher levels. Invariably, the higher the ozone level, the more severe the symptoms are.

The duration of exposure directly influences how long an individual feels the effects of ozone pollution—i.e., the longer the period of exposure, the longer it takes to get back to normal once an individual is removed from the polluted environment.

Animal toxicology studies have shown that ozone can interfere with the body's immune system. This contributes to lowering the body's resistance to infection and increases its susceptibility to acute respiratory infection. Animal test data also show that there is a "point of no return," after which adverse effects of ozone cease to be reversible. These study results show that exposure to high levels of ozone—on repeated occasions that span a long period of time—can cause or contribute to permanent damage to the lungs.

Effects on Agriculture and Forests

In addition to a growing body of evidence about the health effects of ozone, there are recent findings about ozone's adverse effects on cash crops, forests, and other forms of vegetation. Since the late 1970s, EPA has conducted extensive field surveys of ozone's effects on agriculture through the National Crop Loss Assessment Network (NCLAN) study. This study puts the agricultural loss from ozone pollution at between $2 and $3 billion each year. One set of studies showed that even levels of ozone below the health standard can reduce several major cash crops by as much as 10 percent a year. Additional studies conclude that higher ozone levels have reduced plant yield in tomatoes by 33 percent, beans by 26 percent, soybeans by 20 percent, and snapbeans by up to 22 percent.

Conclusive statements about the role of ozone and other air pollutants in damage to forests are not possible at present because data are limited. Many scientists, however, think ozone is a major contributor to the decline in growth of many species of trees. The existing data, though limited, do suggest strongly that ozone pollution has played a role in the loss of at least some forests. One study in the San Bernardino Mountains of California concluded that ozone was the cause of foliar injury, premature leaf drop, decreased radial growth and photosynthetic capacity, and death by bark beetles in ponderosa and Jeffrey pine. Repeated ozone peaks near the standards have been implicated in damage to white pine in the eastern United States and Canada, and reduced growth rates for the red spruce at numerous high elevation sites in the Appalachian Mountains.

Ozone: the Twentieth-Century Pollutant

Ozone has been and will continue to be the nation's major air pollution challenge in the foreseeable future. It adversely affects far more people than does any other kind of air pollution, and very specific health effects have been well documented in both humans and laboratory animals. Long-term exposure to high concentrations of ozone is particularly threatening to certain vulnerable portions of the nation's population. It is also clear that even relatively modest concentrations can damage forests and diminish the quantity and quality of several agricultural crops.

All air pollutants are at least in part products of modern industrial society, but ozone is truly a twentieth-century pollutant since it is essentially a byproduct of the massive and dispersed transportation and industrial systems that have emerged in this nation over the past several decades. It also seems likely that it will take what's left of this century to bring ozone pollution under full control. □

(Burke is on the staff of EPA's Office of Public Affairs.)

Situation Reports: From Los Angeles to Atlanta

by Roy Popkin

People who think of traffic—and traffic-related pollution—as a strictly modern irritation might do well to consider New York City in 1894. Half a million horses and their associated carts and carriages jostled for space with pedestrians. Not only were the streets littered with tons of ripe manure, but the methane gas generated as it rotted was literally making people sick—in today's terms, a case of solid waste disposal problems complicated by volatile organic compounds (VOCs) in the air. The solution back then was straightforward. The city set up the "White Wings"—a corps of white-uniformed street sweepers whose special function was to rid New York of the equine public health menace. But controlling transportation-related pollution is not so simple anymore. Today, New York and scores of other major metropolitan areas face the problem of ground-level ozone caused

Steve Delaney

Some changes in life styles may be necessary in certain areas to control ozone pollution. For example, more people may use computers at home to do their jobs instead of driving to offices daily.

AP/Wide World Photos

Carl Lewis, Lane 5, wins the men's 100-meter dash at the 1984 Los Angeles Olympics. The city took special measures that reduced smog so that it would not hamper athletes' performance during the Olympics. A 12 percent drop in ozone levels was measured during that time.

mostly by cars, and it will take a lot more than brooms and shovels to eliminate it.

Ozone is the principal ingredient of smog, and has been shown to seriously affect the human respiratory system, as well as damage crops, forests, and manmade materials. It's usually not emitted directly into the air from any individual source; instead, it is produced in the atmosphere by complex chemical reactions between VOCs and nitrogen oxides. These reactions are stimulated by sunlight and temperature, so that peak ozone levels typically occur in warmer climates and during warmer times of the year. Although ozone has been regulated since 1971, 62 areas, mostly major cities, have not yet attained the national standards for ozone levels, and most are not expected to meet them by the statutory deadline of December 31, 1987.

Unfortunately, reducing ozone levels is a lot harder than sweeping up manure piles. Because the atmospheric reactions that produce ozone take time, it can often appear many miles from the VOC and nitrogen oxide emissions that create it. In addition, these "precursor" emissions come from hundreds of different sources, including dry cleaners, bakeries, auto body paint shops, household consumer products, the burning of fossil fuels, and most importantly, the automobile. One-third to one-half of all VOC and nitrogen oxide emissions come just from using, fueling, and maintaining our motor vehicles. It may take extraordinary changes in cars and car-centered lifestyles to reduce ozone concentrations to the 0.12 parts per million level mandated by the Clean Air Act, not only in typical pollution centers such as New York, Los Angeles, Houston, and Atlanta, but also in areas like North Carolina, where new development is increasingly fouling the air.

According to Tom Helms of EPA's Office of Air Quality Planning and Standards, many areas will have to implement a variety of innovative strategies over the next 20 years. Programs already in place, such as stationary source controls, inspection and maintenance (I/M) for cars, and changes in industrial processes, are only the beginning. At the very least, the use of cars must be sharply reduced in metropolitan areas, and Helms does not scoff, for example, at such suggestions as New York City's proposal to charge commuters a daily $10 fee for bringing autos into lower Manhattan.

New York City's ozone problem is not its alone, of course. William Baker, chief of EPA Region 2's Air Programs branch, sees the city as a victim of "ozone precursor transport" whose efforts to further reduce ozone levels are frustrated by its own huge population, by its position in the urbanized Northeast corridor, and by atmospheric pollution from upwind states. These and other problems have resulted in a 41-percent shortfall in the ozone reductions anticipated by the area's state implementation plan (SIP). Thousands of tons of VOCs annually reach the air over the New York-New Jersey metropolitan area from such everyday sources as cars, gasoline pumps, paints and coatings, dry cleaners, and consumer/commercial products, as well as from noncomplying industrial stationary sources.(SIP)

New York and New Jersey have I/M programs that exceed federal requirements by including strict emissions limits, heavy-duty gasoline vehicles, and state-wide inspection for tampering. Even the ubiquitous New York City taxis are inspected three times a year. Even so, the additional ozone reductions needed in order to meet the ozone health standard are still several years away, and they are unlikely to be greater than originally anticipated. It's possible that controlling VOC emissions from sewage treatment plants will help reduce ozone levels, but according to Baker, automobiles still cause about half the ozone problem even though more than 80 percent of New York commuters already use mass transit. Ratcheting down on mobile sources would perhaps mean higher gasoline taxes, automobile-free zones, and odd/even driving days in the city. "Solutions that involve people or businesses leaving the city will be painful," he says, "but someone has to bite the bullet."

Biting the bullet is something Los Angeles has been facing for a long time. Year-round sunshine, a car-centered lifestyle, and a geographic location favorable to air inversions all combine to help Los Angeles violate the ozone standards 140 times a year. Still, says David Calkins of EPA Region 9, this is an improvement over the past, when there were days so smoggy that people on City Hall's twenty-second floor couldn't see the street below them. He credits state and local efforts, as well as EPA's, for bringing the number of exceedance days down from over 300 in the 1970s to the present 140. "The number of such days—and the size of the population involved—is continuing to decrease," he says, "but not enough. They've been doing things for 10 years that are far ahead of the rest of the country. For example, they have nozzle controls on gas pumps that catch at least 84 percent of the VOC emissions from gas stations, and the nozzles are capped as soon as someone reports them to be defective. The state's inspection and maintenance program enforces extremely high standards. Finally, Los Angeles is trying to encourage use of mass transit by allowing smaller parking areas for new buildings if the owners provide bus service or tokens so the tenants can use public transportation."

Nevertheless, it will take drastic changes in the southern California lifestyle to reduce ozone to acceptable levels. There are some 12 million people and 7 million cars in and around Los Angeles, but even with all the cars removed, the problem would still be only partially solved. Los Angeles would still fall victim to its sunlight and continued population and industrial growth. Planners expect the area to grow by three million people in the next 10 years alone; the places they work and the products they use will be new sources of emissions that turn into urban smog. "If the growth in the numbers of cars and population is not offset," warns Calkins, "the ozone levels may start to increase again, rather than continue to drop." Among his suggestions are alternative fuels, such as methanol or ethanol (the city is already trying these on some buses); greater use of mass transit; and a massive lifestyle switch to teleconferencing and working at home with computers rather than going to an office.

Joanne Aplet, a planner for the South Coast Air Quality District, agrees with Calkins that the solution has to come from improved technology and lifestyle changes. She looks for technology to produce practical electric cars, electric motors to replace small gasoline-combustion engines, and emission-free coatings and solvents for the workplace. "In the short-term," she says, "we are going to ratchet down on everything we already are doing. What we will have to do is find ways to tighten our control over emissions from the many small businesses and industries that keep proliferating around here. If this makes living here more expensive and more difficult, perhaps the reaction may force the technological advances we need over the next 20 years."

Although its industrial emissions are more of a problem than its cars, Houston like Los Angeles suffers from a surplus of sunshine and hot weather. According to Becky Caldwell of EPA's Region 6, Houston has been a nonattainment area ever since Texas began monitoring its air. Nonetheless, there has been considerable progress towards the VOC emissions reductions called for in the Texas SIP. The Texas Air Control Board says that Harris County, where Houston is located, has reduced VOC emissions by 45.8 percent, and that peak ozone concentrations have dropped by 21 percent since 1980.

Even so, says Caldwell, controls on industrial emissions will have to be tightened further; there is need to improve enforcement of anti-tampering and inspection and maintenance programs, as well as improve the city's rapid transit system. Mandated use of alternative fuels would have a significant impact in terms of cleaner air. Until then, she adds, respiratory ailments will continue to increase as ozone levels rise during the Gulf Coast's overheated afternoons.

Atlanta is another sunbelt city whose ozone problems are among the nation's worst. As elsewhere, more people mean more cars, and Atlanta's population has boomed. In fact, some Atlantans wryly joke that Atlanta's cars alone throw more pollution into the air than did General Sherman's fires when he burned the city during the Civil War. Still, the new Atlanta subway system is attracting a significant number of riders, and Tom Lyttle of EPA Region 4 believes that expanded use of public transportation and an improved I/M program may ultimately bring Atlanta within desired ozone limits.

