







*United States Congress. House. Committee on Interstate  
and Foreign Commerce. Subcommittee on Public Health  
and Environment. Part 1*

## CLEAN AIR ACT OVERSIGHT—1973

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### HEARINGS

BEFORE THE

### SUBCOMMITTEE ON

### PUBLIC HEALTH AND ENVIRONMENT

OF THE

### COMMITTEE ON

### INTERSTATE AND FOREIGN COMMERCE

### HOUSE OF REPRESENTATIVES

NINETY-THIRD CONGRESS

FIRST SESSION

ON

A REVIEW OF THE IMPLEMENTATION OF VARIOUS PROVISIONS  
OF THE CLEAN AIR ACT OF 1970

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SEPTEMBER 10, 11, 12, 13, 14, 17, 18, 19, 20, AND 21, 1973

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## ORGANIZATIONS REPRESENTED AT HEARINGS

## American Petroleum Institute:

- Gammelgard, Peter N., senior vice president, Public and Environmental Affairs.
- Stone, R. K., chairman, Engine Fuels Subcommittee, Committee on Environmental Affairs, API, and senior staff engineer, Chevron Research Co.
- Weaver, Dr. Neill, associate medical director.
- Weiss, Fred T., Shell Development Co.

## California Air Resources Board, John A. Maga, executive officer.

## Central City Association of Los Angeles, and Los Angeles County Federation of Labor, AFL-CIO, Hon. Edward R. Roybal, a Representative in Congress from the State of California.

## Chamber of Commerce of the United States:

- Burner, Fred W., executive vice president, Greater San Antonio Chamber of Commerce.
- Coffey, John J., senior associate for natural resources and environmental quality.
- Harwood, Roane, president, Greater San Antonio Chamber of Commerce.

## Chrysler Corp.:

- Heinen, Charles, director, Vehicle Emissions Planning.
- Terry, Sydney L., vice president, Environmental and Safety Relations.
- Tomlinson, Victor C., counsel.

## Council on Environmental Quality, Executive Office of the President, Hon. Russell Train, chairman.

## Edison Electric Institute:

- Craig, John.
- Crawford, W. Donham, president.
- Hayslip, Richard, Southern California Edison.

## Energy Policy Office, Executive Office of the President, Hon. John A. Love, Director.

## Engelhard Industries Division, Engelhard Minerals and Chemical Corp.:

- Keith, Carl D., senior vice president, Engelhard Industries.
- Leventhal, Robert S., executive vice president, Engelhard Industries and vice president, Engelhard Minerals and Chemical.
- Mooney, John J., manager of technical services and application engineering, Engelhard Industries.

Enviro-Control, Inc., Pierre M. Sprey, vice president.

Environmental Protection Agency:

Finklea, Dr. John F., director, National Environmental Research Center, Research Triangle Park, N.C.

Greenfield, Dr. Stanley M., Assistant Administrator for Research and Development.

Quarles, Hon. John A., Jr., Acting Administrator.

Sansom, Robert, Assistant Administrator for Air and Water Programs.

Shy, Dr. Carl, director of the Human Studies Laboratory, Durham, N.C.

Steigerwald, Dr. Bernard J., Deputy Assistant Administrator for Air Quality Planning and Standards.

Stork, Eric, Deputy Assistant Administrator for Mobile Source Air Pollution Control.

Train, Hon. Russell, Administrator.

Ford Motor Co., Herbert L. Misch, vice president, Environmental and Safety Engineering.

General Motors Corp.:

Bowditch, Dr. Frederick W., executive assistant for vehicle emissions.

Starkman, Ernest S., vice president, Environmental Activities Staff.

Stempel, Robert C., special assistant to the president, Engineering and Product.

Tuesday, Dr. Charles, head, Environmental Sciences Department of General Motors Research.

Weber, William L., legal staff.

Gould, Inc., Dr. Edward E. David, Jr., executive vice president.

Greater San Antonio Chamber of Commerce. (See Chamber of Commerce of the United States.)

Honda Motor Co., Ltd. and Honda R. & D., Co., Ltd.:

Ikemi, Kiyoshi, public relations manager.

Kobayashi, Tadao, staff engineer.

Sailer, Henry, Washington counsel.

Smoot, Roland, counsel.

Sugiura, Hideo, director and member of the boards.

Los Angeles County Federation of Labor, AFL-CIO. (See Central City Association of Los Angeles.)

Massachusetts Office of Governor Francis W. Sargent, Michael Padnos, special assistant to Governor.

Motorcycle Industry Council, Inc.:

David, Dennis E.

Ross, Stuart Philip, general counsel.

National Academy of Sciences:

Handler, Dr. Philip, president.

Hutcheson, Dr. J. A., member, Committee on Motor Vehicle Emissions.

Stern, Arthur C., chairman, Panel on Emission Standards, Committee on Motor Vehicle Emissions.

National Coal Association:

Bagge, Carl E., president.

Mullan, Joseph W., vice president, Government Relations, and director, Environmental Affairs.

Price, Robert V., executive vice president.

National League of Cities and U.S. Conference of Mayors:

Garn, E. J. "Jake", mayor, Salt Lake City, Utah.

Snowwhite, Larry, legislative counsel.

Natural Resources Defense Council:

Hawkins, David.

Phillips, Helen.

New York City Environmental Protection Administration, Department of Air Resources:

Hart, Fred C., commissioner.

Walsh, Michael, director, Bureau of Motor Vehicle Pollution Control.

Ohio Environmental Protection Agency, Samuel A. Bleicher, deputy director, Regulation and Enforcement.

Public Interest Research Group, Clarence Ditlow.

Statewide Air Pollution Research Center, University of California, Riverside, James N. Pitts, Ph. D., director.

**Texas Air Control Board:**

Barden, Charles, executive director.

Bell, Eli, administrative assistant.

Giblin, Pamela, chief, legal staff.

**Transportation Department:**

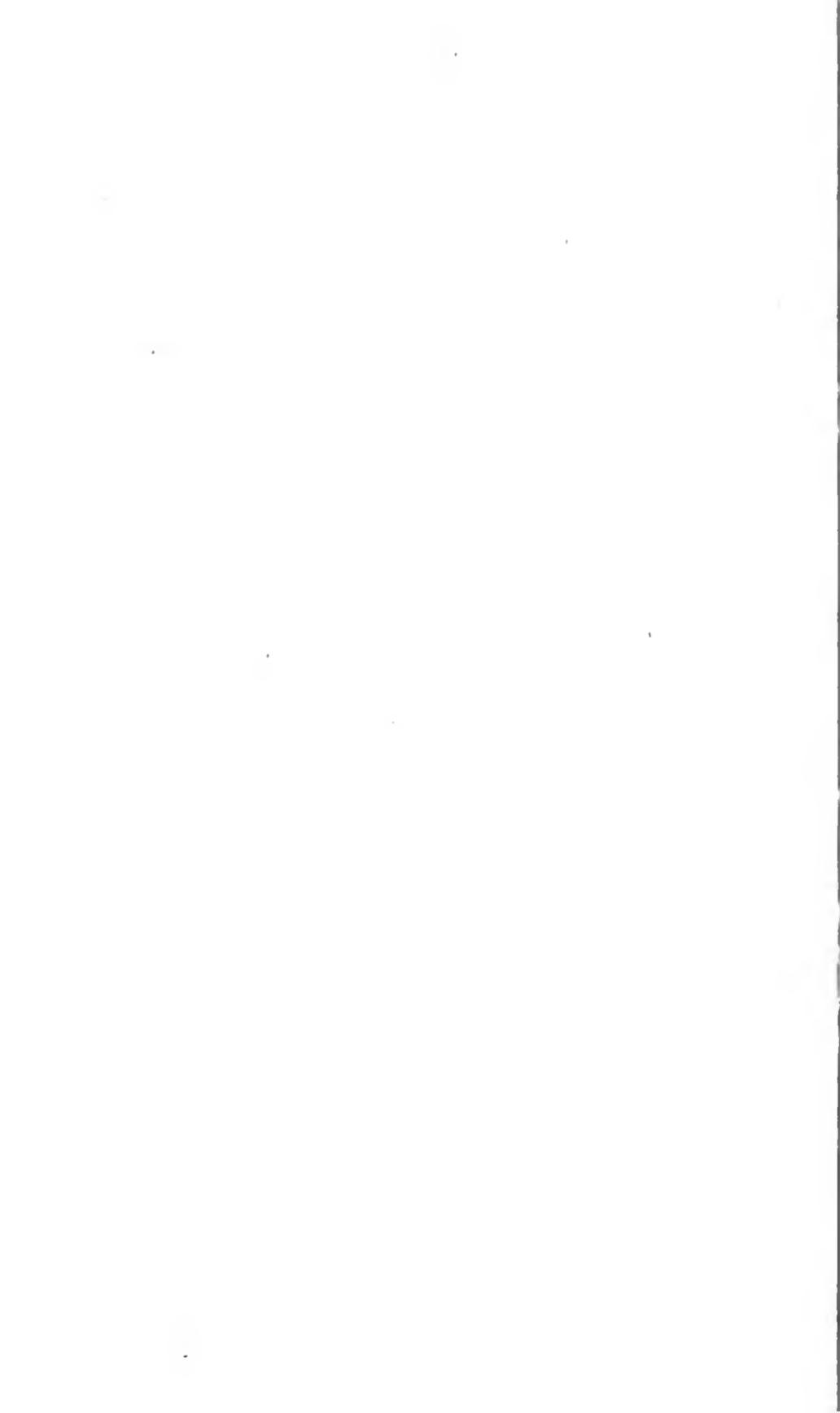
Convisser, Martin, Director, Office of Environmental Affairs.

Davis, Hon. Benjamin O., Assistant Secretary for Environment, Safety, and Consumer Affairs.

McManus, Robert H., Associate Administrator for Transit Planning, Urban Mass Transportation Administration.

U.S. Conference of Mayors. (*See* National League of Cities.)

Vortex, John Quirk, president.



## CLEAN AIR ACT OVERSIGHT—1973

MONDAY, SEPTEMBER 10, 1973

HOUSE OF REPRESENTATIVES,  
SUBCOMMITTEE ON PUBLIC HEALTH AND ENVIRONMENT,  
COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE,  
*Washington, D.C.*

The subcommittee met at 10 a.m., pursuant to notice, in room 2123, Rayburn House Office Building, Hon. Paul G. Rogers, chairman, presiding.

Mr. ROGERS. The subcommittee will come to order, please. Today is the first day of oversight hearings on implementation of the Clean Air Act.

Three years ago, this subcommittee developed amendments to the Clean Air Act which have had vast implications. On the one hand, we are advised by the Council on Environmental Quality that the air, in fact, has gotten cleaner—reversing a 30-year trend.

On the other hand, the Clean Air Act has been indicted by some as responsible for this country's energy shortage. The purpose of these hearings will be to explore the effects of the act—both desirable and undesirable—with a view toward determining whether amendments to the act are in the best interests of the American public.

The recent 2-week episode of air pollution alerts here in Washington, in the Nation's Capital—and its attendant increases in hospital admissions—brings home all too clearly the fact that the quality of air in our country represents a danger to our health—a danger which can and must be overcome.

On the other hand, some of the methods presently proposed as means of combating air pollution may be unattainable. If so, new methods should be found.

During these hearings, the subcommittee will be concerned with health effects of pollutants, the effect of the act on energy shortages, means of achieving automobile emissions standards, proposals for transportation controls, and implementation plans.

In addition the committee will find of great interest the President's recent proposals with respect to lifting restrictions on the burning of high-sulfur coal and oil. I think we will be most interested in having facts presented which would back up the President's comments which categorically state a shortage is imminent and a lessening of clean air standards necessary.

If this Nation is, indeed, as the President says, on the verge of an immediate fuel crisis, then I think the Congress and the American public will make every effort to do what is necessary to conserve what fuel supplies we have available.

But I think this committee, as well as the Congress and the American public, will, in all fairness, ask for a great deal of more specific information before we abandon those portions of the Clean Air Act which were designed to protect the health and safety of the American public.

Our witnesses this morning are representatives of the Environmental Protection Agency—present and future. The Honorable Russell Train, presently Chairman of the Council on Environmental Quality and EPA's Administrator-designate, is our first witness.

He will be followed by the Acting Administrator of the EPA, John Quarles. May I say that I am particularly pleased by the nomination of Mr. Train to be EPA Administrator. His devotion to a clean environment had been known for years and his service as the first Chairman of the CEQ has been most distinguished.

Mr. Quarles performed capably as EPA's General Counsel and I am likewise pleased by this elevation to the position of Deputy Administrator.

Since Mr. Train has not been confirmed, he will testify as Chairman of the CEQ, and, of course, will not be in a position to reflect on EPA policy. Mr. Quarles will represent the EPA. After Mr. Train's confirmation, he will return,<sup>1</sup> and has so stated, to give testimony to the committee at a later date when it is projected we will wind up the hearings which will be in about 2 weeks.

So, welcome to the committee, Mr. Train. We will be pleased to receive your statement.

**STATEMENT OF HON. RUSSELL TRAIN, CHAIRMAN, COUNCIL ON ENVIRONMENTAL QUALITY, EXECUTIVE OFFICE OF THE PRESIDENT**

Mr. TRAIN. Thank you, Mr. Chairman. I appreciate the opportunity to appear briefly before you this morning. As you noted, I had hoped to be the lead witness for the Environmental Protection Agency on this very vital subject of the Clean Air Act which is so important to the health and well-being of the American people. Also, as you know, the Senate has not had an opportunity as yet to act on my confirmation. Hopefully, this will be done early this afternoon. But, in the meantime, it seems the better part of wisdom that I do not seek to testify for the Environmental Protection Agency.

I do appreciate the opportunity to make a few opening remarks, as you, yourselves, have indicated, I am very ready, willing and anxious to return to testify before this committee at your convenience as soon as I am confirmed, either during these hearings or at the close as you wish.

First, I am particularly glad to have the opportunity to introduce, although I know you know him well, John Quarles, whom the President has designated as Acting Administrator during this period, and also whom the President has indicated his intention to nominate as Deputy Administrator.

<sup>1</sup> Mr. Train was confirmed by the Senate on Sept. 10, 1973, and he returned to testify before the committee on Sept. 21, 1973 [see p. 996].

I know you know him well. I also know him well, and I am personally thoroughly delighted with the President's choice. I have worked with Mr. Quarles over the past 4 years. When he first came to Washington to join the administration, it was with my office when I was Undersecretary at the Department of the Interior.

So, we have had a long association, a long working association, as well as one of personal friendship. This is a very welcome development, and I can assure you that we will constitute a team that will work very closely together and of course, with you.

Second, Mr. Chairman, I am glad to have the chance to introduce another new member of the top team at EPA, Mr. Alvin Arm. Al is the new Assistant Administrator for Planning and Management. He has been confirmed, but I believe this is his first opportunity to meet with you. He has recently been Staff Director of the Council on Environmental Quality, so I can speak very personally and directly to his outstanding competence. He has contributed enormously to the success of the Council ever since its inception early in 1970, and I know that he will bring important new strength in the planning and management field to EPA.

Turning briefly, Mr. Chairman, to the Clean Air Act for which you and this subcommittee have played such an important part in developing, and I think you can really feel proud of that fact, we welcome this review, this series of oversight hearings which you are about to undertake.

The law has been on the books now for about 2½ years which, while not sufficiently long enough to permit a detailed definitive appraisal of its effectiveness and its workings, certainly does provide the experience with which to take a preliminary look.

As you will hear, we do feel that there are some problem areas in the act and Mr. Quarles will develop these details with you, areas where we believe that some legislative attention may be needed and as other such areas develop, we certainly will bring these to your attention.

I think it is important to stress that the effectively working parts of the act far outweigh the problem areas. So, as we necessarily give our attention to problems, we do not let their existence cover over the very real strengths that are inherent in this legislation.

I think the Clean Air Act is basically sound legislation, and we are making significant progress in improving air quality under the act. I think that clearly was not the case under previous legislation. So, again, I think this committee in particular can take very real pride in this fact.

We must sustain that progress. As we do look at the problem areas, as I have mentioned, let us keep the problems in perspective. I think the fact is that with legislation as complex, comprehensive, and strong as this law is, cutting across matters of not only great environmental importance, but economic and social importance as well, it is surprising to me that there have been indeed so few problems.

So, I think these are important points to keep in mind. Also, I think that this committee in particular will take a great deal of interest in the health impact aspects of this legislation. I think again this is an important perspective to have in mind at all times. We are not

simply dealing with matters of amenity or esthetics. We are dealing with the basic health and well being of the American people. That is what is at stake in the Clean Air Act. I know your interest, Mr. Chairman, in this matter and the other members of this committee. So I think this is an important perspective, I repeat, to keep in mind at all times as we review the workings of the act.

Mr. Chairman, I think that probably will conclude any opening remarks. I said I wanted to make them brief. I do not want to turn brief remarks into a speech.

Mr. ROGERS. We appreciate your presence here today. I might ask one question that I think it might be well for you to address the committee on, since you are chairman of the Council on Environmental Quality, and that is if you could give us a comment, maybe a little broadening of the perspective which was the foundation of the President's statement over the weekend on the environmental standards and the possible shortage of heating fuels in the winter months.

Could you give us some statement on that?

Mr. TRAIN. Mr. Chairman, I participated in the meeting at the White House on Saturday morning, quite an extensive meeting with the President, his energy advisers, and other members of the administration.

Following that meeting, the President and Governor Love addressed the press and pointed to the very likely possibility of a heating oil shortage in certain areas of the country this winter. I think that our own analysis at the council, and also as I understand EPA's would confirm that there are real problems from a supply standpoint.

As I think you know, last winter the Environmental Protection Agency granted variances on applications from several States to their State implementation plans under the Clean Air Act in order to permit the States in certain emergency situations to utilize dirtier fuel oil than would otherwise be required in order to meet their local standards.

Some of these applications were turned down. I think there were some 13 requests made of EPA late last winter and 8 were granted, but I am not too sure of these details. So, this is what is involved here. The President has asked that the Governors be contacted, be met with, and urged to develop contingency planning to permit the expeditious handling of such variance applications, should the need arise, to meet emergency conditions this coming winter.

In a sense, what I am saying is essentially what was the program that we conducted last winter, but that was, frankly, a sort of hashed up program brought together on quite short notice, and we are anxious to see that to the extent humanly possible, more regularized procedure under the Clean Air Act be followed in dealing with variances this winter.

So, this is the reason for getting advanced planning underway now. That was the thrust of the President's message.

Mr. ROGERS. In other words, no specific relaxation of standards at this time?

Mr. TRAIN. Absolutely, because standards, as I understand it, are not what are involved. It is variances to State implementation plans of a temporary, very temporary nature. I do not think I have emphasized

that enough. We are talking here about temporary actions which probably would not extend more than a month or 2 months at the most should we get a cold winter and should the supply situation turn difficult.

So we are dealing with temporary variances in State implementation plans, not any change in its standards.

Mr. ROGERS. And that would particularly be true, I guess, as to primary standards?

Mr. TRAIN. That is correct. I think in all fairness what we probably will be dealing with would be variances in primary standards.

Mr. ROGERS. I think it is helpful to the committee to have this clarification because I am not sure that came across in some of the reports.

Mr. TRAIN. It is a highly technical matter, as you know better than I do. It is susceptible to misunderstanding.

Mr. ROGERS. Yes. I might say too, for the committee's benefit, I am sure the members know, that Governor Love will be here to testify, and perhaps we can go into some detail with this. But, you are telling us that the President is not saying he wants primary standards changed but simply some variance for a short period of time if this condition arises?

Mr. TRAIN. The President wants the Nation to be put into the posture that it can be able to meet its fuel needs this winter under emergency situation conditions. In this effort, I certainly fully concur. I am sure the Environmental Protection Agency does likewise.

We went through this process, as I indicated, last winter. The variance system worked quite well. I am sure it will work better given the additional experience we have had and the additional advance planning that the President is trying to get underway.

Mr. ROGERS. Thank you.

Mr. Satterfield?

Mr. SATTERFIELD. Thank you, Mr. Chairman. I wish to welcome you here today and certainly look forward to your return.

I have just one question in line with Mr. Rogers' questions. I realize that perhaps we have not looked too far ahead, but it is my understanding and my feeling that we might anticipate even more serious energy shortages by way of heating and other fuel in the years immediately ahead.

Has any thought been given to provisions which we might add to this Act which would give some latitude of action if and when emergencies might occur in future years rather than just this coming year?

Mr. TRAIN. First, let me say I think it is quite plain that the supply problem that we are talking about is going to extend beyond this winter. I do not want any misapprehension about that.

Let me make a point on that. I think again it is important to keep in mind the supply problem is not the existence of environmental standards obviously. It is due to a lot of things. In its relation to the environment, the supply problem is due to the lack of desulfurizing capacity and new refinery capacity.

This technology is fully available, as we know. So, it is important that we keep moving ahead in that area because as we provide the

desulfurization capacity we will essentially solve the sulfur problem insofar as it relates to oil.

It is my understanding that Japan is moving very rapidly in this direction. You might wish to inquire about this, Mr. Chairman. I am not sure of my facts, but I understand that Japan may have gotten itself in a situation where it will have no sulfur problem after 1975 with respect to its oil.

As you know, 90 percent of its energy is coming from imported oil. So, Japan is moving very rapidly, I believe, using American technology to a great extent. Now, the question you asked about shouldn't we be taking actions now with respect to these later years? Of course, you will want to consider this in the course of your hearings. I do not believe that I feel prepared to comment in detail on this.

We do feel that the variance procedure is appropriate under the Clean Air Act as it now exists. So that we can address these problems as they arise, and now whether there should be changes in this is something else again. Frankly, I am not sure that there is any need for any change in that respect.

Mr. SATTIERFIELD. Thank you very much. As I said, we look forward to seeing you again in these hearings.

Mr. ROGERS. Dr. Carter.

Mr. CARTER. Thank you, Mr. Chairman. Certainly I feel it is the opinion of this side of the aisle and I believe both sides that you will be confirmed within the immediate future, and we are happy that that will be the case.

We do not think that there is any question about that. We are most happy that this will come to pass. I have been disturbed for some time about the energy shortage in our country. I do not think that there is any question but what such an energy shortage does exist at the present time.

Of course, I noticed in your remarks and in some things that I have read that our high sulfur content coal is quite a problem. There are areas of our country though in which we have low sulfur content coal and in huge amounts. Particularly in the West, as I understand it, less than 1 percent sulfur.

In that area, there are veins as much as 100 feet thick, which is almost unheard of in other parts of the world. As it happens, I have coal producing counties in my area which too have a low sulfur content, less than 1 percent, Hardin County, Leslie County, Bell County particularly.

It seems to be then if such emphasis is to be placed upon obtaining coal of low sulfur content that we should make some effort to obtain more coal from the West. Am I correct in this or not?

Mr. TRAIN. Dr. Carter, I did not wish to give the impression that only the winter heating oil aspects of the problem were receiving attention. I think that the administration has consistently emphasized the need to continue to develop and use coal as a major energy resource of this country. It is probably our most available and largest reserve.

So, this is essential. Now, EPA last year in November announced what it calls a clean fuel policy, one aspect of which was to urge the States to delay implementation of secondary standards if this would permit the use of coal to meet primary standards.

We have continued to push in this direction as we think it is a very important way to maintain the use of coal. Likewise, the administration is pushing clean coal reserve, gasification, liquefaction, stack gas cleaning technology, which as it comes on line will make it possible to use the dirtier coals which we have.

The Western coals insofar as the Eastern market is concerned are really quite a ways off, and I think transportation costs do put these at a considerable disadvantage. Now, the Department of the Interior does have a number of studies underway with respect to these Western coal deposits in part to see where the water supplies can come from for the utilization and development of those reserves and also to see how these areas can be properly reclaimed so that they are not left as devastated areas.

Mr. CARTER. Of course that is quite important. You say that there are studies and pilot projects going on toward liquefaction of coal, gasification of coal and so on. I am familiar with a few of them. What is the project which shows most promise at the present time?

Mr. TRAIN. I cannot answer your question, Dr. Carter.

Mr. CARTER. Do you know the maximum production of gas or gasoline from coal at any one of these plants?

Mr. TRAIN. No sir, I do not.

Mr. CARTER. I know that our Navy has such a project at the present time. Do you know what the rate of production of fuel from that plant is?

Mr. TRAIN. No, sir, I do not.

Mr. CARTER. Five barrels a day. So, we have a great deal to do in this area. Is that not correct?

Mr. TRAIN. I think this is correct. I think the President, in his last energy message, emphasized the need to step up our research and development with respect to this new coal technology.

Mr. CARTER. I should think it would take a maximum effort, a great effort, on our part.

Mr. TRAIN. I agree with you.

Mr. CARTER. What are our known supplies of natural gas in the United States? How long would they last?

Mr. TRAIN. How long will our natural gas supplies last?

Mr. CARTER. That is right.

Mr. TRAIN. I do not have any information at my fingertips.

Mr. CARTER. I believe just a few years ago it was testified before this committee that our natural gas reserve would last only 6 years, something like that. How long will our supplies of petroleum last in this country? Do you know that, sir?

Mr. TRAIN. I do not believe anybody knows that.

Mr. CARTER. I believe it has been testified before this committee, even 2 years ago, that our known supplies would last approximately 12 years—2 or 3 years ago. So, we see the urgency of this program.

We cannot be dependent on other countries for our energy supplies. I think it will take a crash program involving the greatest scientific minds in our country to the use of the coal in the West in particular, since it is estimated that these supplies should last this country approximately how long, do you know that?

Mr. TRAIN. I did not hear your question.

Mr. CARTER. The supplies of coal in the West should last this country how long?

Mr. TRAIN. Oh, the theory is, several hundred years.

Mr. CARTER. Four to six hundred years. We should take advantage of that and try with all of our energy and mental acuity to develop adequate supplies of gas and gasoline or fuel oil from this source in the West. Do you not agree?

Mr. TRAIN. I think that is generally true; yes, sir.

Mr. CARTER. Thank you, sir.

Mr. TRAIN. If it can be done under the law, with the protection of the environment. That has been our effort to insure that these resources be utilized and developed in a balanced fashion so that we do protect the environment at the same time.

Mr. CARTER. I would agree with that, too. I am an environmentalist myself, and have been for many, many years. At the same time, sometimes compromises must be made rather than have our youngsters get cold in the winter.

Thank you, Mr. Chairman.

Mr. ROGERS. Mr. Preyer?

Mr. PREYER. Thank you, Mr. Chairman.

I join my colleagues in applauding your nomination, Mr. Train, as the new EPA Administrator. I am delighted because I do not think we could find a better man in the country for the job. I have one general question I would like to ask.

You have been asked about the supply side so far as the fuel crisis goes, and what can we do to increase the supply. I wonder how feasible you think it is to take action on the demand side, to reduce the demand. We have an extraordinary per capita consumption of energy in this country compared to the rest of the world.

Can we do something about easing the crisis by attacking it from the demand side; specifically, by limiting the miles of automobile travel. How far can we go to limit that without disrupting the economy? Or is it realistic to make design changes in our buildings that would save energy? Would these types of approaches be wise?

Mr. TRAIN. Mr. Preyer, there is a great deal that can be done by way of energy conservation. I would not go so far as to say we can solve our energy problems in the years ahead solely by energy conservation, but surely every bit helps.

Every bit of energy that we can conserve and avoid its wasteful use will protect our balance-of-payments situation, will protect the environment, and will protect our own resources. So all of these add up to the importance of energy conservation. The President's message last April on energy called for a new national energy conservation effort.

Obviously, this is not going to solve the winter heating problems of this winter. Again it can help ameliorate, but the chances are we will not be able to move aggressively enough on the demand side to solve those problems.

Certain areas will definitely reduce energy demand. The apparent movement of the American public toward smaller automobiles, I think something like 40 percent of the sales over the last 3 months have been small cars, has very important implications for this Nation's use of energy.

Smaller cars definitely use less energy. So that we are moving in this direction, and the administration has established an Office of Energy, Conservation in the Department of the Interior; our own Agency, or what will be my Agency, the Environmental Protection Agency, considers this a matter of very high priority in its affairs.

I think there are a great many ways in which we can conserve energy. You mentioned building design. The administration has consistently over the past 3 years, I believe, moved to improve the insulation standards, the specifics for Government-financed housing, both single-family and multiple-family housing.

This can have very substantial affects on the saving of energy. In the fully private construction area, which is more difficult for the Government to influence, but here some very substantial savings can be made.

I am happy to say that the engineering and architectural communities have been showing increasing interest—as the price of energy goes up, I suspect it creates a real incentive for that movement to develop more energy-efficient buildings.

Mr. PREYER. Specifically on the automobile side, is there any goal that you have in mind with regard to miles traveled per automobile? Is it unrealistic to hope that we can reduce the total mileage traveled by cars in this country?

Mr. TRAIN. My offhand reaction, Mr. Preyer, is that that would be a fairly arbitrary kind of rule to impose and would probably produce inequities among the users.

I know I live here in the middle of Washington and have a short distance to drive. Other people live out of town and have a further distance to drive. I don't know that you can very fairly arrive at a rigid rule applicable to everyone.

I think that we should retain freedom of choice in as many respects as we can, including transportation. At the same time, we should endeavor to provide alternative options that people will have available to them, such as mass transit. That, I think, is the best way to reduce vehicle mileage.

Mr. PREYER. That is what I had in mind. I certainly don't suggest that we should propose a rigid rule that everybody drive 10 percent fewer miles this year, but through mass transit, through use of smaller cars. I would hope that we could save both mileage and fuel in that respect.

Thank you very much, Mr. Train.

Mr. TRAIN. Thank you, Mr. Preyer.

Mr. ROGERS. Mr. Hastings?

Mr. HASTINGS. Thank you, Mr. Chairman.

I welcome you here, Mr. Train, as Chairman of the CEQ. I think your nomination is a very wise choice. I look forward to your appearance back here again as Administrator of the EPA.

Mr. ROGERS. Mr. Symington.

Mr. SYMINGTON. Thank you, Mr. Chairman.

Mr. ROGERS. I might say for members who may not have heard that Mr. Train has not yet been confirmed, so he has simply made a statement as Chairman of the President's Council on Environmental Quality. He will return after his confirmation, which we anticipate this afternoon, to answer specific questions.

You may ask whatever questions you have. I did not mean to restrict your questions.

Mr. SYMINGTON. Probably a great deal of enlightenment will not come to you between now and this afternoon. I certainly want to congratulate you in this regard because I think you are an ideal choice.

I have one question on the automobile emissions. There was some ominous footnote in the paper recently to the effect that the catalytic converters were creating more problems than they solved, emitting platinum and some other noxious substance into the air. Is this something we should be concerned about?

Mr. TRAIN. It is a matter which the Environmental Protection Agency has under careful study and review. I believe that the witnesses who will follow me will be in a much better position to address that highly technical question than I am at this time.

Mr. SYMINGTON. I understand that there has been an international air agreement between the city of Leningrad and St. Louis, Mo. Are you familiar with that?

Mr. TRAIN. I am generally familiar, yes. It comes under the Environmental Protection Agreement which was signed by the President at the Summit. I am the Chairman for the U.S. implementation of this program. Particularly, the Leningrad-St. Louis project is a joint air quality modeling project to hopefully assist in the development of more effective strategies for achieving air quality in metropolitan areas.

Mr. SYMINGTON. Has there been any implementation of note today?

Mr. TRAIN. There has been an exchange of working groups to examine the capabilities on both sides. These have now returned to their own countries and are developing the project further. That is the nature of the implementation so far.

Mr. SYMINGTON. Thank you very much.

Mr. ROGERS. Mr. Heinz.

Mr. HEINZ. Thank you, Mr. Chairman.

Mr. Train, welcome to the committee. I suppose this will be the first of many opportunities we will have to get to know each other better. I would join my colleagues in their most complimentary wishes for you which are based both on past and expected performance.

I have one question I would like to pose to you which I suppose you can take in the nature of a warmup for this afternoon, or for your reappearance here, which I hope will be possible toward the end of next week. It is the issue of nondegradation of the environment which was recently clarified in the Supreme Court's decision where they upheld the lower court ruling that the Clean Air Act prohibits significant deterioration of air quality. Certainly when you come back before us at the end of next week I am sure you will get some questioning on this and I for one believe this decision brings to a head probably the most important environmental issue and that is the issue, the growth versus no growth. Of course, a specific case of that is really how the electrical utility industry, often a coal fired industry, can hope to provide the electrical energy that we as a Nation are going to need without the development of facilities and coal gasification plants in the relatively nondegraded areas of the Midwest plains and the Rocky Mountain area. I hope that we will be able to discuss that with

you, specifically what the administration is in fact doing to resolve what is an extremely difficult problem, and what would happen to it if the Supreme Court decision were to be applied quite literally.

Finally, of course, it gets down to what actions we as a Congress ought to be required to take. I do not expect you to answer these before the committee at this time. I think it is a very difficult question. Perhaps you will have a opportunity this afternoon on the other side of the Hill to get into it. We will save our breath and your breath until you come back before us later.

Mr. TRAIN. Thank you, Mr. Heinz. You certainly have opened up a very important issue. I am glad you said the Supreme Court clarified the problem. We are still looking for the clarification, frankly. I agree with you it is terribly important. I don't think there is any more difficult or significant decision that I will have to make after I become Administrator.

Mr. HEINZ. I thank you for appearing before the committee.

Mr. ROGERS. Dr. Roy?

Mr. ROY. Thank you, Mr. Chairman.

I am extremely pleased to have you here and I was extremely pleased, as a junior member of the committee, to hear the compliments of my colleagues, because they all hold you in very high regard. I think that is very important because I believe that EPA has had the confidence of the public, and of the Congress during these past years, and I am sure will continue to have that confidence in the future.

I am going to get back to what is a primary standard, I guess this is as good a time as any, as far as the granting of the variances, and so forth. With the passage of this act certain primary and secondary standards were set with regard to health. As I understand it, each State was to establish programs to meet these standards; is that correct?

Mr. TRAIN. Implementation plans, yes.

Mr. ROY. And that implementation date is about January 1, 1975, as far as finally meeting the standards?

Mr. TRAIN. As to meeting the ambient air quality standards, yes, they must have implementation plans now but they do not have to actually get down to it until mid-1975.

Mr. ROY. I presume many States have plans implemented whereby they can only burn fuel oil with a given sulfur content, is that correct?

Mr. TRAIN. That is correct.

Mr. ROY. These are the result of State law and the efforts to meet the standards in 1975 and the process of meeting the standards at the present time?

Mr. TRAIN. That is correct; it is interesting to note that some of these do go back prior to the Clean Air Act. This was a movement that started in the cities and States before the Clean Air Act.

Mr. ROY. Now this is the normal moving forward to meet the primary standards by that given date. The States that have implemented programs are given permission by the EPA to put those programs into abeyance for a given period of time, is that what you are speaking of by granting variances?

Mr. TRAIN. Yes; what happened last year, and I think that is the best way to approach it, is that a particular importer, I imagine, or a

shipper of oil, would ask the State for a variance in order to bring certain oil into the State and market it in a certain way. Usually the particular variance was tied to a specific user, a utility company or something of that sort, or it could have been of a geographic nature. The State then requested approval by EPA for those variances.

Now, the variance is a change in the implementation plan. That is all it is. Under the law the Clean Air Act, implementation plans must be amended by the States with a process of notice, 30-day notice, I believe, and public hearing. It is our belief that this is the appropriate way to make changes in those implementation plans. Last year in dealing with these variances the problem came on us without the necessary preplanning so that the cold weather was really right on top of us in January before we got into the variance effort. So that the States did not have a chance to go through those procedures which I have described. So what we are trying to do now is to insure to the extent we can—maybe it won't be possible in all cases—to insure that in our procedures the public notice and hearing be followed.

Mr. ROY. A higher sulfur fuel oil may then be shipped in an area or to an industry or both, is that correct?

Mr. TRAIN. That is correct.

Mr. ROY. Sometimes it would be an area and sometimes it would be a given industry that had a great demand for fuel oil.

Mr. TRAIN. Yes; I think typically these would be utility power companies. I believe some of the variances sought last year were for entire States. They were turned down. I believe they were turned down by the States. We had in EPA about 13 requests for variance which I presume had been approved by the States. We finally approved in EPA about eight, as I recall. The case sometimes is that even though a variance is denied to a given supplier it may be possible to get the cleaner fuel from another supplier. This in fact did happen. So that a variance is not always necessary and there are alternatives.

Mr. ROY. I presume that some of the variances which were granted were using the low sulfur fuel oil, in areas that had met the primary standard, is that correct? And in other areas, the request was made to use a higher sulfur oil where they were already using a lower sulfur oil, even though using the lower sulfur oil did not permit the meeting of the primary standards within that geographic area?

Mr. TRAIN. If I understand your question, I believe that is right. The variances generally speaking did go to permitting the use of a fuel which would result in a violation of primary standards for a short period of time. That was generally the problem.

Mr. ROY. I think that final statement is what I was seeking.

Mr. TRAIN. Yes.

Mr. ROY. I thank you very much.

Mr. ROGERS. Thank you very much, Mr. Train. The committee will look forward to your return after your confirmation.

Mr. TRAIN. Thank you, Mr. Chairman.

Mr. ROGERS. Mr. Quarles, if you and your associates will take your seats at the table, we will proceed with your statement on behalf of EPA. You may have anyone sit with you you would like. We welcome you and your associates, and we will be pleased to receive your statement on behalf of the Environmental Protection Agency.

**STATEMENT OF HON. JOHN A. QUARLES, JR., ACTING ADMINISTRATOR, ENVIRONMENTAL PROTECTION AGENCY; ACCOMPANIED BY DR. STANLEY M. GREENFIELD, ASSISTANT ADMINISTRATOR FOR RESEARCH AND DEVELOPMENT; DR. BERNARD J. STEIGERWALD, DEPUTY ASSISTANT ADMINISTRATOR FOR AIR QUALITY PLANNING AND STANDARDS; AND DR. JOHN F. FINKLEA, DIRECTOR, NATIONAL ENVIRONMENTAL RESEARCH CENTER, RESEARCH TRIANGLE PARK, NORTH CAROLINA**

Mr. QUARLES. Thank you, Mr. Chairman, it is a pleasure to be here this morning.

Mr. Train promised at the outset that his testimony would be brief. I am not able to make that promise. My testimony is quite extensive but I believe—

Mr. ROGERS. I might say on behalf of the committee that we can't promise you our questions will be too brief, either. I think we probably will have a rather extended session and we probably will have to go into the afternoon.

Mr. QUARLES. That is my expectation and we are prepared to accommodate you on that.

I am accompanied this morning by Dr. Stanley Greenfield, on my right, who since the inception of the Environmental Protection Agency has served as the Assistant Administrator for Research and Development. I am also accompanied by Dr. Bernard Steigerwald, on my left, who is Deputy Assistant Administrator for Air Quality Planning and Standards, and by Dr. John Finklea, on my far right, who is Director of the National Environmental Research Center, Research Triangle Park, North Carolina.

Mr. ROGERS. We welcome you, gentlemen.

Mr. QUARLES. Mr. Chairman, the Clean Air Act was enacted in late 1970, just about the time the Environmental Protection Agency came into being. Thus, this milestone legislation has been on the books less than 3 years. Indeed, many of its major provisions are still to become fully effective. However, sufficient time has now passed to permit a preliminary assessment of the act and the extent to which it is meeting the intent of the Congress. Mr. Chairman, I welcome this hearing and the opportunity you and your committee are affording the Environmental Protection Agency and other interested groups—in both the public and private sectors—to express their views on this important subject.

Let me set out at the beginning some basic considerations. Environmental protection is essential to the health of the American people. Continued progress in this regard is essential to the future growth of our Nation, since environmental quality is a vital ingredient to our standard of living. The continued healthy functioning of the natural systems of which man and his institutions are a part is the fundamental basis upon which all human activity, including economic activity, depends.

The Clean Air Act provides strong comprehensive tools for bringing about a major improvement in air quality in this country.

Most importantly, the Clean Air Act provisions have already resulted in measurable progress in the improvement of our air environ-

ment. Long-term air quality measurements of particulate matter show a significant decrease of pollutant levels in 66 of 116 urban sites between 1960 and 1972. A similar improvement has occurred in the case of sulfur dioxide. Between 1968 and 1972 significant decreases have been observed in 42 of 95 measuring sites—that is about half—in each case the air quality has been getting better. Increases in pollutant levels have been observed at only a few places, 8 of 116 for particulate matter and 3 of 92 for sulfur dioxide.

We do not have the historical data to make similar comparisons for pollutant levels of carbon monoxide and oxidants. However, in the case of these pollutants, largely associated with emissions from the automobile, the Clean Air Act has forced technological change in the level of control. The mandated reduction of 90 percent in the emissions of hydrocarbons and carbon monoxide can be met.

Before I review in detail the provisions of the act and the action we have taken in carrying them out, I think it important as an overview to provide some perspective to the discussion that follows:

First, the act prescribes the establishment of a set of environmentally important goals to be achieved within certain time frames. These goals are set forth as ambient air quality standards.

Second, the act mandates the adoption of regulations setting forth legally enforceable emission reduction plans for the achievement of the environmental goals.

Third, the act provided for the adoption of certain technologies in the private sector, for example, "best adequately demonstrated technology" in the case of new stationary air pollution sources and a mandated 90 percent emission reduction from new light duty motor vehicles.

Fourth, the act requires the institution of other emission reduction techniques such as land use and transportation controls when control technology seems inadequate to meet the environmental goals within the time schedule set forth in the act.

Thus, any debate about the Clean Air Act, regardless of how it is presented, essentially reflects differing views about four fundamental issues:

1. Are the goals of the act as translated into standards by EPA reasonable and realistic?
2. Are the deadlines established for meeting the requirements of the act reasonable and realistic?
3. Is the required control technology available, within the time frame of the act, or available at a cost commensurate with the environmental protection afforded by the Air Quality Standards?
4. Is the imposition of land use and transportation controls within the time frame of the act a reasonable extension of the effort required to attain and maintain ambient air quality standards or does it constitute an unwise disruption of the existing institutional patterns of societal growth and development?

In presenting these questions for discussion let me be as explicit as I can as to how EPA has viewed these issues.

First, environmental goals.

The act requires the Administrator to set forth as ambient air quality standards levels of pollution, for widely prevalent pollutants,

that with an adequate margin of safety to protect the public health—the primary standard and which protects against all other adverse effects—the secondary standard. In the spring of 1971, EPA promulgated standards covering six pollutants—sulfur oxides, particulate matter, carbon monoxide photochemical oxidants, hydrocarbons and nitrogen dioxide. Dr John Finklea will review for you in detail the basis for these standards, but I want to make some general observations about the philosophy of environmental standards which underlies the specific standards which have been set.

The intent of the law as I read it is that an air quality standard is intended to offer protection to all segments of society. What this means in practice is that the specific standards are set at levels which are intended to be protective of the most susceptible groups in the population, the asthmatic, the persons with bronchitis or emphysema, persons with coronary artery disease, in short, persons whose ability to function productively in society is already impaired with some form of respiratory disease or cardiovascular involvement. Numerically these individuals may only represent 3 to 5 percent of our population.

I want to emphasize that our knowledge of these pollutant effects are based upon symptoms exhibited by persons with diagnosed disease problems. We really know very little about how air pollution over time contributes to the development of respiratory impairments nor do we know what percent of a presently well population will in the course of their lifetime become victims of these diseases. We can only be sure that whatever degree of protection we afford to those most susceptible to air pollution is likewise protection for the rest.

As I mentioned previously, in addition to the primary ambient air quality standard, the Act also required the Administrator to prescribe secondary standards, which are protective of public welfare broadly defined. In the case of only two pollutants, sulfur dioxide and particulate matter, were we able to determine that adverse pollutants effect on other receptors occurred below the levels set in the primary standard.

Mr. Chairman, I would like to let that sink in. In other words, we do not have secondary standards on these other pollutants different from the primary standards. What this means is that as we go on to talk about the achievement of these other standards for pollutants primarily associated with the automobile we are in every case talking about standards required for the protection of public health.

In the case of sulfur dioxide, vegetation damage and in the case of particulate matter, reduced visibility was evident at pollutant levels lower than those covered by the primary standards. Our original secondary standards for sulfur dioxide included an annual average not to be exceeded of  $60 \mu\text{g}/\text{m}^3$ . Reevaluation of the scientific studies on which this standard was based have convinced us that the observed crop damage was more properly associated with short term peaks than with the annual average and we are consequently withdrawing the  $60 \mu\text{g}/\text{m}^3$  annual secondary standard. The present short term standard remains in effect. Changes in previously submitted State implementation plans will not be required.

Let me address the problem of achievability of the ambient air quality standards and the more general question of the technology requirements of the Clean Air Act.

The achievement of the sulfur dioxide standards has impacted most severely on the consumers of fossil fuel—coal and oil—whose sulfur content exceeds that allowable by the State-adopted regulations. In some quarters the shift from high to low sulfur content fuel is considered to be a major factor in the energy crisis that we face today and over the next decade. Last fall EPA made an intensive analysis of the implications of the regulations that States had adopted in response to implementation plan requirements. EPA concluded that there was a short fall of almost 100 million tons of low sulfur coal or its equivalent to meet the ambient air quality standards in 1975. Others believe the deficit may be considerably greater. At the same time the Agency identified that requirements were being imposed on coal users where the achievement of primary standards was not at issue which, if relaxed either in degree of stringency or compliance time, may largely eliminate the projected deficit.

Therefore, the Agency adopted a clean fuels policy which was calculated to encourage the States to relax their sulfur requirements for coal in areas where regulations were not necessary to achieve the primary, health-related standard. The purpose of this policy is to concentrate the use of clean fuels in the area where they are needed most.

This policy is currently being implemented through a program of positive assistance to the States in modifying their regulations. Changes in regulations are currently under consideration in Ohio, Tennessee, Alabama, Michigan, Illinois, and a few other States.

I would like to note here that the "clean fuels policy" with respect to generally relaxing fuel regulations extends only to coal and not to oil.

Its extension is under consideration. In our view the technology for desulfurizing heavy fuel oil is clearly available and should be promoted. When I talk about desulfurization I do not include the blending of distillate oil with heavy fuel oil. Distillate oil is in short supply and analysis suggests that the near term pressure on distillate supplies results from natural gas curtailments and environmental considerations.

We are basically optimistic that the present "Clean fuels policy" will have the effect of assuring low sulfur coal availability where needed to meet the primary health-related standards. However, to meet standards over the long run the coal burning utilities must make a major commitment to the installation of stack gas cleaning technology if they are to continue to burn readily available high sulfur fuel supplies. A Federal interagency group, the sulfur oxide control technology assessment panel (SOCTAP) in its report this spring confirmed the technical feasibility of retrofitting a large fraction of the Nation's coal-fired steam plants with commercially available stack gas cleaning systems.

You may be interested to know on that SOCTAP committee, comprised in addition to EPA and CEQ also representatives of the Federal Power Commission, the Office of Science and Technology and the Commerce Department.

A full scale system, using American technology, is operating in Japan and several U.S. utilities have installations in the design or construction stage in addition to the ongoing demonstration projects.

Mr. ROGERS. May I interrupt?

How long has that been operating in Japan? Is it for a short period of time or a considerable period of time?

Mr. QUARLES. There are several plants in Japan that have been installing or have installed stack gas sulfur oxide removal technology. The most significant of these has been operating I believe in the range of 12 to 18 months.

Mr. ROGERS. Twelve to 18 months, and the results are favorable?

Mr. QUARLES. Yes. I understand that the results have been favorable. As you know, a number of the efforts to install stack gas cleaning technology in this country have encountered a great many bugs and have resulted in many reports of frequent down time for repairs. In the Japanese case, however, they have been operating substantially without interruption for a period exceeding 12 months.

Mr. ROGERS. Can you get some details on that and submit it to the committee?

Mr. QUARLES. Yes, we will be glad to furnish a more detailed report. [Testimony resumes on p. 26.]

[The following information was received for the record:]

#### JAPANESE SCRUBBER EFFORTS

The report, "Sulfur Oxide Control Technology—Visits in Japan, August 1972" is a thorough evaluation of the status of sulfur removal technology in Japan at that time. Attached pages 1-10 of the report offer a brief summary of the evaluation. A later report prepared by Dr. Jumpei Ando ("Recent Developments in Desulfurization of Fuel Oil and Waste Gas in Japan—1973" Jumpei Ando, Processes Research Inc. Cincinnati, Ohio, Contract No. 68-02-0242, May 1972) under contract with EPA describes more recent developments in Japan. A summary of the portion of that report pertaining to flue gas sulfur removal is attached:

[Pages 1-10 of report "Sulfur Oxide Control Technology—Visits in Japan, August 1972"]

#### SULFUR OXIDE CONTROL TECHNOLOGY VISITS IN JAPAN—AUGUST 1972

##### SUMMARY

During the period August 2 to August 16, 1972, a U.S. Government Interagency team visited organizations in Japan to evaluate technology for control of sulfur dioxide emission. The team consisted of:

Dr. S. J. Gage, Executive Office of the President, Office of Science and Technology, Washington, D.C.

F. T. Princiotto, Control Systems Division, Environmental Protection Agency, Research Triangle Park, North Carolina.

Dr. G. A. Hofflinden, Division of Power Resource Planning, Tennessee Valley Authority, Chattanooga, Tennessee.

H. W. Elder, Division of Chemical Development, Tennessee Valley Authority, Muscle Shoals, Alabama.

Dr. Jumpei Ando, a professor at Chuo University in Tokyo, served as consultant, interpreter, and guide during the visits. His knowledge of the subject and facility with both languages were extremely helpful in promoting effective dialogue.

The primary purpose of the trip was to observe a full-scale lime scrubbing system in operation on a coal-fired power plant at Mitsui Aluminum Company; the visit was arranged by the Chemical Construction Corporation (Chemleo), the company that designed the system. Several other important large-scale and pilot-scale projects were visited and discussions were held with the Japanese regulatory agencies. The list of organizations is shown below in chronological order.

Mitsui Aluminum Company, Ltd. (Chemleo)

Kawasaki Heavy Industries, Ltd. (magnesium oxide)

Nippon Kokan KK (ammonia)

Chiyoda Chemical Engineering and Construction Company, Ltd.  
 Mitsui Shipbuilding and Engineering Company, Ltd. (Grillo)  
 Japan Synthetic Rubber Company (Wellman-Lord—Mitsubishi)  
 Kureha Chemical Industry Company, Ltd. (double alkali)  
 Mitsubishi Heavy Industries, Ltd. (Tokyo)  
 Kansai Electric Power Company (lime-gypsum and Sumitomo carbon)  
 Mitsubishi Heavy Industries, Ltd. (Osaka)  
 Japan Environmental Agency  
 Ministry of International Trade and Industry (MITI)  
 Tokyo Electric Company (Hitachi carbon)  
 Kashima Oil Company (hydrodesulfurization)  
 Showa Denko KK (double alkali)

Detailed accounts of the discussions are presented in this report. A summary of each visit follows:

#### JAPAN GOVERNMENT AGENCIES

##### *Japan Environmental Agency*

The Japan Environmental Agency is responsible for coordinating all of Japan's research and development program. The agency also plays a major role in developing air quality and emission standards and regulations. Ambient air quality standards have been set in Japan for SO<sub>2</sub>, CO, and suspended particulate matter in order to protect the public health. The national government sets emission standards for SO<sub>2</sub> according to an equation which relates the allowable emission rate to the product of the square of the effective stack height and a constant is specified based on the severity of pollution in a given region.

Japan has instituted a comprehensive air monitoring program on both a national and a local basis. National stations obtain basic data for establishment of environmental standards, formulation of control programs, and understanding of photochemical smog. Local monitoring is performed to assess air quality on a continuous basis.

##### *Ministry of International Trade and Industry (Energy Policy Division and Public Utilities Bureau)*

In order to meet environmental ambient air quality standards for SO<sub>2</sub>, MITI has formulated a "sulfur diminishing policy." Presently the ambient standards are to be met by 1978; however, due to public pressure, it appears likely that more stringent standards, to be met by 1975, may be announced in the near future.

Since combustion of oil is the primary cause of SO<sub>2</sub> pollution, a comprehensive strategy involving oil utilization is being formulated. In order of their importance in meeting the present 1978 requirements, the strategies are: desulfurization of heavy oil, lowering the average content of imported crude oil, installation of flue gas desulfurization systems, and importation of liquefied natural gas.

MITI has sponsored development of two flue gas desulfurization systems: carbon adsorption (Hitachi) and the manganese oxide process (Mitsubishi Heavy Industries). These systems do not seem to be playing an important role; wet scrubber facilities appeared to be favored by users.

It was stated that most flue gas desulfurization systems in Japan have been installed on industrial-size boilers rather than the large utility boilers since large-fuel oil users have been able to get low-sulfur oil due to their economic leverage.

#### LIME SCRUBBING

##### *Chemico Scrubber at the Miike Power Station of Mitsui Aluminum Company, Ltd.—Lime Scrubbing with Throwaway Product*

Chemico has designed a two-stage carbide sludge (calcium hydroxide) scrubbing system for the Miike Power Station near Omuta. The system consists of two parallel two-stage venturi systems, each capable of handling 75% of the flue gas from the boiler. The boiler burns a high-ash, low heating value sub-bituminous coal, and the flue gases are desulfurized downstream of a 98% efficient electrostatic precipitator. After a 10-month construction period, the unit was started up on March 29, 1972, and has been operating with close to 100% availability since then. A bleed stream is pumped from the scrubber circuit to a disposal pond for throwaway product storage. SO<sub>2</sub> removal efficiencies have been reported at from 80–90%; the system passed guarantee tests by removing

90% of the inlet  $\text{SO}_2$  at 120 stoichiometric ratio during April 1972. The Ministry of International Trade and Industry witnessed these tests.

The  $\text{SO}_2$  control system has exhibited reliable, essentially trouble-free operation since startup. After its performance passed the guarantee tests in late April, the control system has been operated under less stringent conditions just adequate to meet the current Japanese  $\text{SO}_2$  standards. No serious chemical or mechanical problems have been detected in the two-stage venturi scrubbing system.

The sludge in the disposal pond appears to be settling quite well, in fact, much better than experienced at U.S. facilities. Ultimate disposal of the throwaway product, a major problem in the United States, remains an open question.

It should be noted that the reliable performance of this system to date is of real significance to the U.S. air pollution control program, since the design ground rules for the Japanese unit are quite similar to those of many of our power utilities requiring desulfurization systems. The following are among the areas of commonality: use of existing coal-fired boiler, moderately efficient electrostatic precipitators, installation on moderately large size boiler (156 mw), production of a throwaway product, and availability of calcium-based absorbents. The unit takes on additional significance since the system was designed based on U.S. technology (Chemico) and a similar unit, using calcium hydroxide on a coal boiler, is being constructed in the United States for Duquesne Light Company's Phillips Station, with startup scheduled during spring 1973.

It should be noted that long-term reliability of the Mitsui unit has not yet been demonstrated. Also, there is some question regarding the validity of extrapolating Mitsui performance to those U.S. applications with substantially different design ground rules, such as: much higher  $\text{SO}_2$  inlet concentrations, units with widely varying boiler loads, and much higher inlet ash concentrations.

*Mitsubishi Heavy Industries-Japanese Engineering Consulting Company (JECCO)—Lime Scrubbing with Gypsum Production*

Mitsubishi Heavy Industries has licensed JECCO's lime-gypsum process and installed a 35-mw system to treat about 25% of the flue gas generated from one of the two 156-mw oil-fired boilers at Kansai Electric's Amagasaki plant. The boiler burns 1.5% sulfur residual oil leading to a 600-750 ppm inlet  $\text{SO}_2$  concentration to the absorbers. The process involves contacting flue gas with a calcium hydroxide slurry in two absorbers in series packed with plastic grids. A bleed stream containing the predominantly calcium sulfite-calcium sulfate reaction product is oxidized in a specially designed rotary atomizer developed by JECCO to form high-purity salable gypsum.

The system was started up during April 1972 and operated in a totally closed-loop mode. Except for a 1-month period when the boiler was down, the system has operated continuously and has reliably removed from 85-90% of the inlet  $\text{SO}_2$ .

The  $\text{SO}_2$  control system exhibited reliable, trouble-free operation for approximately a 3-month period since startup. This process with its demonstrated oxidation technology allows production of high-purity gypsum ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) instead of a sludge rich in  $\text{CaSO}_3 \cdot 1/2\text{H}_2\text{O}$ . The oxidation technology has been in use over the last 8 years in the lime-gypsum system treating sulfuric acid tail gases in the Koyasu Mill of Nippon Kokan KK. Gypsum has advantages over calcium sulfite for throwaway systems, since it is much more easily dewatered, either by settling, centrifuging, or filtering operations. This can lead to lower volume requirements for sludge disposal ponds and allow more economical reclaiming of such ponds. For throwaway systems where the sludge is transported for landfill, disposal costs can be reduced since a drier (lower weight) material would be handled and transported to the disposal site.

It should be noted that there are certain factors relative to this unit which make extrapolations to the U.S. situation difficult. The 35-mw boiler burns low-sulfur residual oil giving an inlet  $\text{SO}_2$  concentration to the scrubber of only 700 ppm. Most U.S. utilities require control on boilers burning high-sulfur coal or oil with inlet concentrations to a desulfurization system generally greater than 2000 ppm. Experience has indicated lime scrubbing systems are more prone to scaling, plugging, and other reliability problems at higher inlet  $\text{SO}_2$  concentrations. Also, utilization of the Mitsubishi technology in the United States would be more difficult compared with use of Chemico and Wellman-Lord technology, for example, since they are U.S.-based companies.

## MAGNESIUM OXIDE SCRUBBING PROCESSES

*Kawasaki Heavy Industries Magnesium Process*

The Kawasaki process uses magnesium hydroxide slurry as the absorbent, which is obtained by processing seawater with lime. The magnesium sulfite produced from the reaction of magnesium hydroxide and  $\text{SO}_2$  is either regenerated by thermal decomposition in a manner similar to the Chemico  $\text{MgO}$  process or oxidized to sulfate and discharged to the sea. At present, the latter procedure is recommended for Japanese installations due to an increasing overabundant supply of sulfuric acid and the rather limited water quality codes in Japan.

The magnesium oxide process closely resembles the Chemico process being demonstrated in the United States at Boston Edison's Mystic Station. Since this unit has recently started up, important information on a full-scale system should be available soon. One of the Kawasaki variations of this process, involving production of magnesium sulfate for discharge to a body of water, is not considered acceptable in the United States due to water quality considerations.

*Mitsui-Grillo Desulfurization Process*

This process was developed by Grillo-Werke Company in West Germany with whom Mitsui has entered into a license agreement since December 1970.

The Grillo process is a wet-type stack gas desulfurization process.  $\text{SO}_2$  is absorbed in a magnesium-manganese oxide slurry mixture. The absorbent is regenerated in a fluidized roaster where the released  $\text{SO}_2$  is processed to concentrated  $\text{H}_2\text{SO}_4$ . Testing to date has been performed on a pilot-scale basis. Design plans for testing this process on a 120,000-scfm (40-mw) oil-fired system are being completed.

The process is quite similar to the magnesium process being developed in the United States and presently being demonstrated at Boston Edison's Mystic Station, except that some  $\text{MnO}_2$  is carried along with the  $\text{MgO}$  in the circuit. If successfully demonstrated, it represents an important  $\text{SO}_2$  removal process with potential for reasonable capital and operating costs and high  $\text{SO}_2$  removal efficiencies. Since commercial sulfuric acid is a byproduct, the necessary markets must be established.

## SODIUM SCRUBBING WITH THERMAL REGENERATION

*Japan Synthetic Rubber Company—Wellman-Lord Process*

Wellman-Lord has designed a flue gas desulfurization system for a 75-mw oil-fired power plant at the Chiba Plant of Japan Synthetic Rubber. Mitsubishi Chemical Machinery (MCK) was the constructor. The system involves absorbing  $\text{SO}_2$  with a soluble liquor containing sodium sulfite as the active alkaline agent. A sieve tray absorption tower is used to absorb  $\text{SO}_2$  forming sodium bisulfite. The sodium bisulfite is regenerated back to sodium sulfite and concentrated stream of  $\text{SO}_2$  in a steam-evaporator-crystallizer. The  $\text{SO}_2$  evolved is sent to an acid plant for production of a high-quality, concentrated sulfuric acid. The system started up during June 1971 after only a 10-month construction period and has reliably removed on the order of 90% of the inlet  $\text{SO}_2$  for over 1 year. However, due to the difficulty in regenerating sodium sulfate, which forms by oxidation in the absorber, approximately 10% of the absorbed  $\text{SO}_2$  is purged from the system as  $\text{Na}_2\text{SO}_4$ ; this corresponds to about a 4% oxidation rate.

Successful reliable operation of the Wellman-Lord process at Chiba for greater than 8000 hours is considered quite significant from the U.S.  $\text{SO}_2$  control situation. It appears the process should be applicable to coal-fired boilers if flyash removal equipment is installed upstream of the Wellman-Lord absorber. The NIPSCO unit, partially funded by EPA, will treat coal boiler flue gas. Cost studies indicate that capital and operating costs for a Wellman-Lord system in the United States on a coal-fired boiler are not a great deal higher than those for wet limestone systems, which are generally considered the least expensive of the flue gas desulfurization systems.

The major problem with the process is the requirement for a bleed to remove contaminants, primarily  $\text{Na}_2\text{SO}_4$ . Present data indicate about 10% of the total incoming sulfur is lost as soluble  $\text{Na}_2\text{SO}_4$ . This is undesirable from an environmental viewpoint since future Federal regulations for waste streams will probably prohibit such discharge; also, sodium makeup costs are significant. However, based on an oxidation retardant tested by Sumitomo, such losses might be reduced

55%. Also, additional techniques are available to further reduce this effluent; e.g., crystallizing out the  $\text{Na}_2\text{SO}_4$ . Although such techniques would add to the cost, they will probably be necessary for general U.S. application.

Another potential problem with this and all the other concentrated  $\text{SO}_2$ -producing processes is the requirement to sell large quantities of low-value sulfur product. Although there is little doubt that  $\text{H}_2\text{SO}_4$  can be marketed in the United States in certain localities (near  $\text{H}_2\text{SO}_4$  users), it does not appear that such production can be absorbed by users if a large percentage of U.S. electrical utilities would produce acid. However, elemental sulfur, which will be produced in the NIPSCO unit, is another potential product which is both storable and potentially salable; this could ultimately be the most desirable end product of all, including the throwaway sludges associated with lime-limestone processes.

#### DOUBLE-ALKALI PROCESSES

##### *Showa Denko KK Double-Alkali (Sodium-Calcium) Process*

A major pilot plant program is under way to study a double-alkali process based on sodium and calcium producing gypsum as a salable product. An 8,500-acfm system, complete with all the required process equipment, has been in operation about 8 months at the Kawasaki plant. Tests with both calcium hydroxide and calcium carbonate have been made with acceptable results. Sulfuric acid is used to regenerate any sodium sulfate produced. Based on information obtained from operation of the pilot plant, a full-scale 200-mw (500,000-acfm) plant is being designed and built for operation on an oil-fired boiler beginning in June 1973.

The comprehensive pilot test program on a double-alkali system to produce gypsum could represent an important alternative throwaway process to wet limestone systems in the United States. Double-alkali systems offer potential reliability and performance advantages over wet lime-limestone systems with comparable capital and operating costs. The full-scale unit presently being constructed is considered quite significant and the operational experience should be carefully monitored.

##### *Kureha Chemical Industry Company, Ltd., Double-Alkali (Sodium-Calcium) Process*

Kureha is developing a double-alkali process to preprecipitate calcium sulfite from the sodium scrubbing liquor by addition of calcium carbonate followed by oxidation to produce gypsum. This process is quite similar to the Showa Denko process. Tests in a small pilot plant (220-acfm) over a period of 1½ years led to construction of a 4200-acfm pilot plant which has been in operation for about 4 months. The larger pilot plant program is a joint effort with Kawasaki Heavy Industries. At the present state of development, disadvantages are long retention time in the decomposition and oxidation steps and requirement of sulfuric acid addition for regeneration of sodium sulfate.

##### *Jinkoshi-Nippon Kokan KK—Double Alkali (Ammonia-Calcium) Process and Ammonium Sulfate Process*

Ammonia and sodium scrubbing processes are being developed by Nippon-Kokan using a new type of screen absorber developed by Jinkoshi. The reactive absorbent flows down on the surface of stainless steel screens (about 10 mesh) placed vertically or with inclination to form stable thin liquid films which are reported highly effective for removal of  $\text{SO}_2$  and dust.

The ammonia work has been primarily conducted on iron-ore sintering plants where ammonia from coke-oven gas is used as the absorbent. Pilot studies for regenerating the bisulfite liquor with lime (double-alkali mode) have also been completed.

The sodium scrubbing work has been carried out on an oil-fired boiler where the sodium sulfite solution is used primarily for paper production.

The most significant aspect of Jinkoshi-Nippon Kokan's development activities is their pilot-scale testing of an ammonia-lime double-alkali process with gypsum formation. This process could represent an attractive alternative to wet lime-limestone throwaway processes being utilized in the United States. Ammonium sulfite was selected as the scrubbing medium as opposed to sodium sulfite, due to the ease in regenerating the sulfate. However, fume problems have plagued similar ammonia scrubbing systems in the past; such problems would be avoided in a sodium double-alkali process.

### *Chiyoda "Thoroughbred 101" (Sulfuric Acid-Calcium) Process*

The Chiyoda Thoroughbred 101 flue gas desulfurization process features absorption of  $\text{SO}_2$  by use of very dilute sulfuric acid (about 2-5% by weight). By-product gypsum is produced without discharging any undesirable waste steam which may cause secondary pollution.

Based on laboratory work and bench-scale test results, a pilot plant (maximum 650 scfm) was constructed to collect the data needed for commercial applications of the process. The pilot plant started operation in early July 1971 and operated over 1 year in Kawasaki. Efficient  $\text{SO}_2$  removal required extremely high liquor recirculation rates and low gas velocities. Four commercial plants are now under construction in Japan and two of them are scheduled to be placed on steam toward the end of 1972.

The large liquid:gas ratios and large absorbers required for high efficiency removal (>90%) from units burning high-sulfur coal could lead to unacceptably high capital and operating cost requirements for many U.S. applications. The process may be more applicable to flue gas control of both low and medium content sulfur fuels where  $\text{SO}_2$  removal efficiencies below 90% may be acceptable. For those U.S. applications where this process can be made competitive to a wet lime-limestone system in terms of costs, it represents a potentially attractive alternate throwaway approach.

### CARBON ADSORPTION PROCESSES

#### *Kansai Electric Company—Sumitomo Carbon Process*

A process based on adsorption of  $\text{SO}_2$  on activated carbon was developed by Sumitomo Shipbuilding and Machinery Company, Ltd. Operations of a 10,000  $\text{Nm}^3/\text{hr}$  pilot plant led to construction of a 175,000  $\text{Nm}^3/\text{hr}$  (62-mw) prototype plant on an oil-fired boiler at the Sakai plant of Kansai Electric. The investment of \$3 million was split between Sumitomo and Kansai. Cost of operation is being shared by a group of electric companies.

Operation of the plant was begun in February 1972 and, except for a 2-month boiler outage, has operated nearly continuously. A moving-bed system is used and the desorbed  $\text{SO}_2$  is converted to sulfuric acid. Removal efficiency has been 80-95%. Carbon loss through attrition has been excessive. Investment requirement is relatively high.

The major advantage of this process is the production of concentrated sulfuric acid in a system that may be applied to existing power plants without appreciable reduction in gas temperature. Disadvantages include high investment costs because of the need for large gas-contacting equipment in addition to a sulfuric acid plant, potentially high operating cost because of attrition of carbon in the moving-bed system, and the need for precise atmospheric control in the desorber.

Cost of reheat of the gas in an alkaline wet-scrubbing system plus the energy required for drying the sulfite may be small economic penalties compared with the investment required to avoid reheat by utilizing a dry process; it appears that wet-scrubbing regenerative systems have more potential.

#### *Tokyo Electric Company at Kashima—Hitachi Carbon Process*

The Japan Ministry for International Trade and Industry provided part of the funds for construction of a large-scale (450,000  $\text{Nm}^3/\text{hr}$ ), activated carbon process to treat one-fourth of the gas from one 600-mw, oil-fired boiler. The process was developed with government funds by Hitachi, Ltd., and Tokyo Electric operated a prototype-scale plant (150,000  $\text{Nm}^3/\text{hr}$ ) at their Goi Station prior to installation of the Kashima system.

Gas containing about 800 ppm  $\text{SO}_2$  is passed at low velocity (0.5 m/sec) through three towers in series packed with activated carbon. The  $\text{SO}_2$  is adsorbed on the carbon, oxidized in place, and absorbed in wash water while the gas flow is diverted to another section. About 80% of the inlet  $\text{SO}_2$  is removed in the form of dilute (20%)  $\text{H}_2\text{SO}_4$ . Pulverized limestone is used to convert the acid to salable gypsum.

Investment is relatively high and operating costs are strongly dependent on life of the carbon which has not been established.

Without a concentration step, the acid strength produced is only 20% which is too dilute for commercial use. Concentration of dilute sulfuric acid is difficult and expensive. Use of limestone to produce gypsum may be practical in Japan where there currently is a market for gypsum; but in the United States, it would

probably be a prohibitively expensive throwaway system. The fact that the Japanese have not planned further installations after demonstration on a large scale would indicate that the alternatives, such as wet-scrubbing systems, are more practical.

#### SUMMARY OF "RECENT DEVELOPMENTS IN DESULFURIZATION OF FUEL OIL AND WASTE GAS IN JAPAN—1973."

##### 4 OUTLINE OF WASTE-OAS DESULFURIZATION

Major commercial and prototype plants in operation and under construction for SO<sub>2</sub> removal and recovery are listed in Tables 4.1 to 4.4. The tables show about 40 plants (70 units) in operation with a total capacity of about 5,000,000 scfm and several plants under construction. Nearly a half of the plants treat flue gas from oil-fired boilers and the rest waste gases from pulp plants, sulfuric acid plants, smelteries, iron ore sintering plants, Claus furnaces, etc. The unit capacity of most of the desulfurization plants ranges from 20,000 to 250,000 scfm. There are many other smaller commercial plants treating waste gas from various sources which are not listed in the tables. The capacities of the desulfurization plants in operation total 6,000,000 scfm.

Major electric power companies were interested in dry processes but have recently decided to build many large plants using wet processes as shown in Table 4.5. The capacities of the desulfurization plants of the major power companies will total 2,700MW in 1974, 3,700MW in 1975, and 4,800MW in 1976 (Table 1.6).

A salient feature of the desulfurization efforts in Japan is that they are oriented toward processes that yield salable by-products. Of the plants in operation about 60%, in terms of capacity, use sodium scrubbing to produce sodium sulfite and sulfate for paper mills (Table 4.1), 27% other recovery processes to produce concentrated SO<sub>2</sub>, sulfuric acid and gypsum (Tables 4.2 and 4.3), and only 13% removal processes to produce waste by-products such as solid calcium sulfite and solutions of ammonium sulfate and sodium sulfite or sulfate (Table 4.4).

This is because Japan is subject to limitations in domestic supply of sulfur and its compounds as well as in land space available for disposal of useless by-products. The by-produced sodium sulfite, however, has already filled the demand. Most of the plants now planned (Table 4.5) as well as the pilot plants in operation (Table 4.6) aim at the production of salable gypsum or sulfuric acid. As desulfurization is making rapid progress, it will not be long before the supply of by-products runs ahead of demand.

TABLE 4.1.—MAJOR SO<sub>2</sub> RECOVERY PLANTS BY SODIUM SCRUBBING (CHARGE: NaOH)

Process developer	Product	User	Plant site	Unit capacity (1,000 scfm)	Date of completion
Oji Paper	Na <sub>2</sub> SO <sub>3</sub>	Oji Paper	Kasuga	805 (in 12 units) <sup>1, 2</sup>	1966-72
Do	Na <sub>2</sub> SO <sub>3</sub>	Tokai Pulp	Shimada	467 (in 5 units) <sup>2</sup>	1970-72
Do	Na <sub>2</sub> SO <sub>3</sub>	Oaio Paper	Mishima	470 (in 6 units) <sup>2</sup>	1972
Oji-Jinkoshi	Na <sub>2</sub> SO <sub>3</sub>	Oji Paper	Tomakomai	400 (in 4 units) <sup>1</sup>	1971-72
Kureha Chemical	Na <sub>2</sub> SO <sub>3</sub>	Kureha Chemical	Nishiki	176 <sup>1</sup> , 176 <sup>1</sup>	1978
Do	Na <sub>2</sub> SO <sub>3</sub>	Mitsui Toatsu	Nagoya	112 <sup>1</sup>	1971
Do	Na <sub>2</sub> SO <sub>3</sub>	Konan Utility	Konan	123 <sup>1</sup>	1972
Showa Oenka	Na <sub>2</sub> SO <sub>3</sub>	Showa Oenka	Kawasaki	88 <sup>1</sup>	1970
Do	Na <sub>2</sub> SO <sub>3</sub>	Ajinomoto	do	159 <sup>1</sup>	1971
Do	Na <sub>2</sub> SO <sub>3</sub>	Nippon Phosphoric	Sodegaura	47 <sup>2</sup>	1971
Do	Na <sub>2</sub> SO <sub>3</sub>	Asia Oil	Yokohama	142 <sup>1</sup>	1972
Tsukushima	Na <sub>2</sub> SO <sub>3</sub>	Sumitomo Mining	Toyo, Besshi	82 <sup>2</sup> , 88 <sup>2</sup>	1970
Bahco-Tsukishima	Na <sub>2</sub> SO <sub>3</sub>	Oaishowa Paper	Oaishinaga	129 <sup>2</sup> , 65 <sup>2</sup> , 26 <sup>2</sup>	1971
Do	Na <sub>2</sub> SO <sub>3</sub>	Oaio Paper	Iyomishima	88 <sup>1</sup> , 70 <sup>1</sup>	1972
Cadelius	Na <sub>2</sub> SO <sub>3</sub>	Hokuetsu Paper	Niigata	100 <sup>2</sup> , 100 <sup>2</sup>	1971
Do	Na <sub>2</sub> SO <sub>3</sub>	Sanyo Kokusaku Pulp	Asahikawa	77 <sup>1</sup>	1972
Hitachi Ltd	Na <sub>2</sub> SO <sub>3</sub>	Jujo Paper	Miyakojima	57 <sup>1</sup>	1972
Ishikawajima-TCA	Na <sub>2</sub> SO <sub>3</sub>	Tsurumi Soda	Yokohama	35 <sup>1</sup>	1971
Do	Na <sub>2</sub> SO <sub>3</sub>	Mitsuisenpoku Oil	Sakai	88 <sup>1</sup> , 88 <sup>1</sup> , 88 <sup>1</sup>	1973
Mitsubishi (MKK)	Na <sub>2</sub> SO <sub>3</sub>	Asahi Glass	Amagasaki	41 <sup>1</sup>	1972
Do	Na <sub>2</sub> SO <sub>3</sub>	do	Tsurumi	130 <sup>2</sup>	1973

<sup>1</sup> Oil-burning boiler.

<sup>2</sup> Kralt recovery boiler.

<sup>3</sup> H<sub>2</sub>SO<sub>4</sub> plant.

<sup>4</sup> Smelting furnace.

<sup>5</sup> Glass furnace.

TABLE 4.2.—SO<sub>2</sub> RECOVERY PLANTS BY WET PROCESS TO PRODUCE GYPSUM

Process developer	Absorbent	User	Plant site	Unit capacity (1,000 scfm)	Date of completion
Mitsubishi-JECCO	Ca(OH) <sub>2</sub>	Nippon Kokan	Koyasu	1 37	1968
Oo	Ca(OH) <sub>2</sub>	Kansai Electric	Amagasaki	2 59	1972
Oo	Ca(OH) <sub>2</sub>	Onahama S. & R.	Onahama	2 54	1972
Oo	Ca(OH) <sub>2</sub>	Tomakomai Chemical	Tomakomai	2 35	1972
Oo	Ca(OH) <sub>2</sub>	Kawasaki Steel	Chiba	4 71	1973
Bahco-Tsukishima	Ca(OH) <sub>2</sub>	Yahagi Iron	Nagoya	4 47	1971
Ishikawajima-TCA	Ca(OH) <sub>2</sub>	Mitsubishi Metal	Onahama	2 70	1972
Oo	Ca(OH) <sub>2</sub>	Chichibu Cement	Kumagaya	2 61	1972
Oo	Ca(OH) <sub>2</sub>	do	do	2 61	1973
Kawasaki H. I.	Ca(OH) <sub>2</sub>	Jujo Paper	Akita	2 53	1973
Chiyoda	H <sub>2</sub> SO <sub>4</sub> , CaCO <sub>3</sub>	Nippon Mining	Mizushima	7 20	1972
Do	H <sub>2</sub> SO <sub>4</sub> , CaCO <sub>3</sub>	Fuji Kosan	Kainan	2 93	1972
Do	H <sub>2</sub> SO <sub>4</sub> , CaCO <sub>3</sub>	Mitsubishi Rayon	Otake	2 53	1973
Oo	H <sub>2</sub> SO <sub>4</sub> , CaCO <sub>3</sub>	Tohoku Oil	Sendai	7 8	1973
Oo	H <sub>2</sub> SO <sub>4</sub> , CaCO <sub>3</sub>	Oaicel Ltd.	Aboshi	2 59	1973
Nippon Kokan	NH <sub>3</sub> , Ca(OH) <sub>2</sub>	Nippon Kokan	Keihin	4 88	1972
Nippon Steel Chemical	NaOH, Ca(OH) <sub>2</sub>	Nippon Steel Chemical	Sakai	2 12	1972
Showa Oenke	NaOH, CaCO <sub>3</sub>	Showa Oenke	Chiba	2 340	1973

- 1 Sulfuric acid plant.  
 2 Oil-burning boiler.  
 3 Smelting furnace.  
 4 Sintering plant.  
 5 Diesel generator.  
 6 Kraft recovery boiler.  
 7 Claus furnace.

TABLE 4.3.—OTHER MAJOR PLANTS FOR SO<sub>2</sub> RECOVERY

Process developer	Absorbent	Product	User	Plant site	Unit capacity (1,000 scfm)	Date of completion
Wet process:						
Wellman-Lord (MCK)	NaOH	SO <sub>2</sub> , H <sub>2</sub> SO <sub>4</sub>	Japan Synth. Rubber	Chiba	1 118	1971
Oo	NaOH	SO <sub>2</sub> , H <sub>2</sub> SO <sub>4</sub>	Chubu Electric	Nishinagoya	1 365	1973
Oo	NaOH	SO <sub>2</sub> , H <sub>2</sub> SO <sub>4</sub>	Nihon Synth. Rubber	Yokkaichi	1 237	1973
Wellman-Lord (SCEC)	NaOH	SO <sub>2</sub> , S	Toa Nenryo	Kawasaki	2 35	1971
Oo	NaOH	SO <sub>2</sub> , H <sub>2</sub> SO <sub>4</sub>	Sumitomo Chiba Chem.	Chiba	1 212	1973
Mitsui Min. & Sm.	MgO	SO <sub>2</sub> , H <sub>2</sub> SO <sub>4</sub>	Mitsui Min. & Sm.	Hibi	2 47	1971
Onahama-Tsukishima	MgO	SO <sub>2</sub> , H <sub>2</sub> SO <sub>4</sub>	Onahama Smelt	Onahama	4 53	1972
Mitsubishi-IFP	NH <sub>3</sub> , OH	SO <sub>2</sub> , S	Maruzen Oil	Wakayama	4 24	1974
Dry process:						
Sumitomo S.M.	Carbon	SO <sub>2</sub> , H <sub>2</sub> SO <sub>4</sub>	Kansai Electric	Sakai	1 100	1971
Mitsubishi H.I.	MnOx, NH <sub>3</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Chubu Electric	Yokkaichi	1 193	1972
Hitachi Ltd.	Carbon	E <sub>2</sub> SO <sub>4</sub>	Tokyo Electric	Kashima	1 250	1972
Shell	CaCO <sub>3</sub>	Gypsum				
	CuO	SO <sub>2</sub> , S	Showa Y.S.	Yokkaichi	1 71	1973

- 1 Oil-burning boiler.  
 2 Claus furnace.  
 3 Sulfuric acid plant.  
 4 Smelting furnace.

TABLE 4.4.—MAJOR PLANTS FOR SO<sub>2</sub> REMOVAL (WASTE PRODUCT)

Process developer	Absorbent	Product	User	Plant site	Unit capacity (1,000 scfm)	Year of completion
Kurabo Ind.	Waste NaOH	Na <sub>2</sub> SO <sub>4</sub>	Kurabo Ind.	Hirakata	132	1970 <sup>1</sup>
Do.	NH <sub>3</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Mitsubishi Elec. Co.	Amagasaki	124	1971.
Do.	NH <sub>3</sub>	NH <sub>4</sub> SO <sub>4</sub>	Ishigasome Sarashi	Tokyo	114	1971
Do.	NaOH	Na <sub>2</sub> SO <sub>4</sub>	Bridgestone Tire	Tokyo, Nasu	171, 128	1972 <sup>2</sup>
Do.	NaOH	Na <sub>2</sub> SO <sub>4</sub>	Rengo	Ibaraki	130	1972
Do.	NaOH	Na <sub>2</sub> SO <sub>4</sub>	Kanzaki Paper	Amagasaki	124, 124	1972
Mitsubishi H.I.	NaOH	Na <sub>2</sub> SO <sub>3</sub>	Morinaga Milk	Tama	131	1972
Toyobo Co.	Waste NaOH	Na <sub>2</sub> SO <sub>3</sub>	Toyobo Co.	Moriguchi	126	1970
Do.		Na <sub>2</sub> SO <sub>3</sub>	do.	Shogawa	124	1971
Kawasaki H.I.	NaOH	Na <sub>2</sub> SO <sub>3</sub>	Sumitomo Rubber	Kobe	117	1972
Bahco-Tsukishima	NaOH	Na <sub>2</sub> SO <sub>3</sub>	City of Tokyo	Odai	110	1972
Ishikawajima-TCA	NaOH	Na <sub>2</sub> SO <sub>4</sub>	Hokushin Goban	Osaka	126	1971
Do.	NaOH	Na <sub>2</sub> SO <sub>4</sub>	Eidai Sangyo	do.	124	1972
Do.	NaOH	Na <sub>2</sub> SO <sub>4</sub>	Nissan Motor	Oppama	167	1972
Chemico Mitsui	Ca(OH) <sub>2</sub>	CaSO <sub>3</sub>	Mitsui Aluminum	Omuta	226	1972

<sup>1</sup> Oil-fired boiler.<sup>2</sup> Burning of sludge from sewage treatment plants.<sup>3</sup> Coal-fired boiler.

TABLE 4.5.—FLUE GAS DESULFURIZATION PLANTS OF MAJOR POWER COMPANIES TO BE COMPLETED IN 1973 AND 1974 (OIL-FIRED BOILER)

Power company	Plant site	Capacity (megawatts)	Process developer	Absorbent	Product
Tokyo Electric	Yokosuka	130	Mitsubishi-JECCO	CaCO <sub>3</sub>	Gypsum.
Tohoku Electric	Hachinoe	125	do.	Ca(OH) <sub>2</sub>	Oo.
Do.	Shinsendai	150	Kureha-Kawasaki	NaOH, CaCO <sub>3</sub>	Oo.
Chubu Electric	Nishinagoya	220	Wellman-Lord (MKK)	NaOH	SO <sub>2</sub> , H <sub>2</sub> SO <sub>4</sub> .
Kansai Electric	Amagasaki	125	Mitsubishi-JECCO	Ca(OH) <sub>2</sub>	Gypsum.
Do.	Kainan	150	do.	Ca(OH) <sub>2</sub>	Do.
Chugoku Electric	Mizushima	100	Babcock-Hitachi	CaCO <sub>3</sub>	Do.
Shikoku Electric	Shintokushima	150	Kureha-Kawasaki	NaOH, CaCO <sub>3</sub>	Do.
Hokuriku Electric	Shinminato	250	Chiyo-da	H <sub>2</sub> SO <sub>4</sub> , CaCO <sub>3</sub>	Oo.

TABLE 4-6.—MAJOR PILOT PLANTS FOR SO<sub>2</sub> RECOVERY

Process developer	Absorbent	Product	Plant site	Unit capacity (scfm)
<b>Wet process:</b>				
Grillo-Mitsui S.B.	MgO, MnO	SO <sub>2</sub> , H <sub>2</sub> SO <sub>4</sub>	Chiba	710
Kawasaki H.I.	Ca(OH) <sub>2</sub>	Gypsum	Kakogawa	2,900
Mitsui M.B.-Chemico	CaCO <sub>3</sub>	do.	Omuta	1,200
Hitachi S.B.	NaClO, CaCO <sub>3</sub>	do.	Maizuru	290
Kureha-Kawasaki	NaOH, CaCO <sub>3</sub>	do.	Nishiki	2,900
Showa Oenko	NaOH, CaCO <sub>3</sub>	do.	Kawasaki	5,900
Babcock-Hitachi	CaCO <sub>3</sub>	do.	Kure	1,800
Kurashiki Boseki	NH <sub>3</sub> , Ca(OH) <sub>2</sub>	do.	Hirakata	5,900
Furukawa Mining	NH <sub>3</sub> , Ca(OH) <sub>2</sub>	do.	Osaka	350
Hitachi, Ltd.	NaOH, Ca(OH) <sub>2</sub>	do.	do.	880
Nippon Kokan	Ca(OH) <sub>2</sub>	do.	Koyasu	1,200
<b>Dry process:</b>				
National R.f.P.R.	NaCO <sub>3</sub>	SO <sub>2</sub> , S	Kawaguchi	120
Sumitomo S.M.	Carbon	H <sub>2</sub> SO <sub>4</sub>	do.	5,900

Mr. ROGERS. Do you know the reason why theirs seem to be successful and ours is not successful?

Mr. QUARLES. That system was designed by an American firm and was utilizing technology which is certainly available for us in this country.

Mr. ROGERS. I think it would be well to set that forth in a rather detailed fashion so that industry can benefit from the information. Also, could you let us know where the ongoing demonstration projects are being conducted?

Mr. QUARLES. In this country?

Mr. ROGERS. Yes.

[The following information was received for the record:]

#### STATUS OF U.S. EFFORT

The attached portions of the report entitled, "Present Status of Coal Fired Steam Electric Power Plant Sulfur Dioxide Control" (Appendix C<sup>1</sup>) describes the essential features of various sulfur dioxide control systems operating or under construction in the U.S. In addition two tables are included which summarize present and planned facilities using alkali scrubbing techniques for sulfur dioxide removal.

Mr. QUARLES. Yes, sir, I will. There are I believe in addition to the demonstration projects, a number of others. There are roughly 33 stack gas removal systems which either have been constructed in this country or are currently in construction. So there certainly is at this point in time a major beginning in this country of the application of this technology. But the extensive application of this technology remains one of the most serious concerns that we have in the entire area.

Mr. ROGERS. When you use this technology does this permit the burning of high sulfur coal?

Mr. QUARLES. Yes. That is exactly the purpose. Obviously the concern that we have in the relationship between the Clean Air Act problems of environmental protection and the energy supply problems is the fact that so much of our energy supply come with sulfur included in either the coal or oil. If it is possible to remove the sulfur then there is no longer any problem in achieving a Clean Air Act requirement. There is technology available to do this.

Mr. ROGERS. Thank you.

Mr. QUARLES. A second major technology consideration under the Clean Air Act relates to the control of automobile-related pollutants. Three of the six ambient air quality standards, carbon monoxide, hydrocarbons, and nitrogen dioxide, cover pollutants directly emitted by the Nation's cars and a fourth, photochemical oxidants, results from the interaction of two of the emitted pollutants in the atmosphere. In fact, the importance of hydrocarbons as pollutants relates solely to their role in oxidant formation. The achievement of ambient air quality standards for the automotive-related pollutants is largely dependent upon our ability to control or otherwise restrict their emissions from mobile pollution sources. This involves a two-pronged effort (1) control of emissions from the vehicles themselves, and (2) reductions in the total emissions through concern with the number of vehicle miles traveled in severely polluted metropolitan areas. Let me first address myself to the automobile emissions standards themselves.

<sup>1</sup> Appendix C may be found in the committee files.

The Clean Air Act mandated a reduction of 90 percent in hydrocarbons and carbon monoxide from those in effect in 1970. Of course at that time about half of the pollutants were being controlled. So in a total sense this would represent about 95 to 96 percent reduction requirement. Also the Clean Air Act required a 90-percent reduction in nitrogen oxides emissions as measured from 1971 model year light-duty motor vehicles. The hydrocarbon monoxide reductions were to be achieved by 1975 model year cars and the nitrogen oxides by 1976.

The Administrator of the Environmental Protection Agency was authorized to grant a 1-year suspension of the appropriate standards in each case. Former Administrator Ruckelshaus did act to grant the 1-year suspension of the hydrocarbon and carbon monoxide standards in the spring of this year setting interim standards more stringent than those now in effect, and last month Acting Administrator Fri similarly granted a 1-year suspension for nitrogen oxides.

The reductions of 90 percent in hydrocarbon and carbon monoxide emissions are clearly technologically feasible. However, their achievement will require, in most cases, the use of an oxidation catalyst. In the opinion of the Agency, and one in which I concur, it was unwise to mandate this technology nationwide in the course of 1 year's model change. Consequently, interim standards were proposed which will require catalysts for new cars sold in the State of California and to a limited extent on some models in national distribution. Under the law the more stringent original requirements will become effective in 1976 and I do not think they should be further extended at this time.

There are two reasons why I think this is the case that these standards should not be extended. First, the present analysis shows that we will fail to meet the ambient air quality standards for carbon monoxide or oxidant in 1975, as the statute require in 29 air quality control regions. Some 43 percent of the Nation's population reside in these areas. Additional control beyond the Federal new car standards are required in these areas, but a relaxation of new car emissions requirements beyond 1976 will create the need for further transportation system changes in urban areas. It would have the practical effect of shifting the nature of the problem of automotive pollutant control from Detroit, where there are both the resources and the technical expertise, to the consumer. To the extent that these other requirements prove infeasible, a higher degree of risk must be borne by those most susceptible to air pollution effects if standards other than those presently required by the act come into effect. We would oppose such changes.

Second, the imposition of air pollution restrictions on new cars since 1968 has been associated with an average fuel penalty estimated to be in the neighborhood of 10 percent. It is worthy of note here that there has been an actual improvement in the fuel economy of small cars over this time period, whereas fuel penalties as high as 30 percent have been observed in large, over 3,500-pound automobiles. The use of catalyst technology although involving a somewhat higher original cost can be expected to redress favorably some of the fuel penalty associated with current engine modifications.

Although I believe that the legislatively mandated motor vehicle standards for hydrocarbons and carbon monoxide should remain as

promulgated, I cannot make the same case with respect to nitrogen oxides. When Congress acted to pass the 1970 Clean Air Act Amendments, and when EPA promulgated its ambient air quality standards for nitrogen dioxide, we were of the opinion that the air in a sizable number of cities throughout the country exceeded levels which constituted a threat to public health. Since that time, we discovered a major error in the measurement methodology used to determine nitrogen dioxide levels in the ambient air.

In other words, the air is not as dirty as we had thought it was.

Whereas we originally thought that some 47 areas were in violation of the standards, we now believe that there are only two, Los Angeles and Chicago; and of these, we expect that Chicago will meet the air quality requirements through controls other than the 90-percent reduction in nitrogen oxides emissions from light duty motor vehicles, which leaves only Los Angeles as a problem area.

Mr. ROGERS. This is as far as nitrogen oxides only?

Mr. QUARLES. Yes, sir. In formulating our position on the motor vehicle standards, we have projected the growth in nitrogen oxides emissions under a variety of automotive control assumptions and have concluded that given a continuation of the interim standards set by Mr. Fri of 2 grams per mile, that no region in the country, except Los Angeles, will fail to maintain an air quality level better than the standard through the year 1990. Los Angeles, however, will not meet the standard in any year even if the 90-percent reduction standard of 0.41 grams/mile were attained. In short, as EPA has stated publicly on a number of previous occasions, from an air quality point of view, the degree of stringency associated with the 90-percent reduction is just not required.

Second, in terms of technology, we do not believe that a standard much below the 2 grams per mile interim standard is feasible at the present time. The achievement of a reduction to 1.5 grams/mile may require excessive exhaust gas recirculation which would unduly increase fuel penalties. The achievement of levels of 1 gram/mile and below would require the installation of a reducing catalyst which has not yet been demonstrated as being technically feasible.

The last major issue involved in the Clean Air Act that I want to mention today involves transportation controls and land use. The Clean Air Act clearly contemplated that technology might not be adequate to provide for the achievement of ambient air quality standards and mandated that the States and the Administrator of the Environmental Protection Agency apply such other emissions reduction devices, including transportation controls and land use, as may be necessary.

The act is quite explicit in this regard. In section 110(a)(2)(B), the Administrator is authorized to approve a State implementation plan to achieve air quality standards only if it provides for "such measures as may be necessary to assure attainment and maintenance of such primary or secondary standard including, but not limited to, land use and transportation controls." If the plans do not contain such provisions, the Administrator must promulgate appropriate regulations.

As I previously mentioned, there are some 29 areas of the country in which some degree of control more stringent than that provided by

the Federal new-car automotive standards is required to meet ambient air quality standards in the 1975-77 time phase. These additional requirements include inspection and maintenance for new cars, varying degrees of retrofit on older cars, major transit system improvements, and a variety of other measures calculated to reduce the number of vehicle miles traveled within a metropolitan area.

Those of us who were exposed to the continued high pollution levels in Washington, D.C., during the pre-Labor Day period—and I think there have been six or seven pollution alerts in this city involving 22 days when the levels of pollution exceeded the warning level—can only acknowledge the reality of automotive-related air pollution and be increasingly convinced of the necessity of doing something about it as rapidly as possible. Here, I think, we have not only the specific protection we need to provide to the persons most susceptible to the harmful effects of air pollution, but a larger quality of life consideration which is important to all who reside in the major metropolitan areas of this country. Must our cities become increasingly uninhabitable, or can we take meaningful and productive steps to restore to our urban environment some of the quality that made them a vibrant and driving force in the life of America? In feudal society, the city was looked upon as a place of liberation—city air meant free air. In modern America, city air has come to mean polluted air and the city entrapment not liberation. I think we must redress this situation; the time is now. The health and well-being of a large segment of the American population are at stake.

However, when we proposed the transportation control requirements needed to meet ambient air quality standards in the 1975-77 time frame set forth in the act, we were forced to propose some requirements that were clearly unreasonable. For example, gas rationing calculated to reduce automobile travel by more than 50 percent would be clearly disruptive of a city's economic and social life. In 14 of the 29 areas, the amount of reduction estimated in 1977 in vehicle miles traveled was in excess of 20 percent. Such reductions appear to me unreasonable and even in the six other areas where a reasonable VMT reduction is contemplated, such change cannot occur in the absence of significant improvements in mass transit systems. Some transportation plans submitted by the States are truly exemplary. For example, in New York City where there has been a clear realization of the magnitude of their air quality problems, constructive and workable proposals have been developed. New York City's solutions, however, are not necessarily applicable to all of the Nation's problem areas. Each has unique problems and each has reasonable options. We should settle on no less than the adoption of the most reasonable approach in such area where some transportation system change is required. The opening up of the highway trust fund provides greater flexibility to local officials to make some improvements, but, of course, we know that is only a start.

I think we have here a situation in which the direction that we are forced under the act is the right direction, but the time required is just greater than the act in its present form allow us. What we needed is some degree of flexibility in the attainment dates of the automobile pollutant-related ambient air quality standard but the retention of a

system which maintains pressure on government at all levels to improve our urban situation and reduce the level of risk of health impairment which now characterizes our urban environment.

Before concluding, let me mention one other far-reaching aspect of the Clean Air Act with respect to land use controls. As you know, the courts have ruled that State implementation plans must provide for the prevention of significant deterioration where the air is now already cleaner than required by our Clean Air Act standards. Since the legislative history of the Clean Air Act is silent as to a definition of "significant deterioration" and the court's decision did not provide further guidance EPA has proposed four alternative approaches to the issue. Included in all of them is the requirement that any new source locating in a clean area adopt best technology. This is related to the basic provision in the statute for new source requirement.

However, there are problems involved in defining other constraints either in relationship to increase in total allocable emissions or the air quality increments which may be permitted.

There is clearly a need in some areas of the country for resource development and growth just as there is a need for areas to retain their pristine air environment in as pure a state as is practicably possible. It is the balancing of these needs which must be accommodated.

We are strongly of the opinion that the Clean Air Act was not intended to foreclose orderly growth and development. The proposals we have made encompass a range of possibilities from fairly arbitrary limits applicable nationwide to State options as to the degree of deterioration to be permitted. Since we are still in the public comment, public hearing phase of these proposals, I will withhold any recommendations for legislative change in this regard at this time.

In summary, let me restate that I think the Clean Air Act is both important and generally workable. Its provisions afforded major protection to our environment. At the same time, in general, it provides the requisite degree of flexibility to accommodate other major social concerns. As we have stated on prior occasions, some amendments in the act are indicated with respect to time schedules and the nitrogen oxide automobile standard, and I have presented my thoughts on these in the course of my remarks this morning. Further, EPA has continued and will continue to brief this committee and the Senate committee on any problem areas we are encountering in administering the provisions of the act and we will inform you if, in our judgment, they require legislative resolution.

Mr. Chairman, that is a long statement. I wonder if I might add just a brief personal comment which perhaps could add a little further perspective on this issue.

I have dealt directly and deliberately with the problem areas as they have become known and have been debated in the country in the course of our implementation of the Clean Air Act. The act is bold, it is strong, it is far-reaching, it is comprehensive, it has many different types of requirements in it. But I think that there are several themes which run throughout which are important to bear in mind. One is the theme that action is required to clean up air pollution. It is obvious that throughout every provision of the Clean Air Act there is reflected a determination by Congress that a massive sustained national effort

is required to bring relief from conditions of air pollution which blight the American landscape and threaten the health of citizens throughout the country.

The second theme which I find continuously is that in the implementation of this massive national effort decisions would be required to be made on the basis of the best information available. To state this in another way, the entire approach in many instances has been that pollution control perhaps should not be undertaken until the damage could be clearly demonstrated, the degree of control documented, the ability of achieving the obvious, and only then could something be done.

I think this is in the Clean Air Act, a general philosophy, if you will, that faced with the uncertainty of overcontrol and excessive expense, on the one hand, or undercontrol and damage to health on the other, the decision should not automatically be made against the health consideration and in favor of saving the money because all of the facts are not known. Therefore, strict time schedules have been set in the act that do require decisions to be made within the very near future. We have gone ahead I think in all of our implementing action with reference to both of these philosophical principles.