Less optimistic, however, is the *Atlanta Constitution*. In a July 24 editorial, the paper said:

> ...Ozone pollution is a serious problem in these parts. The feds say it sometimes hits hazardous levels in metro Atlanta. It can cause respiratory problems in humans. Yet every time the EPA moves toward specific fixes, the dodging begins...Meanwhile, sigh, the great majority of metro Atlantans...who have everything to gain from strong ozone pollution controls continue to wait.

Even areas not typically associated with urban congestion and pollution are starting to feel the ozone problem as booming industrial growth and residential development create more local VOC emissions. The Raleigh-Durham area, for example, is an ozone problem waiting to happen. According to EPA's Tom Helms, whose office is right in the middle of the region, ozone has already joined carbon monoxide as an increasingly serious concern. "We hear a lot about the West and the Sunbelt," he says, "but ozone is also going to get worse in places like this. When I came here, the main road was easy to travel. It's now choked with a 100- to 125-percent traffic increase, and they're going to have to double its width. One firm alone is planning to bring 1,500 new employees into the area. That means more cars, more use of VOC-emitting household and other products. North Carolina better start doing something now about the cars, and their refueling and gasoline pumps."

In the meantime, cities big and small continue their battles not only against ozone, but also against the December 31, 1987, attainment deadline. The hope is that Congress will realize that the original deadline did not sufficiently consider variations in local meteorology and unanticipated growth and development patterns. Although deadline extensions of three to 13 years are being considered, a Los Angeles air-pollution official recently expressed the hope that the city would have clean air by the year 2020. Tom Helms also hopes that revised EPA ozone policies and Congressional actions will provide enough flexibility to sustain cities through a long, hard effort. "EPA has no silver bullet," he says, "no guidelines that say you do these five things and you'll be OK. Some hard decisions will have to made, perhaps millions of people will have to live, work, and travel in ways far different from the way they do today. It will probably be expensive. But if they don't change, the price they pay may be their lungs, or even their lives." □

(Popkin is a writer/editor in EPA's Office of Public Affairs.)

Finding Technologies to Control Ozone Pollution

by Jack Lewis

EPA has proposed that auto manufacturers be required to install onboard equipment on new gasoline-powered vehicles to control VOC emissions that occur during refueling. Pictured is a diagram of an onboard control system. During refueling, vapors from the gas tank are routed through a hose at the top of the fill neck into a carbon canister for collection and recycling into the engine, thus avoiding their release to the air through the fill neck.

The Clean Air Act of 1970 required EPA to set National Ambient Air Quality Standards (NAAQS) for various pollutants, including ozone. Ambient standards are "health-based," which means they have to be set at a level sufficient to protect public health with an adequate margin of safety.

EPA, founded in 1970, set its first ozone standard in 1971. Health data available at that time indicated that the maximum amount of ozone to be permitted for one hour one time daily should be 0.08 parts per million (ppm). New health data, gathered through scientific research, led to a revised ambient standard of 0.12 ppm in 1979.

The setting of the first and second NAAQS defined what 'nonattainment" of health-based ozone standards meant on a nationwide basis. Then it was up to EPA and to state governments to decide what needed to be done, in general, to improve air quality and what specific technological steps might be taken to reduce ozone-related emissions and increase attainment levels.

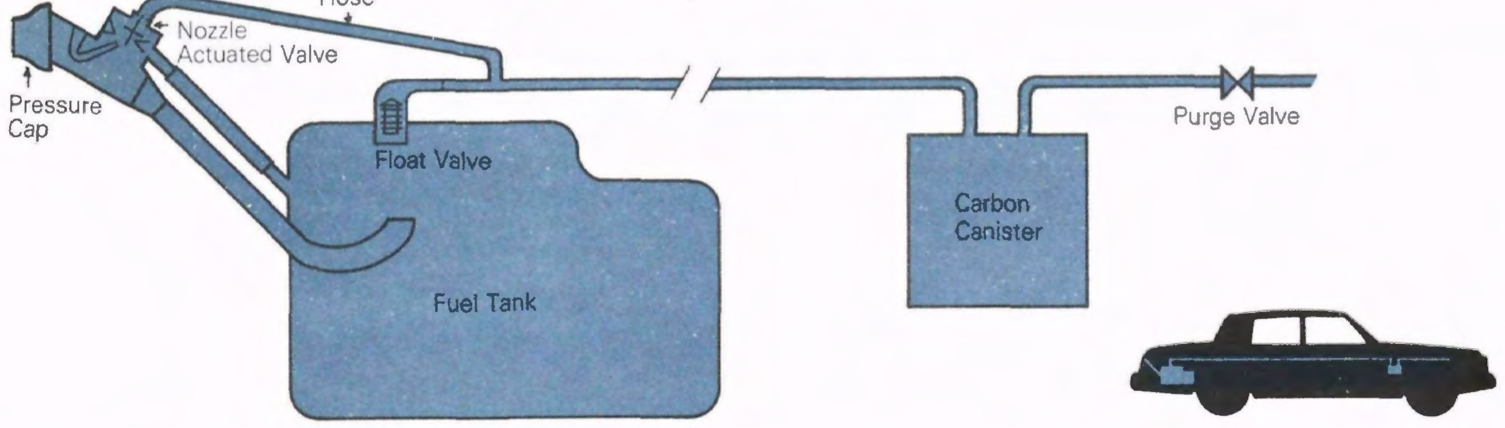
Both NAAQS were targeted for achievement through the application of controls on stationary and mobile sources of ozone-generating smog "precursors." These precursors are volatile organic compounds (VOCs), which combine with other pollutants under solar influence to create ozone-containing smog, a major pollution problem in many heavily populated urban areas.

In general, the stationary sources of VOCs—which vary considerably from area to area—are under the control of state governments. Mobile sources, such as cars, trucks, and other vehicles requiring uniform levels of nationwide control, are the regulatory responsibility of EPA.

EPA also has responsibility for stratospheric ozone, a valuable global resource not to be confused with its troublesome earthbound counterpart. It is ironic that an excess of ozone close to the surface of the earth is responsible for one environmental problem—namely, smog—while a dearth of the same substance in the upper atmosphere is currently the source of international concern, for altogether different reasons.

It should be noted that the actual chemistry of smog formation is extremely complicated. There are variations according to temperature level, quantity of sunshine, and wind patterns. Also, substances other than VOCs play a role in the photochemical reaction that generates ozone. Prominent

Onboard Vapor Control System



Various new technologies, most notably the catalytic converter, have led since the mid-1970s to major reductions in tailpipe emissions of VOCs.

among these are nitrogen oxides. EPA has determined, however, that VOCs should be the principal target of efforts to control ozone-containing smog in most cases.

Also exceedingly complex is the synergy between regulatory efforts to control emissions and trends in the world of technology and engineering. In some cases, the emission standards EPA sets are "technology-forcing." In other words, the standards set are so stringent that technological innovation is necessary for them to be achieved.

Such was the impact upon the auto industry of ambitious Clean Air Act goals set in 1970: Congress called for a reduction in automotive carbon monoxide and hydrocarbons (including VOCs) by over 90 percent from uncontrolled levels, and reductions in nitrogen oxides by 75 percent. This, and other goals set in later years, virtually forced the development of the catalytic converter and other automotive technologies.

All these strenuous efforts have brought substantial improvements in air quality. From 1970 to 1985, VOC emissions fell by 48 percent. But the urban smog problem continues to frustrate the experts. As of October 1987, EPA estimates that over 60 major metropolitan areas are still not in compliance with the federal standard for ozone. Furthermore, the Agency predicts that more than 35 of these areas will probably still fall short of attainment by the end of 1987.

Mobile Source Controls

The fumes from internal combustion engines contain many VOCs that, when released into the atmosphere, interact with other gases in the presence of sunlight to generate the ozone components of urban smog.

Various new technologies, most notably the catalytic converter, have led since the mid-1970s to major reductions in tailpipe emissions of VOCs, as well as the nitrogen oxides also linked to the smog problem. In fact, the use of the catalytic converter on passenger cars and light trucks became virtually universal by the early 1980s as the auto industry scrambled to meet new EPA regulatory deadlines. Unfortunately, its effectiveness has in many cases been undermined by motorists who fouled the devices with leaded gasoline or by mechanics who illegally removed them.

Another step toward VOC control also dates back to the mid-1970s. EPA (and states to which EPA has delegated primary enforcement responsibility) ordered companies responsible for bulk transfers of gasoline to put control equipment on storage tanks and other equipment used in such transfers to control evaporative losses.

More recently, 1980s technological advances have led to the introduction of sophisticated computer-controlled emissions reduction and fuel delivery systems. In particular, there have been dramatic improvements in fuel injection systems over the past few years.

A few states also have required service-station owners to install vapor recovery systems on gasoline pumps. These are the somewhat unwieldy but by now familiar devices that keep VOC fumes from escaping as individuals refuel their vehicles in some communities. Their use will continue for a time in certain areas.

The objective vapor recovery systems were intended to meet will most likely be achieved nationwide through a new method of VOC control recently proposed by EPA. The Agency's proposal would require automobile manufacturers to install onboard equipment on all new vehicles to control VOC emissions that occur during vehicle refueling. This equipment would be a modification of onboard canisters that have been used since the early 1970s to control other types of evaporative emissions from fuel tanks and carburetor systems. Redesign of existing canisters will permit control of refueling emissions from individual mobile sources without any inconvenience to consumers at the pump.

EPA estimates that these new onboard controls will add about $19 to the cost of new vehicles, but will save drivers approximately $5 over the lifetime of the vehicle in the form of recovered fuel vapors. Thus, the net cost per vehicle owner will be about $14: a small price to pay for urban air less saturated with smog.

Another EPA initiative will also help to alleviate the smog problem. The Agency is planning to force a rollback

Other companies have found that they can significantly reduce VOC emissions by using more efficient spray painting machines.

on the volatility of American gasoline. U.S. gasoline refineries have affected automotive evaporative-emissions control equipment by gradually changing the mix of gasoline. The addition of butane, for instance, leads to higher octane fuel that can be marketed at reduced prices. Unfortunately, this practice increases urban smog problems, especially during the warmer summer months, by subjecting VOC control equipment to levels of fuel volatility they were not designed to handle. The controls recently proposed by EPA should gradually rectify this problem over the next five years by placing limits on the summertime volatility of gasoline.