I think wholly consistent with that is a recognition that we must not try to resolve specific problems purely on the basis of this type of philosophy or doctrine, that we have to look at the realities of implementing actual requirements in specific cases. We have to ask what is the benefit to air quality and the protection of health from a given requirement, what is the cost, what is the feasibility, what are the other implications?

Then after getting all of this information from our staff of scientists, economists and others we may ask the basic question in the light of the circumstances and in reference to the underlying principles, does the particular requirement make sense.

I think we have been under an obligation to inject commonsense in all decisions and to let you know if in our judgment some of the requirements in the end don't make commonsense. In this testimony I have focused on a couple of the areas where we have real difficulty. But I would like to emphasize a point made by Mr. Train that it is important to keep the perspective on the full breadth and complexity of this statute. We have been required under the statute to issue regulations setting forth ambient air quality standards, implementation plans, hazardous emission standards, new source performance standards, aircraft emission standards, automotive emission standards, fuel and fuel additive limitations, and a host of other related miscellaneous standards, and requirements to carry out this act.

We are dealing with 50,000 to 60,000 individual point sources each emitting more than 100 tons of pollutants a year. For the wide range of cases, what has happened under this Clean Air Act is that standards have been set and abatement programs have been established which are working. Hence, the Clean Air Act has achieved the results of getting this country moving in a very urgent way toward clearing up the air pollution problem.

We feel, I do as a citizen, and as a father, and I think, the public does, that we should commend you, Mr. Chairman, this committee,

and the Senate committee, for having the foresight and the courage to propose that the Congress enact legislation as bold and as strong and as innovative and as comprehensive as the Clean Air Act.

As we talk about some of these problem areas we must make sure to propose any resolution of them in a manner that does not break the momentum that has been established under this act. This is the perspective that we have, I am sure it is the perspective that you have, and I hope it will be a perspective reserved by all who are discussing these problems.

I thank the chairman. I will be delighted to try to answer any questions you and the other members of the committee may have.

Mr. ROGERS. Thank you very much, Mr. Quarles, for giving us a summary of the problems, the conditions, what has happened to the Clean Air Act. I think it is encouraging that you believe that we have made significant progress in cleaning up the air already in the short period of a year.

I see we have a call to the House. I think we will try to come back at 2. Let me just ask a couple of questions right now, and then we will all have further questions this afternoon.

Are you aware of the action taken by the American Medical Association House of Delegates in June 1973, this year, their resolution 61, where they resolved as follows:

*Resolved*, That the American Medical Association endorse present levels and time schedules as promulgated by the Clean Air Act of 1970; And be it further

*Resolved*, That the American Medical Association encourages Congress to preserve levels and time schedules as necessary public health measures.

Are you aware of that, and is the agency aware of that?

Mr. QUARLES. Yes, sir.

Mr. ROGERS. Has any discussion been conducted with the American Medical Association as to its feelings on any proposed changes or modifications that might be contemplated, which you anticipate doing?

Mr. QUARLES. I have not certainly been involved in such discussions. I think we look to the American Medical Association as one of the foremost sources of authority in this country on the medical need for the levels of control required by the ambient air quality standards. I believe that that position coincides generally with the positions of other experts as to the health needs of the standards that we have promulgated.

Mr. ROGERS. I would hope that you would have some liaison and let this committee be aware of any.

Mr. QUARLES. I am sure we will have that liaison and we will make plans to make you aware of it.

Mr. ROGERS. I understand, too—and this will be my only other question at this time—that a Dr. Carl M. Shy, who is an acting director of the Human Studies Laboratory Division at the Research Triangle in North Carolina, did a study and came to the conclusion that definite increases in death occurred from exposures to pollutants below the levels specified for sulfur oxides and particulate matter. He said the data on which this statement is based were recently obtained from 5 years of observation on daily mortality in the New York metropolitan area and were carefully adjusted for other major influences

on daily mortality, including season, temperature extremes, and influenza epidemics. The results are striking and raise some crucial policy as well as scientific issues.

First, he says we observed increased deaths at levels even below existing national primary short-term 24-hour standards.

Then he goes into a discussion that he has evidence that suspended sulfates rather than  $\text{SO}_2$  of total particulate matter is the most reactive or toxic component of the atmospheric exposure to sulfur oxides.

He states that they have found it not only in certain areas but it is becoming quite widespread. He suggests that we must have immediate scientific knowledge for making judgments on this.

I wonder if you would comment on those statements.

Mr. QUARLES. Yes, sir, I will be glad to. I am not a scientist. As you know, I am a lawyer and I don't have the scientific understanding of the biological processes through which these mechanisms work. But from the viewpoint of administering the programs I can say that as we have continued to make scientific analyses of the effects on human health from exposure to various levels of sulfur oxides, the various bits of evidence that we receive, do support the standards that have been established and suggest that if there is an area of doubt as to where the standards should be set, that one would tend to look toward a more stringent standard rather than a less stringent standard.

We have not yet reached a point where we believe that analysis of all of the information that we have suggest the desirability of revising our existing standards but we do have—I guess I could say—renewed confidence in the need for achieving the degree of control which is called for by those standards.

We have also made arrangements with the Department of HEW and others, both in and out of the Government, to be reviewing the evidence which we have reviewed and we are constantly evaluating and reevaluating our standards, but we have the position on them that I just indicated.

Now, with regard to sulfates, this is an area in which I have been briefed, it is increasingly being recognized as a significant area requiring intensive study and evaluation. There does appear to be perhaps greater indication that we had a couple of years ago as to the severity of health effects associated with sulfates in the air, and we are continuing to make greater studies of these facts.

Mr. ROGERS. Who is doing the study on those points?

Mr. QUARLES. I might turn to Dr. Greenfield or Dr. Finklea, first to Dr. Greenfield and ask if he would like to go further into this.

Dr. GREENFIELD. First, Mr. Chairman, let me start by going back to the question you raised with Mr. Quarles earlier on the contact with AMA. Our people together with at least one member of CEQ has met with the AMA Environmental Council on a regular basis over the past 2 years. There is constantly contact going on with the environmental people in the AMA which exposes them to the result of our studies and requests their comments.

Second, on the question of—

Mr. ROGERS. You might put some of those in the record.

Dr. GREENFIELD. We will, indeed, Mr. Chairman.

[The following information was received for the record:]

## EPA/AMA RELATIONSHIP

Since its establishment, the Environmental Protection Agency has maintained a close professional liaison with the American Medical Association. Our scientists have made briefings and presentations to regional and national meetings of the American Medical Association's Council on Environmental, Occupational and Public Health. Our Agency has also provided financial support and scientific inputs for the biennial Air Pollution Medical Research Council sponsored by the American Medical Association. We believe that EPA should continue its liaison and further strengthen its tie with interested professional societies like the American Medical Association and the American Public Health Association. Our Agency will also assure that these health professionals have an adequate opportunity to apply their considerable expertise to the environmental health problems which face our medium. Our Administrator will look to the health professions for counsel as he moves to establish his Health Advisory Panel. Our Agency is most grateful for the support already given by the American Medical Association.

Dr. GREENFIELD. Second, on the question of the health standards, we are continuously attempting to update our standards. There is a program that the chairman may be aware of, called the community health environmental surveillance system, under Dr. Finklea conducted out of the Research Triangle Environmental Health Research Center, whose purpose is in 33 communities around the country with over a quarter of a million people to constantly look at and examine the impact of pollutants on health.

The information that you quoted from Dr. Shy is part of this study. As a result of this study and others, we have a schedule laid out in front of us as to a continuous looking at and evaluation and possibly updating of our standards so that on a rather rigorous schedule we are examining the impact and improving our health data with the full realization that if the need ever appears to arise where standards should be changed, we will take action immediately.

I should ask Dr. Finklea possibly to expand on this, if he cares to.

Dr. FINKLEA. Mr. Chairman, with your permission I would cover that general topic along with other topics relating to the short-term effects of ambient air pollutants in the briefing on the primary ambient air quality standards. We do have a summary of the sulfates, the research work on acid aerosols and sulfates that the agency has underway, which we will be glad to submit for the committee's consideration.

Mr. ROGERS. When will the briefing on ambient air quality standards be done?

Dr. FINKLEA. It is my understanding that the Agency will provide a briefing on the primary air ambient quality standards either in your session this morning or your session this afternoon, sir.

Mr. ROGERS. Let me ask you this: I know you have competent scientists, but do you have the National Academy of Sciences looking at this sulfate problem?

Dr. FINKLEA. Yes, sir, the National Academy of Sciences as a group examines the toxicological effects of air pollution. One of the panels in this group is looking at the adverse health effects that are caused by fine particulate pollutants including the sulfate portion of the fine particulate pollutant. Their report will be finished in about another 6 or 9 months.

The Agency has an accomplishment plan for the control of fine particulate pollutants including the sulfates that Dr. Steigerwald and his

group are responsible for. We are moving as fast as one prudently can toward acquiring the information necessary for the control of this group of pollutants, sir.

Mr. ROGERS. I think we would be interested to get a discussion in the record or a memo on just what the National Academy of Science is doing for you. For example, the time frame when this is due and who in the scientific group is actually doing the study.

[Testimony resumes on p. 43.]

[The following information was received for the record:]

#### NAS STUDY

The Agency has previously provided the subcommittee a draft copy of its position paper dealing with suspended particulate sulfates and sulfuric acid aerosols. The summary and conclusions sections from this report are attached. Our scientists have also responded to written queries from the Subcommittee on this matter. Briefly stated, our Agency believes that acid aerosols and fine particulates, including fine particulate sulfates, are causally associated with adverse effects on human health. Our scientists have testified that it is their best judgment that the threshold for adverse health effects following short-term exposures (24 hours) is quite low, 8 to 10  $\mu\text{g}/\text{m}^3$ . It is also likely that long-term exposures to elevated levels of acid aerosols and fine particulates including suspended particulate sulfates will be associated with an increase frequency of adverse health effects. Since acid aerosols and an important proportion of fine particulates (including suspended particulate sulfates and nitrates) are generated from gaseous pollutants in ambient air, there are formidable only partially solved technical problems associated with measurements, monitoring, atmospheric chemistry, effects studies, exposure modelling and control technology. EPA is moving as rapidly as possible to acquire the technical information needed to understand these problems. Armed with this information our Agency will choose the most effective control options to protect the health of the American people. The control of fine particulates will require several years of intense effort. EPA has also furnished the Subcommittee an up-to-date appraisal of acid aerosols and suspended sulfates emitted from mobile sources.

EPA has asked the National Academy of Sciences through its Committee on the Biologic Effects of Atmospheric Pollutants to prepare background documents on a series of pollutants including fine particulates. Members of the panel which is reviewing fine particulates (including suspended sulfates) are as follows:

Ian T. T. Higgins, M.D. Chairman, School of Public Health, University of Michigan.

Roy E. Albert, M.D., New York University Medical Center.

Robert J. Charlson, Ph. D., Department of Civil Engineering, University of Washington.

Benjamin G. Ferris, M.D., School of Public Health, Harvard University.

Robert Frank, M.D., School of Public Health, University of Washington.

Paul E. Morrow, M.D., School of Medicine and Dentistry, University of Rochester.

Kenneth T. Whitley, Ph. D., Department of Mechanical Engineering, University of Minnesota.

This panel is scheduled to furnish EPA a draft report in the Spring of 1974 and a final report in the Summer of 1974. The scope of work for the applicable EPA-NAS contract and a status report on the pollutants being considered is also attached. EPA has also summarized its current research related to sulfates and this is also attached for the Committee's consideration.

#### POSITION PAPER ON SUSPENDED SULFATES AND SULFURIC ACID AEROSOLS

##### SUMMARY

Progress is being made in our efforts to control  $\text{SO}_2$  emissions into the atmosphere. However, there is now evidence suggesting that sulfuric acid aerosols and some sulfates may be more potent irritants than  $\text{SO}_2$ . Should this prove to be true, our control strategy should be examined with a view toward the need for sulfate criteria. However, it should be emphasized that sulfates found

in the ambient atmosphere have not been well characterized. A working definition, for the purpose of this document is—material collected on a glass fiber filter over a 24-hour period, and analyzed as water soluble sulfate. Specific sulfates are not identified.

Based upon theoretical considerations, the primary urban sources of sulfate is the atmospheric oxidation of  $\text{SO}_2$  to  $\text{H}_2\text{SO}_4$ , with subsequent neutralization or exchange reactions giving a variety of sulfates. Few data are available on the sulfate content emitted directly from stationary sources. Sulfate from mobile sources has not been considered significant due to the low sulfur content of refined fuels. Approximately 95 to 98% of these emissions are in the form of  $\text{SO}_2$ . The remaining few percent is primarily  $\text{SO}_2$  which is rapidly converted to sulfur acid.

The chemical mechanisms for converting  $\text{SO}_2$  to  $\text{H}_2\text{SO}_4$  in the atmosphere are not well known. Two current hypotheses are: 1) catalytic oxidation, and 2) chemical oxidation by photochemically generated reactants.

The principal mechanisms for removal of sulfur from the atmosphere are precipitation, and deposition on soil and vegetation. Essentially all of the  $\text{SO}_2$  in the atmosphere is converted to XSO, prior to or during the removal processes. Estimates of residence times range from approximately one day to one week. Therefore, the effects of sulfur loading in the atmosphere by man's activities may be significant several hundred miles from the source regions.

There is a substantial volume of aerometric data on water soluble sulfates, but little on sulfur acid or individual sulfate compounds. In 1970 the national average sulfate concentration at urban locations was  $10.1 \mu\text{g}/\text{m}^3$ . The 24-hour maximum observed was  $197 \mu\text{g}/\text{m}^3$ . The non-urban average was  $6.3 \mu\text{g}/\text{m}^3$ . A slight seasonal variation was observed at non-urban sites. No marked long-term trend has been observed in the United States, despite the decrease in  $\text{SO}_2$ . Available data indicate that essentially all of the sulfate particles in the free atmosphere are in the respirable size range.

Most available data have been collected using either impaction or filtration techniques. Measured values of size and number density are not obtained. Total sulfate concentrations have been determined largely by colorimetry, and the acidity by colorimetry or pH techniques. There is a question concerning the sample integrity using these sampling techniques. A suitable method for measuring sulfuric acid in the atmosphere is not available.

Experimental biological studies have indicated that certain of the particulate sulfates have a greater biological effect than  $\text{SO}_2$ . It has been demonstrated that sodium chloride in an atmosphere of  $\text{SO}_2$ , and high relative humidity, enhances the biological response. Large differences have been found in the degree of biological activity among the various sulfate compounds, and as a function of particle size. However, there are serious gaps in the toxicological information concerning sulfates. Most of the experiments, performed by one laboratory using the guinea pig, have been concerned with the effect of acute exposure on pulmonary function. There is a paucity of information concerning the role of sulfates (or even  $\text{SO}_2$ ) in the production of chronic pulmonary disease. The relevance of the toxicological studies conducted to date to ambient pollutants atmospheres is questionable.

Recent CHES program studies indicate that adverse health effects may be more closely associated with suspended sulfate than with  $\text{SO}_2$  or total suspended particulates. The CHES investigators felt there was substantial evidence that the levels of sulfate necessary to cause adverse health effects were one to two orders of magnitude lower than with  $\text{SO}_2$  or total suspended particulate. Laboratory studies have shown that sulfuric acid and some metallic sulfates are more potent irritants than  $\text{SO}_2$ . More information is needed on the irritating effects relative to specific sulfates and various mixtures found in polluted air, and the relationship with temperature, particle size and relative humidity.

Acid rain may adversely effect the pH of soil and fresh water lakes, and hence the ecology at great distances from emission sources. However, under certain conditions, the acid rain may be beneficial. Acid rain also results in the leaching of mineral nutrients from plant surfaces. The sulfate ion is considered to be the form which is toxic to plants.  $\text{SO}_2$  entering through the stomata is converted to  $\text{SO}_3$  and  $\text{SO}_4$ .  $\text{SO}_2$  absorbed by the leaves may be converted to  $\text{H}_2\text{SO}_4$  with consequent damage.

Sulfates accelerate the degradation of certain materials. Rates of deterioration have not been determined.

The impact of sulfates on weather, visibility and climate evolves from their chemical and physical properties. Atmospheric sulfate (and other) particles influence the heat budget, visibility, and cloud and precipitation processes. They play a role in the development and intensity of the so-called heat island. Particle size and number density are the important parameters. Significant effects are known but quantitative data are not available to characterize the problem.

Although there are many uncertainties concerning the total sulfur cycle in general and sulfates in the atmosphere in particular, some conclusions can be drawn: (1) Sulfuric acids and sulfates are known to exist in the atmosphere in sufficient concentrations can have a deleterious effect upon human health and welfare. Certain of these compounds appear to be more potent irritants than  $\text{SO}_2$ . The irritants response of certain mixtures is probably greater than the sum of the responses of the individual compounds, and is related to the size and number density of the sulfates; (2) Sulfates present in the atmosphere may have an adverse effect upon the weather, climate, and visibility; (3) Removal by atmospheric processes may result in adverse ecological effects at large distances from sources; (4) Sulfates exist in the atmosphere as a result of natural processes; however, the concentration is significantly influenced by anthropogenic activities; (5) Current knowledge and available data are inadequate at this time to establish criteria which might be used as a basis for standards for control.

It is recommended that particular attention be devoted to the problem of sulfuric acid and sulfates in the atmosphere in order that the question of pollutant potential from anthropogenic sources might be resolved. Study areas should include: (1) the relationship between adverse health and welfare effects and sulfates in the atmosphere as a function of particle size, number density, temperature, humidity, pressure, and chemical composition; (2) the biological effects of sulfates using a variety of specimens in realistic dynamic atmospheres as related to the variables listed in (1); (3) principal mechanisms, or reactions, and rates for conversion of  $\text{SO}_2$  and  $\text{H}_2\text{S}$  to sulfuric acid and sulfates in the atmosphere; (4) suitable techniques for routine sampling and measurement of sulfuric acid,  $\text{H}_2\text{S}$ , and specific sulfates in the atmosphere, including size distribution and number density, and implementation of an adequate monitoring program; and (5) potential technology to achieve an adequate reduction in sulfur emissions from point sources. A balanced research and development program well coordinated in time and substance will be required. A summary of the recommended research and development programs follows. Detailed tasks are included in Section VII. No attempt has been made to structure the research program in terms of priority of tasks. It is not envisioned that it would be necessary to implement such a broad program at a given starting date. The estimated time for completion applies to each given task. Sequential scheduling would be desirable for at least a portion of the program. For example, the scope of the health effects program clearly would be dependent upon measurement capability and the characterization of sulfates in the atmosphere.

<i>Research program</i>	<i>Time period for completion (years)</i>
1. Modification and expansion of health effects research to include specifically sulfuric acid and suspended sulfates in the ambient atmosphere as related to acute and chronic diseases, and mortality -----	5-10
2. Conduct biological experiments to determine the ecological effects of atmospheric sulfates -----	5
3. Conduct studies to determine the rate and mechanisms for sulfuric acid and sulfate formation in urban atmospheres, and expansion of monitoring program to include sulfuric acid, ammonium sulfate, and other sulfates as feasible -----	3
4. Develop reliable field and laboratory methods for measuring acids and sulfates in the ambient atmosphere -----	3
5. Develop methods for measuring sulfate emissions from stationary sources and determine the characteristics of the sulfur emitted -----	2
6. Conduct a technology development program to achieve the required abatement of total $\text{SO}_2$ -----	2

## VII. CONCLUSIONS AND RECOMMENDATIONS

## A. Conclusions

There are still many uncertainties concerning the total sulfur cycles, and the effects of atmospheric sulfur species on human health and welfare. Particularly the role of suspended sulfates and sulfuric acid aerosols is not well known. There are reasons to suspect that control of  $\text{SO}_2$  may not result in a proportionate control of  $\text{SO}_4$ . However, a number of conclusions can be drawn from current knowledge and available data:

(1) Anthropogenic sources contribute approximately one half as much as nature to the total sulfur content in the atmosphere. The anthropogenic contribution from urban area sources is much greater than the natural sources. This ratio is increasing.

(2) Approximately 95% of the sulfur emitted to the atmosphere from urban sources is in the form of  $\text{SO}_2$ . The primary urban source of sulfate is the atmospheric oxidation of  $\text{SO}_2$  to  $\text{H}_2\text{SO}_4$  with subsequent neutralization of exchange reactions giving a variety of sulfates. Essentially all of the  $\text{SO}_2$  in the atmosphere is converted to  $\text{XSO}_4$  prior to or during the removal processes.

(3) The major portion of the sulfate particles in the atmosphere are in the respirable range.

(4) Sulfates can have a deleterious effect on human health and welfare, including the eco-system; (reliable threshold levels have not been established.) Sulfuric acids and certain sulfates are more potent irritants than  $\text{SO}_2$ .

(5) Current knowledge and available data are inadequate at this time to establish criteria which might be used as a basis for standards.

## B. Recommendations

There are critical gaps in our knowledge concerning the total sulfur cycle in general and of the acids and sulfates in particular. Little is known regarding the rates of conversion of  $\text{SO}_2$  and  $\text{H}_2\text{S}$  to sulfate particles in urban and non-urban atmospheres. Suitable means of distinguishing contributions by anthropogenic and biogenic sources to sulfates in the atmosphere are not available, and the nature and efficiency of removal processes are not well known. There is substantial evidence that sulfuric acid and sulfates may have more detrimental effects of human health and welfare than  $\text{SO}_2$ , however, there are serious gaps in our knowledge concerning the biological and ecological effects of these potential pollutants. There is a paucity of information concerning the role of sulfates in the production of chronic pulmonary diseases. Particle size and number density appear to be important parameters, and the effect of certain sulfates in combinations likely to be found in the ambient atmosphere may be greater than the sum of the individual effects—these aspects have not been studied extensively. Suspended sulfate may have a significant effect upon weather, visibility and climate but sufficient quantitative data are not available to characterize the problem. Suitable methods for measuring sulfuric acid and sulfates in the atmosphere are not available, and the integrity of much of the data collected to date is in question.

Solutions to these problems must be achieved before meaningful and rational decisions can be made concerning the need for control, the optimum control strategy to be employed should be need for control exist, and the nature of the program necessary for monitoring and enforcement.

To achieve the necessary level of knowledge and understanding will require a research and development effort well coordinated in time and substance. The problems are indeed multidisciplinary and milestone decisions may depend heavily upon the results obtained from the various approved tasks. Parallel efforts will be required and a certain element of risk must be accepted in initiating the long-term projects which may require controlling input from other program elements. For example, the success of the CHESS studies will depend heavily upon sampling and measurement capability and the collection of proper and reliable atmospheric data. The research task below constitutes the substance of the recommended research program.

Task	fn-house man-years	Time period for comple- tion (years)	Labor division contact
1. Conduct Community health and surveillance system (CHESS) study designed specifically to investigate the effects of sulfuric acid and suspended sulfates in the atmosphere on human health using 3 separate communities. (Cost \$200,000 per community per year.) The current CHESS studies in New York and Salt Lake Basin will be modified to include necessary new parameters.	60.0	5.0	OHER; J. G. French.
2. (a) Conduct biological experiments using dynamic atmosphere with gases and particulates similar to urban atmospheres for exposure of various species of animals, and other biological models to determine both direct effects and effects through interaction with other pollutants and infectious agents. Use acute, subacute, and chronic exposures to determine such factors as influence of particle size, specific sulfate, and various combinations on particle deposition, retention, translocation, pulmonary clearance rates, acceleration of infectious states, and various parameters related to pulmonary defense (coordinate with CHESS studies).	6.0	4.0	DHER; D. L. Coffin.
(b) Generation of sulfuric acid aerosols and sulfate aerosols for biological and health effects studies: Aerosols will be produced by chemical techniques which simulate their formation in the atmosphere. Particle size distribution and chemical composition will be monitored and adjusted to give the desired pulmonary dose.	3.0	4.0	DCP; W. E. Wilson.
3. Rate and mechanism of sulfuric acid and sulfate formation: Additional studies of the conversion of SO <sub>2</sub> to sulfuric acid in urban atmospheres are needed. Emphasis should be placed on the reactions of oxygenated radicals with SO <sub>2</sub> and catalytic reactions in or on aerosols. This information is required to determine if control of urban sulfate levels can be obtained by lowering SO <sub>2</sub> levels or if better control can be obtained by lowering oxidants or catalytic particulate matter.	-----	-----	-----
(a) Gas-phase reactions. ....	9.0	4.0	Oo.
(b) Gas-surface reactions. ....	12.0	4.0	Oo.
4. Formation of sulfate compounds: New studies are needed to determine the extent to which sulfuric acid may react with other particulate matter in the atmosphere to form sulfate compounds.	-----	4.0	Do.
5. Research measurements of specific compounds and particle size distribution: At a number of research sites, including CHESS sites, measurements of total-water-soluble sulfate should be expanded to include sulfuric acid, ammonium sulfate, and metallic sulfates. Measurements should include SO <sub>2</sub> for SO <sub>2</sub> to sulfate ratio data, particle size distribution (total particulates, total sulfate, and individual sulfates to the extent possible).	12.0	5.0	Do.
6. Effects of relative humidity on particle size: Studies to determine the rate of growth and particle size of sulfuric acid or sulfate particles exposed to high relative humidity should be expanded with emphasis on relative humidity conditions in the pulmonary tract.	-----	4.0	Oo.
7. Investigative sulfate emissions from stationary sources: The 1st major consideration which needs to be addressed is the question whether the sulfate is emitted from stationary sources in the gas phase as H <sub>2</sub> SO <sub>4</sub> vapor or in the particulate phase as sulfate. The measurement of the actual amount of H <sub>2</sub> SO <sub>4</sub> vapor present in source emissions will determine the ultimate control strategy required. The following R. & D. tasks are recommended.	-----	-----	DCP; J. Wagman.
(a) Develop an in situ H <sub>2</sub> SO <sub>4</sub> measurement method. ....	.25	.7	J. Wagman.
(b) Verify existing manual compliance test methods for SO <sub>2</sub> and H <sub>2</sub> SO <sub>4</sub> .	.25	1.0	Oo.
(c) Develop Raman scattering end/or fluorescence technique for analysis of particulate sulfate in situ.	.25	1.0	Oo.
(d) Conduct a study of particulate/filter/H <sub>2</sub> SO <sub>4</sub> /sulfate interactions, temperature dependence of sulfate conversion on probes and filters, verifications of true particulate sulfate (as distinct from condensible H <sub>2</sub> SO <sub>4</sub> ).	.25	1.0	Do.
8. Evaluate current laboratory analytical methods for H <sub>2</sub> SO <sub>4</sub> and sulfates.	-----	1.0	E. Sewlcki and E. Wittgenstein.
9. Develop a reliable method for total sulfate, and evaluate collection techniques for atmospheric sulfates in the presence of SO <sub>2</sub> and other critical pollutants.	-----	1.0	Do.
10. Develop a reliable ion-selective electrode for sulfate.	-----	1.0	Oo.
11. Develop a reliable collection method for H <sub>2</sub> SO <sub>4</sub> .	-----	1.0	Do.

Task	In-house man-years	Time period for completion (years)	Labor division contact
12. Determine the various type of sulfates and their relative proportions in the atmosphere. ....		1.0	Do.
13. (a) Characterize the various types of sulfur compounds in particulates in the atmosphere in urban and nonurban atmospheres. ....		1.0	Do.
(b) Determine to what extent manmade sulfates contribute to the acidity of precipitation. ....		3.0	L. Niemeyer.
14. Determine the sulfate and sulfuric acid composition relative to size and mass distribution. ....		1.0	E. Sawicki and E. Wittgenstein.
15. Collect additional urban and nonurban sulfate data including particle size and number density. ....		3.0	G. G. Aklund.
16. Conduct biological experiments to characterize the physiological and morphological responses of plants to sulfates and to relate these responses to growth and yield of plants. (To be conducted at the Corvallis NERC.)	4.0	5.0	H. A. Bond.
17. Conduct biological experiments to determine the effects of acid rainfall of plants, the soil and on microorganisms in the soil. To determine the changes which occur in the ecosystem due to acid rainfall and how these affect mineral cycling. (This project has already been submitted and has received funding for fiscal year 1973. There is need for further funding for fiscal year 1974.)	6.0	4.0	Do.
18. Develop prototypes for field methods for determining H <sub>2</sub> SO <sub>4</sub> :			
(a) Filter tape collection followed by heating and FPD or Xrf detection. ....	1.0	3.0	T. G. Dzuby and R. K. Stevens.
(b) NH <sub>3</sub> -cha nitrofluorescence. ....	1.0		Do.
(c) C <sup>14</sup> detection from carbonate-H <sub>2</sub> SO <sub>4</sub> reaction. ....	1.0	3.0	Do.
19. Develop method for analysis of sulfur groups:			
(a) Total sulfur by X-ray fluorescence. ....	1.0	2.0	Do.
(b) S <sup>-</sup> , SO <sub>3</sub> <sup>-</sup> , SO <sub>4</sub> <sup>-</sup> , by ESCA. ....	1.0	2.0	Do.
20. Initiate technology development program to achieve up to 99 percent removal of SO <sub>2</sub> emissions:			
(a) Evaluate and select options: Evaluate technology for high-efficiency gas cleaning (90 to 99 percent).	5.0	1.0	G. Foley.
(b) Clean fuels: Increase the impact of the existing clean fuels program.	3.0	5.0	Do.
(c) Source control—utilities:			
(1) Modify current gas cleaning demonstration to get 90 to 99 percent (these projects are 50-50 cost shared with private industry).	2.0	5.0	Do.
(2) Demonstrate new high-efficiency gas cleaning (currently under development) to increase the probability of success for achieving 99 percent removal and cut costs (cost shared 50-50 with private industry).	3.0	3.0	Do.
(d) Source control—industrial combustion: Develop and demonstrate flue gas cleaning for industrial combustion SO <sub>2</sub> sources, providing from 70 to 99 percent efficiency.	2.0	2.0	Do.
(e) Source control—industrial processes:			
(1) Identify and develop technology for control of industrial processes (up to 99 percent removal).	2.0	2.0	Do.
(2) Demonstrate industrial process technology (cost shared 50-50 with private industry).	2.0	2.0	Do.
(f) Source control—area sources: Develop and demonstrate package sorption techniques for SO <sub>2</sub> from area sources providing from 70 to 99 percent efficiency.	2.0	2.0	Do.

<sup>1</sup> Fiscal years 1975-76.

<sup>2</sup> Fiscal years 1975-78.

<sup>3</sup> Fiscal years 1976-78.

<sup>4</sup> Fiscal years 1976-79.

<sup>5</sup> Fiscal years 1975-77.

<sup>6</sup> Fiscal years 1977-79.

## NERC/RTP

### SUMMARY OF FY-74 RESEARCH RELATED TO SULFATES

The following briefly outlines the FY-74 sulfate research at RTP. In major areas, like CHESS and atmospheric chemistry, it is not possible to separate sulfate work from other closely related work. In these cases, the resources given include substantially more than sulfate related work.

The FY-75, FY-76 program does not differ significantly from the FY-74 program as concerns sulfate research.

#### HEALTH EFFECTS RESEARCH

Within the CHESS program, sulfate ion is analyzed for in all hi-voi samples collected. Such data are correlated against health indicators in the usual manner. These data are of particular interest in the CHESS areas of New York City, St. Louis, Utah, and possibly California. The combined SO<sub>2</sub> and TSP-RSP projects amount to about \$700K.

We also have an \$80K contract with Battelle-Columbus to develop a respirable suspended particulate sampler (0.3 to 8 micron sized particles) that can collect a large enough sample to allow for the analysis of sulfate and other sulfur compounds.

A contract to determine the relative toxicity of various chemical fractions of TSP (including sulfates) on human subjects (21ABY-11) is not scheduled until January 1975.

A preliminary report on suspended sulfates is not expected until June 1979.

Mary Amdur's work at Harvard University terminates August 1974.

#### BIOMEDICAL RESEARCH

One major effort is devoted to biological effects of sulfates. This will determine the relative biological effects of specific sulfates, and sulfates created through complex gas-particle interaction with SO<sub>2</sub>-oxidant-hydrocarbon mixtures. The study will be directed to respiratory physiologic alterations and their inter-relationship to host's resistance and the development of acute and chronic respiratory infection. This task is tentatively funded for FY-74 at \$160K and 5 man-years. It is an ongoing project from FY-74 to FY-79. The Chemistry and Physics Laboratory will contribute \$5K and 0.1 man-years in support of this task in FY-74.

#### METHODS DEVELOPMENT

Little work is planned in FY-74. One task, laboratory and field evaluation of sulfuric acid and sulfate instruments, is funded in FY-74, at \$11K and 0.4 man-years. Another task is scheduled for funding in FY-76. Two other tasks have been cancelled for technical reasons.

#### ATMOSPHERIC CHEMISTRY

Three tasks are to be funded in FY-74 which include some sulfate work. The major one is an interagency grant concerned with SO<sub>x</sub>-NO<sub>x</sub> transformers in plumes, as part of the RAPS project. This is planned at \$120K.

A task on aerosol modeling includes sulfate formation. The FY-74 funding is \$14K and 0.5 man-years.

A task concerned with the effect of relative humidity on aerosol growth includes sulfate work. The FY-74 funding is \$8K and 0.3 man-years.

#### MONITORING

Three tasks are concerned with sulfate. One, funded in FY-73, will look at acid mist from power plants. Another, also funded in FY-73, will look at acid mist from smelters. A task, funded at approximately \$15K with NBS, will provide standard reference material for sulfate.

Another task provides for collecting samples at selected sites (up to 400 samples) to analyze for 6 non-metals including sulfate. FY-74 funding is \$10K and 0.5 man-years.

A study to characterize TSP indoors and outdoors may include sulfate. This has FY-74 funding of \$70K and 2 man-years.

#### CONTROL SYSTEMS

There is no direct work on sulfate emissions as such. Since atmospheric sulfate originates largely from atmospheric transform of SO<sub>2</sub> (approximately 95% of sulfate appears to result from SO<sub>2</sub> emissions), sulfate control will require an adequate reduction in SO<sub>2</sub> emissions. While we have a substantial program in SO<sub>2</sub> control, our SO<sub>2</sub> program has been substantially reduced from FY-73 and placed in lower priority. FY-74 funding for the entire SO<sub>2</sub> control program is \$9430K.

## METEOROLOGY

There is no work associated with sulfates.

In summary, NERC/RTP's sulfate program for FY-74 amounts to \$1190K approximately distributed as:

	<i>Thousands</i>
CHESS <sup>1</sup> -----	\$ 780
Biomedical Research -----	160
Methods Development -----	10
Atmospheric Chemistry <sup>2</sup> -----	150
Monitoring <sup>3</sup> -----	90
Total -----	1190

<sup>1</sup> Includes SO<sub>x</sub> and TSP-RSP.

<sup>2</sup> Includes SO<sub>x</sub> and NO<sub>x</sub> transforms.

<sup>3</sup> Includes other pollutants also.

NATIONAL ACADEMY OF SCIENCES CONTRACT WITH NERC/RTP—PREPARATION  
OF BACKGROUND DOCUMENTS ON ENVIRONMENTAL POLLUTANTS

EXHIBIT A—SCOPE OF WORK

*Preparation of Background Documents on Environmental Pollutants*

The Contractor shall prepare an open-ended series of comprehensive state-of-the-art reports which will reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on health and welfare which may be expected from the presence of a variety of pollutants in the environment. In developing these reports, consideration shall be given to the sources, chemical and physical characteristics of the pollutants, the techniques available for their measurement, their prevalence, and possible modifying conditions, such as: reaction time, effects of other pollutants simultaneously present and meteorological conditions. Documentation of the effects of these pollutants on human health and well being, on animals, on agriculture, on materials and on man's environment in general is deemed to be of primary importance. These reports shall contain detailed comment on dose/response relationships and margins of safety which may be used in establishing environmental quality standards. They shall indicate groups in the general population known to be or likely to be particularly sensitive to exposure, documented with literature citations.

The Contractor's Division of Medical Sciences, through its Committee on Biologic Effects of Atmospheric Pollutants and in collaboration with other interested groups within the NAS-NAE-NRC, shall make comprehensive surveys of available scientific knowledge of the effects of environmental pollutants especially in connection with but not restricted to their occurrence in ambient air. These surveys will form the basis for consensus reports that describe the sources, physical and chemical nature, effects on human health and well-being, effects on animals and vegetation, and any other appropriate effects. Each report shall also consider research needs in connection with the characteristics of the pollutant, its measurement, its relation with other pollutants, ways of modifying its effects, margins of safety, possible dose-response relations in causing adverse health effects, and any other information that the study group thinks will be important to the sponsor.

The Environmental Protection Agency, through its Office of Research and Monitoring, will indicate to the contractor the specific pollutants to be studied and the order of priority, if any, in which they are to be considered during the contract period. Scheduling and priorities thus established may be changed, by mutual agreement, without change in the cost structure of the contract.

In addition to the reports indicated in Article III—(Reports of Work), the Contractor shall furnish three hundred (300) copies of any official publications which relates to any study performed under the contract. A copy of the transmittal letter shall be forwarded to the Contracting Officer.

RESEARCH TRIANGLE PARK, NORTH CAROLINA

SSS STAFF LIAISON ASSIGNMENTS FOR NAS PANELS, JULY 26, 1973

The following table represents the agreed upon assignments relative to the above referenced subject:

*SSS staff (panel liaison and document review)**NAS panels***(Ongoing):**

VPOM.....	Dr. Garner
Nickel.....	Dr. Horton
Chromium.....	Dr. Horton
Vanadium.....	Dr. Horton
Chlorine-HCl.....	Dr. Garner
Selenium.....	Mr. Boksleitner
Copper.....	Dr. Horton
Zinc.....	Dr. Horton
Fine Particulate.....	Mr. Smith

**(New):**

Carbon Monoxide.....	Mr. Boksleitner
Hydrocarbons.....	Dr. Garner
Photochemical Oxidants.....	Dr. Horton
Nitrogen Oxides.....	Dr. Horton
Arsenic.....	Dr. Horton
Platinum Group Heavy Metals.....	Dr. Horton

Dr. Horton will serve as the SSS primary interface for the NAS-BEAP Committee and, for purposes of continuity, will attend all NAS Panel meetings whenever possible. Subsequent to attendance at all Panel meetings, the assigned SSS liaison representative will submit a brief written synopsis of the meeting to my office, with a copy to Dr. Horton. The NAS has been informed as to your assignments in order that their respective staff can notify you.

**STATUS OF POLLUTANT REVIEWS BY THE NATIONAL ACADEMY OF SCIENCES****Completed:**

Asbestos.  
Fluorides.  
Lead.  
Particulate polycyclic organics.  
Manganese.

**1974:**

Selenium.  
Chlorine & Vapor Phase.  
Hydrochloric Acid  
Copper.  
Zinc.  
Particulates.

**1973:**

Vanadium.  
Chromium.  
Nickel.  
Vapor phase polycyclic organics.

**1975:**

Platinum group.  
Arsenic.  
Carbon monoxide.  
Oxidants.  
Nitrogen oxides.  
Hydrocarbons.

Note: Sulfur Oxides are also being reviewed (1974-75) for Senator Muskie's Senate Subcommittee.

**Possible Recommendations for 1976 Completion**

Aeroallergens  
Iron  
Infectious Aerosols  
Barium  
Boron  
Ammonia

Mr. CARTER. Mr. Chairman.

Mr. ROGERS. Yes, Dr. Carter.

Mr. CARTER. Along that very line, you were speaking of sulfate emissions and so on, I recently read and I guess many of you did, that a catalytic converter doesn't always convert to harmless substances. Is that correct or not?

Mr. QUARLES. Yes, sir, that is correct we believe. I think perhaps I would like to ask Dr. Greenfield or Dr. Finklea to comment in general.

I know there was a newsstory in the Washington Post, I believe Saturday morning, on this subject. It is a subject of some importance which I feel would benefit from an airing during this hearing. This might be an appropriate time to go into it if you wish.

Dr. GREENFIELD. The evidence we now have would be, with the realization that it is just preliminary evidence, that indeed in the catalytic converter the sulfur in the gasoline is converted to sulfur dioxides and eventually to sulfur, and comes out of the exhaust pipe as an acid mist; also that possibly trace metals such as platinum may be coming out of the exhaust pipe that this is something we have under intensive study right now, examining exactly what is coming out and what the potential health effects are.

Mr. CARTER. In other words, your catalytic converter also converts toxic substances into substances as toxic, or even more so; is that correct?

Dr. GREENFIELD. No, I wouldn't say that. What we have is evidence that things like acid mist are coming out of the catalyst. The question of how bad this is relative to the other pollutants that are taken out by the catalyst, this is what we have under study at the present time.

Mr. CARTER. Do you think sulfur dioxide then is less toxic than sulfuric acid?

Dr. GREENFIELD. No, sir, I am not saying that. I am saying that the set of pollutants associated with sulfur dioxide,  $\text{SO}_2$  itself, in association with the particulates and sulfates that are formed we know have an effect on human health.

Mr. CARTER. We also know that sulfuric acid has a disastrous effect on human health or anything else with which it comes in contact. Is that not correct?

Dr. GREENFIELD. That is right. Of course, the effect of weak sulfuric acid as opposed to the sulfate particles that are formed and are taken into the lungs—

Mr. CARTER. Is it not also true that platinum has almost as deleterious effect as lead?

Dr. GREENFIELD. We know very little about platinum and its effect on human health. We know that the occupational health people have set as a matter of course, standards for platinum ingestion by workers in platinum industries; but the actual impact of platinum in various concentrations on human health, very little is known about it.

Mr. CARTER. Thank you, Mr. Chairman.

Mr. QUARLES. May I comment further before we leave this subject. I think there are risks of misunderstanding that may arise in this area. We know from very extensive evidence that we have extremely severe pollution problems from the auto exhaust that are causing adverse health effects. We also know that catalysts can be extremely effective in removing those pollutants.

We recognized, quite early in the game when catalysts began to be proposed as a method of dealing with the auto exhaust problem, that a study should be undertaken on the effect of using such hardware. We have undertaken a research program to bring in information as to what effects there might be. Two areas of uncertainty require further examination. First is the qualitative effect of some of these pollutants upon health. Second is the quantitative evaluation of how much of

such pollutants might result from the widespread use of catalysts. We are proceeding on an accelerated basis to analyze both facets of the problem, and we are confident that we will have information available to the Agency as we go along in this process.

Mr. ROY. May I inject this at this time, because I made reference to the fact that Dr. Shy has come up with some indications that these fine particulate matter. The sulfate particulate matter and sulfuric acid do not necessarily correlate with the sulfur dioxide measurements which you are using as standards.

What about this memorandum from Dr. Shy to Dr. Finklea charging that the EPA health program and air pollution research monitoring is being reduced substantially in terms of money and manpower? Is this memorandum of July 27 correct? If it is correct, isn't this an inappropriate time to be reducing this research when we are staring right now at the fact that some of our measurements may not be adequate?

Mr. QUARLES. I am very glad to get this question surfaced. Dr. Greenfield will comment.

Dr. GREENFIELD. The question of whether or not this Agency considers health effects research important is an undisputed one. Yes, we think it is extremely important, and in fact we are increasing our health effects research program, not decreasing it. The memorandum you refer to that Dr. Shy wrote is in reference to the fact that for historical reasons, a good portion of the personnel that were on the roles of the health effects program down in North Carolina were temporary, not permanent, personnel, and that when the consolidation of the temporaries occurred in the Agency, a certain portion of these people were dropped from the program because of the fact they were temporary, we simply didn't have positions to put them into.

The other point that Dr. Shy made in his memo was the fact that if you add in such things as the cost-of-living increases that have occurred over the years and had held the program at constant level or increased it just slightly, then in effect the whole program went down. This unfortunately we run into continuously in our entire research program, the research program goes down if you hold the program at a constant level. This is not something to the health program. In fact, the health program has suffered much less because we deliberately increased the health program, and we intend to go on with that.

Mr. ROY. His statement, then, that you have not been able to maintain the 1972 level of effort, is indeed correct?

Dr. GREENFIELD. It is correct as much as any research program. I still have to make sure that what is on the record is the fact that the health program, has increased because we are so concerned about it. In real dollars terms it has suffered less than the other research programs.

Mr. ROY. Relative to other programs, the health program is doing well. Relative to 1972, it is indeed not doing so well. In fact, you did not get the \$5 million Presidential initiative fund for each of the 2 years; you got considerably less than that.

Dr. GREENFIELD. No, we got the \$5 million. The question is how you do your bookkeeping on it, Mr. Roy.

Mr. ROY. Thank you very much, Mr. Chairman.

Mr. ROGERS. I think it might be well for you to put in the record the amounts of money that are actually designated and the number of people working on the health-related research programs.

Dr. GREENFIELD. We will do that, Mr. Chairman.

[The following information was received for the record:]

#### EPA HEALTH RESEARCH BUDGET FOR AIR POLLUTION

EPA and its predecessor, the National Air Pollution Control Administration of the Department of Health, Education, and Welfare, have supported a vigorous health effects research program for many years so that the Federal Government might later understand the exposure response relationships linking ambient air pollutants to adverse effects on human health. This program envisioned a three-pronged mutually supportive research effort involving community studies, clinical studies and animal toxicology. Our Agency strives for a proper balance between the extramural and intramural research components. During the five years preceding the formation of EPA approximately four million dollars and 120 to 140 man years were annually allocated to air pollution health effects research. EPA has increased its commitment to this program increasing the annual level of expenditures to over eleven million dollars. President Nixon recognized the importance of this program by providing a substantial increment through a Presidential Initiative in FY 1973. Our Agency recognizes that much remains to be done in this area and we plan an appropriate expansion of this effort. During the current fiscal year the health effects research effort has been impacted by additional information requirements arising from our need to assure that public health will not be adversely affected by non-regulated mobile source emissions. This has required some internal readjustments with the health effects program. These internal stresses were largely of a temporary nature and are being reduced by reprogramming actions within the Agency. Our scientists have testified before the Committee on the current status of our health effects knowledge and on the clear need to fill the identified information gaps in this information base. Our Agency intends to do this as expeditiously as possible. We have provided the Subcommittee the requested resource summary for air pollution health effects research in the attached table.

#### RESOURCES FOR AIR-HEALTH RESEARCH 1969-74

	Fiscal years					
	1969	1970	1971	1972	1973	1974
Amount (thousands).....	\$4,040	\$3,835	\$4,030	\$6,350	\$10,700	\$11,100
Man-years <sup>1</sup> .....	134	120	118	179	150	156

<sup>1</sup> Includes 5,000,000,000 Presidential add-on.

<sup>2</sup> Permanent positions only.

Mr. ROGERS. Mr. Satterfield.

Mr. SATTERFIELD. Thank you, Mr. Chairman.

I have a number of things that I wanted to discuss with you, but I am going to go first to the matter which Dr. Carter touched upon because I have some questions which relate to his.

I remember 3 years ago when we were holding hearings there was much talk about catalytic devices, and that one of the problems was that they had not developed a catalytic device that would last for at least 50,000 miles.

Is that still the situation or do we have catalytic devices today which do meet that test?

Mr. QUARLES. Sir, tremendous progress has been made and anything said 3 years ago on catalysts is way out of date by now.

Mr. SATTERFIELD. Understand, I am trying to get up to date.

Mr. QUARLES. Our regulations do permit one change of catalysts during the 50,000 mile period. Consequently, that is something that the auto companies can do if they need to. There have been a great many catalysts which have been run for 50,000 miles or for very substantial mileages, in the range of 30,000 to 40,000 mile, and have continued to function well throughout the entire distance. I know that many experts in the field now believe that catalysts can be manufactured which normally will run for the full 50,000-mile duration.

Mr. SATTERFIELD. That would require, if I remember correctly, that one operate it on unleaded gas.

Mr. QUARLES. Yes; the catalysts do require unleaded gas.

Mr. SATTERFIELD. What consideration are you giving to the fact that with an energy shortage which is confronting us and the experience that we have had this summer that the 1975 cars, equipped with catalytic devices, may not be able to operate on unleaded gasoline all the time?

Mr. QUARLES. There are two questions presented by that I believe. One is the overall national capability to provide sufficient quantities of unleaded gas and the other is the actions we have taken to establish regulatory requirements that that be done.

Mr. SATTERFIELD. You are right about the two points.

The question I am asking is this: If you put a catalytic device in an automobile in 1975 and you can't guarantee that the operator can get unleaded gasoline you are not going to do very much good because you are going to destroy those devices in less time than their life expectancy is now and that obviously is not 50,000 miles.

Mr. QUARLES. That is the question that came up very much in our auto hearings. We did need to satisfy ourselves that there would be an adequate supply of unleaded gasoline available for use and we are satisfied that there will be. We have established regulatory controls under which all large gasoline stations, all stations in chains, must have one pump of unleaded gasoline. That means from a regulatory point the machinery has been laid in place to assure that the driver will be able to pull up to his neighborhood gas station and purchase unleaded gasoline.

From an overall viewpoint we also needed to assure ourselves that once we set those requirements, the oil companies and others could meet them. We believe on that score also that the job can be done. A great deal of unleaded gasoline of course is sold now.

Mr. SATTERFIELD. Are you aware of what happened this past summer at those pumps which sold unleaded gasoline?

Mr. QUARLES. I am not sure what specific you have in mind.

Mr. SATTERFIELD. I have a 1973 automobile that requires unleaded gasoline. I run on unleaded gas and the stations I go to happen to have one, sometimes two pumps for unleaded gas. During the summer months approximately, 40, maybe 50 percent of the time I could not get unleaded gasoline. I had to buy leaded gasoline. If I had had a catalytic device on my automobile it probably wouldn't function at all now. My question is this, is EPA experimenting or researching with any other device or alternative which will not be damaged should this situation continue to develop?

Mr. QUARLES. No; we are not trying to develop technology ourselves. The way the statute applies, the burden for the development of technology is almost wholly placed on the automobile companies.

Mr. SATTERFIELD. You are bestowing your blessings on the catalytic device?

Mr. QUARLES. That is the device that has been developed and we believe it will work. I would like to make a few further points on this. One important question is, what happens if there is lead in the gasoline? What happens to the catalyst?

Initially the testimony we received at the hearing a year and a half ago, indicated that this could produce a severe effect, that is permanent damage to the catalyst. If you did damage the catalyst you might be in for a far worse situation than if you had put no catalyst at all on the automobile.

The testimony that we received this year was much more encouraging on a couple of important points. One was that the testimony suggested rather strongly that the effects of leaded gasoline in poisoning the catalyst might well be reversible. That is to say, when one goes back to using unleaded gas the poisoning disappears and the activity chemically of the catalyst is restored, at least in large part.

The second important point is that if a catalyst is on a car and ceases to function, the exhausts are what you would have in the absence of a catalyst. So you are not worse off.

Mr. SATTERFIELD. Except the man who owns the automobile, he is about a hundred and some dollars out of pocket for it.

Mr. QUARLES. That is correct.

Now, if we felt that there would be a very widespread failure on the part of the oil industry to be able to furnish the unleaded gasoline, this would be, of course, a tremendous concern. But we anticipate a phasing-in situation in which over a period of years increasing numbers of automobiles will be equipped with catalysts and their demand for nonleaded gas will rise.

Simultaneously, the ability of the oil industry to supply unleaded gas will also rise if they are assured that there will be a market for it. We certainly anticipate that some situations may occur where unleaded gas is in short supply but this will be a phasing-in difficulty and hence will not be of any duration.

Mr. SATTERFIELD. On the question of supply and demand, I wish I were as optimistic. I think you are correct, if we had a situation of fuel excess, but at a time when we have a shortage I am not sure you will get that kind of split.

Mr. QUARLES. We have a great many difficulties here with the oil industry. They are being required to develop unleaded gasoline, being required to install desulfurization plants and for a variety of reasons having nothing to do with the environment, in a condition of short supply. It is not going to be easy, but the need is to move ahead aggressively to get the job done as soon as it can be done.

Mr. SATTERFIELD. I don't argue that. I agree that you are behind the "8-ball" in one respect and that you have to deal with the automobile at the production level and you don't have the capability for inspection and approval in the hands of the operator.

The point I am making is that if you have a reasonable probability that this expensive device in the hands of the manufacturer is not

really going to work, I think this is something that ought to be considered.

This brings me to another point.

We were talking about the suggestion that there may be platinum and sulfuric acid in the emissions from these catalysts and that a very intensive study about this is going on.

May I inquire when the result of that study is anticipated?

Mr. QUARLES. Yes. We anticipate that we will begin to get results during 1974 on the quantitative analysis of the emissions from the tailpipe through the catalyst.

Mr. SATTERFIELD. That will be too late to be effective for the 1975 cars which will have the catalytic devices, will it not?

Mr. QUARLES. Yes; very likely, it will be too late.

Further, I should also explain, and you should clearly recognize, that good information on the health effects that may result from these elements in the atmosphere probably will not be available until the first of 1975. Consequently, we do anticipate that a significant part of the automotive population, particularly in California where catalysts will be required universally in 1975, those cars will be produced with catalysts before we have completed all of the information that is ideally desired to deal with these issues.

So, what we have to do is to analyze the relative risks. In our judgment the relative risks that may arise from the sulphate and very minute quantities of platinum and other trace elements of heavy metals, relative to the known pollution on the other side. We feel no doubt that we should move ahead with the national effort to install catalysts.

Mr. SATTERFIELD. Well, I would feel a whole lot better if you had some results first. We get back to the problem that really concerned me 3 years ago. I thought it became very obvious then that notwithstanding the fact nobody knew what a catalyst would do and notwithstanding the fact that their longevity was greatly in doubt, the decision was being made then which I think became solidified when we passed the act that this was the way we would go.

The result is that no one is looking for alternative methods and we may be faced with a very serious problem if we have to go pursue a route other than catalytic device.

I would hope your agency would make this information available to other people and perhaps use the pressures that you can see if we cannot look at some alternative methods as backstop.

I do have other questions but I have used up my time.

I do want to compliment you on one respect. One of the things which concerned me 3 years ago when we were discussing this matter was that we in Congress were trying to do a job which had to be done and I think we did in terms of an act. I think we realized at the time that there is a lot of information, medical, scientific, and otherwise, which we didn't have. I think you are finding that you don't have it yet because we are going into a whole new area.

I want to compliment you on your attitude of considering all of the possibilities and all of the information and acting on the basis of the best reasonable information that you can obtain. I think this is the only way that this can succeed.

Mr. QUARLES. Thank you.

Mr. ROGERS. Mr. Nelsen.

Mr. NELSEN. Thank you, Mr. Chairman.

I mainly have some comments on your testimony.

I noticed that on page 4 you stated:

Are the deadlines established for meeting the requirements of the act reasonable and realistic?

It has been one of my observations that a situation may develop and suddenly we try to reach it legislatively and demands are made to correct the problem that may have been building up for many years. So, we suddenly pass an act and we demand, maybe unrealistically, of an agency that they do certain things.

I was glad to see the comment about the realistic requirements and deadlines, and I think that we in the Congress should give all agencies time to reach the goal that you are attempting to reach.

Now we have had a good deal of discussion about the catalysts. I remember the conference committee—I was on it—and at that time a suggestion was made that our export automobiles would have the same catalyst on it as our domestically used automobiles. I remember at that time that it was the feeling of the conference committee that unless the United States of America was in a position to dictate the quality of fuel in a foreign country it would be useless to put a catalytic converter on an automobile for export trade. So, we just required them to meet the standards of other countries in which they were sold.

I am a little bit of a blacksmith, myself, and have overhauled automobiles. It would seem to me that we are converting to nonleaded gasoline to accommodate a catalytic converter. So, if the converter does clog up, it seems to me the effectiveness of it would be destroyed.

I hope that we will find an engine design that will have better combustion because putting on devices obviously is not going to totally solve the problem.

Now you mentioned that if we reduce the size of the automobile we will get better fuel. I recall hearings where Mr. Nader was against small automobiles because more lives were lost. So, we are in the middle here between Mr. Nader and your suggestion.

As to the fuel for the powerplants, we are having some difficulties in our own State. We started out with the fond hope that nuclear fission and heat would supply the power generation. The first loan that was made for a small capacity nuclear plant I made when I was with REA. It was at Elk River and we have since abandoned that. We are going to larger facilities but again we run into an environmental problem in the use of coal.

I am wondering if a powerplant is built in an area where your air quality is extremely good, does your agency have the authority to relax on some of the demands so that we can accommodate a building of plants in areas where the problem of polluted air doesn't exist?

Mr. QUARLES. Sir, the way the act operates it provides more flexibility in the areas where there is not a serious pollution problem. Our air quality standards establish a quality of air that must be met at all times and in an area where there already is a lot of pollution it becomes a great deal more important that stringent control be established.

Mr. NELSEN. I am thinking of some of the deposits of coal that contain sulfur which in one area might be dangerous and in another might not be.

I think, without question, there will be a power shortage in many parts of the country and, to some degree, our demands in the environmental field have almost stopped powerplant construction, so I am just wondering if there is anything we need to do in the way of an examination of where could a plant be placed, where the deposits are, if the fuel could be carried to other areas where there is more concentration?

Now, the reference to the desulfurization, it seems to me that if we think that we can attach a gadget on an automobile to lessen pollutants resulting from exhaust emissions, certainly on a powerplant something can be designed that would make it possible for us to use high-sulfur coal because of desulfurization or lessening of stack effluents.

Has there been research on that?

Mr. QUARLES. Yes, sir; there has been. I want to make something clear.

One of the reasons there has been so much progress in developing a mechanism that can clean up the exhaust from an automobile is a very strong statutory mandate for the development along that line. There has not been that push in the past from Congress and in the statute for the development of scrubber technology. We now are getting to a point where the implementation plans are beginning to put some pressure on but we are lagging behind.

I think if there had been as intensive an effort to solve the problems in the stack gas removal technology, those problems very likely would be much farther down the road toward solution.

Mr. NELSEN. We will take all the credit we can get out of the deal due us because of the act.

Now, I was interested in our chairman's question on the research in Japan. That has already been covered. It seems to me if research has been done in Japan we should have been doing it in our own country and I agree with our chairman that this is certainly something we ought to be doing.

Well, I am pleased with your report. I think it is very good. I think if there are areas where we need to make accommodations in the law we should be advised of it because certainly the goal that we seek is one we are all after.

Thank you very much, Mr. Chairman.

Mr. ROGERS. Thank you.

It is now 12:15. I think, if it is agreeable to the members, and if you and your associates can come back at 2 o'clock, the committee will stand adjourned until 2 o'clock this afternoon.

[Whereupon, at 12:25 p.m., the subcommittee recessed, to reconvene at 2 p.m. of the same day.]

#### AFTER RECESS

[The subcommittee reconvened at 2 p.m., Hon. Paul G. Rogers, chairman, presiding.]

Mr. ROGERS. The subcommittee will come to order, please.

We will continue our oversight hearings on the Clean Air Act.

We interrupted the testimony of Mr. Quarles and, as I understand it, we thought we might start with a briefing on the health effects of the Clean Air Act and ramifications of it.

Mr. QUARLES. Thank you, Mr. Chairman.

We are prepared to give you at this time and set forth on the public record on this matter a briefing by Dr. Finklea. I think this would be very helpful.

Mr. ROGERS. This will be excellent. It will be fine to proceed in that manner.

Dr. FINKLEA. Thank you, Mr. Chairman.

With your permission, I will go to the corner of the room where we have visual aids.

We are going to talk about the primary ambient air quality standards. That is those standards that are related to health.

I think Mr. Miller had some material which covers this briefing.

Mr. ROGERS. Has the material been given out?

Oh, yes; we have it.

Dr. FINKLEA. The briefing charts here will contain most of the charts you have in your handout material. In addition, in the material you have some finely detailed charts which will contain additional information. I will refer to that as we go along but I will not present it because of time constraints.

Mr. ROGERS. Very well.

Dr. FINKLEA. First of all, the scientific defensibility of our primary ambient air quality standards must be supported by a broad interlocking technical information base, not just by health information alone.

Now, this information base contains a number of components. First of all, we have to have adequate measurement methods. I think that the subcommittee is aware of some of the problems we have had with the primary air ambient quality standards for nitrogen oxides because the measurement methods were not adequate.

We have to have good information on emissions sources. We have good emissions profiles for annual averages but in terms of the short-term emissions profiles we are trying to improve the information we have.

We have to understand how pollutants are changed through the environment, the so-called transport and transformations of pollutants.

I think the committee is quite concerned with the oxides of sulfur which are changed in the environment from a gaseous material, sulfur dioxide, to a fine particulate, the so-called suspended sulphates which include also sulfuric acid mists. These materials seem to be more detrimental to health.

The committee was concerned about the oxides of nitrogen. As oxides of nitrogen are changed in their environment, they become fine particulate nitric acid. This is an area where we need much better understanding of the transformations.

Another area is the air monitoring data base. Our agency and State governments and regional offices of EPA are moving to strengthen the air monitoring data base that we have.

We need to know the health effects of pollutants. We will spend a good deal of time detailing what that knowledge should be. We need to know the welfare effects, the effect on materials, the effect on

vegetation, especially the quantitative damages which occur with various levels of pollution.

We need to have predictive models by which we can relate emissions to the effects and to the processes that go on in the environment. These predictive models will help in the control and management of air quality and also will help us in understanding human exposure to pollutants and therefore the adverse health effects.

We have to have an adequate control technology for those pollutants for which we have concern.

You have been discussing some of the problems in sulfur dioxide control technology this morning. We must know the impact of the controls, both on the environment and on health.

I think Mr. Satterfield expressed concern about the oxidation catalysts and their impact on environmental health. It is fair to say and we will quantitate some of our problems on health but it is fair to say that we lack incontrovertible evidence in one or more of these areas for every one of the primary ambient air quality pollutants.

We need to move forward at the same time that we acquire this information and that is what our agency is trying to do.

Let us remember how the Clean Air Act looks at public health. Remember, the Clean Air Act requires that primary ambient air quality standards be set to protect the public health with an adequate margin of safety, thus, basically assuming a no-effects threshold.

Mr. Roy pointed out this morning how we are still going on this assumption even though our new information does show that even low levels of pollutant can adversely affect health.

The law also specifies who must be protected. Congress has said that both specifically susceptible subgroups, which are the very young and the very old and the sick as well as healthy members of the population, must be fully protected.

Excluded are persons who require an artificial environment, that is, those who are not free living. I think that will bear a little bit on our discussion of the mortality effect in just a moment.

We also have some controversy in the scientific community and in the regulatory hearing as to what constitutes an adverse health effect.

In our agency and in the Advisory Committee to our agency our scientists feel that adverse effects include both an aggravation of pre-existing disease and an increased frequency of new disease. In other words, air pollution can aggravate a disease that one has for other reasons or can induce a new disease order.

Evidence for an increased risk of future disease is, in our professional opinion, an adverse health effect. We know there are certain measurements that one can make on the way the human body functions and predict people who have increased risk to later disease.

We believe that if these measurements are most frequent in a population, then it is a point of some concern that increased disease may occur at some time in the future.

One can think about it in terms of this pyramid. The pyramid was originally thought up by Dr. Shy who was mentioned this morning by your committee, I believe. One thinks of this horizontal axis as a proportion of the population affected and thinks about an effect going from a simple pollutant burden all the way up to death; one can see

almost all members of our urban society bear some evidence of pollutant burden.

Then there are changes in the way the body works. Some of these changes are of uncertain significance. Some of these changes are definite precursors of disease. There is a great deal of scientific dispute about whether a particular change is one of these or the other. Therefore, it would be appreciated that scientists may disagree as to whether an effect is really adverse or not.

Then I think all of us can agree that illness that is, morbidity, or death, mortality, are adverse effects. Of course, all of us turn to life from birth to mortality and Mr. Quarles pointed out this morning that only about 1 percent of our population will die each year, but we will all eventually make it.

There are a variety of diseases that we can attribute to pollution or variety of health disorders. First, we must worry about common respiratory disease. We think that common respiratory diseases occur with increased frequency in our urban populations that are exposed to increased pollution levels.

Second, we must worry about aggravation of preexisting diseases.

We are particularly worried about asthma, heart disease and chronic lung disease such as bronchitis and emphysema.

All of our populations are exposed to huge levels which can cause some irritation to the eyes, nose, throat, and chest.

One hundred percent of the American public has experience with common respiratory diseases each year. Although this seems to be minor, an increase of 15 percent or so in these illnesses is a very major health problem because about 2 to 5 percent of our public at any one point in time will have asthma; about 2 percent will have active asthma.

Around some areas of the country there are fewer asthmatics. They have sought to avoid specific areas.

Around 5 percent of our public will have some evidence of heart disease at any one point in time. Around 3 to 5 percent will have trouble with chronic lung disease. Sometimes these two diseases occur together.

When we want to think about some of the chronic diseases that occur, we feel now that chronic bronchitis and emphysema are partially caused by urban air pollution in this country.

I don't think there is any doubt that the increase in these chronic respiratory diseases in England was caused by air pollution in that country. We would think that air pollution has roughly one-fifth to one-third of the effect of cigarette smoking in causing disorders of the population exposed.

We are concerned that common air pollution may contribute to the burden of lung cancer with which our population is faced. We cannot quantitate this concern very well at this time. The National Academy of Sciences has made some initial efforts in this area but it is difficult to quantitate this relationship.

We are concerned that certain hazard pollutants may themselves contribute to the frequency of coronary heart disease in this country. Probably this effect is much smaller than the effect of the poor diet and

inadequate exercise and cigarette smoking that some of us pursue but we think it is a real concern.

We are also concerned as to what effect pollutants may have on congenital abnormalities of the lung and on impairment of the defense mechanisms of the body resulting in higher risk of multiple diseases.

Once again, these are areas in which we have very little information at this time.

In a general sense, then, what would a minimally adequate health intelligence base for primary air quality pollutants consist of.

First of all, we would think we would need to know the effects of chronic, continuous exposure and the effects of a single or repeated short-term exposure. In a large urban area such as Washington and New York, we have a chronic exposure extending over time. Around industrial sources, we may have fumigation resulting from an accidental release or some changes in the weather which makes a plume sweep down on a certain community.

We would need to know all three of these things. We don't know all three of these things in all cases.

We would need to have some information about all expected adverse health effects.

I will show you what information we have and what information we don't have for each of the primary pollutants.

We will need a blend of research approaches and research information, a blend of epidemiology; those are community studies involving people as they actually live, clinical studies involving human volunteers and occupationally exposed groups, and toxicology studies involving animals and experimental groups.

Each one of these study approaches is different and we need all three to get an incontrovertible picture of evidence.

We also will require that the adverse effects be biologically plausible. From all we know about biology, it would be a reasonable thing to worry about. We would ask that they be coherent; in other words, as a result of all three of these approaches support each other. We would ask that they be consistent, that is, that we would be able to repeat these studies at different times in different places and show the same effect.

Finally, we would really like to have a very good exposure-response relationship showing when pollution increases the increased risk for the adverse effect also occurs.

Now, in fact, we do not have good disease-response relationship for each adverse effect so that we can predict what a small increment in pollution would cause in terms of increased risk in disease. We must therefore often settle for a least case, worst case and best judgment estimate of a threshold. We think this is a realistic minimum.

I will show you how we try to do this for each adverse effect. In this case, a "least" case, worst case estimate would give us a boundary. We would hope this boundary would be one where men of scientific good will not disagree. "Best" judgment is simply what it says our best judgment within the boundary and which Mr. Ruckelshaus and now Mr. Quarles and Mr. Train would have to apply a margin of safety.

If I might then move into the pollutants for which we have established standards.

I would like to first point to the fact that we are going to consider the sulfur oxides, the suspended particulates and the suspended sulfate portions of the suspended particulates together.

Although standards were originally established for these two solutions, suspended particulates and sulfur dioxides, separately, they are in fact very difficult to consider separately because the evidence on which the standards are based is very closely intertwined.

You will see that we will be concerned about increased susceptibility of respiratory disease, aggravation of asthma, aggravation of heart and lung disease, irritation of the eye, respiratory altered lung function and increased risk of chronic lung disease as well as three effects for which we have little information: cancer, congenital defects, and impaired defense mechanisms.

The important thing to note in dealing with sulfur oxides and particulates is that we have many community studies but we have very few studies in the clinical and toxicologic area.

This means that we will find that these particular standards will be under attack for the immediate future because of certain shortcomings in the way we can approach community studies. In community studies, we can't look at single pollutants alone and you will find it very difficult to disentangle the effects of separate pollution.

With that in mind, I would like for you to consider just a minute the best judgment exposure thresholds that we have for these three pollutants.

First of all, we will look at the 24-hour threshold and we will compare those against the present standards for those pollutants. We will look first at sulfur dioxide.

Once again, remember we cannot really separate these three components.

I ask you to note, too, that we do not have any standard at this time for particulate sulfate or for other finely divided particulates.

As we have stated this morning, our agency will require some 4 to 5 years to develop an effective standard in this area.

I think, though, the chairman expressed an interest in the mortality harvest here or the increase in daily mortality. We use the word "harvest" advisedly because this is an increased number of deaths among people who would, by and large, expire in the succeeding few weeks in any case. So, it is a harvesting of those people who are most susceptible to death, those people who are ill with heart and lung disease, those people who are hospitalized.

Mr. CARTER. Mr. Chairman, I am having a little difficulty hearing.

Mr. SATTERFIELD [presiding]. Dr. Finklea, could you speak a little louder? We would appreciate it.

Dr. FINKLEA. First of all, we experience a mortality of harvest, an increase in daily mortality rates or increased number of deaths each day in an urban area. We would say this effect occurs among that portion of the population that is already quite ill, that portion that already is suffering from heart and lung disease, frequently that portion that is already hospitalized.

We see this effect occurring in our best judgment somewhere between 300 and 400 micrograms per cubic meter of sulfur dioxide when

accompanied by elevated levels of suspended particulates of roughly 250 to 300 and we would think elevated levels of particulate sulfates. We do not have the information here.

We pointed out today that Dr. Shy's paper talked about some evidence for an increase in this effect below the primary ambient air quality standard of 365. The range of uncertainty for this effect would extend from 30 micrograms per cubic meter for lowest possible effects to 500 micrograms per cubic meter for the upper boundary of this effect in which this effect might occur.

So, we would think on the basis of the information we have now that the present primary ambient air quality standard for a 24-hour period leaves very little range for error, but we cannot be assured that excess mortality is actually occurring within that range.

When we get down to aggravation of symptoms in the elderly, we see that it appears to be aggravated at particulate levels which are quite a bit lower than the present primary ambient air quality standards for a 24-hour period. We feel this is in large part due, if not completely due, to the suspended sulfate components.

We are also concerned about aggravation of asthma following short-term air pollution exposure and we see, too, this aggravation occurs at levels which are somewhat lower than the present ambient air quality standards. Again, our research leads us to believe that this increase is most probably due to the suspended particulate sulfate in common.

We are working with acute irritation symptoms. We see effects occurring almost at the sulfur dioxide level and perhaps at the suspended particulate levels that are somewhat lower than the present allowable 24-hour standards. These irritating effects of particulates are particularly noticeable during the summer time, that is during pollution episodes such as we have just experienced.

I might go into the long-term effects of sulfur dioxide suspended particulates and particulate sulfate exposures.

We shall decrease lung function in children beginning at exposures which are roughly  $2\frac{1}{2}$  times the present  $\text{SO}_2$  standard and which is only one-third greater than the present standard for particulates on an annual average basis and at a level which could be allowed under the present standards when we are concerned about particulate sulfates.

Again, our evidence supports that any effect due to air pollution exposures lower than the present standards would be due to the sulfate component.

When worrying about acute or respiratory diseases in families, that is, bronchitis or pneumonia or croup, we see that effects are occurring at levels which are again 25 to 33 percent above the present primary standards.

We also seem to be seeing effects at low levels of particulate sulfates.

We were worried about chronic lung disease, the occurrence of cough or sputum 3 or 4 or more months a year in our patients. We see these effects are occurring at levels which are not much greater than our present ambient air quality standards.

I must have one word of caution here, though. The increased prevalence we see with the levels of sulfur dioxide at only 95 occur near

point sources. So, there are short-term repeat exposures that are much higher than annual average.

In summary, we do not think that the primary ambient air quality standards for suspended particulate for sulfur dioxide are in any way too stringent. They are stringent to me but they are not too stringent as far as protecting health. We think the margin of safety for the annual average standard is very modest. We think that effects are occurring within the limits set by the short-term 24-hour standard and we think these effects are most probably due to fine particulates, and our agency is moving toward controlling fine particulates.

If we might move on to a favorite of this committee and of the Senate, nitrogen dioxide, you will see that we are concerned generally about the same range of effects. I think we are little more concerned about the problem of cancer arising after exposure to nitrogen dioxide degradation.

We are more concerned about possible mutations with nitrogen dioxide than with, say, a pollutant such as photochemical oxidants.

I think the point we would like to make here is that we have made our decision to control nitrogen dioxide on the best evidence available. We have evidence here which is limited to a small number of community studies and with supporting and consistent studies in toxicology. This is an information base which we in no way consider adequate and our agency is moving to supplement this base as rapidly as possible.

You will recall that we do not now have a short-term standard for nitrogen dioxide. The State of California has one which has been promulgated. Our annual average standard is equivalent to 1.400 micrograms per cubic meter for 1 hour on the basis of an air quality model. If we look at that based on our limited information we apparently have an adequate margin of safety when dealing with acute exposure short-term effects for nitrogen dioxide. It is not a very large one but it is a factor of 2 to 5.

As far as the long-term effects, you will recall our original standard for nitrogen dioxide was based on increased susceptibility to acute respiratory infection and also on the basis of our concern for increased severity of acute respiratory disease and decreased lung function.

Our studies there after intensive reevaluation lead us to believe this standard is not excessively stringent. We still have some concern about the breadth of the information base but the standard does seem necessary to protect human health.

You will notice some of the studies here, particularly those that indicate an increased risk of chronic respiratory disease are based solely on animal studies and they are very limited animal studies.

We move on to carbon monoxide, another of the pollutants which is primarily emitted from mobile sources. We are quite concerned about diminished exercise tolerance in healthy adults and in people who have heart disease. We are concerned about decreased mental activity, especially the ability to maintain vigilance in certain conditions like driving. We are concerned about an aggravation of existing heart disease, particularly coronary heart disease and that portion of our population that has angina.

We are concerned about increased risk of heart disease primarily on the basis of some very limited information of risk factors.

We are concerned about the impaired fetal development. This probably relates back to the studies of smoking that have been done.

As you will see, we have once again a limited number of studies and on this occasion most of our studies are based on voluntary human exposures and we have limited studies in toxicology and limited community studies.

We have two standards for carbon monoxide. Both of them are for short-term exposure. One of them is a 1-hour standard; the other is an 8-hour standard.

I am showing you the material from the 1-hour standard. It is a standard with a large safety factor.

I have the material for the 8-hour standard should you want to see it.

I think you can see here that your safety factor you have in the carbon monoxide standard depends on the level of activity which you are engaging in. If one was engaging in moderate exercise, one would have a safety factor of less than twofold. If you were concerned about the diminished exercise tolerance in people who already had existing heart disease, you would have a little bit larger safety factor. This is at sea level.

If one goes up to some of the higher altitudes in our country like Denver, this safety factor diminishes markedly and becomes vanishingly small.

Another way that this has been approached is to look at the percent of carboxy hemoglobin that has been associated with the problem which we are discussing here. You can see if we do this we have a somewhat larger safety factor.

I presented both of these approaches in your material so that you would have them handy for public discussion with other witnesses who will be approaching your committee.

Now we come to photochemical oxidants which, of course, are a matter of great concern on the west coast of our country and increasing concern in other metropolitan areas.

We have a somewhat longer list of effects that we are concerned about. I will just point out the new ones for you.

Photochemical oxidants can cause an aggravation of hematopoietic disorders, particularly anemias. The photochemical oxidants can increase the wilderness of your red blood cells and therefore decrease their life. So, people who already have an impairment of red blood cell life, this would tend to make their condition worse.

We have predicted it might cause, accelerated aging. We have no studies on this at present.

We are much more concerned here, I think, about the risk of mutations. Oxidants are emitting radiation and they have been shown to cause some chromosome damage in animals at levels which are only  $2\frac{1}{2}$  times our primary ambient air quality standards.

One other thing I should have shown you.

When we deal with the oxidants, most of our information comes from very early community studies or from later animal studies. We have a situation here in which we usually have a single or one study for each approach which makes us think we are quite sure about effect but does not give us enough information to be quite confident about a full dose response.

Given those limitations, here are the best judgment threshold estimates that we can furnish to the committee at this time; for the aggravation of asthma, we think the exposures which are roughly three times the present ambient air quality standard will cause aggravation in asthma.

We think that the exposure necessary to cause aggravation of chronic lung disease based on fragmentary studies is less than this amount.

We think that aggravation of certain anemias we have predicted to occur, based on animal studies, at levels which are roughly two and a half to three times the present ambient air quality standard.

We think irritation of the eyes will occur at levels which are only about 25 percent above the present primary ambient air quality standards.

Irritation of respiratory tract is in the same range as asthma. This is again roughly three times the present ambient air quality standard.

There is a decrease in the heart and lung reserve of the healthy adult that occurs at roughly one and a half times the present ambient air quality standards.

We would predict that an increased susceptibility to acute respiratory disease would occur at the present standard based on the animal information.

We have done one or two studies in children that have not been able to demonstrate this defect in the general population at this level.

Increased risk of mutations we would predict would again occur at levels three or four times the present standard on the basis of animal studies.

We will be concerned about impaired fetal survival at levels not much over twice the present standard.

We will be concerned about reduced visual acuity at night in healthy adults at levels which are about three times the present standards.

I have given you some safety margins. In the material that we furnished for your consideration, there were safety margins attached to each one of the estimates, whether it were a lower boundary of effect, upper boundary, or best judgment estimate.

I would like to caution you about these percentages that look so precise.

First, these safety margins are not at all as precise as their calculation might seem to indicate because, as we have pointed out, there are underlying uncertainties in the measurement methods used and in the best judgment estimate of the effects threshold.

First we as an agency are challenged by law to make our best judgment estimate of the effects threshold. Second, the consistency in safety margins was not a major consideration in setting the primary ambient air quality standards.

The third factor is that in general the apparent safety margins in the primary standards have decreased as more complete health information becomes available.

When the standards were set, I think almost everyone in the health field would have felt that we had a much larger safety margin than we are telling you that we have today. As we have gotten more information, the trend has been to find adverse effects at lower levels of exposure.

Fourth. The safety margins contained in the primary ambient air quality standards are much smaller than those maintained when dealing with pesticides and radiation, two other environmental hazards which our agency deals with. This has to do with the enabling legislation and how these facts approach the problem.

Finally, I would like to sum up, where we are now in our scientific information base for the primary ambient air quality standards.

We should emphasize again that we have moved to begin the control of these pollutants but that we do not have an adequate information base to assure scientifically incontrovertible primary ambient air quality standards. These are best judgment standards based on what we know. They are not incontrovertible.

With a strengthened overall air pollution research program, we will require several more years to obtain this information.

A cost-benefit approach to air quality control would require more data than the present threshold approach.

If we are going to have to make tradeoffs for adverse health effects that might follow small changes in the standards, we would have to have much more precise information than we have now.

The fourth factor is that we do have a problem with fine particulates, fine particulate sulfates. Our agency is moving prudently to meet the obvious need to control these.

The last statement is that the present primary ambient air quality standards are stringent but their safety factors are very modest.

Thank you.

[The tables and charts referred to follow:]

#### PRIMARY AMBIENT AIR QUALITY STANDARDS

Scientifically defensible primary ambient air quality standards must be supported by a broad interlocking technical information base

##### WHAT KINDS OF INFORMATION ARE NEEDED TO CONTROL AN AIR POLLUTANT

1. Measurement methods.
2. Emission sources.
3. Transport and transformations.
4. Air monitoring data base.
5. Health effects.
6. Welfare effects.
7. Predictive models.
8. Control technology.
9. Impact of controls.

##### HOW DOES THE LAW LOOK AT PUBLIC HEALTH?

The Clean Air Act requires that primary ambient air quality standards be set to protect fully the public health with an adequate margin of safety.

Thus, a no-effects threshold for any adverse health effect is assumed.

##### WHO MUST BE PROTECTED?

Both specifically susceptible subgroups and healthy members of the population must be fully protected.

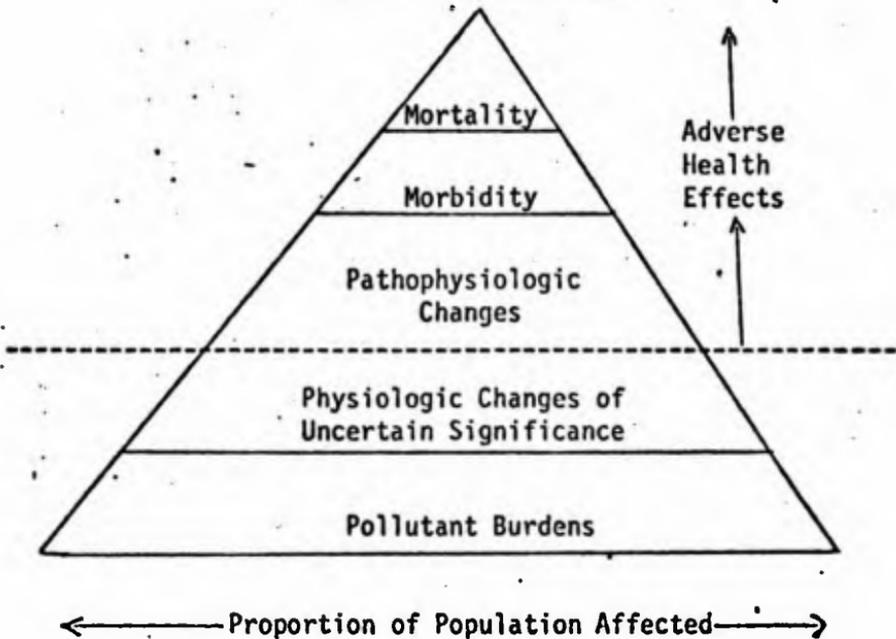
Excluded are persons who require an artificial environment. That is those who are not free living.

##### WHAT IS AN ADVERSE HEALTH EFFECT?

Adverse effects include both aggravation of preexisting diseases and increased frequency of disorders.

Evidence for an increased risk of future disease is an adverse health effect.

**SPECTRUM OF BIOLOGICAL RESPONSE  
TO POLLUTANT EXPOSURE**



**VARIETY OF DISEASES ATTRIBUTABLE TO POLLUTION**

- I. Acute diseases:  
 Common respiratory illnesses  
 Aggravation of preexisting diseases  
     Asthma  
     Heart disease  
     Lung disease  
 Irritation symptoms: Eye, nose, throat, chest

**VARIETY OF DISEASES ATTRIBUTABLE TO POLLUTION**

- II. Chronic diseases:  
 Chronic bronchitis and emphysema  
 Respiratory (and other) cancer  
 Coronary heart disease  
 Congenital abnormalities  
 Impairment of defense mechanisms, resulting in higher risk of multiple diseases

**WHAT SHOULD MINIMALLY ADEQUATE HEALTH INTELLIGENCE ASSESS?**

1. The effects of chronic exposure and the effects of single or repeated short-term exposures.
2. All expected adverse effects.
3. A blend of epidemiology, clinical and toxicology studies.
4. The biologic plausibility, coherence, consistency and exposure-response relationship for each adverse effect.
5. Dose-response relationships for each adverse effect: "least case," "worst case" and "best judgment" threshold estimates for each effect are a realistic minimum.

**ADVERSE HEALTH EFFECTS WHICH MIGHT BE ATTRIBUTED  
TO EXPOSURES INVOLVING SULFUR OXIDES  
AND SUSPENDED PARTICULATES**

Expected Effect	RESEARCH APPROACH		
	Epidemiology	Clinical Studies	Toxicology
Increased susceptibility to acute respiratory disease	Multiple studies	No data	Isolated studies
Aggravation of asthma	Few replicated studies	No data	No data
Aggravation of heart or lung disease	Multiple studies	No data	No data
Irritation symptoms	Multiple studies	Few replicated studies	No data
Altered lung function	Multiple studies	Few replicated studies	Multiple studies
Increased risk of chronic lung disease	Multiple studies	No data	No data
Cancer	No data	No data	No data
Congenital defects	No data	No data	No data
Impaired defense mechanisms	No data	No data	No data

**BEST JUDGMENT  
EXPOSURE THRESHOLDS FOR ADVERSE EFFECTS  
(SHORT TERM)**

EFFECTS	24-HOUR THRESHOLD ( $\mu\text{g}/\text{m}^3$ )		
	Sulfur Dioxide	Total Suspended Particulates	Particulate Sulfate
Mortality Harvest	300 to 400	250 to 300	No Data
Aggravation of symptoms in elderly	365	80 to 100	8 to 10
Aggravation of asthma	180 to 250	100	8 to 10
Acute irritation symptoms	340	170	No Data
Present Standard	365	260	No Standard

THRESHOLD ESTIMATES FOR ADVERSE HEALTH EFFECTS ATTRIBUTABLE TO SULFUR DIOXIDE (SO<sub>2</sub>) PARTICULATE SULFATES AND TOTAL SUSPENDED PARTICULATES (TSP) (Short Term)

Adverse Effect on Human Health	Research Approach	Type of Estimate	Exposure			Safety Factor (%) Contained in Primary Standard		
			Level $\mu\text{g}/\text{m}^3$		Duration	SO <sub>2</sub> Std. $365 \mu\text{g}/\text{m}^3$ (No. std.)	TSP Std. $260 \mu\text{g}/\text{m}^3$ (No. std.)	
			SO <sub>2</sub>	Particulate Sulfates				TSP
Mortality Harvest	Epidemiology	Worst Case Least Case Best Judgment	30 500 300-400	No Data No Data No Data	250 500 250-300	24 hrs. 24 hrs. 24 hrs.	None 37 None to 9	No Data None None to 15
Aggravation of chronic lung disease	Epidemiology	Worst Case Least Case Best Judgment	119 500 365	6 No Effect 10	100 >250 >250	24 hrs. 24 hrs. 24 hrs.	None 37 None to 37	No Data None None
Aggravation of asthma	Epidemiology	Worst Case Least Case Best Judgment	23 >365	6 10 8-10	75 >260 100	24 hrs. 24 hrs. 24 hrs.	None Less than 100 None	* None None None
Aggravation of combined heart and lung disease	Epidemiology	Worst Case Least Case Best Judgment	180 >365 365 to 500	6 10 to 17 8 to 10	61 260 70-100	24 hrs. 24 hrs. 24 hrs.	None Less than 100 None to 37	None None None
Irritation of respiratory tract	Epidemiology	Worst Case Least Case Point Est.	340 340 340	No Data No Data No Data	170 192 170	2-3 days 2-3 days 2-3 days	None None None	No Data No Data No Data

Safety Factor = Effects threshold minus standard divided by standard x 100.

BEST JUDGMENT  
EXPOSURE THRESHOLDS FOR ADVERSE EFFECTS  
(LONG TERM)

EFFECT	Annual THRESHOLD ( $\mu\text{g}/\text{m}^3$ )		
	Sulfur Dioxide	Total Suspended Particulate	Particulate Sulfate
Decreased lung function of children	200	100	11
Increased acute lower respiratory disease in families	90 to 100	80 to 100	9
Increased prevalence of chronic bronchitis	95	100	14
Present Standard	80	75 (Geometric)	No Standard

THRESHOLD ESTIMATES FOR ADVERSE HEALTH EFFECTS ATTRIBUTABLE TO SULFUR DIOXIDE (SO<sub>2</sub>),  
PARTICULATE SULFATES AND TOTAL SUSPENDED PARTICULATES (TSP)  
(Long Term Exposures)

Adverse Effect on Human Health	Research Approach	Type of Estimate	EXPOSURES			Safety Factor (%)		
			SO <sub>2</sub> Level (µg/m <sup>3</sup> )	Duration In Years		SO <sub>2</sub> Contained in Primary Sulfates (No. Std.)	TSP µg/m <sup>3</sup>	
				Suspended Sulfates	TSP			
Excess Mortality	Epidemiology	Worst Case Least Case Best Judgment	120-198 No Data 250 No Data 250	No Data 135 175 No Data 175	unknown unknown unknown	50 to 148 212 212	None None None None None	80 133 133
Increase in Prevalence of Chronic Bronchitis	Epidemiology	Worst Case Least Case Best Judgment	50-90 404 95	9 20 14	60-100 180 100	None to 12 405 19	None None None	None to 33 140 33
Increase in frequency or severity of acute respiratory illness in otherwise healthy families	Epidemiology	Worst Case Least Case Best Judgment	91 200 91	9 23 9	75 200 100	14 150 14	None None None	None 167 33
Increase in family illness during influenza epidemics	Epidemiology	Worst Case Least Case Best Judgment	106 250 106	14 18 14	126 151 151	33 212 33	None None None	68 101 101
Increase in lower respiratory tract infections in asthmatics	Epidemiology	Worst Case Least Case Best Judgment	32 186	8 20	100 No Effect	None 133	None None	33 -
Subtle decrease in ventilatory function	Epidemiology	Worst Case Least Case Best Judgment	118-131 400-500 200	9 28 11	75-141 200 100	48-64 400-525 150	None None None	None to 88 167 33

Safety Factor = Effects threshold minus standard divided by standard x 100.

ADVERSE EFFECTS WHICH MIGHT BE  
ATTRIBUTED TO  
NITROGEN DIOXIDE EXPOSURES

EXPECTED EFFECT	RESEARCH APPROACH		
	EPIDEMIOLOGY	CLINICAL	TOXICOLOGY
			AT LOW EXPOSURE LEVELS ( $<9000 \mu\text{g}/\text{m}^3$ )
INCREASED SUSCEPTIBILITY TO ACUTE RESPIRATORY DISEASE	THREE REPLICATED STUDIES	NO DATA	REPLICATED RODENT STUDIES
INCREASED SEVERITY OF ACUTE RESPIRATORY DISEASE	TWO REPLICATED STUDIES	NO DATA	TWO STUDIES WITH RODENTS
INCREASED RISK OF CHRONIC RESPIRATORY DISEASE	TWO STUDIES SHOWED A WORRI-SOME FINDING OF REDUCED VENTILATORY FUNCTION IN CHILDREN	ANECDOTAL CASE REPORTS	FOUR STUDIES IN RODENTS
AGGRAVATION OF ASTHMA	ONE STUDY SUGGEST PARTICULATE NITRATES AGGRAVATE ASTHMA	NO DATA	NO DATA
AGGRAVATION OF HEART AND LUNG DISORDERS	NO DATA	NO DATA	NO DATA
CARCINOGENESIS*	NO DATA	NO DATA	NO DATA
FETOTOXICITY OR MUTAGENESIS	NO DATA	NO DATA	NO DATA

\*THROUGH NITRATES or NITRITES

BEST JUDGMENT  
EXPOSURE THRESHOLDS FOR ADVERSE EFFECTS  
DUE TO NITROGEN DIOXIDE  
(SHORT TERM)

EFFECT	THRESHOLD ( $\mu\text{g}/\text{m}^3$ )
Diminished exercise tolerance	9400 for 15 minutes
Susceptibility to acute respiratory infection	2800 for 2 hours *
Diminished lung function	3800 for one hour
Present Standard	Equivalent to $1400 \mu\text{g}/\text{m}^3$ for one hour

\*Based on animal studies only

THRESHOLD ESTIMATES FOR ADVERSE HEALTH EFFECTS ATTRIBUTABLE TO NITROGEN DIOXIDE  
(Short Term)

Adverse Effect	Research Approach	Type of Estimate	Exposure		Safety Factor ( * Contained in Prim. Standard (1400 µg/m <sup>3</sup> equivalent)
			Level µg/m <sup>3</sup>	Duration	
Odor Perception	Clinical	Worst Case Least Case Best Judgment	225	5 minutes	None None None
			835	3 minutes	
			225	5 minutes	
Diminished exercise tolerance	Clinical	Worst Case Least Case Best Judgment	1900	15 minutes	36** 936** 571**
			14500	6 hours	
			9400	15 minutes	
Susceptibility to acute respiratory infection	Toxicology	Worst Case Least Case Best Judgment	2800	2 hours	100 1900 100
			28200	3 hours	
			2800	2 hours	
Diminished Lung function	Clinical	Worst Case Least Case Best Judgment	3000	1 hour	114 571** 171
			9400	15 minutes	
			3800	1 hour	
Fatality	Toxicology	Worst Case Least Case Best Judgment	165,000	4 hours	11,685 67,043 13,329
			940,000	1-2 hours	
			188,000	1 hour	

\*Safety Factor = Effects threshold minus standard divided by standard x 100.

\*\*Assumes hourly exposure at same level

BEST JUDGMENT  
EXPOSURE THRESHOLDS FOR ADVERSE EFFECTS  
DUE TO NITROGEN DIOXIDE  
(LONG TERM)

EFFECT	THRESHOLD ( $\mu\text{g}/\text{m}^3$ )*
Increased susceptibility to acute respiratory infection	188
Increased severity of acute respiratory disease	141
Increased risk of chronic respiratory disease	470**
Decreased lung function	188
Present Standard	100 $\mu\text{g}/\text{m}^3$ annual average

\*Annual average equivalent

\*\*Based solely on animal studies

THRESHOLD ESTIMATES FOR ADVERSE HEALTH EFFECTS ATTRIBUTABLE TO NITROGEN DIOXIDE  
(Long-Term)

Adverse Effect on Human Health	Research Approach	Type of Estimate	Exposure		Safety Factor (S)*	
			Level $\mu\text{g}/\text{m}^3$	Duration	Annual Average Equivalent (100 $\mu\text{g}/\text{m}^3$ )	Contained in Primary Standard
Increased susceptibility to acute respiratory infection	Epidemiology	Worst Case Least Case Best Judgment	188 564 376	For ten percent** of hrs. or days for 3 yrs. or less	(94) (282) (188)	None 182 88
	Toxicology	Worst Case Least Case Best Judgment	940 9400 940	3 months 3 months 3 months		20 to 400 9300 90
Increased severity of acute respiratory disease	Epidemiology	Worst Case Least Case Best Judgment	188 470 282	For ten percent** of hrs. for at least 1 year	(94) (235) (141)	None 135 41
	Toxicology	Worst Case Least Case Best Judgment	940 3760 940	For 6 or more hrs. each day for 3 or more months		940 3660 940
Increased frequency of chronic respiratory disease symptoms	Epidemiology	Point Estimate	No increase after 3-years exposure to levels between 188 $\mu\text{g}/\text{m}^3$ and 564 $\mu\text{g}/\text{m}^3$ on ten percent of hours or days		Not Applicable	
	Toxicology	Worst Case Least Case Best Judgment	940 3800 940	For 6 hrs. or more each day for 3 months or more	(470) (1900) (470)	370 1830 370
Decreased Lung Function	Epidemiology	Worst Case Least Case Best Judgment	188	For ten percent of hrs. for 3 years or less	(94) (282) (376)	None 182 276
			564			
Aggravation** of Chronic heart and lung diseases			NO DATA			
Carcinogenesis**			NO DATA			
Fetotoxicity and ** Mutagenesis			NO DATA			

\*Safety Factor = Effects threshold minus standard divided by standard x 100.

\*\*Through either nitrogen dioxide or nitrous acid - nitric acid - nitrate route.

BEST JUDGMENT EXPOSURE THRESHOLDS FOR ADVERSE EFFECTS  
DUE TO CARBON MONOXIDE  
(Short Term, 8 Hours)

Effect	Threshold $\text{mg}/\text{m}^3$		
	Rest	Light Activity	Exercise
Diminished Exercise Tolerance in Heart Disease Patients	29	24	23
Decreased Physical Performance in Normal Adults	71	59	55
Interference with Mental Activity	50	41	39
Present Standard (8 hour)	10 $\text{mg}/\text{m}^3$		

**BEST JUDGMENT EXPOSURE THRESHOLDS FOR ADVERSE EFFECTS  
DUE TO CARBDN MONOXIDE  
(Short Term, One Hour)**

EFFECT	Threshold $\text{mg}/\text{m}^3$		
	Rest	Light Activity	Moderate Exercise
Diminished Exercise Tolerance in Heart Disease Patients	143	90	73
Decreased Physical Performance in Normal Adults	355	223	179
Interference with Mental Activity	249	156	125
Present Standard (One Hour)	40 $\text{mg}/\text{m}^3$		

**BEST JUDGMENT EXPOSURE THRESHOLDS FOR ADVERSE EFFECTS  
DUE TO CARBON MONOXIDE  
(Short Term, 8 hours)**

Effect	Threshold % Carboxyhemoglobin		
	Rest	Light Activity	Exercise
Diminished Exercise Tolerance in Heart Disease Patients	3	3	3
Decreased Physical Performance in Normal Adults	7	7	7
Interference with Mental Activity	5	5	5
Present Standard (10 $\text{mg}/\text{m}^3$ for 8 hrs.)	1.4	1.4	1.5

THRESHOLD ESTIMATES FOR ADVERSE HEALTH EFFECTS ATTRIBUTABLE TO CARBON MONOXIDE  
(Long Term)

Adverse Effect	Research Approach	Type of Estimate	Carboxyhemoglobin Level (%)	8 Hour Equivalent CO Level $\text{m}^3/\text{m}^3$		Safety Factor (%) * Contained in Primary Standard
				Rest	Light Moderate Activity Exercise	
Increased Risk of Atherosclerosis	Epidemiological Clinical and Toxicological	Worst Case Least Case Best Judgment	5 No Effect Insufficient Evidence	50	41 39	400 310 290
				Not Applicable		Not Applicable
Impaired Fetal Development or Survival	Epidemiological Toxicological	Worst Case Least Case Best Judgment	5-10 No Effect Insufficient Evidence	50-103	41-84 39-79	100-930 310-740 290-690
				Not Applicable		Not Applicable
Altered Tolerance to Common Drugs	Toxicologic	Worst Case Least Case Best Judgment	8-15 No Effect Insufficient Evidence	82-156	67-127 63-119	720-1460 570-1170 530-1090
				Not Applicable		No Applicable

\* Safety Factor - Effects threshold minus standard divided by standard x 100.

## ADVERSE HEALTH EFFECTS WHICH MIGHT BE ATTRIBUTED TO PHOTOCHEMICAL OXIDANT EXPOSURES

Expected Effect	Research Approach		
	Epidemiology	Clinical Studies	Toxicology
Aggravation of asthma	Single Study	No Data	No Data
Aggravation of chronic obstructive lung disease	Three early studies	Two early studies	No Data
Aggravation of heart disease	Three early studies	No Data	No Data
Aggravation of hematopoietic disorders	No Data	Single study	No Data
Accelerated aging	No Data	No Data	No Data
Irritation of eyes and respiratory tract in healthy subjects	Multiple studies	Multiple studies	Multiple studies
Decreased cardiopulmonary reserve in healthy subjects	Two studies	Two studies	No Data
Increased susceptibility acute respiratory disease	Single study	No Data	Multiple studies
Increased risk of chronic lung disease	Single study	Single study	Two studies
Respiratory malignancies	Single study	No Data	Single study
Mutagenesis, embryotoxicity and teratogenesis	No Data	No Data	Two Studies

BEST JUDGMENT  
EXPOSURE THRESHOLDS FOR AVERSE EFFECTS  
DUE TO PHOTOCHEMICAL OXIDANTS  
(SHORT TERM)

EFFECT	THRESHOLD	
	$\mu\text{g}/\text{m}^3$	PPM
AGGRAVATION OF ASTHMA	500	.25
AGGRAVATION OF CHRONIC LUNG DISEASE	<500	<.25
AGGRAVATION OF CERTAIN ANEMIAS	400 to 500	.20 to .25
IRRITATION OF EYES	200 to 300	.10 to .15
IRRITATION OF RESPIRATORY TRACT IN OTHERWISE HEALTHY ADULTS	500 to 600	.25 to .30
DECREASED CARDIOPULMONARY RESERVE IN HEALTHY ADULTS	240 to 740	.12 to .51
INCREASED SUSCEPTIBILITY TO ACUTE RESPIRATORY DISEASE	160 *	.08*
RISK OF MUTATIONS	400 to 600 *	.20 to .30*
IMPAIRED, FETAL SURVIVAL	200 to 400 *	.10 to .20*
DECREASED VISUAL ACUITY	400 to 1000 *	.20 to .50*
PRESENT STANDARD (one hour)	160 $\mu\text{g}/\text{m}^3$	.08

\* INVOLVE EXPOSURES OF THREE TO SEVEN HOURS DAILY FOR UP TO THREE WEEKS

THRESHOLD ESTIMATES FOR ADVERSE HEALTH EFFECTS ATTRIBUTABLE TO PHOTOCHEMICAL OXIDANTS

Adverse Effect	Research Approach	Type of Estimate	Exposure		Safety Factor** Contained in Primary Standard (160 µg/m <sup>3</sup> )
			Level µg/m <sup>3</sup>	Duration	
Aggravation of asthma	Epidemiology	Point Est.	500	Peak Hourly Exposure	212
Aggravation of chronic lung disease	Clinical	Worst Case Least Case Best Judgment	100 500 500	Peak Hourly Exposures	None 212 < 212
Aggravation of certain anemias	Toxicology and Clinical	Worst Case Least Case Best Judgment	400 500 400 to 500	One Half to One Hour	< 150 < 212 150 to 212
Irritation of eyes	Epidemiology and Clinical	Worst Case Least Case Best Judgment	100 to 200 300 200 to 300	Peak Hourly Exposure	None to 25 88 88 to 150
Irritation of respiratory tract in otherwise healthy adults	Epidemiology and Clinical	Worst Case Least Case Best Judgment	500 600 500 to 600	Peak Hourly Exposure	< 212 > 275 212 to 275
Decreased cardio-pulmonary reserve in healthy subjects	Epidemiology and Clinical	Worst Case Least Case Best Judgment	200 to 240 > 740 240 to 740	Peak Hourly Exposure	25 to 50 363 50 to 363
Increased susceptibility for acute respiratory disease	Toxicology	Worst Case Least Case Best Judgment	160 > 1340 160	Three Hour Exposures	None** > 738** None**
Risk of Mutagenesis	Toxicology	Worst Case Least Case Best Judgment	< 400 600 400 to 600	For five hours or more	< 150** 275** 150 to 275**
Impaired fetal development or survival	Toxicology	Worst Case Least Case Best Judgment	< 200 > 400 400 to 600	For seven hours daily for three weeks	< 25** > 150** 150 to 275**
Decreased Visual Acuity	Clinical	Worst Case Least Case Best Judgment	< 400 > 1000 400 to 1000	For three hours	< 150** > 525** 150 to 525**
Aggravation of aging	No Estimates Possible				
Respiratory Malignancies	No Estimates Possible				
Aggravation of Heart Disease	No Estimates Possible				

\*Safety Factor = Standard minus effects threshold divided by standard x 100.

\*\*Underestimates the true safety factor because exposures of more than one hour have been compared with a one hour standard.

#### WHAT FACTORS SHOULD BE KEPT IN MIND WHEN CONSIDERING THE SAFETY MARGIN CONTAINED IN THE PRIMARY AMBIENT AIR QUALITY STANDARDS?

1. Safety margins are not as precise as their calculation might seem to indicate because of underlying uncertainties—

In measurement methods; and

In best judgment estimates of effects threshold.

2. Consistency in safety margins was not a major consideration in setting primary ambient air quality standards.

3. In general, the apparent safety margins in the primary standards have decreased as more complete health information becomes available.

4. The safety margins contained in primary ambient air quality standards are much smaller than those maintained when dealing with pesticides and radiation.

## SAFETY FACTORS CONTAINED IN PRIMARY AMBIENT AIR QUALITY STANDARDS

POLLUTANT	Lowest Best Judgment Estimate for an Effects Threshold	Adverse Effect	Standard	Safety Factor %*		For Best Judgment Estimates
				Lowest Best Judgment Estimate for an Effects Threshold		
Sulfur Dioxide	300 to 400 $\mu\text{g}/\text{m}^3$ (short-term) 91 $\mu\text{g}/\text{m}^3$ (long-term)	Mortality Harvest Increased frequency of acute respiratory disease	365 $\mu\text{g}/\text{m}^3$ 80 $\mu\text{g}/\text{m}^3$	None 14		None 14 to 212 0 37
Suspended Sulfates	8 $\mu\text{g}/\text{m}^3$ (short-term) 8 $\mu\text{g}/\text{m}^3$ (long-term)	Increased infections in asthmatics Increased infections in asthmatics	None None	None None		None None
Total Suspended Particulates	70 to 250 $\mu\text{g}/\text{m}^3$ (short-term) 100 $\mu\text{g}/\text{m}^3$ (long-term)	Aggravation of respiratory diseases Increased prevalence in chronic bronchitis	260 $\mu\text{g}/\text{m}^3$ 75 $\mu\text{g}/\text{m}^3$	None 33		None 33 to 133 0 15
Nitrogen Dioxide	141 $\mu\text{g}/\text{m}^3$ (long-term)	Increased severity of acute respiratory illness	100 $\mu\text{g}/\text{m}^3$	41		41 to 370
Carbon Monoxide	23 (8 hour) 73 (1 hour)	Diminished exercise tolerance in heart patients	10 $\text{mg}/\text{m}^3$ 40 $\text{mg}/\text{m}^3$	130** 82**		130 to 610** 82 to 788**
Photochemical Oxidants	200 (short-term)	Increased susceptibility to infection	160	25		None to 363

\*Safety Factor = Effects threshold minus standard divided by standard x 100

\*\*Safety Factors based upon carboxyhemoglobin levels would be 100% for the 8 hour standard with a range of 100 to 100 percent overall best judgment estimates. For the one hour standard the lowest safety factor would be 67 percent with a range of 67 to 400%.

## WHERE ARE WE NOW?

1. We lack an adequate information base to assure scientifically incontrovertible primary ambient air quality standards.
2. With a strengthened overall air pollution research program we will require several years to obtain this information.
3. Cost-benefit approaches to air quality control require more data than the current threshold approach.
4. EPA is moving prudently to meet the obvious need to control fine particulates in ambient air.
5. The present primary ambient air quality standards are stringent but their safety factors seem modest.

Mr. SATTERFIELD [presiding]. Thank you very much.

Are we ready to proceed with questions?

Mr. QUARLES. Yes; you may proceed however you wish.

Mr. SATTERFIELD. Mr. Preyer?

Mr. PREYER. Thank you, Mr. Chairman. I want to first thank Dr. Finklea for his testimony and say we in North Carolina are very proud of the work that the National Environmental Research Center is doing at the Research Triangle.

I have issued an invitation to our subcommittee to visit there and see the work firsthand. I hope we will be able to visit there during these hearings, which would be a very appropriate time.

Your testimony was pretty hard going for a wayfaring man like me, but I gather the general summation of it would be that our standards are not too stringent in any area, and that you would be against relaxing them in any way.

Dr. FINKLEA. That is correct, sir.

Mr. PREYER. Do you suggest strengthening any particular standards?

Dr. FINKLEA. I think our Agency is quite straightforward in saying that we do need a strengthened research program to get the information needed in all of the nine areas that I referred to in my testimony, for each of the primary ambient air quality pollutants.

We also have to make a much better effort to get the information needed for the control of fine particulates.

Mr. PREYER. How do our ambient air quality standards compare with those set by other countries? Do you have a general estimate?

Dr. FINKLEA. Yes, sir. The primary ambient air quality standards set in the United States when compared to those advocated by the World Health Organization or established in most other countries, are not at all unreasonable.

We find that the standards in the United States on a numerical basis are usually a little less stringent than those established in many other countries.

However, there is one other point. That is that our law says that we must attain these standards in a very short period of time. In most other countries there is a much longer period of time required for the attainment of the standards.

Also, the countries are allowed to have variances in many case for certain areas that are most heavily impacted by the pollutant problem. I should qualify this by saying that a number of other countries in Eastern Europe have not established air quality standards for the automotive pollutants because they don't have the automotive transportation we do in this country.

The World Health Organization has advised that the nitrogen oxides problem be carefully studied but like a number of other nations have not set ambient air quality standards for this pollutant.

Mr. PREYER. The World Health Organization has not yet set ambient air quality standards?

Dr. FINKLEA. For nitrogen oxides. They have for the others.

Mr. PREYER. The other standards they have set, I gather, are a little stricter than ours but allow for a longer implementation period.

Dr. FINKLEA. Yes, sir. That is true in most countries.

Mr. PREYER. How do the standards recommended by the National Academy of Sciences compare with the standards that we have now?

Dr. FINKLEA. The National Academy of Sciences has studied the problem of emergency short-term exposures for the Environmental Protection Agency.

In general, the standards set by EPA are consistent with their recommendations with the exception of the standards for carbon monoxide. The standard recommended by the National Academy of Sciences was roughly 10 parts per million on a 1-hour basis lower than the standard recommended by EPA. That is because the National Academy was considering the necessity to protect against adverse effects on human mental activity which would occur at a level roughly one-half of the level at which we in EPA believe that an adverse effect now occurs.

Mr. PREYER. How about the standard recommended by the AMA? There has been some discussion of that here today.

Dr. FINKLEA. It is my recollection that the American Medical Association endorsed the primary ambient air quality standard position of the Environmental Air Protection Agency.

I think constituent groups in the AMA had been through other activity in their environmental group concerned with photochemical oxidants and recommended that that level for occupational exposure be set as low as practicable.

Mr. PREYER. Apparently there is much more to be learned in this area. Your charts show many areas in which there is no data. Is our research on this subject adequate at this time? Dr. Roy went into that somewhat this morning. How much of EPA's research budget, for example, is devoted to the health effects of air pollution?

Dr. FINKLEA. I think it is about between 6 and 7 percent, although Dr. Greenfield might want to clarify that.

Dr. GREENFIELD. When you add in all the health effects EPA is doing it is roughly one-sixth of the research budget going to health effects, about \$20 million a year.

Mr. PREYER. Do you think that is adequate?

Dr. GREENFIELD. That is a question you should never ask a research person or research director. Obviously, I never have sufficient money to do the work that I have to do. Within the Agency's budget limitations, however, I think we are getting a very fair proportion of the moneys required to operate.

Mr. PREYER. One of the questions that occurs to us is whether more money and more manpower might not prevent the kind of problem that occurred with the nitrogen oxide standard where apparently we had not had the right kind of monitoring or measuring tools and therefore promulgated too stringent a standard.

Mr. QUARLES. Sir, could I make a small point here.

I think not that we had promulgated too stringent a standard, but that the number of areas where that standard was violated are much fewer than we believed.

Mr. PREYER. Yes. The measuring is what went wrong. I have a recollection from 3 years ago that on the question of monitoring air standards that we were told, one, there were not anywhere near enough qualified people in the country to monitor standards; and two, there was not anywhere near the technical equipment you needed to monitor air standards.

Is that still the case, or have we licked those problems?

Dr. GREENFIELD. A large part of the air standards network or air monitoring network is run not by the Federal Government but by local and State governments.

In the last 3 years, people have been trained at the State and local level. EPA has helped train some of them. I can't answer whether or not there is an adequate number out there now, but these monitoring networks are in operation certainly. As far as the instrumentation goes, we are constantly working to try to improve this instrumentation.

In the nitrogen dioxide case, we have at least three methods under study right now to provide an improved method of measuring the presence of NO<sub>x</sub> in the atmosphere. I think it is the nature of the work itself that you are trying to constantly improve what you have in order to get a more effective way to do the job.

Mr. QUARLES. Let me add an additional note to that.

The implementation plans layout plans for a monitoring network considered necessary and satisfactory for monitoring the air in each of the regions.

We have now reached the point where in about half of the air quality control regions the entire network is in place. We expect that at the end of another year the networks will be established in virtually all of the regions, so, we are at a point of completing the installation of a national system that is considered necessary for what we should have to monitor air quality.

Mr. PREYER. It is in place in about half of the regions and it will be totally in place in another year?

Mr. QUARLES. It is completely in place in half, partially in place in many others. We are told it will be completed in another year.

Mr. PREYER. From my recollection that is considerable progress.

Mr. QUARLES. Yes, sir, there has been great progress in this area.

Mr. PREYER. I recall that we were supposed to be short something like 2,000 technicians to operate this network. But you are saying that we are not short those technicians now?

Mr. QUARLES. The shortages are being reduced. Part of it is technicians, part of it is equipment. Undoubtedly we will have the experience we have had in other areas in which improvements are made on an ongoing basis. So the first results may not be as thoroughly reliable as we would expect to achieve a short while thereafter.

Mr. PREYER. Thank you very much.

Mr. SATTERFIELD. Dr. Carter?

Mr. CARTER. Thank you, Mr. Chairman.

Certainly we have heard a very good presentation today, some very technical facts and figures. It was quite interesting. It was a little difficult for us to hear all of this good information.

What is the lethal concentration, the smallest lethal concentration of carbon monoxide please, sir?

Dr. FINKLEA. You do not get symptoms of headache and that sort of thing until you get up to 20-percent carboxyhemoglobin.

Mr. CARTER. Carboxyhemoglobin refers to the union of carbon monoxide with hemoglobin. I am talking about concentration in the air at which the patient when exposed, the small amount of it that will cause death. Could you give me that answer?

Dr. FINKLEA. It is many, many times the present ambient air quality standards, sir.

Mr. CARTER. And what is that?

Dr. FINKLEA. I am sorry, sir, I don't recall right now.

Mr. CARTER. I think 1 percent is generally regarded as the lethal level of carbon monoxide. I could be wrong. It is interesting that you did not respond or that your response was a little bit negative about the effect of these different things on health. Of course, we have had many, many cases of air pollution and as a result of such concentrations of pollution, increases in sickness, bronchitis, asthma, pneumonia, and so on. Is that not correct?

Dr. FINKLEA. That is correct, sir.

Mr. CARTER. I understand there has been a study conducted at Chattanooga, Tenn., concerning the health of young children there.

Could you tell me about that study?

Dr. FINKLEA. Yes, sir, I believe you are referring to the Chattanooga Schoolchildren Study which is a study conducted in the neighborhoods around the Volunteer Army Arsenal. These were studies of families that were exposed to increased levels of nitrogen dioxide as well as some nitric acid mist and sulfuric acid mist in the ambient air.

The schoolchildren in that area had decreased lung function and increased susceptibility to acute respiratory disease at ambient air quality standards of nitrogen dioxides that varied between 141 and 188 micrograms per cubic meter during the year.

Mr. CARTER. Do you think it was the nitrous oxide that caused this difficulty?

Dr. FINKLEA. No, sir, this exposure was a mixture of nitrogen dioxide and acid mist.

Mr. CARTER. Which was the causative factor then?

Dr. FINKLEA. From community studies it is very difficult to completely disentangle.

Mr. CARTER. Actually it may well be the sulfuric acid or the nitric acid, is that correct?

Dr. FINKLEA. Yes, sir, they may cause an adverse effect. We do have other studies that showed that an increased susceptibility to respiratory disease occurring in the presence of nitrogen dioxide alone. These studies were at levels about three times as high as the level in Chattanooga, though.

Mr. CARTER. I notice you spoke of the mortality harvest. I have heard of wheat harvest and corn harvest. Today at lunch I talked with another Member of the House of Representatives who spoke about

harvesting doves. You know, this harvest of humans is just hard for me to take. I am not in sympathy with it. I think all of us want to live as long as we can. I would like to have a better term than mortality harvest.

My goodness gracious, let us get away from that, not harvest our people.

Dr. FINKLEA. This is an increase in daily mortality. The term harvest was used because the increased numbers of deaths seemed to occur among those members of the population who were quite ill and in large part probably institutionalized and thus with the Clean Air Act specifying that we should protect all free living individuals I just wanted to call the committee's attention that this effect was occurring in people who were already very very sick.

Mr. QUARLES. I think the terminology comes from the Grim Reaper.

Mr. CARTER. From What?

Mr. QUARLES. Comes from use of the term "The Grim Reaper."

Mr. CARTER. Oh, yes; my goodness.

How is the Wankel engine performing?

Dr. GREENFIELD. In what sense do you mean performing?

Mr. CARTER. In all senses.

Dr. GREENFIELD. As you know, it is the same engine that is used in the Japanese rotary engine car, the Mazda. It seems to be performing quite well. Our concerns with that engine lie in the fact that it uses a great deal of oil in its operation. Hence our concern would be what additives are in that oil and hence what additional pollutants would be coming out of the tail pipe.

Mr. CARTER. We understand it has already passed your standards. Is that correct?

Dr. GREENFIELD. No; we are not talking about the carbon monoxide and hydrocarbon standards. We are talking about additional additives in the oil.

Mr. CARTER. Has it reached your standards, the standards that you have projected previous to this time?

Mr. QUARLES. Yes, sir, I believe it has satisfied the standards for carbon monoxide and hydrocarbons.

Mr. CARTER. There are other things about this car causing difficulty, I understand. Is that correct? What about the oil, the excessive use of oil by this machine? What happens to that oil? What becomes of it? What does it form? Is it toxic?

Dr. FINKLEA. Sir, you are referring to the research being done on nonregulated emissions from mobile sources such as automobiles, the particulate emissions from cars including the two problems that you gentlemen asked us about this morning plus this particular problem are three that are being considered.

I think we are concerned that as oil consumption increases in autos of whatever engine type that we will have increased emissions of polynuclear aromatic particles.

Mr. CARTER. Are these carcinogenic?

Dr. FINKLEA. A number of compounds which are potentially carcinogenic have been identified in auto exhaust.

Mr. CARTER. A number? Just about all of it is carcinogenic, is it not?

Dr. FINKLEA. These were a number of specific different carcinogens.

Mr. CARTER. You have eliminated perhaps some. You have eliminated six or got them down to an acceptable level. But at the same time this particular automobile which you have recommended as having passed safety standards is now found to be emitting very carcinogenic material, is it not?

Dr. FINKLEA. I don't think we have the quantitative information on this, sir. We know this particular automobile uses more oil.

Mr. CARTER. The only reason why you haven't got that information though is really because you have not tested it, is that correct?

Dr. FINKLEA. This has not been evaluated, that is right.

Mr. CARTER. In other words, you have concentrated on just part of the picture. You have not gotten the whole picture; is that correct? You may be overlooking, you may be swapping a devil for a witch in other words, is that correct?

Mr. QUARLES. We have compensated—

Mr. CARTER. Would you answer my question?

Mr. QUARLES. May I provide some comment in response to your question?

Mr. CARTER. All right, sir.

Mr. QUARLES. We have been in our research work and in our regulatory work focusing on many of the most known and obvious problems and other pollution problems which are suspected to be serious.

One of the principal thrusts of the presentation which Dr. Finklea just provided was to indicate what we know and what we don't know. I hope it was obvious, it was intended to be obvious, from that presentation that there is a great deal that we regulate on the basis of what we do know.

We have not recommended the Mazda engine as passing standards. We test cars to determine whether or not they do pass the standards. We either pass them or we don't pass them. This was passed because it passed the tests that we have for the pollutants which we now regulate.

At the same time we are conducting research on other problems which we suspect may be associated with the automobile.

As we learn more in this field, as in other fields, we are undoubtedly going to find that some additional regulation should be established and in many instances we have the authority to establish additional regulatory standards once we have the knowledge to warrant them.

Mr. CARTER. In fact, when you check the aromatic substances emitted by the Wankel engine you may find them more productive of cancer than the six pollutants which you have controlled; is that correct?

Mr. QUARLES. The key word in that sentence is "may." In reference to that I obviously can't answer no.

Mr. CARTER. You can't what?

Mr. QUARLES. The answer to that question has to be correct.

Mr. CARTER. You mean yes; is that right?

Mr. QUARLES. Yes.

Mr. CARTER. Now, we have done the same thing I think with other engines, have we not? For six pollutants we have established standards. Some cars have met those standards. But at the same time these same cars emit other toxic substances which we were not aware of until recently. Is that true?

Dr. FINKLEA. I think the answer is that we have a great deal to learn about the currently nonregulated emissions from our present genera-

tion of internal combustion engines and from alternative powerplants that have been proposed. That is correct.

Mr. CARTER. You know exactly what I am driving at. I believe you are jumping around a little bit. Actually you control the six pollutants which you have listed but these same cars emit sulfuric acid and also platinum. Is that not correct?

Mr. GREENFIELD. Mr. Carter, I think, if I may answer, the six pollutants that we control right now are the six pollutants that were mandated in the Clean Air Act by Congress. These are the ones that are probably the most obvious large polluters in our society today. They are the ones for which previous work had indicated possible deleterious effects and for which we could with a certain amount of commonsense set thresholds and standards on.

This does not mean that these are the only pollutants that this Agency is concerned with. Rather, in the research program we are concerned with a great number of pollutants.

As Mr. Quarles said, as evidence accumulates which indicates that they indeed are producing deleterious effects in quantities that are present in the environment and which we can control, we will set regulations for them. We have a whole set of fuel and fuel additives regulations, for example, and a program which tests these fuels and fuel additives to determine what they are putting out in the atmosphere as a result of combustion to determine what should or should not be controlled.

Anyone of us will admit anyone of these pollutants is a potential candidate for control but we must await adequate information so that we can act in a justifiable and defensible manner.

Mr. CARTER. You are getting rid of some pollutants but at the same time I believe that at least some scientists say that you are creating other pollutants which may be as damaging as the ones which we are controlling.

Dr. GREENFIELD. Mr. Carter, we are as concerned if not more than concerned than any other group that we do not do this very thing.

Mr. CARTER. Really you have not started checking those?

Dr. GREENFIELD. I beg your pardon.

Mr. CARTER. Have you started checking those?

Dr. GREENFIELD. Yes.

Mr. CARTER. When did you start?

Dr. GREENFIELD. We started the fuel and fuel additives program several years ago. The health aspects of it were designed about a year ago. The program itself is underway now in terms of the fuel and fuel additives portion.

Mr. QUARLES. Dr. Steigerwald would like to comment on this, Dr. Carter. We do not believe that we are moving in the direction of forcing the auto industry toward changes that are producing pollution problems worse than the ones we have.

Dr. STEIGERWALD. If I may talk specifically about the polynuclear organic materials which I think are the cancer causing organic compounds you were talking about.

We have been testing major stationary sources and the automobile since about 1965 in an attempt to understand where these things come from that we have found in the atmospheres.

We have a specific group set up attempting to put them into balance. We know, that nationwide much more of this material comes from coal

combustion and from coal byproducts than comes from automobiles or from trucks.

We have about 25 sources of this material identified. We think we understand how much does go into the atmosphere and how much is in the atmosphere. We feel that it is generally being taken care of pretty well by controls on the particulate matter from powerplants and from other coal combustion sources. We are following closely the automobile and the impact of the automotive control on the polynuclear organic materials that comes from the automobile.

Mr. CARTER. When was it you passed the Mazda and said that it complied?

Dr. STEIGERWALD. I don't know this.

Mr. CARTER. It has been a year ago, has it not?

Mr. QUARLES. The certification of the 1973 models which are now being sold was generally completed last summer. The auto industry is now in advanced stages of presenting information for certification of the 1974 vehicles. So the Mazda was found about a year ago to meet the standards for hydrocarbons and carbon monoxide and  $\text{NO}_x$ .

Mr. CARTER. About a year ago you certified that Mazda reached these standards. At that time you had made no statement about the aromatic compounds which result from the oil which is used by that engine, is that correct?

Mr. QUARLES. That is correct.

Mr. CARTER. You find out now—

Mr. QUARLES. We did not attempt to apply regulatory standards to those types of emission problems because the evidence that was available to us at that time, like the same situation that we have now, does not warrant in our judgment the adoption of standards dealing with these problems at the present time.

Mr. CARTER. What are the components of these aromatic compounds? Aren't they hydrocarbons also?

Mr. QUARLES. I am not in a position, sir, to discuss the chemistry.

Mr. CARTER. You have some scientists with you. Perhaps they can answer.

Dr. STEIGERWALD. The hydrocarbon standard or the term hydrocarbon only has meaning in terms of how it is measured. The automotive standard is an emission standard and it is determined by measuring only gaseous hydrocarbons. All of the polynuclear organics you are talking about are particulate matter and would not be seen by the hydrocarbon measurement techniques nor would they be handled by the hydrocarbon stationary source standard.

Mr. CARTER. However, that is a source of worry at the present time and some scientists think that this consists of quite a problem for the people. The three things, the particulate you mentioned, the sulfuric acid, and the platinum which may well be controlled.

Dr. STEIGERWALD. I think what is key however is to put both the sulfuric acid and the polynuclear organic into perspective with all the other sources. I think we do find that the automobile is a fairly small contributor to the total problem of these two air pollutants.

Mr. QUARLES. I think what we are trying to say is that at this point we believe we have not overlooked the problem and that the regulation reflects the scientific information available.

I would want to express our agreement with what I believe is a fundamental point you are trying to make, sir, that this is an area of concern—

Mr. CARTER. I hope you are not overlooking the problem. I am afraid you may have forgotten about the end products, what you are turning these various pollutants into.

By the way, what is a microgram please, sir? How much is a microgram?

Dr. GREENFIELD. One millionth of a gram.

Mr. CARTER. I believe that during the French Revolution we first learned of a gram, didn't we, and the basis of it was a CC of water at four degrees centigrade, is that correct?

Dr. GREENFIELD. The density of water is one gram per cubic centimeter.

Mr. CARTER. That is one gram. All right. We get down to that one microgram would be one millionth. One millionth of a gram, one millionth of a cubic centimeter—

Dr. GREENFIELD. Only for material that has the same density as water.

Mr. CARTER. A meter is how long?

Dr. GREENFIELD. A hundred centimeters.

Mr. CARTER. It is 39.36 inches, isn't it. You have a chart over there that I have been very interested in. Would you mind drawing on that chart a cubic meter and then a cubic millimeter and show the relative proportions? Could you do that, sir?

Dr. FINKLEA. It is about one thousandth.

Mr. CARTER. A meter would be 39.36 inches, isn't it, 3 inches over 3 feet.

Now put a centimeter on that. That is a hundredth of a meter, a fifth of an inch. And a millimeter would be a thousandth of an inch. A microgram would represent about what part? Could you even draw it on there? Would it show up on that? It wouldn't show up on that. One microgram would not show up on that.

Thank you, sir.

Mr. SATTERFIELD. Mr. Kyros?

Mr. KYROS. Thank you, Mr. Chairman.

Mr. QUARLES, I have a couple of questions.

What about the relationship of your Agency to the Department of Transportation, particularly in regard to what has been done in the field of mass transit? After all, you speak in your testimony on page 15 about transportation control requirements and your concern.

What I want you to tell us first is what do you do with the Department of Transportation?

Mr. QUARLES. The relationship has been close and cordial and productive. We have had a very good relationship with the Department of Transportation. At the higher levels we have worked directly with Mr. Herringer on a great many occasions.

On the staff level we have had a very satisfying exchange of help in receiving from them technical guidance with regard to development of transportation modes that have related particularly to the evaluation of what changes could be made in traffic patterns as well as the more obvious question of a mutual effort to develop support for more work on mass transit.

Mr. KYROS. Do you tell them perhaps about a certain city and say this city will never meet the 1975 goals or whatever the goals are, whatever the plan is for that city, unless you do something about mass transit in this city?

Mr. QUARLES. We work with them particularly in that regard on the problems affecting Los Angeles. We, I believe, have not worked with them in quite that manner yet in regard to large numbers of other cities.

I think we have worked more from the viewpoint of an obvious recognition on our part that cities generally cannot do the job without better mass transit systems and that will require support from the Department of Transportation.

Maybe there is more exchange than I am familiar with but I think I have characterized it.

Mr. KYROS. There has been discussion already about various kinds of engines. Are you prepared now in your Agency to compare advantages and disadvantages of various candidate systems to meet the 1975 hydrocarbon, carbon monoxide standards; for example, diesel, Wankel, stratified charge—that is Honda—and catalytic converter?

Can you begin to compare those systems now?

Mr. QUARLES. Yes, to some degree we certainly can. It is important to bear in mind that while we have a very broad concern with all aspects of the automobile which may be produced and sold, our specific statutory concern is whether or not they meet the standards on emissions.

Any engine which is submitted to us is entitled under the law to be tested, and if it is found to meet the standards, it is entitled to be certified and produced and sold.

Mr. KYROS. Do you consider things like the original purchase price? Suppose they came up with an engine but the purchase price was so exorbitant that the American public could not sustain such a price. Isn't that a factor?

Mr. QUARLES. Yes, it is. In our national situation of whether the technology had been developed that would be capable of meeting the 1975 standards, we took that further factor into account. It was one of the factors which led to the determination that the technology had not been developed for 1975 in time to meet the standard as originally set by the statute.

Mr. KYROS. Of course, you say 1975 standards. You have now suspended them until 1976.

Mr. QUARLES. They have become the 1976 standards.

Mr. KYROS. You say, in regard to that on page 10, "In the opinion of the Agency, and one in which I concur, it was unwise to mandate this technology nationwide in the course of 1 year's model change."

You said that in your testimony. In other words, the Congress, you thought, made a mistake in trying to set a fixed standard in this bill rather than permitting the discretion to reside in the Agency that was in charge?

Mr. QUARLES. I would like to modify that slightly, sir. I would like to make a slight change in what you said.

Mr. KYROS. I just read what you said. You said it was unwise to mandate this technology nationwide. That is on page 10 of your testimony.

Mr. QUARLES. I did not mean to say, or even to imply, that Congress had made a mistake in its mandate on this subject. We were directed under the statute to evaluate whether the technology had been developed that would enable the auto industry to sell cars meeting the 1975 standards in 1975. We were given discretion to evaluate technology. In the exercise of that discretion, we made the determination that the technology is here, and one could very reasonably and presumably successfully manufacture and sell a significant number of cars for the 1975 model year that would meet the standard, but the mass production problem was so substantial that we felt that if the industry was required to attempt to do that on all cars for the 1975 year, that would be asking too much and we would be running the risk of very severe problems.

Mr. KYROS. So it was not unwise for Congress to mandate, but you have to check up on it and correct the error.

Mr. QUARLES. The Congress gave us discretion to exercise. I don't think there was an error along the line.

Mr. KYROS. One thing for sure, we could not meet the standard for 1975 in mass producing cars.

Mr. QUARLES. That is right. I am trying to be very precise in my answer. There has been a very widespread public belief that the auto industry didn't get the job done which the statute had required it to do, and that we had given them an extra year beyond what the statute had called for.

In some respects, it is all in how you look at the issue, because it was certainly understood by Congress at the time the law was passed that the technology was not available at that time; and further, it was unclear when the technology could be developed.

I believe the fact that the technology has been developed and can be used in 1976 cars represents a success story under this statute, and that the mandate of the statute to get this job done by either the 1975 year or the 1976 year has been accomplished.

Mr. KYROS. Let me ask you this: By going ahead in the way you have gone ahead, suspending the effect of the statute for a year, what levels will the auto companies achieve? They were supposed to achieve 90-percent reduction in carbon monoxide by 1975. What levels of reduction will they achieve? Do you know?

Mr. QUARLES. Yes, sir. I can state to you what the standards will be, and we have confidence that these standards will be met.

Let me express it in terms of a relationship to an uncontrolled car. The cars which were being sold in 1970, 1971, 1972, basically achieved about 50 to 60 percent degree of control over an uncontrolled car. The standards which are now in effect for 1973 and will be for 1974, require that the emissions be brought down to 28 grams per mile of carbon monoxide and 3.1 grams per mile of hydrocarbons, which represent just about exactly a 66-percent degree of control over an uncontrolled car.

So that today's cars are two-thirds pollution free, if you will. The standards which we established nationwide for the 1975 cars will require a reduction of about half in the emissions levels, bringing them down to 15 grams per mile for carbon monoxide and 1.5 grams per mile in hydrocarbons. That is about an 83-percent total reduction over an uncontrolled car.

The statutory standard is substantially below that, of course, down to 3.4 for carbon monoxide and 0.41 for hydrocarbons, represent about a 95-percent and 96-percent reduction over an uncontrolled car.

So there has been a tremendous improvement. This again is something that I think is not widely understood by the general public.

Mr. KYROS. By 1975, you will be at the 83 level?

Mr. QUARLES. Yes, sir.

Mr. KYROS. And 83 from 90 or 95, is that an awfully significant figure?

Mr. QUARLES. Excuse me.

Mr. KYROS. From 83 percent reduction down to 95 percent, that 12-percent increment, is that 12-percent increment an awfully significant increment, or is it an increment that will better the air but at the same time the 83 percent, itself, has bettered it so much that already people will be getting relief from pollution?

Mr. QUARLES. That degree of reduction to 83 percent is a tremendous step forward. The further step to 95 or 96 percent has tremendous importance. When you look at it from the viewpoint of achieving compliance with the air quality standard for the protection of health in the urban communities that now are badly affected by automotive pollution, we have some analyses on this, and I think it might be best for me to submit a more precise statement for the record so that we get this on the record accurately.

If the standards, for example, should be fixed at the present level, at the 83-percent level, then in a very large number of cities we never would achieve compliance with the air quality standards for photochemical oxidants and carbon monoxide. We will, I expect, probably get into questions of transportation control strategies and the difficulties of those but I might point out that roughly 29 cities representing 43 percent of the Nation's population will require by 1975 to 1977 some degree of control in addition to what the new cars are providing. Even with the degree of control required by the full standards, the 90 percent standards for carbon monoxide and hydrocarbons, in 1985 there would be about 11 or 12 cities representing about 11 or 12 percent of our population which will require transportation control strategies. So that as dramatic as the improvement is in the Federal motor vehicle emissions control program it is not sufficient by itself.

When you realize that the jump from the 83 level to the 95 or 96 level is cutting out about three-quarters of the residual pollution, then you can appreciate that to leave the 1974 standard in effect for later model years would seriously aggravate our problems.

Mr. SATTERFIELD. Mr. Quarles, if you wish to present a more specific statement such as the one you referred to we will be glad to accept it and make it part of this record.

Mr. QUARLES. Thank you, sir. I will be glad to do that.

[The following information was received for the record:]

#### AIR QUALITY BENEFITS OF 1976 EMISSION STANDARDS

The 1975 interim standards for HC and CO are 1.5 grams per mile and 15 grams per mile, respectively. EPA's public statement on clean air and the automobile contains a detailed analysis of the air quality impact of such standards relative to that of the statutory standards (see tables I, II, and III). As indicated therein, moving from the 1975 interim standards for HC and CO to the

statutory standards has a significant effect on the numbers of air quality control regions expected to meet the national ambient air standards without implementation of transportation control measures. (Clean Air and the Automobile was sent to the committee staff in a letter of September 18, 1973.)

Mr. KYROS. Are you aware of a bill, H.R. 10118, introduced by the chairman of our subcommittee, Mr. Rogers, which is a bill to amend the Clean Air Act to require the Administrator of the Environmental Protection Agency to prescribe regulations to promote greater fuel economy in vehicles subject to Federal emission standards? As it is now, we burn more gas in the cars we are driving now, is that right?

Mr. QUARLES. Yes.

Mr. KYROS. The chairman wants you to present a significant decrease in fuel economy of motor vehicle engines which comply with regulations prescribed in section 202 of the act and promotes fuel economy of such vehicles as engines. He said you may do such things as establish fuel economy, performance standards, limitations, or prohibitions of use of equipment or elements of design which increase fuel consumption, limitations in motor vehicle weight. Are you getting ready to design some ideal car by taking bumpers off, perhaps, or air-conditioning, radio, heaters, seats, except for bucket seats? Are you going to do all these things?

Mr. QUARLES. We have not by any means gone that far even in our imagination. We are very keenly aware of the problem. The thing I think makes us maddest is when we hear commentaries that we cannot afford to clean up the car because of the fuel penalty and, yet, we look at other things that create so much greater fuel penalties which are not being attacked at all.

Mr. KYROS. Would you want this kind of power, the ability to practically redesign the car?

Mr. QUARLES. I am familiar with the bill. I was informed, I think, Friday, that such a bill had been introduced. I have not read the bill. I cannot comment on it.

Mr. KYROS. I am going to ask you one more time. You said you read the bill slightly and I will read the bill to you in detail here. It says you will have the power to practically redesign the car to achieve one, the air pollution standards that you desire and, second, to maintain fuel economy, which gives you incredible leeway, it seems to me.

My question to you is, are you prepared to undertake this responsibility and obligation?

Mr. QUARLES. I appreciate your rereading the bill to me, but I think I am still going to follow my inclination of not making any serious comment on a bill I have not had a chance to read or study. I think at this point all I can say is that we very strongly feel that measures should be undertaken to move toward automobiles that consume less gasoline.

Our statutory and programed interest in this area relates to the air pollution problem. The big cars that burn more fuel do not necessarily produce more emissions. That tends to relate more to the weight-power ratio and other factors.

Mr. KYROS. But you can't really be precisely sure in your mind that what you just repeated on the record is what you meant. Let us think about it for a moment. You already are considering competing engine design systems and all kinds of parameters, cost, noise, load, fuel,

et cetera. You are doing that. So you are far beyond just saying what goes in as fuel and what comes out of the tailpipe.

I ask you again, has no one yet in your Agency begun to consider what the kind of ideal car there should be in America so far as you know, and you are the Deputy Administrator?

Mr. QUARLES. I feel quite sure that although many people in our Agency have their personal ideas—

Mr. KYROS. I don't want a Rube Goldberg contraption.

Mr. QUARLES. I am sure the people who work in our program regulating the auto industry, who are dealing with these problems on a daily basis, have opinions of their own as to what the best car would be. There has to my knowledge been no directed effort to develop any sort of Agency position on what the ideal car would be. It is not relevant to the regulatory responsibilities we now have.

Mr. KYROS. You construe section 211, regulation of fuels, in the act as one that does not give you the power to begin to look at what the mechanism is that eats up the fuel?

Mr. QUARLES. If I understand your question correctly, I believe I agree with your statement, the answer is "yes." We understand that section as directing us to analyze the various components of fuel and the fuel additives and to establish regulations where we find that those fuel and fuel additives are causing pollution problems. But it does not direct us to get into the area of fuel consumption as such.

Mr. KYROS. The last question is, Wouldn't it be sound and neat and fair and reasonable and a good thing if all of you in the Agency did have the power to dictate design limitations, weight, and the other items in an automobile that affect its fuel consumption and the emissions from the fuel?

Mr. QUARLES. I am not sure. You know, this raises some fundamental philosophical questions of what regulatory authority should be established and in what agency. We have not had prime responsibility in the energy area. What you are really asking is an energy problem.

Mr. KYROS. Mr. Quarles, thank you very much. Thank you, Mr. Chairman.

The Agency is not prepared to accept your bill, too.

Mr. QUARLES. You particularly scared us off with that word "dictator."

Mr. ROGERS. We put that in the bill, as I am sure you know, in order to have this a proper subject of this committee. Of course, there is a relationship, I presume, between what we do in the environmental field and the fuel field as well. So, we want to have some EPA involvement in the decisionmaking.

Mr. Heinz?

Mr. HEINZ. Thank you, Mr. Chairman.

Mr. Quarles, in the case of the health effects of the pollutants controlled under the Clean Air Act, have they generally been, upon being researched, found to be more severe in their health effects than originally believed?

Mr. QUARLES. Yes; in general our research conducted after the establishment of the standards has tended to confirm that the standards should be as stringent as they are and that if any change should be made, possibly it should be made in the direction of making them more stringent.

Mr. HEINZ. In your statement this afternoon you suggested that it would take several more years of research by EPA and others to make more definitive judgments about what levels can be tolerated while still avoiding a health hazard or risk of a health hazard. Do you have sufficient funding or do other agencies that you rely upon have sufficient funding to do this research?

Mr. QUARLES. Yes; we have sufficient funding to carry out a very extensive research program in this area. One of the main points we meant to convey in the presentation earlier is to make it clear that there is a wide range of questions on which information should be available before one reaches the ideal state of knowledge about a problem. So often people feel that if you just gear it up a little harder, you can get all the answers next year rather than 3 years from now.

It is important, I think, for this committee to realize the complexity of the problems and the fact that one cannot just push a button and 2 years later have all the answers. At the same time, I don't think that we should leave the impression that we will not have any additional standard-setting foundation until the research is completed several years from now.

We have an ongoing program of research and we may from time to time reach a point where we can see a basis for another standard or a modification of an existing standard.

Mr. HEINZ. So it is possible 2 or 3 years from now you might request tighter standards on one or all of the controlled pollutants?

Mr. QUARLES. Yes; that is correct.

Mr. HEINZ. At the same time we are discovering pollutants that are dangerous that we did not anticipate at the time of the 1970 amendments. Is that not the case?

Mr. QUARLES. Yes; that is the case. I think I would like to ask Dr. Greenfield to amplify on my answer.

Dr. GREENFIELD. We have rather deliberately set up a schedule for redoing each of the criteria documents that underlie our standards. We have actually published the schedule in the Federal Register saying that at the very least on a 3-year cycle we will redo these criteria documents. However, the research program is not tied to that cycle. It goes on looking deeper and deeper at the problem of pollutants and their effects on people, the idea being that if new data surface that indicate that standards must be made more stringent or relaxed, at that point we will do something about the standard, not wait for the 3 years to elapse.

Mr. HEINZ. Let me ask you this. If you determine that within the class of particulate matter which is controlled there is a much more dangerous subclass; namely, fine particulates which in this hypothetical case you do not now have the authority to control, what would the agency do if it discovered that fine particulates are an extreme health hazard?

Dr. GREENFIELD. Let me correct one thing. We do have the authority to control fine particulates. As a matter of fact, we have a program underway right now to both examine the health effects of fine particulates, those particulates below 2 microns in size which seem to be inordinately important from a health standpoint. So we are looking at ways of controlling these fine particulates.

Our schedule calls for promulgation of regulations controlling fine particulates in the next year or so.

Mr. HEINZ. So you do have authority to control fine particulates?

Dr. GREENFIELD. Yes, sir.

Mr. HEINZ. Would that also be true with respect to polynuclear organic compounds?

Dr. GREENFIELD. If we found that any material was a health hazard that was being put out by either a stationary or mobile source into the atmosphere and could make the case that these materials were in concentrations important to impair people's health and were controllable, then indeed we do have the authority to make these regulations.

Mr. HEINZ. In the Pittsburgh geographic area, a portion of which I am very fortunate to represent, the information available to me suggests that my area will not be able by 1975 or even 1976 to meet the ambient air quality standards with respect to particulates and sulphur oxides, the effluents normally associated with stationary sources of pollution.

At the same time EPA has promulgated procedures for curtailing vehicle-miles in Pittsburgh and other areas such as Philadelphia in my State in an effort to control the emissions of those pollutants; namely, carbon monoxide, hydrocarbons, nitrogen oxides, and resulting photochemical smog. Do you anticipate that EPA will promulgate similar kinds of constraints or restrictions on stationary point sources if an area such as Pittsburgh appears not to be able to meet the 1975 or 1976 ambient air quality standards?

Mr. QUARLES. Yes, sir, we are charged under the law to review the implementation plans submitted by every State and to make a determination whether or not the abatement programs specified are sufficient to achieve the target for the ambient air quality standard within the law. If they are not sufficient, then we have the job of promulgating the implementation plan provisions that will meet the standards.

Mr. HEINZ. Back in June you did promulgate such standards with respect to motor vehicle transportation?

Mr. QUARLES. We proposed them, I believe.

Mr. HEINZ. Proposed them, excuse me. What is your timing anticipated with respect to stationary source pollution?

Mr. QUARLES. May I finish up on the transportation control plan?

Mr. HEINZ. Certainly.

Mr. QUARLES. We proposed those in June. A hearing, I believe, was held in Pittsburgh within the last week or two. We are working on a time schedule of promulgating or having the State promulgate, if possible, the plans by mid-October. In the case of the Pittsburgh area, as has been true in a great many other cases, there has been a great amount of work done in recent weeks and months, particularly since we proposed the original plan back in June. Quite a number of modifications to the Pittsburgh plan have been developed by the local officials there.

We feel that we have a much greater likelihood of reaching agreement with the State and local officials on a plan that will be acceptable to them and to us to handle the Pittsburgh transportation problem.

Mr. HEINZ. May I continue on that? Is this also true with respect to the other areas subject to such regulations in my State; namely, Philadelphia?

Mr. QUARLES. Yes, I believe it is.

Mr. HEINZ. You are optimistic that you will be able to work out something that is satisfactory to the mayor and the Governor and EPA?

Mr. QUARLES. I think that I should not go too far out on a limb because I have not been briefed right up to the minute on Philadelphia.

Mr. HEINZ. If you can get the mayor of Philadelphia and the Governor to agree on anything, you are quite a man.

Mr. QUARLES. We have had extremely good results in the public debates that have been held around the country in many of these cities that have these difficult problems. Two things have happened. One is that we have seen what can be done, and we have instances where it can't be done. The proposals that we have made tend to thrash out these issues and cause others to thrash them out. In that process we have often reached a meeting of minds with State and local officials on what can be done.

We are finding in some instances to achieve a statutory deadline would require adoption of the types of measures that we and they alike agree are just too much within that time frame to realistically expect can be accomplished without severely disrupting the city. For that reason in my prepared statement I indicated we felt that some possibility should be provided in the statute to allow additional time where the problems are most serious.

Mr. HEINZ. When you say "additional time" are you thinking of 1 year or 2 years or are you thinking of a longer time frame?

Mr. QUARLES. It would vary with each city. Because of the very great improvement in the control over the automotive emissions themselves each additional year makes a great deal of difference. In most instances it probably would not take more than an additional year or two to make it possible to achieve compliance with the standards.

In the case of Los Angeles, possibly in one or two other cases, perhaps more time would be required.

Mr. HEINZ. You know, one of the differences between the approach to automobile combustion and the approach to products of stationary source combustion is that the 1970 act said that there would not be any more than  $x$  emitted per mile by an automobile. On the other hand, the act uses only ambient air quality standards with respect to stationary sources.

While there have been some problems associated with the manufacture of automobiles meeting the standards, the fact is that they have made remarkable progress and are within sight of meeting the stringent standard imposed upon them by the 1970 law. The same cannot be said in many cases for the stationary source of pollution. What is the agency's position on the possibility of adopting emissions standards for certain kinds of point sources of pollution similar to what we now have on automobiles which is, let us say, no more than  $x$  micrograms of sulfur dioxide for every ton of steel produced? Has consideration been given to this? Do you think in the future it will

be necessary to have this kind of standard to reach our ambient air quality goals?

Mr. QUARLES. The basic question raised by what you are saying is how do you force the development of technology?

Mr. HEINZ. That is exactly what I am saying.

Mr. QUARLES. At this time we have no thought of proposing such statutory amendments to do more in the way of forcing development of technology. It has certainly been our experience with regard to water pollution and it is being our experience with regard to air pollution that the establishment of abatement requirements related to the receiving environment will of itself tend to force the development of technology because the implementation plans set targets and in many cases those are very tough to meet.

As individual companies grapple with the problems of compliance at individual plants, they will be looking at all of the possibilities of technological innovation to try to find a better way of meeting that standard. So that will tend to exert a strong pressure for technological advance.

Mr. HEINZ. May I interrupt you at this point? I believe you are saying, if I hear you correctly, is that under the new water pollution law, all point sources essentially are controlled. As I recall, there is a rather stringent objective of zero discharge by a certain date as it was characterized in the preamble to the water pollution bill?

Mr. QUARLES. In the preamble, it is there as a policy or goal, I have forgotten which, but the standards that are set forth in the Water Act are analogous to the new source performance standards in the Clean Air Act on the basic principle that they mandate the utilization of the best technology which has been developed to date. In regard to further advance in technology, that is something that evolves as industries strive to meet a specified emissions limitation or effluent limitation. The way these standards are being applied, and we think it is a very good way, is that the numerical standard is set. It is up to the industry to figure out how to meet that standard. It leaves them maximum flexibility. In the course of that, they will do some research and development on their own.

Mr. HEINZ. Where do the most difficult technological problems seem to be encountered most frequently by industry? Is it with respect to particulates, or is it with respect to  $\text{SO}_2$ , or both?

Mr. QUARLES. Certainly there are difficulties with respect to both. I think at this point we are more concerned with the need to develop technology to control sulfur oxide because of the tie-in to the energy problem. Dr. Greenfield reminds me that we also, of course, have a control technology development program of our own at EPA, and that is worth noting for the record, although it is our philosophy and it is reflected in our program that the basic development of control technology should be done by industry. Would you want to comment further on these questions?

Mr. HEINZ. Maybe we could hold that for a second. I would like to pursue something you suggested earlier. You are suggesting that on  $\text{SO}_2$  you are looking for R. & D. solutions. Have you considered any

more broad-scale approach to develop, within a more or less free-market approach, better technology to control  $\text{SO}_2$ ? If so, are you going to make those proposals to the Congress?

Mr. QUARLES. The administration proposed a year ago a sulfur tax.

Mr. HEINZ. An effluent charge?

Mr. QUARLES. Yes.

Mr. HEINZ. What is your position with respect to effluent charges generally and specifically effluent charges on  $\text{SO}_2$ ?

Mr. QUARLES. I discussed this with Russell Train the other day. I am not sure he and I agree. Probably I should not go too far in trying to generalize on it because there is a wide range of difficult problems one encounters in trying to generalize on emissions taxes. I personally believe that establishment and implementation of emissions taxes would be very difficult to carry out. Many feel that they would work very well. I know Mr. Train very strongly believes in the sulfur tax. I think with his background as a tax lawyer, a tax court judge, he has seen a number of possibilities along that line which I personally, I guess, have not yet come to understand.

Mr. HEINZ. Did the previous Administrator of EPA, Mr. Ruckelshaus, take any public position with regard to effluent charges?

Mr. QUARLES. Mr. Ruckelshaus endorsed the concept of the sulfur tax, but I do not believe that Mr. Ruckelshaus had strong opinions in this area.

Mr. HEINZ. Although he may not have made any legislative proposals other than the endorsement of the  $\text{SO}_2$  tax, did he not feel that effluent charges, in fact, did represent a useful way to control pollution and reduce the amount of effort and resources that had to go into enforcement. Did he not, in fact, feel that effluent charges were self-enforcing?

Mr. QUARLES. I think I can't comment on that.

Dr. Greenfield, do you wish to comment on that?

Dr. GREENFIELD. There are lots of arguments pro and con in the effluent tax area. If you are charging an effluent tax, you have to make sure what each point source is putting out. Therefore, you have to increase the effort you put into the enforcement area.

On the other hand, the effluent tax is to my own personal way of thinking a rather good way of getting equality into the regulatory process because it does not allow anybody to really get a free ride just by sitting back and not putting on the control technology and, therefore, getting a market advantage over the man who is trying to obey the law and putting in technology. It is a way of achieving that. It is a way of internalizing the external cost. That is a very useful way of doing things.

If you would wish, I would go a little more into the control technology as well.

Mr. HEINZ. I suppose what I am most interested in is whether you feel, given the critical period ahead of us with respect to the stationary sources of pollution, there are additional steps that should be taken to encourage the development of better technology to deal with particulates, with fine particulates, and with sulfur oxides?

Dr. GREENFIELD. There are two ways of doing this. I think they both come together. One is the way that says if you have a strong regulatory program that requires abatement of a certain type and a schedule to reach it and with sufficient teeth in it so that the company who is not obeying the standards actually realizes that it has to obey them or action will be taken against it, then it is a strong incentive for it to go out and find control technology or possibly develop it.

In addition to that, it behooves an agency of this sort to have a capability to demonstrate that it knows what it is talking about as to what the fair technical capabilities are in this country to meet these standards. In other words, in most of the stationary source work it is not just a question of what the standards should be, but also whether they can be met. There is an economic overlay that goes in there as well, and being able to defend the technical position of the agency becomes a very important matter.

You should be able to demonstrate to the industries that you are regulating that you know what you are talking about. Along with this goes the question of having some ability to encourage and implement and develop the technology that is needed as well. A typical example of that is the SO<sub>2</sub> stack-cleaning technology which the industry has been instrumental in developing in this country. A particular case comes to mind.

We promoted some five different approaches to stack gas cleaning, at least four of which are moving along to the point where we think we are going to be in relatively good shape as far as having that technology available for the country. One of them is of particular interest. That is the limestone scrubbing process where we are providing in essence a pilot plant and encouraging industries that have particular problems that are peculiar to their geographic location or their particular technical problem to use that pilot plant to help design the specific unique type of equipment that they will need.

It is true that very often you can't design a genuine piece of equipment that will work in all cases. It has to be tailored with individual plants.

Mr. HEINZ. That would be helpful with respect to cement plants?

Mr. GREENFIELD. It will be helpful with respect to certain types of utilities as well.

Mr. HEINZ. High-sulfur, coal-burning electric utilities?

Mr. GREENFIELD. Conditions under which they exist. So that you have to take all these steps to move the country along toward the proper technology.

Mr. HEINZ. Thank you. That is very helpful.

Mr. Chairman, I have no further questions at this time.

Mr. ROGERS. Mr. Symington.

Mr. SYMINGTON. Thank you, Mr. Chairman.

Mr. Quarles, in St. Louis I understand we should be having a regional air pollution study going on, RAPS so called. President Allen Nixon of the American Chemical Society had asked President Nixon how that was going back in effect because he understood there would be a reduction in investment in it and was assured by Richard Fairbanks,

associate director of the Domestic Council, in March that the \$5 million a year funding would go forward on schedule. Is that happening?

Dr. GREENFIELD. Yes, Mr. Symington, it is happening. We are committed. I personally and the agency specifically are committed to pushing that program through because of the importance that is attached to it. The commitment is a multiple-year commitment. We visualize spending \$25 million on that program.

Mr. SYMINGTON. It is the first comprehensive study, is it not, of the complete pollution envelop of a city of that kind?

Dr. GREENFIELD. Exactly.

Mr. SYMINGTON. It might go to Mr. Heinz's question, too, about point source pollution as distinct from automotive. I am sure we have a great deal of both out there. Maybe you will be able to carve it up and tell us who is doing what.

Dr. GREENFIELD. St. Louis was chosen, as you know, because it is a rather unique region. It is not bothered up-wind by other sources. It has a good inventory of various types of pollutants. It has a good data base that we can lean on. As a result we can go in and look to see what pollutants are in that city, what is being emitted, and try to trace them through the city so that we begin to get a good understanding of the dynamics of pollutants in that city.

Mr. SYMINGTON. We will be grateful to learn that we have a good inventory of pollutants there.

Dr. GREENFIELD. You are not alone, Mr. Symington.

Mr. SYMINGTON. Undoubtedly you are achieving a good "harvest" as you go along.

A press release, dated May 7, 1973, announced that air pollution levels have decreased significantly. Your statement said that, too, on the basis of measurements taken in 32 cities for sulfur dioxide, 116 cities for particulate matter. The release indicated there was one monitoring station in the downtown or center-city area.

I understand from your annual report that you have about 2,700 particulate stations, 500 suspended particulate instruments. So my question is, Are these 116 monitoring stations sufficiently representative of the totality of your monitoring to enable you to say where you are in controlling pollution?

Dr. STEIGERWALD. The long-term trend data—10 years back there was not much air sampling done in the country. EPA or the group that was EPA did set up a national air-sampling network which did consist of one sampling site in each of the major cities in which we operated. That is the information that we have to use if we are going to look at a 10-year trend. Since then the cities and States have set up many more sampling networks. Generally we picked our sites rather carefully.

It is in the downtown center. Aside from significant point sources it probably is representative of what is happening to the particulates and the sulfur oxides. It is probably not representative as to what is happening in the oxidant area or the carbon monoxide. We do feel fairly safe for total particulates and sulfur oxides that our single site is representative.

Mr. SYMINGTON. Some time back you indicated that the efficiency loss for your 1973 vehicles with the latest device was less than 7 percent. Your testimony today is 10 or thereabouts. What caused you to upgrade the estimate?

Mr. QUARLES. We made tests on the EPA test cycle which is, of course, the test designed to measure emissions, which indicated the 7-percent figure. That series of tests, we believe was a good series of tests that gave us good information. Most other persons and groups who have taken positions on this issue have indicated a somewhat higher degree of fuel penalty. We used a figure here that I think is more reflective of the general consensus on this subject.

Mr. SYMINGTON. I think in your statement you made the point that smaller vehicles have enjoyed greater efficiency and the larger, 3,500 pounds or more, less efficiency. Why the difference?

Mr. QUARLES. Well, it is important to point out simply at the beginning that there are wide ranges of different vehicles, all of which present different problems. When I try to come up with any single percentage like 7 or 10 percent, whatever it might be, there can be a wide range reflected by a single statistic. I believe that the emissions control problems have been resolved somewhat more easily by the smaller cars and they have, therefore, have been able by improving their power to weight ratio to establish better fuel economy.

Mr. SYMINGTON. I thought you said that in the case of the small cars there has been an actual improvement in the fuel economy?

Mr. QUARLES. Yes.

Mr. SYMINGTON. Whereas the fuel penalties are as high as 30 percent. So when we look at this 10-percent figure should we extrapolate from that that you are going from, say, -5 to 10 plus in the sense of efficiency loss because, in fact, you have an efficiency gain in the smaller car.

Mr. QUARLES. The point is that the fuel power ranges all over the lot for different types of cars. The 7- or 10-percent figure is a very rough average.

Mr. SYMINGTON. It might be useful if you would submit for the record the records of these tests indicating which you deem to be definitive that would justify the flat-out statement, for example, that there has been an actual improvement in the fuel economy of small cars as well as the observable loss in the larger, and which cars, emerging models and so forth, and the data from which you make these determinations.

Mr. QUARLES. We will be pleased to submit a statement for the record.

[The following information was received for the record:]

#### FUEL ECONOMY DATA

The enclosed paper, "Passenger car fuel economy trends and influencing factors," by Messrs. Austin and Hellman, EPA; SAE No. 730790, contains the requested data.

# Passenger Car Fuel Economy- Trends and Influencing Factors

Thomas C. Austin and Karl H. Hellman  
Environmental Protection Agency

The subject of passenger car fuel economy is important to many segments of American society. The motoring public realizes that fuel costs are a significant percentage of the operating costs of an automobile. The oil industry must be able to predict trends in fuel economy so that future demand can be forecasted and production planned. The automobile industry is concerned because passenger cars with good fuel

economy are demanded by some customers. Various local, state and federal governmental agencies are interested in automobile fuel economy for a variety of reasons, including the need to determine such factors as fleet operating costs, revenues from road taxes and national energy usage. This paper presents information about passenger car fuel economy in a form intended to be of use to all of these segments.

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## ABSTRACT

This paper discusses some trends and influencing factors in passenger car fuel economy. Fuel economy and fuel consumption were calculated by a carbon balance method from HC, CO and CO<sub>2</sub> emissions measured by the 1972 Federal Test Procedure.

The information presented was derived from nearly 4,000 tests of passenger cars ranging from 1957 production models to 1975 prototypes. Data are presented for various model year and vehicle weight categories.

Trends in fuel economy are discussed on an overall sales-weighted basis and for

each individual weight class. Some of the factors that influence fuel economy are quantified through the use of a regression analysis. Particular emphasis is placed on the differences in fuel economy between those vehicles that were subject to federal emission regulations and those vehicles that were not.

Three ways to characterize vehicle specific fuel consumption are presented and discussed. Possible ways to improve fuel economy and vehicle specific fuel consumption are also discussed.

## DATA SOURCES

Most of the data used in this study came from work done for or by the United States Environmental Protection Agency (U.S.EPA). There were three major sources of data: in-house testing, certification testing and surveillance programs.

A portion of the EPA in-house data used was generated during the testing of prototype vehicles employing advanced emission control systems. These data were from both the continuing correlation study that goes on between EPA and the automobile manufacturers and the evaluations of systems developed by organizations that are not automobile manufacturers. Data generated during the development of current and future testing procedures were also used.

The applicable EPA certification data consisted of tests run for model years 1972, 1973 and 1974.

The surveillance data were collected for EPA by contractors during programs to determine emissions from in-use vehicles. A further description of this type of data may be found in reference (1)\*. Surveillance data from Denver were not used because of the differences in fuel economy that might result from the significant difference in altitude between Denver and all other test sites.

All of the certification data were generated using the 1972 Federal Test Procedure (FTP) as described in the Federal Register, Vol. 35, No. 219, Nov. 10, 1970, and Vol. 36, No. 55, March 20, 1971. In-house and surveillance data were generated using both the 1972 and 1975 FTP. A description of the 1975 FTP can be found in the Federal Register, Vol. 36, No. 128, July 2, 1971. Fuel economy calculated from data taken using the 1975 FTP was converted to the equivalent 1972 FTP value using the method described in Appendix A.

## DRIVING CYCLES AND MEASUREMENT PROCEDURE

At the time of the writing of this paper, no universally accepted, standardized

\*Numbers in parentheses designate references at the end of the paper.

measurement and reporting procedures for passenger car fuel economy exists in this country. The lack of a standardized test procedure makes comparisons of published data difficult, especially on an absolute miles per gallon (mpg) or liters per 100 kilometer (L/100 km) basis. This paper presents fuel economy data calculated on the basis of the 1972 Federal Test Procedure. The 1972 FTP has been used because there exists a large body of fuel economy data developed from that procedure.

Some of the advantages and disadvantages of using the 1972 FTP for a fuel economy test procedure are as follows:

Advantages

1. The test is run under closely controlled ambient conditions on a chassis dynamometer. This means that wide variations in ambient temperature, humidity, barometer and road surface properties are not encountered. Wind and rain are not a problem.

2. Exactly the same driving cycle (speed versus time trace) is used for every test and is followed within specified, close tolerances. The effect of the human element (driver habits) is minimized. A detailed and specific set of instructions for running the emission test assures that the test is performed the same way each time.

3. Many organizations are equipped with emission measurement equipment and can perform such tests.

4. The driving cycle used is typical of operation in urban-suburban areas, where most of the gasoline for passenger car operation is consumed.

Disadvantages

1. The test does not include modes of vehicle operation which are typical of driving on uncongested freeways and rural roads.

2. Total road load simulated on the chassis dynamometer may not accurately duplicate the rolling resistances and aerodynamic drag experienced on the road.

3. The cooling fan airflow characteristics do not exactly reproduce the airflow characteristics of a moving vehicle. The effect on vehicle warmup may therefore be slightly different.

4. Hot start operation is not included.

5. The method of accounting for the existence of air conditioning, a 10% increase in the road load horsepower at 50 mph, may not exactly duplicate the overall effects of air conditioning on fuel economy.

The disadvantages of the 1972 FTP could be lessened somewhat by a procedure that included both cold and hot starts.

#### CALCULATION PROCEDURES

**CARBON BALANCE METHOD** - The fuel economy and consumption information presented in this report was calculated from the results of exhaust emission tests run in accordance with the Federal Test Procedures. Use of the HC, CO and CO<sub>2</sub> results from the emission tests enables fuel economy to be computed using a carbon balance technique. The major assumptions in using this technique are:

1. The carbon contained in the HC, CO and CO<sub>2</sub> in the exhaust is the only carbon in the exhaust. This means that other carbon-containing compounds, such as oxygenated hydrocarbons that are not detected by a Flame Ionization Detector (FID) and carbonaceous particulates, are ignored.

2. All of the carbon that is measured in the exhaust in the form of HC, CO and CO<sub>2</sub> came from the fuel; there are no other sources of carbon.

3. All of the fuel consumed during the test can be accounted for by the carbon in the exhaust. This means that all of the fuel that leaves the tank is assumed to pass through the engine and that no carbon leaks out of the exhaust system before being analyzed or evaporates from the vehicle.

Appendix A gives a derivation of the equation used to calculate fuel economy on the 1972 FTP.

**CORRELATION WITH WEIGH METHODS** - A direct measurement of the weight or volume of fuel used during the test is not required to determine fuel economy by the carbon balance technique.

To examine the correlation between the carbon balance calculated fuel economy

and the fuel weigh techniques, two sets of comparative tests were examined. The first consisted of eight tests conducted at the EPA Motor Vehicle Emission Laboratory in Ann Arbor, Michigan on three different vehicles. The average difference in fuel economy (calculated fuel economy minus weighed fuel economy, divided by weighed fuel economy) was found to be 4.5% with the calculated fuel economy being higher than the weighed fuel economy. The individual differences ranged from 2.6% to 8.1%. The second investigation was performed using data from the work reported in reference (2). The same calculation was performed on 245 sets of data for which there were both a fuel weight and HC, CO and CO<sub>2</sub> data. The same type of calculation yielded a 3.3% difference with the standard deviation of the difference being 8.1%.

**DISCUSSION OF CORRELATION** - An exact, quantitative explanation of these differences is not available at this time. However, a qualitative explanation may be found by examining assumption 3 above. If all of the fuel that leaves the fuel tank is not consumed by the engine, the carbon balance calculation would yield a lower fuel consumption (better fuel economy) than the weigh method.

Limited, preliminary tests done at EPA to quantify the magnitude of evaporative emissions using the Sealed Housing for Evaporative Determinations (SHED) technique indicate that at least some, and possibly all, of the difference between the weigh and carbon balance methods of determining fuel economy may be attributable to evaporative losses. EPA's preliminary data indicate that the total evaporative loss from a vehicle, even a vehicle with an evaporative control system, could be in the neighborhood of 50 grams during the 1972 test and subsequent one-hour hot soak. Losses which occur when the engine is not operating are significant because fuel from the weigh can must replace any fuel which evaporated from the fuel pump, carburetor bowl, intake manifold and fuel line plumbing between the fuel pump and carburetor since the previous engine shut-down.

Other investigators (3) have also reported high evaporative emission losses from vehicles when the SHED technique is

used to measure hot soak losses. More procedure development is needed, however, before total fuel evaporative losses are accurately determined. SHED techniques for measuring running losses need the most refinement; preliminary in-house attempts have required the use of as yet imprecisely defined correction factors to account for engine air consumption and imperfect sealing of the dynamometer area.

Appendix A includes a modification which can be made to the basic fuel economy equation if total fuel evaporative emissions are known.

**CALCULATION OF "AVERAGE MPG"** - Each "average miles per gallon" value in this paper refers to the harmonic mean, rather than the arithmetic mean, of all the mpg data. The appropriateness of the harmonic mean fuel economy can be illustrated by the following example:

A vehicle makes a 200-mile trip in two 100-mile segments. Ten gallons are consumed on the first segment, five gallons are consumed on the second segment. The fuel economy for the first segment is ten mpg. The fuel economy for the second segment is 20 mpg. What is the average fuel economy for the entire 200 mile trip?

Taking the arithmetic mean of the individual fuel economy values  $[(10 + 20)/2 = 15]$  yields 15 mpg, which is not the true fuel economy for the trip. The trip was 200 miles long. The total number of gallons used was 15. The average miles per gallon, therefore, is  $(200/15 = 13 \frac{1}{3})$  13  $\frac{1}{3}$  mpg.

Average fuel economy should be reported as total miles traveled divided by total gallons used. When all individual mpg values considered in determining an overall average mpg are based on trips of equal length then the harmonic mean of the individual fuel economy values will equal the total miles divided by the total gallons used. This relationship is derived in Appendix B.

#### FUEL ECONOMY TRENDS

The average fuel economy for the model year and inertia weight (IW) classes considered in this study is presented in Table 1. This table includes data for model year 1974 and prototype 1975 vehicles also. The model year 1974 data

were data from the 1974 certification program that were available when this paper was written. The model year 1975 data were from the EPA in-house testing discussed earlier.

Also presented is an uncontrolled vehicle average fuel economy obtained by considering the class of vehicles 1957 through 1967 as one class in each inertia weight category. The '57-'67 average may be considered "uncontrolled" or "baseline" fuel economy since no nationwide exhaust emission controls were required for these model years, and an investigation of Table 1 shows no apparent trend in fuel economy over this eleven-year period. Fuel consumption in liters per 100 kilometers (L/100 km) for the same model year and inertia weight categories as appear in Table 1 is tabulated as Appendix C. Tables D-1 through D-3 of Appendix D contain the number of data points in each model year/inertia weight category and the standard deviations for each category. The percent changes in fuel economy for each model year and inertia weight class compared to the uncontrolled average in the same inertia weight class is tabulated as Appendix E.

Figure 1 shows the percent change in fuel economy of model year 1973 vehicles from the '57-'67 average. This figure shows that 1973 vehicles in all inertia weight classes up to 3500 lbs. have improved fuel economy, compared to uncontrolled vehicles. Vehicles in the inertia weight classes 4000 lbs. and above have worse fuel economy, compared to uncontrolled vehicles.

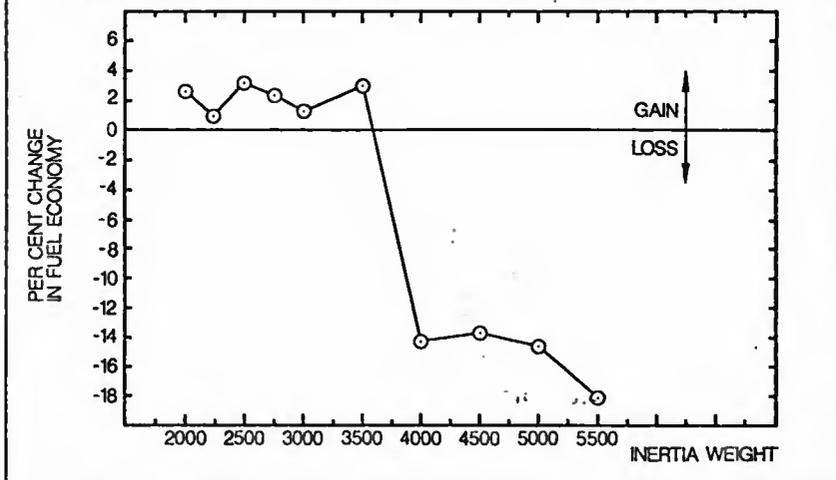
The use of control devices and techniques to meet the federal emission standards, while not the only difference between uncontrolled and 1973 vehicles, may be accounting for some or all of the changes in fuel economy. If one attributes the losses in fuel economy shown to emission controls, then, logically, one must also attribute the gains in fuel economy shown to emission controls.

Why should this difference in fuel economy change exist? The authors offer the following hypothesis. More emission control is required for heavier vehicles, on the basis of grams of pollutant allowable per gram of fuel burned. In general, uncontrolled  $\text{NO}_x$  emissions are proportional to vehicle weight, lighter vehicles re-

Table 1  
 Fuel Economy in Miles per Gallon for Various  
 Model Years and Inertia Weight Categories  
 (— indicates no data)

Model Year	<u>Inertia Weight</u>										
	<u>1750</u>	<u>2000</u>	<u>2250</u>	<u>2500</u>	<u>2750</u>	<u>3000</u>	<u>3500</u>	<u>4000</u>	<u>4500</u>	<u>5000</u>	<u>5500</u>
57	--	26.4	--	--	--	--	14.7	13.0	--	--	12.5
58	--	25.3	18.2	--	13.2	--	13.6	15.2	12.5	8.6	--
59	--	28.6	--	--	--	15.2	15.0	13.2	12.7	13.8	--
60	--	20.4	--	22.3	24.5	--	15.7	12.4	10.8	10.9	--
61	--	29.4	--	20.9	16.3	17.2	11.4	14.0	10.5	10.6	--
62	--	25.8	--	--	18.0	16.3	13.0	13.8	12.6	10.8	--
63	--	23.2	19.5	--	16.1	14.7	12.6	12.0	11.1	10.6	--
64	--	22.8	--	--	17.3	16.2	13.7	12.9	11.4	11.0	--
65	--	23.8	--	--	18.3	15.2	13.7	12.3	11.7	10.3	--
66	--	20.9	--	12.7	14.9	14.6	13.9	12.3	12.1	11.3	9.3
67	--	22.6	25.7	--	18.7	15.9	13.1	12.1	11.6	11.2	10.3
68	--	19.3	20.5	18.5	19.7	15.6	13.3	12.0	11.3	9.3	--
69	--	22.2	20.3	18.8	--	15.4	13.3	11.9	11.3	9.1	10.8
70	--	23.4	19.3	17.5	18.5	15.9	13.3	12.0	10.9	10.1	9.9
71	27.2	22.6	21.4	19.3	18.3	14.8	12.2	11.7	10.7	9.6	10.9
72	--	23.0	21.9	19.6	20.0	14.4	13.3	11.1	10.7	9.6	9.3
73	24.8	23.8	21.9	19.7	17.5	15.6	13.9	10.8	10.1	9.3	8.6
74	--	--	19.2	19.3	19.7	16.9	15.2	11.1	10.3	9.4	8.3
75	--	--	20.1	17.4	16.6	--	14.3	--	10.1	9.6	8.4
57-67 Aver.	--	23.2	21.7	19.1	17.1	15.4	13.5	12.6	11.7	10.9	10.5

FIGURE 1  
PER CENT CHANGE IN FUEL ECONOMY  
BETWEEN '57-'67 AVE. AND '73 VERSUS INERTIA WEIGHT



quiring less  $\text{NO}_x$  control than heavier vehicles. The uncontrolled  $\text{NO}_x$  levels of many lighter vehicles are close to, or below, the level required by the 1973-75 Federal Standards. To achieve the level of control required by the standards, heavier vehicles have required more  $\text{NO}_x$  control than lighter vehicles. The current techniques for  $\text{NO}_x$  control chosen by the manufacturers of heavier vehicles are those which cause fuel economy penalties. Examples of such techniques are spark retard and exhaust gas recirculation (EGR) systems that recirculate a higher percentage of exhaust gas during light loads than during heavy loads.

Manufacturers of lighter vehicles, being less concerned with  $\text{NO}_x$  emissions, may have been able to achieve sufficient emission control by working primarily on improved fuel control. Lean air/fuel ratios tend to reduce HC and CO. While improving fuel control on heavier vehicles may have tended to improve fuel economy, any gains may have been over-

shadowed by the techniques used to achieve the required reductions in  $\text{NO}_x$  levels.

Weight is seen to have a secondary effect on fuel economy when emission standards are in the picture. The fuel economy loss realized by heavier vehicles can be thought of as being attributable to this secondary effect of weight.

Another reason for part of the difference in the fuel economy change between lighter and heavier vehicles may be the use of fuel injection systems by some manufacturers of the lighter weight vehicles. The weight classes in which fuel economy gains have been registered since the advent of federal emission standards are primarily those in which some vehicles are currently offered for sale with fuel injection.

**SALES-WEIGHTED FUEL ECONOMY** - Because the changes in fuel economy are not the same for all inertia weight classes, care must be exercised in determining the over-

all change in fuel economy for a given model year. In order to obtain an estimate of overall average fuel economy, a definition of the term "overall average fuel economy" for any given model year or group of model years is needed. "Overall average fuel economy" has been defined here as the sales-weighted miles per gallon (swmpg) derived from the sales volume in each inertia weight class and the fuel consumption in that class for a given model year. That is:

$$\text{swmpg} = 235.2 / \sum f_i c_i \quad (1)$$

where:

swmpg is sales-weighted fuel economy for a given model year,

$f_i$  is the fraction of total sales for a given model year which occurred in inertia weight class  $i$ ,

$c_i$  is the fuel consumption in liter/100 km in inertia weight class  $i$  for a given model year, and

235.2 is the conversion constant used to convert metric to English units.

For both uncontrolled and controlled model years the  $f_i$  values are obtained from reference (4).

Figure 2 is a plot of sales-weighted fuel economy for the model years 1957 through 1973. Since reference (4) uses registration data which are not yet available for 1973 models, the sales fraction in each inertia weight class for the 1973 models is assumed to be the same as for the 1972 models. Should the 1973 registration data show that the lighter cars have achieved greater market penetration than they did in 1972, then the true 1973 sales-weighted fuel economy may be higher than shown in Figure 2.

Figure 2 also shows sales-weighted fuel economy for U. S. production from reference (5). These data show a different peak controlled year and also are significantly higher in fuel economy than the results of this paper for swmpg. Both 1973 data points on Figure 2 are estimates.

In order to compare the correlation between the fuel economy calculated using the data in this paper and the existing fuel economy data from the Department of Transportation (6), national average fuel economy (nampg) has been calculated for the years in which data were available. The results of these computations are

shown in Figure 3. The maximum difference between the DOT fuel economy and the EPA fuel economy at any given point in time is 6.8 percent, with the average being 5.9 percent. The 1972 test procedure correlates very well with the national average fuel economy reported by DOT. If the nampg had been based on the 1975 Federal Test Procedure instead of the 1972 Federal Test Procedure, the results would have matched almost exactly, since the 1975 FTP yields fuel economy about 5 percent better than the 1972 FTP, on the average, based on our analysis of 1972 FTP and 1975 FTP fuel economy from 68 in-house tests on 1975 prototype vehicles.

The calculation methods and the necessary data for the calculation of awmpg and nampg are given in Appendix F.

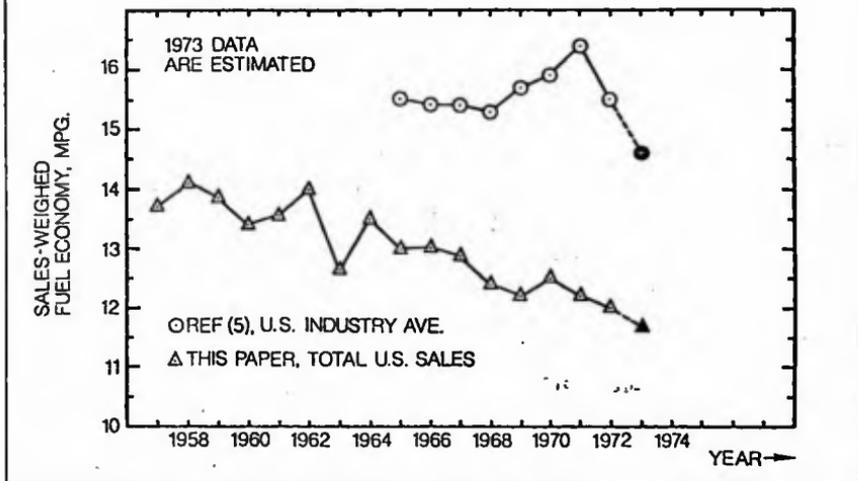
Figure 2 does not show model years beyond 1973 because sales fraction extrapolations cannot be accurately made beyond one year, especially in light of the sales fraction shifts which appear to be occurring. In addition, the fuel economy for 1975 model year vehicles may be significantly different than is indicated by the limited prototype testing conducted by EPA. The EPA data indicate slight losses for light weight vehicles and essentially no change for heavy cars compared to 1973. General Motors has recently indicated, however, that they anticipate significant improvements over 1973 fuel economy levels at either the original statutory 1975 emission levels or the 1975 interim standard levels (nationwide and California).

The GM data indicate 11.5% fuel economy improvement over 1973 levels at the original statutory 1975 standards or the 1975 California interim standards. The nationwide interim standards, which must be met by most of the 1975 production, will result in a 22% improvement according to GM (7). The data cited in reference (7) were for a vehicle in the 5500 lb. inertia weight class.

The reason for the difference in 1975 prototype fuel economy seen in the EPA and GM data is that the GM data resulted from the testing of more sophisticated systems than have been available to EPA.

THE EFFECT OF EMISSION CONTROLS - The trend in sales-weighted fuel economy shown in Figure 2 is the result of many

FIGURE 2  
SALES-WEIGHTED FUEL ECONOMY  
VERSUS MODEL YEAR



influencing factors. In order to isolate the effect of emission controls, it is necessary to eliminate as many other factors as possible. The influence of weight trends can be eliminated by using a fixed set of  $f_i$  (market fraction in IW class "i") values in combination with two sets of  $c_i$  (fuel consumption in IW class "i") values when calculating swmpg. If swmpg is calculated once with  $c_i$  values for the '57-'67 uncontrolled vehicles and once using 1973  $c_i$  values, then comparison of 1973 vehicle fuel economy to "baseline" fuel economy can be made without the confounding influence of a changing market.

The swmpg using the 1972  $f_i$  values and the '57-'67  $c_i$  values is 12.98. Using the 1973  $c_i$  values with the 1972  $f_i$  values yields a sales-weighted miles per gallon of 11.67. Therefore, the loss in sales-weighted fuel economy due to the emission controls applied to the 1973 models is 10.1%.

#### VEHICLE SPECIFIC FUEL CONSUMPTION

In the preceding discussion concerning vehicle fuel economy, all vehicles were treated equally, and light vehicles were shown to have better fuel economy than heavy vehicles. However, merely considering miles per gallon (or liters per 100 kilometers) may be unfair to the heavier vehicle since the heavier vehicle may be able to do more useful work, that is, carry more passengers and luggage, than a lighter vehicle. A way to compare vehicles on a possibly more equitable basis has been suggested (8) and is used here. Vehicle specific fuel consumption (VSFC) is defined by the relationship:

$$VSFC = \frac{K}{MPG (W)} \quad (2)$$

where  $K$  is a constant and  $W$  is a weight term. Appendix G shows that this is dimensionally equivalent to the better

known term "specific fuel consumption" used when discussing the fuel consumption of engines. Three different kinds of vehicle specific fuel consumptions, depending on the interpretation of the weight term in the denominator of the equation defining VSFC, are:

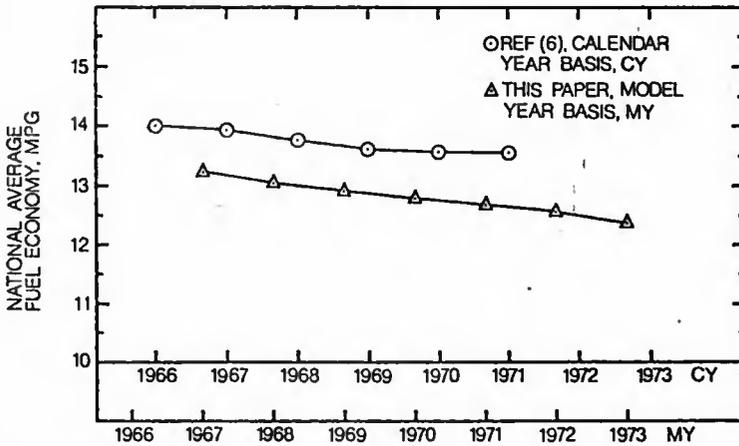
1. Indicated Vehicle Specific Fuel Consumption (IVS).
2. Potential Vehicle Specific Fuel Consumption (PVS).
3. Nominal Vehicle Specific Fuel Consumption (NVS).

IVS is obtained by using the inertia weight in the weight term of the VSFC equation. It is called "indicated" vehicle specific fuel consumption because it is the VSFC indicated by the test, and also because it includes the entire weight of the vehicle and therefore can be considered analogous to indicated specific fuel consumption (ISFC) for engines which includes friction and other parasitic (power absorbing) losses.

PVS is obtained by using the maximum vehicle capacity for the weight term in the VSFC equation. This is analogous to a weighted Brake Specific Fuel Consumption (BSFC) determined over a duty cycle for an engine. Inherent in this definition is the assumption that the useful work done by a passenger vehicle is that work done by carrying passengers and their luggage. In determining PVS, the numerator of the basic VSFC equation is multiplied by a factor to account for the increased fuel consumption of the vehicle when the load is greater than the 300 pounds used for the emission test, and in the IVS and NVS terms. Appendix G discusses this factor in detail.

NVS is obtained by using a nominal vehicle load of 300 lbs. for the weight term of the VSFC equation. Three hundred pounds is a close approximation to the average load carried by passenger vehicles (9). Inspection will show that NVS is directly proportional to the fuel consumption in

FIGURE 3  
NATIONAL AVERAGE FUEL ECONOMY  
VERSUS CALENDAR YEAR



liters/100 km discussed earlier.

IVS, PVS and NVS were calculated for those vehicles for which 1973 certification data were available. Data from 1306 tests were included. One difficulty in calculating PVS was the identification of a capacity for each vehicle. Investigation of owner's manuals for several different manufacturers revealed that the capacities were not always reported the same way and that the maximum vehicle capacity could vary within the same model. Because of these inconsistent data, the designated capacities given in Table 2 were used. These are the authors' estimates of reasonable values for maximum capacities of the types of vehicles considered. These capacities were matched to the various vehicle types in the sample.

Table 3 shows that the IVS is not strongly dependent on vehicle type or inertia weight. There is not much to differentiate vehicles if IVS is the parameter of interest.

Table 4 and Figure 3 both display PVS for different vehicle types and inertia weights. Figure 3 shows that a wide range of different vehicles can obtain essentially equivalent PVS. For example, all passenger car types can achieve a PVS of .4 to .45. Figure 3 also shows for a

given vehicle weight class, the vehicle with the best (lowest) PVS is the one with the greatest capacity. For example, at 3500 lb. or at 4000 lb., the PVS decreases as the number of passengers (and hence the capacity) increases. Therefore, based on PVS, the vehicles in a given weight class that are potentially the most efficient are those which have the largest fraction of their gross weight assignable to passengers and luggage.

Table 5 shows that, considering NVS, the potential benefit of a large vehicle (with a large potential for carrying passengers and luggage) is lost if that capacity is not utilized.

In summary, on a vehicle specific fuel consumption basis, heavy vehicles are not necessarily less efficient than light vehicles, if they are loaded to capacity. Heavy vehicles will have poorer vehicle specific fuel consumption, however, if their potential capacity is under-utilized. Most vehicles on the road today are under-utilized, based on the average number of passengers carried (9), and therefore NVS is the most appropriate concept of the three types of VSPC considered. Light vehicles not only get better fuel economy than heavy vehicles, they are also more efficient since NVS is proportional to fuel consumption.

Table 2

Designated Vehicle Capacities

<u>Number of Passengers Including Driver</u>	<u>Capacity Maximum, lbs.</u>	<u>Nominal Vehicle Type</u>
2	300	"motorcycle"
2	400	"small sports"
2	450	"large sports"
4	725	"subcompact"
4	750	"pony"
5	925	"5 passenger sedan"
6	1050	"compact"
6	1075	"intermediate"
6	1100	"full size"
7	1250	"van"

Table 3

Indicated Vehicle Specific Fuel Consumption (IVS)  
for Various Capacities and Inertia Weights  
(number of passengers in parentheses)

Inertia Weight	Capacities									
	300 (2)	400 (2)	450 (2)	725 (4)	750 (4)	925 (5)	1050 (6)	1075 (6)	1100 (6)	1250 (7)
515*	.187	-	-	-	-	-	-	-	-	-
1750	-	-	-	.087	-	-	-	-	-	-
2000	-	.084	-	.074	-	-	-	-	-	-
2250	-	.088	-	.077	-	-	-	-	-	-
2500	-	.078	.083	.077	-	-	-	-	-	-
2750	-	.092	.082	.076	-	-	-	-	-	-
3000	-	.138	.078	.083	-	.085	.080	-	-	-
3500	-	-	.121	.076	.077	.076	.077	.077	-	.069
4000	-	-	.126	.084	.098	.100	.083	.084	.078	.085
4500	-	-	-	.088	.098	.085	.084	.085	.084	.076
5000	-	-	-	-	-	-	-	.080	.083	.085
5500	-	-	-	-	-	-	-	-	.079	.088

Table 4

Potential Vehicle Specific Fuel Consumption (PVS)  
for Various Capacities and Inertia Weights  
(number of passengers in parentheses)

Inertia Weight	Capacities									
	300 (2)	400 (2)	450 (2)	725 (4)	750 (4)	925 (5)	1050 (6)	1075 (6)	1100 (6)	1250 (7)
515*	.324	-	-	-	-	-	-	-	-	-
1750	-	-	-	.266	-	-	-	-	-	-
2000	-	.443	-	.246	-	-	-	-	-	-
2250	-	.516	-	.285	-	-	-	-	-	-
2500	-	.508	.489	.310	-	-	-	-	-	-
2750	-	.654	.529	.333	-	-	-	-	-	-
3000	-	1.067	.548	.394	-	.333	.286	-	-	-
3500	-	-	.982	.413	.486	.341	.313	.307	-	.245
4000	-	-	1.164	.511	.578	.502	.377	.372	.338	.337
4500	-	-	-	.598	.649	.473	.419	.416	.407	.333
5000	-	-	-	-	-	-	-	.431	.437	.402
5500	-	-	-	-	-	-	-	-	.454	.455

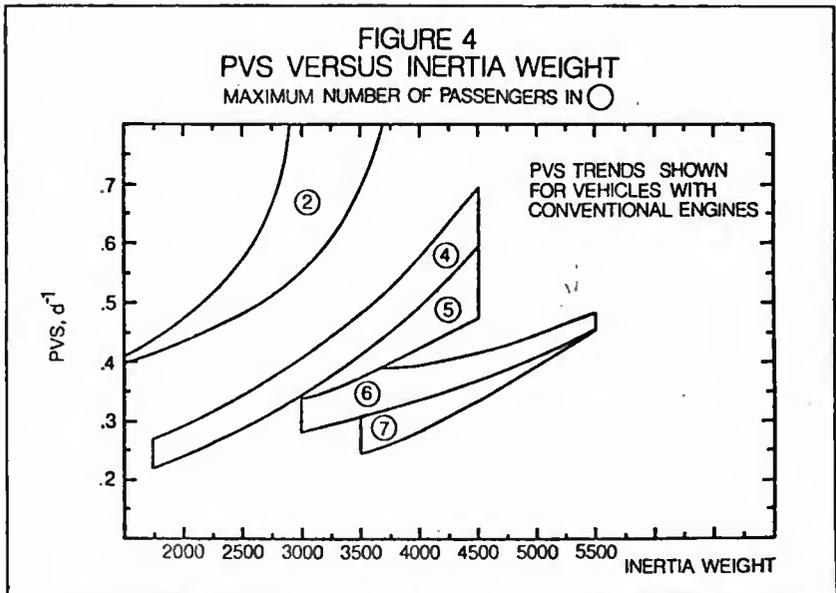
\*Motorcycle data were calculated from data in reference (10), with capacity = 300 lbs., and nominal load = 150 lbs., and inertia weight = curb weight + 150 lbs.

Table 5

Nominal Vehicle Specific Fuel Consumption (NVS)  
for Various Capacities and Inertia Weights  
(number of passengers in parentheses)

Inertia Weight	Capacities									
	300 (2)	400 (2)	450 (2)	725 (4)	750 (4)	925 (5)	1050 (6)	1075 (6)	1100 (6)	1250 (7)
515*	.648	-	-	-	-	-	-	-	-	-
1750	-	-	-	.517	-	-	-	-	-	-
2000	-	.562	-	.490	-	-	-	-	-	-
2250	-	.659	-	.579	-	-	-	-	-	-
2500	-	.651	.691	.641	-	-	-	-	-	-
2750	-	.841	.753	.697	-	-	-	-	-	-
3000	-	1.377	.782	.834	-	.848	.801	-	-	-
3500	-	-	1.413	.890	.892	.892	.901	.902	-	.802
4000	-	-	1.683	1.117	1.300	1.339	1.110	1.116	1.034	1.136
4500	-	-	-	1.320	1.475	1.281	1.257	1.271	1.266	1.145
5000	-	-	-	-	-	-	-	1.338	1.382	1.409
5500	-	-	-	-	-	-	-	-	1.453	1.610

\*Motorcycle data calculated from data in reference (10), with capacity = 300 lbs., nominal load = 150 lbs. and inertia weight = curb weight + 150 lbs.



## FACTORS THAT INFLUENCE FUEL ECONOMY

REGRESSION ANALYSIS - References (11), (12), (13) and (14) all discuss factors that influence fuel economy. In order to see how the data from the carbon balance method compare to the existing literature in estimating the effects of different parameters on fuel economy, an analysis using the 1973 certification data from vehicles with conventional engines was made. The resulting data set represented more than 1400 tests.

Available specifications for each of the vehicles tested included:

1. horsepower (HP)
2. displacement (CID)
3. compression ratio (CR)
4. axle ratio (AR)
5. revolutions per minute per mile per hour in top gear (N/V)
6. inertia weight class (IW)
7. transmission type
8. NO<sub>x</sub> level in grams per mile.

Each of these parameters were judged to have potential for affecting fuel economy.

Other available specifications (bore, stroke, tire size, bore spacing, etc.) were not used because they either were partially accounted for by the specifications that were used (bore and stroke are related to CID, tire size is related to N/V, etc.), were judged to have an insignificant effect on fuel economy (color of car, bore spacing, etc.), or were difficult to quantify because of their transient nature (spark timing and air/fuel ratio, etc.).

After considering the different combinations of the vehicle parameters that could affect fuel economy, a multiple regression analysis was performed on an equation including the following variables:

1. HP
2. HP/CID
3. HP/IW (power to weight ratio)
4. CID
5. (CID) (N/V) (cubic inches per mile)
6. IW
7. N/V
8. CR
9. AR
10. NO<sub>x</sub>

A total of 90 plots was generated in which each of the above variables was

plotted against calculated fuel economy for each IW class and for all weight classes collectively. These plots were constructed to allow the type of relationship between each variable and fuel economy to be determined. The plots generated for each inertia weight class eliminated the confounding of the relationships between individual variables and fuel economy which can be caused by relationships between some of the variables and inertia weight. For example, CID values tend to increase as inertia weight increases.

Analysis of these plots indicated that only two of the variables, inertia weight and compression ratio, were nonlinearly related to fuel economy. For some of the other variables, in some inertia weight classes, a nonlinear fit might have been more appropriate. Because the nonlinear trends were inconsistent, however, linear relationships were assumed.

A multiple regression analysis was performed on the following equation:

$$\begin{aligned} \text{MPG} = & A + B(1/\text{IW}) + C(\text{HP}/\text{IW}) + D(\text{HP}/\text{CID}) \\ & + E(\text{AR}) + F(\text{HP}) + G(\text{CID}) \\ & + H[(\text{CR}^4 - 1)/\text{CR}^4] + I(N/V) \\ & + J(\text{CID})(N/V) + K(\text{NO}_x) \end{aligned} \quad (3)$$

Table 6 shows the results of the first regression and nine subsequent regressions in which the least significant terms (determined from the computed "t" values) were dropped one at a time until only the terms A+B(1/IW) were left. Reducing the number of terms in the equation from eleven to two changed the correlation coefficient from .9475 to .9277. The standard error of estimate was changed from 1.45 to 1.66.

Neither the correlation coefficient nor the standard error of estimate were changed when the NO<sub>x</sub> term was eliminated. The resultant ten-term equation appears to be a good predictor of fuel economy for vehicles designed to meet the 1973-74 Federal motor vehicle emissions standards. However, since vehicle weight has such an overwhelming influence on fuel economy (as indicated by the high degree of correlation which still exists when only the terms A+B(1/IW) remain), it is conceivable that the coefficients assigned to some of the last eight terms of the equation could be in error, even directionally in error, without having a sig-

nificant impact on the correlation coefficient of the total equation. It was, therefore, of interest to test how well the ten-term equation predicts the effects of small changes in vehicle parameters made one at a time.

Reference (12) reported the changes in measured urban fuel economy as a number of alterations were made to a vehicle, one at a time. Reference (12) did not specify the vehicle used in sufficient detail. Only the weight (3600 lbs.), compression ratio (8.6:1) and axle ratio (2.7:1) were given. If the displacement of the vehicle in reference (12) was 318 CID (as one of the co-authors of reference (12) has indicated to the authors of this paper) and the vehicle was the same as the vehicles of that type certified by EPA, then values for the other parameter were 150 horsepower and 35.4 N/V. The test weight assumed as a baseline is 3900 lbs., allowing 300 lbs. for test equipment and the driver. Table 7 shows the percent change in fuel economy measured by reference (12) and predicted by the ten-term equation for changes in compression ratio, axle ratio, weight and displacement.

The changes predicted by the equation are in each instance directionally correct and, generally, in close agreement with the measured values. The only significant difference appears in the effect of a change in CID. Reference (12) did not report how this change was made and whether HP/CID remained constant. Our calculation is based on the assumption that HP/CID remained constant as displacement was changed by exactly 10%. This assumption may be in error. If the engine in the vehicle was changed, then engines of 273 CID, 340 CID or 360 CID could have been used. The differences in displacement would then be -14%, 7% and 13%, respectively, not 10%. Some method must have been used to estimate the effect on fuel economy of a 10% change in displacement.

The effect of the changes in axle ratio, compression ratio and weight on the other variables were, of course, considered. For example, a change in vehicle weight affected the value of both the (1/IW) term and the (HP/IW) term. The effect of the compression ratio change on engine horsepower was assumed to be that predicted by theory, i.e.

Table 6

Values of the Coefficients and the Correlation Coefficient (R) from the Regression Analysis for Different Numbers of Terms

	<u>Number of Terms</u>									
	<u>11</u>	<u>10</u>	<u>9</u>	<u>8</u>	<u>7</u>	<u>6</u>	<u>5</u>	<u>4</u>	<u>3</u>	<u>2</u>
A	-9.9549	-9.8618	-7.6642	-8.1303	5.6678	2.7167	4.4727	2.8861	1.7592	-1.2808
B	47.196	47.161	48.874	49.607	48.702	50.627	44.270	44,930	50,773	52,430
C	-192.20	-192.42	-211.86	-214.40	-204.32	-196.48	-132.64	-117.48	-72.503	---
D	1.6827	1.6774	2.6850	2.7147	3.2784	5.4540	5.1444	3.7790	---	---
E	- .76562	- .76544	- .81220	- .64380	- .66387	- .52651	- .49216	---	---	---
F	.03155	.03158	.03271	.03310	.03012	.01574	---	---	---	---
G	-.00678	-.00682	-.00984	-.00988	-.00909	---	---	---	---	---
H	27.069	27.022	23.850	24.566	---	---	---	---	---	---
I	.04186	.04176	.01532	---	---	---	---	---	---	---
J	-.00011	-.00011	---	---	---	---	---	---	---	---
K	.01816	---	---	---	---	---	---	---	---	---
R	.9475	.9475	.9473	.9473	.9468	.9457	.9447	.9436	.9397	.9277

Table 7

Comparison of Measured\* and Predicted  
Changes in Fuel Economy

Parameter	Originally	Changed to	Percent Change in Fuel Economy	
			Measured	Predicted
Axle Ratio	2.71	2.98	-1.74	-1.55
	2.71	2.45	+1.74	+1.55
Compression Ratio	8.6	9.5	+2.61	+3.29
	8.6	7.7	-2.61	-3.81
Weight	3900	4260	-4.35	-3.46
	3900	3540	+4.35	+3.97
Displacement	318	350	-1.74	-5.11
	318	286	+1.74	+5.11

\*by reference (12).