EPA is also considering other weapons in the war on mobile sources of VOCs. One is stricter requirements on state and local vehicle inspection and maintenance (I/M) programs. I/M programs currently exist in 60 urbanized areas in 32 states. By ensuring better maintenance and deterring tampering with emission controls, I/M programs help to assure that the most benefit is derived from the technology built into vehicles. EPA is also evaluating the benefits available through the use of alternative fuels and tighter emissions standards for light trucks.

Stationary Source Controls

Mobile sources—all motor vehicles, passenger and transport, used nationwide—fall directly under the purview of federal regulators. EPA sets standards that apply nationwide, though some states further strengthen federal standards by enacting even stricter laws of their own.

Stationary VOC sources, on the other hand, come more frequently under the direct control of state and local laws. This makes sense because patterns of urban and industrial development vary so much from community to community. However, there are two federally set emissions standards for stationary VOC sources: new source performance standards and control technique guidelines. These apply nationwide in nonattainment areas, though they are sometimes made stricter by state statutes. According to current estimates, stationary sources account for roughly 50 to 70 percent of current VOC emissions in most U.S. urban areas. What sort of stationary sources are we talking about, and what is being done to control them?

The chemical and petroleum refining industries emit large quantities of VOCs into the atmosphere, as do companies that apply paint or coatings to cans, cars, and other products.

Two methods are currently in use for the control of ozone precursors from stationary sources:

- *Process changes:* The introduction of new raw materials or processing equipment can often lead to significant reductions in quantities of VOCs generated by stationary sources. For example, conversion to new paints or other coatings that contain lower quantities of VOC-containing solvents has made it possible for many spray-painting installations to come into compliance with EPA's VOC standards. Other companies have found that they can significantly reduce VOC emissions by using more efficient spray painting machines.

- *End-of-process changes:* Abatement devices on vents from industrial processes can reduce part of the VOC emissions that come from stationary sources. Many advances are being made in this sphere of technology as government and business scientists seek to put a lid on a host of atmospheric problems: not just ozone-containing smog, but also acid rain, radon, etc.

There is also another category of stationary source that is a growing concern to air pollution experts: hazardous waste treatment, storage, and handling facilities as well as public and industrial wastewater treatment facilities. For example, even when covered with earth, such facilities can—by diffusion through the soil and later evaporation—emit quantities of pollutants, including VOCs. The role of these facilities in the overall ozone pollution is now being studied by EPA, which will formulate regulatory strategies to deal with this increasingly important aspect of the smog problem.

The decline of smokestack industries in the United States could contribute to some reduction in the overall problem, but as long as Americans continue their mass migration to rapidly expanding cities...drive vehicles frequently in urban environments...and make extensive use of VOC-containing products that must someday be discarded, U.S. government and industry will have their hands full, not just reaching ozone compliance but sustaining it as well. □

(Lewis is an assistant editor of EPA Journal.*)*

Alternative Fuels: Their Prospects for Fighting Smog

by Richard D. Wilson

Interest in alternative motor vehicle fuels has come full circle. The first serious research into alternative fuels in the late 1960s was motivated by the realization that gasoline and diesel vehicles were responsible for a large portion of urban air pollution. In the 1970s, the focus shifted to energy supplies and prices as the U.S. economy suffered through two oil crises featuring gasoline lines, price shocks, and, ultimately, cycles of inflation and recession. Today, environmental concerns have again taken center stage, with Clean Air Act deadlines rapidly approaching and EPA and state agencies alike examining every opportunity for additional pollution control strategies.

In July, the President's Task Force on Regulatory Relief, supported by EPA and other federal agencies, released a series of reports and recommendations that may stimulate state initiatives with alternative fuels. Recent tension in the Persian Gulf and concern about our growing dependence on foreign oil are factors behind the new push for alternative fuels. A primary driving force, however, is the realization that alternative fuels can play a key role in assuring that our air quality goals are met.

The Alternatives

Alternative fuels can be divided into two distinct groups: those that could completely replace gasoline and those that can be low-level additives to gasoline. The three primary replacement fuels of interest are methanol, ethanol, and compressed natural gas (CNG).

Methanol, ethanol, and CNG all have the potential to significantly reduce the contribution of motor vehicles to ozone formation. This is not so much because these fuels produce fewer hydrocarbon emissions compared to gasoline, but rather because their hydrocarbon emissions have been shown to be far less photochemically reactive than those of gasoline. We have known for quite some time that methane emissions, the primary hydrocarbon in CNG vehicle exhaust, are very, very slow to react in the atmosphere. More recently, we have learned that methanol emissions also have a low photochemical reactivity, and ethanol has a higher, but still relatively low, reactivity.

Methanol is an excellent engine fuel that can be produced from natural gas, coal, or biomass. It is currently priced at a level fairly close to gasoline on an energy basis. Presently some 1,000 methanol vehicles are operating in California, and these vehicles use engines very similar to those in today's gasoline vehicles. We project that emissions from current methanol vehicles create 20 to 50 percent less ozone than comparable gasoline

California Energy Commission

vehicles. Cold startability and formaldehyde emissions are two areas of concern.

It is important to recognize that current engine designs have been highly optimized for gasoline. We have only recently begun to investigate the potential for engines to take full advantage of methanol's superior fuel characteristics. We believe that engines optimized for methanol could be much cleaner and more efficient than current methanol vehicles. A few prototype vehicles have been tested, and we project that in the future, advanced methanol vehicles could reduce the ozone potential of vehicles by 80 to 90 percent and would also yield much lower carbon monoxide emissions.

Ethanol is produced in the U.S. primarily by fermenting grains such as corn. To date, few vehicles here have been designed to operate on pure ethanol, although Brazil's transportation system runs predominantly on ethanol. We believe that the use of pure ethanol as a motor vehicle fuel would offer emissions benefits somewhat lower but still comparable to methanol. The primary issues associated with ethanol's use are supply and cost.

Most of the vehicles currently operating on CNG use conversion kits to allow the vehicle to operate on either CNG or gasoline. We estimate that such vehicles, when operated on CNG, would contribute 40 to 80 percent less to ozone than gasoline vehicles. If properly performed and maintained, conversions typically provide carbon monoxide emissions reductions as well. Drawbacks associated with CNG conversions include generally higher nitrogen oxides emissions and poorer vehicle performance, due to reduced engine power and increased weight from the pressurized CNG cylinders. As with methanol, we believe CNG is best suited for engines designed specifically for its use. Such vehicles would likely achieve 80- to 90-percent reduction in ozone-producing potential and very low carbon monoxide emissions. Whether the nitrogen oxides emissions and performance problems can be solved remains to be seen. Other issues that must be addressed with CNG include the economic impacts of distributing and compressing a gaseous fuel.

A related benefit from the use of methanol, ethanol, and CNG as pure fuels is that in large truck and bus engines, they would essentially eliminate the particulate or smoke that is characteristic of diesel engines. In certain central city areas, buses and trucks contribute significantly to high particulate levels. EPA's Office of Mobile Sources (OMS) has been very supportive of methanol bus programs ongoing or planned in San Francisco, Jacksonville, Seattle, Riverside, Los Angeles, and Denver, all sponsored by the Urban Mass Transportation Administration (UMTA). OMS and Region 2 have organized a methanol bus demonstration project in New York City involving General Motors, the Natural Resources Defense Council, the Center for Auto Safety, and Celanese. This unique project involves a significant research and development effort by GM; the first six methanol buses are planned to begin operation in New York City in December. Two CNG buses will also begin operating shortly, which will permit a comparison between methanol and CNG technologies. It currently appears that alternative fuel bus engines may be an attractive option for complying with our stringent 1991 bus engine emission standards.

In the longer term, there is still significant interest in two other fuels that could nearly eliminate mobile source pollution in urban areas—electricity and hydrogen. Unfortunately, there is little hope for either of these options until well into the twenty-first century.

Gasoline Additives

The second group of fuels that could reduce motor vehicle emissions include those composed primarily of gasoline with low levels of additives. Four blends have been approved by EPA: gasohol, which contains 10 percent ethanol; DuPont, which includes 5 percent methanol and 2.5 percent ethanol; Oxinol, which contains 5 percent methanol and 5 percent tertiary butyl alcohol, and MTBE, which can be blended up to 11 percent with gasoline. Currently gasohol accounts for 7 percent of all gasoline sales and MTBE blends for approximately another 10 percent. DuPont and Oxinol blends are currently not marketed.

The primary emission benefit of these additives is lower carbon monoxide emissions from increased air/fuel ratio. Our analysis shows that gasohol, DuPont, and Oxinol blends reduce fleet-wide carbon monoxide emissions by around 22 percent. MTBE, which contains less oxygen, would reduce emissions by 12 percent. The magnitude of these reductions will decrease somewhat in the future as new cars with computer controls displace older vehicles.

The one emissions concern with oxygenated blends is that the addition of ethanol and/or methanol to gasoline increases the volatility of gasoline. This in turn increases the amount of evaporative hydrocarbon emissions. Using oxygenated blends could thus increase the ozone-producing potential of motor vehicles unless their use is limited to the winter months when carbon monoxide is typically high and ozone low, or the base gasoline is modified to provide oxygenated blends with the same overall volatility as straight gasoline.

OMS and Region 8 have been working very closely with the State of Colorado in its planning for a mandatory oxygenated fuels program in Denver.

The Outlook

The relevant question is not whether we ultimately will move to alternative fuels, but how to do so. There is considerable inertia in the existing petroleum-based transportation system, and it is not clear how to begin the transition to alternative fuels.

Left to market forces alone, the transition will ultimately occur, but probably not quickly. The current crude oil surplus and low prices have temporarily lessened the energy and economic arguments for alternative fuels. However, the non-crisis atmosphere offers a window of opportunity for sound and creative planning for the post-petroleum period. The use of alternative fuels may well be a cost-effective urban air quality strategy that, at the same time, would help lay the foundation for a longer-term nationwide transition. In this case, good environmental policy today can lead to significant environmental, energy, national security, and economic benefits tomorrow. □

(Wilson is Director of EPA's Office of Mobile Sources.)

Methanol-fueled buses are being used in San Rafael, a San Francisco suburb. EPA believes that in the future, vehicles using advanced methanol technology could reduce their ozone pollution by 80 to 90 percent as well as lowering carbon monoxide emissions.

EPA, Ozone Pollution, and the Law

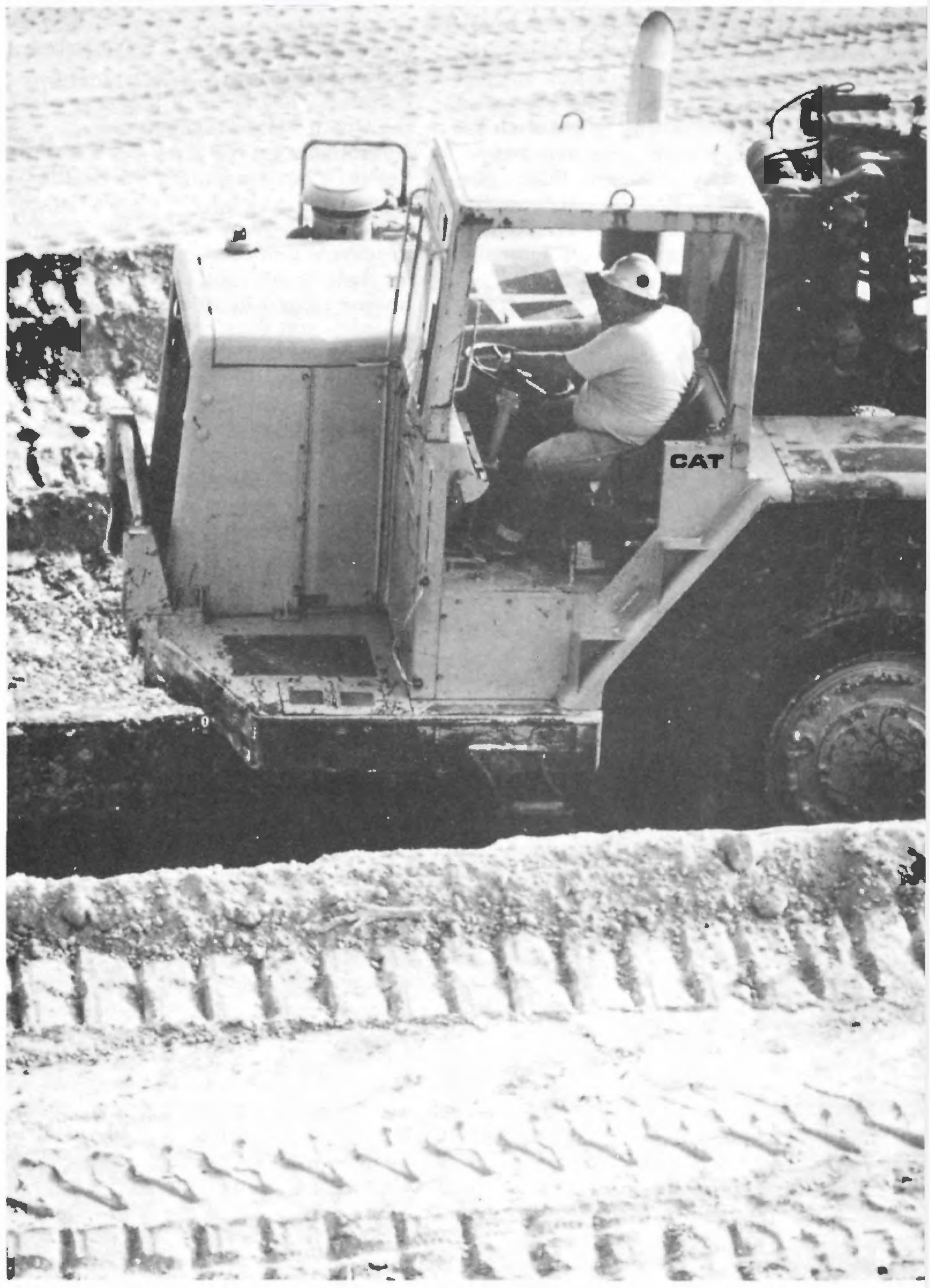
by Richard Ossias

There has been much speculation throughout the country about what might happen to cities whose air does not attain EPA's standards for ozone and carbon monoxide by December 31, 1987. That is the attainment date inserted into the Clean Air Act when Congress amended the law in 1977.

The law authorizes, and in some cases requires, EPA to apply certain types of sanctions in some areas, including bans on certain construction and on funding for air-pollution control planning and construction of highways and facilities for sewage treatment. In some cases the law may also require EPA to step in and create its own federal plan to bring about attainment of the standards. As explained below, these potential outcomes are not universally understood.

Sanctions

Some members of the public believe that the full array of sanctions will automatically apply at the end of the year to all areas that still have not attained the ozone and carbon monoxide standards. Some have suggested, for example, that EPA will have no choice but to ban in all of those cities the construction of certain large projects that would contribute to ozone or carbon monoxide pollution (e.g., chemical and auto manufacturing



Ira Wexler, Folio, Inc.

Highway construction could be limited in a number of areas if EPA finds that a state has not fulfilled the planning requirements of the 1977 Clean Air Act Amendments and is not making "reasonable efforts" to do so. Urban areas also face a possible construction ban if they have not submitted approvable air quality plans to control ozone and carbon monoxide.

Some members of the public believe that the full array of sanctions will automatically apply at the end of the year to all areas that still have not attained the standards.

plants, which emit large amounts of volatile organic compounds responsible in part for ozone). This interpretation would thus apply to the many major metropolitan areas which will not meet both standards by the end of the year.

EPA does not agree. The Clean Air Act does provide for a construction ban under some circumstances. But the Agency has long held that the law does not require EPA to impose a ban in every area that fails to attain the air quality standards by the Clean Air Act target date. Instead, EPA believes that the ban is automatic only in areas whose formal plans to meet the standards have not received the Agency's approval. The Agency put this interpretation into a regulation in November 1983 after almost a year of reviewing the issue with the public and the Congress, and the regulation is still in effect today.

This means that only the few areas without approved air-quality plans will automatically face such a construction ban. That includes Los Angeles, Chicago, and a dozen or so other areas. (EPA proposed on July 14, 1987, to disapprove the plans for most of these areas and to impose the ban in them.)

The ban will *not* apply automatically to many other areas with approved plans, but which, for various reasons, will not attain the standards by the end of the year. However, this second group of cities will become subject to a ban if EPA finds that they are not implementing their approved plans. This would include, for example, failure to submit an adequate state implementation plan (SIP) in response to an EPA call for SIP revision.

Where EPA does impose a ban, it will be removed as soon as the Agency fully approves a corrective plan for the area—even if the area's air quality has not yet met the standards. Again, this is because EPA views the ban as a prod to get the states to produce good plans, not as a punishment for failing to meet air-quality standards.

EPA has other sanctions available at its discretion. But, again, the Agency does not believe they can be imposed in an area just because the area's air quality does not meet the ozone and carbon monoxide standards at the end of the year. Instead, these sanctions come into play only when an area fails to do diligent planning or to carry out its approved plan.

For example, EPA and the Department of Transportation must cut off certain federal funds for state air-pollution control planning and highway construction if EPA finds that the state never fulfilled the planning requirements in the 1977 Clean Air Act Amendments *and* is not making "reasonable efforts" to do so. Because the judgment about whether an area's efforts are "reasonable" is so subjective, EPA has much discretion in deciding whether to impose these sanctions.

The Agency has found a lack of "reasonable efforts" only for a small number of cities through the years, and imposing highway funding sanctions has generally been effective in getting the area's planning efforts back on track. This is because highway construction is popular in many cities, and the public usually is willing to accept the necessary pollution controls (e.g., programs for inspecting tailpipe emissions from cars) when highway construction is at stake. The Agency intends to continue to apply these sanctions selectively in the future.

Similarly, the Clean Air Act allows EPA to cut certain funds for constructing sewage treatment works in areas that either do not submit approvable plans to attain air quality standards or do not implement those plans. Historically, the Agency has used this tool only as a last resort, in cases where other forms of inducement have failed to spark better planning.

Federal Air Quality Plans

Where a state has failed to submit an approvable plan to meet the ozone and carbon monoxide standards, EPA must sometimes step in and do the job. Indeed, one federal court recently ordered the Agency to create a plan to attain the carbon monoxide standards in Phoenix and Tucson.

Since ozone and carbon monoxide pollution is caused partly (and in some cases mostly) by pollution from vehicles, most major metropolitan areas will have to control driving habits to meet the standards. Although some of them were later overturned in court, in the mid-1970s EPA created transportation-control plans that provoked enormous public opposition because they would have rationed gasoline sales, restricted downtown parking, and imposed other limitations on vehicle use. Congress ultimately reacted by amending the Act in 1977 to trigger a new round of state planning under threat of the same sanctions.

EPA is now beginning to consider how to produce plans to attain the carbon monoxide standard in Arizona without causing a rerun of the severe adverse public reaction it sparked in the 1970s effort. In the final analysis, the Agency believes that the attainment of the ozone and carbon monoxide standards depends largely on the public's acceptance of the controls needed to meet those standards. And the public will accept these limitations only if they are based on careful thought and communication about the alternative paths to clean air. □

(Ossias is an attorney in the Air and Radiation Division of EPA's Office of General Counsel.)

Solutions to the Smog Dilemma: A Forum

Now that many areas apparently will not meet the ozone pollution control deadline under the Clean Air Act, how far and how fast should we go in getting states to meet the standard in the future? EPA Journal asked three persons representing a range of opinion for their commentary on this question. The participants in this forum are U.S. Senator George J. Mitchell (D-ME), Chairman of the Senate Subcommittee on Environmental Protection; Richard Ayres, a senior attorney with the Natural Resources Defense Council, an environmental group; and Michael R. Barr, with a law firm in San Francisco, Pillsbury, Madison & Sutro, presenting a viewpoint from the business community. Their comments follow:

Senator George J. Mitchell

An estimated one hundred million Americans live in areas where the air fails to meet the health-based standards of the Clean Air Act. In some cases, people are breathing air that is three times as unhealthy as the standards permit. We must find a way for these areas to come into compliance and protect public health.

Based on extensive hearings before the Senate's Environmental Protection Subcommittee, I am convinced that more effective controls are necessary to achieve cleaner air in a timely manner. The health data are compelling. Air pollution is second only to smoking in causing lung damage. Americans spend $14 billion a year on health costs, and another $40 billion on loss of worker productivity associated with air pollution. Sixteen years ago, EPA set the National Ambient Air Quality Standards for criteria pollutants to protect human health. The Clean Air Act requires these health-based standards to be met through the application of control technology that will reduce emissions continuously and result in improved air quality. The deadline for compliance with the standards was originally 1975, but was extended by the 1977 amendments to the Clean Air Act to December 31, 1982. Areas with severe ozone and carbon monoxide problems were then provided an opportunity for an extension for those two pollutants to December 31, 1987, provided they took certain extra steps to control air pollution sources. EPA now estimates that over 60 areas will *not* meet the 1987 deadline. Clearly, the effort to date has not been adequate in reducing ozone and carbon monoxide pollution. After 10 years of experience in implementing the provisions of the 1977 amendments, the magnitude of the remaining problem of so-called "nonattainment" points to the urgent need for strengthened approaches to improving air quality.