$HP_2 = HP_1 [((CR^4 - 1)/CR^4)_2 / ((CR^4 - 1)/CR^4)_1]$ . The comparison of the values predicted by the fuel economy equation and values measured by reference (12) indicates that the equation may provide a good estimation of the effect of the changes in various parameters on urban-suburban fuel economy. The accuracy of the absolute fuel economy values predicted by the equation could be further increased if the variables of carburetor calibration, spark timing and valve timing were included.

To determine the effect of an automatic transmission on fuel economy, twenty-four regressions were run. One equation was developed using only the data from manual transmission equipped cars and another equation was developed using only the data from automatic transmission equipped cars. Additionally, equations were developed for automatics and manuals in each inertia weight class.

The effect of automatic transmissions on fuel economy was determined by using a given set of variables (s.g. HP, CID, N/V, etc.) in the equation developed for manual transmissions and also in the equation developed for automatic transmissions. The fuel economy calculated using the auto-

matic transmission equation was subtracted from the fuel economy calculated using the manual transmission equation. The resultant differences in fuel economy was divided by the fuel economy value calculated using the manual transmission equation to determine the percent difference. Automatics are calculated to result in only a 1.8% loss in fuel economy.

Similar calculations made for the individual inertia weight classes show that the loss associated with automatics is not the same for all weight classes. Heavier vehicles (above 3000 lbs. IW) show no penalty associated with the use of automatic transmissions while lighter vehicles show about a 6% penalty, perhaps due to the use of less sophisticated transmissions or low power to weight ratios which require more use of the torque converter.

The penalties calculated by the equation developed with this regression analysis are much lower than others have reported in the past, including reference (12). A possible reason for the difference in the levels reported here is that emission levels have been held to the same limits (i.e. 1973 standards). Manual transmission equipped vehicles may require more severe calibrations to achieve emission

levels achieved by automatic transmission equipped vehicles. The use of greater amounts of spark retard, for example, can lead to reduced efficiency which tends to negate any efficiency advantages of the manual transmission over the automatic.

The lack of any significant difference between vehicles with automatic and manual transmissions supports the use of the equation developed through the regression analysis of all the data for either automatic or manual equipped cars.

**OTHER FACTORS** - Factors not predicted by the regression analysis discussed above also affect fuel economy. The manner in which the vehicle is driven, the use of convenience devices, ambient conditions, the "state of tune" of the vehicle, rolling resistance and aerodynamic drag are all important.

The effect of how hard the vehicle is driven has been quantified in reference (11). The effect on urban fuel economy due to a change in driver habits (approximated by changing the acceleration rates used for the cycles driven) resulted in the following: doubling the nominal acceleration of 6 ft/sec<sup>2</sup> to 12 ft/sec<sup>2</sup> resulted in approximately a 6% fuel economy penalty, while halving the acceleration to 3 ft/sec<sup>2</sup> resulted in approximately an 8% gain in fuel economy. It can be seen that a more sedate approach to acceleration by the driver will improve his fuel economy.

The use of convenience accessories has been discussed in references (11), (12), and (14). Table 8 gives the effect on fuel economy of the operation of engine accessories and convenience devices. Reference (11) did not break out the specific effect of each accessory and device.

Ambient temperature can affect fuel economy in two ways. First, when the ambient temperature is low, vehicles tend to warm up slower, with a consequent fuel economy penalty. This warm up penalty can be as much as 25% to 30% depending on trip length, based on data from reference (11), for an ambient temperature change from 70°F to 10°F. Secondly, fully warmed up fuel economy also is affected by ambient temperature. A penalty of about 6% is attributed to an ambient temperature of 10°F compared to a 70°F ambient in reference (11).

The effect of vehicle "state of tune" is difficult to quantify. Testing programs conducted by EPA have data from which the effect of a tuneup on fuel economy can be calculated. The results of a program in which randomly selected, privately owned vehicles were tested in the "as received" and "tuned" conditions indicated that, on the average, fuel economy was improved by 6% because of the tuneup. However, reference (15) concluded that the effect of a tuneup on fuel economy, based on tests of 75 vehicles, was insignificant. The fact that the data in reference (15) were taken from vehicles operating at high altitude may have affected the result. From the foregoing, the effect of a tuneup on vehicle fuel economy can be said to range from 0% (no effect) to a 6% gain.

The most readily available data on the effects of changing rolling resistance come from reference (12) which shows approximately a 2.6% gain for radial tires, compared to conventional tires, in urban operation. Others (16) have quoted higher gains, 10% not being unusual, but the vehicle types and driving cycles were not specified exactly. The above data show that using radial tires instead of conventional tires, can improve fuel economy.

The effect of nominal changes in aerodynamic drag in urban operation are negligible (12). However, for highway operation aerodynamic drag can become important, if not dominant. Aerodynamic effects on fuel economy can be separated into two parameters, drag coefficient and frontal area. Drag coefficients for passenger vehicles tend to be between .4 and .6 (17) (18). Frontal areas for most common passenger cars range from about 17 to 25 square feet. Therefore, the product of drag coefficient times frontal area can range from 6.8 to 15 and the fuel consumed in overcoming aerodynamic resistance could vary over more than a two to one range at a given vehicle speed. Light-weight vehicles, because of their generally smaller size, have lower frontal areas than heavier vehicles. Therefore, the fuel consumed to overcome air resistance for a lighter vehicle is less, if the drag coefficients of the two vehicles are equal. However, a large vehicle with an extremely good (low) drag coefficient could match the fuel consumption performance of a small vehicle

Table 8

## Effect of Engine Accessories and Convenience Devices

<u>Reference</u>	<u>Type of Accessory</u>	<u>Fuel Economy Penalty (urban operation)</u>
(11)	Power steering, air conditioning, generator	7.7%
(12)	Air conditioning	13% (85°F ambient)
(12)	Alternator	7.8%
(12)	Fan	about 1%
(12)	Power steering	about 1%
(12)	Automatic transmission	14% to 15.5%
(14)	Air conditioning	9% (70°F ambient)
(14)	Automatic transmission	5% to 6%
This paper	Automatic transmission	0% to 6%

with a poor (high) drag coefficient, considering aerodynamic resistance only. Reference (12) indicates the importance of aerodynamic effects, showing that a 10% decrease in drag coefficient results in a 4.2% improvement in fuel economy at 70 miles per hour.

## POSSIBLE FUTURE IMPROVEMENTS

**SHORT-TERM POSSIBILITIES** - The results of the regression analysis indicate which of the parameters considered have the most significant effects on fuel economy. Vehicle weight, the parameter with the greatest effect on fuel economy, could be reduced significantly in new passenger cars. Previous studies (19) indicate that the replacement of some body components currently made of steel (hood, trunk lid, doors, front fenders, bumpers, misc.) with aluminum components could reduce the weight of a 3600 pound vehicle to 3150 pounds, a reduction of 12.5%. The effect on fuel economy of such a weight reduction can be estimated using the fuel economy equation by calculating the effect of the same percentage weight reduction on an "average vehicle." An "average vehicle" has been defined as a vehicle with specifications equal to the mean specifications from the over 1400 tests

used for the regression analysis. This 12.5% weight change in itself would result in a fuel economy improvement of approximately 6%. Greater improvement would be possible if design changes were made to other vehicle components whose weight is affected by total vehicle weight, for example, such load-bearing components as frame, suspension, brakes, etc. The net improvement in fuel economy could then be increased to approximately 9%. Reference (19) also indicates that the total material and fabricating costs for the aluminum components could be essentially equivalent to those of the steel components replaced. The resultant vehicle with aluminum components and lighter steel components could be less expensive to produce due to the lesser amount of steel required.

Horsepower and displacement have a significant effect on fuel economy. The above-mentioned weight reductions would allow reductions in the engine size and output without any accompanying loss in vehicle performance. For an equivalent power-to-weight ratio the engine size of the vehicle could be reduced by approximately 17%. This would further improve fuel economy for a total savings, as predicted by the ten-term equation, of approximately 19%. The total 19% improvement is the result of the combined effects of

weight reduction and engine size reduction.

Other techniques are also available for reducing engine size without degrading vehicle performance. Turbocharging is one such technique. During periods of low power demand, typical of most operating modes, the turbocharged vehicle fuel economy would be similar to that of a vehicle powered by a naturally aspirated engine of equivalent displacement. CID reductions of 25% and more are possible with this approach (20) due to the higher HP/CID attainable with turbocharging.

Another technique for reducing the engine displacement required for a given maximum horsepower has been investigated (21). The "RamAire" system increased the output of a 235 CID six cylinder engine to that equivalent to a 283 CID V-8 by utilizing a volume of compressed air, generated by an onboard compressor, to operate an air ejector supercharging system at wide open throttle. This allowed a 12.7% improvement in "city" fuel economy with no performance loss. "Highway" fuel economy was improved 11.5%.

The combination of the (CID), (N/V) and (AR) terms of the fuel economy equation indicate that for a given engine size, drive trains which allow the necessary power to be generated at the lowest possible engine speed would be advantageous. Transmission concepts which would accomplish this may warrant investigation. Previous studies (16) indicate that N/V reductions could improve fuel economy by 11%.

Previous studies (12) indicate that transition from conventional and fibreglass belted tires to radial tires could result in a 3% improvement in fuel economy. This should be a feasible technique for improving the fuel economy of both new and used passenger cars.

**LONG-TERM POSSIBILITIES** - Long-term solutions may include significant body and engine design changes. Concentration on improved aerodynamics and further weight reductions would result in further fuel savings. The development of powerplants with greater efficiency than the conventional gasoline engine could result in significant improvements. How the use of alternate powerplants might affect the calculation

of "overall average fuel economy" is discussed in Appendix H.

**Diesel Engine** - Diesel powered passenger cars currently demonstrate approximately 70% better fuel economy than gasoline powered vehicles of equivalent weight (14). Currently marketed Diesel vehicles, however, have a power-to-weight ratio of only about half that of most gasoline powered vehicles.

Using equation (3) of the text to predict the effect of halving the power-to-weight ratio of a gasoline vehicle may make comparisons more meaningful. It was assumed that the power-to-weight ratio change would be accomplished by reducing the engine displacement by a factor of 2. A 200 lb. weight decrease was also assumed to approximate the effect of a smaller engine. The equation predicts that the average gasoline powered vehicle would realize a 27% improvement in fuel economy as the result of these changes. However, the difference between Diesel and gasoline powered vehicles with equivalent power-to-weight ratios is still 33%. The good fuel economy of Diesel powered vehicles appears to be due more to engine type than to low power-to-weight ratios.

It may be possible that Diesel powered vehicles with power-to-weight ratios comparable to gasoline powered vehicles will be developed in the future. Diesels have a greater tolerance for increases in intake manifold pressure (boost) than do conventional gasoline engines. The maximum practical boost which can be used in spark ignition engines running on pump gasoline is limited by the octane of the fuel to a pressure ratio of less than 2:1 (20). This limit can be extended with the use of water-alcohol injection, but this approach adds complexity to the system and requires another volume of fluid to be monitored and maintained. The maximum practical boost for a Diesel engine, however, is over 4:1 pressure ratio (22). A boosted Diesel may be capable of delivering fuel economy comparable to that obtained by current Diesel cars even though the power-to-weight ratio would be much higher. A boosted Diesel car of 120 maximum horsepower could achieve equal or improved fuel economy compared to a naturally aspirated Diesel car of 60 horsepower.

Techniques to obtain compact, lightweight power units may not have been in-

investigated fully in the heavy-duty Diesel market where the size and weight characteristics of the powerplant are not as important as they are for passenger cars. The U. S. Army, however, is interested in engines with high specific output for combat vehicles. Diesel engines developed for the military have been run successfully at pressure ratios exceeding 4:1 (22). Horsepower per pound figures higher than those for conventional passenger car engines have been achieved with engines designed for service more stringent than experienced by passenger cars (22). While gasoline engines can be designed for significantly higher horsepower per pound than they develop currently, this usually results in an accompanying loss in fuel economy which is not experienced with the highly boosted Diesel.

**Stratified Charge Engines** - The fuel economy aspects of the Hooda CVCC engine have been the subject of discussion in the past. It has been theorized that prechamber concepts will result in increased heat rejection and decreased volumetric efficiency with an accompanying loss to both horsepower and efficiency. The two Chevrolet engines converted to the CVCC process by Honda, however, are reported (23) to have developed more power and returned better 1975 FTP fuel economy than in their standard form. Fuel economy of the CVCC Vega was 9.9% better than the standard Vega and power was increased 1.4%. The 350 V-8-powered Impala realized a 3.8% fuel economy benefit and the power was increased 10.3%. A reduction in engine displacement to obtain power levels equivalent to the standard engines should improve fuel economy further. The emission levels of the vehicles with the CVCC engines were much lower than with the standard engines. The emission and fuel economy performance, reported to date, indicate that more extensive investigations of the CVCC engine are warranted.

Open chamber stratified charge engines, especially when unthrottled, also have potential for reducing the fuel consumption of passenger cars. An analysis of eighteen tests reported by Ford (24) indicates that 4500 IW class vehicles using the Ford PROCO engine had 12.5% better fuel economy than the average 1973

car in the same weight class. The engines in these vehicles were throttled and calibrated to an emission level of less than .4 gpm NO<sub>x</sub>.

**Waste Heat Recovery** - Long-term improvements may result from work to recover the energy now lost in the exhaust and cooling systems of current engines. Previous studies (25) have shown that for every gallon of fuel converted to useful work, more than two gallons are wasted to exhaust and coolant losses.

The turbocharging technique discussed earlier recovers a small portion of the waste heat in the exhaust and uses it to pump air into the engine. Much more energy is available in the exhaust than is currently tapped by the turbocharger. The logical extension of the turbocharging concept is a compound engine, an internal combustion engine in series with a turbine. The turbine would not only drive a compressor to supply high pressure air to the internal combustion engine, it would also be geared to the output shaft. Such engines have been built to the past for aircraft application (26).

Heat loss to the coolant can be essentially eliminated if the engine can be developed to operate at piston, cylinder and head temperatures of 1300 - 1500°F (27). The energy saved would increase the output of the reciprocating engine (or improve the fuel economy for a given output) and make more energy available in the exhaust to drive a turbine connected in series. In reference (27) it is estimated that such an adiabatic turbo-compound engine would be capable of a .29 BSFC. This concept could improve the fuel economy of passenger cars by nearly 100%.

**ENERGY USAGE CONSIDERATIONS** - Efforts to reduce passenger car fuel consumption are only worthwhile if the goal of reducing the total energy demand is kept in mind. Previous studies (28) indicate the fuel directly consumed by passenger cars amounts to only 62% of the automobile's total energy impact. If future lightweight automobiles are not built to last as long as current automobiles, the beneficial effects of reduced fuel consumption due to weight reductions will be at least partially negated by the energy required to replace these vehicles more often. Concepts which have potential for reducing

both the direct and indirect energy consumption of passenger cars will be the most beneficial.

Another technique which improves passenger car fuel economy does not involve any modification to the vehicle itself. Vehicles obtain better mpg when traffic is at a minimum. Traffic congestion increases the stop and go nature of urban driving and reduces fuel economy (29). If plans to reduce and restrict urban travel are implemented, the vehicles which are not removed from the road should obtain improved fuel economy compared to the fuel economy they were realizing during operation in heavier traffic. If the operators of vehicles made fewer trips per day, of their own volition, the same result would also be obtained.

#### CONCLUSIONS

Based on the investigations of passenger car fuel economy reported in this paper, the authors conclude:

1. For current vehicles, weight has the most influence on fuel economy.
2. Passenger cars in the lighter inertia weight classes (up to 2500 lbs.) generally achieve double the miles per gallon of passenger cars in the heavier inertia weight classes (5000 lbs. and above).
3. Light passenger cars (3500 lbs. inertia weight or less) designed to meet 1973 Federal Emission Standards have shown gains in fuel economy compared to pre-1968 passenger cars not subject to federal emission standards. Heavier passenger cars have shown losses.
4. If one considers the average sales-weighted fuel economy, current (1973) passenger cars show a 10.1% loss in sales-weighted fuel economy compared to vehicles that were not subject to federal exhaust emission standards. An individual model may show a greater penalty if its weight has increased in recent years.
5. Urban-Suburban fuel economy can be estimated for current (1973) vehicles by the ten-term equation presented in this paper. The effect on fuel economy due to changes in engine and vehicle parameters can also be estimated by this equation.
6. A national average fuel economy

calculated using fuel economy values determined from the 1972 Federal Test Procedure is always within 7% of the national average fuel economy reported by the Department of Transportation. Use of fuel economy values determined from the 1975 FTP will result in even better correlation with the DOT values.

7. Ultimately, vehicle weight reductions and the use of engines that utilize currently wasted energy could result in improvements in passenger car fuel economy of more than 100%.

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[EDITOR'S NOTE: Appendix not printed.]

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Mr. SYMINGTON. I suppose it would be fairly useful for the buying public at some point to have this kind of information made available on a regular basis.

Mr. QUARLES. As you may know, we recently proposed an auto-labeling program under which tests on fuel consumption or gasoline mileage would be made for all cars and labels would be placed on all new cars so that the customer at time of purchase could see what the mileage would be for that group of cars, various groups that he might be considering buying. This type of public education program, I think, would do a tremendous amount to make people realize the variances among cars and particularly to make them realize how much better mileage one does get with a small car than with a heavy car.

We are expecting to move forward with that program and get some very real benefits from it.

Mr. SYMINGTON. I hope that is done.

Thank you, Mr. Chairman.

Mr. QUARLES. Mr. Chairman, I have just been handed a note that the Senate has confirmed Mr. Train as Administrator of our agency by a unanimous 85 to 0 vote.

Mr. ROGERS. That is very encouraging. I am delighted and pleased to extend to Mr. Train the congratulations of this subcommittee.

Dr. Roy.

Mr. ROY. Thank you, Mr. Chairman. I will try to be brief also. I think you gentlemen have shown great patience here with the number of questions. I probably will repeat some questions. I am sure you will extend to me the same patience.

Mr. ROGERS. Would anyone like a recess for 5 or 10 minutes just to stretch? You have been sitting there a long time.

Mr. QUARLES. I wonder if we could have a brief recess.

Mr. ROGERS. The committee will stand in recess for 5 minutes.

Mr. QUARLES. Thank you very much.

[Brief recess.]

Mr. ROGERS. The subcommittee will come to order.

Dr. Roy.

Mr. ROY. Plans are being made for a coal-burning generating plant that will produce 2.8 million kilowatts when it is entirely on line. I don't know whether you can give me a definitive opinion, but I have been told that any of the four proposals regarding degradation of air will preclude the building and operation of this plant. Would you like to comment on that?

Mr. QUARLES. Yes, sir. I believe the third proposal would not necessarily preclude it. That proposal requires that every new plant has to put in the best available technology, and leaves further judgment whether it would be permitted within the significant deterioration limit to be made by the State after public comment and public hearing.

So I think that particular proposal I can say would not block it necessarily. The other proposals are more specific. I couldn't make a comment without having some technical analysis. The other three proposals were designed to provide for growth and development within some restraints and in general to permit the construction of a large powerplant or a large facility of some other sort.

Now a 2.8 million kilowatt powerplant is a big one. That might stretch the limits. I am just not sure. We are, of course, anxious to

receive information on exactly this type of question. I think it is really timely for those who are preparing plans for that plant to make their own analysis of whether it would be prohibited or not. This is the very type of information we want to get before we promulgate a regulation.

Mr. ROY. At the present time, other than the best available technology requirement, there is no requirement for this power company to submit their plans to you, is this correct?

Mr. QUARLES. That is correct. The States do, however, have to meet new source performance standards.

Mr. ROY. For the new source performance standards?

Mr. QUARLES. That's right. We have promulgated a new source performance standard with regard to coal-fired powerplants.

Mr. ROY. Let me shift to another subject. The primary standards are to protect the health of individuals. It is felt that if the primary standards are not met, there will be a "mortality harvest," I believe that is the term—increased mortality and morbidity rates, especially among that 3 to 5 percent that have some type of pulmonary disease?

Mr. QUARLES. I think Dr. Finklea's testimony was that mortality is one of the adverse health affects, obviously the most severe health effect.

Mr. ROY. I wanted to ask if these standards are exceeded, as they might be with permission for variance in any given State, does it thereby follow that we are going to have increased mortality and morbidity as a result of burning this high-sulphur fuel oil in the State as requested by the President?

Mr. QUARLES. Not necessarily because the standards are established to set the maximum conditions which can be permitted without having adverse health effects. Once the standards are established, then the implementation plan analysis is made on a worst-case basis so that assurance is provided that even under the worst-weather conditions the standards will not be violated.

Now often better weather conditions exist and more pollution could be emitted without actually causing a violation of the standards. So, it would depend on the duration of a variance and the extent to which a greater amount of high-sulfur fuel was burned during that period and what the weather would be during that period. Many factors would go into the equation.

Of course we are functioning now with levels of pollution which have come into existence over the past years and the whole program is to reduce the existing levels of pollution. So, the variance would be, if you will, a temporary delay in achievement of the improvement in the existing air pollution conditions.

Mr. ROY. It is my understanding from Mr. Train that there were perhaps 13 variables approved by the EPA last year. Did you monitor the ambient air standards within the area of those variances?

Mr. QUARLES. I believe that we did not, sir. Those were quite small variances in terms of their duration and the size of the area that was involved. They came up pretty much at the last moment. I don't have personal knowledge on this, but I feel sure that we would not have had time to set up a special monitoring arrangement. I feel sure the answer is no, we did not.

Mr. ROY. Are there plans to monitor any variances that are permitted this coming year?

Dr. STEIGERWALD. I have to say that in most of these cities we have a substantial SO<sub>2</sub>-monitoring network that is already there. It is a sizable job to add to it. I would say right now our plans are to operate the monitoring networks. I believe last year we did operate these systems every day.

We basically made sure they were operating during the variance period. That seems to be a good thing to do. I do not think we added to the monitoring system for this period of time.

I would like to add that one of the reasons why we are attempting to do it in advance or to set the groundwork in advance right now is so that if the situation comes up, we will know and the Governors will know who can best burn the higher sulfur fuel with the least impact on the air quality. This again is a function of the location of the source and the height of the stack.

I think part of the reason for attempting to get it set up in advance if it is needed is so that it can be done in a way that will have the least effect on the ambient air quality.

Mr. ROY. At the present time you have six area standards.

Mr. QUARLES. Six pollutants for which we have issued standards.

Mr. ROY. On the six, you are actually measuring pollutants by classes rather than measuring specific pollutants or at least entire spectrum of specific pollutants; is that correct?

Mr. QUARLES. In our monitoring program one monitors for a specific pollutant so that we would be recording levels of hydrocarbons or levels of photochemical oxidants or levels of sulfur oxide. Is that responsive?

Mr. ROY. That answers my question. I understand there is not always a good correlation between SO<sub>2</sub>, the sulfate and the sulfuric acid, for example; is that correct?

Mr. QUARLES. Yes. These relationships vary. We have more to learn about them.

Mr. ROY. Are there any special plans at the present time to measure the other specific pollutants which come from the burning of sulfur, for example? In other words, sulfuric acid acid or sulfate particulates?

Dr. FINKLEA. The Agency has a research and development program to develop the measurement techniques that are needed to measure acid aerosols and to measure other types of fine particulates both as far as their mass and as far as their chemical constituency. This program will not be complete for some time in the future, however.

In the meantime the Agency is continuing to measure the sulfate and nitrate portions of total suspended particulates as we have done in the past.

Mr. ROY. Is it correct in about four of these areas you have problems, you have problems in every area except carbon monoxide and nitrous dioxide?

Dr. FINKLEA. As far as measurement method?

Mr. ROY. As far as whether or not the thing you are measuring really gives you the adequate information as to the pollution which is occurring in this broad area of particulates?

Dr. FINKLEA. We have measurement methods which are useful both in nitrogen oxide and the ozone. We feel that the measurement of total suspended particulates is a very useful index. We would agree with you that that needs to be refined so that we can get particle sizes and chemi-

cal constituency also. The carbon monoxide measurement, we feel, is very specific and very accurate.

Mr. ROY. I think the question I would like to ask is, Should the law be amended in order that you might be in a position to move forward more rapidly in these areas?

Mr. QUARLES. I think for the most part, sir, that the problems here are not statutory. They are problems of developing our knowledge. It will take time under the best of conditions to carry out further research and to lay a foundation for further regulations. We think that as we complete research studies and find a need, we have the legal authority to establish the regulations. So our problems are more scientific than legal.

Mr. ROY. The information that I am getting, and it may not be correct, is that you have moved relatively slowly in these areas and perhaps it has been because of lack of money or lack of personnel or lack of deadlines?

Mr. QUARLES. Well, we have had a tremendous volume of work to do under this statute, dozens upon dozens of regulations to be issued.

Mr. ROY. The other thing from the act, in section 110 it is stated that in setting air quality standards the Secretary subsequent to an act—I have the wrong one. Anyway, it states the pollutants to be mandatorily measured and then suggests other pollutants would probably be added. We are 3 years into the act and you have added no other pollutant. I am told at least there are pollutants that are of great importance that have not been added at this time.

Would you agree that there are such pollutants?

Mr. QUARLES. Yes; I think there certainly are other pollutants that do have some serious significance in the overall picture for which, again in the ideal world, there should be some regulation. One of the points that I think is extremely important from a practical viewpoint of moving this country forward effectively toward the conquest of air pollution is to pay attention to some of the administrative difficulties which occur not only with EPA, but also and perhaps much more significantly at the State and local level.

Upon completion of our work to lay a foundation for setting standards and promulgating a standard, there then would need to be developed an implementation plan by the States to establish regulatory requirements on all the point sources that might be emitting that particular pollutant. There is already a tremendous amount of, I don't want to say "confusion" or "chaos," but there is about as much work as the system can bear in setting up these requirements, getting the implementation plans developed, getting them adopted, holding the public hearing, and then on the part of the State agencies, going from there to get those requirements communicated to the industries and getting them started on abatement programs.

If we were to be continuously revising the requirements for the implementation plans and by so doing require the States to be continuously revising the implementation plans and require then that industries be continuously revising their abatement programs, we might find we would make less progress in the long run. Now this is not the reason why we have not yet promulgated additional standards, but I think it is something you need to understand and in evaluating whether it is a good thing or bad thing that we have or have not

additional standards out yet. It is worth pointing out that in addition to the six pollutants covered by these standards we have also issued hazardous emissions standards covering emissions of mercury, asbestos, and beryllium.

Moreover in the new source standard area we address every pollutant that is known to be emitted from the industrial category being covered. In the course of issuing our various new source standards we have dealt with chloride and with acid mist in regard to some of the industries. So, the breadth of the attack is being continuously expanded.

My own judgment is that it would be counterproductive for it to be expanded at a more rapid rate than we have. However, as we develop more information that will justify additional standards, we will proceed to issue such standards.

Mr. ROY. Do you have any adequate information now to develop standards for lead?

Mr. QUARLES. We are at this time on the verge of completing the preparatory work that is required for issuing additional standards for this pollutant. I expect that the national ambient air quality standards that have been established for six pollutants will remain in effect for the foreseeable future. I do not anticipate action by the Agency in expanding the number of pollutants covered by ambient air quality standards in the near future.

Mr. ROY. Do you anticipate that there will be additional pollutants within the broad classes that will be measured during the sulfate and sulfuric acid measurements on a regular basis?

Dr. GREENFIELD. I think in the area of fine particulates, in the area of sulfates, possibly in the area of nitrates, you can foresee standards coming down the road in the next year or 3 years.

Mr. ROY. One other thing that troubles me. I understood you to say this morning that compared with 1972, you had not been able to maintain an equal level of effort so far as health research is concerned, and that that really this is not all that bad because you have not been able to maintain a 1972 level of effort in the rest of EPA either?

Dr. GREENFIELD. No, Doctor, I did not say that. What I said was that under any sort of level budget, as you know, given the cost-of-living increases that have gone on in the last 3 years, there is no doubt that our research program has gone down in real terms. The health program has suffered in exactly the same way.

In regard to the health program, we have made a larger effort to try to keep that one up as compared to the others, so that it has not suffered quite as much as the others. I would be wrong to say that the entire research program has not suffered under the cost-of-living increases.

Mr. ROY. There is a great similarity between what I said and what you said again.

Dr. GREENFIELD. I just feel more comfortable with what I said.

Mr. ROY. Thank you very much. Thank you, Mr. Chairman.

Mr. ROGERS. Thank you very much. I have a few questions here. Also I think all members may want to submit written questions which you could answer which could be helpful when we meet again a week from this Friday. Do any other nations have clean air laws?

Dr. FINKLEA. The legislation of all nations will be under review by the World Health Organization in a meeting beginning in December.

We do not have an analysis of all those laws at the present time. At the completion of the WHO meeting we will be glad to submit a summary of this information to the subcommittee.

Mr. ROGERS. Does Japan have any?

Dr. FINKLEA. Yes, sir.

Mr. ROGERS. You may not know about all nations. You probably know about Japan. Is their law similar to ours, less stringent or more stringent?

Dr. FINKLEA. In general the Japanese standards are similar, but somewhat more stringent than our own. Their achievement schedule for meeting their air quality standard is more stretched out than our own. They do allow specific variances for certain areas in their country.

Mr. ROGERS. I think it might be interesting for the committee and for the public to have a comparison basically of those laws, the basic features of the law. Do they have any penalty? Perhaps you could supply that for the record.

[See "Foreign Air Pollution Legislation," below.]

Mr. ROGERS. You say they have a longer period of time to obtain ambient air standards?

Dr. FINKLEA. Yes, sir.

Mr. ROGERS. What about car pollutants, specific pollutants?

Dr. FINKLEA. They had not at the time of our last analysis legislated emissions standards for automotive pollutants.

Mr. ROGERS. I thought they had almost the same standard as we did?

Dr. FINKLEA. Their ambient standards are the same.

Mr. ROGERS. Wasn't there some discussion that Japan would not relax their standards as we have done? We have given them an additional year, as you know, which was provided by law, but it was my understanding that the Japanese have not taken that action. Does anybody know? Could you find out for us?

Dr. STEIGERWALD. The understanding I have is that they have similar regulations, but they have a different test procedure, a different driving cycle and different instrumentation. Any numerical regulations only meaning something in regard to how it is going to be tested. I think the best thing to do would be to attempt to supply the detailed information.

[EPA says information will be supplied to the committee upon translation of the regulations.]

Mr. ROGERS. I think it would be helpful. I understand they are rather strict and have not granted any extensions to the extent that we have.

Also there is some fund which a pollutant pays in and anyone proving damage collects from that fund?

Mr. QUARLES. It appears to be the case that we don't have any experts on the Japanese law here.

Mr. ROGERS. Let us know that.

[The following information was received for the record:]

#### FOREIGN AIR POLLUTION LEGISLATION

EPA is participating in the World Health Organization's Inter-Regional symposium on air pollution in December. Our participants at this conference plan to write a report on the status of air pollution legislation of other nations. We believe a copy of this report would be most useful for the Committee. Hence, as soon as it is completed a copy will be forwarded.

Mr. ROGERS. It might be well to look at the other laws. In London, for instance, I think they have cleaned things pretty much in their coal situation. Is anyone familiar with that?

Mr. QUARLES. I think they have made tremendous progress there.

Dr. FINKLEA. English law is related to emissions. They don't have ambient air quality standards per se. Their home islands are pretty well ventilated by prevailing winds. They don't as a rule have the complex meteorological problems that we have in this country.

Mr. ROGERS. Didn't they also make a drive to change the coal burning?

Dr. FINKLEA. Yes, sir, fuel switching especially in the domestic heating area.

Mr. ROGERS. What about in Italy? Have they done anything there? There is a community where I think they were about ready to require everybody to wear a face mask.

Mr. QUARLES. I don't know about Italy in any specific detail, Mr. Chairman. I think that most of the industrialized European countries have developed very extensive pollution control programs. I know from discussions with individuals in engineering firms and others who design plants to be installed in Europe that the levels of control in Germany and France and Italy and the Scandinavian countries are quite stringent. They have taken the air pollution problem seriously. There has been a pattern of increasing stringency in the control requirements in Western Europe just as there has been in this country.

Mr. ROGERS. Has Germany developed any technique to control stationary sources?

Mr. QUARLES. Germany has regulatory programs that impose emission limitation requirements on stationary sources, and of course, the technology that is available in this country is for the most part available in Germany as well.

Mr. ROGERS. I just wondered if they had any. Could you let us know?

Mr. QUARLES. We will, Mr. Chairman.

Mr. ROGERS. What about in the steel mills, some of the processing there? Is there any more advanced technology than we have here you are aware that the Russians have?

Dr. GREENFIELD. One thing that does come to mind is the fact that the Germans have been pushing pretty hard on what is known as the combined power cycle, the so-called system where you use coal gasification as a mechanism to produce your power. One of the advantages of this system is that you get more of the Btu's from a clean gas than out of burning the coal in its natural state.

Mr. ROGERS. I think it might be well for us to take a look at that if you could get some information comparing what is being done and what the state of technology is.

[The following information was received for the record:]

#### GERMAN SO<sub>2</sub> REMOVAL SYSTEM

The attached summary by Mr. Slack of the Tennessee Valley Authority provides the most recent information we have on the German effort. We have also included a listing of our files on the Lurgi system and a brief description of the process.

## Summary by Mr. Slack of TVA

## COAL CLASSIFICATION (ADVANCED POWER CYCLE)

Coal Classification (Advanced Power Cycle)

The 170-mw test system at Lunenburg for coal gasification in an advanced power cycle has been described generally in the previous visit reports. In the present visit, however, Dipl. Eng. Meyer-Mahroeg gave a detailed discussion of both design factors and operating problems.

There are five Lurgi pressurized (20 atm) gasifiers; four can carry the load, however, leaving one as a spare. The product gas (about 150  $\text{m}^3/\text{hr}$ ) is washed to remove tar and dust and burned in a pressurized boiler; the boiler exit gas then passes through a gas turbine and finally through a boiler feed water heater. The boiler steam turbine produces 96 mw and the gas turbine 74 mw.

The gasifiers were started up in late 1972 but trouble with overheating of the outlet duct system forced a shutdown for revising the design. Startup by April is expected. In the meantime the rest of the system is being operated on oil. Everything is running smoothly, and full design guarantees have been met.

The gasifier trouble was said to be caused by operating error in startup. In the Lurgi system, coal is fed from a feed hopper into a lock equipped with upper and lower valves; when the lock is full, the upper valve is closed, the lock pressurized with gasifier effluent gas, and the lower valve opened. The coal moves downward through three roughly defined zones: (1) preheating (gas cooling), (2) reduction, and (3) oxidation. The resulting ash moves downward through a rotary grate and into an ash lock. Air and steam blown up through the grate keep the grate cool, oxidize residual coal (to supply heat for offsetting the endothermic steam-coal reaction), and finally convert the main portion of the coal to fuel gas.

Proper operation requires good control of the vertical location of these zones. Once the proper location is established, it is necessary to withdraw ash and feed coal at rates such as to maintain the location. It is not so bad to withdraw ash too fast since this moves the oxidation zone down to the grate and it can go no lower because the air enters there. If the ash is withdrawn too slowly, however, the oxidation zone moves upward, the incoming coal cannot cool the gas adequately, and high exit gas temperatures result. This is what happened during startup; instead of the design temperature of 550°C, a temperature of about 1000°C was reached within 50 minutes after start of operation, burning out the flange on the duct leading from the gasifier to the gas washer. Three gasifiers were involved.

The design is being changed to use of welded construction rather than a flange, and water cooling will be installed.

Various data, much of it new, were provided on the system. Air requirement, supplied by a compressor driven by the gas turbine, is 1200 mt/hr. About 90% goes to burn the gas in the boiler and 10% goes to the gasifier. The main compressor gives 10 atm, the design pressure for the boiler and gas turbine. Since the gasifiers are designed for 20 atm, a booster compressor is used on the gasifier air and the product gas is reduced to 10 atm by an expander that drives the booster.

Steam drawn off from the steam turbine is mixed with the air and passed into the gasifier. Steam requirement is 40 mt/hr and coal 70 mt/hr. Gas production is 300 mt/hr and boiler steam 330 mt/hr at 130 atm and 525°C. The gas turbine exit gas preheats the boiler feed water to 300°C max. Final stack gas temperature is 150-170°C.

The gasifier has a heavy crossarm "plow" arrangement at the top to distribute the coal; it turns at 10 rev/hr. The bottom grate also rotates, through gearing to a motor outside.

The entire gasifier is water-jacketed, producing steam at 20 atm.

For each feeding of a batch of coal, some gas escapes from the lock. This goes to an auxiliary boiler where it is burned at 2 atm, and then vented. The feed cycle is repeated six times per hour. Any dust from the coal hopper is vented to the atmosphere. The ash lock is also vented when depressuring; the gas at this point is mainly air and steam with little dust. The ash contains practically no unburned carbon.

Gasifier exit gas composition is roughly 24% H<sub>2</sub>, 15-20% CO, 4% CH<sub>4</sub>, 14% CO<sub>2</sub>, and 40% N<sub>2</sub>. Design temperature is 550°C from the gasifier and 160°C from the washer. There is a second wash tower in series; the fresh water to it feeds back to the first washer. Both washers are of the spray type.

About 4 mt/hr of washer liquor is purged as blowdown after decantation of tar. The tar is fed back to the coal lock where it helps keep fine coal in the charge. The blowdown liquor is presently disposed of by feeding into one of the other STEAG boilers. For a future plant based entirely on the gasifier system, this would not be feasible since the gas to the gas turbine must be kept as clean as possible. Disposal of the liquor is regarded as an important further development problem. There is some fear that the sodium salts will harm the boiler in which the liquor is burned in the present operation; the concentration is about 70 gpl NaCl and phenolic compounds 70 gpl.

Each gasifier has independent controls. It is expected that eight men per shift will be required for the entire plant, including a lock operator for each gasifier, an operator on coal and tar handling, and one on pumps. Perhaps seven maintenance men will be required.

The coal lock can be made automatic by tying the charging to lock temperature; the temperature goes up when the lock is empty.

The gasifiers can be operated at as low as 10% of capacity by cutting back on air and steam. The entire plant can be cut to 45%, the limitation being boiler feed water flow.

In startup, probably 4 hours will be required to get to full load. Oil is required during startup. It is thought that no oil will be required at full load, although this has not been demonstrated; some oil was used in the 50 minute full-load run described above. During the next test run, the boilers will be run on oil and the gas flared.

The site is being cleared for the 1.7-mw pilot plant (1% of gasifier exit flow) being installed to test H<sub>2</sub>S removal by the hot carbonate process. The main problem is getting adequate removal of H<sub>2</sub>S without absorbing too much CO<sub>2</sub>. Dr. Goldschmidt said that although CO<sub>2</sub> is the weaker acid in this particular case, the CO<sub>2</sub> is present in such large excess that it is difficult to avoid significant absorption. This is undesirable both because nonessential cost is incurred (both in absorption and regeneration) and because the relatively heavy CO<sub>2</sub> increases power output from the gas turbine.

It is planned to use such low gas retention time in the absorber that H<sub>2</sub>S will be preferentially absorbed. By limiting H<sub>2</sub>S absorption to about 90% it is hoped that CO<sub>2</sub> pickup will be restricted to 20-30%, or reduction from 14% of the total gas down to 10-11%.

STEAG thinks the advanced power system has a good future unless serious problems are encountered. Although the present system has a thermal efficiency of only 36%, by refining the heat cycle and going to larger size, say 400 mw, 42% should be obtainable (about 10% better than in a normal system). The investment for such a system should be 15-20% lower than for a normal one. One advantage is that the large amount of steam in the gas gives up to 50% more power from a given gas turbine than obtainable with straight combustion gas.

An extended program is planned to test parameters such as type and particle size of coal and degree of precleaning. In the current tests, hard coal (noncaking) is used, particle size is mainly 3-30 mw (a few % fines), and the coal is precleaned.

If the hot carbonate tests are successful, a unit will be built large enough to accommodate the full gasifier system.

LURGI-PRESSURE GASIFICATION  
FUEL CONVERSION - COAL GASIFICATION

FOLDER CONTENTS

- F-1.01-11.1 Summary Sheet: April 13, 1973, pp 1-3, with two flow sheets.
- F-1.01-11.2 Telephone Memorandum: D. Schroer, American Lurgi Corporation, and B. D. Cox, Processes Research, Inc., August 27, 1971.
- F-1.01-11.3 Business Card: Dieter Schroer, President, American Lurgi Corporation.
- F-1.01-11.4 Paper: "Power Plant Integrated With Lurgi Pressure Gasification of Coal," American Lurgi Corporation, pp 1-5.
- F-1.01-11.5 Paper: "New Fossil-Fueled Power Plant Process Based On Lurgi Pressure Gasification of Coal," Rudolph, P. F. H., American Lurgi Corporation, Joint Conference of Chemical Institute of Canada With American Chemical Society, May 26, 1970, pp 1-33.
- (Partial) F-1.01-11.6 Technical Bulletin: "Clean Fuel Gas From Coal," American Lurgi Corporation, May 1971, pp 1-19.
- F-1.01-11.7 Other: Lurgi-Pressure Gasification Process, September 30, 1971, p 1.
- F-1.01-11.8 Article: Bresler, Sydney A., Ireland, John D., "Substitute Natural Gas: Processes, Equipment, Costs," Chemical Engineering, October 16, 1972, pp 94-108
- F-1.01-11.9 Article: Rudolph, P. F. H., "The Lurgi Process Route Makes SNG From Coal," Oil and Gas Journal, January 22, 1973, pp 90-92.
- F-1.01-11.10 Article: Mehta, D. C. and Crynes, B. L., "How Coal-Gasification Common Base Costs Compare," Oil and Gas Journal, February 5, 1973, pp 63-71.
- F-1.01-11.11 Article: Siegel, H. M. and Kalina, T., "Coal Gasification Costs May Lower," Oil and Gas Journal, February 1, 1973, pp 87-88 and 93-94.

F-1.01-11.12 Article:

"SNG Process Description, American Lurgi Corporation, Lurgi Process for SNG from Coal," Pipeline and Gas Journal, February, 1973, pp 40 and 43.

COAL GASIFICATION

Process: Lurgi - Pressure Gasification

Developer: Lurgi Gesellschaft Fur Wärme-Und Chemotechnik, MBH  
Licensed in U.S.A. by: American Lurgi Corporation  
5 East 42nd Street  
New York, New York 10017

Description: This process gasifies coal or lignite to fuel gas (heating value approximately 180 Btu per cubic foot) in a countercurrent, fixed-bed, pressurized gasifier using a steam-air mixture as an oxidizer. Alternately, synthesis gas (heating value 400 to 450 Btu per cubic foot) can be produced if oxygen is substituted for air.

Crushed fuel (lignite, bituminous coal, subbituminous coal, or anthracite) enters the top of the pressurized gasifier through a coal lock and encounters a rising stream of hot combustion gases generated from fuel previously added. As the fuel falls toward the bottom, or grate, of the gasifier, it is dried and carbonized under conditions of rising temperature. Depending upon the fuel used, temperatures are 300 to 800C near the top of the gasifier and 1000 to 1200C at the bottom.

Operating pressure has normally been approximately 300 psi although the process and equipment can be adapted to higher or lower pressures, if required.

As the fuel approaches the bottom of the gasifier, the remaining carbonaceous solids are combusted by a steam-air mixture entering through the grate. The ash from the fuel deposits on the rotating grate where it is continuously removed, cooled and dumped through an ash lock.

The gas resulting from the above process contains steam, tars, H<sub>2</sub>S, and a small percentage of coal dust - as well as CO<sub>2</sub>, CO, H<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>. The tars and dust are removed by water scrubbing, while the H<sub>2</sub>S is removed by washing with aqueous ammonia or the potassium salt of dimethylamine acetic acid. Sulfur (by the Claus process) or sulfuric acid is obtained as a by-product.

The raw gas produced when oxygen is used in the reaction can be converted to Synthetic Natural Gas (SNG) by further processing.

After removal of the dust and tars, the gas is subjected to a CO shift reaction in which the following reaction takes place:



The ratio of  $\text{H}_2$  to CO in the gas from this reaction is controlled to about 3/1.

The acid gases ( $\text{CO}_2$  and  $\text{H}_2\text{S}$ ) are then removed by a gas sweetening process and the fuel gas goes to a methanation step. The following reaction occurs in the presence of a catalyst:



The fuel gas then is dried and fed to a pipeline.

**Applicability:** Applicable to the production of low Btu fuel gas from coal, with additional processing steps the process is applicable to production of synthetic natural gas.

**Status of**

**Development:** This process is now in commercial operation. A total of 58 gasifier units in 12 plants are installed and operating. These include units producing synthesis gas.

**Economics:** Based on coal costing 20 cents per million Btu, the operating cost for Lurgi product gas is 42.1 cents per million Btu.

**Reference:** United Aircraft Corporation Final Report to NAPCA, Contract CPA 22-69-114, December 1970, p 87.  
(PG 198-392 -- #4) ARD 0661

Estimates have been made for producing 250 million scfd SNG (heating value 900 to 1000 Btu per cubic foot) using the Lurgi gasifier.

Capital \$/MM	Fuel Cost Cents per MM Btu	Gas Sales Price \$/MM Btu	Reference
300	--	1.25	(a)
286	25	1.09 - 1.30	(b)
286	35	1.24 - 1.46	(b)
240 - 260	17.5	1.05 - 1.15	(c)
260 - 280	35	1.40 - 1.50	(c)

**References:** (a) Breslar, S. A. and Ireland, J. D., "Substituted Natural Gas: Processes, Equipment, Costs," Chemical Engineering, October 16, 1972, pp 94-108.

(b) Mehta, D. C. and Crynes, B. L., "How Coal-Gasification Common Base Costs Compare," Oil and Gas Journal, February 1973, pp 68-71.

(c) Siegel, H. M. and Kalins, T., "Coal-Gasification Costs May Lower," Oil and Gas Journal, February 12, 1973 pp 87, 88, 93 and 94.

Advantages: A wide variety of coal types can be used as raw material without pre-treatment to avoid caking.

Provision is made for removal of sulfur by the proven Claus process.

Product gas is supplied at high pressure suitable for use by power plants. When power is generated by a combination of gas turbines and steam turbines, the gas can be utilized at relatively low cost.

The process has a relatively short start-up time and can operate efficiently under less than full load; thus offering advantages when operated during periods of peak load power demand.

Disadvantages: Production of synthesis gas (heating value approximately 400 to 450 Btu per cubic foot) requires the heavy use of oxygen rather than air for mixing with steam in gasification. The synthesis gas must be further enriched with methane in order to equal the heating value of natural gas (approximately 1000 Btu per cubic foot).

The process cannot use coal fines directly. Briqueting equipment or a similar compacting means would be required to permit fines utilization.

OAP Interest/

Involvement: No involvement.

Lurgi's SNG from coal process

Fig. 1

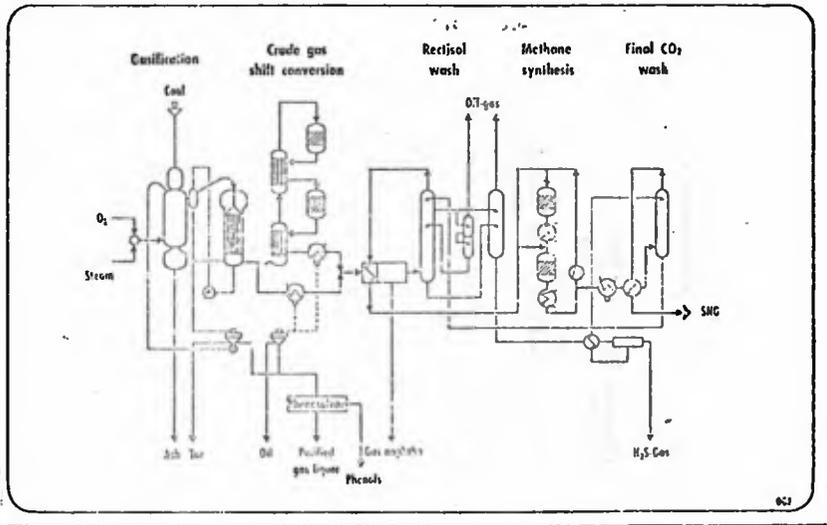
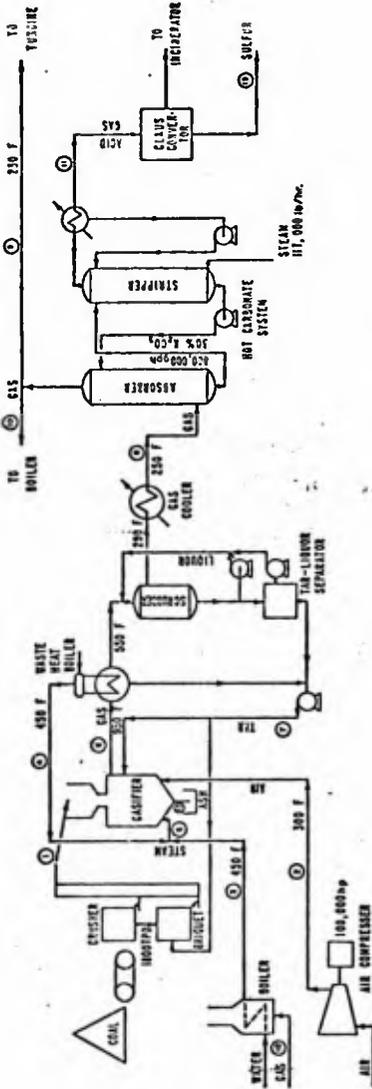


FIG. 8

LURGI GASIFICATION PROCESS

1000-MW NOMINAL COGAS POWER PLANT



DRY ASH  
File No. F-1.01-11.1

Stream #	Temp. °F	Press. psia	Flow Rate	Component	Flow Rate	Component	Flow Rate	Component	Flow Rate
(1)	70	15	1,700	Water					
(2)	480	450	450	Gas					
(3)	550	350	550	Gas					
(4)	550	350	550	Gas					
(5)	550	350	550	Gas					
(6)	550	350	550	Gas					
(7)	550	350	550	Gas					
(8)	550	350	550	Gas					
(9)	550	350	550	Gas					
(10)	550	350	550	Gas					
(11)	550	350	550	Gas					
(12)	550	350	550	Gas					
(13)	550	350	550	Gas					
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# CLEAN FUEL GAS FROM COAL

A new concept  
to solve environmental problems  
and to improve power plant technology

(Partial)

Advantages available by utilizing the Clean Fuel Gas Concept are demonstrated by comparing the results when firing the same gas turbine with natural gas:

For example, in case b) the feed to the gas turbine cycle is 542 MM BTU/hr. and 48 MW are generated. If the same gas turbine would be fired by natural gas containing the same amount of heat (542 MM BTU/hr.), only 42 MW would be generated. The difference in favour of the Clean Fuel Gas fired gas turbine is due to the higher amount of inerts in this gas, resp. due to the higher ratio of

$$\frac{\text{mass flow through gas turbine}}{\text{mass flow through air compressor}}$$

which is in a clean fuel gas fired gas turbine 1.17  
and in a natural gas fired gas turbine 1.02.

### Example 3: Advanced power cycle

This feature ostensibly may be used on a wider scale in advanced power cycles for fossil fuels. A typical example is the STEAG Power Plant at Luenen (Ruhr district), which starts with LURGI Pressure Gasification of subbituminous coal.

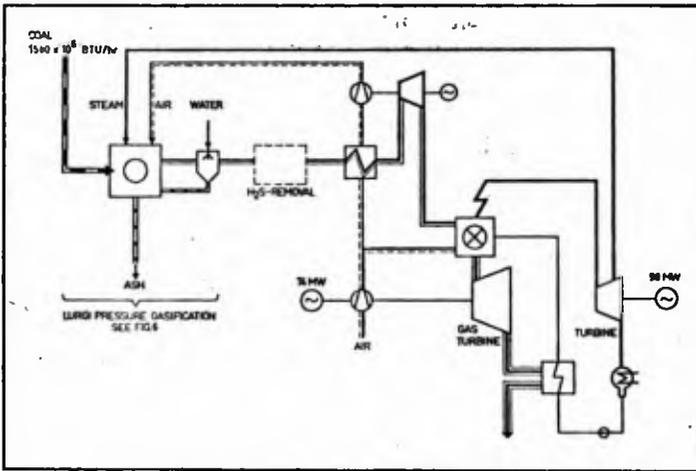


Fig. 5 Combination of Gasification with Gas Turbine Power Plant

This plant generates 165 MW and has a thermal efficiency of 36%. The investment cost is approx. 20% lower than that of a conventional

power station. Another feature of this plant is the supercharged boiler. Since then, this cycle has been further developed with the result that at a greater capacity and with reheating of the steam, the thermal efficiency can be improved to 40% without an increase in the specific investment cost. Curiously, a more sophisticated design is accompanied by lower investment cost. Finally, a plant of this type including desulfurization, will not cost more than a conventional type of power plant beginning with a pulverized fuel boiler.

### 3. PROCESS DESCRIPTION

The overall process scheme (see figure 2) comprises:

Gasification  
Purification of gas to gas turbine purity  
Desulfurization  
Expansion Turbine.

#### a) Gasification

The coal is gasified in the LURGI pressure gasifier. This well-known gasification process has so far been applied on a commercial scale for the manufacture of town gas and synthesis gas. The commercial plants process lignite, subbituminous coal and anthracite. Ash contents of up to 35% do not create any difficulties. When producing town gas or synthesis gas, oxygen and steam are used as gasification agent.

When applied to the production of fuel gas for gas turbine power plants, air and steam can be used as gasification agent. This simplifies the arrangement and operating conditions of the plants considerably compared with town gas and synthesis gas plants.

The gasifier is illustrated in figure 6.

The coal is gasified in a fixed bed under a pressure of, say, 300 psi in counter-current with the gasification agent and the produced gas, which results in a high gasification efficiency.

The coal is charged to the pressure gasifier via fully automatically operated lock chambers. The gasifier top is equipped with a rotating coal distributor. When gasifying caking coals, the

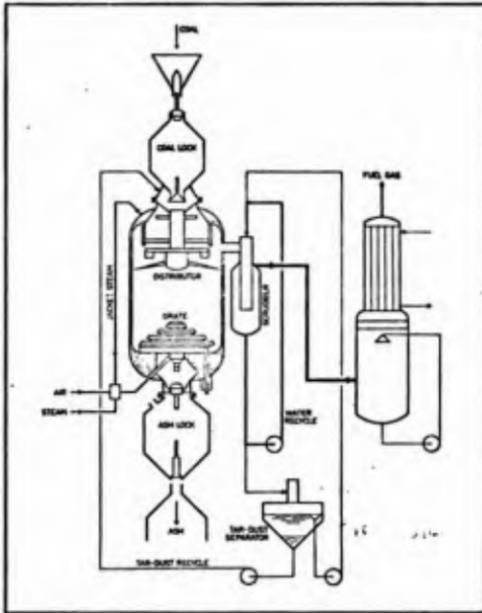


Fig. 6 LURGI Pressure Gasification for Fuel Gas Production

coal distributor is provided with a special device which prevents the coal from caking together when it has reached the plastic state. The coal distributor also serves for the recycling of tar to the gasifier where it is cracked.

While travelling from top to bottom in counter-current with the gas the coal is dried, devolatilized and gasified, the remaining ash being removed by a rotating grate and discharged via a semi-automatically operated ash lock chamber.

The gasification agent consists of air and steam. Part of the steam is generated in the gasifier proper. The gasification agent is introduced through the rotating grate into the ash bed. The partial combustion of the coal with oxygen supplies the heat necessary for the gasification reactions. The residual carbon in the discharged ash is practically zero.

The crude gas leaves the gasifier at a temperature of between 600 and 1200 °F depending upon the type of the coal.

The composition of the crude gas (dry basis) is about

CO <sub>2</sub>	14 % by vol.
CO	16 "
H <sub>2</sub>	25 "
CH <sub>4</sub>	5 "
N <sub>2</sub>	40 "
	<hr/> 100 % by vol.

This gas further contains

Steam from coal moisture and undecomposed steam,

Tar, oil and naphtha in vapor form,

Other carbonization products of the coal, such as phenols, fatty acid, NH<sub>3</sub>

The sulfur from the coal is present in the gas as 95% H<sub>2</sub>S and 5% organic sulfur. Very little coal dust is also present.

The gasification efficiency at the gasifier outlet is about 95%, the losses comprising 1-2% losses due to unburnt matter in the ash and 3-4% heat losses.

b) Purification of gas to gas turbine purity

As the hot gas leaving the gasifier still contains little coal dust (0.01 - maximum 0.5% wt. of the coal input) and traces of alkali and sometimes also chlorine, it must be subjected to purification treatment to make it suitable for the gas turbine process.

Pressure gasification affords complete removal of solids from the gas by quenching and washing with hot tar-containing water which is circulated. Cooling of the gas to saturation temperature of, say 320 °F causes a loss in efficiency which can, however, be tolerated because it provides on the other hand for the gas purity which is required for undisturbed continuous operation of the gas turbine.

As higher-boiling tar fractions are condensed during cooling, the circulating wash water contains tar to which the traces of coal dust are bonded. A partial stream of the circulating water is withdrawn from the saturator and routed to a separator. The precipitated mixture of tar and dust is returned from the separator to the gasifier for cracking and gasification.

The scrubbing cooler/saturator system also removes other impurities, such as alkali and chlorines which would be de-

Mr. QUARLES. It may be useful to do that, although I think you have indicated you would like us to try to answer questions by next week so that you could review them before we come back. I would suggest in this case that you allow us a little longer timeframe.

Mr. ROGERS. I understand you may not be able to get it immediately, although I think you might be amazed as to what these embassies might have right here for you. I think they would be willing.

Now, what about this little black box I keep hearing about? Are you aware of that?

Mr. QUARLES. Which one?

Mr. ROGERS. This is one, I think, from Japan, too. It cuts the engine to save car fuel. The Toyota Motor Co. said today it soon will market an electronic black box that turns off the car's engine automatically when it stops at an intersection and restarts the engine when the driver shifts the car into gear and steps on the accelerator. A spokesman said the device will offer major savings in fuel consumption and contains antipollution features for big cities where most driving is on a stop-and-go basis.

Called the automatic engine stop-and-start system, the device will sell in Japan for \$75.50. A spokesman said driving tests in Tokyo indicated fuel savings of more than 12 percent and reduction of the vehicle's output of air-polluting gases by about 21 percent. You might want to check into that and see.

Mr. QUARLES. That would certainly require a high degree of stop-and-go traffic conditions.

[The following information was received for the record:]

#### ANALYSIS OF TOYOTA "BLACK BOX"

Toyota advises that it has developed an experimental device which automatically shuts off an automobile's engine when the vehicle is stopped, and automatically restarts the engine when the accelerator is depressed. Toyota says that the purpose of the device is to reduce fuel consumption (by avoiding extended idling periods), but that it shows no improvement in emissions as measured by the Federal emissions test procedures. This is probably because the idling emissions eliminated are offset by the higher emissions during restart. An extensive analysis, considering the frequency and length of idle periods characterizing U.S. driving habits, and the relative rates of fuel consumption during idling and restart, would be necessary to quantify the fuel savings such a device might achieve in the U.S. EPA has asked Toyota to provide more data on the device and its effects on emissions and fuel economy.

Mr. ROGERS. I was amazed that you would have a fuel savings with stop and go like that, but they indicate what the testing shows, and if you could save fuel up to 12 percent and polluting gases by 21 percent, it might be worth looking into. Now, are you using the authority we have given you to do this type of research, to check on this type of information, or have you had an opportunity to? I think we called for that in the bill, as I recall.

Obviously, it has not been done, I think, quite to the extent that the law envisioned. I would hope you would look at that and see.

Mr. QUARLES. I would not want you to draw the inference that it has not been done from the fact that we do not have at our fingertips the information on it.

Mr. ROGERS. I understand you do not have all the information at your fingertips. I think certain reports were called for, and I am not

sure that Congress has received those reports. We will take that up with the staff people if we can.

Now, I keep hearing that this fuel shortage is perhaps greatly caused by the environmental acts taken by Congress, the States and the local areas. For instance, how many refinery companies has EPA prevented from being built?

Mr. QUARLES. I don't believe EPA has prevented any major industrial facilities from being constructed. I don't believe that any refineries or any other major industrial facilities have been prevented from being constructed by the Clean Air Act or by the Federal Water Pollution Control Act or by any regulations or actions taken thereunder or any State agencies operating programs in those fields.

Now, there have been a number of incidents, examples where a proposed facility has been opposed in a local community by persons concerned with the environmental impact of the location of a facility at the particular site in question, because of its anticipated adverse impact on fish and wildlife, on esthetic values, on recreation areas, or for other land-use considerations. Those may well be valid or they may be invalid reasons for opposing the location of a facility at a particular point.

I believe that much of the advertising which has been done by a number of large corporations, much of the other information that has been disseminated, has created a very misleading picture of the extent to which environmental reasons may have affected the growth.

Mr. ROGERS. I think it is well for us to look at this because we keep hearing that. I think the public is being given that impression. If it is true, I think we should know. This Congress would want to know.

Mr. CARTER. How many refineries have been built in the past year in the United States?

Mr. QUARLES. How many refineries have been constructed?

Mr. CARTER. Yes, gasoline and petroleum refineries in the past year.

Mr. QUARLES. I do not know. I know that for a long number of years there have been very few new refineries constructed in this country for a variety of reasons.

Mr. CARTER. Have there been any built in the United States in the past year?

Mr. QUARLES. I don't know.

Mr. CARTER. It seems you should know that. Do you know how many have been built in the past 5 years?

Mr. QUARLES. None have been constructed. There was a period during which none were constructed. I believe many of the existing refineries now are being expanded, and construction has commenced because it has become apparent that the supply is inadequate, and the oil companies are expanding their facilities.

Mr. CARTER. I would like to have the answers to those two questions, how many in the past year and in the past 5 years. If there have been expansions, how many have there been and where, if you please, sir.

[The following information was received for the record:]

#### REFINERY EXPANSION DATA

The attached charts show (1) that one new refinery has been built so far this year; (2) that two new ones were built, and 13 other expanded in 1972; and (3) for the five years 1968-1972 inclusive, capacity expanded by about 15 percent.

TABLE I.—PETROLEUM REFINING CAPACITY AND ACTUAL CRUDE RUNS  
 (Thousands of barrels per calendar day)

Year	District I		District II		District III		District IV		District V		Total, United States	
	Capacity	Runs	Capacity	Runs	Capacity	Runs	Capacity	Runs	Capacity	Runs	Capacity	Runs
1965	1,286	1,163	2,316	2,136	3,038	2,863	285	255	1,297	1,063	8,226	7,480
1966	1,351	1,231	2,436	2,284	3,189	3,051	299	269	1,375	1,124	8,597	7,959
1967	1,423	1,296	2,532	2,279	3,265	2,922	301	273	1,352	1,149	8,876	8,919
1968	1,484	1,199	2,643	2,318	3,346	2,779	381	266	1,403	1,080	9,257	7,642
1969	1,546	1,215	2,727	2,424	3,447	2,925	391	291	1,448	1,135	9,498	7,954
1970	1,537	1,220	2,765	2,422	3,464	2,989	330	286	1,488	1,170	9,585	8,067
1971	1,556	1,223	2,784	2,433	3,520	3,026	345	284	1,515	1,219	9,722	8,184
1972	1,543	1,214	2,809	2,463	3,584	3,178	360	304	1,519	1,252	9,815	8,410
1973	1,493	1,246	2,847	2,541	3,671	3,325	323	307	1,555	1,268	9,941	8,687
1974	1,463	1,216	2,870	2,578	3,671	3,419	386	320	1,589	1,299	10,113	8,807
1975	1,420	1,206	2,896	2,645	3,864	3,506	386	330	1,600	1,362	10,166	9,043
1976	1,400	1,259	2,951	2,790	3,906	3,665	398	338	1,649	1,392	10,292	9,444
1977	1,415	1,267	3,049	2,849	4,228	3,903	398	344	1,707	1,452	10,794	9,815
1978	1,452	1,307	3,161	2,967	4,581	4,129	418	367	1,770	1,571	11,312	10,312
1979	1,477	1,309	3,220	3,013	4,737	4,264	428	385	1,875	1,658	11,731	10,629
1980	1,487	1,250	3,360	3,154	5,027	4,357	421	393	1,974	1,676	12,272	10,870
1971	1,515	1,330	3,482	3,230	5,345	4,482	421	405	2,081	1,742	12,847	11,199
1972	1,541	1,376	3,476	3,230	5,481	4,482	423	405	2,179	1,742	13,104	11,989
1973	1,553	1,373	3,460	3,230	5,489	4,482	423	405	2,208	1,742	13,248	12,779
1974	1,553	1,373	3,642	3,230	5,517	4,482	423	405	2,208	1,742	13,348	12,779
1975	1,553	1,373	3,642	3,230	5,517	4,482	423	405	2,215	1,742	13,355	14,360

Note: Capacity of operating refineries—average of Jan. 1 in given year and Jan. 1 in following year—U.S. Bureau of Mines 1972 and later obtained by adding known projects, U.S. Bureau of Mines crude runs in year indicated. Projections 1972 and later represent volumes needed to be run to hold product

Imports to current levels. Demand based on Interior Alyeska study with minor updating revisions for the year 1975.

Source: Hydrocarbon Processing, Oil and Gas Journal and miscellaneous sources.

TABLE II.—NEW REFINERIES OR EXPANSIONS SCHEDULED IN THE UNITED STATES BY PAD DISTRICTS

[In millions of barrels per day of crude distillation]

Company/location	I	II	III	IV	V	Total
<b>1972:</b>						
Witco Chemical Corp. (Bradford, Pa.).....	7.5					
Mobile (Paulsboro, N.J.).....	6.9					
Quaker State (Hancock County, W. Va.).....	10.0					
Ashland Oil Co. (SL Paul, Minn.).....		10.0				
Total Leonard (Alma, Mich.).....		5.0				
Alabama Ref. Co. (Mobile, Ala.).....			4.0			
Murphy Oil Corp. (Meroux, La.).....			31.0			
Southland Oil (Lumberton, Miss.).....			1.0			
Sage Craak Ref. (Cowley, Wyo.).....				1.0		
Refinarcia Corp. (Commarca City, Co.).....				4.0		
Chevron Asphalt (Portland, Oreg.).....					6.0	
Hawaiian Ind. Ref. (Barbers Point, Oahu).....					35.0	
Mobil (Ferndale, Wash.).....					8.1	
San Joaquin Oil Co. (Oildale, Calif.).....					6.0	
Douglas Oil Co. (Santa Maria, Calif.).....					2.0	
<b>Total.....</b>	<b>24.4</b>	<b>15.0</b>	<b>36.0</b>	<b>5.0</b>	<b>57.1</b>	<b>137.5</b>
1973: Mobil (Joliet, Ill.) <sup>1</sup> .....		164.0				164.0
1974: None.....						
1975: Energy Co. (North Pole, Alaska).....					15.0	15.0

<sup>1</sup> New.<sup>2</sup> Expected to be on stream about Jan. 1, 1973.

Mr. ROGERS. I think that would be helpful. I would hope the Agency would look at that and would let us know if there has been any delay as a result of the environmental law. It is my understanding that the tax benefits for building outside the country have been the incentive for the building of refineries not in this country, but outside. I also would like to know if this is a legitimate criticism of the environmental laws. We should look at that, and this committee should know in making any judgment if we need any modifications.

[The following information was received for the record:]

#### REFINERY LOCATION

No hard and fast answer can be given, but several points can be made in answering this question:

1. The Department of the Interior has cited the lack of certainty in the supply of imported crude due to the import quota program as the most important constraint on refinery capacity expansion. This has been substantiated by the spate of announcements by the oil companies of plans to increase refining capacity that followed the demise of the import quota program. The President's Energy message of June 29, 1973 stated that 8 companies have made "firm" decisions to expand existing capacity by 1.5 million barrels daily—a ten percent increase.

The importance of this increase in domestic capacity is that it seems to point to the import quotas as the limiting factor. While Environmental constraints have remained constant during this period, the demise of import quotas has served to trigger a rash of plans to increase capacity. Certainly, environmental constraints have played a lesser role than generally attributed to them.

2. The term "environmental constraints" also merits some clarification. With regard to refineries, we are talking of two distinct phenomena. The first is federally imposed emission and effluent requirements (in addition to NEPA). The second is the uproar at the State and local level engendered by any attempt to site a refinery. While the Federal requirements may raise costs, the chart below demonstrates that the crucial factor in blocking new refinery projects has been opposition at the State and local level. There is no evidence that federally mandated emission or effluent standards under the air and water laws have been instrumental in retarding the expansion of domestic refining capacity.

In discussing this point, we may wish to stress that siting new refineries is only part of the larger siting problem surrounding all power-producing and indus-

trial facilities. There is no way around the fact that all such projects will receive the closest possible scrutiny by local communities, and properly so. We see a solution not in relaxing this scrutiny, but rather in the type of comprehensive planning that will insure these projects are environmentally sound from the outset.

3. There is a variety of complex economic and technical considerations that have retarded the expansion of domestic refining capacity. In addition to the import quota program, these include:

a. A higher rate of return on investment in Europe (10-12 percent than in the U.S. (6-8 percent) principally due to greater demand and the absence of competition from independents.

b. Higher capital investment per barrel due to the American practice of refining more gasoline from crude than the Europeans. This requires additional processing which in turn reduces the potential for higher returns on investment.

c. Higher costs due to environmental regulations; particularly the required use of low sulfur fuels while the Europeans can often use high sulfur fuel. The increased costs imposed by environmental regulations have been estimated at 5-8c per barrel.

#### REFINERIES BLOCKED OR DELAYED BY ECOLOGISTS

Company	Location	Size (Barrels per day)	Final action blocking project
Shell Oil Co.....	Delaware Bay, Del.....	150,000	State reacted by legislature passing bill forbidding refineries in coastal area.
Fuels Desulfurization <sup>1</sup> .....	Riverhead, Long Island.....	200,000	City council opposed project and would not change zoning.
Maine Clean Fuels <sup>1</sup> .....	South Portland, Maine.....	200,000	City council rejected proposal.
Do <sup>1</sup> .....	Searsport, Maine.....	200,000	Maine Environmental Protection Board rejected proposal.
Northeast Petroleum.....	Tiverton, R.I.....	65,000	City council rejected proposal.
Supramarine, Inc.....	Hoboken, N.J.....	100,000	Hoboken project withdrawn under pressure from environmentalist groups. Considering site near Paulsboro, N.J.
Commerce Oil.....	Jamestown Island, N.J., Nar-ragansett Bay.	50,000	Opposed by local organization and contested in court.

<sup>1</sup> Maine Clean Fuels is a subsidiary of Fuels Desulfurization and the refiner in question is the same in each case, so the capacity in barrels per day is not additive, but the incidents are independent and additive.

Mr. ROGERS. Also we need to know how many new additions are being put on. I think it would be well for us to know and we will go into this with the oil companies, what their planning showed and if it was not possible to foresee what was coming about.

Mr. QUARLES. I think it would be highly beneficial if you would go into that with the oil companies. I don't think I need any staff work to comment on the basic question you asked. It is my judgment, not a criticism of the Clean Air Act, that it has retarded establishment of oil refineries in this country. Certainly any proposed construction of oil refineries in this country would have to take into account the fact that we now do have a tough air pollution control law and that would probably require some modification of the design which might increase the cost.

That feature would not in my judgment be inappropriate. I would consider that appropriate. Now as to the motivation of where these refineries have been built or why they haven't been built, that involves a lot of factors. It involves the import quota system. It involves the return on profit which I understand has been somewhat higher in Western Europe than it has been in this country as well as the factors you mentioned.

Mr. ROGERS. I think we should have definitive answers as best we can get them. I think it would be helpful to have that.

Now what about the question of catalytic converters which makes us use up all of our gas? Is this so? What has been the extent of it, what is the result and what is the future outlook? Could you just quickly give us that?

[The following information was received for the record:]

#### LEAD FREE GASOLINE

To begin with it should be noted that the fuel penalty currently associated with motor vehicle emission controls, i.e., engine modifications, is about 10 percent, as compared to the average fuel economy of 1957-67 models. This fuel penalty is entirely attributable to cars weighing more than 3,500 pounds. Among cars weighing 3,500 pounds or less, average fuel economy of 1973 models is one to three percent better than the 1957-67 average. Since the use of catalyst systems will enable auto manufacturers to get away from engine modification techniques, it will have a favorable impact on fuel economy.

Catalyst-equipped cars, however, must use lead-free gasoline. Production of such fuel is expected to increase crude-oil demand by approximately 0.3 to 0.4 percent in 1980. In addition, the auto industry began using lower compression engines in most cars in 1971. This step was taken both to help control NOx emissions and to permit the use of 91 octane gasoline. The industry has stated that it was done to pave the way for use of 91 octane lead-free fuel. The fuel penalty associated with this reduction in compression ratio is 3.5 percent. If this penalty is included as part of the impact of the shift to lead-free gasoline, the increase in crude oil demand is approximately 1.6 to 1.7 percent in 1980. It is far from certain, however, that elimination of the need for 91 octane lead-free fuel would result in an increase in compression ratios.

The use of catalysts helped offset the fuel economy impact of more stringent standards. For example, cars meeting the 1975 interim standards are expected to have about 10 percent better fuel economy than today's cars (or in other words, fuel economy equivalent to that of pre-controlled cars). Cars meeting the 1976 interim standard (2.0 grams NOx per mile) should have about four percent better fuel economy than current cars. Depending on which control systems are used, it is possible that cars meeting the statutory NOx standard (0.4 grams per mile) could have fuel economy equal to or somewhat better than that of today's cars.

The use of catalysts can save fuel because it provides automobile manufacturers more flexibility to configure their engines for performance and fuel economy. To the extent their catalysts permit this, their use will probably offset the negative impact of the use of lead-free fuel. An exact estimate of the fuel savings from catalysts (as opposed to other control systems) is not possible because, with today's engines, the statutory standards appear to be attainable only with catalytic systems.

Mr. QUARLES. The relevance of catalytic converters to the petroleum supply picture is that the catalysts do require unleaded gas and unleaded gas requires a somewhat higher volume of crude oil to produce the equivalent volume of gasoline. I understand it is roughly about 4 percent more crude that is required. However, that additional crude oil generates additional resid, so that the additional amount is not a complete energy loss.

What one then has to ask is whether the additional resid is needed and will be used and for the most part it will be. So that our position is that the catalytic converters exert a relatively minor influence on the overall supply picture of petroleum.

Mr. ROGERS. I think any definitive information, the particular cars you have tested, would give us some picture of that. What about for the future? Does it look as though there will be any gasoline penalty or mileage penalty from the use of converters?

Mr. QUARLES. The catalytic converter according to our best analysis now will not of itself create any fuel penalty, nor will it create any improved gasoline mileage of itself. However, catalytic converters will tremendously improve the ability to control emissions and will make it possible for the automobile manufacturers to meet the standards through an overall system which entails less in modification of the engine than is presently being done to meet the less stringent standards that are now in effect. In other words, if automakers use catalysts, they will be able to move up to the more stringent emissions requirement and simultaneously improve their engine design from the viewpoint of efficiency which could result in improved gasoline mileage.

Mr. CARTER. Would you yield, Mr. Chairman?

Mr. ROGERS. Certainly.

Mr. CARTER. On that question I believe you stated in your presentation today that small cars use 10 percent more gasoline due to the necessary extra antipollution equipment, is that correct?

Mr. QUARLES. The average figure was 10 percent. Small cars, I think, were somewhat less.

Mr. CARTER. For large cars it was 30 percent, is that correct?

Mr. QUARLES. Excuse me. The average was 10 percent for all cars.

Mr. CARTER. With large cars it went up to 30 percent?

Mr. QUARLES. That is the very maximum that we have any indication to believe. I think it would be a gross mistake from what I know to take that 30 percent as representing the average fuel penalty for large cars.

Mr. CARTER. No one has tried to tell you that. As I read it, you stated 10 percent, I thought, for small cars as an increase in the consumption of gasoline and 30 percent for larger cars.

Mr. QUARLES. It is 10 percent as an average for light-duty vehicles.

Mr. CARTER. You are reading your paper correctly, that is the way it was, 10 percent for lighter vehicles, 30 percent for heavier ones.

Mr. QUARLES. Sir, I wonder if I can make a point that when we talk about light-duty vehicles, we are distinguishing in very rough terms passenger cars from trucks. A large car like an Oldsmobile is a light-duty vehicle.

Mr. CARTER. The average increase in it is only 10 percent, is that correct?

Mr. QUARLES. Yes, sir.

Mr. CARTER. What about Chevrolet?

Mr. QUARLES. Chevrolet is included in the average.

Mr. CARTER. Ten percent?

Mr. QUARLES. No, not 10 percent. It is included in the average. I don't know the figure for Chevrolets. It would vary among different models of Chevrolets.

Mr. CARTER. For Oldsmobile it is only a 10-percent increase. That is what you said. You said it was a light-duty vehicle, is that correct?

Mr. QUARLES. We may be bogging down a little bit. What I said was that the average figure for light-duty vehicles is 10 percent. Light-duty vehicles are a class. The class includes Oldsmobiles, Chevrolets and most all the other passenger cars that come to mind. The 10-percent figure being an average does not necessarily stand for any single entry in the class.

Mr. CARTER. What is the weight of the average Oldsmobile?

Mr. QUARLES. I would guess that Oldsmobiles might tend to fall in the 3,500- to 4,000-, 4,500-, 5,000-pound class. This would depend on whether you are talking about a sedan or station wagon.

Mr. CARTER. Let me read you back your statement: "It is worthy of note here that there has been an actual improvement in the fuel economy of small cars over the time period whereas fuel penalties as high as 30 percent have been observed in large over-3,500-pound automobiles."

That would seem to include the Oldsmobile in that case. I suggest that that figure is approximately right. In driving and observing cars and the use of gasoline in those cars which weigh over 3,500 pounds I would say the penalty is at least 30 percent.

Mr. QUARLES. We would differ from you, sir, because we would say that in some instances a maximum of 30 percent has been noted and I couldn't go along with the statement that it is at least 30 percent.

Mr. CARTER. You did not state a maximum though in your paper, my good friend.

Mr. QUARLES. What I said was up to 30 percent. That sounds like a maximum to me.

Mr. CARTER. As high as 30 percent have been observed in large over-3,500-pound. I think that is "average." I don't want to belabor the question. Will the use of catalytic converters diminish the use of gasoline or not?

Mr. QUARLES. Yes.

Mr. CARTER. Below this 30 percent that we mentioned?

Mr. QUARLES. Yes.

Mr. CARTER. And below the 10 percent?

Mr. QUARLES. Yes, sir. It was particularly the testimony of General Motors at our hearings, as I recall, that they expect to achieve very significant improvements in gasoline mileage through the use of converters. They expect that their efficiency will be dropped back to the higher levels which they achieved before these catalysts were developed and going back before the emission requirements were established. I think General Motors will testify before you.

Mr. ROGERS. General Motors will testify.

Mr. QUARLES. You can get the particular directive from them.

Mr. CARTER. In other words, the 30-percent penalty will be negated, is that correct?

Mr. QUARLES. Yes, sir.

Mr. CARTER. Thank you, Mr. Chairman.

Mr. ROGERS. I think it has been brought out that there is concern about side effects on health from fuel additives and lubricants when used with catalysts. Now, we gave authority to EPA in the law to get the necessary information from manufacturers of fuels that use the additives. That has been in existence since 1970?

Mr. QUARLES. Yes, sir.

Mr. ROGERS. Have you used that authority and have you issued regulations under section 211 to require manufacturers to conduct those tests and give you such information?

Mr. QUARLES. We are currently requiring information as to the fuels and I understand some degree of fuel additives under the authority that was in existence before the 1970 act was enacted, under the 1967 act.

Mr. ROGERS: Have you issued regulations?

Mr. QUARLES: We have not issued regulations yet.

Mr. ROGERS: Should that not be done?

Mr. QUARLES: Yes.

Mr. ROGERS: Do you plan to do that?

Mr. QUARLES: Yes, we have those under development.

Mr. ROGERS: Will you let us know what time element and when that will be done?

Mr. QUARLES: Yes, sir.

[The following information was received for the record:]

#### ADDITIVE REGULATION

EPA is currently incorporating the received comments into a final regulatory packet. Promulgation is expected within the near future.

Mr. ROGERS: What about the Agency's reasons for proposing changes in NO<sub>x</sub> and how far it would be reduced? What about that Chattanooga study, the conversion to arsenite? What brought you to this change all of a sudden? What studies, what scientific basis?

Dr. FINKLEA: We are back to an old friend of mine, nitrogen oxide, Congressman Rogers. At the time the primary ambient air quality standards were promulgated and a Federal reference method was established in 1972, there were two generally used methods to measure nitrogen dioxide, one of which was the buckler method that then became the Federal reference method. This was a method that had been used by the health people in the Chattanooga health study. The other method was the continuous Saltzman method, a method which had been used by the Air Pollution Division of Abatement in Chattanooga, about the same time as the health study, actually 1-month overlap.

The methods of measurement were internally consistent, but they did not compare well with each other. Subsequent to that time, we developed a much better measuring tool to standardize these methods. This was the permeation tube for nitrogen dioxide. It was then apparent that we had grave difficulties with the Federal reference method that was established and that this method was incorrect.

It was incorrect because there was a variable in the collection efficiency. The method when applied understated nitrogen dioxide concentrations at high levels and overstated them at low levels. There also are additional variations in the Saltzman method. The Saltzman method in relation to the old method will depend on the particular kind of Saltzman device being used as well as apparently on the operators that have been using it.

After that, we reassessed what the exposure to nitrogen dioxide in Chattanooga would have been like using the Saltzman measurement method, and we found that the average annual exposures in the Chattanooga situation differed very little. This was due to a combination of the kind of Saltzman device used, the operators that were using that device in Chattanooga, and to the fact in Chattanooga we did not have some of the substances that interfered with some of the Federal reference methods in other locales.

Subsequent to that, we did brief members of this subcommittee staff as well as other congressional subcommittees on the measurement

method problem, and our agency stated its position in the Federal Register. Subsequent to that time, the National Air Quality Advisory Committee had considered this problem and has endorsed the Agency's decision that there is no immediate change in the primary ambient air quality standard required, and that there should be a careful consideration of a number of measurement methods for nitrogen oxide before a new Federal reference method is chosen.

We hope to have this method chosen by the end of this present fiscal year. Our advisory committee and some of our colleagues in the scientific community think it may take us somewhat longer to accomplish this task.

Mr. ROGERS. What about the study of health effects of  $\text{NO}_x$ ? Has anybody done it?

Dr. FINKLEA. In the earlier testimony, we summarized those health effects that had been completed of oxides of nitrogen as well as the gap areas in which we had no information at the present time. We have a number of studies based upon the Chattanooga experience.

Mr. ROGERS. Who did the study?

Dr. FINKLEA. The studies that were done in Chattanooga were done by the Division of Health Effects Research of the Environmental Protection Agency.

Mr. ROGERS. What are those results?

Dr. FINKLEA. Those results did show that exposures to nitrogen oxide in combination with the acid mists that occurred around the Army Volunteer Arsenal plant led to susceptibility to acute respiratory diseases. It caused increased severity of respiratory illnesses once people contracted them. It caused decrease in lung function of adults and children. We were not able to find any increase in chronic respiratory disease in that community. We must caution that the exposures to nitrogen oxides in that community had lasted only about 3 years. Longer term exposure to the same level may have caused chronic lung problems.

Mr. QUARLES. Mr. Chairman, we have just entered into an agreement with the National Academy of Sciences to do an additional \$300,000 worth of analysis and study on the nitrogen oxide health effect problem.

Mr. ROGERS. Your studies showed very severe damage then?

Dr. FINKLEA. Showed adverse health effects, sir. The matter of severity would be subject to interpretation.

Mr. ROGERS. At the same time you find that you are proposing a reduction in the standards?

Dr. FINKLEA. No, sir, we have not proposed that the ambient air quality standards be changed at all.

Mr. QUARLES. We need to make a distinction between the ambient air quality standards and automotive emissions standards. We have not made any proposal for statutory change in the ambient air quality standard. Of course, if we found the health effects different from what we thought they were, even that would not require a statutory change. That would be something that we would address administratively.

Mr. ROGERS. You feel then that your ambient air standard for  $\text{NO}_x$  is sufficient?

Dr. FINKLEA. Yes, we do.

Mr. ROGERS. Is that what you are testifying to?

Dr. FINKLEA. Based on the judgment we can make at this time with the evidence we have before us we feel that they are proper.

Dr. GREENFIELD. The testimony, Mr. Chairman, is just as Mr. Quarles said, we think with the present information the  $\text{NO}_x$  standard, ambient air quality standard, is basically correct. When you look at the measurement problem, what did emerge was that there were far fewer cities in the United States which had that high a  $\text{NO}_x$  concentration as to make them candidates for priority 1 consideration.

Mr. ROGERS. You have changed your monitoring technique, but you just really resulted in doubling the standard just about. If arsenite had been used in Chattanooga, wouldn't the adverse health effect be found at one-half the levels found according to the Federal measurement method?

Dr. FINKLEA. That is not our interpretation of the differences in measuring methods.

Mr. ROGERS. What is your interpretation?

Dr. FINKLEA. Our interpretation is that had we used the Saltzman continuous monitor, we would have gotten adverse effects at about the same level. If we had used the arsenite method, we would think at most effects would have been observed at a somewhat lower level. The figure we had used is certainly no more than 30 percent lower.

Mr. ROGERS. How do they convert?

Dr. FINKLEA. The relationship as we informed the subcommittee between the arsenite method, the chemoluminescent method, and Saltzman method, all three of which are being evaluated, is less than unity. They do not convert one to one.

Mr. ROGERS. In other words, you went back 1 year later and measured nearby, assumed the weather conditions were the same, and drew these conclusions?

Dr. FINKLEA. No, sir. We had measured the year before when the weather conditions were the same with the Saltzman method and overlapped the health study by a month.

In addition the U.S. Army had measured on the same days with the Saltzman device in one of the areas of Chattanooga.

Mr. ROGERS. I thought there was a year's difference in the time of measurement.

Dr. FINKLEA. In Chattanooga there were three different groups measuring.

One group was the abatement group, another group was the health people. They were using the Federal reference method. The third group was the U.S. Army. The Army and the abatement group were both using the Saltzman method.

Mr. ROGERS. At the same time?

Dr. FINKLEA. Yes. The Army group was sampling for the year prior to the health study and for 1 month during the health study.

Mr. ROGERS. How do you do the 1 year prior? How do you measure 1 year prior?

Dr. FINKLEA. How were they measuring?

Mr. ROGERS. Yes. In other words, you wait and measure 1 year after.

Dr. GREENFIELD. They were measuring to determine the  $\text{NO}_x$  concentrations around the arsenal.

Mr. ROGERS. One year prior.

Dr. FINKLEA. One year prior. The Army was measuring during the health study at the site nearest the plant. One is able to reconstruct exposures by knowing what the meteorological conditions were and what the distribution of pollutants were during the time when the Saltzman measurements were actually being done.

Mr. ROGERS. It was not done at the exact same spot was it?

Dr. FINKLEA. The sulfur measurements were done at the highest exposure spot. Excuse me, within one-quarter of a mile of the highest exposures. They were not done through all areas of the health study. That is correct.

The other point is that the adverse health effects noted in the Chattanooga study were at least in part attributed to exposures lasting more than 1 year.

So, in fact the measurement made by the U.S. Army and the abatement group which covered a period of almost 2 years were a more complete picture than the initial measurement made by the Environmental Protection Agency health group.

Mr. ROGERS. I want to get how this was done because there is great concern about this. Let me ask about this.

In the hearings that Ruckelshaus held he said Chrysler had not done all that they should have. Do you feel that they are now doing what they should? What is the situation?

Mr. QUARLES. We held hearings in March on the second round of applications of the auto companies for suspension of the 1975 CO and HC standards. We held hearings at the end of June and the first of July on the applications of the auto companies for extension of the NO<sub>x</sub> standards.

It was in the earlier hearings this year that the question arose as to the good faith efforts of Chrysler. Mr. Ruckelshaus stated, based largely on interrogation which I conducted at the hearings, that he did have some doubts in his own mind—I am paraphrasing what he said but basically it was this—as to the extensiveness of the efforts of Chrysler in the depth of their program.

In the later hearing we did not have any of the issues arise that would have triggered another analysis of that question. So I can't really comment on whether or not Chrysler is doing an adequate job at this time.

Mr. ROGERS. You have not monitored what progress is being made?

Mr. QUARLES. That is correct. We do not monitor the progress of the companies on an ongoing basis.

Mr. ROGERS. Do you have anyone monitor it for you?

Mr. QUARLES. No, sir. The responsibility we have is to make an evaluation at the time they request that suspension.

Mr. ROGERS. As I recall we directed the National Academy of Sciences to monitor what progress was being made, did we not? Weren't you to have a contract with them? Wasn't that contract renewed with the National Academy of Sciences? Didn't the National Academy report to you?

Mr. QUARLES. The National Academy of Science has been doing work for us in evaluation of the status of technological development in the industry as a whole. They are giving us help in that regard.

Mr. ROGERS. They also went into the good-faith effort did they not.

Let me know when they reported to you on this and how often they do and what are you requiring the National Academy to do—I think this would be helpful—and if they are not doing what the law asks them to do.

[The following information was received for the record:]

#### EPA/NAS RELATIONSHIP

EPA is committed to continuing its support of the NAS technology assessment efforts under section 202 of the Clean Air Act. Negotiations on a new agreement with NAS currently are in progress. It is anticipated that this agreement, as a minimum, will provide for an assessment of NOx control techniques, to be completed by August 1974.

Mr. QUARLES. I think it might be helpful to put it in a more accurate perspective to say that there were some specific questions that arose in the course of the Chrysler testimony as to the speed with which they had followed up on possibility of technological development.

In their description of the efforts they had made and in the written material that they submitted to us, as we put those together and tried to analyze the motivation and the background for the choice that they made on a supplier of catalysts and other details of the way they carried out their program we were not clear as to whether in particular there might have been some motivation of rejecting Engelhardt as a potential supplier of catalysts for reasons related to the testimony given by Engelhardt at a prior EPA hearing.

That specific issue has not, I am sure, risen in any way nor would it be expected to arise in any way in the analysis of the National Academy of Sciences.

Mr. ROGERS. Now I understand that if a company did not want to, it would make a decision whether to shut that plant down or not, which is a rather drastic remedy if you are not doing a proper job.

Now should we look at different penalties? Should there be a penalty on executive officers? Should there be a fine against a company? Should there be a criminal sanction for those who do not obey the law so that you are not given an alternative of requiring a complete shutdown of a plant which I think is a rather drastic remedy that one hesitates to use?

I think it would be well to have the Agency's recommendations as to what penalty provisions for refusal to carry out the law should be considered by the committee in its review of oversight?

Mr. QUARLES. We will be glad to consider that and perhaps comment further on it when we return.

Mr. ROGERS. Thank you. I think it would be well, too, for you to present the data on the comparison between measurements by the arsenite method and the measurement by the Federal method at the same locations in time.

Mr. QUARLES. We will be happy to.

[The following information was received for the record:]

#### COMPARISON OF NO<sub>x</sub> MEASUREMENT METHODS

These two methods were employed simultaneously in Chattanooga during calendar year 1972 after the Volunteer Army Arsenal Plant had greatly reduced its emissions of nitrogen dioxide. These reductions were the result of the installation of emission controls at the plant and a reduced requirement for the muni-

tions manufactured by the plant. Thus, direct comparisons between the two methods could be made only when ambient levels of nitrogen dioxide were quite low. As shown in the following table the Federal Reference Method, which assumes a constant 35 percent collection efficiency, gave readings at two Chattanooga stations which were 60 percent higher than the more reliable arsenite readings (corrected for 85 percent collection efficiency).

Site No.	Number of 24-hour samples	Average levels (ug/m <sup>3</sup> )		Ratio <sup>1</sup>
		Federal reference method	Arsenite	
Chattanooga 632.....	211	56	34	1.6
Chattanooga 633.....	227	54	34	1.6

<sup>1</sup> Federal reference method divided by arsenite.

Since the arsenal emits very little nitric oxide the difference between the two methods should be largely if not completely accounted for by the variable collection efficiency of the Federal Reference Method. This can be roughly estimated assuming constant nitrogen dioxide levels equal to the overall level measured by the arsenite method. When this is done the actual collection efficiency of the Federal Reference Method at 34  $\mu\text{g}/\text{m}^3$  would actually be 53 percent instead of the assumed 35 percent. Under these conditions it would be expected that the Federal Reference Method would be 53 (true collection efficiency) 35 (assumed collection efficiency), giving a ratio 1.5 times the actual nitrogen dioxide value. This expected ratio is very close to the observed ratio between the Federal Reference Method and the more reliable arsenite method (1.6). Additional data comparing the Federal Reference Method and the arsenite method have been forwarded to the Subcommittee in response to a previously submitted question. (Additional materials are available in the nitrogen dioxide package transmitted to the Subcommittee staff.)

Mr. QUARLES. I might say we published a very complete statement of our analysis in the Federal Register requesting commentary and criticism of it about 2 months ago.

We have not received any substantial amount of critical comment that would suggest any changes in the analysis we made.

Mr. ROGERS. Do you know when definitive recommendations will be made on the  $\text{NO}_x$  matter?

Mr. QUARLES. No, I think it would be a mistake for me to be terribly definite on that. What is called for now is only a decision by us in the reclassification. We presumably will be moving forward to promulgate regulations, reclassifying the AQCR's in the relatively near future, in the next month or two.

Mr. ROGERS. What about transportation controls? Describe what they are, if you would please. How many cities are affected and of that number, how many do you anticipate would need extensions of time as recognized by your testimony?

Mr. QUARLES. This question is to some extent covered by my prepared testimony.

Mr. ROGERS. How many cities have this problem?

Mr. QUARLES. Roughly about 20 cities which would require some form of transportation controls plan and of those roughly 14 present the types of serious questions for which we think some modification of the deadline should be considered.

Mr. ROGERS. I think if you could expand on that in your testimony that would be fine.

Mr. QUARLES. Yes, sir.

[The following statement was received for the record:]

**TRANSPORTATION CONTROLS**

The most authoritative study to date is EPA's white paper on Transportation Controls forwarded to the Subcommittee staff in a September 18 letter.

Mr. ROGERS. I think if you have any basis for the statement that we went into just a little earlier on energy, it would be helpful if you could furnish us with information as to whether the act has affected the fuel shortage or not, and what would be its projection.

Mr. QUARLES. Yes, sir. We have done some analysis on that and we will be glad to supply it to you.

Mr. ROGERS. Then I think it would be well for you to let us know, if you have taken a position or if you have any thinking on the engines that are desired to meet the 1975, 1976 standards, the catalyst, the stratified charge, the diesel engine, rotary engine, and so forth.

Then I would think we might get some comment particularly on the 1976 standards. What is your experience to date, what information do you have and what are your positions?

As I recall there is a Gould catalyst that reduces just NO<sub>x</sub> as I understand it. I think there is a three-way catalyst that reduces all three.

[Testimony resumes on p. 173.]

[The following information was received for the record:]

**ACHIEVEMENT OF 1975, 1976 AUTO STANDARDS**

EPA's thinking on these issues is laid out in detail in the Administrator's decision on applications for Suspension of the 1976 Automobile Emission Standards (June 30, 1973) [attached] and the Technical Appendix [not printed]. Also see EPA's white paper on Clean Air and the Automobile.

**BEFORE THE ADMINISTRATOR, ENVIRONMENTAL PROTECTION AGENCY,  
WASHINGTON, D.C.**

**IN RE APPLICATIONS FOR SUSPENSION OF 1976 MOTOR VEHICLE EXHAUST  
EMISSION STANDARDS**

**Chrysler Corporation, Ford Motor Company, and General Motors  
Corporation, Applicants.**

**DECISION OF THE ADMINISTRATOR**

*I. Introduction*

Section 202 of the Clean Air Act, 42 U.S.C. 1857f-1, requires that emissions of oxides of nitrogen from automobiles sold in this country during the 1976 model year be reduced by at least ninety percent from their 1971 levels. The only authority which I as Administrator have been given to affect the application of this standard is set forth in Section 202(b)(5) of the Act. That section allows me to suspend the effective date of the reduction for one year only, provided the following conditions are met:

"The Administrator shall grant such suspension only if he determines that (1) such suspension is essential to the public interest or the public health and welfare of the United States; (ii) all good faith efforts have been made to meet the standards established by this subsection; (iii) the applicant has established that effective control technology, processes, operating methods, or other alternatives are not available or have not been available for a sufficient period of time to achieve compliance prior to the effective date of such standards, and (iv) the study and investigation of the National Academy of Sciences conducted pursuant to subsection (c) and other information available to him has not indicated that technology, processes, or other alternatives are available to meet such standards."

The first application for a suspension of the 1976 nitrogen oxides standard was filed with EPA on May 29, 1973, by Chrysler Corporation. On June 18 and 19, respectively, applications were received from Ford and General Motors.

Public hearings on these applications were held from June 25 to July 3, 1973. At these hearings testimony was taken from the applicants, other domestic and foreign automobile companies, makers of catalysts and other emissions control components, the National Academy of Sciences, and representatives of the public. Written material was also presented by these witnesses.

Although this is the first time EPA has considered any applications for suspension of the nitrogen oxide emissions standard, the governing statutory language quoted above also controlled previous decisions on suspension of the 1975 standards for hydrocarbons and carbon monoxide. Accordingly, rules laid down by the Court of Appeals for the District of Columbia Circuit in *International Harvester Co. v. Ruckelshaus* (Slip Opinion No. 72-1517, February 10, 1973) in vacating the Administrator's initial denial of suspension of the 1975 emissions standards are also applicable here.

Technical information received in previous hearings on the 1975 standards is also relevant to this decision. Control of nitrogen oxide emissions is affected by techniques that are employed in controlling emissions of hydrocarbons and carbon monoxide. Since vehicles produced during the 1976 model year must comply with the Act's hydrocarbon and carbon monoxide standards, the record in previous hearings contains relevant information on the nature and functioning of systems that will be employed to control these pollutants in 1976 vehicles. Our earlier proceedings have also developed relevant information on such topics as industry lead time, research programs, manufacture-vendor relationships and catalyst technology in general. For these reasons, the complete record of those proceedings has been incorporated by reference into the record before me in this matter.