Addressing this complex issue is a priority for me as Chairman of the Environmental Protection Subcommittee. The comprehensive legislation which I introduced, and which the Committee recently approved, will strengthen the Clean Air Act and provide new guidance to the states where the federal standards are exceeded. Deadline extensions will be provided, but as a condition, states and localities must commit to additional measures to reduce emissions. Most areas of the country should be able to meet the standards within 10 years. State and local governments should commit to meeting that or a shorter deadline. The federal government must be an active partner if that goal is to be achieved.

The necessary reductions will not be easy. Each source can state with some justification that its contribution to the problem is only a small one. But there are many small sources. Taken as a whole, these sources create a serious national problem that must be addressed.

The magnitude of the existing health and environmental risks requires Congress to press for tough controls so we can safely breathe the air.

Richard Ayres

Americans want air quality that protects their health, their aesthetic experiences, and the integrity of the natural environment. In poll after poll, they say overwhelmingly they want better air quality, believe it can be attained, and are prepared to pay for it. But tens of millions of Americans still live in areas with chronic smog problems. Though the compliance deadline is upon us, the cleanup effort has been inadequate. Some in government are already lamenting that all the "reasonable" pollution control measures have been exhausted. But to the American people, it seems too many public officials have not taken the law seriously. EPA has not taken the lead, and all too often state and local officials have failed to pick up the mantle of responsibility.

The deadlines in the law, put there to encourage action and assure accountability, mostly get a wink. Potential emission reductions have been turned into property rights for emitters through the "bubble" and new source policies. The Agency has eschewed improvements in public transportation systems called for by the Clean Air Act. EPA guidance on control techniques has all but dried up, and aggressive implementation plans have fallen by the wayside.

In short, perhaps our most sweeping public health program is in shambles.

To make it effective again will take structural changes, to be sure. But perhaps more important, policy-makers must first change their habit of thinking of reasons why Americans cannot have clean air. Government agencies and Congress must adopt a positive approach that matches the public's desire for healthy air.

The issue is not how to extend deadlines, but how to apply available, sensible pollution controls to achieve healthful air quality as soon as possible.

It is remarkable that EPA has not come forward with a call for Congressional direction, a laundry list of "must" provisions, or a comprehensive bill of its own. Instead, the Agency proposes by administrative fiat to eliminate the deadlines in the law and authorize another multi-year planning exercise as a substitute for further cleanup measures. While offering little of its own, the Agency rejects efforts by members of Congress to revitalize the law.

In truth, there is a host of sensible control measures that can drastically reduce Americans' exposure to health-threatening levels of "smog" and other urban pollutants. The costs of these measures are reasonable. None of them are free; but few things worth having are. We have heard these measures characterized as "Draconian." But are the following "Draconian?"

- Tightening new car standards to the state of the art already achieved by a majority of the latest models.
- Improving assembly-line monitoring, warranties, and state inspection systems to assure that auto emissions control devices actually perform up to their capabilities.
- Requiring existing uncontrolled industrial polluters to adopt reasonably available control technology.
- Eliminating the various EPA "bubble" and "offset" rules that have become a system to award perpetual easements in pollution.
- Imposing emission fees to induce industries to find cost-effective ways to achieve emission reductions.
- Converting local vehicle fleets (e.g., buses, taxis, delivery vans) to natural gas or other clean fuels.
- Improving the quality and availability of public transportation.

Most of the concern about "Draconian" measures relates to the handful of urban areas where local authorities say that continued unfettered use of the private car is incompatible with attaining health standards, yet there are a myriad of incentive measures that could improve both the quality of life *and* the air by altering the transportation mix between cars and public transportation.

For those who observe with a sympathetic eye the efforts of federal and state officials to deal with the smog problem, it is sad indeed to see a debate in which such sensible pollution control measures are ignored. In 1970, this nation set an example for the world with its commitment to vigorous air-pollution control—a commitment that has paid handsome dividends in better health. It is time to revivify that effort and reclaim that leadership.

Continued to next page

Michael R. Barr

The business community saw the 1977 Clean Air Act Amendments as a good news/bad news joke without the good news: Congress told us we won't be able to build in dirty-air areas because they're dirty and we won't be able to build in clean-air areas because they're clean.

Now, the regulatory and legislative proposals so far advanced to deal with the "post-1987 ozone nonattainment problem" may finish off the American economy. Existing industry won't be able to continue operating in our major industrial areas (most of which do not attain the ozone standard) and still won't be able to relocate anywhere else in America.

Most of these proposals are loaded with more commands, more controls, more prescriptions, and various extraordinary nostrums. They all suffer one fundamental flaw: they fail to ask what problem they aim to solve. More specifically, they ignore the substantial progress we have made in ozone attainment in America since 1970. They fail to ask what has worked in cleaning our air, what hasn't, and why. They ignore our incredibly rich ozone databases and characterize all nonattainment areas with a single number (the notorious "design value").

Not surprisingly, 17 or more years of air quality control has had an effect. The effect is illustrated by ozone exposure maps prepared for the San Francisco Bay Area for 1969-1983-1986. They show that a widespread, general ozone nonattainment problem in 1969 yielded to a decade of careful air quality planning and comprehensive control. By 1983, the problem was much reduced in geographic scope and frequency. By 1986, the ozone problem had all but vanished by comparison to 1969. Peak ozone levels were down, the geographic extent of ozone exceedances was limited, and the duration of excess ozone periods was slashed. Public health had improved dramatically compared to levels in the 1960s and 1970s.

Yet, the San Francisco Bay Area—like most ozone nonattainment areas in 1987—still gets a failing grade for ozone attainment based on the "design value" approach.

EPA should discard this "pass-fail" system. We need more realistic measures of air quality—"Bs," "Cs", and "Ds"—which express the severity of ozone nonattainment. When graded fairly, most of the remaining ozone nonattainment areas show substantial progress in achieving the ozone attainment goal. Indeed, almost all areas have achieved actual ozone attainment an overwhelming proportion of the time (typically greater than 99 percent) almost everywhere for almost everyone. Because we have come so far in attaining the ozone standard, we now have an opportunity to plan our remaining ozone attainment efforts in a rational manner on a reasonable schedule. For example, EPA should:

- Help the states update their emission inventories to ensure that the contribution of *all sources* to the residual nonattainment problem is clearly understood before drastic new controls are imposed.
- Help the states refine their ozone monitoring systems and develop photochemical models to improve their accuracy in predicting air quality levels.
- Evaluate each nonattainment State Implementation Plan to see what worked, what didn't, and why. Existing measures which are either ineffective or not cost-effective should be identified.
- Work with Congress to obtain authority to set new attainment date targets to reflect the severity of each areas's ozone problems and not penalize areas which are making good-faith efforts to control ozone.

Very importantly, new source development commensurate with air quality goals should be encouraged, not squashed. The construction ban is counter-productive because it prevents modernization of industrial sources which will result in air quality improvements. Instead, EPA should refine and preserve the mechanisms of air permitting that facilitate the modernization of existing industrial and commercial facilities. Finally, EPA's mission has always included informing a concerned public about environmental matters. Americans are receiving distorted and incomplete information about their remaining ozone problems. EPA can help by continuing to publicize the great progress we have made, the limited scope of our remaining problems, and the environmental and economic choices we face in managing our remaining ozone problems. □

A Look at Air Quality Trends

by Bob Burke

The "brown cloud" over Denver is an example of the challenges that remain in the nation's air quality cleanup. Much of the cloud is particulates. Actions are being taken to deal with Denver's air pollution.

In addition to ozone, EPA regulates and reports on lead, carbon monoxide, suspended particulate matter, nitrogen dioxide, and sulfur dioxide, air pollutants which, like ozone, are known or suspected causes of illness or disease. They all still occur in some places in concentrations that are above health standards set by EPA.

The latest EPA report that charts the nation's progress in reducing these pollutants is *National Air Quality and Emissions Trends for 1985*, which includes data spanning a 10-year period for ozone and the five other major air pollutants. In most respects, the report's data for the past decade are encouraging: levels for the five air pollutants were lower in 1985 than in 1976, some considerably so.

Here, in summary, is what the 1985 air trends report has to say:

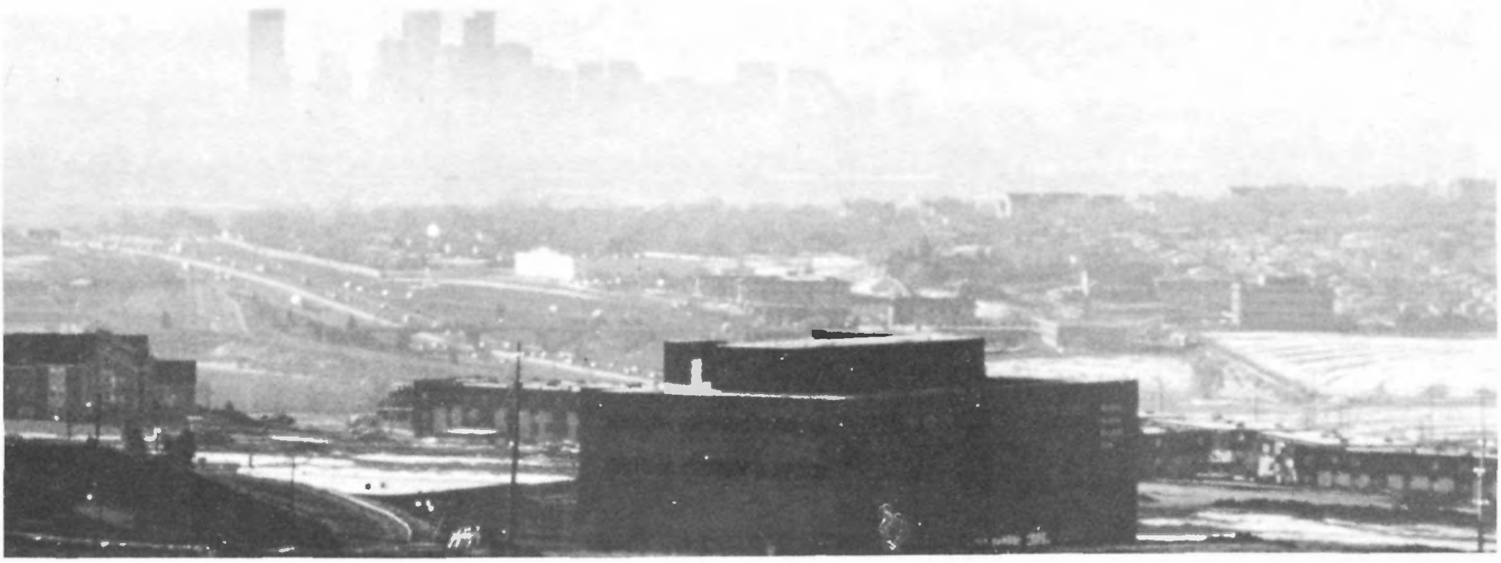
Lead

Lead additives in gasoline are the major source of lead emissions in the United States, but the overall share from this source has dropped significantly because of federal programs to reduce and phase out lead in gasoline (See article on page 28). Non-ferrous smelters and battery plants are other major sources of lead emissions. The adverse health effects of lead poisoning have been well-documented, particularly the permanent damage lead can cause to the central nervous systems of infants and children.