As in the case of our prior hearings on control of hydrocarbons and carbon monoxide, substantial testimony was taken at the hearings on these applications concerning the extent to which nitrogen oxide emissions can be controlled in vehicles powered by engines different from the traditional internal combustion engine. Earlier decisions on suspension of the 1975 standards concluded that certain alternate engine systems presently in use or under development can probably comply with the statutory requirements for hydrocarbons and carbon monoxide. It is less certain that these same alternate systems can achieve the reduction in nitrogen oxide emissions required by the Act. In any event, it is clear from the record that basic new car demand, as defined by the Court in *International Harvester*, cannot be met in 1976 without continued production of large numbers of conventional internal combustion engines. The technical feasibility of controlling emissions of nitrogen oxides from conventional engines remains, therefore, the crucial issue for resolution in this decision.

## II. Summary of Decision

The evidence presented before me leaves little doubt that control of NOx emissions to the statutory level of .4 grams per mile on any substantial fraction of new cars sold in this country in the 1976 model year would depend on the use of a reducing catalyst of some sort. The only apparent alternative is the Honda CVCC engine, which has shown its ability to control NOx emissions to these levels on light weight cars. However, its ability to do the same for heavier vehicles has not yet been demonstrated, and in any event, there is not enough time to convert a significant fraction of the engine production lines to this engine by 1976.

It is clear from the record that successful NOx control is a more complex technical problem than was meeting the HC and CO standards, particularly if catalysts are to be used. The reduction catalyst presents problems of durability, although of a somewhat different character than the oxidation catalyst. Most, and very likely all, reduction catalysts require more precise control of air/fuel ratios than current automobiles can achieve or is needed to apply oxidation catalysts. And the resultant problem of integrating the catalyst, the fuel metering system, and the HC and CO control devices is more severe than for earlier decisions.

Reducing catalyst technology has advanced dramatically in the past year, and the rate of progress seems to be accelerating. Gould Inc. and Questor Corporation have each begun to obtain a significant and encouraging body of test

results indicating the durability of their respective systems. Laboratory work gives reason to hope that solutions to such problems as getting the catalytic material to stay on the substrate for 25,000 miles and reducing catalyst damaging variations in the composition of the exhaust stream passing through the catalyst may soon be achieved. Similarly, progress is impressive in developing sensing devices to control air/fuel ratios more precisely. However, in all cases our knowledge is still too incomplete to support a prediction that all the basic problems will be solved by 1976.

In addition, as the Technical Appendix indicates, the body of vehicle test data is still severely limited. In the absence of vehicle data, especially durability data, it is impossible to determine that the system integration problems can be overcome or that a working system has adequate durability.

I am also confronted by the fact that no one—manufacturer or supplier—testified that the statutory standard could be met in 1976. Indeed, only one witness argued that it was possible to use reduction catalysts widely in 1976 at any level of emissions.

For these reasons, I have concluded that the technology to meet the standards is not yet available. This was also the conclusion of the National Academy of Sciences.

The statute also requires that before a suspension is granted, I must find that it is essential to the public interest to grant it and that all good faith efforts to achieve the standard have been made.

As was true in our decision of April 11 of this year, the finding that technology is not available has been a main ingredient in the decision that a suspension is in the public interest, since the auto industry would be forced to close down if a suspension were not granted and the technology were not available.

Both Mr. Ruckelshaus and I have on previous occasions stated EPA's view that new measurements of the amount of NOx in the air indicate that the 1976 emissions standard for NOx may be too strict. However, I do not believe that in administering the statutory emissions standards established by Congress in its judgment of the public interest, I should weigh the view that these standards may not be necessary to protect the public health or welfare. That is a matter for the Congress to weigh. Instead, I have restricted myself here to an analysis of the increase in NOx emissions that will result from the sale of one model year of cars that meet the interim standard established today rather than the statutory standard. I conclude, as in the 1975 decision on remand, that this one year's increment is not significant.

Another element of the public interest which almost every witness spoke to was the possibility that a significant fuel economy penalty might be associated with the use of a reduction catalyst. Estimates of what the effect on fuel economy might be ranged from a 20 or 30 percent decrease in miles per gallon from the 1973 levels up to a modest improvement of a few percent. Though the data are not sufficient and the development programs are not far enough advanced for any firm judgment here, I incline to believe that the latter estimate is more accurate than the former.

While not well documented, it appears that there may be some risk of increased HC and CO emissions if reduction catalysts were used in 1976. This risk arises from either a potential failure of the reduction catalyst or the possible problems of meeting statutory HC and CO levels simultaneously with a low NOx level. While not of great weight in my decision, I am sensitive to these risks, since they bear on pollutants of acknowledged harm.

The good faith question is little changed from prior hearings. As in May 1972, I am disturbed by the apparent lack of adequate coordination between automobile companies and catalyst suppliers.

As before, however, the evidence, when weighed with an eye to the drastic consequences of a denial of suspension on this ground, supports the conclusion that the requirements of the statute have been met.

Having granted this one year suspension, I am required to establish an interim standard for 1976. I have set the interim standard at 2.0 grams per mile of NOx. Of course, statutory HC and CO standards will be in effect in that year.

The standard is amply justified on the statutory tests of technology and cost. This statutory basis for the interim standard is discussed later in this decision. I feel compelled here, however, to make two observations about the interim standard.

First, California 1975 interim standards established last April contain a 2.0 gram/mile NOx standard. I would in any case be reluctant to establish a 1976 interim standard for NOx in excess of that level.

Second, Los Angeles clearly requires NOx control on automobiles, and California retains the option of asking for a waiver for a 1976 standard lower than 2.0 grams/mile. To deny that request, should it come, would require me to show technology is not available to meet a more stringent standard.

I make these observations to dispel any feeling that may arise that technological progress on NOx emissions can or should be slowed as a result of this decision. It should not. The need to develop technology to protect the health of any segment of the public is reason enough to pursue those developments aggressively and in good faith.

### III. Discussion

#### 1. TECHNOLOGY

##### (a) Catalyst technology in general

In order to understand the problems that accompany the development of durable reducing catalysts, some technical background is necessary. In particular, it is important to understand that NOx control technology presents technical problems of fuel metering and engine system integration more complex than those raised by HC/CO control technology.

All conventional internal combustion engines work by burning a mixture of air and fuel in the piston chambers. If this mixture contains just enough air to completely burn all the fuel, on the assumption that all chemical reactions proceed as far as the materials present allow, the engine is said to be running "at stoichiometric." Since chemical reactions in the real world are not this perfect, there will be incomplete combustion even in an engine running at stoichiometric.

If the air to fuel ratio is greater than stoichiometric, the engine is said to be running "lean"; if it is less, the engine is running "rich." The excess oxygen associated with slightly lean combustion tends to minimize emissions of hydrocarbons and carbon monoxide, which are products of incomplete combustion, but it also tends to increase nitrous oxide emissions. The amount of NOx formed is dependent on high temperature, length of combustion, and the amount of oxygen present, all of which combine to maximize NOx emissions when the air/fuel ratio is slightly lean. However, if the combustion is very lean, NOx emissions will fall off too, since the smaller amount of fuel makes a high-temperature burn impossible.

Conversely, if an engine runs rich, emissions of hydrocarbons and carbon monoxide will tend to rise, and emissions of NOx will fall.

Conventional internal combustion engines get their best fuel economy when running slightly lean and their best performance when running slightly rich. Tr. 30-31 (Chrysler); Tr. 350 (GM); Tr. 944 (Matthey Bishop); Tr. 1069 (UOP); Tr. 1498 (Esso).<sup>1</sup>

In most cars designed to meet the statutory hydrocarbon and carbon monoxide standards the exhaust stream will be passed through an oxidizing catalyst, after being diluted with air from an air pump in order to maintain the oxidizing (oxygen-rich) atmosphere the catalyst requires to control these two pollutants. The reducing catalyst to control NOx will be built into the exhaust system somewhere upstream of both the oxidizing catalyst and the input of air from the air pump.

Reducing catalysts operate to control NOx emissions by causing the NOx to reduce to nitrogen by reacting with the reducing agents present in the exhaust gas, primarily carbon monoxide and hydrogen. For this to take place, a supply of carbon monoxide is necessary, and in practice this has required the engine to be calibrated rich. F. App. 2-50; GM App. A4-1; C. App. IV-C-1; Tr. 354 (GM). Most catalysts, however, including oxidation catalysts, will also reduce NOx if the engine is running at stoichiometric or only marginally on the rich side. In fact, most reducing catalysts perform best at only slightly rich conditions. GM App. A4-9, A5-1; F. App. 2-5; Tr. 895 (Matthey Bishop).<sup>2</sup>

<sup>1</sup> In this Decision, the following abbreviated citations are used:

Tr.—The transcript of the June-July 1973 hearings.

C. App.—The Application for Suspension of 1976 Motor Vehicle Emissions Standards filed by Chrysler Corporation.

F. App.—The Request for Suspension of 1976 Motor Vehicle Exhaust Emissions Standards filed by Ford Motor Company.

GM App.—The General Motors Request for Suspension of 1976 Federal Emission Standards.

NAS Rept.—The Report by the Committee on Motor Vehicle Emissions of the National Academy of Sciences dated February 12, 1973.

<sup>2</sup> Work is being done on developing a NOx catalyst that will operate even when the engine is running somewhat lean, but with very limited success to date. C. App. IV-C-2; Tr. 221-22 (Ford); Tr. 890 (Matthey Bishop); Tr. 1029 (W. R. Grace).

The task of metering fuel to keep an engine slightly rich all the time is too sophisticated for any carburetor or fuel injection system currently in use. F. App. 2-50; C. App. IV-A-3, I-D-3; Tr. 903 (Matthey Bishop); Tr. 1028 (W. R. Grace). Not only are the mechanical tolerances and response times of existing equipment inadequate to maintain any given air-fuel ratio precisely under all the differing influences of normal driving; the stoichiometric air/fuel ratio itself varies with altitude and the composition of the fuel, which in turn can vary from filling station to filling station. F. App. 4-41-48; C. App. IV-C-1; Tr. 349-51 (GM); Tr. 922 (Matthey Bishop).

This problem may well be solved in the near future. All major companies are working on electronically controlled fuel metering systems that would sense the composition of the exhaust gas and readjust the fuel flow accordingly to keep the engine at a given combustion chemistry. F. App. 2-58-74; GM App. A9; C. App. III-A-3-4. This more precise control, according to all witnesses who addressed the point, would make all forms of emission control easier, and would help to improve fuel economy and driveability as well. GM App. 4a-10; Tr. 122 (Chrysler); Tr. 159-60, 187 (Ford); Tr. 476 (GM); Tr. 1122, 1125-26 (Bendix). In addition, this more precise control might allow the engine to operate consistently at an air/fuel ratio where one catalyst, by controlling HC, CO, and NOx simultaneously, could do the job now planned for two.

In the absence of feedback control, setting a fuel metering system at an only slight rich position can be expected to result in variations of the air/fuel ratio from rich to lean and back again. Not only will NOx control be lost when the catalyst is exposed to an oxidizing (lean) atmosphere; the weight of the testimony indicates that exposure either to oxidizing conditions or swings from reducing (rich) atmospheres to oxidizing atmospheres and back again has an adverse effect on reducing catalyst durability.

Accordingly, it has proved advisable in most current development tests to set the fuel metering on 1976 test cars considerably richer than stoichiometric, so that random swings to the lean side will not bring the catalyst into oxidizing conditions. Tr. 922-24, 941 (Matthey Bishop); Tr. 1009 (Engelhard). Such a rich calibration decreases fuel economy, and may increase the output of HC and CO and thus the burden on the oxidizing catalyst that must deal with them, on the assumption that the oxidation catalyst itself must oxidize all the HC and CO present. C. App. I-10, I-19; GM App. 4a-6-8, A6-7; Tr. 354 (GM); Tr. 924-25 (Matthey Bishop). Limited tests indicate, however, that some reduction catalysts can effect some CO and HC oxidation with injections of small quantities of air upstream of the NOx catalyst. This would tend to offset the effect of the rich calibration. Nevertheless, because of the rich calibration, a 1976 emission control system would emit more HC and CO to the atmosphere if the oxidizing catalyst failed than would a 1975 system in the same circumstances.

In addition, many reducing catalysts when operated in an excessively rich atmosphere reduce some NOx not to nitrogen, but to ammonia (NH<sub>3</sub>). The ammonia is then reoxidized to NOx in the oxidizing catalyst downstream, and passes into the atmosphere in that form. To the extent this happens, the net efficiency of the NOx control system is, of course, reduced, and so are the chances of meeting the statutory NOx standards.

#### (b) Specific applications of catalyst technology

Four different applications of reducing catalysts are under active investigation by the auto industry, and appear to have promise as a means of controlling NOx. They are discussed individually below.

i. *Three-Way Catalyst*.—As mentioned above, if an engine can be calibrated to burn very close to stoichiometric all the time, a single catalyst can control all three of the statutory pollutants. Since this catalyst will be very similar in composition and construction to oxidizing catalysts and since the more precise fuel metering can be expected to reduce the transient high-temperature conditions that are a major source of strain on those catalysts, no insoluble problems with the catalyst need be anticipated here.

To achieve such precise control, however, will require both the development of a sensor that can measure the composition of the exhaust gas, and the use of a fuel metering device that can respond to the sensor's signals very quickly.

The main problems to date with the sensor have been (1) developing a sensor that will be able to last for at least 25,000 miles when inserted into the exhaust stream. GM App. 4a-13-14; Tr. 657 (Volkswagen); Tr. 1113-14 (UOP); Tr. 1128

(Bendix), and (ii) developing a sensor that can control the engine to a marginally rich condition rather than stoichiometric. F. App. 2-60, 2-71; Tr. 121-22 (Chrysler); Tr. 165-66 (Ford). This latter ability is particularly needed if the sensor is to be used to improve the performance of a two-catalyst system.

There seems little doubt that electronic fuel injection (EFI) can respond to the sensor's signals quickly enough to keep the combustion process within the desired limits, and several witnesses stated that this was the most promising device for use as part of a three-way catalyst system. F. App. 2-43, 2-62, 2-70, 4-40; GM App. 4a-17, A22-3; Tr. 665, 672 (Volkswagen); Tr. 1162 (Bendix). A GM representative testified that advanced carburetors were as good for this purpose as EFI; however, in the judgment of my technical staff the case for EFI is stronger. Tr. 477-79. See also F. App. 2-38 ("It should be noted that a satisfactory technique for controlling air-fuel ratio with feedback has not been obtained with any carburetor."); 2-65-69, C. App. IV-D-3.

If EFI were to be installed on a substantial portion of 1976 cars, production commitments would have to be given immediately. Tr. 1176 (Bendix). There is little reason to believe such commitments could be made until an exhaust sensor of proven durability had been developed.

ii. *Noble Metal Reducing Catalysts*.—By far the bulk of reducing catalyst test work by the auto companies has been done on catalysts which, like the three-way catalysts, resemble those currently planned for use as oxidizing catalysts on most 1975 California vehicles. In these catalysts, an inert ceramic honeycomb or pebbles of some inert material (the "substrate") supports a thin coating of the catalytic material, which is generally a mixture of platinum, palladium, or other noble metals.

The problem here has been that in order to hold ammonia formation down to acceptable levels, it has been necessary to add very small amounts of ruthenium to these catalysts.<sup>3</sup> Catalysts with even a small amount of ruthenium tend to form significantly less ammonia even in quite rich atmospheres than catalysts without it. In addition, such catalysts have relatively low "light-off" temperatures—that is, they begin to convert significant amounts of NO<sub>x</sub> to nitrogen while they are still relatively cool. F. App. 2-4; GM App. A5-7; C. App. I-19, II-C-2, IV-A-2, IV-C-3; Tr. 435 (GM); Tr. 978 (Engelhard).

However, the vehicle tests to date have shown that ruthenium is very easily oxidized and removed from the catalyst when exposed to lean conditions.<sup>4</sup> GM App. 4a-5, A5-7; F. App. 2-4, 4-27; C. App. I-19.

Even if more accurate fuel metering could eliminate oxidizing conditions during normal vehicle operation, it would still be essential to make reducing catalysts stable in oxidizing conditions. The first part of the EPA emissions test, called a "cold start," produces a relatively large amount of HC and CO, and a relatively small amount of NO<sub>x</sub>. Since it is very hard to heat up the oxidizing catalyst, which lies further from the source of heat in the engine than the reducing catalyst, in time to control these pollutants adequately, it will probably be necessary in order to meet these standards to use the reducing catalyst to control HC and CO emissions during cold starts. This can only be done by pumping air into it, thus creating an oxidizing atmosphere. See F. App. 4-10-12, 4-26, 4-36-37; GM App. A4-3. Many witnesses at the hearings claimed that the problem of ruthenium oxidation had been solved, but vehicle test results are not yet available. F. App. 2-27, 4-8-9, 4-27-32, Tr. 197-98 (Ford). See also C. App. IV-D-1; Tr. 948-49 (Matthey Bishop); Tr. 978 (Engelhard); Tr. 1108 (UOP); Tr. 1243-44 (Gulf).

Because the problem of ruthenium oxidation has prevented much durability testing of these catalysts, it is impossible to say what other durability problems they might encounter if they were run long distances on vehicles. There is some

<sup>3</sup> It may also be possible to eliminate the low air/fuel ratios that are particularly conducive to ammonia formation with these catalysts by introducing a small amount of air into the reducing catalyst to lean out the mixture while still keeping it on the rich side of stoichiometry. GM App. A4-3, A5-8; F. App. 2-23; Tr. 76-77 (Chrysler), Tr. 1322 (Monsanto). This is the approach used to control ammonia formation in the Gould catalyst. Some HC and CO control is also afforded by this approach. Matthey Bishop and Monsanto both claim to have developed a stable catalyst that does not contain ruthenium. Tr. 949; Tr. 1210-11.

<sup>4</sup> Some ruthenium oxides are very toxic. However, such extremely small amounts of ruthenium would be used in each catalyst that it is not clear at this time that even if a high percentage of it were lost by oxidation there would be a health hazard. Tr. 66, 75 (Chrysler); Tr. 950-53 (Matthey Bishop); Tr. 1003 (Engelhard); Tr. 1108-09 (UOP); Tr. 1243 (Gulf).

suggestion in the record that they may prove vulnerable to trace elements in the exhaust system. F. App. 2-10, 2-28-30; 4-12-13, 4-37-39; GM App. A5-7; Tr. 1222-23 (Monsanto). But see Tr. 1242-43 (Gulf).

Other durability problems of this class of reducing catalysts can be expected to largely parallel those encountered, and, for the most part, solved, with oxidizing catalysts.

These would include weaknesses in the substrate, mechanical failure due to vibration of the engine, and the like. The experience gained in curing such failures in oxidation catalysts should be directly applicable to preventing them in reduction catalysts as well.

Oxidizing catalysts work by causing the carbon monoxide and hydrocarbons to burn up inside the catalyst, thus releasing heat. If the catalyst receives and overdose either of these gases or of some unburned fuel, the heat released by the resulting combustion may be enough to damage the catalyst. By contrast, the reaction by which a catalyst reduces NOx to nitrogen produces essentially no heat. Tr. 440-41.

III. *Gould*.—Gould was the only catalyst manufacturer to testify that reducing catalysts for the control of NOx were sufficiently far advanced to be installed on all or almost all 1976 model vehicles.

The Gould catalyst (also called the GEM catalyst) is a stainless steel screen on which the catalytic material—a mixture of nickel and copper—is deposited. The screen is then rolled into a cylinder measuring about four inches in each dimension and weighing about a kilogram, and installed in the exhaust system where the exhaust gases can pass through it. Gould estimates that each catalyst would cost about \$30 to make and install in a new vehicle, Tr. 1345, and that one such catalyst would be needed for engines of less than eight cylinders and two for V-8s. Tr. 1343.

Tests on GEM catalysts have been carried out by Gould itself, by Esso Research and Engineering, and by various auto companies.

Gould has run three cars over 20,000 miles, one on the EPA test cycle and two on a freeway cycle. The first car came within .02 grams of meeting the NOx standard at the last reported data point, while one of the latter two did meet it. Tr. 1359. One GM car, ES-3341A, went 12,000 miles meeting all three statutory emissions standards, and was tested at .5 grams of NOx after 25,000 miles. GM App. A4-35.

The other major auto companies report somewhat different results. Ford, though conceding that metallic catalysts are cheap and highly active and that they avoid at least most of the fuel penalty and ammonia formation associated with other control methods. F. App. 1-14, 2-7, 2-113, 4-13, Tr. 201, claims that fifteen out of seventeen Gould catalysts tested failed under 3,000 miles. F. App. 2-178. See also F. App. 2-S4-S6, 4-13-14.

Chrysler's testimony was to much the same effect. C. App. IV-A-30-31. Tr. 98-99, 101, as was GM's, despite its encouraging durability test<sup>5</sup> and admittedly good low-mileage test results, GM App. 4a-5-6, A4-10.

No witness offered a satisfactory explanation for the wide difference between Gould results and auto company results. Tr. 101 (Chrysler); Tr. 1393-94 (Gould); F. App. 2-S6; Tr. 201 (Ford).

All manufacturers identified basically the same problems with GEM catalysts. They are said to require high operating temperatures before they will reduce NOx effectively, which decreases the margin of safety before a transient hot condition either in the gas coming out of the engine or created in the catalyst by a short-term shift to oxidizing conditions will result in significant catalyst damage. GM App. 4a-5-6; C. App. IV-A-3; F. App. 1-14-15, 2-7, 2-S1-86. Tr. 202 (Ford); Tr. 436-37, 439-40 (GM). They are also said to deteriorate if exposed alternately to oxidizing and reducing atmospheres, Tr. 202, 211-12 (Ford), and partly as a consequence of this, to require very precise fuel metering and metering of secondary air. Tr. 107-08 (Chrysler); Tr. 469-71 (GM).<sup>6</sup> They apparently do not

<sup>5</sup> The only other GEM catalyst GM has tested failed on the dynamometer at low mileage when the car ran out of gas. Tr. 472.

<sup>6</sup> It seems, however, that at least the first Chrysler tests were run without injecting any air in front of the NOx catalyst. C. App. p. IV-A-32. Injecting some air in front of the catalyst lowers the light-off temperature several hundred degrees and so makes overtemperature failure less likely. Tr. 1478, 1492. Esso testified overtemperature failures could be avoided. Tr. 1493-94.

It also appears that once Chrysler did start to inject air into the reduction catalyst, it injected far too much, which caused the catalyst to burn up. Tr. 1399.

suffer from being exposed to oxidizing conditions at relatively low temperatures, and therefore can be used as oxidizing catalysts during cold starts.

Most of these concerns are shared by Esso. Esso data, however, is not a good test of GEM catalyst emissions control durability since Esso made a practice of stopping the test when evidence of physical damage appeared on the catalyst even though emissions control performance was still satisfactory and might have remained satisfactory for ten or fifteen thousand miles more. Tr. 1494-95, 1502, 1515-18.

It is nevertheless true that one of the most serious problems with the Gould catalyst is that of particulate emissions. Oxidation and reduction cycles on this type of material can cause the surface of the catalyst to become changed and active material can be lost from the catalyst in the form of particulate emissions. It is not known at present whether this loss of material could be prevented by use of a more sophisticated fuel metering system, since no vehicles have been run with both Gould catalysts and fuel metering systems that would prevent excessive rich-lean excursions.

Gould disputes the need for extremely precise air-fuel ratio control, and claims that some of its best durability results have been on a car that used a slightly modified 1973 production carburetor. Tr. 1341. Gould apparently does not dispute that repeated switching between reducing and oxidizing conditions must be avoided. Tr. 1382-84, 1423-24, 1432-34, 1465-67.

One company reported that disintegration of a GEM catalyst resulted in poisoning of the oxidation catalyst downstream. Tr. 496-97 (Nissan). See also F. App. 2-7; Tr. 210 (Ford). However, Gould had examined the allegedly poisoned catalyst, and had not found any of the metals from the GEM catalyst on it in significant quantity. Tr. 1378-79.

Gould testified that its catalyst would enhance the life of the oxidation catalyst. Since the GEM catalyst has some oxidizing capacity, the levels of HC and CO to the oxidizing catalyst downstream may well be lower than in 1975 cars. Tr. 1375-77. Gould did admit that certain rare instances of gross failure could result in poisoning of the downstream catalyst. Tr. 1380-81.

No witness claimed that poisoning of GEM catalysts by lead or sulphur was a problem, and Gould and Esso asserted it was not. Tr. 1341, 1496, 1504.

To summarize, although the Gould catalyst has shown by far the best durability results of any catalyst tested to date, more work on matching the catalyst to the engine and on improving fuel metering, accompanied by extensive durability testing, will be required before it will be ready for widespread vehicle use.

iv. *Questor*.—The Questor Reverter system differs from the systems outlined above for achieving the 1975-76 emissions standards in not using an oxidizing catalyst for control of hydrocarbons and carbon monoxide. It consists instead of a reducing catalyst bracketed by two thermal reactors,<sup>7</sup> each attached to an air pump. The engine is run very rich, and this automatically produces exhaust gases high in HC and CO and low in NOx (as well as a fuel penalty). In the first thermal reactor, some air is introduced to oxidize most of the HC and some of the CO, but not enough to destroy the reducing atmosphere. The exhaust stream, still rich in CO and relatively poor in oxygen, but with almost all the HC taken out, then passes through the reducing catalyst, made of stainless steel, where the NOx is removed. Finally, large amounts of air are pumped into the second thermal reactor to oxidize the rest of the CO.

The effort the auto companies have put into testing this system has been quite limited, even though the results have been highly promising. Chrysler tested a Questor system in August 1972 that met the 1975-76 standards, and has not tested one since. C. App. IV-A-56, F. 999a-c. Ford tested a Questor vehicle that met the standards in March 1972 and others (which each had to be reworked by Questor before they would pass) in February and April of this year. F. App. 2-123-28. GM's application stated that each of the five Questor vehicles tested "at low mileage, showed the potential of achieving or approaching the 1976 certification test levels." GM App. 4a-22. One durability car has been run and went to 10,000 miles before exceeding any of the statutory standards. It still met the NOx standard at 20,000 miles. GM App., Appendix S, Figures 6, 7.

<sup>7</sup> These are simply heat-resistant chambers in which carbonmonoxide and hydrocarbons can burn to CO<sub>2</sub> and water in the presence of air. For this to happen, the reactors must be designed to provide the correct combination of combustion time, temperature, and oxygen concentration.

Nevertheless, the auto companies all claim that this system is not very promising because of its high fuel economy penalty. C. App. I-22-23 ("Typical fuel penalties . . . [are] 30%"; F. App. 1-16, 2-124, II-258, Tr. 262 (12-14%); GM App. 4a-22 (20-25%), and the high temperatures at which it must operate. C. App. IV-A-56, F. App. 2-127; GM App. 4a-24; Tr. 120-31 (Chrysler); Tr. 262 (Ford); Tr. 451, 453 (GM).

In addition, the rich fuel mixture which the Questor system requires would result in very high emissions of HC and CO to the atmosphere if the air pump failed. Chrysler estimates the emissions in this event at 200 grams per mile of CO and 6.5 grams per mile of HC, C. App. IV-A-56, apparently on the basis of a relatively unsophisticated system, while Questor's own estimates based on their latest system are 200 grams per mile of CO and 20 of HC. Tr. 870. Ford testified to 360 grams of CO. Tr. 263, 265. See also F. App. 4-5. By comparison, the 1973-74 standards for emissions of these pollutants are 3.0 grams per mile of HC and 28 of CO.

The present method of dealing with overtemperature in the system, which consists of dumping a flame-retarding fluid into the reverter, is generally admitted to be unsatisfactory. Tr. 838-40 (Questor); Tr. 267-68 (Ford).

Questor claims to have solved the overheating problem. Tr. 811, 817, 829-31, and to have reduced the fuel penalty on a 1973 baseline from 30% to 6 or 8 percent in its latest systems, which the auto companies have not yet tested. Further improvement is foreseen. Tr. 807, 820.

Even so, Questor testified that the first production commitments would have to be made in a few months if the Questor system were to be used extensively in the 1976 model year, and that there was too much additional testing to be done to permit design freeze in time for that. Tr. 827, 831-32 (Questor); Tr. 269-70 (Ford); F. App. 1-16.

#### (c) *Honda*

There is little doubt that the Honda CVCC engine can meet the 1976 NOx standard as well as the original 1975 HC and CO limitations. Honda testified that they had met the standards at low mileage with a 2,000 pound vehicle and no catalyst. Tr. 580. Though no durability testing has been reported, durability has never been a problem for Honda engines, and Honda testified that they did not expect it to be a problem here. Tr. 584-85.

It is not known, however, whether the Honda approach to NOx control will work for larger vehicles, and no test data has been introduced on that point.<sup>8</sup>

#### (d) *The Current State of the Art*

When the Clean Air Amendments of 1970 became law, reducing catalyst technology was far less advanced than oxidizing catalyst technology. According to an EPA staff report:<sup>10</sup>

When the Clean Air Act was passed, automobile and catalyst manufacturers already had some background in oxidizing catalysts. The development of HC/CO catalysts for California in the 1960's and the very extensive experience of the catalyst manufacturers in the use of oxidizing catalysts in other applications had already established a basis from which the catalyst technology for oxidation catalysts could start and be adapted to the legal requirements for 1975. This was not the case with NOx catalysts. No automobile-related development work was done on NOx catalysts in the California program in the 1960's and the use of NOx reduction catalysts in other non-automobile applications was not as extensive as the use of oxidation catalysts. Therefore, the baseline for the application of NOx catalysts was much less advanced than the baseline technology level for oxidation catalysts. The demonstrated emission control technology at this point in time reflects this difference.

<sup>8</sup> It developed at the hearing that this figure was somewhat misleading, since the car with the Questor system also weighed more than the "baseline" car it was compared with. Tr. 123-25. Comparison of the Chrysler car with certification cars at the same weight indicates that the proper fuel penalty is about ten percent. Automotive Emission Control—The State of the Art as of December 1972, 6-16-17.

<sup>9</sup> There was a marked conflict of testimony at the hearings on whether vehicles of higher weight tend to produce more NOx per mile than lighter ones. Two American manufacturers, who for the most part make heavy cars, testified this was not so. Tr. 40-45 (Chrysler); Tr. 251-258 (Ford); but see GM App. 4a-18. Two manufacturers who make lighter cars stated it was. Tr. 522-27 (Toyota); Tr. 573-74 (American Motors). Four witnesses from the National Academy of Sciences agreed with the smaller manufacturers. Tr. 1294-98. So does my technical staff.

<sup>10</sup> Automotive Emission Control—The State of the Art as of December 1972, pp. 4-6.

It appears that much progress has been made since the beginning of 1971. This is shown most dramatically by the development of the Honda, Gould, and Questor systems, and by the very considerable steps that have been taken toward perfecting durable exhaust gas sensors for use in fuel metering systems and in making reducing catalysts more stable in oxidizing conditions and less likely to form ammonia. Progress in the last two and a half years has been greater than was anticipated, and the rate of progress appears to be accelerating. Tr. 1280-82; Tr. 1354; Tr. 1533. This accelerated progress can be expected to continue in the future as the large emissions control research teams the industry has built up increasingly turn their attention away from systems designed to meet the 1975 standards to those designed to control nitrogen oxides. Tr. 1034. Despite these promising results on component technology, durability testing of complete 1976 systems appears to be lagging some eighteen months behind comparable testing on 1975 systems.

As a result, the available data is not enough to support a conclusion that the development problems have now been overcome. Even the Gould catalyst, for which development seems furthest advanced, has demonstrated a gradual deterioration when exposed to alternating oxidizing and reducing conditions, and this problem has not clearly been solved. To solve it may well require individual adjustment of the engine-catalyst relationship for each separate engine family. More importantly, the body of test data is so limited that there can be no assurance that further, unanticipated problems will not occur when more testing is done, or that these problems, if they arise, will be solved before the 1976 model year.

There is even less testing experience for the Questor system. In addition, the Questor system would require extensive reworking of the exhaust system, and all witnesses agreed that there was not enough time to freeze the design before the lead time for production runs out.

Other catalytic systems have not yet demonstrated any appreciable durability, and there appear to be problems here with ammonia formation, deterioration in oxidizing conditions, and need for precise fuel metering which, though they may be on the way to solution, have not clearly been solved. Although the Honda engine does appear able to meet the standards, the domestic industry, for the reasons given in EPA's April 11, 1973 decision, is probably unable to switch over enough of its engine lines to this engine by 1976 to supply basic demand with that engine alone.

For these reasons, I cannot predict that enough vehicles to meet basic demand would be able to pass EPA's certification test in 1976 if the oxides of nitrogen standard were held at the statutory level.

This should not be taken in any way as a conclusion that control of NOx to the statutory levels is not feasible, or that reducing catalysts are not an acceptable control technique. In new technological fields, there is a pattern of development that repeats itself. Typically, once the preliminary basic research has been done, progress becomes very rapid, and continues until the field has reached a high degree of sophistication. This was shown dramatically in the case of oxidizing catalysts. At the time of our first suspension hearings in the spring of 1972, only a handful of cars had run more than 20,000 miles and still met the standards. The auto companies all claimed that there were many unresolved problems with catalysts, including safety hazards, fuel penalties, and lack of durability. A year later, at the time of our suspension decision in April of this year, the data were sufficient to support a prediction based on a rigorous methodology that 66% of the market could meet the 1975 standards in 1975, the claims of fuel penalties and safety hazards had proved to be unjustified, and the manufacturers appeared to have largely solved the problem of catalyst durability. Since that time, all domestic manufacturers have indicated, by their failure to challenge the interim standards we established, that drastic emissions reductions based on the use of catalysts for a least ten percent of their production are within their power. In fact, General Motors is considering plans to use catalysts even where they are not strictly necessary to achieve the standards in order to realize the benefits in increased fuel economy and driveability that the catalyst makes possible.

At present the development of reduction catalysts does not appear as far advanced as the development of oxidizing catalysts was in April of 1972, and the data base is certainly smaller. In my judgment, however, the difference is of degree and not of kind, and I fully expect that if development efforts continue as the Clean Air Act requires, the next year should show us something

like the rate of progress we have just seen where oxidizing catalysts are concerned. My decision only means that there can be no assurance that the progress will be sufficient to meet the standards by 1976, rather than one or two years later. As I read the NAS Report, this was also their conclusion. Even though they conceded a significant probability that the standards could not be met in 1976, their assessment of the rate of progress based on their experience in similar fields also led them to the conclusion that the technology to meet the standards would very likely be developed a least shortly after that date. See p. 22, *infra*.

Since the finding that not enough vehicles to meet basic demand would certify in itself requires a conclusion that the technology to meet the standards is not available, there is no necessity to consider the other two findings that would have to be made before a conclusion that technology is available would be justified. There are that it would be feasible to mass produce the vehicles in question once they have been certified, and that the control system would function acceptably in the hands of customers. Nor does the record afford much basis for discussion of these problems—very little was introduced concerning them.

One point, however, may legitimately be made here. I would be much less inclined than we were last April to accept the argument that serious production difficulties would arise if the auto industry were forced to install some new emission control component on all their vehicles in a single model year. As noted above, and as one representative of a public interest group emphasized, General Motors, the company that laid the most stress on production difficulties arising on this score, is considering plans to improve fuel economy and driveability by putting catalysts on all or almost all of its 1975 vehicles, even where the standards could be met without them. Tr. 1732-35. Apparently the problems are not as grave as we were told.

## 2. THE 1973 REPORT OF THE NATIONAL ACADEMY OF SCIENCES

Under Section 202(b) (5) of the Clean Air Act, I may only grant a suspension if a study of auto pollution controls which the Clean Air Act requires to be made by the National Academy of Sciences "has not indicated that technology, processes, or other alternatives are available to meet such standards."

In its most recent report, dated February 12, 1973, the NAS concluded that,

"At this time, no experimental engine modified to include the dual-catalyst system has exhibited the durability required to achieve compliance with the 1976 standards. Nevertheless, assuming a continuation of the intensity of the current effort, extrapolation of the rate of recent progress suggests that catalysts with the durability required by the 1976 standards will be developed. But it cannot be stated with certainty that such developments will occur in time for 1976 production of automobiles." NAS Rept., p. 115.

See also NAS Rept., pp. 4, 34, 89, 118.

At the hearings on these suspension requests, Dr. Hutcherson, Vice Chairman of the NAS Committee on Motor Vehicle Emissions, confirmed that the message of the February report had been that no firm prediction could be made that enough vehicles to meet basic demand could certify at the statutory NOx standard for the 1976 model year. Under the rules laid down by the Court of Appeals, if such a prediction cannot be made, the technology must be found unavailable.

Dr. Wei of the Committee testified that NOx catalyst technology was perhaps advancing more rapidly than the NAS predicted in its report, and Dr. Hutcherson agreed. Tr. 1281-82. This is consistent with my finding that technology is rapidly advancing. Dr. Wei concluded, however, that the progress did not substantially mitigate the Academy's inability to make a firm prediction. Tr. 1288.

## 3. THE PUBLIC INTEREST

The compelling reason that causes me to find that the public interest requires a suspension of the 1976 standard is that there is no assurance that enough vehicles to meet basic demand could certify at this level. Other factors bearing on the public interest are discussed below.

### (a) Air Quality

Several manufacturers have urged that the statutory 1976 emissions standard is far more strict than necessary to protect public health, and that this judgment is a necessary component of the "public interest" determination. For-

the reasons given on page 4 above, however, I have rejected this argument and concluded that my consideration of air quality effects is limited to a review of the effect of one year's emissions increase resulting from granting a suspension.

The information available to me shows that, even viewed in this light, the effect of the suspension on air quality will be modest. The difference in control levels will result in about a 1% increase in the amount of NOx in the air of the ten cities with the worst NOx problem. This increase will not change the number of cities (4) that may exceed the NOx air quality standard in 1976. It can be compensated by better controls on stationary sources, and so will not require new transportation controls anywhere.

(b) *Fuel Economy*

The major reason other than the alleged overstringency of the standard that was offered to support a finding that the public interest required a suspension was that a very great decrease in fuel economy would be necessary to meet them. Chrysler stated that achieving the 1976 standards would entail a "possible 10%-20% [fuel economy] penalty over 1972 production vehicles." C. App. IV-C-11, and repeated this in their testimony. Tr. 13.<sup>11</sup> Ford's estimate was 15% over 1973 levels if a noble metal monolith were used, F. App. 1-21. About 5% is estimated to result from achieving the 1975 standards, and the remaining 10% from adding the 1976 system onto that. Tr. 166. GM's estimate is apparently about a nine percent loss from 1973 levels on the EPA cycle. Tr. 329, 332. UOP's was of the same magnitude. Tr. 1092-93. Both GM and UOP apparently also assumed use of a noble metal monolith.

Gould testified, in sharp contrast to these predictions, that use of their catalyst would result in a fuel economy gain over 1973 cars. Tr. 1343-44. Esso and Ford corroborated this. Tr. 184, 186 (Ford); Tr. 1491 (Esso).

On a record of this nature, no firm assessment of the state of the art is possible. Indeed, the state of the art is changing so fast that no assessment of its position at a given moment in time may be feasible.

It is clear, however, that even if systems now under test do exact a fuel penalty over 1973 levels there is no physical reason why that should be true with fully developed systems and that some improvements might well be possible. It is equally clear that in the process of developing NOx control technology, the manufacturers have learned how to improve fuel economy at virtually any level of emissions control.

The fuel penalty foreseen for 1976 cars is not inherent in the control of nitrogen oxides by a catalyst. Instead, it is caused by the rich air/fuel ratios that are necessary to minimize the exposure of the catalyst to oxidizing conditions, Tr. 188-89 (Ford); Tr. 345-47 (GM); Tr. 673-75 (Volkswagen), and the other engine modifications that are necessary to reduce NOx emissions into the reducing catalyst to a level low enough to ensure that emissions out of it are no more than .4 grams per mile. Tr. 167-71 (Ford).

However, as discussed on pp. 6-9 above NOx catalysts work best at stoichiometric or slightly richer. Accordingly, most of the excess fuel in current mixtures is not needed for the operation of the catalyst itself, but to protect the catalyst against being exposed to oxidizing (lean) conditions when the air/fuel ratio fluctuates randomly around the point it is set at. To the extent fuel metering systems could be devised to reduce the swings from rich to lean, this margin for error could be reduced, and fuel economy would improve. Tr. 187 (Ford); Tr. 348 (GM) Tr. 943-46 (Matthey Bishop). In addition, a highly effective NOx catalyst should make it possible to eliminate some of the other engine modifications used to control NOx, which do have a fuel penalty.<sup>12</sup> Tr. 1010-12, 1016 (Englehard). It appears that this is already possible with the Gould catalyst. See F. App. 1-14, 4-13; Tr. 205 (Ford). More precise fuel metering would increase the Gould catalysts fuel economy advantages, while use of a three-way catalyst would increase gas mileage further still.

<sup>11</sup>Chrysler also admitted, however, that the field of NOx control was very low and that "there is a wide range of proposed solutions, some of them involving much more fuel economy penalties than others." Tr. 82.

<sup>12</sup>The Honda CVCC engine, which does not rely on catalysts, apparently takes an 18 percent fuel penalty to meet .25 grams per mile of NOx when installed on a 2,000 pound vehicle, 9 percent to meet .5 grams, and none at all to meet .9. Tr. 583, 602-03. A 5,000 pound vehicle modified to use the Honda system emitted about 1.5 grams per mile of NOx and met the statutory HC and CO levels, while showing a slight improvement in fuel economy. Tr. 690.

(c) *Cost and Driveability*

Very little data is available on such other "public interest" factors as the cost of the hardware to control emissions to 1976 levels, or the effect of such levels of control on performance or driveability.

Cost estimates were given by Ford, Chrysler, the National Academy of Sciences and two catalyst makers. Chrysler estimated the additional cost of the 1976 emissions control components over those required to meet the 1975 statutory standards at \$100, C. App. IV-H-22; while the NAS put it at \$133, and Ford at \$275, F. App. 4-62. Questor estimated the cost of their system, which is designed to meet both the 1975 and the 1976 standards, at \$224 for a standard-sized car, Tr. 826, while Gould, as noted on page 13 above, puts the cost of installing their reducing catalyst on a V-8 engine at \$60.

The record contains very little discussion of the effect of achieving the 1976 standards on driveability. It appears to be generally agreed, however, that the richer air/fuel mixtures to be used with the NOx catalyst will tend to improve driveability. If use of exhaust-gas recirculation can be reduced, this will also tend to improve driveability; that EGR systems are not improved. It is almost certain, however, that EGR systems will be improved. See "Interim Standards," *infra*.

## 4. GOOD FAITH

The Act requires that, before I grant an extension of time to any auto manufacturer, I must find that "all good faith efforts have been made to meet the [1976] standards." The good faith issue, as it has developed in these proceedings, has reminded me both of our original suspension hearings in the spring of 1972 and of the proceedings on remand held last March.

As was true in the remand proceedings, large amounts of money are being spent by each of the manufacturers to meet the 1976 standards. Ford testified that it had spent \$3.3 million to this end in 1972 and would spend \$9.1 million in 1973 not including very large expenditures on systems useful to meet both the 1975 and 1976 standards. According to Chrysler, the corresponding figures for that company are \$4.6 million and \$7.8 million. GM did not break out its 1976 emissions expenditures from its total emissions control expenditures, which have in general been about 40% more than Ford's.

It is clear once again, as it was last April, that Chrysler's total emissions control expenditures, even when adjusted for Chrysler's smaller size, lag far behind those of Ford or GM. Expenditures on emission control in 1972 averaged about \$44 per car for Ford and GM and about \$13 for Chrysler. Though Chrysler has substantially increased its emissions control budget in recent months, it has not increased it enough to significantly affect this ratio. Two catalyst manufacturers testified that their contracts with Chrysler were not as satisfactory as those with Ford or General Motors, Tr. 1035 (W. R. Grace); Tr. 1420 (Gould).

The aspect of these proceedings that is disturbingly reminiscent of the spring of 1972 is the apparent faulty coordination between catalyst makers and the auto companies. Given the special need to match fuel metering and other system characteristics with reduction catalyst, this fault is of particular concern. See NAS Rept. p. 43 ("coordination of research by the automobile manufacturers and catalyst suppliers is far from ideal"). In addition, it appears that two of the most promising systems have received the least attention.

This is particularly clear in the case of Questor. Despite the encouraging emissions results reported on page above, Chrysler testified that only about four percent of its 1976 development effort was going to Questor, Tr. 126, while Ford stated it only had one professional working on the system, Tr. 260-61, and only one vehicle under test, Tr. 258. General Motors, though it has done more work here than the other two applicants, has only run one Questor car on durability out of a total of about 20 durability vehicles, Tr. 450-51; GM App., Appendix 8.

Chrysler argues that its limited effort was caused by Questor's insistence on building up the test vehicle itself, which led to long delays due to limited capacity, Tr. 127-28, 133-35. Ford claimed that since Questor seemed to be doing such a good job, they had moderated their own efforts in that field, Tr. 268-69.

Though these explanations have some validity, Tr. 836-37, 852, they are far from being complete. Questor testified that lack of funds had been a limitation on their own program, and that the auto companies had refused to make additional funds available, Tr. 850, 860-62. Questor also testified—and it seems plain from the data—that the extent of vehicle testing now being carried out by the major auto companies was not enough to permit them to make an informed choice to install Questor on their cars in the 1977 model year, Tr. 855-858.

Similarly, the amount of effort put into Gould catalysts by each of the applicants seems less than the promise of the system would warrant. Here, however, Gould only started its own test program, from which the most promising results come, in the fall of 1972, and the results did not begin to become available until early this year. There may simply not have been enough time since then for the manufacturers to undertake testing programs that would have yielded results in time for this hearing.

As was true last April, it appears with hindsight that the manufacturers might profitably have devoted more of their efforts to alternate engine systems. The one system that could clearly meet the standards, at least on small vehicles, is the Honda CVCC, an alternate engine.

As before, however, I also find that the extensive sums spent by all manufacturers, combined with the fact that progress towards achieving the 1976 statutory standards is moving at nearly the same rate as progress towards the 1975 standards, indicates that the "good faith" requirements of the statute have been met.

#### IV. Interim Standards

The Act requires that if I grant a suspension of the 1976 emissions standards for oxides of nitrogen, I must "simultaneously with such determination prescribe by regulation interim emissions standards which shall apply (in lieu of [the statutory standards]) to emissions of oxides of nitrogen from [light duty] vehicles and engines manufactured during model year 1976." These standards must "reflect the greatest degree of emission control which is achievable by application of technology which the Administrator determines is available, giving appropriate consideration to the cost of applying such technology within the period of time available to manufacturers."

In accordance with these statutory requirements, I am today imposing an interim standard of 2.0 grams per mile of oxides of nitrogen for all 1976 model year light duty vehicles which are subject to emissions standards under the Clean Air Act.<sup>13</sup>

This two-gram standard has already been achieved on 1974 model cars certified for sale in California, and will also be achieved by 1975 model cars subject to the California interim standards of .9 grams per mile of HC, 9.0 grams per mile of CO, and 2.0 grams per mile of NOx.

The basis for giving this standard nation-wide application in 1976 is set forth at length in Appendix A, the Technical Appendix. According to this analysis, at least 91% of the auto market can be predicted with a high degree of confidence to certify in 1976 at the levels of .41 grams per mile of HC, 3.4 grams per mile of CO, and 2.0 grams per mile of NOx. The methodology and data used are almost identical to those employed in Appendix B to the Administrator's decision of April 11 of this year to predict whether or not the manufacturers could achieve the statutory HC and CO standards in 1975. In my judgment, the interim standards established today are supported by a methodology which complies with the requirements laid down by the Court of Appeals in *International Harvester* for predicting certification.<sup>14</sup>

<sup>13</sup> However, if California were to request waiver of Federal preemption under section 209 of the Clean Air Act in order to enforce a more stringent NOx standard, EPA might well be able to grant that waiver. For one thing, more data might be available at the time the request was made. More important, the burden of proof would be reversed in those proceedings, since under the statute the Administrator must grant California's request unless he finds technology is not available, while to set an interim standard the Administrator must affirmatively find that technology is available.

<sup>14</sup> In using this methodology, I believe I have been more conservative than the law requires. The Court of Appeals in *International Harvester* spoke to the question of an appropriate methodology for evaluating the manufacturers' efforts to achieve the statutory HC and CO levels in 1975. It certainly could be anticipated that less data would be available for use in a methodology to predict compliance with an interim standard, since none of the test programs would have been aimed at achieving this standard. Indeed, GM asserted that the one series of tests which it had run aimed at achieving the statutory HC and CO levels together with a 2 gram NOx level had been "run opposite to the way you [EPA] would like us to run them." Tr. 419.

If there were such a lack of data, it might be impossible to set any interim standard that could be justified by the same rigorous analysis a denial of suspension would require. Yet to fail to set an interim standard stricter than existing standards simply because of the absence of data would be both false to the Congressional purpose to use the interim standard as a stepping-stone toward ultimate achievement of the statutory standard, and unjustified by the risk-balancing considerations on which the Court of Appeals laid such weight. The task of achieving an interim standard is, almost by definition, significantly easier than the task of achieving the statutory standard.

For these reasons, the 1975 interim standards for HC and CO set on April 11 of this year were based on a qualitative judgment of the technology available, rather than the more conservative car-by-car analysis of the data used in predicting certification.

Most features of this methodology were discussed exhaustively during the 1975 remand proceedings. The only new features which have been adopted since then are:

1. The use of somewhat less conservative assumptions about the degree of technology transfer between engine families that will be possible before the start of certification testing. This was done because in April of 1973 only about six months remained before the start of 1975 certification testing, while about fourteen months now remain before the start of 1976 certification testing.

2. The adoption of a new correction factor to account for the fact that very few of the cars for which data are available employed an advanced exhaust-gas recirculation (EGR) system.

To understand this second factor, some explanation of exhaust-gas recirculation is necessary.

Nitrogen oxides tend to vary directly with the power output of the engine, and therefore to be a function of speed and far more strongly of acceleration. This is true because total NOx production is a function of both high temperature and the total flow of gas through the engine, both of which increase at high engine loadings. To control NOx emissions, most current engines recirculate some exhaust gas back to the engine air intake, where it is put into the air-fuel mixture and passed through the combustion process once again. Since most of the oxygen in the exhaust gas has of course been burned, the use in the combustion mixture of this inert substance rather than air tends to lower the oxygen concentration and the combustion temperature. Although the use of more than a relatively small amount of EGR tends to decrease engine efficiency and may affect performance somewhat, these effects decrease at high engine loadings. At high engine loadings, the throttle is opened further, and a greater quantity of air-fuel mixture enters the cylinder. In consequence, at the end of the compression stroke, the air-fuel mixture will be denser at high loadings, a condition that promotes combustion and therefore engine performance.

GM App. pp. A12-25 and A12-26 shows that a car which at 55 mph could tolerate 10% EGR without loss of fuel economy and 15% without any increase in HC and CO emissions could at 25 mph only tolerate 5% without loss of fuel economy and 10% without an HC or CO increase.

However, even though the engine can tolerate more EGR at higher loadings, and even though more EGR is needed at higher loadings because NOx emissions are higher there, current EGR systems ("port type EGR") tend to give more EGR at lower engine loadings, where it is not needed and the engine cannot tolerate it well. This happens because the opening of the valve that lets the exhaust gas recirculate into the engine (the "EGR valve") is keyed directly to manifold vacuum, which tends to decrease as engine loading increases.

The EGR system that GM has developed, and which is used in the methodology, works by sensing a parameter—backpressure in the exhaust system—that varies directly, not inversely, with engine loading. It is called "proportional EGR." Other proportional systems for which test data is not yet available would use different means to accomplish the same result. Ford is working on a system that would sense Venturi vacuum, F. App. 4-18, which also varies directly with engine loading. Since engine loading also varies with the position of the accelerator, still other prototype systems would simply increase the EGR rate when the accelerator pedal is depressed.

Any of these proportional EGR systems could be expected to provide significantly better NOx control. In addition, they could be expected to do this without any corresponding increase in HC and CO emissions, since, as noted above, the ability of the engine to tolerate EGR without such an increase is greater at higher engine loads.

Given the several different ways of developing proportional EGR, and the fact that GM already claims to have developed such a system and claims certain results for it, I find it reasonable to predict that proportional EGR will be available for industry-wide application fourteen months from now, and that it will achieve at least the results that GM already claims for it. Indeed, both GM and Chrysler plan to use some variety of proportional EGR in 1975, and so, apparently, does Ford. Tr. 34 (Chrysler); Tr. 154-55 (Ford); Statement of General Motors on Remand A12-5.

Under the statute, interim standards must reflect the maximum emission control that available technology can achieve, giving appropriate consideration to the cost of applying it. Cost considerations are thus of only secondary importance.

Nevertheless, it is my opinion that today's interim standard can be achieved at costs which are reasonable by any definition. The increase in sticker price resulting from the use of proportional EGR instead of current systems is estimated by my staff to be ten to twenty dollars per car at most.

The use of proportional EGR should result in a significant fuel economy saving over current EGR systems at any given level of NO<sub>x</sub> control. For lighter cars, the use of this new EGR system should be enough to prevent the more stringent standard from causing a fuel economy penalty. For heavier cars, which must use more EGR, the new system should allow some improvement in fuel economy even after accounting for the adverse effect of the more stringent NO<sub>x</sub> standard.

#### V. Administrative Finality

The decision issued today is final for purposes of judicial review, and no formal agency proceedings for its reconsideration are presently contemplated. The Court of Appeals has emphasized, however, that even such a "final" decision remains open to a petition for reconsideration or modification, and that such petitions, if found meritorious, should be acted on.

ROBERT W. FRI,  
*Acting Administrator.*

Mr. QUARLES. There is a point I would like to make in regard to this. In addition we will supply you with the information we have.

At the hearings we conducted a month or two ago there was a very striking impression so far as I was concerned and others, top officers of the Agency, that the industry has made a good deal of progress and that there are prospects for major technological advances which could make feasible a high degree of NO<sub>x</sub> control without necessarily involving substantial fuel penalties.

It is purely speculation at this point whether those chickens can be brought into the coop or not, whether those prospects can be realized. The problem which I think you are going to face and one which we have given a good deal of thought to without coming up with any clear answer on is how does one continue to keep the pressure on for the research and development work required to maximize the chance of developing that technology.

Right now we are very much impressed by the fact that as we look around the country and relate our existing NO<sub>x</sub> ambient standards to the existing air quality we don't see that strong a need for gigantic efforts to control NO<sub>x</sub>.

We also are struck by the cost of NO<sub>x</sub> control devices both in original installation cost and in the fuel penalties. However, if there is a prospect of achieving very real control at relatively modest cost and without significant fuel penalty, then that is something which we very likely should develop to have as an option.

The question is, How does one properly reflect what we presently know about this in statutory modification and yet at the same time maintain the momentum in the research and development program? I don't have any answer to that problem, but I think it needs to be very squarely before you as you consider this problem, and talk to the auto industry, and talk to the others as they testify before you.

Mr. ROGERS. The committee will be aware of that. Do you think we would have made the progress in cleaning up the air had not the Clean Air Act been passed?

Mr. QUARLES. Absolutely not.

Mr. ROGERS. Also, I have before me the reply from you to a letter I sent to you on August 9. The answer is rather detailed. Without objection this will be made a part of this report at this point.

[Letter referred to follows:]

U.S. ENVIRONMENTAL PROTECTION AGENCY,  
OFFICE OF THE ADMINISTRATOR,  
Washington, D.C., September 7, 1973.

HON. PAUL G. ROGERS,  
Chairman, Subcommittee on Public Health and Environment, Committee on  
Interstate and Foreign Commerce, House of Representatives, Washington,  
D.C.

DEAR MR. CHAIRMAN: Enclosed are the responses of the Environmental Protection Agency to the questions contained in your August 9 letter. I trust you will find our answers fully responsive. If we can be of further assistance, please do not hesitate to contact us.

Sincerely yours,

JOHN R. QUABLES, Jr., *Acting Administrator.*

Enclosure.

#### QUESTIONS SUBMITTED BY CHAIRMAN ROGERS AND EPA'S ANSWERS

**Question 1.** An analysis of the data and conclusions pertinent to the scientific basis of the national primary ambient air quality standards contained in Charles H. Connolly's, "Air Pollution and Public Health," New York Dryden Press, Inc., 1972 (Chrysler Corporation supported study).

**Response.** Mr. Connolly's report states the position that the automobile-related health standards, particularly those for carbon monoxide are too stringent. This contention is not based on any hard data, but rather reflects a belief that where there is incomplete scientific data, no standard at all should be set.

The position of the Environmental Protection Agency, in response to Mr. Connolly's report, can be summarized as follows. Although the health intelligence base for existing primary air quality standards is tentative and incomplete, our re-evaluation of the scientific literature to date strongly reinforces the health basis for the existing standards. Secondly, rather than suggesting a relaxation of efforts to limit automotive emissions, new knowledge reveals that highly susceptible groups of diseased individuals are extremely sensitive to low levels of carbon monoxide at ambient levels, and that even the stringent carbon monoxide emission standards required by 1976 may not be sufficient to achieve fully protective air quality in all of our country's major air quality control regions.

With regard to the other auto-related pollutants, an analysis of well controlled animal experiments on the health consequences of photochemical oxidants imply that any exposures above background levels of these pollutants can be a threat to health in terms of normal body defenses against respiratory infections and the normal process of cell division. While the consequences of these findings have not as yet been investigated in humans, the evidence in no way should suggest a relaxation of existing air pollution control strategies. With new scientific investigations employing more sensitive biological indicators and identifying more vulnerable groups in the population, we may well question whether our present modest margins of safety are truly "adequate" to protect the public health, as required by the Clean Air Act of 1970. While current knowledge does not suggest the need to revise existing standards, the direction of new health intelligence is clearly towards confirming the need for the existing standards and controls.

A review of the scientific evidence at hand prior to and since the promulgation of national air quality standards supports the above contentions. Dr. John Knelson and fellow investigators of the Environmental Protection Agency<sup>1</sup> have demonstrated, under laboratory-controlled exposures of human subjects with coronary artery disease, that low levels of carbon monoxide, sufficient to result in carboxyhemoglobin saturations of only 3 percent, result in significant shortening of the exercise time required to induce chest pain, and changes in the

<sup>1</sup> Anderson, E. W., Andleman, R. J., Strauch, J. M., Fortnin, N. J. and Knelson, J. H. Effect of Low Level Carbon Monoxide Exposure on Onset and Duration of Angina Pectoris. *Ann. Intern. Med.*, 79:46-50, 1973.

electrocardiogram associated with definite oxygen deprivation of the heart muscle. These findings were recently substantiated by Dr. Willbert Aronow<sup>2</sup> who repeated Dr. Knelson's laboratory experiments and obtained identical results at carboxyhemoglobin saturations of only 2.7 percent.

The existing primary air quality standard for carbon monoxide will allow CO exposures resulting in carboxyhemoglobin saturations, under conditions of moderate exercise, of 1.6 percent (10 ppm for 8 hours) and 1.7 percent (35 ppm for 1 hour)—less a modest margin of safety. Further, conflicting results from psychomotor function tests as carried out by Beard and Wertheim<sup>3</sup> and by Stewart<sup>4</sup> (these were extensively discussed in Mr. Connolly's report) have been reasonably clarified by Dr. G. G. Fodor<sup>5</sup> who observed a CO-induced drop in the general level of psychophysiological reactivity to environmental signals, as measured by the vigilance test, at carboxyhemoglobin saturations as low as 2.5 percent. Direct tests of psychomotor function, under other than vigilance conditions, were not sensitive to low levels of CO exposure. Similarly, Dr. Elizabeth Groll-Knapp<sup>6</sup> found that subjects who were submitted to acoustic vigilance tests manifested reduced capacity to react to monotonous external stimuli at carboxyhemoglobin contents of only 3 percent. This effect was clearly detectable by measuring the specific electrical activity of the brain (anticipation waves on the electroencephalogram) as well as by scoring each person's performance in the acoustic vigilance test. The investigators noted that direct tests of reaction times and motor coordination, as carried out by Stewart<sup>4</sup> and Mikuika,<sup>7</sup> were remarkably insensitive to low CO concentrations. The vigilance test results are significant, however, in that they more closely model a driver's general level of attentiveness and ability to respond to unpredictable occurrences when he is distracted by a multiple of stimuli or is otherwise not performing at the peak of his psychomotor system's ability.

Considering these recent research results, exposures to CO resulting in carboxyhemoglobin saturations of 2.5 to 3.0 percent are demonstrably undesirable both for the relatively large adult population with clinical coronary artery disease (approximately 5 percent of adults) and most likely for the general population of automobile drivers. Present CO air quality standards afford a minimal margin of safety. More sensitive measures of cardiovascular function in diseased groups may reveal the need to reduce environmental exposures below those now promulgated.

Another national primary standard of concern to this Agency is the standard for photochemical oxidants. The main constituent of photochemical oxidant pollution is ozone, a substance which has clear demonstrable biologic reactivity under controlled laboratory conditions. At ozone concentrations as low as the existing primary standard (160  $\mu\text{g}/\text{m}^3$ ), animals exposed for 3 hours exhibited increased susceptibility to experimentally induced bacterial infections; a firm linear dose-response relationship was established for this effect.<sup>8</sup> At ozone concentrations of 196  $\mu\text{g}/\text{m}^3$  for 2½ hours, the stability of the pulmonary cells which protect the deep lung against infection was reduced in experimental animals.<sup>9</sup> Long-term low level ozone exposures of 1960  $\mu\text{g}/\text{m}^3$  (1 ppm) for 6 hours per day, repeated 268 times (conditions mimicking the Los Angeles environment) produced lung

<sup>2</sup> Aronow, W. Effect of Freeway Travel on Angina Pectoris. Presented at the Air Pollution Health Effects Investigators Meeting, California Air Resources Board, Sacramento, California, May 9, 1973.

<sup>3</sup> Beard, R. R. and Wertheim, G. A. Behavioral Impairment Associated with Small Doses of Carbon Monoxide. *Amer. J. Public Health* 57:2012-2022, 1967.

<sup>4</sup> Stewart, R. D., Peterson, J. E., Baretta, E. D., Bachand, R. T., Hosko, M. J., and Hermann, A. A. Experimental Human Exposure to Carbon Monoxide. *Arch. Environ. Health* 21:154-164, 1970.

<sup>5</sup> Fodor, G. G. and Winneke, G. Effect of Low CO Concentrations on Resistance to Monotony and on Psychomotor Capacity. *Staub-Reinhalt. Luft* 32:46-54, 1972.

<sup>6</sup> Groll-Knapp, E., Wagner, H., Hauck, H., and Harder, M. Effects of Low Carbon Monoxide Concentrations on Vigilance and Computer-Analyzed Brain Potentials. *Staub-Reinhalt. Luft* 32:34-38, 1972.

<sup>7</sup> Mikuika, P., O'Donnell, R., Helning, P. and Theodore, J. The Effect of Carbon Monoxide on Human Performance. Published in *Biological Effects of Carbon Monoxide*, Annals of the New York Academy of Sciences 174:409-420, 1970.

<sup>8</sup> Coffin, D. L., Blommer, E. J., Gardner, D. E. and Holzman, R. S. Effect of Air Pollution on Alteration of Susceptibility to Pulmonary Infections. Published in Proceedings of the 3rd Annual Conference on Atmospheric Contaminants in Confined Spaces, Dayton, Ohio: Wright-Patterson Air Force Base, Aerospace Medical Research Laboratories, 1967.

<sup>9</sup> Gardner, D. E. Environmental Influences on Living Alveolar Macrophages. Doctoral Dissertation available from University Microfilms, Ann Arbor, Michigan, 1971.

tissue changes in experimental animals very similar to human chronic bronchitis and emphysema.<sup>10</sup> Of even greater potential consequences in terms of human health, a significant increase in chromosomal aberrations was induced in the circulating white blood cells of hamsters who were exposed, while living, to only 392  $\mu\text{g}/\text{m}^3$  (0.20 ppm) of ozone for 5 hours.

The investigators who reported this study calculated that the ozone-induced lymphocyte chromosome break frequency expected from one week of ozone exposure allowed by the present air quality standard is more than 7,000 times the break frequency resulting from one week exposure to radiation as permitted by occupational standards.<sup>11</sup> This mutagenic capacity of ozone was not taken into account when the air quality standard was established, since the evidence then, as now, cannot be simply extrapolated to humans. Neither radiation standards nor ozone standards use chromosomal break frequencies as a basis for setting human exposure limits. However, the American Industrial Hygiene Association's Community Air Quality Guide<sup>12</sup> recognized the radiation-like potential of ozone when it was stated that "theoretically, the recommended air limit for ozone . . . should be zero, or as close to zero as possible, i.e. less than 0.01 ppm (20  $\mu\text{g}/\text{m}^3$ )." The sum of these scientific investigations again fail to provide evidence to justify any relaxation of the air quality standard for photochemical oxidants. The ozone health effects experimentally produced in animals are, by nature, of far-reaching consequences. Lacking solid evidence concerning the full implications for human health, the air quality standard represents the best judgment for the minimum difference between allowable exposures for humans (160  $\mu\text{g}/\text{m}^3$ ) and demonstrable adverse biological effects in intact animals (196-392  $\mu\text{g}/\text{m}^3$ ).

This discussion concerning the nature of the health hazards attributable to carbon monoxide and ozone has identified some of the uncertainties in our health intelligence base. However, unlike the interpretation given by Mr. Connolly in the Chrysler report, the conclusion of the Environmental Protection Agency is that these uncertainties make us uneasy about the adequacy of the margin of safety provided by the current air quality standards. The sum of scientific evidence strongly argues against any changes in the direction of more relaxed standards (i.e. allowing human exposures above current standards). The best judgment decisions should by necessity allow adequate protection of the public. To relax the standards without any assurance of a definite margin of safety is not in the best interest of the public.

**Question 2.** An analysis of the data and conclusions pertinent to the scientific basis of the national primary ambient air quality standards contained in General Motors' "The Basis for the National Air Quality Standards for Automotive Pollutants", *A Current Study of Automotive Air Pollution: April-October 1972*, published by GM Inter-staff Committee on the Environment, October 1972.

**Response.** The General Motors (GM) Paper "The Basis for Air Quality Standards for Automotive Pollutants", dated October 1972, reviews the scientific evidence underlying the Federal Primary Air Quality Standards for carbon monoxide, nitrogen dioxide, photochemical oxidant, and hydrocarbons. Our response to the General Motors review is presented in the following sections.

#### CARBON MONOXIDE

The GM recommendation is that the CO standard be set to limit the blood COHb level to 2½ to 3 percent. The assertion is made that such a level "will protect the general population with an adequate safety margin for its older and weaker members." No data in support of this statement is presented.

Recently published studies suggest that limiting COHb levels to 2½ to 3 percent will *not* protect the general population nor provide any safety margin for the susceptible groups, hence, the recommended GM position would result in a less protective standard. Two studies under laboratory controlled exposure conditions of subjects with coronary artery disease demonstrated that COHb

<sup>10</sup> Stokinger, H. E., W. D. Wagner, and O. J. Dohrogorski. Ozone Toxicity Studies. III. Chronic Injury to Lungs of Animals Following Exposure at a Low Level. *Arch. Ind. Health*, 16 (6) : 514-522, December 1957.

<sup>11</sup> Zilac, R. E., Cromroy, H. L., Bolch, W. E., Jr., Dunavant, B. G. and Bevis, H. A. Inhaled Ozone as a Mutagen. I. Chromosome Aberrations Induced in Chinese Hamster Lymphocytes. *Environ. Res.* 4 :262-282, 1971.

<sup>12</sup> American Industrial Hygiene Association. Community Air Quality Guides. Ozone. *Amer. Ind. Hyg. Ass. J.* 29 :290-303, 1968.

levels of 3 and 2.7 percent resulted in significant shortening of the exercise time required to induce chest pain and changes in the electrocardiogram associated with definite oxygen deprivation of the heart muscle.<sup>1,2</sup> Studies of the ability of two different groups of normal subjects to react to stimuli under vigilance conditions demonstrated impairment at 2.5 percent COHb in one case and 3 percent in the other.<sup>3,4</sup> These latter findings are of special significance in considering drivers' abilities to react to unpredictable occurrences.

#### NITROGEN DIOXIDE

As stated in the General Motors Report, the primary epidemiologic evidence for the NO<sub>2</sub> standard is the studies conducted in Chattanooga by Sly et al.<sup>5,6</sup> and Pearlman<sup>7</sup> et al. from November 1968 through April 1969. These studies are criticized first on the ground that the Jacobs-Hochheiser NO<sub>2</sub> measurements were unreliable. It is quite true that the Jacobs-Hochheiser method is not generally reliable because of its variable collection efficiency. However, during the Chattanooga study, data from the Jacobs-Hochheiser method agreed rather well with the more reliable Saltzman measurement. The National Air Pollution Control Administration collected Saltzman NO<sub>2</sub> measurements from December 1967 through November 1968. The U.S. Army also conducted Saltzman NO<sub>2</sub> measurements throughout the period covered by the health study. These studies were within 15 percent of the Jacobs-Hochheiser at the station closest to the point sources of NO<sub>2</sub>.<sup>8</sup> There is no reason to believe that average exposure levels would have differed between 1967 and 1969, for the major point source, a munitions plant, was operating at maximal capacity all three years.

The Chattanooga study was further criticized because school 3 in the high exposure neighborhood had levels of NO<sub>2</sub> comparable to the school in the intermediate exposure neighborhood. However, the concentration of suspended nitrates was higher at school 3 than at the intermediate neighborhood school. Also, school 3 drew its enrollment from essentially the same high-exposure neighborhood as did school 1 and 2. Thus, the children attending school 3 were very likely exposed to higher levels of nitrogen dioxide during non-school hours than were children in the intermediate exposure neighborhood. There is little doubt that children in all three schools in the high exposure neighborhood had higher long-term doses of nitrogen oxides than children in the other neighborhoods.

Further epidemiologic studies<sup>9</sup> were conducted in Chattanooga in the last quarter of 1970, and their results were not available for use in setting the NO<sub>2</sub> standard. By the end of 1970, the munitions plant had curtailed production, and the average daily ambient concentration of NO<sub>2</sub> had fallen to 0.04 ppm in the high exposure neighborhood. Adults in that neighborhood were shown to have no increase in chronic respiratory symptoms over other Chattanooga adults. However, a decrease in one-second forced expiratory volume of about 75 cc, on the average, was shown in adults in the high exposure neighborhood. Whether this decrement was an irreversible effect, attributable to higher exposures of earlier years, or a potentially reversible effect, due to current exposures, could not be determined. In either case, it is prudent to assume that the present NO<sub>2</sub> standard of 0.05 ppm (annual average) contains less than a two-fold margin of safety.

<sup>1</sup> Anderson, E. W., et al. Effect of Low Level Carbon Monoxide Exposure on Onset and Duration of Angina Pectoris. *Ann. Intern. Med.*, 79:46-50, 1973.

<sup>2</sup> Aronow, W. Effect of Freeway Travel on Angina Pectoris. Presented at the Air Pollution Health Effects Investigators Meeting, California Air Resources Board, Sacramento, California, May 9, 1973.

<sup>3</sup> Fodor, G. G. and Winkele, G. Effect of Low CO Concentrations on Resistance to Monotony and on Psychomotor Activity. *Staub-Reinhalt. Luft* 32:46-51, 1972.

<sup>4</sup> Groll-Knapp, E. et al. Effects of Low Carbon Monoxide Concentrations on Vigilance and Computer-Analyzed Brain Potentials. *Staub-Reinhalt. Luft* 32:64-68, 1972.

<sup>5</sup> Sly, C. M. et al. The Chattanooga School Children Study: Effects of Community Exposure to Nitrogen Dioxide. I. Methods, Description of Pollutant Exposure, and Results of Ventilatory Function Testing. *APCA Journal* 20: 8:539, August 1970.

<sup>6</sup> Sly, C. M. et al. The Chattanooga School Children Study: Effects of Community Exposure to Nitrogen Dioxide. II. Incidence of Acute Respiratory Illness. *APCA Journal* 20: 9:582, September 1970.

<sup>7</sup> Pearlman, M. E. et al. Nitrogen Dioxide and Lower Respiratory Illness. *Pediatrics* 47: 2:391, February 1971.

<sup>8</sup> Federal Register, Vol. 38, No. 110, June 8, 1973.

<sup>9</sup> Carmenter, U., Poole, W. K., and Jackson, D. W. Prevalence of Chronic Respiratory Disease in Chattanooga: Effect of Community Exposure to Nitrogen Oxides. Contract Report. Research Triangle Institute, June 25, 1971.

from impairments in ventilatory function, if  $\text{NO}_2$  alone, and not nitrates, acid mist,  $\text{NO}_2$  or combinations thereof, was primarily responsible for the observed impairments. Additional health studies will be needed to disentangle these effects. Though the General Motors report advocates changing the  $\text{NO}_2$  standard to 0.25 ppm (hourly maximum), GM presents no concrete justification. Further, available information indicates that the 0.25 ppm (hourly maximum) standard may be more stringent than the annual average standard of 0.05 ppm.

#### PHOTOCHEMICAL OXIDANTS

General Motors correctly observed a mistake in the Federal Register notice announcing the standard for photochemical oxidants. They noted that a figure in a cited study reported as .15 should have been in fact .25 ppm. But General Motors misinterprets the importance of this mistake in the Schoettlin and Landau<sup>9</sup> report in stating that "only a small percentage of the subjects experienced 'significantly more' (otherwise unspecified) asthma attacks when the maximum photochemical oxidant concentration exceeded 0.25 ppm." Our own review of Schoettlin and Landau reveals that the number of asthma attacks was increased in the panel as a whole when oxidant levels exceeded 0.25 ppm, and that a few of the panel exhibited an increase in attacks at lower levels, i.e. "on days having plant damage (our underlining)." These lower oxidant levels at which plant damage occurred were not specified in the report.

Furthermore, there are other studies showing adverse effects at less than 0.25 ppm. In Wayne's study,<sup>10</sup> a consistent deleterious effect on performance was found in cross-country runners. Application of mathematical techniques to Wayne's data indicates an effect threshold estimated at 0.12 ppm oxidant. Thus, the 0.08 ppm standard provides less than a two-fold margin of safety for one of the healthiest, best-conditioned segments of the population.

The safety margin may be considerably smaller, or nonexistent, for potentially more vulnerable groups like the very young, the very old, the ill, and the pregnant. Indeed, recent studies,<sup>11,12</sup> in which animals have been exposed to ozone levels of 0.08 to 0.1 ppm, have shown increased susceptibility to infection, and decreased macrophage longevity. At higher ambient-level exposures (0.20 ppm) chromosomal abnormalities have been shown in hamsters.<sup>13</sup> Results from animal studies naturally must not be directly extrapolated to humans but they must not be disregarded, either.

Thus, there is considerable reason to believe that the oxidant standard of 0.08 ppm is not unduly restrictive. GM gives no concrete reason in relaxing the standard to 0.10 ppm.

#### COMMENTS ON THE GM RECOMMENDATION THAT THE NAQS FOR HC BE ABOLISHED AS BEING UNECESSARY

The hydrocarbon standard was obtained from the hydrocarbon-oxidant relationship so as to provide the level of hydrocarbon control needed to protect the public health in terms of the oxidant standard. Through studies of aerometric data available from a number of U.S. cities, a numerical standard of 0.24 ppm hydrocarbon (minus methane) was shown to be consistent with the oxidant standard.

The need for a NAQS-HC is fully justified because of the following well established requirements: (a) emission standards for autos must be national rather than regional; (b) the NAQS-HC must be the point of departure in development of numerical emission standards for automobiles; and (c) the monitoring of ambient air hydrocarbons provides an independent check on the effectiveness of the hydrocarbon emission control programs.

<sup>9</sup> Schoettlin, C. E. and Landau, E. Air Pollution and Asthmatic Attacks in the Los Angeles Area. Public Health Reports 76: 6:545, June 1961.

<sup>10</sup> Wayne, W. S., Wehrle, P. F. and Carroll, R. E. Oxidant Air Pollution and Athletic Performance. JAMA 199: 12:901, March 20, 1967.

<sup>11</sup> Coffin, D. L. et al. Effect of Air Pollution Alteration of Susceptibility to Pulmonary Infections. Published in Proceedings of the 3rd Annual Conference on Atmospheric Contaminants in Confined Spaces, Dayton, Ohio: Wright-Patterson Air Force Base, Aerospace Medical Research Laboratories, 1967.

<sup>12</sup> Gardner, D. E. Environmental Influences on Living Alveolar Macrophages. Doctoral Dissertation available from University Microfilms, Ann Arbor, Michigan, 1971.

<sup>13</sup> Zilac, R. E. et al. Inhaled Ozone as a Mutagen. I. Chromosome Aberrations Induced in Chinese Hamster Lymphocytes. Environ. Res. 4:262-282, 1971.

It should be stressed here that other considerations also enter in the development of numerical emission standards. Such considerations may have led Congress to the definition of the emission standards for autos; however, it is believed that the point of departure was the numerical standards derived from the hydrocarbon standard.

In conclusion, a hydrocarbon concentration standard is needed, provided it serves as intended, that is, not as an actual air quality goal; rather as a guide to development and implementation of control strategies.

**Question 3.** An analysis of the data and conclusions pertinent to the scientific basis of national ambient air quality standards contained in the Library of Congress, Congressional Research Service, "A Brief Report on the Status of Research on the Health Effects of Air Pollution", published in Congressional Record (daily edition), April 4, 1973, S. 6638-6644.

**Response:** This is a comprehensive and accurate report which describes the state-of-the-art of research into the effects of air pollution on health. Current literature is reviewed against a background indicating basic difficulties in designing, interpreting, and generalizing from this type of research.

The report stated that knowledge in this field had not substantially increased since 1970, and deficiencies in selected individual studies were pointed out. Nevertheless, it was stated that consistent findings across studies presented a convincing picture of the existence of both acute and chronic health effects from air pollutants while falling short of establishing definitive dose-response or threshold relationships.

Specific areas in which current knowledge was found to be deficient and additional research was recommended may be summarized as follows:

1. More research is needed to determine the effects from nitrogen dioxide, photochemical oxidants, and (low-level) carbon monoxide exposures.
2. Cost-benefit analyses of health benefits in relation to improvements in air quality should be undertaken.
3. Long-term commitments should be made to support longitudinal and follow-up studies of insidious effects.

Although several subsequent studies (either recently published or in press and not available for review at the time this report was written) tend to corroborate previous findings, no major changes in the state of our knowledge in these specific areas have occurred.

EPA has initiated research in several of these areas. Clinical studies of low-level carbon monoxide exposure are underway. Information from health studies of nitrogen dioxide and photochemical oxidant exposures from CHES will soon be available. One of the stated objectives of CHES is to document the health benefits from improvements in air quality.

In the past the major thrust of the health research effort within EPA has been to obtain sufficient intelligence upon which to establish or evaluate air quality standards. The time frame for this mission has necessitated conducting relatively short-term studies. The cogent arguments for long-term studies of chronic effects presented in this report deserve consideration in future research programming.

In summary, the Library of Congress report concludes with support for the standards while advocating the desirability of additional research studies.

**Question 4a.** An analysis of the data and conclusions pertinent to the scientific basis of the national ambient air quality standards contained in the following NAS reports:

(a) National Academy of Sciences—National Academy of Engineers: Effects of low levels of carbon monoxide on human health behavior and performance, Washington, D.C., 1969.

**Response.** The carbon monoxide summary included as Appendix A is a concise overview of the carbon monoxide problem with special emphasis on those aspects relevant to the development of environmental criteria and standards. This analysis is intended to provide a very brief description of research results that have become available since 1969 which may amplify conclusions or recommendations based on data available prior to 1969. It is organized as a point-by-point discussion of the summary of tentative conclusions, followed by a concluding paragraph.

#### *Basic Reactions of Carbon monoxide in the Body*

The basic physico-chemical rules governing interactions of CO with respiratory pigments have been well understood for a long time and there is no new work to alter these concepts. Interference of CO with activity of some important

physiologic systems such as cytochrome oxidase and cytochrome P-450 has been demonstrated, but usually at high CO concentrations using *in vitro* systems. Rondla<sup>1</sup> reported altered activity of an aromatic hydrocarbon hydroxylase in livers of rats exposed to CO concentrations as low as 60 ppm. This observation is particularly interesting because of the possible implications for interactions between biological effects of atmospheric CO and hydrocarbons.

Permutt and Farhi have commented on the possibility of significant tissue hypoxia resulting from relatively low level CO exposure. Zorn<sup>2</sup> measured oxygen tension in liver and brain and documented an inverse relationship between the partial pressure of oxygen in tissue and levels of blood COHb between 3 percent and 30 percent. He found that COHb levels as low as 8 percent could result in critical oxygen tension threshold values in the microcirculation of tissues that have a high oxygen demand, confirming the theoretical predictions of Permutt and Farhi.

#### *Blood Carboxyhemoglobin Concentrations*

Formation of COHb is a complex function not only of CO exposure, but many physiologic variables. Coburn et al<sup>3</sup> have done an extensive theoretical analysis of this problem, and recent human exposure data confirm the accuracy of their predictions in normal subjects.<sup>4,5</sup> The Coburn formula is very useful in predicting the effects of physiologic changes on COHb formation, but most of these predictions have not been experimentally validated. Some of these predicted effects are discussed further in the section *Hypothetical Effects of Carbon Monoxide on Susceptible Persons*.

The actual frequency distribution of carboxyhemoglobin levels in people living under varying environmental conditions has not been well studied. A large survey of blood donors from 17 urban areas and 13 small communities in Vermont and New Hampshire has been conducted by Stewart and his colleagues and provides the best available data on this topic.<sup>6</sup> No attempt was made to acquire a statistically valid stratified sample but there is no *a priori* reason to believe the 29,000 subjects of that study are not representative of the population at large. Forty-five percent of all non-smoking donors studied had COHb concentrations greater than 1.5 percent. Stewart concludes that excessive exposure to CO is occurring in many metropolitan areas.

#### *Probable Effects of Breathing Carbon Monoxide on Mental Performance*

The studies of Beard and Wertheim on time interval discrimination are often cited in connection with the carbon monoxide ambient air quality standard. More recently Beard and Grandstaff reported impairment of ability to estimate time intervals as well as decrement in several parameters of visual function at COHb levels from 3 percent to 7 percent.<sup>7</sup> Mikulka<sup>8</sup> and Stewart<sup>9</sup> have studied similar aspects of mental function and found decrement only at relatively high levels of COHb. Other investigators are finding interference in human mental performance as well as psycho-physiologic alterations with low CO exposure conditions. Bender has found impairment of cognitive function and manual dexterity at 7 percent COHb,<sup>10</sup> Fodor found decreased auditory vigilance at 3 to 8 percent

<sup>1</sup> Rondla, D. Effect of low carbon monoxide concentrations on liver enzymes. Staub 32(4):38 April 1972.

<sup>2</sup> Zorn, H. The partial oxygen pressure in the brain and liver at subtoxic concentrations of carbon monoxide. Staub 32(4):24 April, 1972.

<sup>3</sup> Coburn, R. F., R. E. Forster, and P. B. Kane. Considerations of the physiology and variables that determine the blood carboxy-hemoglobin concentrations in man. J. Clin. Invest. 41:1899-1910, 1965.

<sup>4</sup> Peterson, J. E. and R. D. Stewart. Absorption and elimination of carbon monoxide by inactive young men. Arch. Environ. Health 21:165-171, 1970.

<sup>5</sup> Hanks, T. G., and R. D. Ferguhor. Analysis of human performance capabilities as a function of exposure to carbon monoxide. NAPCA contract PH-22-68-31 final report, June 1969.

<sup>6</sup> Stewart, R. D., et al. "Normal" carboxyhemoglobin levels of blood donors in the United States. Contract report CAPM-8-68, May 1973.

<sup>7</sup> Beard, R. R. and N. Grandstaff. CO exposure and cerebral function. Arch Environ Health 21:154-164, 1970.

<sup>8</sup> Mikulka, P. et al. The effect of CO on Human Performance. 5th annual conference on atmospheric contamination in confined spaces, Air Force Aerospace Medical Research Lab, Wright-Patterson AFB, Dayton, Ohio 1969.

<sup>9</sup> Stewart, R. D., et al. Experimental human exposure to carbon monoxide. Arch. Environ. Health 21:154-164, 1970.

<sup>10</sup> Bender et al. Effects of low CO concentration on Psychological function. Staub 32:54-59, April 1972.

'OHb,<sup>11</sup> and Horvath found decreased visual vigilance at 6.6 percent COHb.<sup>12</sup> Groll-Knapp et al also have studied auditory vigilance at these levels and described a negative linear correlation between CO level and the amplitude of aurally induced EEG potentials.<sup>13</sup>

The interpretation of all these studies is controversial, but there seems to be enough consistency in them to suspect a real effect of relatively low CO concentrations on certain aspects of vigilance (signal detection) and visual performance. Experimental situations where these factors are not carefully controlled can lead to conflicting results.

#### *Possible Effects of Carbon Monoxide on the Normal Circulation*

Increased oxygen debt and decreased maximal oxygen uptake following CO exposure in normal exercising subjects have been accepted as evidence of effects on normal cardiovascular function. These observations have been substantiated by the more recent work of Vogel et al<sup>14</sup> and Anderson et al.<sup>15</sup> Vogel's group found maximal oxygen uptake reduced by 24 percent and heart rate increased at all levels of exercise in normal men after attaining 20 percent COHb. Anderson also found increased heart rate at all levels of exercise in normal men at 5 to 7 percent COHb and in addition found significant worsening of mechanical myocardial function as indirectly determined by systolic time intervals.

#### *Hypothetical Effects of Carbon Monoxide on Susceptible Persons*

Some of the hypothetical effects described in the NAS monograph have been explored. Astrup<sup>16</sup> has found a negative correlation between COHb level in pregnant women and subsequent birth weight in their offspring. Other hypothetical effects not described include the effect of anemia and increased endogenous CO production from hemolysis.

#### *A Possible Effect of Increased Ambient Levels of Carbon Monoxide in Coronary Vascular Disease*

Interpretation of several epidemiologic studies referred to in the NAS monograph remains controversial. A more recent study by Wald et al.<sup>17</sup> found the incidence of arteriosclerotic heart disease to be more closely correlated with COHb levels than with number of cigarettes smoked. Aronow et al. found significant changes in electrocardiograms of men with coronary artery disease who were exposed to CO in freeway traffic.<sup>18</sup> Anderson et al. found very similar changes in men with angina pectoris exposed to low level CO by face mask.<sup>19</sup> In addition they found a decrease in time to onset of angina during exercise at 2.9 percent COHb and 4.5 percent COHb.

#### *Innocuous Result Anticipated Whenever Exposure to Increased Ambient Carbon Monoxide Levels in Brief*

The summary statement in the monograph, "It is the blood level, rather than the concentration breathed at the moment, that counts," remains valid and needs only be emphasized. Investigators in the field of CO toxicity are paying increasing attention to careful COHb analysis, leading to more consistent interpretation of results.

#### *Possible Adverse Health Effects of Carbon Monoxide Absorbed While Inhaling Cigarette Smoke*

In view of the new evidence relating CO exposure to cardiovascular effects and the findings of Wald et al.,<sup>17</sup> it seems likely the CO content of cigarette smoke is an important health factor.

<sup>11</sup> Fodor and Wincke. Effect of low CO concentrations on resistance to monotony and psychomotor capability. Staub 32:46-53, April 1972.

<sup>12</sup> Horvath et al. CO and human vigilance. Arch. Environ. Health 23:343-347, November 1971.

<sup>13</sup> Groll-Knapp et al. Effects of low CO concentrations on vigilance and computer analyzed control potentials. Staub 32:64-67, April 1972.

<sup>14</sup> Vogel, J. A. et al. Carbon monoxide and physical work capacity. Arch. Environ. Health 24:198-203, March 1972.

<sup>15</sup> Anderson, et al. Effects of carbon monoxide on exercise electrocardiogram and systolic time intervals. Circulation 44:135, 1971.

<sup>16</sup> Astrup et al. Effect of moderate CO exposure on fetal development. Lancet 2:1220-22, 1972.

<sup>17</sup> Wald, et al. Association between atherosclerotic disease and carboxyhemoglobin levels in tobacco smokers. Brit. Med. J. 1:761-765, March 1973.

<sup>18</sup> Aronow, et al. Effect of freeway travel on angina pectoris. Annals of Internal Medicine. 77:669-676, 1972.

<sup>19</sup> Anderson, et al. Effect of low-level carbon monoxide exposure on onset and duration of angina pectoris—a study of ten patients with ischemic heart disease. Annals of Internal Medicine, 79:46-50, 1973.

## CONCLUSION

The data and conclusions presented in the NAS monograph carefully outlined the basic pathophysiology of CO toxicity, the areas of special concern for human health and behavior, and the exposure levels that would probably be associated with adverse effects. At the time it was prepared there were very few studies suggesting significant effects below 5 percent COHb. There is still much controversy concerning interpretation of studies showing deleterious effects below 5 percent COHb. The trend of recent research results, however, is confirming the previous findings at low levels rather than refuting them.

*Question 4b.* An analysis of the data and conclusions pertinent to the scientific basis of the national ambient air quality standards contained in the following NAS reports:

(b) National Academy of Sciences. Particulate polycyclic organic matter. Washington, D.C., 1972.

Response. The NAS Particulate Polycyclic Organic Matter (PPOM) is the best published current review pertaining to airborne POM. There are, however, some areas of interpretation with which one may take exception.

(1) "Benz(a)pyrene could be used as an indicator or urban pollution etc." (See page 246 of NAS report) This may not be a safe assumption from the standpoint of carcinogenesis for the following reasons: (a) It is not firmly established at this time that BaP or even associated carcinogens are the prime cause of the urban increment in lung cancer, (b) While BaP usually associates well with other polycyclics it is entirely possible that other carcinogenic substances might not be in proportional amounts to BaP in a given atmosphere. There are not sufficient data from detailed air monitoring to substantiate this claim, (c) Co-factors or promoting factors, i.e. metallic particles, irritant gases, dust may be playing a role in carcinogenesis beyond that of BaP and associated substances. (See pages 109 and 113 of NAS report) If such co-factors were supplied through exposure to polluted air it is possible that exposure to carcinogens from other sources, i.e. tobacco smoking might be sufficient to explain the urban increment. We do not believe there is a sufficient data base from epidemiologic studies to substantiate or refute such a presumption.

(2) A working hypothesis is set forth in the document "there is a causal relationship between air pollution and the lung cancer rate in which there is a 5 percent increase in death rate for low increments of urban air pollution. In this study an increment of air pollution corresponds to 1  $\mu\text{g}$  BaP/1,000 m<sup>3</sup> of air." On the basis of this assumed relation a reduction in urban air pollution equivalent to 4 mg BaP might be expected to reduce the lung cancer death rate by 20 percent. (See page 246 of NAS report). While this is prefaced and succeeded by qualifying caveats in the document it is possible that it may be misinterpreted and stated to be an established fact. Such is far from the case since such relationship between BaP and lung cancer does not appear to hold for all situations. The above hypothesis is interesting and may be useful in planning epidemiological surveys. It could, however, if misinterpreted, place undue importance on the control of BaP while ignoring other factors.

The tentative EPA position on PPOM is covered in a draft position paper on PPOM (Appendix B). A summary of the conclusions is as follows:

(1) There is a significant difference in the occurrence of human lung cancer between residents of urban and non-urban areas—some components of PPOM might contribute to the difference;

(2) Several of the polycyclic hydrocarbons known to exist in the urban air are animal carcinogens, although they have not been proven to be human carcinogens at observed ambient atmospheric concentrations;

(3) Prolonged occupational exposures to environmental mixtures containing high concentrations of PPOM have caused human cancer;

(4) PPOM found in urban atmospheres is primarily of anthropogenic origin and is produced by incomplete combustion of materials containing hydrogen and carbon;

(5) Particulate control technology currently available will be at least partially effective in the control of PPOM from point sources; however, specific control techniques for PPOM have not been developed;

(6) There is no conclusive evidence that control of BaP will result in a reduction in the occurrence of human lung cancer;

(7) Suitable rapid and reliable PPOM test methods for ambient air, stationary, and mobile sources are not currently available;

(8) Current knowledge and available data are inadequate at this time to establish criteria which might be used as a basis for standards and control strategies; and

(9) Available evidence suggests that design and performance standards, and local ordinances, would be the logical mechanisms for control.

*Question 4c.* An analysis of the data and conclusions pertinent to the scientific basis of the national ambient air quality standards contained in the following NAS reports:

(c) National Academy of Sciences—National Research Council, Guides for short-term exposures of the public to air pollutants. Washington, D.C., 1971.

Response. An analysis of the data and conclusions pertinent to the scientific basis of the national ambient air quality standards contained in "Guides for Short-term Exposures of the Public to Air Pollutants" and prepared by the NRC of NAS.

Guides prepared to date include the following:

1. Basis for Establishing Guides for Short-term Exposures of the Public to Air Pollutants.

2. Guides for Short-term Exposures of the Public to Air Pollutants. I. Guide for Oxides of Nitrogen.

3. Guides for Short-term Exposures of the Public to Air Pollutants. II. Guides for Hydrogen Chloride.

4. Guides for Short-term Exposures of the Public to Air Pollutants. III. Guide for Hydrogen Fluoride.

5. Guides for Short-term Exposures of the Public to Air Pollutants. IV. Guide for Ammonia.

6. Guides for Short-term Exposures of the Public to Air Pollutants. VI. Guide for Carbon Monoxide.

7. Guides for Short-term Exposures of the Public to Air Pollutants. VIII. Guide for Chlorine.

From this group of seven documents, only three relate in any way to existing primary quality standards. These are the initial background documents and the guides for  $\text{NO}_2$  and CO. Each of the three is considered individually below.

#### A. Basis for Establishing Guides for Short-term Exposures of the Public to Air Pollutants

This document discusses the differences between short-term exposure standards for predictable and for unpredictable events. In the case of predictable exposures, the philosophy developed was that although some predictable releases of pollutants may require that the general public be exposed briefly to relatively high concentrations, such exposures must not submit the public to any appreciable risk. In this regard the short-term exposure limits during predictable events must be considered as an added restriction to the 24-hour standard just as the 24-hour standard is an added restriction to the annual standard.

Guides for unpredictable short-term exposure relate to emergency or accidental situations and therefore have no relevance to ambient air quality standards.

#### B. Guides for Oxides of Nitrogen

Short-term public limits recommended were as follows:

10 minutes, 1.0 ppm (1880  $\mu\text{g}/\text{m}^3$ )

30 minutes, 1.0 ppm

60 minutes, 1.0 ppm

5 hr/day, 3-4 days/mo., 0.5 ppm (940  $\mu\text{g}/\text{m}^3$ )

1 hr/day/yr, 1.0 ppm (1880  $\mu\text{g}/\text{m}^3$ )

The guide emphasizes that in all instances 1.0 ppm (1880  $\mu\text{g}/\text{m}^3$ ) is a "ceiling" value which should never be exceeded.

These guides were based largely on studies that demonstrated lipoperoxidation in rats exposed to 1 ppm (1880  $\mu\text{g}/\text{m}^3$ )  $\text{NO}_2$  for four hours,<sup>1</sup> and alterations in mast-cell morphology that were observed in rat lung tissue after exposure to 1.0 ppm (1880  $\mu\text{g}/\text{m}^3$ )  $\text{NO}_2$  for one hour or to 0.5 ppm (940  $\mu\text{g}/\text{m}^3$ )  $\text{NO}_2$  for four hours.<sup>2</sup> The morphological alterations were reversible within 24-27 hours.

The conclusion reached after reviewing these reports was that the morphologic study demonstrated that, at least in animals, exposure to 1.0 ppm (1880  $\mu\text{g}/\text{m}^3$ )

<sup>1</sup> Thomas, H. J., Mueller, P. K., and Lyman, L. L. Lipoperoxidation of Lung Lipids in Rats Exposed to Nitrogen Dioxide. *Science*: 159, 532-534, Feb. 2, 1968.

<sup>2</sup> Thomas, H. V., Mueller, P. K. and Wright, R. Response of Rat Lung Mast Cells to Nitrogen Dioxide Inhalation. *Air Poll. Cont. Assoc. J.* 17: 33-35, January 1967.

for one hour or 0.5 ppm (940  $\mu\text{g}/\text{m}^3$ ) for four hours produces no irreversible adverse effects, but that such effects are produced by exposures to 1.0 ppm (1880  $\mu\text{g}/\text{m}^3$ ) if they extend much beyond one hour in length.

The authors of this document acknowledge that the levels indicated represent only "best judgment" estimates due to the lack of critical information.

The shortcomings in the data available relative to short-term standards pertain primarily to (1) the lack of human data, (2) the difficulties in extrapolating from animals to humans, and (3) the fact that the animal studies were conducted on healthy rather than susceptible subjects.

These short-term standards are relevant to the primary ambient air quality standard for nitrogen oxides only in the fact that no 24-hour national standard exists. A relatively strong case is made for the one hour maximum exposure of 1.0 ppm (1880  $\mu\text{g}/\text{m}^3$ ) as an absolute ceiling. This is compatible with the national primary ambient air quality standard. When the annual average standard is related by an air quality model to an hourly guideline not to be exceeded more than once yearly, one sees that the current standard is equivalent to 1400  $\mu\text{g}/\text{m}^3$  for one hour.

### C. Guide for Carbon Monoxide

Short-term public limits recommended were as follows:

- 10 minutes, 90 ppm (103  $\text{mg}/\text{m}^3$ )
- 30 minutes, 35 ppm (40  $\text{mg}/\text{m}^3$ )
- 60 minutes, 25 ppm (29  $\text{mg}/\text{m}^3$ )
- 4-5, hr/day, 3-4 day/mo, 15 ppm (17  $\text{mg}/\text{m}^3$ )

These are time weighted averages but excursions above the recommended levels are limited to a factor of 1.5. The recommendations are designed to prevent COHb levels from exceeding about 2% in non-smoking persons engaged in light work and in no instance should significantly exceed 3% even in individuals engaged in heavy physical exercise.

These recommendations were based primarily on studies which reported significant myocardial changes in patients with elevations of COHb about 6%<sup>2</sup> and decreased tolerance to exercise in angina patients exposed to sufficient CO to produce COHb of 3-5%.<sup>3</sup> The study of angina patients, conducted in-house by the Clinical Studies Branch of the Human Studies Laboratory of the National Environmental Research Center, N.C., has now been replicated and verified by another non-government investigator.<sup>4</sup>

There is consistency between the recommendations for short-term limits and the national ambient air quality standards, since both are designed to prevent COHb levels in non-smokers from significantly exceeding 2%, and both depend on the same studies for strongest scientific support. There is a discrepancy in the one hour maximum exposure recommendations, however. This is

- Short-term public limit, 25 ppm ; 1 hour
- National Air Quality Standard, 35 ppm ; 1 hour

The discrepancy derives from the fact that the short-term limit was designed to prevent elevations of COHb much above 2% in persons engaged in light exercise; whereas the effects assessment preceding the establishment of air quality standard did not consider the influence of exercise. It is not consistent for the short-term limit to be more stringent than the ambient air quality standard and the most logical solution might be to prevent COHb from exceeding 2% in individuals engaged intermittently in light exercise.

*Question 5.* An analysis of the data and conclusions pertinent to the scientific basis of the national primary ambient air quality standards contained in "Air Quality Criteria and Guides for Urban Air Pollutants", World Health Organization technical report series, No. 506. World Health Organization, Geneva, 1972.

Response. In general, the Environmental Protection Agency (EPA) sup-

<sup>2</sup> Ayers, S. M., Giannini, S., Jr., and Mueller, H. Myocardial and Systemic Responses to Carboxyhemoglobin, New York Acad. Sciences, Annals 174, Article 1:268-293, Oct. 5, 1970.

<sup>3</sup> Anderson, E. W., Andelman, R. J., Stranch, J., Fortuin, N. J., and Knelson, J. H. Effect of Low-level Carbon Monoxide Exposure on Onset and Duration of Angina Pectoris—A Study in 10 Patients with Ischemic Heart Disease. Ann. Internal. Med. 79: 46-50, 1973.

<sup>4</sup> Aronow, W. Presented at the Air Pollution Health Effects Investigators Meeting, California Air Resources Board, Sacramento, Calif., May 9, 1973. Earlier Study Published in Ann. Intern. Med. 77: 669, 1972.

ports and agrees with the philosophy expressed in the afore-mentioned document. EPA is working closely with World Health Organization (WHO) in the development of air quality criteria documents, in air pollution monitoring and in mounting a coordinated air pollution research program. WHO recognizes that the United States of America is a highly industrialized nation which experiences remarkably extreme variations in the meteorological parameters. These profoundly influence the ambient concentrations of primary air pollutants and the atmospheric formation of secondary air pollutants including ozone, nitrogen dioxide and fine particulate fractions such as acid mists, sulfates and nitrates. These variations immensely complicate the development and implementation of air pollution control programs. EPA recognizes that different nations are bound by different legislative mandates and different national priorities. Thus heterogeneous national approaches to achieving wholesome ambient air quality are expected. National air quality goals, which are largely based upon admittedly limited scientific studies, are remarkably similar. Major differences are noted however, when one compares the time frame for achievement of these goals. The United States has established an extremely rigorous air pollution control schedule. On the other hand, though WHO air quality goals are generally as stringent as the primary ambient air quality standards of the United States, WHO specifies no achievement schedule.

WHO and EPA both recognize that ambient levels of sulfur oxides, suspended particulates, carbon monoxide and photochemical oxidants should be controlled to protect public health. WHO, in 1970, did not feel that sufficient health related data existed to justify establishing ambient air quality standards for nitrogen oxides. EPA and a number of other nations felt that prudence demanded that ambient nitrogen dioxide air quality standards be established to protect public health. Both WHO and EPA advocate a vigorous, comprehensive research program to ascertain the dose-response relationships linking nitrogen dioxide exposures to adverse health effects. Moreover, both WHO and EPA are concerned about the possible adverse effects upon human health and welfare of aerosols containing suspended particulate nitrates which are formed from gaseous nitrogen oxides.

EPA agrees with WHO that the effects of ambient exposures to sulfur oxides and suspended particulates can be considered together. Indeed sulfur dioxide can be transformed into toxic aerosols which are measured as part of the particulate burden. Since the WHO report, EPA has conducted and reported to the Committee further health studies, which indicate that the present ambient air quality standards for sulfur dioxide and total suspended particulate matter should be supplemented by the control of fine particulates including suspended particulate sulfates. EPA is conducting the research necessary to support the regulation of these pollutants. EPA differs with WHO in its interpretation of the effects of short-term peak exposures to sulfur dioxide and total suspended particulates. WHO advocates more stringent controls. EPA believes that the adverse effects occurring at low levels of these pollutants which are lower than the current United States primary ambient air quality standards are probably best attributed to acid aerosols and fine particulates.

In general EPA agrees with the WHO assessment of the effects of carbon monoxide exposure. EPA has reported to the Committee additional studies linking carbon monoxide exposures to the aggravation of manifestation of atherosclerotic heart disease. EPA believes the current United States primary ambient air quality standard for carbon monoxide to be stringent and fully protective of the public health.

EPA generally agrees with the WHO assessment of the adverse effects on public health which follow oxidant exposures. In addition, EPA has developed important dose-response information linking photochemical oxidant exposures to irritation of the eye and respiratory tract. EPA, like WHO, is concerned about the radiomimetic effects of ozone. Both organizations support a vigorous research program to delineate the health benefits which will be achieved by meeting the ambient air quality standards.

EPA and WHO recognize that the health costs of air pollution exposures cannot be accurately estimated without acceleration of national and international research programs. Both organizations also recognize the need to quantitate adverse health effects of short-term and long-term exposures to elevated concentrations of urban air pollutants. Subsequent to the 1970 publication, WHO desig-

nated the EPA federal reference methods for measurement of sulfur dioxide and suspended particulate matter as the international methods of comparison.

In summary, the EPA and WHO positions with respect to the common urban air pollutants is one of general agreement. The major difference between the two is the demanding time frame in which the United States standards must be met.

*Question 6.* An analysis of the relationship between national primary ambient air quality standards and occupational safety and health criteria and standards for pollutants subject to ambient standards under the Clean Air Act.

Response. This problem has been well reviewed in detail recently by H. E. Stokinger of the National Institute of Occupational Safety and Health (Ann. Rev. Pharmacol. 12: 407-422, 1972). The following general comment is quoted from this paper:

"The working population is drawn, by and large, from essentially normal, healthy, adult individuals, certainly those who are to be exposed to potentially noxious fumes, dusts, mists, and vapors. This is far from true of the community dweller in the home. The urban dweller is a composite of all ages, with all the ranges in susceptibilities of the very young and the indispositions and debilities of the very old, including in particular, as far as air pollutants are concerned, diseases of the cardiorespiratory system, chronic obstructive pulmonary disease, chronic bronchitis, emphysema, and other related diseases associated with aging. Such individuals are not in the work force because of age of infirmity. Second, separated out from the work force likely to be exposed to respiratory irritants by virtue of job selection, are the intrinsic and extrinsic asthmatics, for whom the susceptibility factor is estimated to be 5- to 10-fold, depending on the pollutant. Clearly, this and similar job-selective processes make for a worker group with far greater capacity for exposure without response to air pollutants than the population at large. The factors expressing the differential susceptibility between diseased and healthy populations vary widely according to extent of the disease and age of the diseased. The factor for age alone is widely variant."

Certain other factors may also enter into differences between ambient and industrial standards. Pollutants in outdoor air are always accompanied by other pollutants. In some cases these may interact, producing effects not seen where the substances are present alone. An example is the absorption of gases on particles. This leads to the practice of regarding some pollutants as indices of complex mixtures in ambient air rather than as specific substances acting alone. This is true of particulates, sulfur oxides, and oxidants. This practice is not usually appropriate in industrial settings.

Another important difference between ambient and occupational exposures is that of time. Exposures in industry are always intermittent, and for the most part uniform, while ambient exposures are frequently continuous, and usually variable in intensity.

Industrial and ambient standards share a common base in criteria from laboratory experiments. Both employ epidemiologic criteria obtained from field studies. Since these must differ, particularly in exposure time patterns, the study designs are not normally identical.

Of the six existing primary air quality standards only four can be compared with industrial standards. No industrial standards exist for particulates or hydrocarbons except as individual chemical substances. Of the 4 remaining pairs, oxidant (ozone) standards are nearly the same. This appears to be due to the fact that ozone effects are not presently known to differ markedly between workers and survey groups in the same general population. More extensive general population studies may alter this opinion. The fivefold difference between the ambient and occupational standards for carbon monoxide is principally related to the increased susceptibility of those with cardiovascular illness rather than to anything which reduces oxygen transport. The considerable differences between the two standards for sulfur and nitrogen oxides are due to several of the factors such as: sensitivity of several groups in the population to these substances, particularly those with cardiopulmonary illness, admixtures with other pollutants found in the ambient air and not found in the occupational exposures, and exposure duration.

*Question 7.* An analysis of the relationship between the national primary ambient air quality standards for sulfur oxides and particulates and NATO's Criteria Document, "Air Pollution: Air Quality Criteria for Sulfur Oxides," November 1971.

**Response:** The NATO "Air Quality Criteria for Sulfur Oxides" was based on the U.S. document "Air Quality Criteria for Sulfur Oxides." However, new information, both U.S. and foreign literature, not contained in the U.S. Document was examined. In general, the new material and reinterpretations of existing data add support for what has been reported in the U.S. Criteria document.

Three<sup>1,2,3</sup> of the recent papers cited in the NATO document state that SO<sub>2</sub> correlates better than particulate concentration with an effect. Glasser and Greenburg<sup>1</sup> found mortality to be more closely correlated to SO<sub>2</sub> concentration than to smoke shade. Watanabe and Kaneko<sup>2</sup> found mortality to correlate more closely with SO<sub>2</sub> than suspended particulate. A British report<sup>3</sup> indicates that disability from bronchitis correlates more closely with SO<sub>2</sub> level than with smoke. To the contrary, Belanger<sup>4</sup> found a closer correlation between soiling index and hospital admissions for respiratory problems than for SO<sub>2</sub> or suspended particulate levels.

This serves to point out again that any one pollutant measured in ambient air does not necessarily represent the total physiological burden imposed by the complex pollutant matrix in urban air.

Hodgson<sup>5</sup> and Glasser and Greenburg<sup>1</sup> have studied mortality in New York City. The latter estimated that the difference in mean number of daily deaths on days with 524  $\mu\text{g}/\text{m}^3$  (0.20 ppm) SO<sub>2</sub> or less compared to days with 1048  $\mu\text{g}/\text{m}^3$  (0.40 ppm) SO<sub>2</sub> was 10 to 20 deaths, that is a one hundred percent difference. This indicated that deaths are occurring at pollution levels not far above the level of the primary standard—365  $\mu\text{g}/\text{m}^3$  (0.14 ppm) 24-hour average.

Watanabe and Kaneko<sup>2</sup> have also studied mortality and air pollution. They conclude, based on a 5-year study in Osaka, Japan, that an SO<sub>2</sub> concentration over 262  $\mu\text{g}/\text{m}^3$  or 0.1 ppm (3-day running average) should be regarded as an index of unhealthy atmospheric pollution in a city area. Particulate levels were also quite high (300  $\mu\text{g}/\text{m}^3$  annual average).

The NATO document also reports a study in London where 24-hour average SO<sub>2</sub> or particulate matter levels of 250  $\mu\text{g}/\text{m}^3$  (0.1 ppm) or 0.2 mg/m<sup>3</sup>, respectively, were related to increased absenteeism of factory and office workers.<sup>6</sup>

The data as presented in the NATO document from the study of Watanabe and Kaneko<sup>2</sup> and the London Study<sup>6</sup> would indicate that these criteria—262  $\mu\text{g}/\text{m}^3$  SO<sub>2</sub>, 3-day average, as index of unhealthy air, or 250  $\mu\text{g}/\text{m}^3$  SO<sub>2</sub> 24-hour average associated with absenteeism—are indications of need for reassessment of the effects of repeated short-term peak exposures and their implications for standard setting. EPA is reassessing this problem.

The particulate effect reported in the London study of absenteeism<sup>6</sup>—250  $\mu\text{g}/\text{m}^3$ —indicates additional support for the U.S. primary particulate standard.

**Question 8.** An analysis of the relationship between national primary ambient air quality standards and the ambient standards adopted by the State of California.

**Response.** The Clean Air Act of 1970, as amended, required a national primary ambient air quality standard to be promulgated by the Administrator for each air pollutant for which air quality criteria had been issued prior to its enactment. The required national primary standards were defined as, "ambient air quality standards the attainment and maintenance of which in the judgment of the Administrator, based on such criteria and allowing an adequate margin of safety, are requisite to protect the public health." National secondary ambient air quality standards were to be set to protect the public welfare. Under this law each state is required to adopt plans to implement all national primary ambient air quality standards (or revisions thereof) within nine months of their promulgation. Each state is further required to attain and maintain the

<sup>1</sup> Glasser, M., and L. Greenburg. Air Pollution, Mortality, and Weather. Arch. Environ. Health Vol. 22:334-343, March 1971, pp. 334-343.

<sup>2</sup> Watanabe, H., and F. Kaneko. Excess Death Study of Air Pollution. In: Proceedings of the Second International Clean Air Congress. Englung, H. M. and W. T. Reery (eds.). New York, Academic Press, 1971, pp. 199-201. Washington, D.C. (Dec. 6-11, 1970).

<sup>3</sup> Air Pollution and Health. London, Pitman Medical and Scientific Publishing Co., 1970, pp. 30-31, 35-38.

<sup>4</sup> Belanger, W. E. A Study of the Effects of Air Pollution on Hospital Admissions. Presented at the meeting of the Air Pollution Committee of the Philadelphia County Medical Society, October 27, 1969, Philadelphia, Pa.

<sup>5</sup> Hodgson, Thomas, A., Jr. Short-Term Effects of Air Pollution on Mortality in New York City. Environ. Sci. Technol. 4(7):589-597, July 1970.

<sup>6</sup> Air Pollution and Health. London, Pitman Medical and Scientific Publishing Co., 1970, p. 31.

primary standards no later than three years after the State's implementation plan is approved by the Environmental Protection Agency. Federal standards other than those based on annual averages or annual geometric means, are not to be exceeded more than once a year.

The California Health and Safety Code required that the State Department of Public Health publish air quality standards and determine maximum allowable standards of emissions of exhaust contaminants from motor vehicles before February 1, 1960. The California air quality standards were to reflect the relationship of air pollution to damage to vegetation and interference with visibility as well as the public health. The law does not require that a margin of safety be provided. Explicit implementation plans were not required as the standards were to be used as goals or guides.

Both the National Primary and the California ambient air quality standards are shown in Table 1 by pollutant.

**Photochemical Oxidants.**—The two standards are comparable but the Federal standard is somewhat more stringent (160 vs. 200  $\mu\text{g}/\text{m}^3$ ). The following condition was specified in the recommended air quality standards for California: "The standard will be said to be exceeded . . . when 0.1 ppm or more of oxidant, including ozone, occurs seven days or more in any 90 consecutive days or 3 or more consecutive days."

**Carbon Monoxide.**—The Federal standards are those levels which would provide an equilibrium concentration of blood carboxyhemoglobin (COHb) near 1.7% after breathing the maximum permissible levels for one and eight hours respectively. The California one and twelve hour standards are both somewhat higher, being designed to produce COHb levels of 2 to 2.5% near equilibrium. A twelve hour rather than an eight hour averaging time was chosen to include both daily traffic peaks.

**Nitrogen Dioxide.**—The Federal annual average is based upon epidemiologic and toxicologic evidence which was not available when the California standard was set. The California one hour average was initially based upon visibility and subsequently upon toxicologic data as well.

**Sulfur Dioxide.**—The federal annual average was based upon epidemiologic evidence; the Federal 24 hour standard was derived by application of a mathematical model to empirical data given the annual average as a constraint. California does not have an annual average and the 24 hour average is much lower than the comparable Federal average (105 vs. 365  $\mu\text{g}/\text{m}^3$ ). The California 24-hour average was set somewhat arbitrarily. Sulfur dioxide pollution is not a serious problem in California as measured levels are generally quite low.

**Total Suspended Particulates.**—The annual standards are comparable as the California standard is the same as the national secondary standard. The Federal 24 hour average (260  $\text{g}/\text{m}^3$ ) was derived mathematically in a similar fashion to the 24 hour sulfur dioxide standard but is consistent with epidemiologic data. The 24 hour California standard is based upon visibility. The following condition was specified in the recommended air quality standard for California: "This standard is said to be exceeded when prevailing visibility of 7.5 miles or less occurs 7 or more days in 90 consecutive days or 3 or more consecutive days."

**Hydrocarbons.**—The Federal standard is based upon aerometric comparisons of hydrocarbons to oxidants. The standard is for the control of oxidants and not based upon health effects. California did not establish a hydrocarbon standard because the consensus was that there was no health basis for such a standard and it was not required to control photochemical oxidants since they already had a photochemical oxidant standard.

In summary, national primary ambient air quality standards must be determined by judgment, must explicitly protect public health, must be implemented and enforced, and must provide for an adequate margin of safety. Conversely, California air quality standards must include both health and welfare effects, are established as goals or guides, and do not explicitly require a margin of safety.

TABLE 1.—PRESENT U.S. NATIONAL PRIMARY AMBIENT AIR QUALITY STANDARDS AND CALIFORNIA AMBIENT AIR STANDARDS\*

Pollutant and averaging time	Ambient air standards	
	National primary	California
Photochemical oxidants (corrected for ND <sub>2</sub> ): 1 hr**	160 $\mu\text{g}/\text{m}^3$ † (0.08 p.p.m.)	200 $\mu\text{g}/\text{m}^3$ (0.10 p.p.m.)
Carbon monoxide:		
12 hrs	None	11 mg/m <sup>3</sup> (10 p.p.m.)
8 hrs	10 mg/m <sup>3</sup> (9 p.p.m.)	None
1 hr	40 mg/m <sup>3</sup> (35 p.p.m.)	46 mg/m <sup>3</sup> (40 p.p.m.)
Nitrogen dioxide:		
Annual average	100 $\mu\text{g}/\text{m}^3$ (0.05 p.p.m.)	None
1 hr	None	470 $\mu\text{g}/\text{m}^3$ (0.25 p.p.m.)
Sulfur dioxide:		
Annual average	80 $\mu\text{g}/\text{m}^3$ (0.03 p.p.m.)	None
24 hrs	365 $\mu\text{g}/\text{m}^3$ (0.14 p.p.m.)	105 $\mu\text{g}/\text{m}^3$ (0.04 p.p.m.)
Total suspended particulates:		
Annual geometric mean	75 $\mu\text{g}/\text{m}^3$	60 $\mu\text{g}/\text{m}^3$
24 hrs	260 $\mu\text{g}/\text{m}^3$	100 $\mu\text{g}/\text{m}^3$
Hydrocarbons (corrected for methane): 3 hrs (6 to 9 a.m.)	160 $\mu\text{g}/\text{m}^3$ (0.24 p.p.m.)	None

\*Modified from table 1, J. Env. Sci, XIV(6):11, 1971.

\*\*Federal standards, other than those based on annual averages or annual geometric means, are not to be exceeded more than once a year.

†Corrected for SO<sub>2</sub> in addition to NO<sub>2</sub>.

**Question 9.** An analysis of the relationship between national primary ambient air quality standards and ambient standards adopted by other countries, including Japan.

Response. Legislative measures for the control of air pollution have recently been established or are now being enacted in many nations. National ambient air quality standards are established only in those nations where legislation mandates this action. Some nations choose to rely exclusively on emissions standards rather than promulgating ambient air quality standards based upon the need to protect human health.

The World Health Organization (WHO) last published a compilation of national air quality standards in 1971 and this document is appended (EP/71.3 Air Quality Criteria and Guides). WHO has scheduled another review of national air quality standards in Geneva on 10-14 December 1973. The tentative agenda for this review entitled "Inter-Regional Symposium on the Use of Air Quality Criteria in National Air Pollution Control Programs" is also attached. In preparation for this symposium, WHO has requested member nations to furnish information on their enabling legislation, ambient air quality standards and control programs. EPA and WHO are together supporting the collation of this information and publication of a summary report which will be provided to the Subcommittee as soon as it becomes available.

To assist the Subcommittee, EPA has summarized the status of existing and pending ambient air quality standards for the United States of America, the World Health Organization, Israel, Canada, Mexico, Japan, United Kingdom and the Union of Soviet Socialist Republics (Table-1). Note that most nations which choose to promulgate ambient air quality standards focus on the same set of pollutants, namely carbon monoxide, sulfur oxides and particulate matter. Ambient air quality standards for nitrogen dioxide have been promulgated by the United States, Israel, Japan, and the USSR. Photochemical oxidants, which are elevated only when their precursor pollutants, reactive hydrocarbon and oxides of nitrogen, react under proper meteorological conditions, are specifically controlled only in the United States of America, Israel, Canada and Japan.

The Committee should note that Mexico, has not adopted any ambient air quality standards. Mexico, like the United Kingdom, believes that wholesome air quality can be achieved by a combination of emissions controls, meteorological conditions conducive to good dispersion and land use planning. A number of other industrialized countries are now following this same course. On the other hand, many less developed countries have not promulgated any air pollution control measures. In these cases, economic development and environmental health problems other than air pollution are prime considerations.

The national primary ambient air quality standards of the United States are, in general, no more stringent than those of the other survey nations as is shown in Table 9-2. However, no other nation has set as restrictive a time schedule for meeting ambient air quality standards. Hence, their sometimes more stringent standards might be considered somewhat more distant national goals. There is little or no reason to believe that the international community has judged the established United States standards as too stringent.

Tables 9-3 through 9-8 were prepared from initial compilations made by a contractor to EPA who is compiling the world's air quality management standards. Minor variations in the numbers reported from those in other sources may be due to the use of different standard conditions of temperature and pressure when converting between parts per million (ppm) and micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ).

Reviews of air quality standards in general show low values (most-stringent standards) in Eastern European countries. This is attributed to basing these standards on sensitive neurophysiological measurements. The changes noted are considered adaptation to changes in the subjects environment (from the pollutant being tested) but are not necessarily thought to be detrimental to health.

Though other nations consider these neurophysiological effects as criteria in developing standards, considerably more weight is placed on epidemiological studies where effects are also supported by toxicological findings.

TABLE 9-1.—NATIONAL PRIMARY AMBIENT AIR QUALITY STANDARDS

Country	Ambient air quality standard					
	Nitrogen oxides	Photochemical oxidants	Carbon monoxide	Sulfur oxides	Particulate matter	Other
United States.....	Yes.....	Yes.....	Yes.....	Yes.....	Yes.....	Yes.....
WHO.....	No.....	Yes.....	Yes.....	Yes.....	Yes.....	None.....
Israel.....	Yes <sup>1</sup> .....	Yes <sup>1</sup> .....	Yes <sup>1</sup> .....	Yes.....	Yes.....	Yes. <sup>1</sup> .....
Canada.....	No.....	Yes.....	Yes.....	Yes.....	Yes.....	No.....
Japan.....	Yes.....	Yes.....	Yes.....	Yes.....	Yes.....	No.....
U.S.S.R.....	Yes.....	No.....	Yes.....	Yes.....	Yes.....	Yes.....
United Kingdom.....	No.....	No.....	No.....	No.....	No.....	No.....
Mexico.....	No.....	No.....	No.....	No.....	No.....	No.....

<sup>1</sup> Denotes a pending standard.

TABLE 9-2.—RELATIONSHIP BETWEEN NATIONAL PRIMARY AMBIENT AIR QUALITY STANDARDS IN UNITED STATES AND OTHER SELECTED STANDARDS<sup>1</sup>

Country	Primary ambient air quality standards				
	Nitrogen oxides	Photochemical oxidants	Carbon monoxide	Sulfur dioxide	Particulate matter
United States.....	Baseline.....	Baseline.....	Baseline.....	Baseline.....	Baseline.....
WHO.....	No standard.....	More stringent.....	do.....	More stringent.....	More stringent.....
Israel.....	(?).....	(?).....	(?).....	do.....	Do.....
Canada.....	No standard.....	More stringent.....	More stringent.....	do.....	Do.....
Japan.....	More stringent.....	do.....	Less stringent.....	do.....	Do.....
U.S.S.R.....	do.....	No standard.....	More stringent.....	do.....	Do.....

<sup>1</sup> Stringency comparison is for standards of comparable averaging times. With respect to achievement schedules, no nation has a more stringent program than the United States.

<sup>2</sup> Denotes a pending standard.

TABLE 9-3.—AIR QUALITY STANDARDS FOR SULFUR DIOXIDE

Country	Concentration		Averaging time	Remarks
	P.p.m.	ug/m <sup>3</sup>		
United States (primary)	0.14	365	24 hr	Not to be exceeded more than 1 time per year.
	0.03	80	Annual mean	
Belgium	0.06	150	24 hr	Only for zones exceeding 0.15 mg/m <sup>3</sup> /yr (annual average).
Bulgaria	0.2	500	30 min	Not to be exceeded.
	0.02	50	24 hr	
Canada (objectives)	0 to 0.17	0 to 450	1 hr	Desirable.
	0 to 0.06	0 to 150	24 hr	Do.
	0 to 0.01	0 to 30	Annual average	Do.
	0.17 to 0.34	450 to 900	1 hr	Acceptable.
	0.06 to 0.1	150 to 300	24 hr	Do.
	0.01 to 0.02	30 to 60	Annual average	Do.
Czechoslovakia	0.2	500	30 min	Not to be exceeded.
	0.06	150	24 hr	
Federal Republic of Germany	0.3	750	30 min	Not to be exceeded more than 1 time in 2 hr.
	0.15	400	do	Mean of set of 30 min random samples.
Finland	0.25	625	do	Not to be exceeded.
	0.10	250	24 hr	
	0.05	125	1 mo	
France	0.4	1,000	24 hr	Alert.
	0.3	7,500	do	Not to be exceeded more than 8 days (running (97.8 percent/yr.) Concurrent standard of 0.35 mg/m <sup>3</sup> 24 hr. for particulate.
German Democratic Republic	0.2	500	15 min	Not to be exceeded.
	0.06	150	24 hr	
Israel (tentative)	0.3	750	30 min	Not to be exceeded more than 1 percent of the time per year.
	0.1	250	24 hr	
Italy (tentative)	0.30	800	30 min	Not to be exceeded more than once in 8 hr.
	0.15	400	24 hr	
Japan	0.1	260	1 hr	
	0.04	100	24 hr	
Netherlands (nationwide with low smoke)	0.03	75	24 hr	50th percentile: of cumulative frequency distribution.
	0.1	250	24 hr	98th percentile: of consecutive 24 hr. samples.
Transitory limit if—				
Smoke < 0.03 <sup>1</sup>	0.06	150		50th percentile: of consecutive 24 hr. samples.
Smoke < 0.09	0.13	350		98th percentile: of consecutive 24 hr. samples.
Smoke > 0.04	0.05	125		50th percentile: of consecutive 24 hr. samples.
Smoke > 0.12	0.11	275		98th percentile: of consecutive 24 hr. samples.
Poland	0.34	900	20 min	Not to be exceeded.
	0.13	350	24 hr	
	0.1	250	20 min	Not to be exceeded in specified zones.
	0.03	75	24 hr	
Romania	0.28	750	30 min	Not to be exceeded.
	0.1	250	24 hr	
Sweden	0.25	720	30 min	Not to be exceeded more than 15 times per month.
	0.1	290	24 hr	Not to be exceeded more than 1 time per month.
	0.05	140	1 mo	Not to be exceeded.
Switzerland (summer) (March-October); (winter) (November-February)	0.3	750	30 min	Not to be exceeded.
	0.2	500	24 hr	
	0.5	1,250	30 min	
	0.3	750	24 hr	
Turkey	0.06	150	24 hr	Residential.
	0.1	30	24 hr	Industrial.
U.S.S.R.	0.2	50	30 min	Not to be exceeded.
	0.02	50	24 hr	
Yugoslavia	0.2	500	30 min	
	0.06	150	24 hr	

<sup>1</sup> Smoke measured by OECD method using reflectance units.

TABLE 9-4.—AIR QUALITY STANDARDS FOR PARTICULATE MATTER

Country	Concentration $\mu\text{g}/\text{m}^3$	Averaging time	Remarks
United States.....	260	24 hr.....	Not to be exceeded more than 1 time per year.
Primary.....	75	Annual mean (geometric).	
Bulgaria.....	500	30 min.....	Maximum on 1 occasion.
Nontoxic dust.....	150	24 hr.....	
Soot.....	150	30 min.....	
.....	50	24 hr.....	
Canada.....	0-60	Annual mean (geometric).	Desirable.
Objectives.....	0-120	24 hr.....	Acceptable.
.....	60-70	Annual mean (geometric).	Do.
Czechoslovakia.....	500	30 min.....	Maximum permissible.
Dust.....	150	24 hr.....	Do.
Soot.....	150	30 min.....	Do.
.....	50	24 hr.....	Do.
Federal Republic of Germany.....	480	30 min.....	Basis for calculating stack height.
Finland.....	500	2 hr.....	Nor more than half the samples to exceed in 1 mo.—Residential.
.....	150	24 hr.....	Do.
France.....	350	24 hr.....	Not to be exceeded on more than 8 consecutive days.
German Democratic Republic.....	500	15 min.....	Not to be exceeded.
.....	150	24 hr.....	Do.
Israel.....	500	30 min.....	Not to be exceeded more than 1 percent of the time.
Tentative.....	150	24 hr.....	Do.
Soot.....	300	30 min.....	Do.
.....	100	24 hr.....	Do.
Italy.....	1,000	30 min.....	Not to be exceeded more than once in 8 hr.
Tentative.....	750	2 hr.....	Do.
.....	300	24 hr.....	Do.
Japan.....	200	24 hr.....	Not apply to special industrial areas.
.....	100	1 hr.....	Do.
Poland.....	600	20 min.....	Residential.
.....	200	24 hr.....	Do.
.....	200	20 min.....	Special zone.
.....	75	24 hr.....	Do.
Romania.....	500	30 min.....	
.....	150	24 hr.....	
Sweden.....	100	1 hr.....	Not to be exceeded more than 1 time per month.
Turkey.....	300	24 hr.....	Industrial.
.....	150	24 hr.....	Residential.
U.S.S.R.:			
Nontoxic dust.....	500	30 min.....	Not to be exceeded.
.....	150	24 hr.....	Do.
Soot.....	150	30 min.....	Do.
.....	50	24 hr.....	Do.

TABLE 9-5.—AIR QUALITY STANDARDS FOR CARBON MONOXIDE

Country	Concentration		Averaging time	Remarks
	p.p.m.	$\mu\text{g}/\text{m}^3$		
United States.....	35	40	1 hr	Not to be exceeded more than 1 time per year.
Bulgaria.....	9	10	8 hr	
	2.4	3	30 min	
Canada (objectives).....	0.8	1	24 hr	Desirable.
	0 to 13	0 to 15	1 hr	Do.
Czechoslovakia.....	0 to 5	0 to 6	8 hr	Acceptable.
	13 to 30	15 to 35	1 hr	Do.
Federal Republic of Germany.....	5 to 13	6 to 15	8 hr	
	4.8	6	30 min	
Israel.....	0.8	1	24 hr	
	44	50	30 min	Not to be exceeded.
Italy.....	35	40	1 hr	
	9	10	12 hr	
Japan.....	15	17	30 min	
	5	6	24 hr	Not to be exceeded more than 1 percent of days in year.
Romania.....	50	55	30 min	Not to be exceeded more than once in 8 hr.
	20	23	8 hr	
U.S.S.R.....	20	23	8 hr	Not apply to roadways for driving or parking.
	10	12	24 hr	
Yugoslavia.....	4.8	6	30 min	
	1.6	2	24 hr	
.....	2.7	3	30 min	Maximum on 1 occasion.
	0.9	1	24 hr	
.....	2.4	3	30 min	
	0.8	1	24 hr	

TABLE 9-6.—AIR QUALITY STANDARDS FOR NITROGEN DIOXIDE

Country	Concentration		Averaging time	Remarks
	p.p.m.	$\mu\text{g}/\text{m}^3$		
United States.....	0.05	100	Annual mean	
Bulgaria.....	0.04	85	Peak (30 min)	Maximum on 1 occasion.
	0.04	85	24 hr	
Czechoslovakia.....	0.15	300	30 min	
	0.05	100	24 hr	
Federal Republic of Germany.....	0.5	1,000	30 min	Mean of set of 30 min sample.
	1.0	2,000	30 min	Not to exceed 1 sample (30 min) in 8 hr.
Israel (tentative).....	0.3	600	30 min	Not to be exceeded more than 1 percent of the time.
	0.1	200	24 hr	
Italy (tentative).....	0.3	500	30 min	Not to be exceeded more than once to 8 hr.
	0.1	200	24 hr	
Japan.....	0.02	38	24 hr	
Romania.....	0.15	300	30 min	
	0.05	100	24 hr	Maximum admissible.
U.S.S.R.....	0.15	300	20 min	
	0.05	100	24 hr	
Yugoslavia.....	0.04	85	30 min	
	0.04	85	24 hr	

TABLE 9-7.—AIR QUALITY STANDARDS FOR PHOTOCHEMICAL OXIDANTS (OXIDANT CALCULATED AS O<sub>3</sub>)

Country	Concentration		Averaging time 000	Remarks
	P.p.m.	$\mu\text{g}/\text{m}^3$		
United States.....	0.08.....	160.....	1 hr.....	Not to be exceeded more than 1 time per year.
Canada.....	0 to 0.05.....	0 to 100.....	1 hr.....	Desirable.
(Objectives).....	0 to 0.015.....	0 to 30.....	24 hr.....	Do.
	0.05 to 0.08.....	100 to 160.....	1 hr.....	Acceptable.
	0.015 to 0.026.....	30 to 50.....	24 hr.....	Do.
	0 to 0.015.....	0 to 30.....	Annual mean.....	Do.
Israel.....	0.15.....	300.....	30 min.....	Not to be exceeded more than 1 percent of the year.
(Tentative).....	0.1.....	200.....	24 hr.....	Do.
(Dzone).....	0.1.....	200.....	30 min.....	Do.
(Dzone).....	0.05.....	100.....	24 hr.....	Do.
Japan.....	0.02.....	38.....	24 hr.....	
Romania (ozone).....	0.05.....	100.....	30 min.....	
(Ozone).....	0.014.....	30.....	24 hr.....	Not to be exceeded.

TABLE 9-8.—AIR QUALITY STANDARDS FOR HYDROCARBONS

Country	Concentration		Averaging time	Remarks
	P.p.m.	$\mu\text{g}/\text{m}^3$		
United States (calculated as methane).....	0.24.....	160.....	3 hr (6 to 9 a.m.).....	Not to be exceeded more than 1 time per year. Nonmethane hydrocarbon calculated as methane.
Italy.....	100.....	350,000.....	30 min.....	Not to be exceeded more than 1 time (30 min) in 8 hr.
(Calculated as hexane).....	50.....	175,000.....	24 hr.....	

**Question 10.** An explanation of the degree to which each national primary ambient air quality standard contains a margin of safety, of the reasons why this margin may differ from one pollutant to another, and the basis for the Agency's judgment as to what represents a reasonable margin of safety for protection of the public health.

Response. Each primary ambient air quality standard<sup>1</sup> must consider a broad range of plausible adverse effects on human health. Our knowledge of the dose effects relationships linking pollutant exposures to each of these effects is admittedly incomplete. Thus, it is not surprising that different groups of scientists will evaluate the scientific evidence linking pollutant exposures to adverse effects in different ways. Our Agency has sought to define an arena in which reasonable men may disagree by making three threshold estimates for each effect that may be reasonably attributed to a given pollutant exposure:

1. A worst case threshold estimate that attributes the adverse effect to the lowest likely pollutant exposure.

2. A least case threshold estimate that attributes the adverse effect to the highest likely pollutant exposure.

3. A best judgment threshold estimate that attributes the adverse effect to the exposure that is most reasonable in view of medical scientists within EPA and EPA's Advisory Committees.

One can examine the lowest best judgment thresholds for each of the pollutants for which a primary ambient air quality standard has been promulgated. These thresholds, their associated safety factors and the range of safety factors associated with the whole array of best judgment thresholds for each pollutant are summarized in an attached table.

In the case of short term exposures involving the sulfur dioxide-suspended sulfate-total suspended particulate complex, we probably have little or no safety factor for the most sensitive adverse health effects. Other standards contain

<sup>1</sup> Except for the hydrocarbon standard.

## SAFETY FACTORS CONTAINED IN PRIMARY AMBIENT AIR QUALITY STANDARDS

Pollutant	Lowest best judgment estimate for an effects threshold	Adverse effect	Standard	Safety factor, percent <sup>1</sup>
Sulfur dioxide	300 to 400 $\mu\text{g}/\text{m}^3$ (short term)	Mortality harvest	365 $\mu\text{g}/\text{m}^3$	None
	51 $\mu\text{g}/\text{m}^3$ (long term)	Increased frequency of acute respiratory disease	80 $\mu\text{g}/\text{m}^3$	14
	8 $\mu\text{g}/\text{m}^3$ (short term)	Increased infections in asthmatics	None	14 to 212
	8 $\mu\text{g}/\text{m}^3$ (long term)	Increased infections in asthmatics	None	None
Suspended sulfates	70 to 250 $\mu\text{g}/\text{m}^3$ (short term)	Aggravation of respiratory diseases	260 $\mu\text{g}/\text{m}^3$	None
Total suspended particulates	100 $\mu\text{g}/\text{m}^3$ (long term)	Increased prevalence in chronic bronchitis	75 $\mu\text{g}/\text{m}^3$	None to 15
Nitrogen dioxide	141 $\mu\text{g}/\text{m}^3$ (long term)	Increased severity of acute respiratory illness	100 $\mu\text{g}/\text{m}^3$	33 to 333
Carbon monoxide	23 $\text{mg}/\text{m}^3$ (8 hr)	Diminished exercise tolerance in heart patients	41	41 to 370
	73 $\text{mg}/\text{m}^3$ (1 hr)		10 $\text{mg}/\text{m}^3$	<sup>2</sup> 130
Photochemical oxidants	200 (short term)	Increased susceptibility to infection	40 $\text{mg}/\text{m}^3$	<sup>3</sup> 82
			160	<sup>3</sup> 182 to 788
				23
				None to 363

<sup>1</sup> Safety factor equals effects threshold minus standard divided by standard times 100.

<sup>2</sup> Safety factors based upon carboxyhemoglobin levels would be 100 percent for the 8-hr. standard with a range of 100 to 400 percent overall best judgment estimates. For the 1-hr. standard the lowest safety factor would be 67 percent with a range of 67 to 400 percent.

<sup>3</sup> Safety factors based upon carboxyhemoglobin levels would be 100 percent for the 8-hr. standard with a range of 100 to 400 percent overall best judgment estimates. For the 1-hr. standard the lowest safety factor would be 67 percent with a range of 67 to 400 percent.

modest safety factors from 14 to 130 percent. The ranges of safety factors for the whole array of best judgment thresholds is much larger, from zero to 589 percent.

It should be emphasized that uniformity of safety factors is not the single most important consideration in the complex standard setting process and that the larger safety factors often reflect greater uncertainties. The Agency feels that the present air quality standards coupled with the scheduled standards for control of finely divided particulates including suspended sulfates, suspended nitrates, metals and particulate polycyclic organic matter will fully protect public health.

*Question 11.* An analysis of the data and conclusions pertinent to the national primary ambient air quality standards contained in current research reports prepared by Enviro-Control, Rockville, Maryland (Sponsored by Gould, Inc.).

Response: The report considered three aspects of the pollution problem caused by photochemical oxidants:

A review of toxicological and epidemiological data related to NO<sub>2</sub> and O<sub>3</sub>

Analysis of the relationships between oxidant levels and sulfate levels in metropolitan areas, and

Analysis of mortality data to determine associations with NO<sub>2</sub>.

In general, the conclusions that have been drawn cannot be considered firm based upon the evidence presented. The investigative approach involves non-parametric analyses of mortality data in relation to indices of pollutant exposure that are considered inadequate to characterize true exposures of the populations that are being studied. Several important covariates that would greatly affect these relationships, especially in the study of chronic health effects, have not been considered. What has been described as an in-depth review of existing knowledge related to the health effects of NO<sub>2</sub> and O<sub>3</sub> is, in fact, a poor and inadequate summary of the literature without adequate appreciation of biologic mechanisms or uncertainties in the studies themselves. The long-term mortality studies presented do not establish firm cause-effect relationships and are of questionable value in the standard setting process. More specific comments follow.

1. Use of NASN annual average NO<sub>2</sub> data based upon the Jacobs-Hochheiser procedure does not give accurate measures of exposure due to the well documented problems with variable collection efficiencies and NO interferences. These data are not valid exposure measures to relate to biologic endpoints as has been done in this study. Placing a single, sampling station at isolated locations in a city does not sufficiently characterize total city exposure so that conclusions regarding cause-effect relationships for all people living in that city can be drawn.

2. Considerable emphasis is placed on the fact that sulfate pollution has recently been associated with impairments of human health and that sulfate formation may result from photochemical processes. It is true, as emphasized in this report, that reduction in localized urban atmospheric levels of SO<sub>2</sub> have not been associated with concomitant reductions in sulfate fraction of TSP. However, this may well be explained by increases in regional sulfur dioxide emissions, by the presence of certain rate limiting intermediates (including free radicals) in the atmosphere, by the concentration of metallic pollutants that catalyze the conversion and by the facilitating influences of gases other than NO<sub>2</sub>.

3. The statistical studies presented in the report provide evidence of associations but the acknowledged deficiencies are such that firm conclusions cannot be drawn, i.e. no firm association-causation relationships can be drawn. These deficiencies include primarily the use of one monitoring site per city, utilization of the discredited Jacobs-Hochheiser bubbler method for measuring NO<sub>2</sub>, and estimation of prior exposure on the basis of current exposure without considering secular changes in concentrations of various pollutants.

Concomitant intervening factors might well be responsible for the observed variation in mortality. Among these are area differences in personal characteristics such as age, ethnicity and occupation; differences in socioeconomic status; and differences in environmental pollutants other than nitrogen dioxide.

4. Observations that short term peak exposures to O<sub>3</sub> and sulfate may be related to variations in total weekly mortality appear more plausible than similar conclusions drawn about chronic NO<sub>2</sub> exposure and deserve additional investigation, but any firm conclusions at this time are unwarranted especially in view of previous failures to consistently relate mortality to photochemical oxidant levels in California. Perhaps peak sulfate exposures are important in this regard but

this possibility requires further investigation before any more definite conclusions can be drawn.

In conclusion this report does highlight problems that are worthy of additional scientific investigation. There is however, no information contained in this report that can be utilized at this time to justify revision of the primary ambient air quality standard for nitrogen dioxide. The report does little to assist the Agency in recommending a more appropriate mobile source emission strategy for nitrogen dioxide than presently exists.

*Question 12a.* An analysis of the data and conclusions contained in any of the above or in any other information available to the Agency pertinent:

a. To the health effects associated with various levels of sulfates, nitrates, polycyclic particulate organic matter, and sulfurous or sulfuric or nitrous or nitric acid mists.

Response. With the exception of certain particulate polycyclic organic matter, the above mentioned compounds are formed in the ambient atmosphere by chemical or physical processes after emissions of primary pollutant such as sulfur dioxide or oxides of nitrogen. Our knowledge of the formation and behavior of these secondary pollutants in the ambient atmosphere is incomplete. They are found in the particulate phase, and are normally in the respirable size range. There has been a limited number of health effects studies on these fine particulates. Although the biological consequences of human exposure to each of these pollutants, alone or in combination, have not been delineated, the evidence suggests that they may be more important than those related to the primary gaseous pollutants.

Recent EPA CHES studies have identified adverse respiratory effects attributable to suspended sulfate (collected on a glass fiber filter and analyzed on water soluble sulfate) concentrations exceeding  $10 \mu\text{g}/\text{m}^3$ .

Amdur<sup>1</sup> and her associates used an increase in pulmonary air flow resistance of guinea pigs as an assay tool in lung mechanics. Particles of sulfuric acid, ammonium sulfate, zinc sulfate, and zinc ammonium sulfate have been shown to produce a response in this system. An atmosphere of sodium chloride and  $\text{SO}_2$  was found to enhance the biologic response, but not sodium chloride alone.

Frank and McJilton<sup>2</sup> recently conducted studies in which guinea pigs were exposed to combinations of atmospheres of  $\text{SO}_2$  ( $262 \mu\text{g}/\text{m}^3$ ) and sodium chloride ( $900\text{--}100 \mu\text{g}/\text{m}^3$ ) at "high" (80%) and "low" (40%) relative humidities. Significant changes in pulmonary flow resistance occurred only in the combined  $\text{SO}_2$ /sodium chloride aerosol atmosphere at "high" humidity.

Hazleton Laboratories<sup>3</sup> in a series of studies found histologic alterations of the lungs in Cynomolgus monkeys exposed to  $0.99 \mu\text{g}/\text{m}^3$  of  $\text{H}_2\text{SO}_4$  mist and  $0.53 \mu\text{g}/\text{m}^3$  of fly ash. These effects were not observed when the concentrations were reduced to  $0.11 \mu\text{g}/\text{m}^3$   $\text{H}_2\text{SO}_4$  and  $0.53 \mu\text{g}/\text{m}^3$  fly ash. Small but progressive changes in pulmonary air flow resistance were observed at both levels of the pollutants.

A recently published epidemiological study of chronic respiratory disease symptom prevalence in Japan contains some information on the influence of sulfuric acid mist emissions (Appendix D). This is found in urban areas situated near large sources with high peaks of exposure. In two such areas the prevalence of illness symptoms is much in excess of that expected on the basis of local sulfation rates (pg. 24, item c of the paper). It is also interesting to note in this study that a threshold of sulfation rate was observed at  $1 \mu\text{g}/\text{m}^2/\text{month}$  (conclusion #4 & 5, p. 26). This threshold level is approximately equal to the 0.03 ppm of our present  $\text{SO}_2$  standard.

Polycyclic aromatic hydrocarbons and heterocyclic compounds constitute a group of known animal carcinogens that are present in the atmosphere.<sup>4,5</sup> The carcinogenicity of a mixture of compounds may be greater than the sum of that of individual compounds (for example—benzo[a]pyrene (BaP) and hematite): hence cofactors may be as important as the polycyclic hydrocarbons themselves.

<sup>1</sup> Amdur, M. O. Toxicology of Decay Products of Sulfur Dioxide in the Atmosphere. A review prepared for the Division of Health Effects Research, NAPCA, 1969.

<sup>2</sup> Frank, R. and McJilton, C. The Role of Relative Humidity in the Synergistic Effect of  $\text{SO}_2$ -Aerosol Mixture on the Lung. In Press, Science.

<sup>3</sup> Hazleton Laboratories, Chronic Exposure of Cynomolgus Monkeys to Sulfuric Acid Mist and Fly Ash Mixtures, Report submitted to Electric Research Council, December 1972.

<sup>4</sup> National Academy of Sciences, Particulate Polycyclic Organic Matter, 1972.

<sup>5</sup> EPA Draft Position Paper on Particulate Polycyclic Organic Matter, NERC/RTP, 1973.

Occupational exposure to high concentrations of polycyclic aromatic hydrocarbons and heterocyclic compounds has resulted in human lung cancer. In most cases the actual concentrations to which the subjects were exposed were not known. BaP concentrations of 3-216  $\mu\text{g}/\text{m}^3$  were measured in gas-works retort houses in England. This is an order of magnitude higher than normal BaP levels in London. Dose response relationships or threshold values for particulate polycyclic organic material (PPOM) in the ambient atmosphere have not been established. Available data suggest that PPOM may contribute to the higher rate of lung cancer observed in urban areas, as opposed to non-urban areas, however this has not been confirmed.

There has been virtually no work done on the biological consequences of nitrates and nitrous or nitric acid mists. In the Chattanooga school children studies,<sup>6</sup> long-term exposure to ambient  $\text{NO}_2$  concentrations between 117 and 205  $\mu\text{g}/\text{m}^3$  accompanied by suspended nitrate concentrations between 3.8 and 7.2  $\mu\text{g}/\text{m}^3$  for 6 months and longer was associated with an excess in respiratory illness and decreased lung function. These effects may have been produced by  $\text{NO}_2$ , acid mists, or combinations of pollutants.

N-nitrosamines are compounds that have received recent attention because of their powerful biological activity. Included in the list of compounds investigated are some of the most potent chemical carcinogens and mutagens. Several of these compounds are also teratogenic and others can induce severe acute cellular injury. The carcinogenic activity of these compounds spans a wide range of animal species and tumors may result after only a single dose. The nitroso compounds behave as alkylating agents in biological systems and react with genetic and other cell components. This action may be responsible for the biological activity of these compounds.

Recent evidence has demonstrated the occurrence of these compounds in the environment, either naturally or the result of unknown chemical reactions. Experiments have shown that N-nitrosamines can be formed in man by the reaction of nitrites and secondary amines. These reactions occur most favorably under conditions of high acidity, as those found in the stomach. One may speculate on the exposure of man to these compounds from other avenues of entrance. Nitrosamines have been suggested as being present in cigarette smoke. The possibility exists that N-nitrosamines can be formed in other organs of the body, besides the stomach, with oxides of nitrogen entering through the lungs. The optimal chemical conditions present in these organs, however, do not favor these chemical reactions.

*Question 12b.* An analysis of the data and conclusions contained in any of the above or in other information available to the Agency pertinent:

b. To the relationship between the six pollutants subject to ambient standards and sulfates, nitrates, ppm's, sulfurous or sulfuric acid and nitrous or nitric acid mists.

**Response.** Atmospheric fine particles which contain sulfates, nitrates and organic aerosols are largely derived from the controlled pollutants subject to ambient air standards. The relationships between the particles and gases are a major subject of the EPA research program on the formation and decay of atmospheric pollutants. The relationships are understood in a general way by now, but they have not yet been placed on a quantitative basis. Therefore, a main objective of the current research program is to develop mechanism and rate information which will allow particle formation, growth and disappearance to be included in a mathematical model of the chemical processes in the air.

Atmospheric sulfates, nitrates, and related acids are largely derived from the sulfur dioxide, nitric oxide and organic vapors emitted by mobile and stationary pollution sources. Generally, the mass of gaseous pollutants in the air is considerably larger than the mass of condensed phase pollutants. Fine particle pollutants develop and grow from this reservoir of gaseous pollutants. The light scattering by these fine particles is responsible for visibility reduction in the atmosphere. Sulfuric acid and nitric acid vapors are also emitted directly into the air from some industrial stationary sources. This form of emission is particularly important near the particular source.

Atmospheric nitrates are almost entirely derived from the atmospheric nitrogen oxide gases. The result is not necessarily a nitric acid "mist", because of

<sup>6</sup>Shy, C. M., et al. The Chattanooga School Children Study: Effects of Community Exposure to Nitrogen Dioxide. *J. Air Pollution Control Assoc.* 20(9): 582-588, September 1970.

likely interactions with other constituents of the particulate matter; but it is fair to call the result a nitrate-containing mist. Nitric acid vapor has been detected in the stratosphere, but never in the lower atmosphere.

Nitric acid is formed in the atmospheric fine particles when nitrogen pentoxide,  $N_2O_5$ , or nitrogen trioxide,  $NO_3$ , react with a water-containing droplet. The  $NO_3$  is formed by the interaction of nitrogen dioxide and ozone. Such interaction is especially prevalent in the afternoon stages of photochemical smog. The  $NO_3$  may go directly to nitric acid, but it is more likely that it first reacts with  $NO_2$  to yield  $N_2O_5$  which then goes to nitric acid at the surface. In droplets the result is a solution of nitrate salts rather than a solution of nitric acid.

Nitrous acid,  $HNO_2$ , is assumed to be a gaseous constituent of the polluted air even though it has not been directly detected. However, nitrites are not considered likely to exist in the condensed phase in the air. Although some nitrite might exist in the aerosol in the dark, when the air is exposed to daylight, the nitrite will be photolyzed. The nitrous acid is dissociated by sunlight and plays at least a minor role in atmospheric photochemical processes.

Sulfur dioxide is the gaseous precursor of sulfate in atmospheric particulate matter. As in the case of the nitrogen compounds, the condensation seems to follow the oxidation of dioxide to trioxide. The oxidation proceeds to some extent in power plant plumes. It also takes place with the assistance of sunlight hydrocarbons and nitrogen oxides in the photochemical smog. The mechanism of oxidation of  $SO_2$  to  $SO_3$  is not fully understood. There is no general agreement on what the oxidizing species might be under photochemical conditions. Possibilities include excited oxygen molecules, peroxide free radicals, and nitrogen trioxide. As the  $SO_3$  is formed, it reacts with water vapor or water droplets, to produce sulfuric acid particles. Further reactions of the sulfuric acid in the droplets may include formation of ammonium sulfate, decomposition of carbonate ions and displacement of hydrogen chloride. Sulfate and sulfuric acid may also occur by catalytic reactions in droplets or on surfaces.

The formation of sulfurous acid mist would occur upon direct solution of  $SO_2$  in aqueous droplets. The sulfurous acid solution can then be oxidized to sulfuric acid by catalytic materials. This reaction is self-limiting, its rate decreasing as the acidity of the droplet increases. Ammonia reduces acidity and the reactions will continue as long as ammonia is available to dissolve in the droplets.

The need to develop a deeper and more quantitative understanding of the relationships between sulfur oxides and sulfates is recognized in the emphasis of the EPA research program in chemistry and physics. It is also recognized in the recent decision to concentrate the effort of the St. Louis Regional Air Pollution Study on the sulfur compounds.

Carbon monoxide gas at its concentration in the polluted ambient air does not significantly affect the interactions among the nitrogen oxide gases and the nitrates and nitrites, nor does it affect the interactions among the sulfur compounds. A marginal effect of carbon monoxide on the rate of conversion of nitric oxide to nitrogen dioxide has been observed. In considering aerosol formation, growth, and removal, carbon monoxide may be treated as an inert gas.

Hydrocarbons play a role in the conversion of nitrogen oxides to the nitrogen salts and acids through a rather complex chemical mechanism, as discussed in the Air Quality Criteria Documents. The key reaction derived from the hydrocarbons is probably the oxidation of  $NO$  by peroxide free radicals. A reduction in hydrocarbon emission is expected to inhibit the formation of the nitrate containing aerosols.

Hydrocarbon emissions from a particular source are related to the PPOM emissions of that source. The primary sources of PPOM's in the atmosphere are stationary sources such as asphalt and tar operations. Mobile sources also contribute. From stationary sources the contribution is directly related to the composition of the material present in the source. From mobile sources this is also true but the combustion process plays an overwhelming role. Initial evidence is that the PPOM's are reduced more rapidly by catalytic control systems than are the hydrocarbons. The amounts emitted are also highly dependent upon the amount of oil that passes through the engine and the POM composition of that oil. The high molecular weight POM's are usually only slightly modified and are not formed in large quantities in the combustion process.

There is no evidence that lower molecular weight hydrocarbons react to form PPOM's in the atmosphere. Control measures for the control of hydrocarbons from emission sources also control the POM emissions.

Hydrocarbons are oxidized in sources and by photochemical reactions to form organic aerosols. The mechanisms of formation of organic aerosols are not known at present.

The proportions of sulfate, nitrate and organic aerosols vary considerably with community and regions of the U.S. Sulfates are particularly important in the Northeast and midwestern U.S. Organic aerosols are about equal in concentration to sulfates in the Southern and Western U.S. Nitrate concentrations are smaller than sulfates or organic aerosols except in the Los Angeles basin area. In Los Angeles, nitrates can exceed sulfates or organic aerosols.

*Questions 13 and 14.* These questions request EPA's analysis of the data and conclusions pertinent to the 1975-76 new motor vehicle emission standards contained in:

(a) Charles H. Connolly, *Air Pollution and Public Health*, New York Dryden Press, 1972 (Chrysler Corporation Study); and

(b) "Necessary Automotive Emission Standards for the Mid Seventies," *A Current Study of Automotive Air Pollution: April-October 1972*, published by General Motors Inter-staff Committee on the Environment, October 1972.

Response. The above documents raise many questions about the mandated 90 percent reduction in automotive emissions. The following analysis deals with the principal questions relating to the air quality, technology, and cost implications of the mandated standards.

#### *Extent of the Air Pollution Problem*

The ambient standards for the motor vehicle related pollutants, CO, O<sub>3</sub> and NO<sub>x</sub>, are being exceeded in a number of our major urban areas. Out of the 247 Air Quality Control Regions in the United States, in 1970, 54 exceeded the air quality standards for oxidant, 29 exceeded the CO standard, the 2 exceeded the NO<sub>x</sub> standard (under the old monitoring technique it was believed that 47 AQCR's exceeded the ambient standard for NO<sub>x</sub>). A list of the air quality regions exceeding the standards for each of these pollutants is included in Appendix A.

#### *Reductions Needed in Automotive Emissions*

The Environmental Protection Agency's plan to achieve the air quality standards on a national basis includes the implementation of controls on stationary sources (power plants, industrial facilities and general area sources), the Federal motor vehicle emission standards, and transportation controls. The State implementation plans previously submitted to EPA primarily relied upon the control of stationary sources and the implementation of Federal emissions control on motor vehicles to meet the ambient air quality standards for motor vehicle related pollutants. However, State plans for 38 air quality control regions were unable to provide adequate emissions reductions through these control approaches to meet the carbon monoxide and/or oxidant standards by 1975. Accordingly, these States must submit transportation control plans to meet the ambient air quality standards. These 38 regions include approximately 43 percent of the nation's population and 42 percent of the motor vehicles.

Since the presence of these pollutants in the ambient air is largely attributable to motor vehicles, the amount of transportation control is directly related to the severity of the emissions control placed on automobiles. For example, if the 1975 Federal motor vehicle standards were permanently relaxed, more extensive transportation controls would be needed, involving more metropolitan areas for a longer period of time. The following is an analysis of the impact that changes in the automotive standards would have on air quality and transportation controls.

*A. Improved Rollback Technique.*—Using observed maximum pollutant levels and the generally accepted relationship that ambient pollutant concentrations are proportional to pollutant emissions, one can apply a "rollback" analysis to determine the degree of overall emission reduction required to achieve the ambient air quality standard. In the case of carbon monoxide and nitrogen dioxide, the rollback calculation assumes a direct relationship between carbon monoxide and oxides of nitrogen emitted and the ambient carbon monoxide and nitrogen dioxide levels. The oxidant calculations, however, are based on a relationship between the hydrocarbon emissions and resultant production of oxidant concentrations as published by EPA and used by the States in the development of the implementation plans.

Prior to the writing of the Clean Air Act Amendments of 1970, rollback calculations were made to determine the degree of emission reduction required to attain ambient air quality standards. These analyses used a worst case approach and dealt with the highest measured levels of CO (Chicago), Oxidant (Los Angeles) and Nitrogen Dioxide (New York). The analysis also assumed that all emitters of a given pollutant would be rolled back proportionally. On the basis of this analysis, order of magnitude automotive emission reductions were derived assuming 1985 as the air quality attainment date.

Several changes have been made in the rollback model to determine the impact of various levels of motor vehicle control in the attainment of air quality standards.

(a) Recognizing that all emitting sources cannot be reduced proportionally, more realistic estimates of reductions possible from various categories of sources were made;

(b) Weighting factors were introduced to take into account the spatial distribution of sources and the height of their emissions from the ground;

(c) Since the worst case approach using the highest measured air quality values may reflect unusual situations, more representative second worst case values were used in making the analyses;

(d) Rather than using a uniform growth rate for all categories, an individual growth rate was employed for each type of source based on projections for each region;

(e) Provision was made for the introduction of new technology, the attrition of old sources, and degradation of control system efficiencies while in use.

#### B. Impact of Various Emission Standards

The alternative emissions control standards shown in Table I include the continuation of the 1973/74 Federal Emission Standards; the implementation of advanced engine modifications on 1975 and later model vehicles achieving emission levels of 15 grams per mile CO and 1.5 grams per mile HC; and the implementation of the 1975 standards mandated by the Clean Air Act.

TABLE I.—ALTERNATIVE EXHAUST EMISSION CONTROL STRATEGIES

	Emission levels			
	CO grams per mile	Percent reduction	HC grams per mile	Percent reduction
Continuation of 1973-74 Federal standards.....	28.0	18	3.0	27
Implementation in 1975 of standards representative of advanced engine modification controls.....	15.0	56	1.5	63
Implementation in 1975 of standards prescribed in the Clean Air Act.....	3.4	90	.41	90

Note—Percent reduction over model year 1970 new car emissions.

In order to determine the impact of varying the automobile standards on ambient CO and oxidant levels, the rollback analysis was applied to the 38 air quality control regions (AQCR) which require transportation controls. The 38 regions include 26 AQCR's transportation controls to meet the carbon monoxide standard and 30 AQCR's requiring transportation controls to meet oxidant standards.

The results of these calculations are stated in terms of the number of AQCR's which would not meet the standards for CO and Ox in given years, assuming the implementation of the given strategy and anticipated controls for heavy and medium duty vehicles and stationary sources. The impact of transportation controls is not included in this analysis.

*Carbon Monoxide Control.*—Table II summarizes the impact of the various vehicle emission control strategies on carbon monoxide ambient air concentrations. The greatest improvement in air quality is demonstrated for 1985. Because of the growth in mobile and stationary sources of emissions, some AQCR's which meet the standards in 1985 may no longer meet them by 1990. The final column on the table enumerates the number of AQCR's which will never meet the standards without supplemental control of stationary and/or mobile sources.

TABLE II.—EFFECT OF VEHICLE CONTROL STRATEGIES ON THE 26 WORST AQCR'S—CARBON MONOXIDE

	Number of AQCR's exceeding the standard <sup>1</sup>			
	1977	1985	1990	SNA <sup>2</sup>
Cont. of 1973-74 standards (30 gpm CO).....	24	21	22	21
1975 standard based on adv. eng. mod. (15 gpm CO).....	24	15	18	15
1975 Clean Air Act standards (3.4 gpm CO).....	20	3	7	3

<sup>1</sup> Assumes present stationary source technology and intermediate control of medium and heavy-duty emission. Implementation of transportation controls and/or stringent stationary source controls is not assumed.

<sup>2</sup> Standard never achieved.

**Oxidant Control.**—Table III summarizes the impact of the three vehicle emission control alternatives on ambient oxidant concentrations. Thirteen of the 30 regions would achieve the required air quality in 1985 if the 1973/1974 emission limits were continued; 17 would meet the oxidant air quality standard with the emissions standard attainable with engine modifications and 20 of the 30 would meet the standard with the 1975 Federal automotive emission standards prescribed in the Act.

TABLE III.—EFFECT OF VEHICLE CONTROL STRATEGIES ON THE 30 WORST REGIONS—PHOTOCHEMICAL OXIDANTS

	Number of AQCR's exceeding the standards <sup>1</sup>			
	1977	1985	1990	SNA <sup>2</sup>
Cont. of 1973-74 standards (2.8 gpm HC).....	26	17	22	17
1975 standard based on adv. eng. mod. (1.5 gpm HC).....	24	13	15	13
1975 Clean Air Act standards (0.41 gpm CH).....	22	10	12	10

<sup>1</sup> Assumes present stationary source technology and intermediate control of medium and heavy duty emissions. Implementation of transportation controls and/or stringent stationary source controls is not assumed.

<sup>2</sup> SNA = Standard never achieved.

The data indicates that to achieve ambient air quality standards for both CO and oxidants even as late as 1985 some 12 regions<sup>1</sup> would still require additional controls even with the most stringent auto emission standards considered.

It is important to recognize that the rollback analysis, even using the more realistic assumptions, is at best an imperfect tool. There is no known precise technique to estimate the specific automobile emission requirements related to air quality; however, the rollback technique does permit some generally valid order of magnitude estimates of the relations of emitting sources to changes in air quality.

**Oxides of Nitrogen Control.**—With only two regions, Los Angeles and Chicago, having a significant NO<sub>x</sub> problem, the degree of control required is not as severe as in the case of CO or HC. It is expected that the measures to be taken to deal with the photochemical oxidant problems in Los Angeles will also yield reductions in emissions of oxides of nitrogens which will solve the NO<sub>x</sub> problem. In the Chicago region, it is expected that the current Federal motor vehicle NO<sub>x</sub> standards coupled with transportation plans for this region will be adequate. Elsewhere, it is clear that major cutbacks in nitrogen oxides emissions are not necessary at this time.

In light of this, the 90 percent reduction in NO<sub>x</sub> emissions as prescribed by the 1970 Clean Air Act Amendments needs to be re-examined as being too stringent to be required for implementation and maintenance of the NO<sub>x</sub> Air Quality Standard. For the next decade, an emission standard based on consideration of available technology and its cost would be more appropriate.

#### *The Consumer Costs of Alternative Emissions Standards*

Our recent findings on the need for the NO<sub>x</sub> emission standard and the widespread concern over the stability of catalytic systems dictates that any analysis of consumer costs must consider more than the cost implications of meeting the

<sup>1</sup> Nine regions for oxidant, 2 for CO, and 1 for both oxidant and CO.

1976 emissions standards. This analysis examines the cost implications of three alternative levels of emissions control.

I.—A standard which can be met by modifications to the conventional internal combustion engine. Catalysts would not be required to meet this standard.

II.—The continuation of only the 1975 standards for HC, CO and NO<sub>x</sub>. This would require the use of an oxidation catalyst, but would eliminate the need for a reduction catalyst to bring NO<sub>x</sub> to the level of the 1976 NO<sub>x</sub> standard.

III.—The implementation of the existing 1976 standards.

The cost estimates used in this analysis take 1973 control systems costs as a base, and therefore represent the incremental costs over what the consumer is presently incurring with the purchase and use of a 1973 vehicle. The cost analysis has been done in this manner to provide a better feel for the magnitude of the cost of moving to emission standards more stringent than those applicable to vehicles being produced today.

*Engine Modifications.*—An engine modification control system is essentially a 1975 catalytic system without the oxidation catalyst. The engine modifications include a quick heat manifold, high energy ignition, electric choke, advanced carburation, proportional EGR and air injection. The estimated sticker price increase of this system is approximately \$100 over the price of a 1973 vehicle. Because this type of system can be run on leaded gasoline and is estimated to have no additional fuel penalty over 1973 models, there is no incremental operating cost. Assuming a degree of vehicle maintenance comparable to that generally practiced today, maintenance costs are not projected to increase and should actually fall by \$55 over the life of the vehicle because of the reduction in ignition maintenance resulting from the use of long-life high-energy ignition systems.

*1975 Standards with Oxidation Catalysts.*—It is estimated that the addition of an oxidation catalyst (includes a long-life exhaust system) to the engine modifications sighted above will add approximately \$85 to the sticker price of the average 1975 vehicle. This conservative estimate (the NAS estimated the price of the catalyst to be \$58) could be substantially reduced with the introduction of a new generation of catalyst technology. Based on the recent public testimony of the large American manufacturers, there will be little or no fuel penalty associated with the use of catalyst systems being designed for 1975. However, operating costs will increase because catalytic systems require the use of a lead free gasoline. The higher price of the lead free 91 octane gasoline (the removal of lead will increase the price by nearly 1¢ per gallon) will increase operating costs to the average consumer by \$10 per year. Annual maintenance costs, on the other hand, are estimated to remain about the same as those experienced today. Although there will be increased maintenance costs for an assumed catalyst change (only one replacement is allowed under EPA certification regulations) and EGR maintenance, these will be offset by the reduction in costs from the use of long-life high energy ignitions, long-life exhaust systems and the less corrosive lead free gasoline.

*1975/76 Standards with Catalyst/Thermal Reactor System.*—Systems designed to meet the 1975/76 standards are still very much in the developmental stage. However, two distinct system configurations already show a great deal of promise. These systems are the dual catalyst system, discussed in great detail in the recent NAS report and the catalyst/thermal reactor system. Because the dual catalyst system was analyzed in detail by the NAS, and because of the good low mileage emissions performance of the catalyst/thermal reactor system at EPA's automotive laboratory, this cost analysis will focus on the cost of meeting the 1975/76 standards with the latter system.

The estimated increment in sticker price is \$205, or \$20 higher than the 1975 oxidation catalyst system. Although this system can be run on leaded gasoline, and thereby save approximately \$10 per year in operating costs over most catalytic systems, it has a significant fuel penalty of 11 to 12 per cent because of its rich fuel mixture.

This fuel penalty increases the annual operating cost by nearly \$47 per year for the average consumer. Because this system is not likely to require a catalyst change and does not employ EGR, the maintenance costs, assuming maintenance in the field does not change from that required today, will actually fall by \$55 over the life of the vehicle reflecting the longer life of the high energy ignition used in this emission control configuration.

### Cost Summary

Table IV enumerates the individual consumer costs of the alternative emissions standards and examines the long-run cost implications to the nation of each control strategy. We assume no technological learning curve, and therefore hold costs constant over the eleven year period 1975-1985.

TABLE IV.—COMPARATIVE COSTS—1973 BASE

	Sticker price	Annual O. & M.	1975-85 total national cost (billions)
Engine mods. ....	\$100	—\$5	\$10.8
1975 standard .....	185	10	40.9
1975-76 standard .....	205	142	70.8

<sup>1</sup> Gasoline prices are assumed to be \$0.36 per gallon.

### V.—Impact of Interim Standards

The cost and air quality comparisons made above were discussed in the context of a legislative change in emission standards over the period 1975-1985. Such legislative changes have not been made. However, an adjustment in the emission standards time schedule has recently been made in the form of a one year extension of the statutory 1975 HC and CO standards. This extension decision will have a marginal impact on air quality and cost.

(a) *Air Quality.*—It is estimated that the adoption of the interim standards for 1975

*National*  
 HC = 1.5  
 CO = 15

*California*  
 HC = .9  
 CO = 9

will generally not alter the predicted air quality levels of individual AQCR's by more than 1 ppm. However, for 2 AQCR's this shift of 1 ppm implies that these regions will not meet the ambient standards by 1977, whereas these standards would have been achieved by that year under the original statutory time schedule. Table V compares the air quality implications of the original and modified emission reduction time schedules:

TABLE V.—EFFECT OF INTERIM STANDARDS ON THE 26 WORST AQCR'S

	Number of AQCR's exceeding the standards		
	1977	1985	1990
Original 1975 CO standard .....	20	3	7
1-year interim CO standard .....	21	3	7
Original 1975 HC standard .....	22	10	12
1-year interim HC standard .....	23	10	12

(b) *Costs.*—The 1975 interim standards were set to permit a rational phase-in of new emissions control technologies in 1975 and 1976. The impact on costs in 1975 is a function of the technology phase-in schedule adopted by the automotive industry. It is estimated that those vehicles produced with catalysts in 1975 will cost approximately \$185 more than 1973 vehicles, while those without catalysts would experience an initial price increase of about \$100. If the automotive industry installs catalysts on California cars only, and if catalysts manufacturing costs are spread to all cars produced, the incremental sticker price of a 1975 vehicle can be expected to be approximately \$105-\$110.

### Comparative Expenditures

The magnitude of the emissions control cost is such that it is useful to put it into perspective by comparing it to the price consumers seem willing to pay for convenience and esthetics in their automobiles.

Table VI compares the sticker price, annual O&M cost and the long-run cost to the nation of the alternative automotive emissions standards, and three new car options found in an increasingly greater number of American automobiles.

TABLE VI

	Sticker price	Annual O. & M.	1975-85 national cost (billions)
Engine mods.....	\$100	\$5	\$10.8
1975 standards.....	185	10	40.9
1975-76 standards.....	205	142	70.8
Vinyl roofs (46 percent) <sup>2</sup> .....	92	-----	6.9
Radio (80 percent).....	59	-----	7.7
Air-conditioning (69 percent).....	350	36	65.1

<sup>1</sup> Gasoline prices are assumed to be 36 cent per gallon for leaded regular.

<sup>2</sup> Percentage figures indicate the percentage of cars sold with this option.

<sup>3</sup> Calculations adjusted for percent of sales figure.

<sup>4</sup> Air-conditioning is estimated to have an average fuel penalty of 9 percent in urban driving. Maintenance costs were not included because of lack of data.

Even without including the maintenance costs, the estimated cost of only these three non-safety related new car options is nearly twice that of the 1975 standards and falls just short of the incremental cost of the 1976 standards. For the sake of brevity other vehicle options such as power windows (15% of cars), power seats (13%), AM-FM radio (10%), movable steering wheels (10%) and automatic transmissions (90%) were not included in the table.

### CONCLUSIONS

The foregoing analysis suggests the following conclusions:

The primary health standards for oxidants (HC) and carbon monoxide are exceeded in a large number of AQCR's. Control of the automotive pollutants to the statutory 90% reduction will bring most of these AQCR's within the OX and CO standards by 1985, although as many as 12 AQCR's may still require supplemental controls in 1985, i.e., transportation and/or stationary source controls, even with the 90% reduction in automotive emissions.

The evidence indicates that the mandated 90% reduction of NO<sub>x</sub> emissions is not required at this time. Violations of the NO<sub>x</sub> standard are limited to a small number of cities, while the cost of applying the NO<sub>x</sub> control technology nationwide could be very high. Special abatement techniques tailored to the few AQCR's in violation of the NO<sub>x</sub> standard should permit attainment of the health standard without the mandated 90% reduction in exhaust emissions of NO<sub>x</sub>.

While the catalyst appears to be the short-term technology preferred by the automotive industry, other technologies such as the diesel or stratified charge may prove to be superior. Such an outcome is by no means certain, although the fuel economy advantages of these approaches are attractive. Until the relative performance of these alternative technologies and the catalyst is clarified, the approach that gets them on the road as soon and in as great a variety as possible should be preferred. This will permit consumer preference to dictate the superior technology. If at a later date the evidence indicates that alternative technologies are not being vigorously pursued, a more direct regulatory approach might then be considered.

A lack of data prohibits a full cost-benefit analysis of the automotive pollutant health standards. However, a comparative cost analysis shows that the total cost of an emissions system capable of meeting the stringent HC/CO standards and a relaxed NO<sub>x</sub> standard is commensurate with other automobile related costs incurred by the consumer in the purchase and use of a relatively few automobile convenience options.

APPENDIX A.—REGIONS EXCEEDING THE AIR QUALITY STANDARDS FOR CO, NO<sub>2</sub> AND OXIDANTS  
[1969 to 1971 monitoring data]

AQCR	Pollutant			AQCR	Pollutant		
	OX	CO	NO <sub>2</sub>		OX	CO	NO <sub>2</sub>
Birmingham	X	X		Baltimore	X	X	
Mobile-Pensacola	X			Boston	X	X	
North Alaska		X		Toledo	X		
Clark-Mohave	X	X		Minneapolis-St. Paul		X	
Phoenix-Tucson	X	X		New Jersey		X	
Memphis	X			Albuquerque-Mid-Rio Grande	X		
Los Angeles	X	X	X	El Paso-Las Cruces	X	X	
North-central coast	X			Genesee-Finger Lakes	X		
Sacramento Valley	X	X		Niagara Frontier	X	X	
San Diego	X	X		Charlotte	X		
San Francisco	X	X		Cleveland	X		
San Joaquin	X	X		Columbus	X		
Southeast Desert	X			Central Oklahoma	X		
Denver	X	X		Northeast Oklahoma	X		
Hartford-New Haven	X	X		Portland		X	
New York-New Jersey-	X	X		Southwest Pennsylvania	X	X	
Connecticut				Middle Tennessee	X		
Philadelphia	X	X		Austin-Waco	X		
National Capital	X	X		Corpus-Christi	X		
Jacksonville-Brunswick	X			Dallas-Fort Worth	X		
East Washington-North Idaho		X		Houston-Galveston	X		
Chicago	X	X	X	San Antonio	X		
St. Louis	X	X		Wasatch Front	X	X	
Louisville	X			Hampton Roads	X		
Cincinnati	X			State Capital	X		
Indianapolis	X	X		Puget Sound	X	X	
South Central Iowa	X			Southeast Wisconsin	X		
Kansas City	X	X		Central New York	X		
South Central Kansas	X			Dayton	X		
South Louisiana-Southeast Texas	X						

*Question 15.* This question requests "An analysis of the data and conclusions pertinent to the 1975 and 1976 new motor vehicle emission standards contained in the Panel 1-Panel 7 reports to the Committee on Motor Vehicle Emissions, National Academy of Sciences on the basis of the CO, HC and NO<sub>x</sub> new motor vehicle emission standards."

*Response:* It is EPA's understanding that the above reports will be released in the very near future. EPA has had an opportunity to review and comment on an early draft of the reports but has not seen the final draft. As soon as these reports are issued, EPA will be pleased to prepare an assessment of them and make it available to the Committee.

*Question 16.* This question requests "An analysis of the relationship between Federal new motor vehicle emission standards, California new motor vehicle emission standards and attainment and maintenance of the national primary ambient air quality standards."

*Response.* The following table shows the relationship of the California standards to the 1975-76 emission standards mandated by the Clean Air Act:

[Grams per mile]

	California	Federal 1975-76
Hydrocarbons	0.89	0.41
Carbon monoxide	17.4	3.4
Nitrogen oxides	1.55	.4

A comparison of the air quality impact of the California and Federal standards has been made by means of the improved rollback approach previously described. For comparability with previous analyses, the year 1985 was chosen, since, assuming a ten-year turnover in light duty vehicles, any standard would have its maximum impact at that time. The one-year extension of 1975 Federal Stand-

ards for CO and HC is not included in the analysis; however, for comparative purposes, this action will have only a small effect on the results presented below.

There are presently 29 air quality control region (AQCRs) above the national ambient air quality standards (NAAQS) for CO, 26 of which will require transportation controls to meet the NAAQS by 1975. If the present 1973-74 Federal CO motor vehicle standard was continued, only five of these AQCRs could meet the NAAQS in 1985, assuming no transportation control programs would have been initiated. Using the California standards, eight AQCRs would achieve the NAAQS, and with the 1975 Federal Standard, 23 AQCRs would meet it. It is also determined that of the five AQCRs in California, only two would meet the NAAQS using the California standard, whereas all five would achieve it under the Federal 1975 emission standard.

There are 54 AQCRs which are presently above the oxidant NAAQS; 30 of these will require transportation controls to meet the oxidant NAAQS by 1975. Assuming no transportation control plans were initiated, only 13 AQCRs could achieve the required air quality in 1985 if the current emission limits were continued; 18 would attain the NAAQS using the California standard, and 20 would meet the air quality requirements with the 1975 Federal motor vehicle emission standard.

Two conclusions are evident from the preceding comparison:

(1) The main difference in the impact of the California standards when compared to the Federal is in carbon monoxide; and,

(2) The problem of achieving the ambient air quality standard for oxidants is more difficult than for carbon monoxide.

A similar analysis has not been made for Nitrogen Dioxide since, as previously noted, a major nitrogen dioxide control problem exists only in Los Angeles.

The analysis as to the achievability of standards assumes only the imposition of emission controls and does not consider the emission reductions associated with various transportation control alternatives. The regions chosen for analysis are those required to submit transportation control measures to achieve air quality goals. To achieve ambient air quality standards in 1985 some 12 regions would need to impose transportation controls even with the 1975 Federal auto emission standards. To achieve these goals without transportation plans the degree of reduction from 1970 emissions for carbon monoxide from light duty vehicles would have to be in the 96-98% range for the two worst case regions, Portland and Phoenix. (North Alaska is a special case whose high winter time stationary source emissions overwhelm mobile sources and 100% elimination of light duty vehicle emissions would not provide for standard achievement.) In the case of hydrocarbons ten regions would not meet the oxidant ambient air quality standards without the continued imposition of transportation control regardless of the reduction in emissions from light duty vehicles.

Mr. QUARLES. Thank you.

Mr. ROGERS. I think if it is agreeable with you, Mr. Quarles and your associates, we will adjourn now and we do have Governor Love tomorrow and another witness, too.

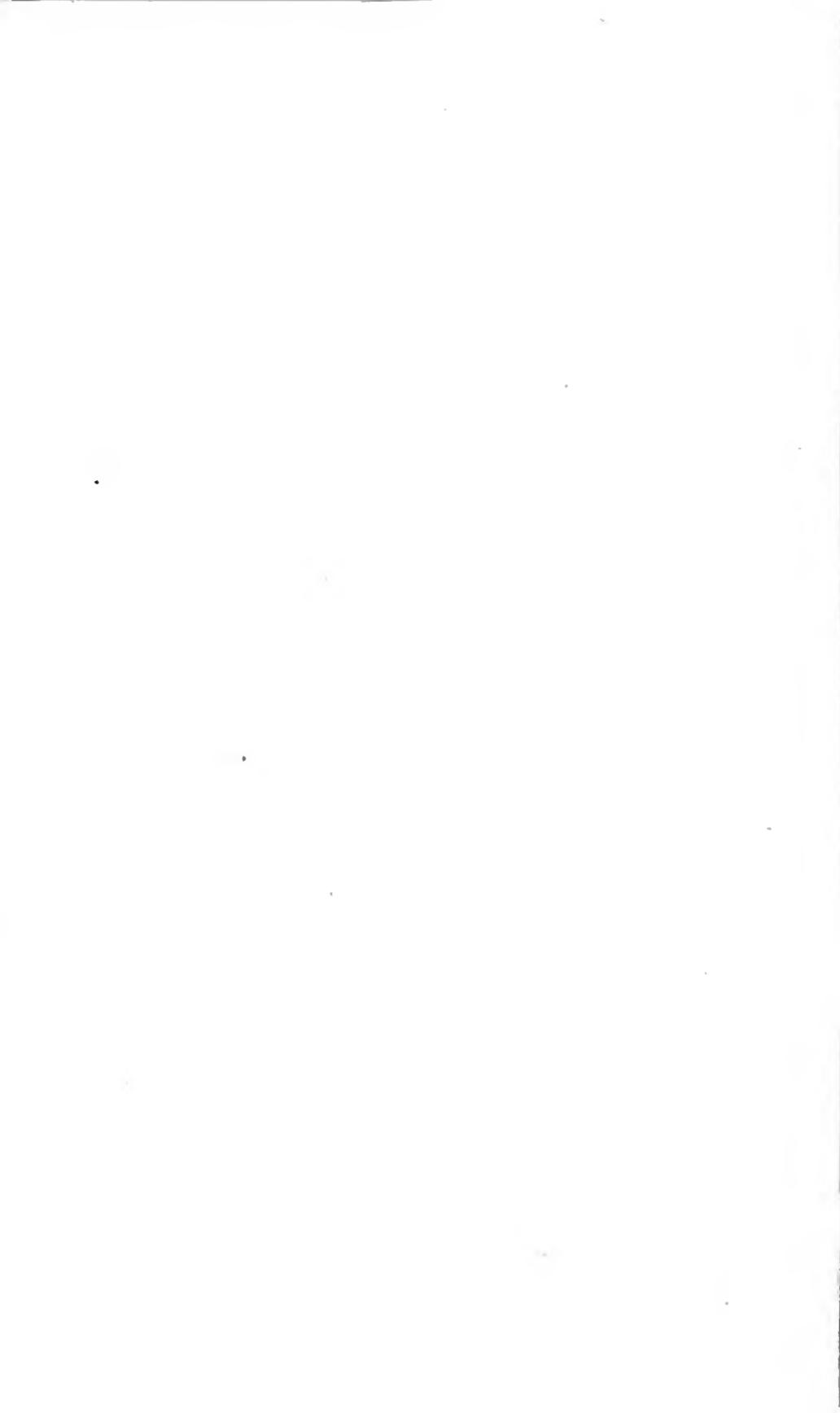
So, if you could plan to be back this would be helpful to the committee.

Mr. QUARLES. Yes, we are planning to do that.

Mr. ROGERS. Thank you.

The committee stands adjourned until 10 o'clock tomorrow morning.

[Whereupon, at 5:40 p.m. the committee adjourned, to reconvene at 10 a.m., Tuesday, September 11, 1973.]



## CLEAN AIR ACT OVERSIGHT—1973

TUESDAY, SEPTEMBER 11, 1973

HOUSE OF REPRESENTATIVES,  
SUBCOMMITTEE ON PUBLIC HEALTH AND ENVIRONMENT,  
COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE,  
*Washington, D.C.*

The subcommittee met at 10 a.m., pursuant to notice, in room 2123, Rayburn House Office Building, Hon. Paul G. Rogers, chairman, presiding.

Mr. ROGERS. The subcommittee will come to order please.

We are continuing hearings on implementation of the Clean Air Act.

We are very pleased to have as our first witness today Mr. Pierre M. Sprey, Enviro-Control, Inc., Rockville, Md.

We welcome you to the committee. If you would have a seat at the witness table that will be fine. We appreciate your being here. We will be pleased to receive your statement.

### **STATEMENT OF PIERRE M. SPREY, VICE PRESIDENT, ENVIRO-CONTROL, INC.**

Mr. SPREY. Thank you very much, Mr. Chairman. I am both pleased and grateful to have the opportunity to appear before your committee. I hope that my testimony may be of some use to the committee in its deliberations.

First of all, I would like to request permission from the chairman to submit my prepared statement for the record and then to give a short verbal discussion.

Mr. ROGERS. Without objection your statement will be made a part of the record following your summation.

You may proceed as you desire.

Mr. SPREY. Thank you, Mr. Chairman. Let me start by explaining the nature of the project that led to the results I am reporting.

My company, Enviro-Control, Inc., Rockville, Md., has a continuing interest in health research. We are doing work both in health effects of air pollution as well as in cancer research.

Last fall we formed a team to investigate some new ideas on health effects of air pollution. In particular we were interested to see whether we could use available data, available published health indices, in the form of mortality rates from specific diseases and link them with measures of air pollution on a city-by-city basis.

We proposed this project to EPA. It has been funded by EPA. The project is continuing. The methodology for the results I am going to

report on today come out of that EPA supported research. The specific results that I will talk about today on the toxicology of nitrogen dioxide as well as on the analysis of disease rates related to nitrogen dioxide, that specific research was supported by Gould, Inc.

Mr. ROGERS. By whom?

Mr. SPREY. Gould, Inc., they are a manufacturer of automotive parts and are interested in catalyts.

Let me briefly describe to you the research team that worked on this project. We had a senior biochemist from Cambridge University, John Morton, who has 5 years of experience in toxicology and respiratory diseases; we had Istvan Takacs, a graduate epidemiologist from Johns Hopkins University; Mr. Kenneth Allison was our air pollution meteorologist. He has 15 years of experience in meteorology; and myself.

I am a mathematical statistician and a systems analyst with a number of years of experience in biostatistics and health statistics.

The full results of our work relating to photochemical pollutants are contained in a document that I would like to request permission to submit for the record also. That document is called "A Study of Photochemical Pollutants and their Health Effects," dated September 1973.

Mr. ROGERS. Without objection it will be made a part of the committee files.

Mr. SPREY. Today I would very briefly like to touch on the highlights of what is contained in that document that may be applicable to this committee's deliberations.

Our first set of results are derived simply from the review of the available toxicological literature, that is, experiments with animals and, much more rarely, humans relating to exposures to oxidants and also to nitrogen dioxide.

I think the most striking result of this review is one that is very clear and simple and that is that the levels at which we observe various damages in animal experiments due to both nitrogen dioxide and ozone exposures are very close to the levels of the national ambient standards.

In the case of nitrogen dioxide we see damages down to perhaps twice the national ambient standard.

In the case of ozone we see damages to animals at levels that are almost equal to the national ambient standards. This is very much out of line with usual practice in setting safety factors for human exposure to various toxicants and is also out of line with the equivalent safety factor for SO<sub>2</sub>.

If you look at the SO<sub>2</sub> experiments in literature with animals you will find that the significant effects on animals there occur perhaps 10 to 100 more times higher concentrations than the ambient standard.

So, the margin of safety in the case of SO<sub>2</sub> is quite different than it is in the case of these two photochemical pollutants I am discussing.

Let me add just very briefly that the effects in both cases, both of NO<sub>2</sub> and O<sub>3</sub>, appear to be cumulative and somewhat irreversible and in fact hard to distinguish the effects of NO<sub>2</sub> and O<sub>3</sub> from the animal experimentation seemed to be fairly similar.

Let me go on to the next step of our research which was to examine historical trends in these pollutants in a number of major cities using Federal data, that is EPA data, from two monitoring networks of theirs.

The first and simplest result is that since 1965 on the average in the cities we have looked at the levels of  $\text{NO}_2$  have increased by about 30 percent whereas the levels of ozone have decreased by slightly more than that.

Mr. ROGERS. Ozone has——

Mr. SPREY. Has decreased by slightly more than 30 percent.  $\text{NO}_2$  has increased by about 30 percent since 1965. In other words, we have made some progress in reducing ozone and I would attribute that to our hydrocarbon reduction program. We have made no progress in reducing  $\text{NO}_2$  yet; in fact quite the opposite,  $\text{NO}_2$  seems to remain on the increase.

Perhaps of more direct interest than that is the relationship between these two photochemical pollutants and sulfates.

Now, the reason sulfates are important is that there has been a fair amount of experimentation that shows that sulfates are perhaps 10 to 100 times more irritating than  $\text{SO}_2$ .

As you know,  $\text{SO}_2$  can be oxidized into  $\text{SO}_4$ ,  $\text{SO}_2$  being a gas,  $\text{SO}_4$  being normally seen in the form of fine particles in the atmosphere.

These fine particles turn out to be a much more irritating form of sulfur according to animal technological experiments. I believe there is some agreement in the area that sulfates do seem to have strong health effects. EPA's CHESS experiments have shown that. The NATO air quality criteria document refers to effects on gastrointestinal cancers.

Our own prior research for EPA also confirms there is at least a statistical association between levels of sulfates and each of the individual gastrointestinal cancers as well as some other effects.

As a result of this, sulfates are of great interest from the point of view of protection of public health.

Because of that we decided to investigate this question of the formation of sulfates. I think people commonly believe that if you were to reduce the source of sulfur, the major source of sulfur, in the atmosphere, that is sulfur dioxide, then you should see a commensurate reduction in sulfates.

Unfortunately, the data does not support that belief. In fact, it shows quite differently that even in cities where we have major sulfur dioxide reductions such as in New York where we reduced sulfur dioxide since 1965 by a factor of 8, even in cities like that we have seen no change in sulfate levels.

Sulfate levels have been quite constant from year to year and there has been no improvement due to this very large and commendable cleanup in sulfur dioxide.

Given that disappointing evidence, that reductions in sulfur dioxide don't seem to have helped the sulfate situation very much, we decided to go further and see what, in fact, sulfate levels were related to.

Looking at the data for Chicago, Philadelphia, Washington, and St. Louis, I think we found significant clues and those clues are that sulfate levels do, in fact, respond to ozone and  $\text{NO}_2$  levels. That is, looking at historical data in a purely statistical way, if you pick days that have high ozone or high  $\text{NO}_2$ , you will find that associated with that are higher-than-normal sulfates.

In fact, the bulk of the evidence shows that sulfates are probably somewhat more sensitive to  $\text{NO}_2$  than to ozone levels. As a result of the

strength of those associations it is our opinion that the investigation of photochemical pollutant reductions represents one of the more promising strategies for reducing sulfates; certainly at this time more promising than the strategy that satisfies simply to reduce sulfur dioxide.

I might add that all the smog chamber experiments seem to confirm our historical and statistical findings; that is, in smog chambers when you add  $\text{SO}_2$  to a good strong photochemical mixture you get similar results to what we found, a reduction of sulfates.

Our last research was to actually begin analysis of the health data. The health data we were able to work with consisted of specific disease mortality rates for about 42 cities, categorizing something in excess of 60 diseases covering almost all the major diseases in the United States, and about 25 different pollutant measurements for each city, pollution measurements based again on EPA monitoring networks.

Let me start by saying that I have very serious reservations about the data. I see all kinds of problems in the data that we used. We have strong reservations about the monitoring methods. We think they are probably inaccurate; they are not very specific. We have reservations about the idea that one monitoring site per city can possibly quantify human exposure. That is almost certainly not true.

We have a problem with the actual timing of the data. Unfortunately, the way the data are available, we have death rates available for 1959 to 1961 and pollutant levels only available from 1962 on.

So, this is unfortunate. We would much rather have pollutant levels before the deaths occurred.

Finally, as we have heard from a number of medical doctors, the evidence of a death certificate, the actual diagnosis of cause of death, is questionable in some cases, particularly in poor areas where medical care is not as intense.

Having stated those reservations let me also say that I think each of those problems with the data would tend to obscure any possible health relationships that you would find in the data and despite all those obscuring tendencies, in my opinion, we found some strong statistical relationships in that data.

Let me add one more caveat before I get on to the results and that is these are purely statistical results so far. That is, they are very analogous to the first result on smoking and lung cancer. They do not address the question of cause and effect. All they can tell you is that certain disease rates go up in those cities where certain pollutants go up. They cannot tell you in any sense that the pollutant caused the disease.

Given those caveats, let me very briefly tell you the results we found.

The first and perhaps the strongest association that we found was between nitrogen oxide and mortality rates due to hypertensive heart failure, that is heart failure due to high blood pressure, and the relationship was both clear and sizeable. That is to say, going from the cleanest to dirtiest cities we have seen in  $\text{NO}_2$  we see a doubling of death rate due to high blood pressure.

Let me state the numbers while I am at it.

The cleanest cities we have in our data base of 42 cities are the level of  $\text{NO}_2$  have about 0.03 parts per million. That relates to the national standard of 0.05 parts per million. It is not quite half of that.

The dirtiest cities in our sample are running about 0.08 parts per million. So, you can see that the results we are getting for effect of  $\text{NO}_2$  from high blood pressure or death due to high blood pressure extend well below the current national standard.

A second result we found for a much smaller death category was the same kind of relationship, roughly the same doubling from cleanest to dirtiest cities of death due to nephritis, degeneration of the kidney. That is a very small disease category and by itself would not be significant except, as I will discuss subsequently, it led us to some important hypothesis about causal mechanism for nitrogen dioxide versus high blood pressure.

Then we found a considerable less surprising result, a fairly strong relationship between nitrogen dioxide and lung cancer. The relationship incidentally was much stronger among women than among men.

This I think is consistent with the American Cancer Society's findings that smoking induced lung cancer is much lower among women than men, particularly among older women and older men.

Specifically for men over 65 we found a 50-percent increase in lung cancer, death due to lung cancer, between cleanest and dirtiest cities.

For women over 65 we found 130-percent increase in death due to lung cancer. I might add, however, that the absolute levels of lung cancer death rate among women over 65 are much lower than they are for men, perhaps a factor of 7, again consistent with the American Cancer Society's findings.

Smaller disease categories that seem to operate the same way were cancer of the larynx and cancer of the esophagus, both parts of the body that could be exposed to  $\text{NO}_2$  and where you would suspect that whatever mechanism is working in the lung a similar mechanism would be working in those parts.

Let me emphasize again that in the case of each of the statistical associations I have mentioned we have seen the effect down to the cleanest cities we have measured, that is all the way down to .03 parts per million.

Let me now add to those briefly stated conclusions some of the verifying tests and data that we have. First of all, the conclusions that I am stating are not based simply on the fact that in cities with high  $\text{NO}_2$  we see high deaths due to high blood pressure. We went through considerable more extensive statistical testing. We tested independent groups in the population; that is, we tested white males, white females, then by age group.

In the case of the high blood pressure association we have actually 12 independent groups in the population that all show the same association between  $\text{NO}_2$  and hypertensive heart failure. That gives us strong confidence that what we are talking about is not due to chance.

Independent of the question of cause and effect we are not talking about something due to chance.

Second, there is always the problem in this kind of statistical analysis that the effect you see is really due to some unmeasured second factor.

For instance, if it so happened that the true cause of hypertensive heart failure were pickle eating and it just happened that people eat

a lot more pickles in cities where there also happens to be higher  $\text{NO}_2$ , then we would have a completely spurious association.

Now, statistical analysis can only eliminate that type of thing for factors that are measured, and in fact we went through a long list of factors that were measured to make sure that this phenomenon was not happening here. The factors that we tested consisted of social economic variables, poverty level, education level. Percent of manufacturing employment, population density, and in addition to a list of 20 pollutants we tested, we tested specifically to make sure the  $\text{NO}_2$  effect could not really be covering for an underlying  $\text{SO}_2$  effect or sulfate effect or metals effect.

In fact, within the range of these measured values that we were able to get we can state that the effect was associated with  $\text{NO}_2$  specifically and not with the other pollutants that were available.

We cannot assure you that the effects we see are not associated with some unmeasured variable, not measured by EPA or not measured by the Bureau of the Census.

There is always that possibility.

On the medical side I think we have enough evidence to form some plausible hypotheses. I would like to briefly state what that evidence is.

For the cancers, cancer of the lung, et cetera, I don't think we have any particularly new evidence. I think other people long before us have observed that there could be carcinogenic effects of  $\text{NO}_2$ , that it forms nitrous acid which in turn in the tissues forms nitrosamines which are known to be carcinogenic. I don't think a carcinogenic effect of  $\text{NO}_2$  strikes most people in this field as being implausible.

The question of hypertensive heart failure effect of  $\text{NO}_2$  I think is much more surprising and striking, and I think that needs a little more discussing. The chain of evidence that we have constructed is the following:

It is known that breathing in of  $\text{NO}_2$  leads to measurable blood changes. Those blood changes include the formation of some fairly reactive free radicals including nitroxide, or iminoxyl free radicals. These are fairly recent results.

Second, it is known that in animals exposed to  $\text{NO}_2$  over a fairly long period of time the body organ that seems to suffer the most damage is the kidney, as opposed to the lung. I think most prior research in this area has emphasized the lung because it is so directly exposed to  $\text{NO}_2$ . However, a very important piece of work that was done a few years ago in guinea pigs shows that the kidney shows more metabolic damage than either the lung, the liver, spleen or the blood serum. That, from our point of view, is a very important observation.

Finally, it has been well known among doctors for a number of years that the kidney is a very important factor in the control of blood pressure in the body. That is, the kidneys secrete a substance known as renin, and renin is involved in a chain of reactions that in the end control blood pressure, along with other factors.

Therefore, I think it is easy to see where our hypothesis is leading us. Our hypothesis that we oversimplify that  $\text{NO}_2$  produces certain toxic substances in the blood which attack kidney tissue and the degeneration of the kidney tissue in turn upsets the renin balance within

the body which in turn affects blood pressure throughout the body, which in turn results in the end effects that we have seen which are noticeably enhanced death rates due to high blood pressure.

Let me emphasize that this is a hypothesis. The data I have quoted only make it plausible. They do not prove it, in any sense. It remains to be either confirmed or denied by what I think are some fairly simple and so fairly straightforward animal experiments.

In summary, let me say that our results I think are important for pointing the way for investigations to see whether the death effects we are talking about are real cause and effect or not. If they are cause and effect, then I think we have real reason to doubt that the national standards are adequately protecting human health, that is, the photochemical pollutant national standards. And I believe that that doubt is reinforced by all available animal toxicological experiments.

Thank you, Mr. Chairman.

[Mr. Sprey's prepared statement follows:]

STATEMENT OF PIERRE M. SPREY, VICE PRESIDENT, ENVIRO CONTROL, INC.,  
ROCKVILLE, MD.

Mr. Chairman, I am pleased and grateful to have the opportunity to testify before this Committee. I only hope that my testimony may prove to be of some use to the Committee in these important deliberations.