- *National Trends in Lead Concentrations, 1976-1985*. There was a dramatic 79-percent decrease in lead concentrations in the air over the decade. Almost all of the improvement resulted from federal actions aimed at leaded gasoline. In addition, the lead content of what leaded fuel remains in use is down sharply to about a tenth of what it was in 1976.
- *National Trends in Lead Emissions, 1976-1985*. Complementing the reduced ambient air lead levels are the statistics for lead emissions. They show a tremendous decline of 86 percent over the 10-year period.

Carbon Monoxide (CO)

Carbon monoxide is a colorless, odorless, and poisonous gas produced by the incomplete burning of carbons in fuels. As much as 95 percent of the carbon monoxide in the air in some areas comes from automobiles. While ozone (the other major pollutant from motor vehicles) is a pervasive, area-wide phenomenon, excessive carbon monoxide is highly specific to areas where there is a lot of traffic and congestion. Carbon monoxide reduces the amount of oxygen delivered to all tissues of the body, and, even at



Steve Delaney

relatively low concentrations, disrupts mental functions, reduces alertness, and impairs vision. It is particularly harmful—even life-threatening—to people with severe heart disease, anemia, emphysema, and other lung diseases.

• *National Trends in Carbon Monoxide Concentrations, 1976-1985.* Carbon monoxide levels decreased by 36 percent. Most of this improvement was brought about by federal emissions standards on newer vehicles, but some is due also to traffic flow programs designed to relieve congestion and to local weather conditions that encouraged reduced CO levels.

• *National Trends in Carbon Monoxide Emissions, 1976-1985.* Total carbon monoxide emissions were 21 percent lower in 1985 than in 1976 because of federal emissions standards, even though there was a 26-percent increase in vehicle miles travelled. Reported concentration reductions are higher than emissions reductions because of traffic flow patterns in urban areas where the concentrations are monitored. The number of vehicles and the miles they travel are relatively constant in city areas.

Total Suspended Particulates (TSP)

Particulate matter found in the atmosphere comes mainly from industrial processes, but a significant amount is produced from solid waste, fuel combustion, and transportation sources. Some particulates are visible as soot or smoke; others are detectable only with an electronic microscope and pose particularly serious health threats because they can penetrate the most sensitive parts of the respiratory tract. Particulate matter may seriously irritate the respiratory tract; prolonged inhalation of certain types increases the number of chronic respiratory cases as well as their severity.

• *National Trends in Particulate Concentrations, 1976-1985.* Average annual concentrations of total suspended particulate matter decreased 24 percent, largely because of emission controls on a variety of industrial processes. Weather conditions and reduced industrial activity in some areas may also be a factor.

• *National Trends in Particulate Emissions, 1976-1985.* There was also a 24 percent reduction in particulate emissions. Particulate levels in the air do not always improve in direct proportion to estimated emissions reductions because concentration levels may include pollution from street dust, construction, etc., which are not part of an emissions "inventory." Nevertheless, most of the reductions in both emissions and concentrations are due to industrial and public utility pollution controls.

Nitrogen Dioxide (NO2)

The major source of nitrogen dioxide pollution is emissions from high temperature automotive and stationary fuel combustion processes. Nitrogen dioxide plays a major role in the atmospheric reactions that produce photochemical smog, and can irritate the lungs and cause bronchitis and pneumonia. It can also lower resistance to respiratory infections such as influenza.

• *National Trends in Nitrogen Dioxide Concentrations, 1976-1985.* There was an average 11-percent decrease in nitrogen dioxide concentrations over the decade. Although they increased from 1976 to 1979, concentrations subsequently decreased each year from 1980 through 1985. The trends in nitrogen dioxide levels correspond closely to emissions trends from both transportation and stationary sources.

• *National Trends in Emissions of Nitrogen Dioxide, 1976-1985.* A series of gradual decreases interspersed with more modest increases in estimated emissions were recorded from both transportation and stationary sources which contribute about 95 percent of all nitrogen dioxide emissions. Since there was a 26-percent increase in vehicle miles travelled, it is clear that the decrease in nitrogen dioxide emissions from motor vehicles was significant.

Sulfur Dioxide (SO2)

Sulfur dioxide enters the air primarily from the burning of coal and oil, and from various other industrial processes. Studies of serious air pollution episodes have found an increase in death rates among people with existing heart and lung disease when high sulfur dioxide concentrations are present in combination with high concentrations of certain particulate matter.

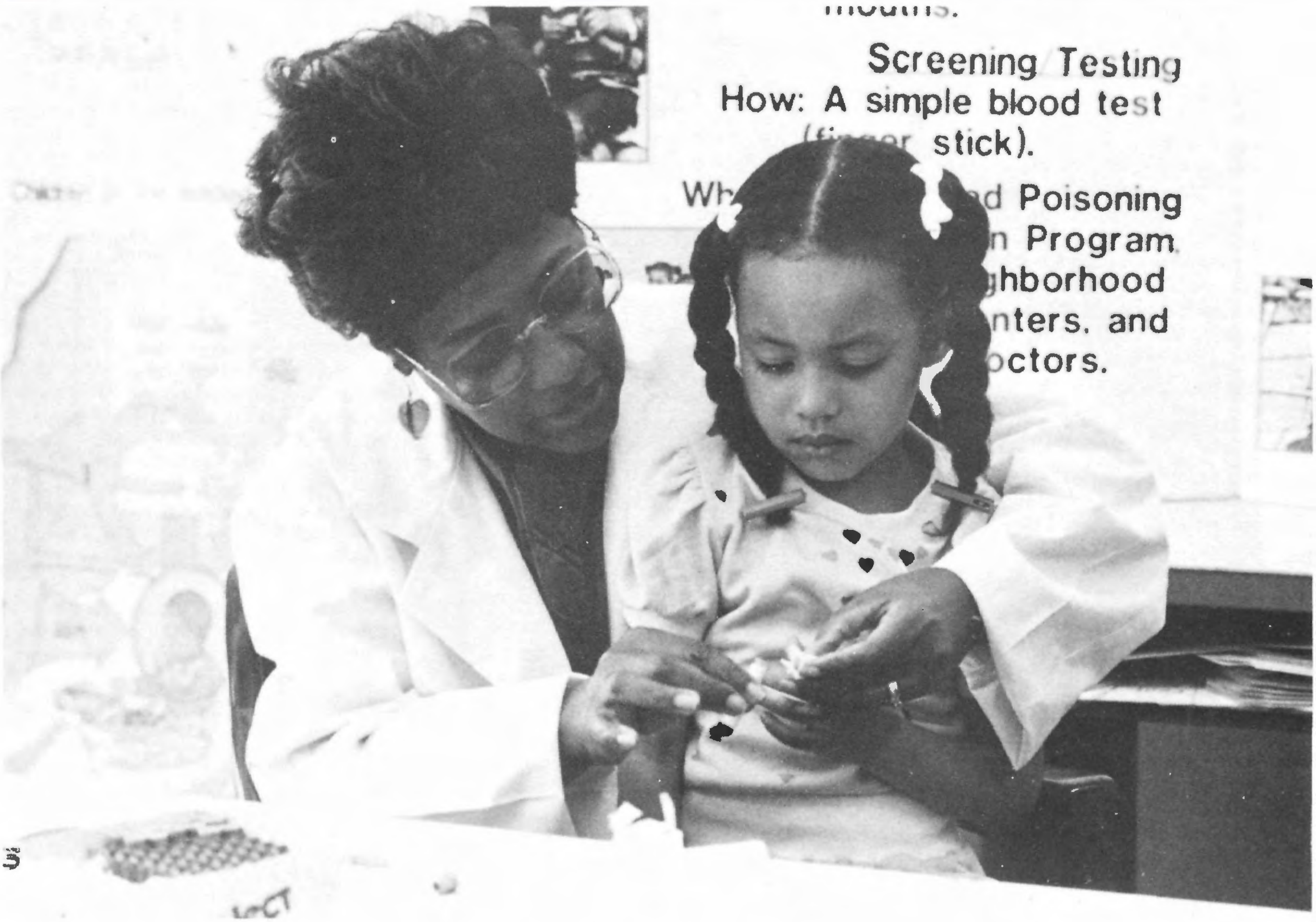
• *National Trends in Sulfur Dioxide Concentrations, 1976-1985.* Average national sulfur dioxide levels dropped 42 percent over the 10-year period. This was mainly due to reductions in average sulfur content of fuels consumed; installation of flue gas control equipment at coal-fired electric stations; reduced emissions from industrial processing facilities such as smelters and sulfuric acid manufacturing plants; and use of clear fuels in residential and commercial areas. These downward trends occurred even though some sources switched from low-sulfur oil to coal for energy conservation purposes.

• *National Trends in Sulfur Dioxide Emissions, 1976-1985.* Sulfur dioxide emissions declined 21 percent in the decade. The difference between this figure and that for concentration trends reflects the fact that monitoring stations are mostly in urban areas that have almost universally shifted to low-sulfur fuel. Rural power plants which are a major source of sulfur emissions aren't generally covered by this monitoring system. Significant improvement in emissions levels is due to the same factors related to concentration trends. □

A Skipjack—a sailboat traditional to Chesapeake Bay—out on a clear day. Clean air is a national goal.

Revisiting the Lead Phasedown

by Richard G. Kozlowski



James Thompson, D C Dept of Human Services

A child has blood drawn for tests. Children are particularly vulnerable to physical or mental impairments caused by high lead levels. Lead in gasoline has been reduced by 95 percent since 1970. At the same time, the U.S. Department of Health and Human Services has reported a trend of decreasing lead levels in the blood of Americans.

The sharp decrease in lead in the air we breathe is one of EPA's most significant success stories. Two EPA programs initiated during the past 15 years have led to a 95-percent reduction in the use of lead in gasoline. This, in turn, has contributed to an overall 79-percent reduction in lead in ambient air, and the Department of Health and Human Services is finding decreasing lead levels in the blood of Americans. (See article on page 25 for the latest report on air pollution trends.)