First, I would like to explain the nature of the project that lead to the findings I will present today. The company of which I am a vice president, Enviro Control, Incorporated, has continuing interest and on-going programs in health research both in the area of air pollution effects as well as in cancer research. As a result of this interest, in October 1972, we formed a team to develop new methods for relating available health indices to measures of air pollution. We developed the methods used in the current study under EPA Contract Number 18-01-0471; this research is continuing with EPA funding. Our team's specific work on the review of photochemical pollutant toxicology and the analysis of disease rates related to these pollutants was funded by Gould, Inc. The senior researchers on the team included John Morton, a Cambridge biochemist with 5 years of experience in toxicology and respiratory disease; Istvan Takacs, a graduate epidemiologist from Johns Hopkins University; Kenneth Allison, an air pollution meteorologist from the Naval Post Graduate School with 15 years of experience in meteorology, and myself, a systems analyst and mathematical statistician with experience in health and biostatistics.

The detailed results to date of our research relating to the effects of photochemical pollutants are contained in an Enviro Control document that I am submitting for the record, titled "A Study of Photochemical Pollutants and Their Health Effects" and dated September, 1973. This document is being distributed to interested authorities in the field in order to obtain thorough and critical review of our work. I would like to briefly summarize findings for the Committee as follows:

1. Based on toxicological studies reported in the air quality criteria documents, as well as new research reported since then,  $O_3$  shows significant cumulative oxidative damage to animal tissue similar to the effects of radioactivity (including genetic effects). Effects have been observed almost down to the level of the national primary standard and well below actual peak levels observed in some American cities.

$NO_2$  also shows cumulative oxidative-type effects in animal experiments. Both lung and other organs are affected at levels down to as little as a factor of 2 above the national primary standard. Short term effects causing cumulative damages are known to exist; this argues the need for a short-term standard in addition to the existing annual standard.

This is in strong contrast to the  $SO_2$  standard, which provides one to two orders of magnitude of safety margin relative to damage-causing levels observed in toxicological experiments.

2. Annual means of  $\text{NO}_2$  have increased slightly less than 30% between 1965 and 1972, based on data from 6 CAMP<sup>1</sup> cities (using Saltzmann  $\text{NO}_2$  values) and 12 NASN<sup>1</sup> cities (using the Jacobs-Hochheiser method). Within this period, most of the NASN cities studied increased sharply in  $\text{NO}_2$  from 1965 to 1968, then decreased sharply for the next two years and have increased again for the last two years. CAMP cities have shown considerably less variation over the same period but confirm the recent rise in  $\text{NO}_2$ .

Over the same period,  $\text{O}_3$  has decreased consistently across the CAMP cities by a slightly greater amount than  $\text{NO}_2$  has increased—presumably due to increasing hydrocarbon emission controls. The level of additional  $\text{NO}$  emission reductions needed to reverse the upward trend in  $\text{NO}_2$  cannot be calculated because of the major uncertainties in quantitatively relating  $\text{NO}$  and hydrocarbon emissions to  $\text{NO}_2$  and  $\text{O}_3$  end-products.

The photochemical process that produces  $\text{NO}_2$  and  $\text{O}_3$  has also been implicated in the production of sulfates (including sulfuric acid) from  $\text{SO}_2$  based on a number of smog chamber experiments. The importance of sulfates as an air pollutant stems from the fact that certain sulfates are a strong lung irritant at concentrations two orders of magnitude lower than irritating levels of  $\text{SO}_2$ . EPA's CHESS experiments in New York show cardiac and respiratory disease symptoms among the ill to be more strongly related to daily sulfate levels than to  $\text{SO}_2$  levels. Previous work by ECI shows a strong statistical association between sulfates and all forms of gastro-intestinal cancer as well as between sulfates and arteriosclerotic heart disease. These findings are in agreement with the NATO CCMS Air Quality Criteria for Particulate Matter which refers to similar sulfate relationships with observed gastro-intestinal cancer rates. Although a sulfate standard has yet to be promulgated, the desirability of sulfate reductions is relatively clear. Unfortunately, the intuitive notion that  $\text{SO}_2$  reductions should lead to sulfate reductions is contradicted by the evidence of the 12 NASN cities studied, where even large reductions in  $\text{SO}_2$  (e.g., a factor of 8 in New York since 1965) led to no change in sulfate levels. In fact, the evidence shows no relationship between sulfates and  $\text{SO}_2$  increases or decreases for any of the cities with the possible exception of Charleston.

Analysis of daily CAMP-monitored pollutant levels for Chicago, Philadelphia, Washington and St. Louis showed a strong statistical association between sulfates and the photochemical end-products,  $\text{NO}_2$  and  $\text{O}_3$ . All cities, except Washington, showed a stronger association of sulfates with  $\text{NO}_2$  than with  $\text{O}_3$ . This historical evidence, combined with the smog chamber results, indicates that (a) the photochemical process is an important part of the total sulfate production and (b) that emission controls for reducing photochemical activity represent a promising sulfate reduction strategy.

3. In order to search for new pollutant vs. chronic disease associations, non-parametric statistical techniques were applied to the analysis of annual age-sex-race-cause specific mortality rates (1959-1961) for 42 cities monitored by the NASN beginning in 1962. Pollutant measurements available included  $\text{NO}_2$ ,  $\text{SO}_2$ , total particulates, sulfates, nitrates, benzo(a)pyrene, and about 20 metals. The deficiencies of the data were manifold:

a. One monitoring site per city gives a very poor representation of population exposure.

b. Monitoring methods for  $\text{SO}_2$ , sulfates, nitrates, particulates, etc. are quite imprecise; in particular,  $\text{NO}_2$  was monitored by the Jacobs-Hochheiser method the deficiencies of which are widely known.

c. The air quality data used to represent individual city pollutant levels was taken after the deaths occurred; one would certainly prefer data over the decade prior to the deaths, were they available. In the absence of prior monitoring, one can only hope that the relative pollutant levels between cities did not change greatly over the preceding 5-10 years.

d. The mortality rates are derived from death certificates which are often based on highly uncertain diagnoses of cause-of-death.

Each of these deficiencies should contribute strongly to obscuring any underlying pollutant vs. chronic adverse health effect relationships. In spite of these weaknesses, a number of clear specific associations between  $\text{NO}_2$  and certain diseases were detected.

<sup>1</sup>CAMP is EPA's Continuous Air Monitoring Program; NASN is EPA's National Air Surveillance Network.

It should be emphasized that these, or any other, statistical association *cannot* represent proof of cause-and-effect; they can only indicate suspicion of cause-and-effect to be confirmed or denied by subsequent laboratory and clinical investigations demonstrating an actual biological disease mechanism. Given this important caveat, the results found were as follows:

a. A strong statistical association between annual mean  $\text{NO}_2$  levels and hypertensive heart disease annual mortality rates (hypertensive heart disease is the third largest fatal disease category in the population at large)—this amounted to a doubling of death rate between lowest and highest annual levels of  $\text{NO}_2$  observed in the sample of cities studied.

b. An equally strong statistical association of  $\text{NO}_2$  with death due to nephritis—a considerably smaller death category.

c. A statistically strong association of  $\text{NO}_2$  with respiratory and upper gastrointestinal cancers, specifically, with lung cancer, cancer of the larynx, and cancer of the esophagus. The latter two cancers are shown to be associated with both ambient  $\text{NO}_2$  and sulfate pollutants. Based on previous ECI studies, the remaining gastro-intestinal cancers are all also associated with sulfate levels: the present work demonstrated that none below the esophagus are affected by  $\text{NO}_2$  levels. Lung cancer death rates for men over 65 increased by 50% from lowest to highest observed levels of  $\text{NO}_2$ ; for women over 65 the increase was 130%.

d. Each of the above associations showed effects down to the lowest  $\text{NO}_2$  levels observed, that is, .03 ppm which is not quite one-half of the current national standard of .053 ppm.

e. A plausible, though yet unverified, mechanism for the observed association between  $\text{NO}_2$  and hypertensive heart disease is proposed: inhaled  $\text{NO}_2$  forms toxic end-products in the bloodstream (possibly nitroxide or iminoxy free radicals) which cause degeneration of kidney tissues and interfere with the kidney's blood pressure regulating function (i.e., the secretion of renin).

All these associations had considerably more support than just the evidence of good single variable statistical curve fits. Each one was tested in two-variable analyses for  $\text{NO}_2$  and the other major pollutants (e.g.,  $\text{NO}_2$ , particulates, nitrates, benzo(a)pyrene, sulfates, metals) in order to ensure that  $\text{NO}_2$  was not operating as a proxy for the second pollutant. Similarly, climate and socio-economic variables for each city (e.g., degree-days, poverty level, population density, percent employment in manufacturing, education level) were also tested. These tests did, in fact, reject a number of promising  $\text{NO}_2$  vs. disease associations. However, none of the associations shown in the study findings were weakened by the addition of two-variable tests; thus, the results can be said to be specific to  $\text{NO}_2$  *within the range of pollutants measured by NASN*. For the largest disease category, hypertensive heart failure, the sample size was sufficiently large to confirm that the association was clear for every single age group above 35-44 for both white males and females. For non-whites, the data were much "noisier" and only showed a good association for the total population rather than the individual age groups.

It is important to note that these statistical associations cannot eliminate the possibility that there is an unknown second factor which varies directly with  $\text{NO}_2$  and represents the true underlying cause of the observed chronic health effects—for instance, some exotic organic nitrogen end-product of the photochemical process which is linearly proportional to  $\text{NO}_2$  levels. However, there are a number of biologically plausible (though certainly unproven) hypotheses to explain the results seen:

a. For the cancers, it is known that  $\text{NO}_2$  forms nitrous acid in the lungs which in turn reacts with amines to form nitrosamines. Certain nitrosamines are known to be carcinogenic. Alternatively, the oxidative effect of  $\text{NO}_2$  destroys vitamin A which is known in rats to protect the lungs against chemical carcinogenesis, presumably via the enhanced mucus production attributed to vitamin A. A more remote possibility is that the oxidative damage caused by  $\text{NO}_2$  is similar to emphysema, which is often thought of as a precursor of lung cancer.

b. For the hypertensive heart failure relationship, the known blood changes associated with  $\text{NO}_2$  may cause damage to the kidney (one significant animal experiment study shows that  $\text{NO}_2$  exposure causes considerably more evidence of metabolic disturbance of the kidney than of the lung, the liver, the spleen and the blood serum). The kidney produces renin, which is thought to be a principal regulator of overall blood pressure levels. Other forms of kidney damage, such as infection and irradiation, have been clinically observed to be precursors of

high blood pressure (one of the NO<sub>2</sub> toxicological studies observed nephritis in 50 to 70% of the older rats exposed to Los Angeles air, though this experiment was not controlled for the NO<sub>2</sub> effects on the kidney). This hypothesis could tie together the observed NO<sub>2</sub>-nephritis and NO<sub>2</sub>-hypertensive heart failure associations.

Summarizing the epidemiological findings, it can be said that there are clear and specific statistical associations between NO<sub>2</sub> and hypertensive heart failure, nephritis, lung cancer, cancer of the larynx and cancer of the esophagus. These findings do not prove cause-and-effect nor are they adequate as a basis for setting standards; however, they do lead to a number of plausible hypotheses which are amenable to direct laboratory proof and which should be tested. Furthermore, because the statistical associations extend down to levels well below the national standard for NO<sub>2</sub>, there are doubts as to whether the existing national ambient nitrogen dioxide air quality standard adequately protects human health—doubts which are meaningfully reinforced by the available toxicological evidence.

Mr. ROGERS. Thank you very much, Mr. Sprey. We appreciate your testimony.

Mr. Satterfield.

Mr. SATTERFIELD. Thank you, Mr. Chairman.

Mr. Sprey, one thing that interests me in connection with these studies is that you give rather specific readings for nitrogen dioxide in the air. What method was used to measure this nitrogen dioxide in the studies upon which you have relied?

Mr. SPREY. We can only use the data that are available. This is one of the reasons that I mentioned my reservations about the data. The method EPA used for these 42 cities was the Jacobs-Hochheiser method, the only Federal reference method. In fact, I think it still is. But EPA has announced that they would like to replace it for pretty good reasons.

Mr. SATTERFIELD. Because of erroneous readings; is that right?

Mr. SPREY. Yes, because of erroneous readings.

Now, what direction they were erroneous in and why is by no means clear. This is one of the reasons why I hasten to say that our study does not form an adequate basis for setting a national standard, nor was it intended to, because we are basing our study on a set of measurements that in fact cannot be related to absolute NO<sub>2</sub> levels.

I might add that no other measurements available today can be related very well to absolute NO<sub>2</sub> levels either, as far as we know.

Mr. SATTERFIELD. I understand that. This places some question upon your observations, it seems to me, that there is not a sufficient cushion. We are relying on figures that you cannot validate.

Mr. SPREY. Let me say this: I think for setting standards these numbers are certainly not adequate. On the other hand, few people doubt that when the Jacobs-Hochheiser measurement indicates a high level of NO<sub>2</sub> in a city as opposed to another, I think few people doubt that in fact the underlying level of NO<sub>2</sub> really is higher. The real problem is that we don't know how much higher and we don't know how to relate it to absolute levels. So I think the fact that as this Jacobs-Hochheiser measurement increases across cities we see an increase in hypertensive heart failure has to have some significance. That does not mean, again, cause and effect significance. It simply means I think we have uncovered a real health problem.

Unfortunately, we cannot quantify it very well. It is very frustrating for us. We wish we had better measurements to rely on.

Mr. SATTERFIELD. Certainly I don't agree with that observation. But you seem to be indicating that the national standard which I think is .05 parts per million may be too high. The point I am raising is that we really don't know that, do we, because the readings we have gotten from the method that EPA employed in the past apparently have not been accurate.

Mr. SPREY. Let me say that the national standard when promulgated was based upon the Jacobs-Hochheiser method, for all its defects.

Mr. SATTERFIELD. But EPA tells us now they don't think there is as much nitrogen dioxide in the air as they had earlier thought. This would lead to the conclusion that the standard may give you a greater cushion.

Mr. SPREY. I think it works the other way, if I am not mistaken. EPA, as you know, has proposed a reclassification of the air quality regions. We have used the data that they published in the Federal Register to examine this question. The main support for their reclassification is based on a measurement method known as arsenite. We have actually plotted arsenite results for 40 cities versus Jacobs-Hochheiser, or Federal reference method results. That is in figure 1 of the document I submitted for the record. Interestingly enough, in that case we find the arsenite measurements are quite close to half the Jacobs-Hochheiser measurements. There seems to be a simple proportional relationship between the two readings.

Now, what that implies from our point of view is simply that if we had used arsenite readings, if someone had given us arsenite readings for 40 cities we would see the same result as we see now, but at half the level. In other words, our cleanest cities would have now measured instead of .03 would have measured .015. Our dirtiest cities instead of .08 would have measured .04. We would now be saying in our data we are observing statistical effects down to a level of .015. I think it is kind of in the opposite direction you are indicating.

If in fact the arsenite method were good we would be seeing  $\text{NO}_x$  effects at considerably lower levels and we would have stronger leads about the numerical level of the national standard of .05.

Mr. SATTERFIELD. Yesterday we were talking about  $\text{NO}_x$ . Is that the same thing as sulfur dioxide?

Mr. SPREY. No. Let me go through the pollutants we are talking about here.  $\text{NO}_x$  is simply the sum of all oxides of nitrogen, whether it is  $\text{NO}_2$ ,  $\text{NO}_3$ , or  $\text{NO}_5$ , any form like that.  $\text{NO}$  is the single largest constituent of the nitrogen family in car exhaust. It is one of the basic fuels for the photochemical process. It is not particularly toxic in its own right. It is only after ultraviolet light works on this photochemical group, which consists of  $\text{NO}$  plus hydrocarbons and other things, that you get the toxic end product, of which the one we are addressing is  $\text{NO}_2$ . The other very toxic end product is  $\text{O}_3$ , ozone. These are both end products. The national ambient standard we are talking about relates to  $\text{NO}_2$ , or nitrogen dioxide.

Mr. SATTERFIELD. We were told yesterday by EPA that they had determined that there was not as much nitrogen pollution in the air as they had previously thought. Just to make the record straight, you are not saying you disagree with that conclusion? Are you? Or are you saying that?

Mr. SPREY. Let me say I don't have any faith yet in any of the measurement methods. So I am not sure whether the statement is true in that sense. In the sense that most of the cities might be at numerically lower levels than we thought under the Jacobs-Hochheiser method, that is perfectly possible. Whether the cities are therefore in less health trouble, I would categorically deny. I don't think whether we change our mind about what the absolute measurement is has anything to do with whether they are in health trouble. Whether they are in health trouble has to do with what the effects of  $\text{NO}_2$  are and what they have been.

The steadily increasing levels I have talked about since the early 1960's and the actual levels experienced by our cities have very little to do with what people think they have measured. At least if we have faith in either the Jacobs-Hochheiser method or the Arsenite method, either way our statistical result would show there is a real association with  $\text{NO}_2$  as it presently exists in the cities, as it presently exists in almost all cities.

We did not find a city that was clean enough to be below the levels of effects we saw. That is not all cities in the United States, it is only 42 cities.

Mr. SATTERFIELD. What you are really saying is that we need better testing methods and we ought to be working on it.

Mr. SPREY. Yes. I know EPA is working hard on that.

Mr. SATTERFIELD. They are? You say you know they are?

Mr. SPREY. They are working very hard on getting better measurement methods for  $\text{NO}_2$ . Everybody is very uncomfortable with the situation.

Mr. SATTERFIELD. They are actually doing research work?

Mr. SPREY. Yes.

Mr. SATTERFIELD. Thank you very much.

Mr. ROGERS. Dr. Carter.

Mr. CARTER. Thank you, Mr. Chairman.

Mr. Sprey, there is one paragraph in your dissertation that strikes me as particularly meaningful at this time, and that is on page 4, the second paragraph. I am in thorough agreement with that:

It should be emphasized that these, or any other, statistical associations cannot represent proof of cause-and-effect; they can only indicate suspicion of cause-and-effect to be confirmed or denied by subsequent laboratory and clinical investigations demonstrating an actual biological disease mechanism.

What you have is suggestive, mildly suggestive, perhaps, that it could affect some people who haven't studied this a little more deeply, very greatly, and influence them a great deal. There certainly is an association but the cause-and-effect premise is not really proven, it is only suggested, as I see it.

According to your testimony, you think that  $\text{NO}_2$  and  $\text{SO}_2$  are the cause of all the ills that flesh is heir to. I can't agree that that is correct. After all, we know that there are many, many other factors which cause arteriosclerotic heart disease. And personally I would like to see more statistics, more figures, showing that heart failure is more prevalent in cities having a high concentration of  $\text{NO}_2$ .

Then when we get down to kidney disease, there is a definite association between kidney disease and the presence of  $\text{NO}_2$  in the air. That

may be so. It might make these diseases worse but we have known most of the causes of kidney diseases over the years.

Then I believe you stated that renin is produced by the kidney. I think you are referring to a substance not produced by the kidney, but by the suprarenal gland, which raises the blood pressure.

All in all, I might say that what you say is suggestive. There may be cases in which there is some basis for what your statistics seem to show. If the air is more polluted in London than it is in the United States, perhaps it could account for the higher lung cancer rate in that area. But London has recently cleared up its air and now they burn coke or gas, I believe, instead of coal, which they formerly burned. I think that the lung cancer situation has gone down.

The same ratio as that in the United States existed in Holland, and also in Australia. Even though those people do not smoke as much, it is possible that contamination in the air is so great it has some effect.

As to the effect on the lungs, there is that possibility. We know of course when we do have smog over areas, as we had over Donora, Pa., that the incidence of respiratory disease increases; we must agree with that. But to say that these factors cause so many diseases would be going a little too far. To say that they aggravate certain diseases I might agree with.

Thank you, Mr. Chairman.

Mr. ROGERS. Thank you.

Mr. Preyer.

Mr. PREYER. Thank you, Mr. Chairman.

Thank you, Mr. Sprey, for some very interesting and strong testimony. I agree with Dr. Carter that it would be easy to sensationalize your testimony. I think you would be the first to complain of that because I certainly admire the scientific restraint you have shown here. You have repeatedly cautioned that this is not proof of cause-and-effect, but that it is suspicion of it. Statistical associations are tricky to deal with. Statistics don't always lie but they seldom voluntarily tell the truth. This may be another such situation.

For instance, take the heart disease association with dirty cities. There are probably a lot of frustrations of city life in addition to NO<sub>2</sub> that may have some bearing on the heart disease rate.

Mr. SPREY. May I comment on that, Mr. Preyer?

That is the reason we collected social and economic variables such as population density, absolute size of city, population level and so on. We found that the effect we saw was independent of those factors. Even when you had corrected for those factors you still saw this strong NO<sub>2</sub> association. So I believe at least to the extent that you can say that city stress is associated with size of city or population density, that we have taken care of that factor.

Mr. PREYER. I am impressed with the caution you have shown and the care with which you have approached this problem. This makes me concerned that you may have hit on something that is quite important.

You say these are hypotheses which are amenable to direct laboratory proof so that we don't have to speculate. Can we expect that proof to be forthcoming? What should we do by way of testing?

Mr. SPREY. I have no control over the kind of testing of animals that is done either in the medical community or in the air pollution-

health community. I can only make my recommendation through my published papers. I believe that the answers could probably be obtained within 6 months to a year, and at relatively low cost. In fact, they could probably be obtained from experiments already planned for other purposes. After all, over the next year there are going to be plenty of rats, mice, and guinea pigs exposed to NO gas. I think all we would need is to have qualified pathologists examine their kidneys after long term exposures and have blood analyses done and have measurements of blood pressure taken between NO<sub>2</sub> exposed animals and controls groups in clean air. I think that would settle the issue of whether we are talking about direct cause-and-effect. It would not have gotten to the bottom of the chemical mechanism but it would certainly either confirm or deny what we have been talking about here.

Mr. PREYER. Is that being done? Is that going to be done?

Mr. SPREY. I have no way of really knowing whether that is planned to be done or not. All I say is that it could be done and at very low cost. Probably it could be done piggyback on already planned experiments.

Mr. PREYER. It seems to me what you have brought out here is sufficiently important that we ought to make sure that it is done.

Thank you for your testimony.

Mr. ROGERS. Mr. Symington.

Mr. SYMINGTON. Thank you, Mr. Chairman.

Mr. Sprey, were these studies you have done financed by EPA or were they paid for?

Mr. SPREY. The bulk of our research in this area, that is in the air pollution health effects, and the basic methodology development, were financed by EPA. Our work for EPA in the area of investigating air pollutants versus the city-by-city mortality rates is continuing. The specific part on toxicology of nitrogen dioxide and of ozone and on analysis of these 40 cities specifically for diseases associated with nitrogen dioxide, was funded by Gould, Inc., as I think I said in the beginning of my testimony. That is the lesser part of our overall project. The same people work in both areas.

Mr. SYMINGTON. But you submit the total findings to EPA?

Mr. SPREY. Yes.

Mr. SYMINGTON. And not simply those that they finance?

Mr. SPREY. Oh, yes, absolutely, though under separate cover.

Mr. SYMINGTON. So one assumes that they incorporate into their final judgments what they think they have learned from your studies?

Mr. SPREY. Yes, sir.

Mr. SYMINGTON. Are you familiar with their testimony before this committee?

Mr. SPREY. I have looked over yesterday's testimony. I can't say I am familiar with it in great detail.

Mr. SYMINGTON. I am just wondering if you concur with the general thrust of their testimony.

Mr. SPREY. I don't think they testified on our work. You know, our work is very new to them. Their review process of a piece of work like this probably takes 2 to 6 months, and only a very small part of EPA has been following our work very closely.

Mr. SYMINGTON. I am referring to their judgments with respect to reducing the standards for emission control, that sort of thing, as

having been too stringent in the past. Are you passing, like ships in the night, you don't know what those standards were all about, to begin with, so you are not going to comment on them?

Mr. SPREY. Oh, no.

Mr. SYMINGTON. Or do you have an opinion about that?

Mr. SPREY. Yes, I can state my opinions on that subject. Let me state that first of all I don't think anybody has close to adequate quantitative knowledge of the relationship between the auto emissions, that is the basic NO, and hydrocarbons that fuel the photochemical process and the end products, the toxic end products, NO<sub>2</sub> and O<sub>3</sub>, to in any sense be able to predict how much reduction of automobile emissions will be necessary to get us down to safe levels of NO<sub>2</sub> and O<sub>3</sub>.

I personally don't believe that the simple rollback calculations are in any sense verified by anything we know about photochemical pollution. What I would say is that if our results are verified on NO<sub>2</sub> and if they turn out to be cause-and-effect, then we will need very large reductions in NO<sub>2</sub> levels in cities.

Mr. SYMINGTON. Is it your understanding that verification is proceeding apace?

Mr. SPREY. Of our results?

Mr. SYMINGTON. Yes.

Mr. SPREY. I have not heard anybody who is verifying them yet. Of course they are new.

Mr. SYMINGTON. Who would do so? Would it be EPA?

Mr. SPREY. It could be EPA, it could be NIH, it could be universities, whoever shows enough interest in our findings to show the worth of the experiment. We have no indications that anybody has committed themselves to do these experiments. We hope somebody will.

Mr. SYMINGTON. You have a relationship with EPA already, as you pointed out, they fund part of our work.

Mr. SPREY. Yes, and they are aware of these recommendations.

Mr. SYMINGTON. Have you asked them for assistance in pursuing them to a conclusion?

Mr. SPREY. We would not do the animal experiments. That is not part of what our company does.

Mr. SYMINGTON. Have you asked that they do it?

Mr. SPREY. We have recommended to them that we think it is of high priority that such experiments get done.

Mr. SYMINGTON. When did you make that recommendation?

Mr. SPREY. Other than as you see it in this written document, prior versions of which they have had for, say, 3 weeks, on the order of 3 weeks. I have also made that recommendation verbally as long ago as perhaps 5 weeks ago. So this is all very recent work that we are talking about.

Mr. SYMINGTON. Can you provide for the record what it costs to produce the information that you have presented to us today? In other words, the budget that your organization worked with?

Mr. SPREY. Sure. I would be delighted to do that.

Mr. SYMINGTON. And the number of people employed and their skills.

Mr. SPREY. Yes, sir.

[The information requested was not available to the committee at the time of printing—March 1974.]

Mr. SYMINGTON. For example, you cover 40 cities, is that right?

Mr. SPREY. Right.

Mr. SYMINGTON. How many people were involved? Did you send teams to each city, or did you do it through correspondence, or how did you actually glean this information?

Mr. SPREY. As I mentioned before, the air pollution measurements were EPA's and EPA's predecessor organization's measurements. They are published and available. Likewise, the death rate data is published and available data. It was really a question of gathering that data, editing it, cleaning it up, looking for mistakes in it, checking with cities on where the actual locations of monitoring stations were, and then getting down to the work of analysis.

Mr. SYMINGTON. Now, the data that you said that were EPA derived, are that data subject to the defect in measurements that you alluded to?

Mr. SPREY. Yes, it certainly is.

Mr. SYMINGTON. So you yourself are dealing with data that you can't really trust?

Mr. SPREY. Yes. As I said before, I have very strong reservations about both medical data and perhaps even more about the air pollution measurements themselves.

Mr. SYMINGTON. And you have made at least one recommendation that there ought to be more monitoring stations. You have a list of recommendations for improving the measurement process?

Mr. SPREY. Yes. Actually, that particular recommendation I made long before this study. I think that is self-evident for other reasons, the fact that air pollution varies quite widely across the city.

Mr. SYMINGTON. I think we are sort of interested in the rapport that would exist between a private concern like yours and EPA, that it is not a one-way street, that if you think they are doing something wrong you point that out, and you expect a fair hearing on it. Is that the sort of relationship you have?

Mr. SPREY. In the first place, I don't think I am saying that they are doing something wrong, per se. I am just saying that we need improvements in these areas. These monitoring networks we are talking about were first set up in 1962. I think you could hardly expect a young organization, straight from birth, to go out and set up a perfect monitoring network. So we are recommending things that we think would improve that monitoring. As far as our relationship with EPA goes, I think it is like with any other large Government organization. As a friend of mine in the Pentagon once said, "Those in the real Air Force please stand up." EPA does not have a monolithic position. Some people have expressed interest in our work at EPA. Others think it is very poor. There is a whole spectrum of opinion on this.

I think the real question is how well can we defend our findings and whether in the end people who are decisionmakers like our work or don't like our work. There is no monolithic relationship between us and EPA. Some think we do good work and listen to our recommendations, and some don't.

Mr. SYMINGTON. Do you think that we know enough, that the data is sufficiently accurate to justify the kind of legislation that has been passed and which is currently pending?

In other words, you don't think we should just wipe everything off the books until we are sure?

Mr. SPREY. No. I wouldn't say that at all. I think perhaps looking back over the history of this legislation the data that existed when the legislation was first passed was certainly quite weak from a scientific point of view. I think subsequent data and subsequent events have been surprisingly confirmatory of the original Clean Air Act requirements. I am talking now about both the kind of data that we work on and what I know of what has been happening in the cleanup technology.

I think on both sides data that were developed subsequent to your passing the act have tended to confirm in a very proximate sense the choice of goals you picked.

Mr. SYMINGTON. The thing that worries you most is the skill in measuring and the degree of skill. Do you think that their research in pursuing accurate measurement procedures is sufficient?

Mr. SPREY. Are you asking me whether I think they are spending enough money on that research now?

Mr. SYMINGTON. Well, we are sometimes told that money helps in these things. Occasionally there are other avenues to progress.

Mr. SPREY. I am not privy to what has been going on in the last few weeks in monitoring research. Looking at the long term, say over the last 5 years, I would say that the progress made in monitoring research has been disappointingly slow. I suspect not enough emphasis has been placed on this question.

Mr. SYMINGTON. Thank you very much.

Thank you, Mr. Chairman.

Mr. ROGERS. May I just ask a question for the record to get this down.

From your data do you see most cities in the country being relatively safe from adverse effects from  $\text{NO}_2$  concentrations?

Mr. SPREY. It is hard to guess about the air pollution levels of cities that haven't been measured. To the extent that our sample I would say there are very, very few cities in this country that are at safe levels. I had better qualify this once again, that are at safe levels in the relationship we are talking about which is cause and effect.

Mr. ROGERS. Had the Arsenite method rather than the Federal reference method been used on the 42 cities that have been measured? I guess that would make a difference in your conclusion.

Mr. SPREY. None whatsoever. As I said before, if we had used our graph that were half the level of what we are saying. That does not change the fact that the cleanest cities according to the Arsenite measurements would probably still be showing these effects of  $\text{NO}_2$ .

Mr. ROGERS. How serious are the health effects that are seen—I realize that you gave a quick overview—in the 42 cities from  $\text{NO}_2$  concentrations?

Mr. SPREY. Let me again qualify. If what we are seeing is cause-and-effect, as Dr. Carter I think pointed out, which we do not yet know, if it is cause-and-effect we are talking about a very large number of deaths, hypertensive heart failure is the third largest killer of the population at large. We are talking about a doubling of hypertensive heart failure.

Mr. ROGERS. Where there is a high concentration there is a doubling?

Mr. SPREY. That is right.

Mr. ROGERS. If that is a cause-and-effect it has not been proved?

Mr. SPREY. We would be talking about a large number of deaths. Similarly with lung cancer, which is not quite as large as cause of death, it is the fifth cause of death, perhaps half as large as hypertensive heart failure.

Mr. ROGERS. Did you submit the figures in the study you have given us?

Mr. SPREY. The doubling?

Mr. ROGERS. Yes.

Mr. SPREY. Yes.

Mr. ROGERS. Those figures are submitted?

Dr. Carter also would like to see them.

Mr. SPREY. Yes, sir.

Mr. ROGERS. Thank you.

Now, what about the significant mortality effects from oxidants in the air?

Mr. SPREY. I think it is important to point out that we have no conclusions from our statistics on oxidants. That is not because oxidants do or do not have effect, it is because, unfortunately, this air monitoring network we worked with never measured oxidants. That is one of the real disappointments in this data. It would have been very important to have both oxidants and nitrogen dioxide measurements simultaneously. All we can say is in the animal toxicology we could expect equal serious effects of oxidants as  $\text{NO}_2$ . Oxidants are by weight a little more toxic than  $\text{NO}_2$ .

Mr. ROGERS. Can you now measure the oxidants?

Mr. SPREY. No, they do not measure the oxidants except at about eight cities in the Federal network.

Mr. ROGERS. But it is possible to do so.

Mr. SPREY. It is very easy to do it. It is not being measured at enough cities that we could do this kind of analysis.

Mr. ROGERS. Is it possible to have formation of photochemical oxidants in the atmosphere without the presence of  $\text{NO}_x$  emissions?

Mr. SPREY. No, that is not possible.  $\text{NO}_x$  is one of the essential fuels for making—I call them fuels—one of the essential inputs for making both oxidants and  $\text{NO}_2$ .

Mr. ROGERS. Is it reasonable to control the formation of photochemical oxidants solely by reduction of hydrocarbon emissions?

Mr. SPREY. That is a very important question. I think popularly the way air pollution control is presented, unfortunately, people are given the impression that if you have an ozone problem then you reduce hydrocarbons. If you have an  $\text{NO}_2$  problem then you reduce  $\text{NO}_x$ . If you have a sulphate problem then you reduce  $\text{SO}_2$ . That is a very unfortunate way to go about reducing pollutants, particularly the photochemical pollutants. We can in no sense separate what causes  $\text{NO}_2$  from what causes  $\text{O}_3$ . All we know is that the basic inputs to that process are hydrocarbons and  $\text{NO}$ , both from cars, and to some lesser extent from stationary sources.

We do not know that cutting hydrocarbons by itself, you know, is the best way to reduce oxidants. In fact, it may be a very unusual way. The State of California takes the view that to reduce the severity of the photochemical problem you should reduce hydrocarbons and

NO<sub>x</sub> in a balanced way. I think that is very important. I think we have not really done enough experiments yet to determine that proper balance.

Mr. ROGERS. Anyhow, your impression is that by just reducing the hydrocarbon emissions one would not necessarily handle the problem?

Mr. SPREY. That is correct. In any case, it almost undoubtedly would not be the most efficient or least costly way to do it.

Mr. ROGERS. What about the current data on air quality concentrations of sulphates in major urban areas? Have you looked at that problem?

Mr. SPREY. Yes, I think I mentioned, although my testimony is not directly connected with that, we have done work in this area confirming EPA's own findings and confirming the air quality criteria. From our own analysis we see something of what we see in NO<sub>2</sub>. We see effects again down to the cleanest cities with sulfates, we are talking about well down to under 10 micrograms, in the area of 4 to 6 micrograms, the effects we are talking about that we have been looking at, each of the gastrointestinal cancers taken by themselves as well as effects in arteriosclerotic heart disease.

Mr. SYMINGTON. Would the chairman yield a moment?

Mr. ROGERS. Yes.

Mr. SYMINGTON. Thank you, Mr. Chairman.

Is it possible to have a chart of these cities, Mr. Sprey?

Mr. SPREY. Oh, yes, I can name the cities, certainly; I will submit them for the record.

Mr. SYMINGTON. If you would submit them for the record, together with the precise pollutant levels and then coordinate with the death rate from the relevant diseases. I think it might be helpful for the committee to contact the health communities of those cities and see if they could corroborate the findings. Wouldn't you think, Mr. Chairman, it might possibly put them on notice?

Mr. ROGERS. Yes, if you would let us have that information.

Mr. SPREY. I will also provide you with the exact reference where we got the death rates and the pollutants measurements.

Mr. ROGERS. That will be helpful.

[The information requested was not available to the committee at the time of printing—March 1974.]

Mr. ROGERS. Dr. Carter.

Mr. CARTER. Do I understand correctly that you said the concentration of sulphates in some of these cities was 4 to 6 micrograms per cubic meter?

Mr. SPREY. What I said specifically was that we have seen effects down to the cleanest cities, which seem to be running something like 4 to 6 micrograms per cubic meter.

Mr. CARTER. Those are in the cleanest cities?

Mr. SPREY. Right; we have dirty cities all the way up to, as I remember, all the way up to maybe 30 to 50. There are one or two cities that are probably well beyond that, but by and large the class of really dirty cities—

Mr. CARTER. Thirty to 50 micrograms, is that correct?

Mr. SPREY. Yes, sir.

Mr. CARTER. To make this a little plainer so that the layman could see it, 1 grain is what part of an ounce, really?

Mr. SPREY. I don't even remember my metric conversions. I guess there are a couple of hundred grams to an ounce.

Mr. CARTER. As a scientist I think you should know these things. A gram is one-thirtieth of an ounce. Of course, 1 microgram is 1 millionth of a gram. One millionth of one-thirtieth would be one-thirtieth of a millionth of an ounce. You are talking about in this case 40 to 60 30-millionths of an ounce in our dirtiest cities.

I just wanted that to show the actual figures. That means 30 or 40 over 30 million for sulfates.

Mr. SPREY. That is absolutely correct, sir.

Mr. ROGERS. How did these levels compare with the levels in which you find serious adverse health effects from sulfates?

Mr. SPREY. I think that is exactly the same conclusion as in the case of  $\text{NO}_2$ . We see effects down to the cleanest cities which is down to well under 10 micrograms.

Mr. ROGERS. How serious are the effects you are talking about?

Mr. SPREY. I think taken quantitatively we are talking, first of all, about death categories that are not as large as hypertensive heart failure or quite as large as lung cancer. The sum of all gastrointestinal cancer death rates is starting to become comparable to lung cancer. That would put them up around maybe the sixth or seventh largest killer of the population at large. So you are talking about a fairly large death category. The effects we see are clear. They do not imply a doubling between cleanest and dirtiest cities. They are considerably lower than that.

In that sense, I think they are not as strong.

Mr. ROGERS. In your view, can a more stringent control of  $\text{SO}_2$  reduce the sulfate levels to the point of safe breathing; and if not, why not?

Mr. SPREY. The only way I could see that working would be extraordinarily stringent control. That is, if you totally moved all  $\text{SO}_2$  from the atmosphere, of course you could not have sulfates form from it. However, given that we have cities that already have an improvement by a factor of seven or eight and we have not started even to move the sulfates downward, I think that would be pretty costly procedure to get enough reduction of  $\text{SO}_2$  to get any effect on sulfates. That is why I am suggesting we investigate another avenue of reducing sulfates which is to reduce photochemical activity.

Mr. ROGERS. I think I will ask you to answer for the record what your conclusions are on these strategies which must be implemented to make our air safe from each of these pollutants, the  $\text{NO}_x$ , the oxidants, and the sulfates. Then the last question. Do you think a modest amount of  $\text{NO}_x$  cleanup will be sufficient to get us to safe levels, or do you think we will need several times less  $\text{NO}_x$  than we presently have in the air?

Mr. SPREY. I think that relates to a previous question. The answer is again if the effects we are looking at are causal, then I think we will need very large reductions in ambient  $\text{NO}$  which in turn will mean large, quite large reductions in  $\text{NO}_x$ , larger than, say, a reduction of from 3 grams per mile to 2 grams per mile.

Mr. ROGERS. Have you given these studies and your conclusions to the EPA?

Mr. SPREY. Yes. I have submitted the studies that you are seeing today to the EPA. I have also given several lectures down there.

Mr. ROGERS. When were these studies submitted to EPA?

Mr. SPREY. The first of our draft documents in this area I believe were submitted on the order of 5 weeks ago. The final drafts, as you see them today, were submitted last week.

Mr. ROGERS. Thank you.

Mr. Satterfield has a question.

Mr. SATTERFIELD. I have a short question to clarify in my own mind exactly what you said.

My recollection is when you were talking about sulfates in the air, that notwithstanding a reduction in  $\text{SO}_2$ , sulfates remained level and that the clue seemed to be that they responded to ozone and  $\text{NO}_2$  levels. Are you saying that  $\text{NO}_2$  levels and ozone levels prevent dissipation of sulfates? Is there some kind of reaction here? You are not saying that they are creating new sulfates, are you?

Mr. SPREY. I think I can best explain it in the following way: Let me start by saying that all these reactions are highly uncertain. These have not been quantified. This is one of the reasons why it is so hard to predict in this photochemical area. As best we can see, the bulk of the sulfates in cities are formed in the air, are not released directly out of smokestacks, they are formed from  $\text{SO}_2$  in the air. However, only something on the order of 10 or 20 percent of the  $\text{SO}_2$  in the air is involved in the reaction. So in most cities we have more than enough sulfur to make lots of sulfates. The question of whether sulfates are created in the air depends on the oxidizing properties of the urban atmosphere. There are really two routes that we know of by which sulfates can be formed. One that has been investigated in laboratories is commonly associated with rain or moist air, and that is the catalytic route. We don't know much other than the fact it is possible to make sulfates.

The second one that I am addressing here is that because of the strong oxidizing reactions that are going on, when you have photochemical smog any  $\text{SO}_2$  that happens to be in the air will be oxidizing at a much more rapid rate than in the absence of the photochemical smog. So what we are really talking about is that the existence of this photochemical pollutant seems to control the rate at which  $\text{SO}_2$  is oxidized into  $\text{SO}_4$ . That is why I say it seems like it is a promising control strategy.

If you could greatly reduce this level of oxidizing activity through the California method of reducing hydrocarbon and  $\text{NO}_x$ , then my belief is that we would see some reduction in  $\text{SO}_4$ .

Mr. SATTERFIELD. May I ask one short question here. I don't know whether you can answer it or not, but do aromatics that are found in some gasolines encourage the kind of photochemical activity which support this conversion, or oxidization of  $\text{SO}_2$ ?

Mr. SPREY. Yes. Hydrocarbons vary in their activity but aromatics are among those that count in the category of hydrocarbons that promote the photochemical process.

Mr. SATTERFIELD. Thank you, sir.

Mr. ROGERS. Mr. Sprey, we are very grateful to you for giving the committee the benefit of your knowledge on the subject. If you will supply the requested material we will be grateful.

Governor Love was to appear but he had a very important meeting. We will schedule him for a later time this week or next week. The full committee is to meet at 11:30 in the session on the blackout. So we will let that black out our subcommittee meeting this morning. We will adjourn until 2 o'clock this afternoon.

The committee stands adjourned.

[Whereupon, at 11:25 a.m. the committee recessed, to reconvene at 2 p.m. the same day.]

AFTER RECESS

[The subcommittee reconvened at 2 p.m., Hon. David E. Satterfield, presiding.]

Mr. SATTERFIELD. The subcommittee will come to order.

We will continue our hearings on the Clean Air Act. We are happy to have Mr. Quarles and members of the EPA back this afternoon to continue the testimony they gave yesterday.

**FURTHER STATEMENT OF HON. JOHN A. QUARLES, JR., ACTING ADMINISTRATOR, ENVIRONMENTAL PROTECTION AGENCY; ACCOMPANIED BY DR. STANLEY M. GREENFIELD, ASSISTANT ADMINISTRATOR FOR RESEARCH AND DEVELOPMENT; ROBERT SANSOM, ASSISTANT ADMINISTRATOR FOR AIR AND WATER PROGRAMS; AND DR. CARL SHY, DIRECTOR OF THE HUMAN STUDIES LABORATORY, DURHAM, N.C.**

Mr. QUARLES. Mr. Chairman, I wonder if I might for the record identify those who are with me. I am accompanied by slightly different persons today. In addition to Dr. Greenfield, Assistant Administrator for Research and Development, who was with me yesterday, we also have Dr. Carl Shy, who is Director of the Human Studies Laboratory in Durham, and Mr. Robert Sansom, Assistant Administrator for Air and Water programs.

Mr. SATTERFIELD. We welcome you, gentlemen. Do any of you have a statement to make at this time?

Mr. QUARLES. No, sir. We will continue our response to questions.

Mr. SATTERFIELD. Yesterday we had a briefing presented to us reciting some studies, I suppose to support the standards. At least I had the feeling that the studies listed were more in support of the standards than were studies conducted to ascertain what the standards should be?

Mr. QUARLES. The purpose of the briefing was to give to the committee as complete a picture as possible of our overall program in conducting research, and to indicate the types of questions that we attempt to look at before we set standards and to point out what deficiencies we sometimes confront in seeking to have complete information on which to base the standards. In the course of that presentation we also attempted to give information on the evidence that we possessed with regard to our existing standards.

Mr. SATTERFIELD. I know that you did allude to the fact in that presentation that they were very sketchy. Frankly, I was a little disturbed, myself, to realize how incomplete they seemed to be. This committee knows something about the smoking studies, for example, and I notice

this was one of the statistics relied upon in connection with carbon monoxide. I assume that the study referred to there was an epidemiological study. Am I correct in that?

Mr. QUARLES. I think so, but let me ask Dr. Greenfield.

Dr. GREENFIELD. First of all, Mr. Chairman, the studies that are referred to there are two types. They are the studies that had been done prior to setting the standards on which the standards are based. Admittedly—and I think that is the thrust of what Dr. Finklea was making in his presentation yesterday—indeed, there are uncertainties and, indeed, there are lots of holes in the information we would like to have.

In addition, there are studies that we continue to make in-house and with contractors and grantees. As we try to look at the whole question of health effects of pollutants with the understanding that if we are wrong we plan to change it, either up or down, more stringent or less stringent. It is not an attempt to prove our standard but an attempt to try to produce additional information as to what the standard should actually be.

Mr. SATTERFIELD. In that connection—and you may have been asked this question yesterday, but I would like to ask you again—do you have a program underway to try to fill in the gaps and plug up the holes?

Dr. GREENFIELD. Yes, we do.

Mr. SATTERFIELD. Do you feel it sufficient?

Dr. GREENFIELD. Once again, sir, as indicated yesterday, as a researcher or research director, I never feel I have sufficient programs.

Mr. SATTERFIELD. When we looked at the chart yesterday there were many categories in which there were no data listed.

Dr. GREENFIELD. Yes.

Mr. SATTERFIELD. Does your program include efforts to obtain the data in each instance where that occurred?

Dr. GREENFIELD. We are making efforts to try to fill in that chart, that is right. Now you can always argue as to whether or not there is a large enough effort to do this. But we are aware of the deficiencies and aware of the holes in that chart and are attempting to fill them in.

Mr. QUARLES. Could I add to that?

Russell Train has indicated that this is an area in which he feels we should do everything that we can do to strengthen our program. I believe it is his feeling, and it is one that I know Dr. Greenfield agrees with, that in the course of responding to the 1970 act we set a great many standards. Those were based on all the dimensions we had at that time. We now face a very important challenge to mass a great deal more information to justify further standards.

Mr. SATTERFIELD. I think it would be important to this committee if we could hear from you with respect to what you think you might need. I certainly think this committee will want to consider including some requirement, if we can identify the needs, and obviously there are needs.

In connection with that I am also disturbed with the methodology being used and what is being done to improve the measuring of the pollutants in ambient air. Do you feel that the methods you are employing now are completely adequate?

Dr. GREENFIELD. To develop instrumentation?

Mr. SATTERFIELD. Well, the measures you are using now to measure pollutants in the air.

Dr. GREENFIELD. As we also said yesterday, Mr. Satterfield, there are some instruments we have strong feelings are indeed adequate, carbon monoxide being one of them, for example. We recognize express deficiencies in the measuring of  $\text{NO}_x$  and the various oxides of nitrogen. By March of this coming year our program calls for the standardization, producing a new standard Federal measurement we had for  $\text{NO}_x$ . In fact, we are testing now three different instruments.

Mr. SATTERFIELD. I am going to come back to that in a minute because I think that ought to be in the record as well.

Do you feel that you are attempting to measure all the pollutants that should be measured?

Dr. GREENFIELD. I think the answer is, "No." Obviously man produces almost an infinite number of materials that he puts into the environment and in no way are we attempting to measure all of those.

Mr. SATTERFIELD. If you find a pollutant other than the six which you have established standards for, that indicates a standard should be established, do you feel you have the authority to go ahead and do that without any additional legislation?

Mr. QUARLES. Yes, sir, we do have fully adequate authority to set standards and are focusing on developing information leading to proper scientific judgment on whether further standards should be set.

Mr. SATTERFIELD. Do you make an effort to measure ozone in the air in your testing?

Dr. GREENFIELD. Yes, we do.

Mr. SATTERFIELD. Do you have a program to try to develop or are you trying to develop any methods of testing these various pollutants which you feel may be more accurate than the ones employed today?

Dr. GREENFIELD. Ozone is part of the oxidants and is one of the six pollutants right now.

Mr. SATTERFIELD. You don't report its contents separately from the oxidants?

Dr. GREENFIELD. No, sir. Ozone is a measure of components in the oxidant.

Mr. SATTERFIELD. We would like to have some indication of what methods are employed to take readings on the six pollutants that you have established. I wonder if you can tell me what they are?

Dr. GREENFIELD. I will be very happy to provide these for the record. I can read off some of them now.

Mr. SATTERFIELD. I would appreciate if you would do so and we will accept it for the record.

Dr. GREENFIELD. I will indeed.

[The following information was received for the record:]

#### MEASUREMENT METHODS

- (1) Sulfur Dioxide: Parosoniline (West-Gaeke), 24-hour integrated sample
- (2) Total Suspended Particulates: High-Volume Sampler, 24-hour integrated sample
- (3) Carbon Monoxide: Non-Dispersive Infrared, continuous
- (4) Photochemical Oxidants (Ozone): Chemluminescent, continuous
- (5) Non-Methane Hydrocarbons: Flame Ionization Detector, gas chromatographic sample workup, semicontinuous

(6) Nitrogen Dioxide: Jacobs-Hochheiser method has been shown to be unreliable. Investigations are underway on the following possible replacements: Chemiluminescent, Saltzman, Sodium Arsenite, TGS, and TEA. The first two are continuous; the others use integrated samples over a period of hours.

The above named methods were published in the Federal Register, Vol. 36, No. 84, Part II, Friday, April 30, 1971, pp. 8187-8201.

Mr. SATTERFIELD. Now to get back to the  $\text{NO}_x$  testing, you have already said that the methodology you were using previously was not accurate. What method was that?

Dr. GREENFIELD. The so-called Jacobs-Hochheiser method.

Mr. SATTERFIELD. I think you testified or somebody did yesterday that it is your feeling that perhaps there are not the concentrations of nitrous oxides in the air that you had previously thought?

Dr. GREENFIELD. It just turned out that the reason that the Jacobs-Hochheiser instrument is deficient is that its efficiency changes with the concentration of  $\text{NO}_x$  in the air. So that at the low levels you are overestimating the amount in the air, at the higher levels you are underestimating.

Mr. SATTERFIELD. Is that the same method that was used to test automobile exhaust also, or nitrogen oxides?

Mr. SANSOM. No, the chemiluminescent method.

Mr. SATTERFIELD. We are talking about ambient air.

Mr. SANSOM. The chemiluminescent method is more costly than the other methods.

Dr. GREENFIELD. The chemiluminescent method is the method we are now testing to stabilize the ambient air as well.

Mr. SATTERFIELD. I understood there were three alternative methods that you are considering. I wonder if you could tell us something about them.

Dr. GREENFIELD. The three methods we are considering are the Saltzman method, the arsenate bubbler method, and chemiluminescent method. The Saltzman has been around for some time. It has some deficiency at low levels of  $\text{NO}_x$ . The arsenate bubbler has an efficiency rating of 85 percent so that we know what the efficiency is as we go out to different concentrations of  $\text{NO}_x$ .

The chemiluminescent method seems to be the most effective method to measure  $\text{NO}_x$ . We are testing all three methods. We are going out on collaborative testing at the present time. By March we will have standardized on one of these, maybe more than one of these, at least one of these will become the Federal standard. In all probability this will be the chemiluminescent.

Mr. SATTERFIELD. You are not examining any other method?

Dr. GREENFIELD. We are open to any other method that comes in. We have opened our list and intend to test any additional method offered for testing along with these three methods.

Mr. SATTERFIELD. How will you ascertain whether or not these methods are more accurate for the purpose of establishing minimum standards than the one which has already been discredited?

Dr. GREENFIELD. The method of collaborative testing involves having a known sample of the gas you are trying to measure and knowing this known sample at various concentrations to examine each of the test methods.

Mr. SATTERFIELD. How will you go about promulgating the use of this method?

Dr. GREENFIELD. The law specifically requires us to have a Federal reference method, published as a reference method associated with the standard that you are setting.

Mr. SATTERFIELD. You will select one to do that work?

Dr. GREENFIELD. We select one, of course, there is provision in the law for equivalent methods also being utilized. You could lay down a set of specifications based on your Federal standard. If another instrument comes along and can meet these specifications it can be tested and certified as an equivalent reference method.

Mr. SATTERFIELD. Yesterday I was asking a question about what efforts were being made by EPA either to oversee or to encourage or to conduct research in the area of devices to remove pollutants from automobile exhaust other than a catalytic device. I understood the answer was that you were not doing anything in this area as such. Is that correct?

Mr. SANSOM. I wasn't here yesterday but I think that we have several projects underway. I think the advanced automotive power system program, which was funded at \$10 million last year and \$7 million this year, is designed to develop alternative engine systems, many of which would remove pollutants as part of the combustion process rather than using an after treatment. EPA in conjunction with the Department of the Army, for example, funded a stratified charge engine. We are also working on the Rankine cycle steam engine and also the gas turbine.

Mr. QUARLES. I believe that much of the discussion we had yesterday related to whether we were developing analyses of pollutants other than CO, HC, and NO<sub>x</sub>. Is that what you are focusing on now?

Mr. SATTERFIELD. I am focusing on the question of the devices to be employed to remove pollutants from the exhaust of an automobile. I guess the next question is would it be a reactor or catalytic device as part of the system?

Mr. SANSOM. You mean whether the catalytic device is part of the system?

Mr. SATTERFIELD. Yes.

Mr. SANSOM. It might be useful to spend a moment on the philosophy of the alternative power system program. As we see the way the law is working we are setting a standard or the law is setting the automotive standard, establishing emissions standards. The private sector should undertake the research and development programs to solve the problem. There are several flaws in that reasoning. One of them is that the private sector generally focusses on short payout items, does not do the research necessary to develop alternative technologies to come on line in the next decade.

So we conduct a rather vigorous research program to determine what the private sector is doing. If we find there is a gap in their research, they are not pushing a technology that is important or has promise, that is where our program is designed to fill in. That is why we are in the gas turbine area and Rankin cycle area.

One of the controversial technologies available is the diesel engine. We are doing some studies on the diesel engine. You don't need to develop it. You just try to figure out why it is people don't buy it and why it has no emission problems.

**Mr. SATTERFIELD.** The reason I ask the question is I was very interested a few years ago when we dealt with those provisions of section 202, which require the reporting to Congress on the extent of progress and effort being made to develop the necessary systems and cost associated with development and application of such systems. I know the report that was filed in consonance with this requirement came in this past April. It actually covers what you have done through June 1972.

I don't see any reference in that report with respect to systems other than the fact that you are involved in the gas turbine, the Rankin system and stratified charge engines. Is that correct?

**Mr. SANSON.** In terms of funding hardware, that is correct. In terms of assessing the status of technology, our people do technical studies on the diesel engine and others. I think in terms of hardware funding that is essentially correct.

**Mr. SATTERFIELD.** Let me get back to the questions of yesterday. I realize you weren't there. Let me go back for a moment to some of the facts that led to this question. I recall 3-years ago there was a lot of talk about several devices being utilized to take pollutants out of the exhaust of an internal combustion engine. At that time a catalytic converter or catalytic device was one. One of the knotty problems it seems to me that confronted the industry at that time was that they had not, at that moment at least, been able to develop one that would stand the test of time, a standard that they set of 50,000 miles.

I understand that we are now talking about putting these devices on 1975 automobiles. The first question I had yesterday was whether or not they have developed such a device that is good for 50,000 miles. I understood, and I may be wrong, that they have not. Is that correct?

**Mr. QUARLES.** I think my testimony yesterday, sir, was that it would be erroneous for us to testify affirmatively that the auto companies have developed a catalyst that will last 50,000 miles in the sense of there being no longer any doubt about having solved that problem. On the other hand, I did indicate that a substantial number of test catalysts have now run the 50,000 mile course. It appears that the development work has proceeded to the point where a catalyst will be manufactured and will run 50,000 miles.

**Mr. SATTERFIELD.** I raise an additional question. With the fuel shortage we have today and the fact that the catalysts have to run on low-lead or no-lead gasoline, based on the experience we had this summer there is certainly no guarantee that there is going to be the quantity of low-lead or no-lead gasoline that will permit these catalytic devices to work even as long as the manufacturer thinks they will work. Isn't that a correct statement?

**Mr. QUARLES.** I think that we probably should make an effort to explore the experience of this summer that you are referring to and determine whether there were significant shortages of gasoline attributable to efforts to provide no-lead gasoline. I am familiar with shortages in the supplies of gasoline around the country. I would not be familiar with people who encountered difficulty containing unleaded gasoline.

Of course, today there is no special need I know of to use unleaded gasoline which I think you indicated was the need at the time, sir, is that correct?

Mr. SATTERFIELD. It is recommended for the automobile I drive and I use low lead gasoline when I can buy it.

Mr. QUARLES. Of course when the catalysts are installed on automobiles the recommendation will be much stronger to use unleaded gasoline. It will be really a requirement. At that point there will be a tremendous need for adequate supplies of unleaded gasoline. But I do not believe that any experience that we have so far with gasoline shortages is relevant to the question of whether adequate supplies of unleaded gas can be furnished. I do think that is the question.

Mr. SATTERFIELD. I think it will be absolutely relevant. Where you have half the automobiles running on leaded gas and the other half on unleaded gas at a time when there are adequate supplies of both fuels you will not have a problem. However, when you have a shortage of fuel you are not going to be able to distribute both fuels to every locality in the amounts needed when it is needed.

Mr. QUARLES. If we continue in the conditions where gasoline is in such short supply in the 1975-76 period that will be, at least to a minor extent, a further complicating factor. Whether it is a complicated factor of material importance I couldn't say at this point.

Mr. SATTERFIELD. I frankly am a little disturbed over what happened 3 years ago. I mentioned this yesterday. There seems to have been a decision to go with the catalytic device and once that decision was made, attention was turned elsewhere. I am fearful that what we are going to find out is that everybody feels that the problem has been solved with the catalytic device and then we will find that it does not really work and do the job.

It seems to me the requirement that we impose on your agency to report to us should include your agency's comment on this sort of thing. I certainly hope in the future that it will.

Before I leave this point I understand and your testimony was that there were three areas in which you were involved, gas turbine, Rankin cycle and stratified charge engines. Is it not a fact you have abandoned your work in connection with the stratified engine?

Mr. QUARLES. We have largely completed that work and abandoned it in the sense that we feel we have finished it because the stratified charge has now been demonstrated to be a viable alternative system and is being used by a number of automotive companies. So that now it has been brought to a stage where any further development work realistically can be expected to be assumed by the auto industry.

Mr. SATTERFIELD. Once you reach this point how do you assure yourself that the auto industry will pick up and utilize these developments. Do you have any method by which you can assure us?

Mr. QUARLES. We assure ourselves on that point by the method of observation and we observed that the auto industry is doing it.

Mr. SATTERFIELD. You believe this development is on track now?

Mr. QUARLES. Yes, sir.

Mr. SATTERFIELD. And is ahead of the gas turbine and the Rankin cycle?

Mr. QUARLES. Oh, yes, it is in commercial application.

Mr. SATTERFIELD. Those are all the questions I have at this time.

Dr. CARTER, do you have any questions?

Mr. CARTER. I have one or two questions.

Thank you, Mr. Chairman.

I am sure you must have noticed this since one of your employees or a group of employed by EPA I believe has produced statistics to the effect that sulfates and the gastrointestinal cancer are closely related?

Mr. QUARLES. I will ask the doctor to respond to that.

Dr. GREENFIELD. I am not aware of any specific sulfates and gastrointestinal cancer relationship by any of our employees.

Mr. CARTER. You are not aware of any work done by—

Dr. GREENFIELD. By any EPA employees.

Mr. CARTER. Or any group contracted by you to do research?

Dr. GREENFIELD. The gentleman who testified this morning, Mr. Sprey, was contracted by EPA to develop a statistical methodology of comparing standards and measurements but he was never contracted by our group to look at toxicology. He was contracted to a private company.

Mr. CARTER. I believe in his statement he has asserted that there is a close correlation between the increase in sulfates and gastrointestinal cancer as well as arteriosclerotic heart disease. Are you familiar with that?

Dr. GREENFIELD. I am familiar with the study you are referring to. This was done by Mr. Sprey but not for our Agency.

Mr. CARTER. Are you conversant with the exact statement?

Dr. GREENFIELD. I have looked at his statement as has Dr. Shy.

Mr. CARTER. You just glanced at it?

Dr. GREENFIELD. I have read the statement that you are referring to.

Mr. CARTER. You have read the statement?

Dr. GREENFIELD. I have read the statement.

Mr. CARTER. Do you agree with what he has said?

Dr. GREENFIELD. No, sir, I have not said I agreed. I said I have read the statement.

Mr. CARTER. You don't agree with this statement?

Dr. GREENFIELD. I have no way of agreeing or disagreeing with it because I have not seen the data to which he refers.

Mr. CARTER. How long has he been under contract with your group?

Dr. GREENFIELD. He has been under contract not for my group but another group in EPA for developing statistical methods, not to do toxicological work which would lead to that kind of assumption.

Mr. CARTER. It seems to me as a very important person in EPA and testifying here before this committee you certainly should be conversant with his work.

Mr. QUARLES. Sir, could I emphasize that he did not do this work for EPA?

Mr. SANSOM. We have sought a copy of the detailed work and we received it last week.

Mr. CARTER. He was under contract?

Mr. SANSOM. Not with EPA.

Dr. GREENFIELD. Not for the toxicological work you are referring to.

Mr. QUARLES. He did this work for Gould which is a developer and manufacturer.

Mr. CARTER. This is what he said and he has been a employee of yours.

Mr. QUARLES. He was a consultant.

Mr. CARTER. He states:

The importance of sulfates as the air pollutant stems from the fact that certain sulfates are a strong lung irritant at concentrations two orders of magnitude lower than irritating levels of  $\text{SO}_2$ . EPA's CHESSE experiments in New York show cardiac and respiratory disease symptoms among the ill to be more strongly related to daily sulfate levels than to  $\text{SO}_2$  levels. Previous work by ECI shows a strong statistical association between the sulfates and all forms of gastrointestinal cancer as well as between sulfates and arteriosclerotic heart disease.

I believe in the light of recent findings that a catalytic converter does release sulfates in rather large quantities, that this may in view of his work, present quite a problem.

Would you care to elucidate?

Dr. GREENFIELD. As I testified yesterday, Dr. Carter, and as Dr. Finklea testified yesterday, we are very concerned about sulfates, whether produced as a result of acid mist coming out of the catalyst or as a result of  $\text{SO}_2$  being present in our atmosphere. We have a considerable amount of work looking at the question of sulfates and their impact on human health and at the point where we feel we have sufficient data to produce the criteria document which would back up a threshold level of sulfates this agency will probably promulgate a standard for sulfates.

Mr. CARTER. Is it wise to get rid of nitrous oxide and change it to sulfates, which is the more toxic?

Dr. GREENFIELD. I think there is maybe a bit of confusion. The class we are talking about which produces the acid mists is the one that comes from the hydrocarbons and carbon monoxide, not the  $\text{NO}_x$ . The tradeoff we have to judge at this point is on the hydrocarbons which are the precursors of the oxidants and whether the oxidants is the more important pollutant as opposed to the sulfate. Now, we have information on the oxidant which has led to standards.

We have suspicions on the sulfate which may ultimately lead to a standard. At this point we are trying to balance the two. Until we have better information we have got, because of the law and what has already been promulgated, to attempt to get rid of the oxidants.

Mr. CARTER. Of course you realize there is a danger and it is recognized as being a danger by some scientists. Is that correct?

Dr. GREENFIELD. There is a suspicion of its being a danger. We are attempting to verify that suspicion.

Mr. CARTER. I believe it has been stated in stronger terms than that.

Mr. QUARLES. Sir, if I understand the scientific matter, I think it has been stated in stronger terms than that as to sulfates representing a potential hazard to health but the further question is whether there is a serious hazard to the public health presented by the quantities of sulfate which realistically can be anticipated from the catalyst. We have to look at both of those questions in evaluating the tradeoffs.

Mr. CARTER. Actually you don't know.

How have these pollution devices affected the drivability of our automobiles? Has it been altered?

Mr. QUARLES. Yes, sir, there have been some effects on drivability of motor vehicles and there has been a very significant amount of commentary on the effects which are either real or supposed.

Mr. CARTER. Do you think it is just supposed?

Mr. QUARLES. I think both are involved. I think there have been some that have been overstated, and there have been some that are real. It now appears, on the basis of the testimony that was presented at the hearings which we most recently conducted, that the effects of the need to control pollution from motor vehicles are being licked by the further design work of the auto companies and that, therefore, the adverse drivability features are likely to be eliminated.

Mr. CARTER. I was unfortunate enough to get one of the 1972 cars. A member of my family told me:

Daddy, that car is going to kill one of us. It stalls every time. I get this real often. When I went up the ramp this morning to get on the super highway, it stalled and it kept on stalling for several thousand miles.

Finally, I traded it, but I took it to the garage many, many times. There was no question about it that this is true, it did affect the drivability. I wonder just how many people have really been killed during the past year due to the poor drivability brought about by the pollution devices we have. I think this is real. I think that many have.

Mr. QUARLES. I feel sure that if there were any documentation of such—

Mr. CARTER. You have some documentation right here, and I would rather you would not try to impeach what I am saying because it is the truth. I can give you sworn testimony to this effect that I did have such a car.

Mr. QUARLES. I am sorry, sir. I was trying to be responsive to your question on whether fatalities have resulted. We have no knowledge of any fatalities. I think that the anticipated use of catalysts is relevant to this issue in that the catalysts will enable the auto companies to achieve the pollutant controls with less engine modifications and a great improvement in the features of automotive performance that you have been describing.

Mr. CARTER. I believe you stated that the consumption of gasoline had increased from 10 percent in light vehicles to 30 percent in those weighing 3,500 pounds and more. Of course, we are dependent today on obtaining a great deal of our oil from overseas, is that correct?

Mr. QUARLES. Yes, sir.

Mr. CARTER. By 1980 it is estimated that we will have to obtain, I believe from sources other than the United States, up to 24 million barrels per day, is that correct?

Mr. SANSOM. Some estimates are that high. We consume about 16 million barrels a day. Five million barrels a day are imported. I have seen some projections that run that high. It depends on a lot of things, one of which is the attitude of the public toward fuel economy, what weight they give in purchase decisions to fuel economy.

There is some sign of a trend toward smaller cars, that the public is inclined to give that greater weight. We have done some calculations that show if we could get the average miles per gallon performance to 20 miles per gallon in 1985 we would be consuming the same amount of fuel for automobiles as we are today.

So, there are a lot of variables at play here, and the supply of gasoline is one of them, and the attitude of the consumer is another.

Mr. CARTER. Contrary to what I was told yesterday by this group now testifying, I found that some of the automobile companies stated

that the catalytic converter would not lessen or diminish the amount of gasoline used.

I believe you stated that it would. I believe that was stated here. I believe our car builders state that is not correct, that there will still be increased consumption, but perhaps not over the level that we have at the present time.

Mr. QUARLES. I believe that is correct, sir. If I said to the contrary yesterday, I did not express it correctly. I think some of the auto companies stated that there would be no improvement. Others testified that there would be significant improvement.

Mr. CARTER. According to my figures, by 1980 we will be importing about 24 million barrels of oil from the Middle East. I believe the entire production in that area will be about 85 million barrels, of which Europe would get 28 million, the United States 24, 14 for Japan and 19 for the rest of the world.

Are you cooperating with the Department of the Interior in the development of oil supplies here in our country?

Mr. QUARLES. Yes, sir; we are consulting with the Interior and other groups in the Government, and particularly under the leadership of Governor Love in the White House, who is working specifically on these problems.

Mr. CARTER. Are you able to produce much oil, petroleum, gasoline, gas in any of these enterprises?

Mr. QUARLES. I am not sure I understand your question. We don't produce gasoline.

Mr. CARTER. I know, but have any of the groups with whom you have been working been able to do this?

Mr. SANSOM. I think we have worked closely with the Department of the Interior, the Council on Environmental Quality and the White House Office on Energy Policy to develop initiatives, the superport initiative, for example, and initiatives to accelerate the rate of development of offshore oil.

We have been involved in these initiatives, power plant siting, for example, refinery siting. As Mr. Quarles said, we do not have any statutory responsibilities to get this done.

Mr. CARTER. Would you rather have developed in this country the capability of producing the oil rather than depend on superports and Arabia for the source of our oil?

Mr. QUARLES. Yes, sir.

Mr. CARTER. Thank you, Mr. Chairman.

Mr. SATTERFIELD. We have a vote on now. The committee will stand in recess.

[Brief recess.]

Mr. KYROS [presiding]. The committee will come to order.

Mr. Quarles, in his testimony yesterday, Dr. Finklea indicated that the present NO<sub>2</sub> standards contain a margin of safety of two times, or 100 percent. I believe that Dr. Finklea also stated that this represents a much smaller margin of safety than is set for pesticides and radiation.

Do I understand that the Federal water criteria in the green book recommend a tenfold margin of safety for the protection of water, fish, and animals? The first question, is it correct, and can we say that we have a central policy when animals, water, and fish are entitled to five to ten times more protection than human beings?

DR. GREENFIELD. In the case of the six pollutants, at the time the mandate was set, the date for setting them, the Agency, as Mr. Quarles testified yesterday, put together what information was available, that had been done prior to the time the standards were to be set, using the information available set the threshold at the levels to protect the most susceptible portion of the population.

We did not have, and still do not have, the full type of epidemiological information across the country which would allow us to set that type of tenfold safety standard on the entire population.

The reasoning that went forward at that time is that if you protect the most susceptible portion of the population, even with a safety factor of two or three you are providing a much larger safety factor for the majority of the population.

MR. SANSOM. Also, with regard to the green book, that statement, and I am not familiar with it firsthand, but certainly it does not apply to dissolved oxygen. It applies to toxic materials, but not to all materials.

MR. KYROS. In this morning's testimony Mr. Sprey indicated that comparisons of mortality rates in the cleanest and dirtiest cities in terms of NO<sub>2</sub> indicated a strong statistical association between high NO<sub>2</sub> levels and increased mortality.

He also indicated that whether there is a cause and effect relationship at work here could be demonstrated by toxicological experiments which could be completed within a year at very low cost. In fact, he indicated that these studies could be piggybacked on other experiments.

The first question I would like to ask Dr. Shy, is: As chief of the EPA health effect effort, do you agree with Mr. Sprey's statement about how soon the test could be completed and about the relatively low costs?

DR. SHY. I think that is a very optimistic statement about how soon he can get data from toxicological studies to support his findings. I don't think 6 to 12 months is a reasonable time.

MR. KYROS. You don't believe it could be done in the short level of time he indicated?

DR. SHY. I think that is being very optimistic.

MR. KYROS. Do you believe the information presented by Enviro-Control warrants further testing, including testing to validate or invalidate the hypothesis test of relationships he finds?

DR. SHY. I think the facts are there and should be validated one way or the other. We have some very serious misgivings about the conclusions presented in that presentation this morning, not so much about his facts but going from his facts to his conclusions is a subject of a great deal of controversy.

MR. KYROS. You know your agency hired Enviro-Control because in a letter replying to a request of the chairman of the subcommittee, sent out by Acting Administrator Quarles, on September 7, 1973, including in it a full response to various questions on page 11-1, it says: "Analysis of the data conclusions pertinent to the national primary ambient air quality standard obtained in current research reports prepared by Enviro-Control, Rockville, Md."

I don't know whether you doubt how they do their studies, but you hired them to do something.

Dr. SHY. I think we get many reports from contractors and grantees that we don't necessarily agree with. Just the fact that we might have funded some of them doesn't mean that they are taken on as Agency policy.

Mr. SANSOM. It is important to get the record straight. Our funding with this firm was not with regard to toxicological studies. Gould, a manufacture of NO<sub>x</sub> catalysts, funded the specific studies that he testified on today.

Mr. KYROS. I am glad you have made that correction in the record. That apparently is how it shows in that report. So, you don't think it is worthwhile to examine and validate their method?

Dr. SHY. I do think it is worthwhile to perform NO<sub>2</sub> human effects research. That is underway. I think it might be a mistaken assumption to say that because of the findings of Mr. Sprey that a whole new NO<sub>2</sub> program has to be launched. There is a NO<sub>2</sub> program in existence which will get at some of the effects that were postulated in Mr. Sprey's presentation.

Mr. KYROS. EPA now has an NO<sub>x</sub> study.

Dr. SHY. We have multiple NO<sub>2</sub> studies.

Mr. KYROS. Will you be prepared by Friday of this week to advise the committee whether EPA has funded the study that you are talking about or is going to fund it?

[The following information was received for the record:]

#### CRITIQUE OF SPREY PAPER

In the draft paper entitled "A Study of Photochemical Oxidants and Their Health Effects," Mr. Sprey attempted to correlate deaths from various specific causes occurring in 42 metropolitan areas of the U.S. from 1959-1961 with the annual arithmetic mean of nitrogen dioxide during 1962 measured by the Jacobs-Hochheiser (JH) method at a single National Air Surveillance Network station in each metropolitan area. This analysis suggested a statistical relationship between nitrogen dioxide (as measured by JH) and hypertensive heart disease mortality, and between nitrogen dioxide (as measured by JH) and lung cancer mortality.

Two important limitations of the basic data should be cited when interpreting the above findings. First, data obtained in one year from a single air monitoring station do not reasonably integrate the air pollution exposure of decedents from an entire metropolitan area. Variations in exposure from a core area to a suburb are usually much larger than differences in air pollution measurements between metropolitan areas. Since 20 percent of the population changes residence each year, air pollution measurements obtained in one year at a downtown site can hardly reflect the integrated exposure of the average person from any metropolitan area. Secondly, while the fact of death is well recorded by our current vital statistics system, the cause of death is notoriously a highly subjective judgment which frequently must be based on the barest of medical evidence. Furthermore, deaths of individuals who die because of a basic disease process such as hypertension or hypertensive heart disease are often precipitated by other causes such as stroke, congestive heart failure or kidney complications. In such situations, it is not at all uncommon to end up with a death certificate which fails to cite hypertensive heart disease as a factor in the death. Therefore, the specific cause of death derived from a death certificate inadequately enumerates the number of persons afflicted with a given disease.

We call attention to these limitations to explain our serious reservations concerning the findings of Mr. Sprey. Nevertheless, if our current careful examination and appraisal of Mr. Sprey's recently completed work indicates that new avenues of research on the health effects of nitrogen dioxide should be pursued, EPA's research in this area can be modified.

EPA's ongoing nitrogen dioxide health effects program is directed towards biological responses which have been experimentally related to nitrogen dioxides. These responses include:

Impairment of natural defenses against respiratory pathogens.

Impairment of lung structure and function.

Induction of chronic respiratory disease.

Aggravation of pre-existing cardiovascular disease.

Aggravation of asthma.

Systematic (extra-pulmonary) effects of NO<sub>2</sub>.

We are evaluating and quantifying the effects of NO<sub>2</sub> exposure on these responses through three lines of investigation: epidemiology, clinical research and toxicology (animal experimentation). During fiscal year 1974, the level of effort allocated to the various NO<sub>2</sub> health effects areas is as follows:

ALLOCATION OF FISCAL YEAR 1974 RESOURCES TO NO<sub>2</sub> HEALTH EFFECTS

(In thousands of dollars)

	Epidemiology	Clinical research	Toxicology	Total
Impairment of natural defenses.....	138	0	240	378
Impairment of lung structure and function.....	184	175	155	514
Induction of chronic respiratory disease.....	230	123	70	423
Aggravation of cardiovascular disease.....	92	70	0	162
Aggravation of asthma.....	276	0	0	276
Systemic (extrapulmonary) effects.....	0	100	40	140
Total.....				1,893

The above studies were instituted or planned prior to Mr. Sprey's report and are not intended to reflect a specific program which would evaluate the assertions made by Mr. Sprey. Should further investigation of Mr. Sprey's findings prove desirable we would have to undertake a series of studies with the following specific objectives:

1. Examine the nitrogen dioxide-mortality relationships in other metropolitan regions in several different time periods;
2. Obtain epidemiologic and clinical evidence from living populations for a relationship between hypertension and nitrogen dioxide exposure;
3. Obtain experimental animal evidence for a relationship between nitrogen oxides and hypertension; and
4. Obtain experimental animal evidence for a relationship between NO<sub>2</sub> and lung cancer.

The necessary studies would require the commitment of substantial resources and could be completed over a period of 18 months. Our scientists agree with Mr. Sprey that the Federal government should investigate the possible relationship between cancers and oxides of nitrogen, including their transformation products, nitrous acid and suspended particulate nitrates. In fact, our scientists have testified on this matter to this Subcommittee. Our Agency also agrees that the associations between nitrogen oxides and hypertension and nitrogen dioxide and mortality increases could be the subject of legitimate scientific investigations. We do not, however, feel that the biologic plausibility of these associations is great enough at this time to justify substantial allocation of research resources. On the other hand, our Agency recognizes the need to investigate the atmospheric relationship linking nitrogen dioxide, nitrates, sulfur dioxide, sulfates, acid mists and photochemical oxidants and this need is reiterated by Mr. Sprey's findings. We estimate that several years will be required to conduct these studies.

Dr. SHY. I am not talking about one study. I am saying there are many studies in existence now on the health effects of nitrogen dioxide, which will pertain to the findings of Mr. Sprey.

Mr. QUARLES. In other words, we have an ongoing research program in this area, and we are funding it.

Mr. KYROS. In response to a question from Mr. Rogers, who was here yesterday, Dr. Finklea indicated that if the arsenite measurement

had been used in Chattanooga, adverse health effects might have been noted at levels 30 percent lower than those measured by FRM.

Dr. SHY. Maybe there is one thing that ought to be said. There was another technique used in Chattanooga, the Saltzman instrument and the Jacobs-Hochheiser. The Saltzman measurement provides us reinforcement for our present air quality standard for nitrogen dioxide.

We could even throw out the Jacobs-Hochheiser measurements all together and still derive a standard from the Chattanooga study based on the Saltzman instrument, which we feel is one of the candidate methods.

The possibility that the use of the arsenite method would give lower values is certainly there, but it is speculative compared to the hard data about NO<sub>2</sub> exposures in Chattanooga as measured by the Saltzman technique.

Dr. GREENFIELD. May I add, Mr. Chairman, it follows that reason that we have not declared the arsenite or the Saltzman or the chemiluminescent as the present standard reference method.

We will have made this decision by March. We are conducting tests now to determine as far as possible what the calibration of these instruments should be.

Mr. KYROS. Isn't that awfully vague, though; not vague in the failure of anyone to try to get a measurement method but vague in the sense that we require the auto manufacturers to act on the basis of the NO<sub>x</sub> quantities in the air?

I don't know how you can make decisions when you haven't decided yourself on the standard measurement.

Dr. GREENFIELD. I have to clear something up here. We are talking right now about the ambient air quality standards, not emissions or testing of automobiles. In the case of the ambient air quality standard, what we have is the epidemiological information associated with the instrument in Chattanooga.

That measurement was made primarily with the Saltzman method and Jacobs-Hochheiser method and the arsenite method. The question is not what the absolute measurement was but whether or not you have a mechanism for judging what level by some measurement technique applies as a threshold and whether you can relate that to other cities in the country as well.

Currently, we feel that the Saltzman measurements in Chattanooga allow us to relate that measurement to other cities as well to determine which ones are in trouble so far as the ambient air quality standard. This has nothing to do with the specific accurate quantitative measurement of what comes out of the tailpipe.

Mr. KYROS. Even if the agency's interpretation of the Chattanooga study is accepted as you have said, doesn't that suggest that even less than a twofold margin of safety may be incorporated in the present NO<sub>2</sub> standards?

Dr. GREENFIELD. I don't think that is true because I think the Chattanooga study for what it is worth was a conservative study. As we discussed yesterday with Dr. Carter, he brought up the fact that in the Chattanooga case weren't there other parameters which might affect the health of the people there. There was the acid mist problem; there was the sulfate problem.

It was assumed that in the absence of additional information it was all  $\text{NO}_x$ . At the very least, it was a conservative measurement.

Mr. KYROS. Well, if the existing ambient air standard for  $\text{NO}_2$  of .05 as measured by Jacobs-Hochheiser were cut in half to .025, how many air quality regions would not meet the national ambient air quality standards for  $\text{NO}_2$ ?

Dr. GREENFIELD. I can't answer that.

Mr. SANSOM. I can only give you a gross estimate. We could submit for the record a more precise one. It would probably be on the order of 30 to 40. That would be my guess. You might have the answer right there if you have the Federal Register notice, which I don't have.

[The following information was received for the record:]

#### REDUCTION OF AMBIENT $\text{NO}_x$ STANDARD

By Jacobs-Hochheiser measurements for 1972, approximately 95 air quality control regions had annual average nitrogen dioxide levels exceeding 50 micrograms, half the current national standard.

Mr. KYROS. In light of the increased number of the air quality control regions affected, and in light of the testimony this morning about the health effects of  $\text{NO}_x$  and lack of information yesterday by EPA, wouldn't it be better to change the year of compliance rather than the standard to gain a year's study and yet not relax the standards?

Mr. SANSOM. What concerns me about that judgment is that you attribute to the study that was discussed this morning far more than our people would dare attribute to it. I think that you have probably been over the problem that DESA measured for 1 year the ambient air quality in a year, 3 years previously to when the deaths were measured, that you have not established any cause-and-effect relationship. I might say we get these sorts of studies quite frequently.

If we were to stop and revise our standards on that sort of a study, then we would be changing the standard quite often, and I think quite inappropriately.

Dr. GREENFIELD. One of the most difficult things our health-effects people contend with when you go into epidemiological studies on death is to try to distinguish after a fact what were the causes and what were the parameters that prevailed at the time. You have no way of doing it.

To assume, as Mr. Sprey does in his study, that by stratifying a sample with one or two additional parameters you have eliminated all the possible causes and hence can draw the conclusions that he draws is what gives us trouble. Not that there may not be effects but to draw the conclusions from the type of data he has available is not realistic.

Mr. KYROS. Let me ask you this: Why don't you provide the committee within the next few days, perhaps by Friday, your position on a 1-year relaxation?

Is that possible?

[The following information was received for the record:]

#### $\text{NO}_x$ AUTOMOBILE EMISSION STANDARDS

The Committee has been furnished EPA's recommendation on altering the  $\text{NO}_x$  motor vehicle emission standard. Accordingly, EPA would be opposed to extending the statutory standard for one additional year.

MR. SANSOM. On a 1-year relaxation as opposed to the position the Administrator has already taken before this committee and the Muskie committee?

MR. KYROS. That is right.

MR. SANSOM. In other words, the date of application will be in 1978 instead of 1977?

MR. KYROS. That is right.

MR. SANSOM. Of 0.4?

MR. KYROS. That is right.

MR. SANSOM. I think we would be glad to do that, but I think we could say right now, based on our experience with the 1-year extension, for example, that a 1-year change in the standard really does not have any material effect on the basic issue. Either you don't believe there are 47 regions that have this problem, you believe there are only two, we still would have that same situation with a 1-year delay.

It only makes at most about a 5-percent difference in terms of the level of the emissions and most probably about 2 to 3.

We had this experience in granting the 1-year extension on the 1975 standards. One year does not change things.

MR. KYROS. Would you be willing, then, to still give us a paper on that?

MR. SANSOM. Yes, sir.

MR. KYROS. Let us say a week from Friday. That will give you a couple of weeks to work on it.

MR. SANSOM. Sir, in running this analysis, do you want us to do it at an interim standard of 2 grams or 3 grams per mile? Do you have any guidance on that?

MR. KYROS. No; but I am sure we can discuss that as you prepare the study.

[The information requested was not available to the committee at the time of printing—March 1974.]

MR. KYROS. Let me ask you this question: Dr. Shy, you say the environmental control study is worth validating as we talked about earlier. I want to ask you specifically again: You said some continuing studies are being made of  $\text{NO}_x$ . Will you provide us by next Friday the information as to whether you will specifically conduct research in order to validate what we talked about today?

DR. SHY. Yes; we can do that.

[See "Critique of Sprey Paper," p. 242, this hearing.]

MR. KYROS. My colleague from North Carolina, Mr. Preyer.

MR. PREYER. Thank you, Mr. Chairman.

I have one question along the line that Mr. Kyros was asking of Mr. Sansom.

When you changed the system of measurement and went from the Jacobs-Hochheiser system to the Arsenite system, which reduced the apparent amount of  $\text{NO}_x$  in the air by a half, why wouldn't you then change the standard? Instead of 0.5, shouldn't it be changed down to 0.25?

DR. GREENFIELD. Mr. Preyer, there may be a little bit of confusion there. Let me see if I can clean it up.

Recognizing that the measurement technique that was used to judge which cities had a problem so far as the  $\text{NO}_x$  standard was concerned was wrong, we went back and looked at what measurements we had as to what the levels in Chattanooga were. The first judgment that was made was whether or not the standard that had been set with instruments that were currently out in the various cities could be still utilized.

It was decided that the standard that we had, the standard that had been set for  $\text{NO}_x$  could be still justified with the Saltzman technique. It was with the Arsenite measurement technique. Hence, when you went out to the cities and looked at what the Arsenite instrument and the Saltzman instrument said were actually the values in those cities, then you found in many of those cities that were once judged to be over the standard for  $\text{NO}_x$  were now below the standard.

It was not changing the amount in the air but really when you corrected for the fact that the instrument that originally was used was wrong we found that many of the cities were below the standard.

Mr. PREYER. I just want to ask one question in the area of coal. I am sorry I missed some of the earlier testimony today. If we have gone over this, Mr. Chairman, I hope you will stop me.

I was interested in the clean fuels policy aspect of Mr. Quarles' testimony. I understand, and this is a simplification, it may be wrong, in which case I hope you will correct me, that there is enough coal in this country to meet all of our energy needs about three times over to the end of the century. When we think of the energy shortage, we really aren't thinking of coal because it is not in short supply. The problem has been an environmental one with coal. It is much easier to meet the environmental standard by switching to oil rather than going through the expensive process of developing the technology which would clean up the coal.

That switch was almost made automatic by all the big utilities and big users of fuel. Now that the oil situation is getting crucial, perhaps it will be economically justified to start developing a stack gas cleaning technology and whatever else needs to be done to clean up coal for use.

You say here that the technology for desulfurizing heavy fuel oil is clearly available. How about for coal?

Mr. SANSOM. Could I respond to that? Let me go back to your previous premise.

The premise that the problem here of increased reliance on external supplies of petroleum is due to the environment I think is one that deserves a little questioning. Five years ago or 10 years ago, one of the impetuses to switching to oil on the east coast was economics. The very low price of imported crude oil was an incentive to get out of coal which was costly to mine and ship that far. It was a contributing factor to the conversions that took place during that period.

Now the economics are reversed. The price of crude is way up. The price of coal is lower.

Another factor was the Coal Mine Safety Act which made deep mining much more costly, and also uncertainty over strip mining legislation which, of course, is an environmental concern.

I think there is a whole series of factors that have been in play here and environment is simply one of several.

Now the desulfurization issue with regard to oil, as Mr. Quarles stated, we feel that desulfurization technology is here; it is widely used in the refinery; it is only a question of getting it applied more broadly.

Now we have to rely on external sour- or dirty-crude versus internal sweet- or low-sulfur crude. The stack gas scrubbing issue as it relates to our ability to use the high-sulfur coal particularly in the eastern part of the United States is one around which there is a very heated debate, primarily between ourselves and the utilities.

The administrator made a decision in late 1971 on these new source performance standards for coal-fired generating plants requiring stack gas scrubbing for all new sources. This was contested in court. There was a decision last Friday upholding the decision with regard to new sources with a couple of technical points. I understand that is what it says.

When the State implementation plans came in in early 1972 imposing sulfur content regulations on existing sources as opposed to new sources, there was controversy again relating to stack gas scrubbing. The Environmental Protection Agency, in conjunction with several other Government agencies, the Office of Emergency Preparedness, the Federal Power Commission and a couple of others, Department of Commerce, formed a team with a charger to go out and find out whether or not scrubbing technology is here. They ended up in Japan.

You probably heard there is a coal-fired powerplant about 200 megawatts in operation in Japan burning 2 percent sulfur coal that has been in operation since March 1972.

Mr. PREYER. Using American technology?

Mr. SANSOM. Using American equipment.

I was just last Friday down to the Louisville Gas and Electric plants in Louisville, Ky., where they have a similar scrubbing operation now.

We continue to believe that scrubbing technology is here. It is a complicated issue. It is a question of the determination of the utility to put it on. It is also a question of their willingness to get the chemical engineering expertise which they don't have within their firms now to make sure it is put on correctly.

We do have questions which underlie our clean fuels policy as to the scale on which it can be applied by 1975. We are asking the States to roll back the secondary standard on about 100 million tons of coal equivalent because we don't think that there will be more than 35 million tons coal equivalent of scrubbing capacity on line by 1977.

While we think the technology is here, we think it ought to be pursued vigorously. We recognize that it may not be available in a large enough quantity by 1977 to meet all the demands, primary and secondary.

Mr. PREYER. What is the cost factor?

Mr. SANSOM. The cost in terms of investment cost on a new plant or a retrofitted plant comes to something like 10 to 30 percent of the capital cost of the plant. The costs are quite high. Translating investment cost and operating cost into the price of electricity, it comes out about 2 to 3 mills per kilowatt. Electricity sells at an average in the United States of about 17 mills per kilowatts. So, it depends on the mix of plants in a system.

You have some oil fired, some low sulfur coal fired, some that don't require scrubbing. The worst case is in the TVA area where they burn a high sulfur coal that will mean 10 to 15 percent higher electricity in that area.

Mr. PREYER. Are you saying, then, that it is technically possible and economically feasible, although the cost will be high?

Mr. SANSOM. That is right.

Mr. PREYER. I should think that is very encouraging.

Mr. SANSOM. I should emphasize there is great controversy and disagreement with my position on this. There are 32 plants either planned or in operation in the United States with scrubbers. So, I think there is an encouraging trend.

Mr. PREYER. So, the time limitation stems from the lack of trained people to install the equipment?

Mr. SANSOM. Another consideration is that you want to phase it into your system and you have so much down time on each powerplant per year. If you can't close them all down 1 year and put scrubbers on all of them, there is a definite scale-up problem.

Mr. PREYER. One of the suggestions that we have heard advanced is in the national security area, where we are "behind the eight ball" with Middle East oil. The suggestion is that we ought to have not only a 60-day supply of oil on hand but also a standby coal availability for the big central utility plants that are using oil and even allow some of them to violate the air quality standards if necessary. Then, if the Middle East cutoff all of our oil we would at least have power.

Has there been any consideration of standby coal facilities for utilities or is this such a costly operation that it is not feasible to consider?

Mr. SANSOM. I am not aware of any specific study on that but I think on a contingency basis it is something that probably ought to be examined.

I think there is a surprising amount of flexibility in what these utilities can do. For example, one in Norfolk, Va., last year, they were short of distillate for one of the powerplants and the powerplant could be converted to use coal and they did use coal.

If all the supplies of crude were cutoff from the Middle East, of course, that would really be a burden on Europe and we would probably have some responsibility to go to the assistance of Europe.

I think we could ration on a short-term basis until we had time to get the coal production up to speed. I don't know about that but it is something worth pursuing.

Mr. PREYER. The Middle East situation being what it is, I certainly hope that we will be looking at coal. The farmer has come into his own. No one expected he would. Maybe our old friend coal will come back now.

Are the other problems you mentioned that inhibit the use of coal, such as problems with deep mining, such that they can't be overcome without too much difficulty?

Mr. SANSOM. I am really not expert in that area. I suspect that the rising price of petroleum will do more than anything else to take care of that problem.

Mr. PREYER. Thank you very much, Mr. Sansom.

Mr. KYROS. Thank you, Mr. Preyer.

I don't believe there are any further questions at this time.

Mr. QUARLES is not going to return, in any event, at this time.

The committee will now adjourn until 10 o'clock tomorrow morning.

Thank you, gentlemen.

[Whereupon, at 4.10 p.m., the subcommittee adjourned to reconvene at 10 a.m., Wednesday, September 12, 1973.]

## CLEAN AIR ACT OVERSIGHT—1973

WEDNESDAY, SEPTEMBER 12, 1973

HOUSE OF REPRESENTATIVES,  
SUBCOMMITTEE ON PUBLIC HEALTH AND ENVIRONMENT,  
COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE,  
*Washington, D.C.*

The subcommittee met at 10 a.m., pursuant to notice, in room 2123, Rayburn House Office Building, Hon. Paul G. Rogers, chairman, presiding.

Mr. ROGERS. The subcommittee will come to order, please, to continue the hearings on the oversight of the Clean Air Act.

We are very glad to have as our first witness Dr. James N. Pitts, Jr., director of the Statewide Air Pollution Research Center and professor of chemistry at the University of California, Riverside, Calif.

I might say Dr. Pitts has been helpful to this committee in the past.

We look forward to hearing your testimony today. Welcome to the committee.

### STATEMENT OF JAMES N. PITTS, JR., PH. D., DIRECTOR, STATEWIDE AIR POLLUTION RESEARCH CENTER, UNIVERSITY OF CALIFORNIA, RIVERSIDE, CALIF.

Mr. PITTS. Thank you, sir.

It is a pleasure and privilege to be here at this time.

You have my full written statement which I am afraid is fairly lengthy but some of the technical aspects are important and required elaboration. I won't go into the details but rather in the interest of time and getting directly to questions which you gentlemen might have, will simply comment on the subjects that I consider to be particularly significant and for detailed analysis refer you to specific portions of my prepared statement.

Mr. ROGERS. That will be fine.

Your full statement will be made part of the record following your summations, without objection. [See p. 258.]

Mr. PITTS. I would like to begin by reemphasizing the point made in part I, that is, that the 1970 Clean Air Act is landmark legislation for which you, Mr. Chairman, Mr. Muskie, your respective committees, and Congress as a whole, deserve a great deal of credit. The legislation was timely and is proving effective.

In preparing for the oversight hearing, I went back and reread the 1970 act very carefully. Frankly, I was deeply impressed by the fact that the goals and overall control strategy for achieving them are set forth very clearly in the existing 1970 legislation.

I then asked myself the question: What are the problems? Why haven't certain control measures progressed in the required direction, and to the degree desired?

My conclusion was that the problems that have beset us have been not so much due to deficiencies in the act itself, but rather to a meager scientific, technical, and medical data base compounded by inadequate research and development funding to build up that base in such areas as health effects, atmospheric chemistry, air monitoring instrumentation, and so forth.

Thus, for example, we are all aware of the confusing  $\text{NO}_x$  situation, a major problem facing the EPA today. It arose largely from the fact that several years ago when key studies were carried out to measure nitrogen dioxide ( $\text{NO}_2$ ) levels in ambient air and to determine the levels at which health effects occurred, no reliable instrument was available that specifically and accurately measured  $\text{NO}_2$  in ambient air. This led to substantial overestimation of ambient  $\text{NO}_2$  levels.

This has had wide ramifications, some of which are discussed in my prepared remarks. My point here, however, is not to criticize earlier work but to point out to you that even today we still do not have a thoroughly reliable field instrument capable of accurately, and specifically, measuring ambient nitrogen dioxide. This exemplifies the pressing need for substantially more research and development in critical areas such as those I have outlined above.

Let me make one other key point at the outset of my testimony. While supporting the need for expanded research, development and training programs for air pollution control, I want to emphasize the continuing critical need for action now based on our present knowledge. In some cases such actions may seem arbitrary. For example, in 1970 you wrote into the act the 90 percent reduction for hydrocarbons, CO and  $\text{NO}_x$ , in exhaust emissions; that was indeed somewhat arbitrary. Nevertheless it was a courageous and effective step. If you had not put that provision into the act, in such specific terms, we would not be controlling automobile pollution to the degree we are today.

In short, the concurrent approach of "control now," while continually expanding and upgrading our data base, is the only way to achieve substantial progress in real time.

I don't believe in the philosophy proposed in some quarters of deferring strict air pollution control measures until many more additional years of research have been carried out. We must control now and at the same time conduct the needed research on a high priority basis. Then, when and if such additional research shows the need for revision of the control measures, to more lenient or to more strict levels, they should be revised accordingly.

One more point should be made at the outset. For emphasis, I would like to repeat here my concluding remarks from the written statement:

I am deeply concerned that the pendulum which, in part because of real and pressing energy needs, now seems to be swinging to economics at the expense of environmental considerations, should not be allowed to swing too far. If it does, this could lead to serious degradation in air quality with its resulting potentially drastic impact on the health and welfare of the American public.

Surely with a reasoned, cooperative, and substantive effort from all sectors, we can, in fact, balance ecology and economics to the benefit of all Americans.

Now I would like to comment on specific portions of my testimony starting with section II where energy and air pollution are briefly discussed. I simply want to say that energy and air pollution are inextricably linked. There is no way to avoid this dilemma. That is the thrust of this section of my prepared statement.

Now let us turn to section III, Air Quality Control.

The concept of air quality criteria documents, set forth in the 1967 Clean Air Act, forms the basis for establishment of health-related air quality standards. The relationship is crucial. It is here in generating such criteria documents, that one encounters serious problems arising from our inadequate data base. For example, we simply don't have an accurate quantitative evaluation of the effect of photochemical oxidant on human health for various segments of our population. It is ironic that even today we know more about the effects of photochemical oxidant, on plants than we do on man. In this regard, Chairman Rogers visited our campus and saw the effect of a PAN attack on our field crops. PAN (peroxyacetyl nitrate) is a phytotoxicant and at low levels also has serious effects on man.

I might add, sir, since your visit to UCR about a year and a half ago, I have been informed by plant scientists that economic losses from damage to crops in the San Joaquin Valley are now becoming important. This trend seems to be continuing.

My basic concern, as indicated, is that without a sound scientific, technical, and medical data base for the air quality criteria documents, the Clean Air Act becomes a battleground for conflicting opinions and interests instead of an effective control strategy.

One important contribution of the CHESS program to public health was presented by Dr. Herbert Wiser of the EPA at a major air pollution research conference held in December 1972. Of great interest was their recent discovery that particulate sulfate present in ambient air at levels of 8 to 12  $\mu\text{g}/\text{m}^3$  is a causative agent in respiratory illness (2,3).

This is an area that should be examined very carefully. For example, one should have an air quality standard, not only for gaseous  $\text{SO}_2$ , but also for particulate sulfate.

Additionally, there is the interesting point that sulfur dioxide gas appears to be transformed (oxidized) into sulfate particles much more rapidly in areas suffering from photochemical smog than in areas where oxidant levels are low.