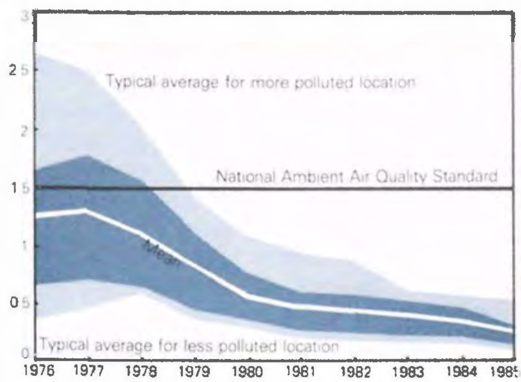
Two EPA efforts are responsible for this success. The lead phasedown program sharply reduced the permissible amount of lead in *leaded* gasoline. The new car emission standards have led automakers to use engine technology requiring unleaded gasoline; as newer vehicles replace the older fleet, the demand for leaded gasoline decreases.

Lead has long been used in gasoline as a cheap way to increase octane levels to avoid engine knocking. EPA's initial moves to reduce amounts of lead allowed in gasoline were greeted with skepticism by refiners, but refinery equipment has been upgraded to produce gasolines of suitable octanes either with low lead levels or no lead at all, so that most vehicles can run properly while emitting very little lead.

The EPA lead phasedown program began with the Clean Air Act, which authorized the Agency to control or prohibit any fuel or additive which could reasonably be considered a danger to the public health or welfare. To EPA, lead in gasoline was an obvious target. Gasoline lead is a major source of lead exposure, accounting for 90 percent of total airborne lead emissions. It contributes significantly to non-air pathways of exposure, such as ingestion of dust and dirt lead. EPA research found a strong correlation between lead in gasoline and levels of lead in the bloodstream of the population, with

This chart shows the drop in lead concentrations in the nation's air from 1976 to 1985, the period covered by the latest available figures. Ug/m^3 stands for micrograms per cubic meter.

Maximum Quarterly Lead Average Concentration (ug/m^3)



blood lead levels following seasonal gasoline use fluctuations as well as long-term trends, other variables notwithstanding.

People are exposed to lead from gasoline in many ways:

- When leaded gasoline is burned in an engine, small amounts of lead remain in the engine and exhaust system, but most of it is emitted from the tailpipe to the air, where it stays suspended for a time before settling to the ground.
- Some exposure occurs through direct inhalation of the emitted lead as it comes from the exhaust system.
- Additional exposure results from ingestion or inhalation of lead-contaminated dust.
- Lead from gasoline is also deposited on food crops which are later eaten.

In the early 1970s, the preponderance of scientific evidence about the capacity of lead to impair the physical and mental health of human beings, particularly children, led EPA to embark on its lead reduction or lead phasedown program. Most recently, on March 7, 1985, EPA reduced the lead content of leaded gasoline from the standard then in effect, 1.10 grams per leaded gallon (gplg), to 0.50 gplg, effective July 1, 1985, and 0.10 gplg, effective January 1, 1986. A subsequent rule allowed refiners who used less lead than the standard in 1985 to use correspondingly more through 1987, thus allowing a smoother transition to the stringent 0.10 gplg standard.

The decrease in the use of lead in gasoline was also fostered by EPA's unleaded gasoline program. After the automakers chose the catalytic converter as their primary emission control device, and because the catalyst is "poisoned" by lead, EPA promulgated regulations requiring the general availability of unleaded gasoline by July 1, 1974. Most gasoline-power, light-duty vehicles since 1975, and all since 1980, have been certified for unleaded gasoline only. Some motorcycles and some heavy-duty engines continue to be certified for leaded fuel; however, EPA is currently finalizing a rulemaking which will prohibit new vehicle and engine certification using leaded fuel, starting in the 1990 model year. As a result, the demand for leaded gasoline has steadily decreased. Currently, it is approximately 25 percent of the market, compared to 37 percent in 1985.

However, total lead use has not decreased as quickly as had been projected, primarily because of misfueling—the use of leaded fuel in vehicles designed for unleaded. The major incentive for misfueling has been the lower retail price of leaded gasoline, but the cost of producing regular 88-89 octane leaded gasoline will ultimately exceed that of the regular 87 octane unleaded gasoline, and the wholesale price of regular leaded gasoline is now greater than that of regular unleaded.

Unfortunately, traditional marketing practices have kept the retail price of leaded gasoline lower than unleaded in many areas. But as the price differential narrowed, misfueling dropped from a rate of 16 percent in 1984 to 10 percent in 1986. When regular leaded gasoline begins to retail at a higher price than regular unleaded, misfueling should all but disappear.

By 1989 or 1990, the leaded gasoline demand should be approximately 15 percent of the market. At that point, EPA expects leaded gasoline to become a specialty item available only in some markets. While reducing the lead in gasoline has important health benefits, it has caused considerable concern in the agricultural community because of problems with older engines that use lead to lubricate exhaust valve seats. Without lead, the exhaust valve seats recede into the cylinder; if this causes enough leakage, an expensive valve job is necessary.

And while most vehicles will not have any problem using unleaded gas, some engines—primarily in tractors and other farm equipment—designed for leaded gasoline might have difficulties if used at high engine speeds or under very heavy loads. While most newer tractors have diesel engines, many pieces of farm equipment are gasoline-powered and used for heavy-duty purposes in harvest seasons.

In response to the concern of farmers and agricultural leaders, the Congress required EPA and the U.S. Department of Agriculture to analyze the potential for mechanical problems associated with the use of other fuels in agricultural engines designed for leaded gasoline. The study found that the engines performed satisfactorily on low-lead gasoline at the 0.10 gplg level, but high-speed engines under moderate to heavy loads will experience excessive valve-seat wear if operated on unleaded gasoline, and that non-lead alternative valve lubricating additives do reduce valve-seat wear. EPA is continuing the investigation.

Farmers are also concerned about the continuing availability of leaded gasoline, because some refiners are discontinuing sale of leaded gasoline and introducing a third grade of unleaded gasoline, particularly in urban areas. This has contributed to the widespread misconception that EPA has banned leaded gasoline effective January 1, 1988. However, independent refiners and distributors have indicated that they will fill the "leaded" void left by the majors in markets with strong demand, which should take care of the farmers' needs.

Whether EPA bans lead or not, the 95-percent reduction of lead in gasoline already attained stands out as one of the great achievements of the Agency.

While EPA had considered banning lead in gasoline completely, we have no present plans to do so. Future actions depend on the availability of alternatives for those engines that need lead, the newer health data on the effects of lead, and the future level of fuel switching. In any event, the 95-percent reduction of lead in gasoline already attained stands out as one of the great achievements of the Agency and one of its major contributions to the health of the nation. ◻

(Kozlowski is Director of the Field Operations and Support Division in EPA's Office of Mobile Sources.)

Look Ma! No Pollution!

by Hagan Thompson

Do you want to feel good, look good, and make friends? Then get a bicycle and start pedaling.

Of course I'm talking about a bicycle that moves from one place to another as you move your feet, not one that stays in one spot in your rec room.

The stationary variety is good, but you need to get out into the country and see the sights, smell the scents, meet the people, and feel the wind at your back and in your face.

Let's get serious, folks. There's nothing like it. I've been cycling for almost 10 years. During most of that time, I've ridden with my colleagues in Atlanta's Southern Bicycle League. There are some 2,000 of us, and we'll ride anywhere. Last year, we went to northern California. This fall, we'll do the "Tour de Vermont, New Hampshire, and New York." Some of our pedal pushers flew to Ireland this summer to cycle.

Whoa! Wait a minute! I've just read what I've written. There may be too many of us already. California is full of cyclists. So is Washington, D.C. Gainesville, Florida, is another hotbed (or hot seat).

People in Washington even ride to work on bikes. Can you believe it? Dodging all these government workers and tourists trying to get around those monuments. But hey, it's healthy. Burn those calories. Push those pedals. It's an endless cycle. Come on, give it a break, it's a good line.

What are the questions asked most often, you ask? Why do you wear those skin-tight pants? For comfort, believe it or not. They don't ride up on you. No pun there.

Doesn't leaning over the handlebars hurt your back? No.

Aren't automobiles a problem? Yes, if you let them. You must be alert and courteous. Don't assume anything. Bumping with another bicycle is a bigger concern, or should be.

Isn't that little saddle hard on your fanny? You'll toughen up in a hurry. No problem.

How can you ride in hot weather like this? You wear skin-tight pants and not much more, and you drink lots of water from the bottle on your bike.

How can you ride in cold weather like this? You wear skin-tight pants and more, and you don't drink as much water from your bike bottle.

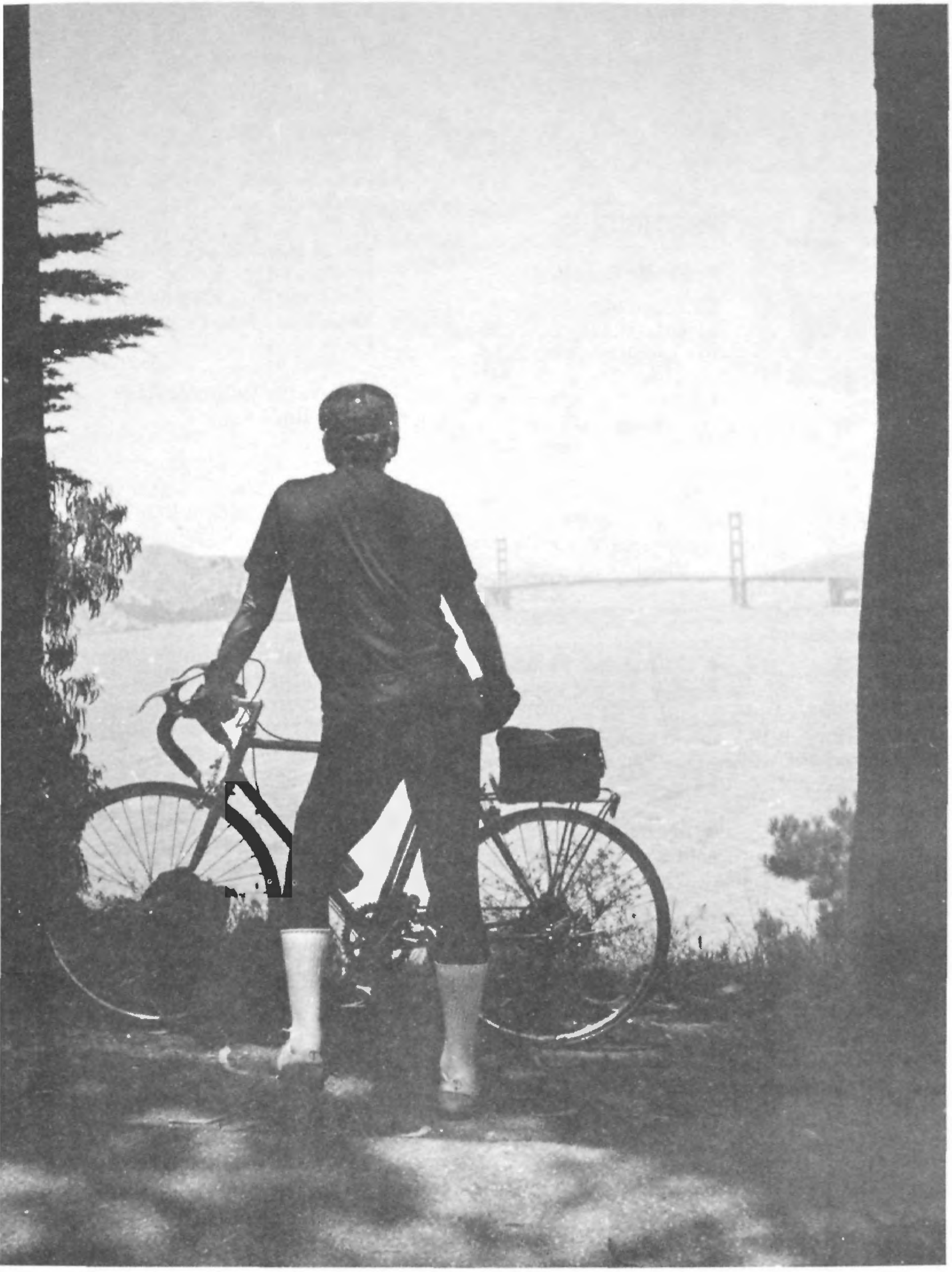
What do you do when a tire goes flat or you have some other failure out in the middle of nowhere? You always ride with people who can deal with such things—those people who were born to fix, who get impatient with your clumsy (fake) attempts at repairs: "Let me do that," they say, "so we can get going again."

Still interested? You should be. It's wonderful exercise. It's kind to your limbs. And bicycles don't make smog.

You meet a lot of nice people. Like the man I met several years ago in a little community in Alabama, somewhere between Aufala and Dothan. It was the middle of July on the third day of a ride from Atlanta to Panama City, Florida. My partner and I were parched. We're talking hot. I had just poured a five-pound sack of cracked ice over my head when I looked up and saw this gentleman eyeing me quizzically. "Is there any shade in this town?" I asked.

"The last we had was about March," he answered. □

(Thompson is Chief of the Public Affairs Branch in EPA's Region 4 Office.)



Bob Lipscomb

Hagan Thompson contemplates the view over San Francisco Bay as he rests during the first day of a 500-mile, 10-day bike trip in northern California. Thompson is a member of Atlanta's Southern Bicycle League.

Update

A review of recent major EPA activities and developments in the pollution control program areas

AIR

Fuel Economy Estimates

For the second consecutive year, a Chevrolet Sprint model has received the highest mileage ranking from EPA.

The minicompact Sprint Metro, which is made for Chevrolet by Suzuki, is rated at 54 miles per gallon (mpg) for city driving and 58 mpg on the highway, the same mileage estimate given last year's Sprint ER.

Other high-mileage vehicles include the Honda Civic CRX HF, Pontiac Firefly, Suzuki Forsa, and another Sprint model.

Radon Brochure

EPA has released a new booklet, "Radon Reduction in New Construction," that describes construction methods homebuilders can use to reduce the chances that new homes will have high indoor radon levels.

The new booklet describes simple and inexpensive construction methods to minimize radon entry into new homes and help in its removal after construction is complete.

EPA developed the booklet in cooperation with the National Association of Home Builders Research Foundation, a non-profit organization, and other federal agencies.

The new booklet is available free from state radiation protection offices, homebuilders' associations, and EPA regional offices.

PESTICIDES

Pesticide Blockade

EPA has begun an investigation to determine the cause of poisoning incidents involving Hartz Mountain Corporation's "Blockade," which is used to control fleas and ticks on dogs and cats.

EPA will require additional toxicity testing by the company. While these tests are being conducted, Hartz agreed to the following additional label statements:

- Do not use Blockade Cat Flea and Tick Repellent on young (less that one year old) or pregnant cats or young (less than 3 months old) puppies.

- Apply lightly. Do not saturate animal's coat.

- Do not apply more often than every seven days.

- Some animals may be sensitive to ingredients in this or similar pesticide products. If salivation, tremors, or vomiting occur after treatment, pet should immediately be bathed with a non-pesticidal shampoo, wrapped in a towel to prevent chilling, and taken to a veterinarian along with the product container.

- Do not use this or any pesticide on sick, old, or debilitated pets.

During the period of January 1 through August 29, 1987, a total of 201 cat and dog incidents (animal reactions), including 26 deaths, connected with the use of Hartz Blockade Cat Flea and Tick Repellent and Blockade Dog Flea and Tick Repellent were reported to EPA.

Cyhexatin Voluntarily Cancelled

EPA announced that Dow Chemical Co. has requested voluntary cancellation of its registration for the pesticide cyhexatin, to become effective on December 31, 1987.

The action was taken after recent studies showed that cyhexatin causes birth defects in rabbits and may pose a risk to the unborn children of women exposed to this pesticide.

Dr. Jack Moore, EPA's Assistant Administrator for Pesticides and Toxic Substances, stated: "Women of childbearing age are our primary concern... We are encouraged by the prompt efforts to voluntarily remove this pesticide from the channels of trade."

Appointments

Steve Delaney

Kathy Petruccelli has been appointed Director of the Management and Organization Division in the Office of Administration.

She brings a wide range of national and international experience to this position. She previously worked for the Department of Navy from 1970 to 1975 and subsequently spent three years in Italy working for the United Nations. She has been with EPA since 1978, and has most recently served as Chief of Personnel Policies and Programs Branch.

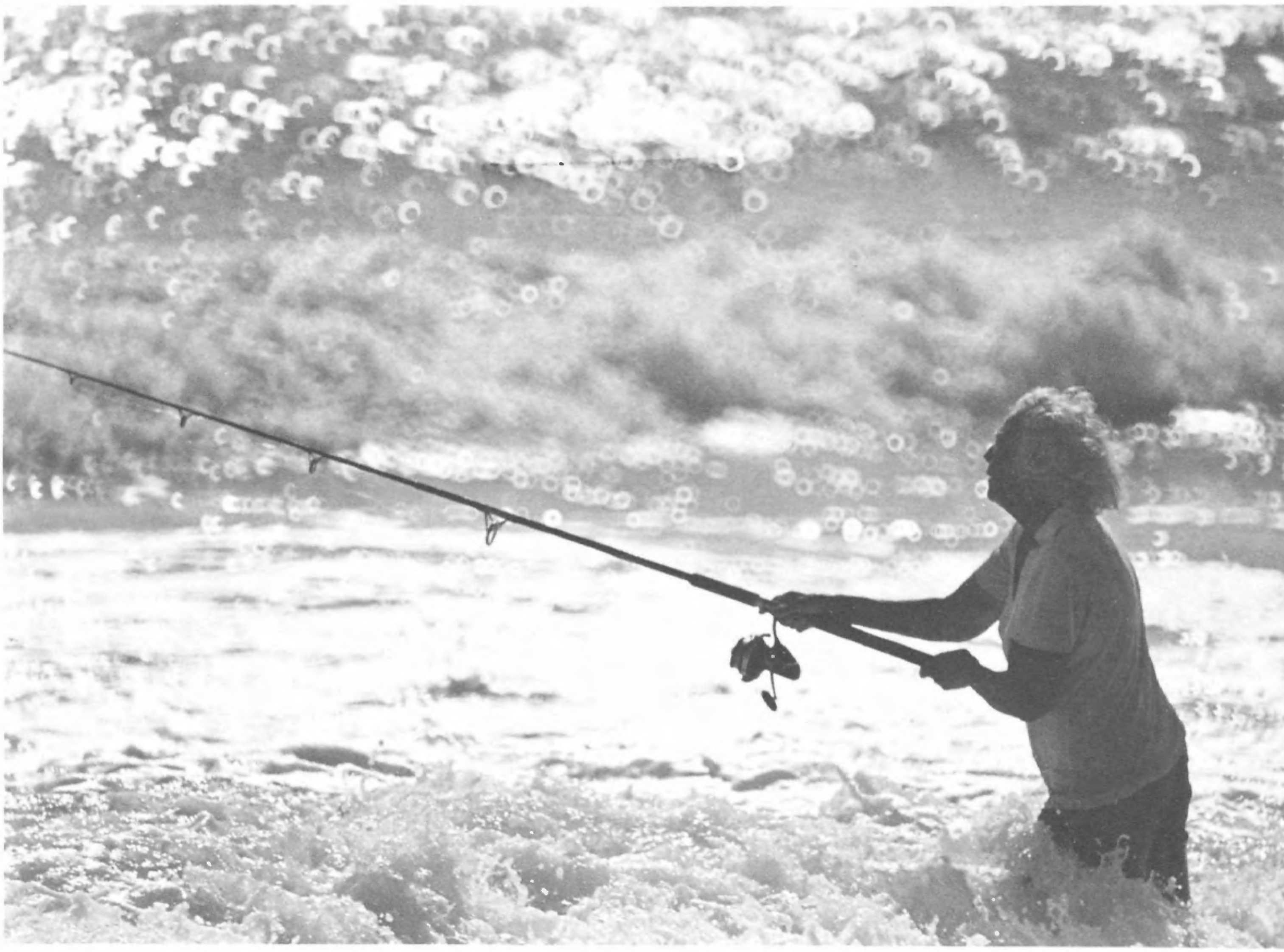
Petruccelli received her bachelor of arts degree in 1971 from the University of Maryland.

Steve Delaney

Sallyanne Harper has been appointed to the position of Associate Director for Superfund/RCRA Procurement Operations.

Harper has recently been in the Agency's Procurement and Contracts Management Division. She previously worked as a Contract Specialist for the Department of Navy in Philadelphia and as a Contracting Officer for the Naval Air Systems Command in Washington, DC.

She received a bachelor of arts degree from LaSalle University and recently her master's degree in business administration from George Washington University.



Everett C. Johnson, Folio, Inc

Savoring an outdoor pastime with a cast into the Atlantic surf.

Back Cover: Going for an autumn walk. Photo by Kahnweiler/Johnson, Folio, Inc.