This is important to consider when proposals are made to go to high sulfur fuel. Thus, in some areas where  $\text{SO}_2$  is not presently a serious problem such as the Los Angeles basin, far more sulfur dioxide and in turn more particulate sulfate will be introduced into an already smoggy atmosphere if even 1 percent sulfur fuel is burned for an appreciable time.

Furthermore, the problem of particulate nitrates should be examined. While we know they are a problem in the soil, we do not know how nitrates in ambient air affect our health.

The ultimate atmospheric fate of  $\text{NO}_x$ , in regions of high photochemical oxidant, is primarily to form nitrate particles. Thus, 100 miles or so east of Los Angeles, one finds large quantities of nitrate in the air. Unfortunately, as indicated above, we know nothing about

effects of nitrates on human health. Furthermore, to my direct knowledge, little monitoring has been done to determine the actual ambient levels encountered.<sup>1</sup>

Now let us turn to section IV, "National Air Quality Standards." At the outset, I want to support very strongly the concept of health-related air quality standards. As you know, that is not the concept employed in Britain today, or in some other parts of the world. Their standards are based on "technological feasibility."

In section A, I point out that in the United States our present health-related air quality standards are under attack from three directions. First, it is claimed that they are not accurate because of the wide gaps in our medical and scientific knowledge. In some cases, there appears to be a valid reason for such an attack.

However, I believe that generally speaking, the air quality standards developed by the EPA are as correct as one can reasonably expect, given the available health effects data. Thus, I generally support them at existing levels and will do so until new and more reliable information comes along that indicates the standards should be more lenient or more strict.

Second, there is a pressure to substitute, in the place of a health-related standard, a "technologically achievable" standard. That would be disaster. If we have technologically achievable standards, the people of our country will never know the price in health which they are paying because it could be said, "Well, you are in good shape; we are doing all that technology can do for you."

The key question really is: What about our health?

Third, of particular concern are proposals to relax certain health-related air quality standards because of pressing "short-term" National, State, and local problems; for example, the current shortage of low-sulfur fuels and the "energy crisis." This approach also is incompatible with the philosophy and goals of the Clean Air Act and should be actively discouraged. If one arbitrarily weakens an air quality standard sufficiently, the public can be led to believe such statements as "the air is getting better because we have not exceeded the air quality standard this year." That is a dangerous approach.

One shouldn't modify a given health-related air quality standard on any basis other than a revised, updated, critical evaluation of the health effects of that pollutant at various ambient concentrations.

There is, however, an alternate approach. In "emergency" situations, rather than relaxing the air quality standards, one should retain the present standards but additionally implement a "variance" system. Thus, the health-related air quality standards remain fixed, but for the duration of the "emergency," the control agency allows a special variance under which the particular air quality standard in question may be exceeded for a certain number of days.

Such a plan is flexible enough to meet emergency needs but still is consistent with a clear evaluation of the effect of the emergency measure on public health and welfare. Further, it leaves, in a sense, some options up to the public; for example, what price in health are we willing to pay in order to furnish the additional energy needed?

<sup>1</sup> Subsequently, I have learned that these have been measured in some cities (see my more detailed response to question 3).

Basically, what I am saying in section IVB on air quality standards for atmospheric  $\text{SO}_x$ , is that, as you heard yesterday, a problem is now appearing with particulate sulfates, not just gaseous sulfur dioxide. We don't know if we have a particulate nitrate problem. All we know is that nitrates are formed in polluted, oxidizing atmospheres.

The sulfate problem may be described as follows: If we go to high sulfur fuel, more sulfur dioxide will be produced. This in turn will be oxidized to sulfate so that one may have a health problem from both gaseous  $\text{SO}_2$  and from sulfate particles. Such problems have to be examined now, before the introduction of high sulfur in fuel smog-plagued areas of the United States.

There is no air quality standard for sulfate. Some information is available, however, on ambient levels at several locations in the United States. I have reference here to a recent paper on the subject by Dr. Paul Altshuler. In my statement, there is a detailed list of references to his paper and to others on the subject.

Implicit in recommendation 4 is the need for a major expansion of the program for monitoring particulate sulfate and perhaps nitrate in ambient air.

Incidentally, I should note that in some areas there are significant amounts of ammonia in the air. It comes from a variety of sources, some natural and some from man's activities, for example, from cattle feedlots.

In the interest of time, I shall not discuss secondary standards. However, I point out in the prepared statement that I strongly feel that secondary air quality standards should be developed rapidly for key phytotoxicants such as ethylene and PAN.

Now we come to implementation plans which have caused you gentlemen, the EPA, and the public a great deal of concern. I go into them in detail in my prepared statement and refer you to section V for the discussion and recommendation.

In section VI on page 7, emissions from stationary sources are discussed in detail. Here I simply restate a fundamental plea—there is a critical need for accurate emission inventories of key air pollutants. We simply don't know how much is going into the air and from what sources. We need to have a much more accurate assessment.

Continually updated and reliable inventories are essential for several reasons.

First, they are necessary for determining, in a given air basin, the relative contributions of mobile versus stationary sources to the degradation of air quality. This is particularly important for  $\text{NO}_x$ . Without a reliable inventory, the automobile industry can say the stationary sources are serious contributors to the atmospheric  $\text{NO}_x$  burden. On the other hand, those responsible for stationary sources can say  $\text{NO}_x$  arises mostly from automobiles. In fairness to all concerned, we ought to get the facts.

Second, emission inventories are important if one is to evaluate the degree of success of ongoing control programs.

Third, if we are going to develop atmospheric models essential for the implementation of adequate health-warning systems with predictive capabilities, we have to know accurately the emission burden. This is necessary in order to predict whether or not a given region is going to have a severe air pollution episode.

Finally, emission inventories are crucial if we are to have sensible, effective programs of land use planning for future development of major urban areas and their suburbs. Such an inventory of existing air pollution sources would provide a firm basis for consideration of proposed locations of new industries, public utilities, residential areas, shopping centers, et cetera, in a given air basin.

Under the Clean Air Act, it is not mandatory that  $\text{NO}_x$  emissions from present major stationary sources including fossil fuel powerplants be monitored.

For some pollutants, such as  $\text{SO}_2$ , it is possible to calculate the emissions from the fuel consumption with a reasonable degree of accuracy since the sulfur occurs as an impurity in the fuel. However, for pollutants, such as  $\text{NO}_x$ , such calculations may be in error by as much as 100 percent in either direction \* \* \* that is overestimated or underestimated. This is my basis, then, for recommendation 7.

It is my understanding that legislation of this type, has, in fact, been developed in Congress.

Now, let us turn to "Section VII: Motor Vehicle Emission and Fuel Standards, Section A,  $\text{NO}_x$  Control."

This is a tough problem that I discussed at length in my prepared statement. I have only the following comments:

There is a report just being delivered to the National Academy of Sciences, dealing with the need for controls of reactive hydrocarbons versus  $\text{NO}_x$  in the development of an overall strategy to reduce photochemical oxidant. The authors of the report are distinguished scholars for whom I have the highest personal and professional regard, and it is only fair to make clear that they take a somewhat different point of view on  $\text{NO}_x$  control than I have given you today. I think the basic difference lies in the question to which their committee addressed themselves versus the question to which I have addressed myself. In the final analysis, there may not be an overall difference of opinion. The point is covered in my written statement, and I will not further discuss this other than to say that I strongly support strict  $\text{NO}_x$  controls.

One other point should be noted in passing—the fact that the Japanese Government has, as indicated in my statement, instigated strict controls for existing as well as new stationary sources. It seems strange, indeed, that our EPA under intense pressure, seems to be relaxing its controls on  $\text{NO}_x$  while the Japanese are strengthening theirs.

Section VII B discusses oxygenated hydrocarbons. This is another potential booby trap that we must avoid at all costs. Many aldehydes are even worse than reactive hydrocarbons in terms of their potential for forming photochemical smog. We must not allow their emissions in significant quantities in auto exhaust, whatever control system is employed.

One problem is the fact that present monitoring devices for hydrocarbons do not measure formaldehyde. Thus, it is possible that if—let us say, a significant fraction of the hydrocarbons in gasoline is converted to formaldehyde, or if one has an uncontrolled motor vehicle fueled by methyl alcohol which produces large amounts of formaldehyde—one would have a very reactive precursor to photochemical oxidant in the exhaust emissions, yet it would go undetected.

There is an interesting story in this regard. I have heard of a car fueled by methyl alcohol that, in fact, passed the 1975 emission standards and yet its emissions of formaldehyde were sufficiently high that they may have been worse, in terms of potential for smog formation, than if one had burned regular gasoline.

There is, indeed, the technical problem of developing accurate and practical instrumentation for monitoring aldehydes in exhaust emissions and ambient air. Nevertheless, this problem can and will be solved and it should not be allowed delay consideration of such oxygenated hydrocarbons.

Section VII C considers fuel additives, the specific example being a manganese compound. I shall not comment further here, other than to indicate that other additives may also constitute potential atmospheric "booby traps."

Each fuel additive and its combustion products must be carefully studied for its potential air pollution impact including health effects.

In Section VII D I comment briefly on an important but enormously large topic; that is, modifications and alternatives to the internal combustion engine. My points are made in the prepared statement, and I shall not comment further here.

Finally, in section VIII, concluding remarks, I addressed myself to the question of funding these urgently needed programs in research, training, and development. I comment specifically on the need for additional support to EPA's efforts in this area, because I personally know of some of their key programs, intramural as well as extramural, that have been wiped out or drastically reduced in scope because of fiscal limitations. Technical people for whom I have great respect and in whose work I have great confidence have had their programs in part either eliminated or drastically reduced. This situation should be rectified on a high priority basis.

Also, I point out that, we need support for new and expanded medium- and long-range research programs. The questions of human health effects at ambient levels of a variety of air pollutants, or the mechanisms of complex chemical and physical atmospheric transformations, are not going to be solved in 6 months by some crash, mission-oriented program. They are research areas that require longer-term, sustained, highly sophisticated efforts. Such medium- and longer-range research programs in key medical and scientific-technical areas would seem logically to fall in the province of "neutral" Federal agencies—that is, agencies which do not have a control function as a major responsibility. I am in no way implying that EPA is not "neutral"; however, problems of "neutrality" were discussed by Senator Muskie in the hearings before the Subcommittee on Air and Water Pollution of the Committee on Public Works, U.S. Senate, April 16-18, 1973.

I do not want to comment further about this particular problem, except to state that we do have in the Government, agencies who do not have a control function as a prime mission yet have had a great deal of experience in working with both basic and applied research of a short-, medium-, and long-range nature. For example, there are the National Science Foundation's basic and RANN programs, and HEW's National Institutes of Environmental Health Sciences. These

might be considered as agencies in which new or expanded research programs of the type I have indicated could be set up, funded, and implemented.

It is worth noting in this regard that in my observation there has been very good cooperation between the EPA, NSF-RANN, and various committees in the National Academy of Sciences, in coordinating and implementing objectives and programs in air pollution. The present problem is that the specific functions of each of these groups has not been clearly defined or adequately funded.

I will conclude my verbal remarks, gentlemen, by stating again that I am sympathetic with the strong, tough, and rational control measures that have been instituted as a result of the 1970 Clean Air Act. If certain of these control measures can be shown to have been overstrict on the basis of hard scientific, technical, and medical data, then, providing our public health and welfare is not compromised, the control measures could be relaxed to the appropriate degree. On the other hand, until such a strong case can be made for relaxing our air quality or emission standards, they should be maintained at their present levels, while intensive research programs are conducted that will continually update our intelligence in the battle against air pollution.

Thank you.

[Testimony resumes on p. 269.]

[Mr. Pitts' prepared statement follows:]

STATEMENT OF JAMES N. PITTS, JR., PH. D., DIRECTOR, STATEWIDE AIR POLLUTION RESEARCH CENTER, UNIVERSITY OF CALIFORNIA, RIVERSIDE

My name is James N. Pitts, Jr. I am Director of the Statewide Air Pollution Research Center and Professor of Chemistry at the University of California, Riverside. While my special competence in air pollution is atmospheric chemistry (in particular, photochemical smog). During the last ten years I have also become increasingly involved with the development of control strategies.

Today, I am speaking to you in my official capacity as Director of the Center, although my views are not necessarily those of the University of California. My recommendations in this testimony have been formulated after extensive consultation with a wide variety of experts in many aspects of air pollution; I am greatly indebted to them.

I. INTRODUCTION

The Clean Air Act, as amended in 1970, represents a monumental piece of legislation, directed through Congress by the distinguished Senator Muskie and Chairman of this Subcommittee, Congressman Rogers. While there may be disagreement with certain aspects of the Act, overall the legislation *was* timely and is proving effective. My remarks, then, should be interpreted as strongly supportive of the Act and the environmental goals it seeks to achieve. My criticisms and recommendations are in the spirit of assisting in making it even more effective.

The goals of the Clean Air Act and their means of achievement, as outlined in Title I—Air Pollution Prevention and Control—are stated with clarity and force in the 1970 bill. Furthermore, considering that the legislation of 1970 represented a quantum jump over previous control strategies and in view of the budgetary and manpower restrictions under which the EPA has been operating, it has been very effective in most respects. Indeed, many of those problems that have arisen to date are not due to deficiencies in the Act itself, but rather to a very meager scientific, technical, and medical data base initially and subsequently to inadequate funding for key elements of the program, such as studies on health effects, atmospheric chemistry, and air monitoring instrumentation—all necessary for improving the reliability and extent of that data base.

While, as a researcher in air pollution, I recognize that my comments indicating a need for funding may appear "self-serving," nevertheless, I have stressed that this lack of reliable information and dearth of funding for many sound and detailed research, training, and development programs has had the unfortunate consequence of making implementation of the Clean Air Act vulnerable to attack from a variety of sources. I hope this situation will be rectified soon for in the final analysis, the effectiveness of a control program, including cost effectiveness to the public, must inevitably rest on a sound information base in all key areas, including economics.

## II. ENERGY AND AIR POLLUTION

This oversight hearing occurs at a crucial time for the citizens of our country. We are faced, on one hand, with what has been termed an "energy crisis," and, on the other, with a degradation of air quality for certain key pollutants in many major urban areas of the U.S.

Thus, today environmental considerations, particularly air pollution, have become in effect, in many cases a limiting factor on our energy supply in the U.S.

The problem of reconciling our overall energy need and our desire for independence from, for example the Middle East oil supplies, *vs.* pronounced environmental concern over further degradation of our air, is enormous! By their very nature, energy and air pollution are inextricably joined; they must be viewed as a total package if sensible, scientific decisions are to be made that are compatible with your goal . . . the health and welfare of the American people.

Appropriately, this inevitable interrelationship has been recognized by the National Commission on Materials Policy in its report of June 1973,<sup>1</sup> which includes the following statement:

*"We recommend that*

1.3 . . . the Federal Government support extensive research and development on the dynamics of materials-energy-environment interplay and its effect on human, animal, and plant life. Studies should emphasize the detection of substances in low levels of concentration, their life cycles and their chronic additive, or delayed effects on public health."

I strongly support this recommendation.

I would like to indicate one specific area which might directly alleviate the energy crisis. This concerns the generation of nuclear energy. Specifically, I would like to reiterate a statement which I made before the Subcommittee on Air and Water Pollution of the U.S. Senate on March 25, 1972. The following recommendation was made at that time which I would like to include again today:

*Recommendation 1: I recommend a definitive study that could lead to the drafting of legislation that would produce, in the near future, a coordinated national effort dedicated to the development of an effective, well-coordinated, high-priority program of research and development aimed at producing more quickly safe, advanced nuclear reactor systems for generation of electrical power in critical smog areas in the 1980's and beyond.*

This statement was true in early 1972, but in terms of subsequent events, it is even significantly more appropriate today. Such a program is of highest urgency.

I shall now comment on specific portions of the Clean Air Act in the sequence in which it is written.

The concept of Air Quality Criteria documents forming the basis for establishment of health-related air quality standards is crucial to the Act. However, while air quality criteria documents for a number of key pollutants have been generated, unfortunately in many cases their scientific and medical foundations are weak, primarily because of a lack of reliable data.

Clearly, it is essential that Section 103(f), which gives "special emphasis to research on the short- and long-term effects of air pollutants on public health and welfare," be implemented on a far more extensive and urgent basis than presently exists. Without a sound scientific, technical, and medical data base for the air quality criteria documents, the Clean Air Act becomes a battleground for conflicting opinions and interests, instead of an effective control strategy.

<sup>1</sup> The National Commission on Materials Policy, "Material Needs and the Environment Today and Tomorrow," June (1973).

While strong efforts are, in fact, going on to effectively update these criteria documents, particularly through the excellent working relationships between the EPA and the National Academy of Sciences and its committees, the problem that is faced is not one of desire or diligence, rather again the question of interpreting a meager data base. A number of volumes have been produced through their Committee on Biological Effects of Atmospheric Pollutants.

An excellent example of a thorough research effort designed to elucidate health effects of several major air pollutants is the EPA's CHES program (Community Health and Environmental Surveillance System), recently outlined in *Environmental Science and Technology*<sup>2</sup>. One important contribution to public health has been their recent discovery that particulate sulfate present in ambient air at the levels of 8–12  $\mu\text{g}/\text{m}^3$  is a causative agent of respiratory illness.<sup>3</sup>

This unexpected result has other implications. For example, one can raise the question of the possible toxicity of particulate nitrates ( $\text{NO}_3^-$ ). The latter species are formed in significant quantities in oxidizing atmospheres characteristic of photochemical smog. They result from the atmospheric reactions of a key primary pollutant, gaseous nitric oxide. Unfortunately, virtually nothing is known about the possible health effects of inorganic nitrate particulates, and regrettably little about the mechanism of the chemical and physical transformations by which they are formed in urban atmospheres.

Unfortunately, the scope and effectiveness of the CHES and other health-related research programs have been seriously reduced by current budgetary limitations.

*Recommendation 2: New health-related research programs, as outlined in Sec. 103(f), should be initiated and existing programs expanded, on a highest priority basis. Furthermore, studies on pollutants for which health-related air quality standards already exist should include detailed investigations (of which some should be at realistic ambient levels) of such recognized toxic air pollutants as the gaseous peroxyacyl nitrates (PANs)<sup>4</sup> and carcinogenic particulate polycyclic organic matter, such as benzo[a]pyrene<sup>5</sup>. Additional studies should be performed on the toxicology and epidemiology of particulate sulfate and nitrate and certain toxic trace metals.*

#### IV. NATIONAL AIR QUALITY STANDARD (SEC. 109)

##### A. Concept of health-related air quality standards

The concept, development, and implementation of health-related primary air quality standards as the basis for national emission control strategies are currently under attack from three directions: (1) their lack of accuracy due to wide gaps in our medical and scientific knowledge, (2) pressure to substitute in their place "technologically achievable" air quality standards, and (3) pressure from some quarters to weaken certain health-related air quality standards in response to "short-term" national needs.

Technologically achievable air quality standards would be generally incompatible with the philosophy and practice of the Clean Air Act, which is founded on the premise of protection of the "public health . . . allowing an adequate margin of safety" [Sec. 109(b)(1)], rather than technological capabilities. Pressure to substitute such standards should be strongly resisted.

Of particular concern are proposals to modify certain health-related air quality standards because of pressing "short-term" national and state problems—for example, the current shortage of low sulfur fuels. This approach is also incompatible with the Clean Air Act and should be actively discouraged.

*Recommendation 3: The continued use of health-related air quality standards as the basis of the Clean Air Act should be maintained regardless of the technological feasibility of their attainment, and even of pressing short-term, socioeconomic needs unrelated to health. When necessary, such needs can be*

<sup>2</sup> C. M. Shy and J. F. Finklea, "Air Pollution Affects Community Health," *Environ. Sci. and Technol.*, 7, 204 (1973).

<sup>3</sup> A. P. Altshuler, "Atmospheric Sulfur Dioxide and Sulfate. Distribution of Concentration at Urban and Nonurban Sites in United States," *Environ. Sci. and Technol.*, 7, 709 (1973).

<sup>4</sup> E. R. Stephens, "The Formation Reactions and Properties of Peroxyacyl Nitrates (PANs) in Photochemical Air Pollution," *Advances in Environmental Science and Technology*, J. N. Pitts, Jr. and R. L. Metcalf, editors, 1, 119 (1969).

<sup>5</sup> National Academy of Sciences, National Research Council, "Particulate Polycyclic Organic Matter (POM)," (1972).

*best met through the use of sound health-related air quality standards, coupled with a variance system. Such a variance plan will clearly demonstrate to the public the price we must pay in damage to public health when air quality is compromised . . . even though in certain cases of high urgency it may be necessary and, indeed, in the overall public interest.*

#### **B. Air quality standards for atmospheric SO<sub>x</sub>**

Because of chemical transformations in the atmosphere, an air pollutant for which a health-related air quality standard exists may be converted to other chemical and physical forms which also may be toxic. Thus, in the atmosphere, gaseous sulfur dioxide (SO<sub>2</sub>) is oxidized to sulfur trioxide (SO<sub>3</sub>), which in turn reacts with water vapor to produce sulfuric acid (H<sub>2</sub>SO<sub>4</sub>). Part of this is ultimately converted to particulate sulfate (SO<sub>4</sub><sup>2-</sup>), which, as the CHESSE program has shown, is also a serious health hazard.

It would appear we may require a health-related air quality standard not only for gaseous sulfur dioxide, as currently exists, but also for particulate sulfate.

The chemistry of sulfur dioxide in urban air is complex indeed. It is important to recognize that normally the rate of oxidation of gaseous sulfur dioxide to particulate sulfate is quite slow, but in the presence of ozone and olefins, both components of photochemical smog and both arising directly or indirectly from atmospheric photochemical reactions of auto exhaust gases, the rate of conversion of sulfur dioxide to sulfate is greatly increased.<sup>6,7</sup>

Furthermore, the details of the sulfur dioxide to particulate sulfate conversion are not clear at the present time. Thus, their relationship to each other in the atmosphere and their relative importance for epidemiological effects need elucidation.

This phenomenon illustrates the continued necessity for a unified control strategy and implementation plan, involving the control of both mobile and stationary sources. Too often, control strategies for stationary sources have been virtually divorced from those involving motor vehicles.

*Recommendation 4: Studies of the physical and chemical transformations involved in the oxidation of sulfur dioxide to sulfate and nitric oxide to nitrate should be strongly encouraged. In addition, further health-related studies are needed to determine whether a health-related air quality standard for forms of atmospheric sulfur other than sulfur dioxide is needed. Subtle effects of cationic species, such as zinc, ammonium, and sodium ions, in combination with sulfate should be included. Implicit in this is the need for a major expansion of the program for monitoring particulate sulfate in ambient air.*

#### **C. Secondary standards**

There is an urgent need for the promulgation of secondary air quality standards . . . those deemed "requisite" to protect the public welfare from any known or anticipated adverse effects of a given air pollutant in ambient air.

It would appear imperative to speed up development of criteria documents for such recognized serious phytotoxicants as ethylene and PAN, both of which are thought to cause substantial economic loss, not only to agriculture, but also to ornamental plants and to vegetation in major recreational areas. Unfortunately, here again, our present information is so meager that no firm estimates can be placed on the true economic loss due to these ubiquitous pollutants.

*Recommendation 5: Criteria documents should be developed on a high priority basis so that secondary air quality standards can be set for such known phytotoxicants as ethylene and PAN.*

### **V. IMPLEMENTATION PLANS (SEC. 110)**

The current EPA implementation plans to achieve the requirements of the Clean Air Act are based on the premise that the health-related air quality standards should not be exceeded *more than one day per year, regardless of the present air quality in a given region*. Such strategies appear feasible for certain pollutants, particularly in areas where the current ambient levels of pollutants are relatively

<sup>6</sup> R. A. Cox and S. A. Penkett, "Aerosol Formation from Sulphur Dioxide in the Presence of Ozone and Olefinic Hydrocarbons," *JCS Faraday I*, 68, 1735 (1972).

<sup>7</sup> M. J. Prager, E. R. Stephens and W. E. Scott, "Aerosol Formation from Gaseous Air Pollutants," *Indust. and Eng. Chemistry*, 52, 521 (1960).

low. However, in major urban areas suffering from, for example, severe photochemical smog, only extreme measures which would cause gigantic socioeconomic problems have been proposed by the EPA.

The EPA's dilemma is exemplified by California's South Coast Air Basin. The agency was required to develop a plan that, by a target date of 1977, would result in the reduction of photochemical oxidant from the present levels, where the existing air quality standard is exceeded over 200 days per year, to the point where the oxidant standard would not be exceeded more than one day per year.

Since, for much of the South Coast Air Basin, this was virtually an impossible goal to begin with, the plan they proposed had to be one of a drastic nature. As we all know, it included such proposals as over 80% gasoline rationing during the smoggy summer months. The reaction of the public, their legislators, and control agencies was intense.

As a result of this experience, I have come to the following conclusion: What is required is not just a single "all or nothing at all" implementation plan, but rather one which also would include a successive set of control measures designed to effectively reduce smog levels by specific increments over some stated period of time and in a way that would be economically and socially feasible. The public would then be presented with the implementation of a series of scientifically sound, short-term programs which would lead to visible improvement of the air within some reasonable time span. In addition, the cost to us of each step, in terms of sacrifice, economics, and our present lifestyles, would be clear. While each successive control step is bound to be expensive, presentation in this form would be far more acceptable to the public and thus operationally more viable than the present "one giant step" plans.

*Recommendation 6: In all air quality regions, for which drastic implementation programs appear necessary to meet the present EPA goals, the public additionally should be presented with a sequence of control options achievable in real time and at acceptable costs that would insure the successive achievement of specific "short-term" improvements in air quality while still retaining the more ambitious, overall goals of the present EPA Implementation Plan.*

#### VII. EMISSIONS FROM STATIONARY SOURCES (SEC. 111)

There is a critical need for accurate emission inventories of key air pollutants, such as SO<sub>x</sub>, NO<sub>x</sub>, hydrocarbons, toxic trace metals, asbestos, and various carcinogens present in urban atmospheres. Continually updated and reliable inventories are essential (i) for determining, in a given air basin, the relative contributions of mobile vs. stationary sources to the degradation of air quality, (ii) for evaluating the degree of success of ongoing control programs, (iii) for the development of atmospheric models essential for the implementation of adequate health-warning systems with predictive capabilities, particularly for NO<sub>x</sub>, SO<sub>x</sub>, and oxidant, and (iv) for predicting the probable impact of proposed new industries, public utilities, and population growth in a given air basin.

With regard to new or modified stationary sources, the 1970 Clean Air Act already provides:

"(g) Every owner or operator of a new source subject to standards established under this section shall (1) establish and maintain such records, make such reports, install, use, and maintain monitoring equipment or methods, and provide such information as the Secretary may reasonably require to enable him to determine whether such source is in compliance with this section and regulations established thereunder, and (2) upon request of an officer or employee at reasonable times, to have access to and copy such records, and to inspect any such monitoring equipment or method."

However, currently it is *not mandatory* that emissions be *actually monitored*. Oftentimes, emissions are simply *calculated*. While this is generally believed to be feasible for SO<sub>x</sub>, from the sulfur content of the fuel employed, for other pollutants such as NO<sub>x</sub> these calculations can be in serious error. Furthermore, there is currently no provision in the 1970 Act that requires stack monitoring devices be installed on all *existing* major stationary sources. This is a critical oversight that should be remedied.

*Recommendation 7: Legislation should be developed that would place on a mandatory basis the installation of continuous monitoring equipment for oxides of nitrogen on all fossil fuel power plants and major industrial stationary sources, existing and proposed.*

## VII. MOTOR VEHICLE EMISSION AND FUEL STANDARDS (SEC. 202)

A.  $\text{NO}_x$  control

There are at least three basic reasons for the control of  $\text{NO}_x$  emissions—the effect of nitrogen dioxide on health, the reduction of atmospheric visibility and coloration of the atmosphere due to the reddish-brown color of nitrogen dioxide, and the role of nitrogen dioxide as they *key precursor* to the formation of ozone in photochemical smog.

In brief, the current  $\text{NO}_x$  control situation appears to be this:

(1) The discovery that the analytical method for determination of nitrogen dioxide in ambient air was substantially in error has now led the EPA to deemphasize  $\text{NO}_x$  control on the basis that the health effects of  $\text{NO}_x$  occur at substantially higher ambient levels than was originally believed.<sup>8 9</sup>

(11) The atmospheric photochemistry of the nitrogen dioxide-oxidant relationship is extremely complex. Thus, while there seems to be general scientific agreement in the need for control of reactive hydrocarbons, at least if one is to meet the health-related air quality standards for photochemical oxidant, the additional need to simultaneously control  $\text{NO}_x$  is currently subject to vigorous debate.

Indeed, before any significant relaxation in the control of nitrogen oxides is implemented, it may be prudent to examine the effects of such a revised control strategy on pollutants *other* than oxidant so that the overall problem is, in fact, alleviated rather than exacerbated. The lessons of the effect on air quality of the 1966 control strategy in California should not go unheeded (vide infra). As indicated below, the current EPA model examines the relationship among three components— $\text{NO}_x$ , hydrocarbons, and oxidants. However, what will be the concurrent effect on levels of, for example, peroxyacetyl nitrate (PAN), oxygenated hydrocarbons, and particulate nitrates and sulfates?

The EPA plan for meeting the oxidant air quality standards in 1977 is based on a relationship between the observed levels of reactive hydrocarbons and oxidant in the ambient air of several major U.S. cities. The plan calls for a "rollback" of reactive hydrocarbons, but no concurrent controls are specified for  $\text{NO}_x$ . To this extent, the EPA "model" for photochemical smog formation differs significantly from that accepted from some years by the State of California's Air Resources Board and the Los Angeles Air Pollution Control District. Their strategy of reducing ambient oxidant calls for reducing both reactive hydrocarbons and oxides of nitrogen to prescribed levels.<sup>10</sup>

Present control strategies of the EPA are based in part on recent smog chamber studies which suggest that reduction of reactive hydrocarbons is the prime factor in controlling oxidant and that the stringent  $\text{NO}_x$  controls are not only unnecessary, but indeed may not be desirable.<sup>11</sup> The experiments were carefully carried out and represent the best available information to date, so that there appears to be a sound chemical basis for this seemingly unreasonable position. However, while this work is of high caliber, its *direct* application to *real world* atmospheric conditions over wide areas and diverse meteorological and topological conditions is not straightforward and may be dangerously misleading.

One "experiment" has, in fact, been conducted in a real atmospheric system. The State of California has required exhaust emission controls on new motor vehicles for seven years, and yet the air quality for photochemical oxidant has not improved in some areas of the state. This is due to a variety of factors, including particularly adverse meteorology for several of these years and rapid urban growth. However, an important reason for the atmospheric deterioration is the fact that legislation requiring emission control devices for hydrocarbons and carbon monoxide (initiated in California in 1966 and nationally in 1968) placed no limit on the emission of oxides of nitrogen.

From a positive standpoint, the controls have led to a relatively small, but nevertheless significant, reduction in the level of carbon monoxide, and at least

<sup>8</sup> T. R. Hanser and C. M. Shy, "Position Paper:  $\text{NO}_x$  Measurement," *Environ. Sci. and Technol.*, 6, 890 (1973).

<sup>9</sup> Bureau of National Affairs, "EPA Seeks Change in  $\text{NO}_x$  Standard for 1976 Autos Because of New Findings," *Environ. Reporter*, 3, 1549 (1973).

<sup>10</sup> A. J. Hagen-Smit, "Abatement Strategy for Photochemical Smog," *Photochemical Smog and Ozone Reactions*, R. F. Gould, editor, *Advances in Chemistry Series*, No. 113, p. 169 (1972).

<sup>11</sup> B. Dimitriadis, "Effects of Hydrocarbon and Nitrogen Oxides on Photochemical Smog Formation," *Environ. Sci. and Technol.*, 6, 253 (1972).

no increase in the hydrocarbon levels of the ambient air in the South Coast Air Basin. Additionally, in *downtown* Los Angeles, the oxidant levels have dropped.

From a negative viewpoint, however, nitrogen dioxide levels have risen in much of the Basin, including downtown Los Angeles. Furthermore, the increased emissions of oxides of nitrogen have apparently resulted in a deterioration in air quality in terms of the key health hazard—photochemical oxidant (mostly ozone)—in much of the eastern portion of the South Coast Air Basin to which a large part of the polluted air mass from Los Angeles and Orange County moves. This real world "experiment" strongly implies that there is a continued need for strict NO<sub>x</sub> controls, if one is to prevent photochemical oxidant from spreading over wide areas which hitherto had "acceptably clear" air.

As an example of the air pollution that has occurred, let me cite data from Azusa, California (which is situated about 15 miles east of Pasadena). One of the reasons for choosing this station is that it has the distinction of having available air quality data for oxidant monitored at the same site continuously since 1957. Two charts attached to this testimony clearly illustrate that photochemical oxidant is still a major problem and, in fact, shows no significant sign of decreasing.

The ramifications of the NO<sub>x</sub> control problem extend to *both* stationary and mobile sources. Once in the atmosphere, oxides of nitrogen, irrespective of their source, interact with hydrocarbons and oxygenated hydrocarbons to produce photochemical oxidant. The need for a coordinated strategy control for NO<sub>x</sub> from stationary sources, as well as from motor vehicles, is imperative.

In this regard, the recent policy shift of the EPA of permitting relaxation of controls on oxides of nitrogen from stationary sources, is regrettable. One distinguished air pollution researcher has pointed out, in effect, "The Environmental Protection Agency has recommended to the states that nitric oxide is not a problem." The researcher then went on to state, "This position is summarized for the Power Industry" in an excerpt from *Power Engineering*, August 1973:

"On February 28, 1973, William D. Ruckelshaus, then EPA head, told a Congressional committee that nitrogen oxides are not the problem they were thought to be earlier. On April 17, he told a Senate committee the EPA would reclassify all the air control regions, except Los Angeles and Chicago, which were originally judged to exceed the NO<sub>x</sub> health-related standard. This, he said, would remove the need for the adoption of NO<sub>x</sub> control strategy, and states which have adopted such a strategy have the option of modifying it."

The excerpt concludes:

"Thus, the states have lost the technical support and guidance which was supposed to be forthcoming from the Federal Government. Now the situation exists in which a state wanting to protect its environment from deterioration may, in fact, be the adversary to EPA environmental witnesses."

It is interesting to note that the Japanese Government, less than two months ago, passed a law strictly regulating NO<sub>x</sub> emissions from both existing and new major stationary sources. In Table I, the Japanese regulations for NO<sub>x</sub> control from new and existing sources are compared with those in the U.S. developed under the original EPA plan and in Los Angeles County under its local control program.

TABLE I.—CDMPARISON OF JAPANESE NITRIC OXIDE REGULATIONS FOR NEW AND EXISTING MAJOR STATIONARY SOURCES VERSUS UNITED STATES AND LOS ANGELES COUNTY NITRIC OXIDE REGULATIONS

[In parts per million]

	Japanese		United States	
	New	Existing	EPA new	Los Angeles County existing
Gas-fired boiler.....	130	170	168	125
Oil-fired boiler.....	180	230	237	225
Coal-fired boiler.....	480	600	500	.....
Heating furnace.....	200	220	.....	.....
Petroleum chemistry.....	170	210	.....	.....

Obviously, the key role played by oxides of nitrogen in smog, which is also a major health hazard in Japan today, has been clearly recognized there. It seems strange, indeed, that our EPA, under intense pressure, seems to be relaxing its controls on  $\text{NO}_x$ , while the Japanese are strengthening theirs.

This is particularly depressing because the control of oxides of nitrogen in existing burners for major stationary sources has been developed substantially and has been implemented in a number of operating boilers throughout the U.S. Thus, in California, a modified firing technique has been employed on all the boilers within the San Diego Gas & Electric system. As a result, within the entire San Diego utility system, the reduction in  $\text{NO}_x$  was over 50%. The combustion expert who furnished me with this information pointed out that:

"The techniques employed in controlling the combustion involved neither significant equipment modifications nor increases in operating expense. In fact, because of better oxygen control, many of these boilers now operate at lower excess air with a significant savings in fuel usage and operating costs. The costs of controlling nitric oxide emissions is often more than paid for by future operating savings."

Finally, it is ironic, indeed, that we taxpayers are paying substantial sums of money for control devices to reduce emissions of oxides of nitrogen from our motor vehicles, and yet at the same time it now appears that major industrial sources and public utilities are not only being permitted, but almost encouraged, to relax their  $\text{NO}_x$  controls from major stationary sources. This is poor science, poor technology, poor control strategy, and extremely poor politics!

*Recommendation 8: Strict controls on  $\text{NO}_x$  from both stationary and mobile sources should continue to be maintained.*

#### B. Oxygenated hydrocarbons

It has become increasingly apparent that oxygenated hydrocarbons play significant roles, both directly<sup>12,13</sup> and in synergism with hydrocarbons, in the formation of photochemical oxidant.<sup>14</sup> Furthermore, in addition to their photochemical reactivity, certain aldehydes (such as formaldehyde and acrolein) are potent eye irritants.

Partially oxygenated hydrocarbons comprise a small but significant portion (5 to 10%) of automobile hydrocarbon exhaust emissions, and, of these, aldehydes are the main component.<sup>15,16,17,18</sup> However, to date, there are no emission standards for aldehydes, nor is the major aldehydic component in exhaust—formaldehyde—detected by analytical techniques used to monitor the exhaust hydrocarbons.

While certain of the exhaust control systems proposed for hydrocarbons in 1975-76 (now 1976-77) will also reduce aldehyde emissions,<sup>19</sup> at least one control system apparently produces significant quantities of them. In addition, since aldehydes are partially oxidized hydrocarbons, their emissions may be significant during the warm-up period (i.e., cold start) of cars equipped with oxidizing catalysts. Furthermore, similar partial oxidation to yield increased oxygenates might occur during catalyst aging.

The aldehyde problem is a potential control loophole that must be examined very carefully to be sure exhaust control systems are going to be truly effective.

*Recommendation 9: The formulation of emission standards, written in terms of the sum of hydrocarbons and oxygenated hydrocarbons rather than hydrocarbons alone, should be considered.*

<sup>12</sup> B. Dimitriadou and T. C. Wesson, "Reactivities of Exhaust Aldehydes," J. Air Pollut. Control Assoc., 22, 33 (1972).

<sup>13</sup> K. L. Demerjian, J. A. Kerr and J. G. Calvert, "The Mechanism of Photochemical Smog Formation," *Advances in Environmental Science and Technology*, Volume 4, J. N. Pitts, Jr. and R. L. Metcalfe, editors, in press.

<sup>14</sup> A. P. Altshuller and J. J. Bufalini, "Photochemical Aspects of Air Pollution: A Review," *Environ. Sci. and Technol.*, 5, 39 (1971).

<sup>15</sup> P. E. Oberdorfer, "The Determination of Aldehydes in Automobile Exhaust Gas," *Automotive Eng. Congress*, Detroit, Mich., Jan. 9-13 (1967).

<sup>16</sup> D. E. Selzinger and B. Dimitriadou, "Oxygenates in Exhaust from Simple Hydrocarbon Fuels," J. Air Pollut. Control Assoc., 22, 47 (1972).

<sup>17</sup> C. S. Wodowski and E. E. Weaver, "The Effects of Engine Parameters, Fuel Composition, and Control Devices on Aldehyde Exhaust Emissions," Presented at the Fall Meeting of the West Coast Section of the APCA, San Francisco, October 8, 1970.

<sup>18</sup> E. E. Wigg, R. J. Campion and W. L. Petersen, "The Effect of Fuel Hydrocarbon Composition on Exhaust Hydrocarbon and Oxygenate Emissions," presented at Automotive Engineering Congress, S.A.E. No. 720251, Detroit, Mich., Jan. 10, 1972.

<sup>19</sup> E. E. Wigg, "Reactive Exhaust Emissions from Current and Future Emission Control Systems," S.A.E. No. 730196, Detroit, Mich., Jan. 8-12, 1973.

### C. Fuel additives

A recent area of concern is the use of manganese compounds as fuel additives to inhibit smoke formation and improve combustion. One such additive—an inorganic manganese compound, methylcyclopentadienyl manganese tricarbonyl [ $\text{CH}_2\text{C}_5\text{H}_4\text{Mn}(\text{CO})_3$ , or  $\text{C}_5\text{H}_7\text{O}_2\text{Mn}$ ], variously referred to as MMT, CI-2 (Combustion Improver-2), or AK-33X (Anti-Knock-33X), and containing 24.7% manganese by weight—does in fact produce a reduction in visible particulates, but the total mass and number of particulate emissions may increase.<sup>30</sup>

Such additives are currently being used, for example, to clean up oil-fired furnaces.<sup>31</sup> Unfortunately, the health effects of the resultant<sup>32, 33</sup> emissions of Mn and its compounds are not well known, although the possibility of a cumulative build-up of Mn in the human body exists. Manganese may or may not be or become a problem, but it does serve to illustrate that the question of fuel additives continues to require a thorough examination, both of their initial composition and final chemical and physical forms as combustion products when they are ultimately released into the atmosphere.

*Recommendation 10: Both currently used and future fuel additives should be closely examined for their ultimate atmospheric emissions and the subsequent health effects.*

### D. Development of modifications and alternatives to the internal combustion engine

It is essential to recognize that some of the control systems proposed and beginning to be implemented for 1975 and 1976 (1977) are really, in effect, stop-gap measures and not satisfactory long-term solutions. Thus, those involving complex "add-on" devices probably will not be acceptable in the long run, either in terms of performance of the vehicle or the fuel penalties involved.<sup>34</sup> This has been pointed out in a recent National Academy of Sciences report,<sup>35</sup> which showed that of all the systems tested, four other approaches—including stratified charge engines—were more suitable than the catalyst system currently proposed by several major U. S. manufacturers.

I shall not enter this debate today. My point is that we must press vigorously forward to develop new engines for the motor vehicles of the late 1970's, and early 1980's. Whether they should be turbine, stratified charge, diesel, steam, stirling, or others, I cannot say. I do, however, strongly support those in the Congress, such as Senator Tunney, in their efforts to introduce legislation which will provide a greatly expanded research and development program designed to encourage the development and commercial production of such practical, low-pollution, and revolutionary propulsion systems for motor vehicles by the early 1980's.

*Recommendation 11: Extensive research and development on modifications and alternatives to the internal combustion engine should be encouraged on a highest priority basis.*

## VIII. CONCLUDING REMARKS

In conclusion, I want to reemphasize that the paucity of reliable, scientific, technical, and medical data used in setting air quality standards has led to complaints, in some cases justified, that certain air quality standards are considerably more restrictive than current knowledge warrants. This has important economic, as well as technical, implications. Thus, for example, initial uncertainties in health effects data are compounded to produce serious socioeconomic penalties by the time the final cost figure for an emission control system is determined.<sup>36</sup>

<sup>30</sup> D. V. Giovanni, P. J. Paeni, R. F. Sawyer and L. Hughes, "Manganese Additive Effects on Emissions from a Model Gas Turbine Combustor," *Combustion Sci. and Technol.*, **6**, 107 (1972).

<sup>31</sup> I. Kuklin, "Additives Can Clean Up Oil-Fired Furnaces," *Environ. Sci. and Technol.*, **7**, 606 (1973).

<sup>32</sup> D. Bryce-Smith, "Behavioural Effects of Lead and Other Heavy Metal Pollutants," *Chemistry in Britain*, **9**, 240 (1973).

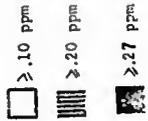
<sup>33</sup> L. Hughes, Ph. D. Dissertation, School of Public Health, University of California, Berkeley (1972).

<sup>34</sup> *Automotive Engineering*, "What Are the Prospects for Alternative Power Plants?," **81**, 50 (1973).

<sup>35</sup> National Academy of Sciences, "Report by the Committee on Motor Vehicle Emissions," February (1973).

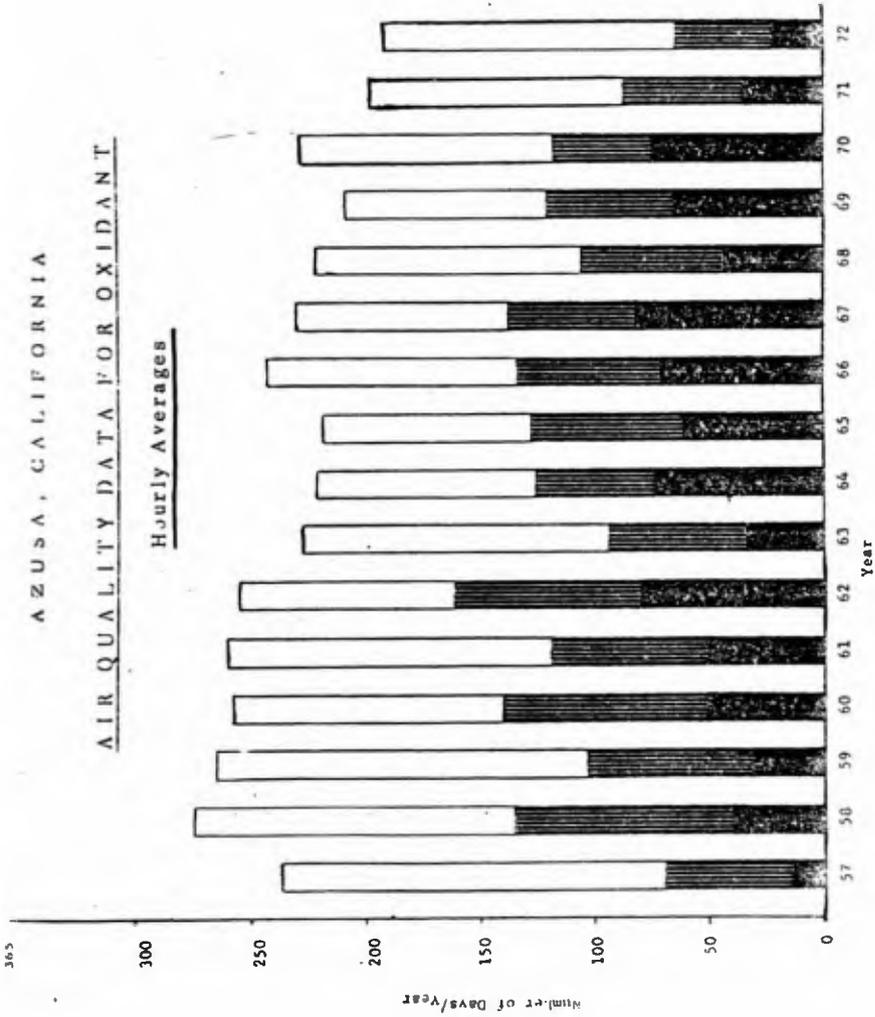
<sup>36</sup> Office of Science and Technology, "Cumulative Regulatory Effects on the Cost of Automotive Transportation (RECAT)," February 28, 1972.

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 RIVERSIDE, CALIFORNIA 92502

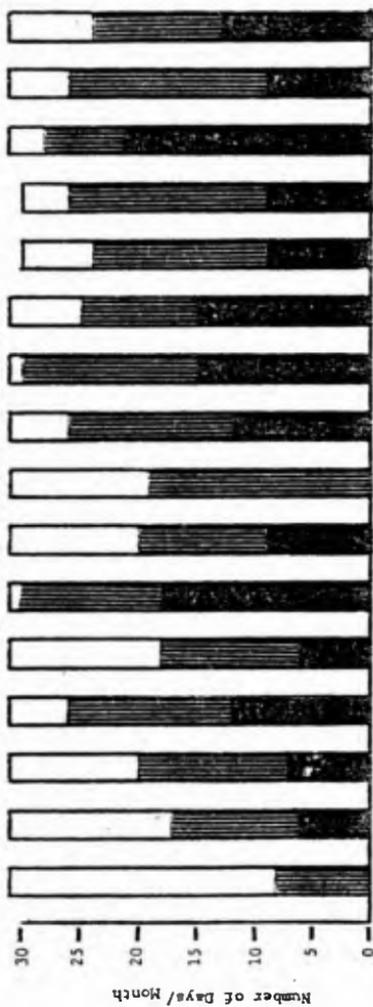


AIR QUALITY DATA FOR OXIDANT

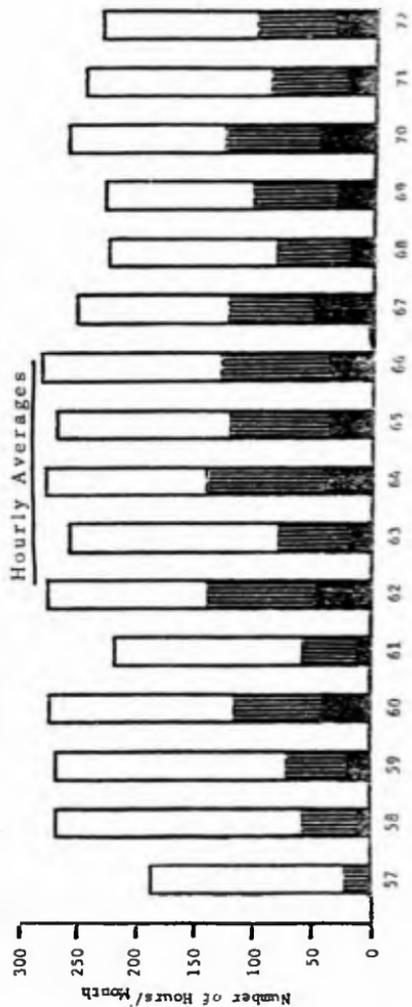
Hourly Averages



## AZUSA, CALIFORNIA



## AIR QUALITY DATA FOR OXIDANT



> 1.0 P  
 1.0 P  
 < 1.0 P

When one considers the billions of dollars being spent on development and installation of control systems *vs.* the relatively modest research expenditures that would be involved in substantially improving our data base upon which the control strategies ultimately depend, it seems clear that our country cannot afford to do other than press forward at the highest priority with key research, development, and training programs. Otherwise, we shall find ourselves several years from today at still another "oversight hearing," reviewing the same old problems, and using virtually the same inadequate data base we have today.

This would be a scientific, medical, technological, and economic tragedy for all of us!

The question of the appropriate funding agencies for such expanded programs is delicate and complex. Certainly, the EPA research programs, both in-house and extramural, which by the very nature of the agency's mandate, are short-term and mission-oriented, must be supported far more vigorously through increased appropriations to the EPA.

On the other hand, support for new or expanded medium- and long-range research programs logically would appear to fall in the province of such highly qualified agencies as the National Science Foundation and HEW's National Institutes of Environmental Health Sciences. I hope that strong consideration will be given to the possibility of substantially increasing their involvement with research programs of direct relevance to the Clean Air Act.

#### A. Necessity for control now

However, while stressing the need for research to provide a much stronger data base for air pollution control, I want to conclude by emphasizing the *continuing critical need for action now, based on our present knowledge! While this may appear arbitrary, and indeed in some cases it must be, the concurrent approach of "control now," while continually refining one's data base, is the only way to achieve substantial progress in real time.*

Finally, I should like to express my concern that the pendulum which, in part because of real and pressing energy needs, now seems to be swinging to economics at the expense of environmental considerations, should not be allowed to swing too far. If it does, this could lead to serious degradation in air quality with its resulting potentially drastic impact on the health and welfare of the American public. Surely, with a reasoned, cooperative, and substantive effort from all sectors, we can, in fact, balance ecology and economics to the benefit of all Americans!

Mr. PREYER [presiding]. Thank you very much, Dr. Pitts.

It is good to hear from an atmospheric chemist, a specialist in photochemical smog. That was a new discipline a few years ago but I think we will be hearing a lot more about in the future.

Thank you very much for some very valuable information and testimony.

Dr. Carter?

Mr. CARTER. Thank you, Mr. Chairman.

This is a rather highly technical paper. It seems that you have done a great deal of work on it. Let me compliment you on your clear dedication to this subject. I think we need more of this in every field.

How is the smog over Los Angeles now, by the way?

Mr. PITTS. How is it?

Mr. CARTER. Yes, sir.

Mr. PITTS. Serious.

Mr. CARTER. You have had anti-pollution devices on your automobiles in California for how long now?

Mr. PITTS. We have exhaust control devices since 1966.

In downtown Los Angeles, photochemical oxidant has decreased. On the other hand, nitrogen dioxide has gone up.

Mr. CARTER. Nitrogen dioxide has gone up, and what has diminished?

Mr. PITTS. Photochemical oxidant, the chief air pollution health hazard in southern California. Its mechanism of formation is a com-

plex technical problem. Basically, it is the action of the ultraviolet portion of sunlight on hydrocarbons and oxides of nitrogen that produces ozone, the major component of photochemical oxidant.

What appears to have happened in downtown Los Angeles is that the increased emissions of nitric oxide, resulting from the 1966 to 1970 exhaust emission controls, reacts with and destroys the ozone in the atmosphere. This tends to lower the reading for photochemical oxidant. However, the quenching reaction produces the brown, toxic gas nitrogen dioxide, and it is nitrogen dioxide that is the precursor to the formation of ozone. Thus, the consequence of the 1966-70 control actions were that the ozone, and thus the photochemical oxidant, has dropped in the downtown Los Angeles area but the nitrogen dioxide levels have gone up. As the nitrogen dioxide drifts across the entire air basin, it reacts with sunlight and hydrocarbon to produce additional ozone over a large area.

Thus, for example, Palm Springs, which is approximately 150 miles east of downtown Los Angeles, and Indio, San Bernardino, Riverside, et cetera, over the last 5 years or so, have developed serious smog problems.

Mr. CARTER. Do you think the smog problem has lessened in intensity over Los Angeles at all?

Mr. PITTS. To take the South Coast Basin—

Mr. CARTER. During the past years.

Mr. PITTS. If you take it solely in terms of photochemical oxidant, and average over the entire basin, recognizing it may go down at one point and rise in another, the available information indicates that on the average it has not improved significantly in the last 6 years.

Mr. CARTER. In spite of all the things we have done in controlling emissions from automobiles?

Mr. PITTS. Yes, but the problem is several fold

First of all, we made a mistake, frankly, and I am perhaps as much to blame as other scientists. In 1966 in California we didn't stress control of oxides of nitrogen concurrently with the controls that we put on hydrocarbons and CO. This has led to the increased emissions of oxides of nitrogen which, in part, are responsible for the tremendous spread in photochemical oxidant over the eastern portion of the South Coast Air Basin. Thus, the first point is that, we simply weren't comprehensive enough in our original legislation in California. I should add parenthetically, however, as indicated in my prepared testimony, that carbon monoxide levels have dropped; that portion of the control strategy is working.

The second problem is societal.

Scientists and technicians are not magicians. Thus, if we reduce emissions, not just from automobiles but also from stationary sources, by 50 percent, but double the number of people living in the air basin, you are even worse off than you were before.

So, you have an enormous socioeconomic problem including that of land use. In short, the major reason smog in the South Coast Air Basin has not decreased as rapidly as we had hoped is that although control devices are becoming more and more effective, concurrently there has been a large population increase in certain areas. In effect, there is a battleground between the technological control strategy and societal demands for more land, more energy, and more transportation.

This is why, in the Clean Air Act, the whole question of societal options also must be considered. In severe smog areas, one just can't do it with technology alone.

Mr. CARTER. You have had an increase in your population, both human and in automobiles; is that correct?

Mr. PITTS. Yes, sir.

Mr. CARTER. You think your problem has been compounded by this, increased by this; is that correct?

Mr. PITTS. Yes.

Mr. CARTER. You think probably that the measures you have taken would have been successful had it not been for the population increase in both people and automobiles; is that correct?

Mr. PITTS. That depends on how you define "successful."

Mr. CARTER. Speak just a little more slowly, please.

Mr. PITTS. It depends on how you define "successful." If our population had been more stable in key areas of the South Coast Air Basin, then we would have had more success today with our smog control measures. However, a different type of success can be defined in terms of the EPA implementation plan for the South Coast Air Basin, which specifies that by 1977 the oxidant air quality standard cannot be exceeded more than 1 day per year. However, overall, the answer is "yes"; we would have been more successful had the population been stabilized and had we had appropriate and timely action in such key areas of transportation as, for example, rapid transit.

Mr. CARTER. And no increase in the population.

Mr. PITTS. That is correct. However, there is a qualifier even here. The energy requirements per capita have also been going up, and more energy generally means more smog.

Mr. CARTER. Let us suppose that you have had no population increase, and we will leave out the mass transportation, but we have had emission control systems on our cars. Would the smog problem then have been alleviated?

Mr. PITTS. Yes, sir. If the proper total control systems had been put on in 1966 and if the cars had been required to be properly maintained—I very strongly believe in mandatory inspection and maintenance of used automobiles to minimize their emissions—yes, the problem would have been alleviated.

Mr. CARTER. Even with no population increase over the last 7 years?

Mr. PITTS. Yes, sir. To illustrate my point, let us look at the air monitoring data from Azusa, Calif., a city located about 15 miles east of Pasadena. We chose this air monitoring station because oxidant data has been generated continuously since 1957.

I should point out, however, under the alleviated conditions, the smog would in no way approach the levels specified for the South Coast Air Basin under the Clean Air Act. That is, all the existing technical measures have no chance of bringing the air quality in the South Coast Air Basin to the point where the air quality standard for oxidant is exceeded no more than 1 day per year. This has been discussed elsewhere, but I should stress again societal control strategies must be employed along with technical controls if we are to approach even 50 days per year in which the air quality standard for oxidant is not

exceeded, much less 1 day per year. I should note that presently in the basin, east of downtown Los Angeles, the air quality standard for photochemical oxidant is exceeded over 200 days per year.

In summary, to even approach the EPA's implementation goals, it will require massive societal sacrifices as well as technological and economic "sacrifices."

On the first graph [see the written statement], the white bar indicates the number of days per year that California air quality standard for oxidant, 0.10 ppm for 1 hour, were exceeded. I might add that the Federal standard of 0.08 ppm oxidant for 1 hour is approximately the same.

The vertical bars are the numbers of days per year in which the hourly average for oxidant exceeded 0.20 ppm. Under a new system proposed by the California Air Resources Board, those are days in which a health warning alert would be called.

Finally, the solid black region, represents the number of days when the hourly average or equaled exceeded 0.27 ppm. The significance of 0.27 ppm oxidant is that this is the level where in Riverside County, we issue a school alert. When that oxidant level is reached, physical education classes are canceled and students must come indoors. Actually, a school alert in Riverside is called for an instantaneous reading of 0.27 ppm, so the data are not directly comparable, merely illustrative.

If you look at the first graph with yearly data, it looks as though smog is in fact getting better. However, this may be somewhat misleading because smog levels are strongly affected by the meteorology, of a given day, season or year.

Thus, while we had a miserable, smoggy summer last year, we had a marvelous fall and winter. About September 15, the weather fronts started to come through southern California; it was beautiful. It rained. There was virtually no serious sustained smog problem in the basin from the first of October on. This is reflected in the 1972 averages.

However, if in 1973, we have a more typical dry fall and winter; then I think the "bars" will go up.

Let us turn to the next chart and examine the data for July, a peak smog month. On the top graph we have number of days for each July since 1957 that the Azusa station exceeded the specified oxidant levels. Note that since 1957, with the exception of 2 years, 1968 and 1969, the health-related air quality standards were exceeded every day of July.

Then in the medically significant values of dosage—that is, the total number of hours of exposure at or above given levels, per month—you will see there was no significant change in photochemical smog over the last 15 years. The data speak for themselves.

I would caution that the data will vary from station to station and that in downtown Los Angeles, the photochemical oxidant levels have dropped.

Mr. CARTER. Thank you very kindly, sir.

Mr. PREYER. Mr. Hastings?

Mr. HASTINGS. Thank you very much, Mr. Chairman.

Dr. Pitts, I appreciate your testimony. I am going to try to clarify my understanding of what you have presented to this committee here.

One point I would like to question you on. On page 3, you refer to nuclear reactors. Your recommendation is that we make a definitive study that could lead to drafting of legislation that would produce in the near future a coordinated national effort dedicate to the development of, et cetera, et cetera.

Are you saying in fact then that we should not proceed with the construction of nuclear plants for the production of electricity at this point in time without further study?

Mr. PIRTS. I am very glad you asked that question. It is very important. I should clarify that portion of my written statement. My answer to your question is a qualified "No." Thus, I think we should proceed with nuclear powerplant construction at an accelerated pace, but only if it is consistent with adequate safeguards for public health and safety. I also believe we should proceed with a greatly expanded program of research to make them safer, and hopefully, to go to fusion systems perhaps 20 years hence.

The current dilemma in southern California is that many of us living in that area, in effect, want something for nothing. We say we don't want more fossil fuel powerplants in southern California because they produce nitrogen and sulfur oxides, and particulates.

On the other hand we don't want nuclear powerplants for various health, safety, and ecological reasons—some of them very sound. However, we want more air-conditioners and other items that consume more energy. What do we do?

One possible solution is exemplified by the Four Corners fossil fuel powerplant complex. However, I don't advocate that strategy as a solution to southern California's energy problem. It is a totally wrong and indeed immoral act to pollute the clean air and water of a beautiful country hundreds of miles away just to produce more electric power for us southern Californians. If we want more power, we must be prepared to pay the environmental price for it, and here, not there.

Mr. HASTINGS. Are you saying we should proceed with the construction of these plants but we should be aware of the risk and we should carry on studies?

Mr. PIRTS. Yes, sir. One approach that should be investigated seriously is the possibility of burying the nuclear powerplants underground. I have heard of this being a possible safety approach.

Mr. HASTINGS. Let me make a point. When we talk here in the Congress about allowing the construction of nuclear plants we are talking about maybe next week. We are not talking about an investigation that you say probably should be carried on. We are reduced to the situation where we have to say yes or no. That, maybe, is what I am looking for, yes or no.

Mr. PIRTS. I can't give an unqualified yes or no because we have to be very sure of the safeguards that are built into a given nuclear plant. Given what I think is the existing technology for safeguards, as updated now because of environmental concerns, given the further approach that the plan might be buried underground for additional safety, then my answer for critical air quality regions such as California is that, if we demand substantially more energy and air free from  $\text{NO}_x$ ,  $\text{SO}_x$  and particulates, we will have to go to nuclear powerplants. I see no other alternative for the short-term future. In the

longer term, geothermal and solar energy are attractive and should be explored and developed at a high priority, but they may not have the capacity to meet projected needs. One would hope that the energy demand could be slowed down; this would ease some of the pressure to construct new generating plants; fossil fuel or nuclear.

Mr. HASTINGS. If I understand the basis of your testimony, it is that we should stick with the standard we currently have in the Clean Air Act, is that correct?

Mr. PITTS. Yes, sir, with one possible exception and that is a debatable point, the NO<sub>x</sub> emission control standard of 0.4 gram per mile in 1976. The present 0.4 gram per mile proposed for 1977 might be too stringent and may well present technical problems which just aren't easily overcome without excessive costs to all concerned. However, I strongly believe that NO<sub>x</sub> emissions from motor vehicles should not be allowed to go to 2, 3, or 4 grams per mile in 1976, as has been proposed in some quarters, but should be kept at 1 gram per mile or preferably less.

Thus, I support 1 gram per mile for NO<sub>x</sub>—or preferably less—and holding hydrocarbons and CO as specified; that is, 3.3 grams per mile for CO and 0.40 gram per mile for hydrocarbons.

Mr. HASTINGS. At the same time you are suggesting some of these standards cannot be met by the time frame in the act.

Mr. PITTS. In that case I was referring to a different matter; that is air quality standards rather than emission standards. In my statement, I proposed retaining the present air quality standards at their existing levels but instituting a variance system for specific urgent needs.

This relates particularly to the energy crisis. In my statement, I was specifically concerned with the additional oxides of sulfur that are going to be introduced into the atmosphere if high sulfur fuel is substituted for natural gas or low sulfur—0.5 percent or less—liquid fuel.

My point was that we should not compromise health-related air quality standards, even because of a pressing national need and even though drastic measures may have to be taken.

My "variance" approach is basically to retain the air quality standard but admit that we are going to compromise air quality for a certain number of days per year during the "crisis."

Mr. HASTINGS. I understand what you are saying. I am not so sure you can write that in legislation. You keep the standard but allow them to violate it; I think this is what you are saying. I don't know how we can get that written in statutory language.

I think you pose a very difficult problem for this committee with that type of suggestion. Yet, I suppose it is a rather practical one.

I think that is really the problem this committee is faced with. You think that we should have in the act the terminology "economic and technological feasibility"?

Mr. PITTS. Should it be in the act?

Mr. HASTINGS. Yes.

Mr. PITTS. That is a very general question.

Mr. HASTINGS. It is a specific one. It was in the act at one time before the gentleman on the other side of the Capitol decided to take it out.

Mr. PITTS. It depends on where that is put. If you put economic and technical feasibility—

Mr. HASTINGS. In meeting the variance from the standards should the terms be included.

Mr. PITTS. It depends. Air quality standards are based on the health effects of a given pollutant on man, and they are not subject to economic or technological considerations.

However, when you come to specific control measures to achieve those health-related air quality standards, then one has to look at economic and technical considerations.

Mr. HASTINGS. I would assume since you highly recommend that we commit a great deal of money to research, training, demonstration, and development programs, in fact, you are saying we need to do a great deal of research and development before we know completely what we are talking about.

Mr. PITTS. That is correct.

Mr. HASTINGS. Here we are again, we have the problem of writing in a statute, guidelines to do something, yet an expert like yourself says we don't know enough about it to be able to know statutorily what we are saying.

That again poses a very very difficult problem. Overall we are simply going to have to balance the needs and demands of energy as opposed to the great interest in achieving clean air.

Mr. PITTS. Yes, sir.

Mr. HASTINGS. Thank you very much, Dr. Pitts.

I have no more questions, Mr. Chairman.

Mr. PREYER. Mr. Heinz?

Mr. HEINZ. Thank you, Mr. Chairman.

Dr. Pitts, I would like to thank you for some very learned and very useful testimony to the subcommittee. I would like to ask you to expand on one or two comments you made just so that I have a totally clear picture.

You made reference to the fact that EPA either was in the process of or had modified and relaxed the NO<sub>x</sub> standards. Did I understand you correctly?

Mr. PITTS. Let me find that section in my statement. I quote on page 10 of my written testimony:

One distinguished air pollution researcher has pointed out, in effect, "The Environmental Protection Agency has recommended to the states that nitric oxide is not a problem."

The researcher then went on to state, "This position is summarized for the Power Industry" in an excerpt from Power Engineering, August 1973:

On February 28, 1973, William D. Ruckelshaus, then EPA head, told a Congressional committee that nitrogen oxides are not the problem they were thought to be earlier. On April 17, he told a Senate committee the EPA would reclassify all the air control regions, except Los Angeles and Chicago, which were originally judged to exceed the NO<sub>x</sub> health-related standard. This, he said, would remove the need for the adoption of NO<sub>x</sub> control strategy, and states which have adopted such a strategy have the option of modifying it.

Mr. HEINZ. Excuse me. Let me ask you then in response to that quotation, to your knowledge has EPA reclassified any or all of the air control regions?

Mr. PITTS. I really can't speak to that point. I do know they are concerned with the reclassification. I do know that letters are going out from the EPA to various State control agencies discussing this entire question.

Mr. HEINZ. What is the nature of the discussion in such letters?

Mr. PITTS. I can quote one. Basically, there is an implication the NO<sub>x</sub> emission standards can, and perhaps should, be relaxed, in certain regions.

Mr. HEINZ. Perhaps it would be helpful, Mr. Chairman, if such a letter could be made a part of the record.

Mr. PREYER. Yes; without objection.

[The letter referred to follows:]

U.S. ENVIRONMENTAL PROTECTION AGENCY,  
REGION IV,  
Atlanta, Ga., July 31, 1973.

PETER P. BALJET,  
*Executive Director, Florida Department of Pollution Control, 2562 Executive Center Circle E., Tallahassee, Fla.*

DEAR MR. BALJET: On June 5 and 8, 1973, EPA published in the *Federal Register* proposed regulation changes related to nitrogen dioxide and State Implementation Plan requirements. Copies of these proposed changes are attached. These proposed actions are the result of a special study that was conducted during 1972 to clarify problems associated with nitrogen dioxide.

In summary the proposed regulatory changes include the following:

(a) Part 50—Proposes to rescind the current nitrogen dioxide reference method and to identify three new potential reference methods.

(b) Part 51—Proposes to modify the requirements of an approvable control strategy for nitrogen dioxide. If this change is finally promulgated States with AQCR's classified as Priority I for nitrogen dioxide would be required to demonstrate the attainment of the national standard and adopt all measures necessary to attain the national standard.

(c) Part 52—Proposes to reclassify 43 AQCR's from Priority I to Priority III for nitrogen dioxide. This proposal also rescinds the EPA disapprovals of various nitrogen dioxide control strategies and the proposed EPA control regulations for certain AQCR's. In addition, the table which indicates the date for attainment of the national standards would be changed, where appropriate, for numerous AQCR's.

While the preambles to the proposed regulations provide a detailed discussion of this complex problem, there are some points that need to be clarified. First, if Parts 51 and 52 are finally promulgated as proposed, a nitrogen dioxide control strategy would not be required from your State. However, all States will need to consider the maintenance of the national standard for nitrogen dioxide, along with the other pollutants, in all AQCR's in accordance with the recently promulgated EPA regulations for maintenance of the national standards and complex sources (40 CFR 51.12, June 18, 1973).

Second, the proposed regulations do not specifically cover what action is necessary in relation to the submission of compliance schedules for sources that control regulations for nitrogen dioxide have been adopted and submitted as part of the State Implementation Plan. Since there is no apparent need to control stationary sources in most AQCR's to attain the national standard for nitrogen dioxide, States will be able to rescind their nitrogen dioxide control regulations that were submitted with the implementation plan. It is our position that States should be encouraged to withdraw their control regulations for nitrogen dioxide where it has been or can be demonstrated that such regulations are not needed. However, States should examine the need for controls on nitric acid plants since these sources may be a nuisance and may, in some cases, cause violations of the national standards in the vicinity of the facilities. In addition, States may want to retain their regulations pertaining to new combustion sources in the interest of maintaining air quality standards. Controls for these new sources are economically reasonable because the control of nitrogen dioxide is an integral part of the design. In those cases where a State intends to withdraw nitrogen dioxide control regulations from its implementation plan, the State must hold a public hearing

on the proposed implementation plan revision and submit it to the EPA Regional Office for review and approval.

Third, in those cases where the State desires to maintain the nitrogen dioxide control regulations that have been adopted and submitted with their implementation plan, they are presently required to submit compliance schedules for individual sources to EPA by August 15, 1973 as specified by the December 9, 1972 *Federal Register*. It is recognized that this deadline date is unrealistic under the current circumstances so we expect that this date will be changed when the proposed EPA nitrogen dioxide regulations are promulgated. At the present time, we anticipate the deadline date for nitrogen dioxide compliance schedules will be changed to require their submittal within four months following the nitrogen dioxide promulgations in the *Federal Register*.

It should be realized that the nitrogen dioxide proposals published in the *Federal Register* are only proposed and there may be some changes in the regulations that are finally promulgated. We hope that these actions will be finalized in the near future so that we can clarify the options that are open to the States and the actions required with these options.

We recently received notices regarding your August 7 and 9, 1973 public hearing which includes compliance schedules for existing sources of nitrogen dioxide. In view of the proposed actions published in the *Federal Register* and the uncertainty as to future EPA requirements for existing nitrogen dioxide sources you may wish to delay the adoption of these compliance schedules by the Board until after the EPA regulations are promulgated. At the present time we do not plan to require the submittal of nitrogen dioxide compliance schedules by the August 15, 1973 deadline date. It is requested that a copy of this letter and the attachments be made a part of the public hearing record for nitrogen dioxide compliance schedules.

Copies of the June 5 and 8 *Federal Register* proposals were forwarded to your office about a month ago and we hope that you have already submitted your written comments on these proposed actions.

We will try to keep you advised as to future development on this issue and if you should have any questions please feel free to contact this office.

Sincerely yours,

GENE B. WELSH, *Director,*  
*Air and Water Programs Division.*

Mr. HEINZ. Dr. Pitts, perhaps you could enlighten me further, if I understand the quotation correctly, why does the reclassification of an air control region have the effect of removing the need for the adoption of NO<sub>x</sub> control strategy?

Mr. PITTS. The present NO<sub>x</sub> control strategy situation is complex and confused. I have a position paper to clarify this question, recently presented by EPA, and which I would like to submit to this committee. It is very well done by Drs. Shy and Hauser [see p. 278]. They go into the questions of reclassification of air quality regions and the ramifications of the distressing problem that the analytical instrument for NO<sub>2</sub> that the EPA used in earlier field studies was seriously in error. The method gave values for ambient levels of NO<sub>2</sub> that were higher than actually existed. The EPA was very forthright about this problem, and I commend them highly for their candor. They said in effect "we blew it; our NO<sub>2</sub> data were wrong because the method was wrong. Such an error is somewhat understandable, because at that time the EPA was under pressure to get data on ambient NO<sub>2</sub> levels and there was no reliable NO<sub>2</sub> air monitoring instrumentation available. Today, as I understand it, they are saying in effect, "On the basis of the new values we have calculated for ambient NO<sub>2</sub> levels, it is not the health problem in some areas that we originally thought it was. However, on the basis of other considerations we are sticking to our original value for the air quality standard for NO<sub>2</sub>."

[Testimony resumes on p. 283.]

[The position paper referred to follows:]

Thomas R. Hauser and  
Carl M. Shy

Environmental Protection Agency  
Research Triangle Park, N.C. 27711



## Position paper:

On July 27, 1972, Willem O. Ruckelshaus, Administrator of the Environmental Protection Agency, deferred implementation of regulations regarding the control of nitrogen oxides (NO<sub>x</sub>) from certain stationary sources from July 31, 1972 to July 1, 1973. The decision to postpone the applicable regulation for one year was dictated by a need to reassess and, where necessary, revise the Administrator's classification of Priority I Air Quality Control Regions (AQCR) set forth on May 31, 1972 (Federal Register 37:10842). The need to reassess was in turn predicated on the results of recent EPA studies which indicated that the reference method for measuring nitrogen dioxide (NO<sub>2</sub>) in ambient air (Federal Register 36:8200, Apr. 30, 1971) seems to possess inherent deficiencies which may have caused an overestimation of the extent of the NO<sub>2</sub> problem in various AQCR throughout the United States.

As a result of the above, EPA has received numerous inquiries into the current status of NO<sub>2</sub> measurement methodology. This article presents an up-to-date status report on the above subject and explains the actions within EPA which are under way to resolve the various questions which have been raised.

The 1967 amendments to the Clean Air Act required the Secretary of Health, Education and Welfare to develop and publish air quality criteria which, in his judgment, were required for the protection of the public health and welfare. Additionally, the Act called for the establishment of Air Quality Control Regions (AQCR) based on jurisdictional boundaries, urban-industrial concentrations, and other factors including atmospheric areas, necessary to provide adequate implementation of air quality standards. Two hundred forty-seven AQCR were designated between June 1968 and January 1972. "Air Quality Criteria for Nitrogen Oxides" was published in January 1971.

The Clean Air Act was further amended in 1970 (PL 91-604) and required the administrator of EPA to establish, among other things, National Ambient Air Quality Standards, National Emission Standards for Hazardous Air Pollutants, and Standards of Performance for New Stationary Sources of air pollution. The administrator promulgated National Ambient Air Quality Standards for six pollutants, including NO<sub>2</sub>, on Apr. 30, 1971. Concurrently the analytical methodology or measurement principle to be used to measure the six pollutants was promulgated, and these methods were called the "reference methods." "Requirements for the Preparation, Adoption, and Submission of Implementation Plans" was published on Aug. 14, 1971, which outlined for the States what was to be included in plans to implement or achieve the National Ambient Air Quality Standards. These regulations included specifications that pollutants be mea-

sured by the published reference method or a method demonstrated to be equivalent to the reference method.

### Reference method

The reference method for the analysis of NO<sub>2</sub> in ambient air to determine compliance with the national air quality standards is the Jacobs-Hochheiser procedure as modified by chemists within the National Air Surveillance Networks (NASN). This method involves the collection of NO<sub>2</sub> by bubbling ambient air for a 24-hr period through an aqueous 0.1N sodium hydroxide solution to form a stable solution of sodium nitrite. The nitrite ion formed in the absorbing reagent is then reacted with sulfanilamide and N-1-naphthylethylenediamine in acid media to form an azo dye which is measured colorimetrically at 540 nm. Calibration of the method is achieved in accordance with directions published along with the reference method using standard nitrite solutions. The collection efficiency of the reference method for NO<sub>2</sub> was previously determined to be 35% and a correction for this efficiency has been applied to all data gathered to date utilizing the reference method. It is precisely this average collection efficiency correction factor that is now in question, and this subject will be addressed later in this discussion.

In the summer of 1971, EPA conducted a special study in urban areas with potential air pollution problems to gather ambient NO<sub>2</sub> data to be used by the states to develop implementation plans for the control of NO<sub>2</sub>. The method used in the 1971 Summer Study was the reference method as published in the *Federal Register*. As a result of that

Doubts about the accuracy of measured concentrations of  $\text{NO}_x$  in ambient air have led EPA to reassess both the analytical technique and the extent to which  $\text{NO}_x$  control will be needed to satisfy federal law

## NO<sub>x</sub> measurement

Summer Study and other available data, 45 AQCR in 29 states were classified as Priority I for  $\text{NO}_x$ —that is, these states may be required to control  $\text{NO}_x$  emissions from stationary sources to have acceptable implementation plans. Concurrent with the Summer Study, intensive investigations were being conducted by scientists at the National Environmental Research Center in the Research Triangle Park, N.C. (NERC-RTP) to re-investigate the analytical parameters of the reference method. These investigations resulted in EPA arriving at its present position as stated earlier—i.e., that the results of recent investigations indicate that the reference method for  $\text{NO}_x$  seems to possess inherent deficiencies which may have caused an over-estimation of the extent of the  $\text{NO}_x$  problem in the various AQCR. It should be noted that EPA has already established the regulatory framework necessary for the control of  $\text{NO}_x$  based on the original data and, hence, control can proceed quickly if warranted by the new data. On the other hand, the one-year delay in the application of control regulations has been instituted by EPA to ensure that final control regulations are consistent with the findings of the new data.

### Recent Investigations

The main investigations leading to the conclusion that the reference method may have some inherent problems were conducted by the Office of Measurement Standardization (OMS) and the Laboratory Measurements Research Section (LMRS) of the Division of Chemistry and Physics and in the Air Quality Analytical Laboratory (AQUAL) of the Division of Atmospheric Surveillance. Nitrogen



dioxide generation-dilution systems based on an  $\text{NO}_x$  permeation tube were used during all investigations. Nitrogen dioxide-air mixtures of varying concentrations were generated by the OMS and the mixtures were sampled and analyzed by the reference method for  $\text{NO}_x$ . The collection efficiency of the reference method was then determined by comparing the amount of  $\text{NO}_x$  found after analyses vs. the known amount of  $\text{NO}_x$  generated and introduced into the sampling train. Before insertion of the permeation device in the  $\text{NO}_x$  generation-dilution apparatus, dynamic blanks were run, and it was found that blank corrections were negligible.

For each test atmosphere generated, at least five simultaneous samples were collected and analyzed. Hence, the data points in Figure 1 are averages  $\geq$  five determinations. Additionally, four different permeation devices were used during the study. The results shown in Figure 1 demonstrate that the collection efficiency of the reference method varies nonlinearly with  $\text{NO}_x$  concentrations from 15% at  $740 \mu\text{g}/\text{m}^3$  to 50-70% at the  $20\text{-}50 \mu\text{g}/\text{m}^3$ . These data agree reasonably well with the limited permeation tube data published in the reference method and by Purdue et al. [ES&E, 6, 152, (1972)]. This method of calibration differs from that published

for the reference method in that  $\text{NO}_2$  gas rather than nitrite ion is dynamically carried through the reference procedure. This, in turn, reflects the advancement in the state of the art and use of the  $\text{NO}_2$  permeation device as a calibration standard which afforded the opportunity to study the  $\text{NO}_2$  analytical problem in much more depth.

The second problem recently found in the reference method is a positive interference caused by the presence of nitric oxide (NO) in the ambient atmosphere. Dilute mixtures of known concentrations of  $\text{NO}_2$  in air were prepared by passing purified air over an  $\text{NO}_2$  permeation tube. Known amounts of NO were then metered into the dilute  $\text{NO}_2$  gas stream, and the entire mixture was analyzed by the reference method for  $\text{NO}_2$ . The response obtained from the reference method, with and without NO in the dilute  $\text{NO}_2$  gas stream, was noted and results appear in Table I.

The reference method as published contains directions on how to calculate the concentration of  $\text{NO}_2$  ( $\mu\text{g}/\text{m}^3$  and ppm) in the air sampled. In these calculations a correction is included for the overall efficiency of the method which historically had been determined to be 35%. Inspection of Figure 1 shows that at low concentrations of  $\text{NO}_2$  in the atmosphere (30–60  $\mu\text{g}/\text{m}^3$ ), where collection efficiencies are much higher than 35%, the reported concentrations of  $\text{NO}_2$  will be much higher than the actual ambient level. The positive interference from NO, the extent of which still needs further evaluation, could also be important in these areas of low concentration. In areas where the ambient level of  $\text{NO}_2$  is above 120–130  $\mu\text{g}/\text{m}^3$ , a 35% collection efficiency factor is approximately valid; at higher atmospheric concentrations, the application of the 35% correction factor will underestimate the actual  $\text{NO}_2$  concentration in the air sampled.

#### Validity of past data

EPA fully recognizes that the validity of a tremendous amount of data collected in previous years may now be in jeopardy. This is especially true for the lower ambient air concentrations of  $\text{NO}_2$ , which may be erroneously high because of the collection efficiency factors or NO interference discussed earlier. Where data have been used not simply for trend monitoring but in decision-making processes for control of stationary sources, the validity of the data becomes all important.

One way to validate the past data is to

apply a true correction factor to the data, if possible, to make them valid. To ascertain if a true correction factor can be generated, it will be necessary to demonstrate a consistent relationship between the current reference method and another analytical technique. If a consistent relationship can be shown, then a correction factor can be applied; if it cannot, then a new reference method should be adopted.

To this end, the Division of Atmospheric Surveillance (DAS) and the Division of Health Effects Research (OHER) of NERC-RTP have added projects to ongoing activities to determine the inter-reliability of existing  $\text{NO}_2$  methodology. In conjunction with NASN activities, DAS is investigating two other new 24-hr integrated methods at all 200 sampling stations on the NASN network in addition to the current reference method now in use. A third new method will be added shortly. In addition, DAS is installing chemiluminescent equipment at the Continuous Air Monitoring Program (CAMP) sites. This means that at each CAMP site,  $\text{NO}_2$  will be concurrently measured by an instrument based on the continuous Saltzman method, by a chemiluminescence instrument, and three or four 24-hr integrated methods employed by NASN.

Similar studies are being conducted by OHER in conjunction with its health effects studies in Los Angeles, Calif., Chattanooga, Tenn., and St. Louis, Mo. In these cities, six 24-hr integrated methods, a continuous Saltzman instrument, and a chemiluminescence instru-

ment are concurrently measuring  $\text{NO}_2$  in the ambient air.

When all the studies are completed and the data are evaluated, the results will be published. At that time, the decisions will be made concerning the validity of past  $\text{NO}_2$  data collected by the current reference method. The new decisions, if needed, concerning the re-classification of AQCR will be made early in 1973.

Another facet of this method evaluation and comparison study is that the data generated will additionally assist EPA in making decisions in the area of equivalent methods mentioned earlier. Guidelines for the demonstration of equivalency of analytical methodology are being developed by EPA with tentative publication scheduled for later this year.

#### Effect on stationary source decisions

The classification of AQCR with respect to  $\text{NO}_2$  was accomplished in November 1971. The determination of whether an AQCR had an  $\text{NO}_2$  problem of such magnitude to require stationary source  $\text{NO}_2$  reduction was based in part on air quality data collected by the reference method. At the present time, some 45 AQCR in 29 states are classified as Priority I for  $\text{NO}_2$  and may require that controls be placed on stationary sources. The sources to be controlled include oil- and gas-fired steam generating plants of more than 250 million Btu/hr of heat input and nitric acid plants. If the deficiencies in the reference method are further substantiated, it must be con-

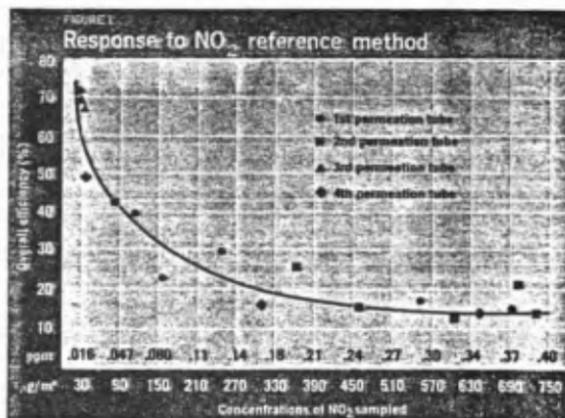


TABLE I  
Effect of NO on the Reference Method for NO<sub>x</sub>

NO <sub>x</sub> , ppb/m <sup>3</sup>		Ratio, NO/NO <sub>x</sub>	Expected NO <sub>x</sub> recovered, %	Apparent NO <sub>x</sub> recovered, %
NO	NO <sub>x</sub>			
100	0	0.0	39	38
102	63	0.6	39	38
105	127	1.2	38	52
122	627	5.1	36	57
189	0	0.0	29	29
244	1205	4.9	24	45
248	1279	5.2	23	55
215	1242	5.8	26	50
311	0	0.0	20	17
316	111	0.4	20	30
318	332	1.1	20	33
356	1060	3.0	18	44

TABLE II  
Calibration of the Reference Method as Used in Chattanooga

No. of replicates	NO <sub>x</sub> introduced, ppm	NO <sub>x</sub> found, ppm	Overall efficiency, %
20	1.00	0.135	13.5
31	0.50	0.090	18.3
26	0.10	0.039	39.0
44	0.056	0.020	35.0

TABLE III  
Computed NO<sub>x</sub> Concentrations, ppm

No. of samples	Site No.	Arith. mean constant collection efficiency	Arith. mean variable collection efficiency	Upper & lower 95% limits for column 4
65	School 1	0.109	0.167	0.141, 0.193
65	School 2	0.078	0.097	0.085, 0.109
65	School 3	0.062	0.069	0.061, 0.078

cluded that some of the AQCR with reported NO<sub>x</sub> problems may not truly have an NO<sub>x</sub> problem but only one resulting from the inadequacies of the reference method. Hence, the EPA decided to defer application of the promulgated regulations to July 1, 1973. To generate data to assist in making the future decisions, the DAS is placing three or four 24-hr integrated methods in addition to the reference method in all 200 NASN sites as previously stated. One 24-hr integrated method has been running concurrently with the reference method at all NASN sites since January 1972 and a chemiluminescent instrument to monitor NO<sub>x</sub> is being placed in every AQCR classified as Priority 1. These monitoring activities coupled with the activities given earlier in the paper will enable the Stationary Source Pollution Control Program to reevaluate their classification of AQCR for NO<sub>x</sub> based on the best-accepted state of the monitoring art.

#### Effect on mobile sources of NO<sub>x</sub>

In Section 202, Title II "Emission Standards for Moving Sources," of the Clean Air Act as amended in December 1970, it is specifically stated: "The regulations under subsection (a) applicable to emissions of oxides of nitrogen from light-duty vehicles and engines manufactured during or after model year 1976 shall contain standards which require a reduction of at least 90 percent from the average of emissions of oxides of nitrogen actually measured from light-duty vehicles manufactured during

model year 1971 which are not subject to any Federal or State emission standard for oxides of nitrogen" (emphasis added). Two points need emphasis. The reference method for NO<sub>x</sub> as published is applicable to ambient air and not emission sources. Second, the law calls for a 90% reduction in the average emissions actually measured in 1971. The methodology used in 1976 should be equivalent to that used in 1971 to measure the NO<sub>x</sub> emission initially. Since the analytical method used for NO<sub>x</sub> from mobile sources in 1971 was not the reference method for ambient air, then the newly recognized deficiencies in the reference method should have no effect on the measurement of NO<sub>x</sub> emissions from mobile sources.

#### Effect on national primary NO<sub>x</sub> standard

As mentioned earlier, NO<sub>x</sub> measurements by the reference method cannot be assumed to have a constant 35% overall efficiency. Since this assumption was made for NO<sub>x</sub> measurements obtained using the reference method as modified for the Chattanooga School Children Study (Shy, C. M., et al., *APCA J.*, 20, 539 (1970)), a reexamination of the data is required. For this purpose, NO<sub>x</sub> concentrations obtained in Chattanooga during the 1968-69 health study were compared with NO<sub>x</sub> measurements obtained by the U.S. Army, which operated continuous monitors based on the Saltzman technique. These monitors ran simultaneously within 0.4 mile of

one of the air monitoring stations established in the high NO<sub>x</sub> exposure area for the health study (School 1 of the Chattanooga School Children Study). The results of these measurements obtained from November 1968 through April 1969 (the period of the EPA health study) were as follows:

U.S. Army instruments (Saltzman method), ppm		EPA health study (reference method), ppm
Number 1	Number 2	
0.099	0.087	0.109
0.093 (av of 1 and 2)		

These data show relatively close agreement between the two methods. EPA results are 17% above U.S. Army values. The two methods provide independent estimates of the population exposure on which our primary national standard was based. The close agreement supports the existing national primary standard for NO<sub>x</sub>.

In addition, the daily NO<sub>x</sub> concentrations obtained during the EPA health study were reevaluated to account for the variable collection efficiency of the method used during the Chattanooga study. The analytical procedure was dynamically calibrated using an NO<sub>x</sub> permeation device, and the results are given in Table II. From the data given in Table II, it is possible to construct a calibration curve by plotting NO<sub>x</sub> introduced on the Y axis vs. the overall amount of NO<sub>x</sub> found on the X axis. Using a regression analysis, a 95%

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confidence band was then placed around this calibration curve. Then, to correct the Chattanooga data for the variable collection efficiency, the results of the individual daily analyses were rectified from NO<sub>x</sub> concentrations found to true NO<sub>x</sub> concentrations by use of the introduced/found ratios given in the calibration curve. At the same time, the corresponding upper and lower 95% confidence limits were also obtained for each individual value. This procedure was followed for each of the three "high NO<sub>x</sub>" stations in the Chattanooga study and the results are given in Table III. Column 3 in Table III is the arithmetic mean of the various individual NO<sub>x</sub> concentrations incorporating a constant 35% overall efficiency; column 4 was developed using the procedure described above to correct for the variable collection efficiency.

These revised estimates must be qualified for values found at School 3 in the high NO<sub>x</sub> area. Most of the individual values in this area were below 0.015 p.p.m. which was the lower limit for calibration data. Corrected NO<sub>x</sub> concentrations for these values were computed by extrapolating the calibration curve data beyond the lower limits of observed introduced/found ratios. However, the results given in the above tabulation represent reasonable best-judgment estimates based on these extrapolations.

Our revisions, based on corrections for variable collection efficiency, increase

by 11.3% the estimate of NO<sub>x</sub> exposure at School 3, the neighborhood at which a significant excess of acute respiratory illnesses was observed at the lowest of the three high NO<sub>x</sub> area exposures.

The U.S. Army also collected NO and NO<sub>x</sub> data by the continuous Saltzman method at six sampling sites in Chattanooga during 1967 and 1968. Two of these sites were located in the high NO<sub>x</sub> exposure area of the Chattanooga health study. A comparison of means of hourly NO and NO<sub>x</sub> data is given below:

	Arithmetic mean, $\mu\text{g}/\text{m}^3$		
	NO	NO <sub>x</sub>	NO/NO <sub>x</sub>
Site A	135	394	0.38
Site B	98	263	0.37

Inspection of the data demonstrates that the ratio of NO to NO<sub>x</sub> in the air of the high NO<sub>x</sub> exposure area is about 0.38. When this ratio is compared with the data available in Table I, it is seen that at low NO<sub>x</sub> concentrations (approximately 100  $\mu\text{g}/\text{m}^3$ ) the NO/NO<sub>x</sub> ratios observed in Chattanooga would have little effect on the apparent collection efficiency of NO<sub>x</sub>. At higher NO<sub>x</sub> concentrations, the NO/NO<sub>x</sub> ratios would increase the apparent collection efficiency from approximately 20 to 30%.

In conclusion, the several independent methods available to estimate NO<sub>x</sub> exposure during the Chattanooga health study do not support a revision of the National Air Quality Standard for NO<sub>x</sub>.



Thomas Hauser is the deputy director of EPA's Atmospheric Surveillance Division. He has been with federal air pollution control agencies for the past 17 years and has published widely in the field of methodology for analysis of air pollutants. Address inquiries to Dr. Hauser.



Carl Shy is the director of EPA's Health Effects Research Division. Dr. Shy has served with the U.S. Public Health Service and NAPCA and holds teaching positions at the University of North Carolina and Duke University. He is an editorial consultant for the Journal of Chronic Diseases.

Mr. HEINZ. I understand that and I have heard EPA say that. I am asking what is a reclassification? I don't understand fully what reclassification means. Does it mean a lowering or raising of ambient air quality standards with respect to a specific pollutant? Does it mean shifting the boundaries around so that you average higher or lower as a result of more or different measurements?

Exactly what does it mean?

Mr. PITTS. I'm not totally sure. As I indicated, I believe they are not recommending, at least in their official position paper, any change in the air quality standard for nitrogen dioxide.

With regard to the reclassification of regions, it seems to me they are saying, "We originally felt that on the basis of the original data, 3 to 5 years from now you will, or may, have an NO<sub>2</sub> problem." Now, with the reanalysis of the data, we feel you won't have an NO<sub>2</sub> problem because our data were wrong. Thus, we are going to reclassify you from a "critical" region, where you were going to have to put on additional controls on emissions, to a region where you don't have to put on NO<sub>x</sub> controls.

Therefore, as I understand from the letter on revised NO<sub>x</sub> controls for stationary sources in certain regions, essentially the new EPA strategy seems to lead to degradation of air quality in some areas presently with clean air, at least with respect to NO<sub>x</sub>.

Mr. HEINZ. Let me ask you one related question.

EPA claims that the measurement techniques overstated the amount, the present existing measurement techniques or the old measurement techniques overstated the amount of NO<sub>x</sub>.

Is it possible that the same devices were used in establishing either the toxicological, epidemiological or clinical effect of a concentration of NO<sub>x</sub> on health?

Mr. PITTS. That is a very good question, Mr. Heinz, but I do not know the answer.

Mr. HEINZ. If you don't know the answer to that I am sure we will get into it eventually. And if you don't know the answer, you are not expected to because you didn't come here as an expert on that particular item of EPA legislation.

That was my last question. If there are no further remarks you would like to make on this I certainly thank you, Dr. Pitts, for appearing before the committee and, Mr. Chairman, I thank you.

Mr. PREYER. Thank you, Mr. Heinz.

Dr. Pitts, I have a list of questions which rise out of your testimony mainly along the lines of asking for a little fuller elaboration of some suggestions you make.

Since we are running short of time I would like to submit this list of questions to you and ask if you could provide us with written answers for the record.

Mr. PITTS. I will be glad to, sir.

Mr. PREYER. We have two important votes this afternoon involving the Health Subcommittee. One is on the HMO bill and the other is on the question of overriding the President's veto of the Emergency Medical Services Act.

So I am afraid we will not be able to hold hearings this afternoon.

I will submit this list of questions to you. Thank you very much for your very interesting and stimulating presentation.

Mr. PITTS. Thank you, sir.

[The following questions and answers were received for the record:]

QUESTIONS SUBMITTED BY CONGRESSMAN RICHARDSON PREYER AND ANSWERS  
SUPPLIED BY DR. JAMES N. PITTS, JR.

The following statements are made in answer to written questions submitted to me at the conclusion of my testimony before the Subcommittee on Public Health and Environment on September 12, 1973. I should particularly like to acknowledge the assistance of Drs. Edgar R. Stephens and George J. Doyle, of the State-wide Air Pollution Research Center, who assisted me in formulating the responses to questions 2(b), (c) and 5.

*Question 1. At page 4 of your statement, you recommend additional studies on "sulfates, nitrates and certain toxic metals." Could you please indicate which potentially toxic metals in specific are deserving of more study?*

Answer. There are a wide variety of toxic metals under investigation by the EPA and by the Committee on Biological Effects of Atmospheric Pollutants (BEAP) of the National Academy of Sciences. Such toxic metals include chromium, vanadium, lead, mercury, cadmium, etc. Their documents should be consulted for scientific, technical, and medical information bearing on the significance of such metals as air pollutants.

Metals that particularly concern me at this time are (a) manganese, because of its actual and proposed use as a fuel additive for reducing visible smoke and for increasing the octane rating of fuels, and (b) metals such as platinum and palladium, which are being used in some systems as catalysts for control of exhaust emissions. The amounts emitted and the chemical and physical forms in which these metals are dispersed in the atmosphere—e.g., as dust from catalyst reactors, compounds, etc.—are of particular interest.

*Question 2. At page 5, your statement indicates that two elements of smog—ozone and olefins—can greatly accelerate the transformation of sulfur dioxide to particulate sulfate in the air.*

*(a) First, could you explain briefly what is an olefin and whether it falls within the general category of hydrocarbons or oxidants?*

Answer. Olefins are unsaturated hydrocarbons. They are made up of only carbon and hydrogen atoms and are particularly reactive in photochemical oxidations because they contain what is termed a carbon-carbon double bond. Molecules possessing carbon-carbon double bonds are very susceptible to chemical attack by such species as ozone or oxygen atoms, both important in the formation of photochemical smog. Olefins are a significant constituent of many types of gasoline. Because of their great reactivity, some areas limit the amount of olefins allowed in gasoline.

*(b) Second, could you tell us a little about the studies which have shown this relationship?*

*(c) A previous witness—Mr. Pierre Sprey—has indicated his opinion that NO<sub>x</sub> may be even more important than ozone in the formulation of sulfates. EPA's draft document on sulfates—dated December 1972—also recognized this possibility. What is your reaction to this idea that NO<sub>x</sub> control may be important to retard formation of sulfates?*

Answer. *Comments by Dr. Doyle:* The eventual fate of sulfur compounds emitted to the atmosphere is conversion to sulfate aerosol followed by rain out to the earth's surface. For urban pollution the pertinent question is "Does the presence of NO<sub>x</sub> accelerate this conversion process enough to appreciably affect the higher sulfate burdens in urban areas near strong sources of sulfur emission? Or does the fact that sulfur compounds exist in higher concentrations in urban areas alone account for the higher sulfate in these areas?"

At the present time the answer can only be an opinion. There are no complete definitive studies on this process in actual polluted atmospheres, at least for the Los Angeles type of pollution. The ongoing California ARB sponsored study of photochemical aerosols at the Rockwell Science Center will furnish at least some indications of the answers when completed.

Laboratory studies have shown:

(1) The presence of a photochemically reacting mixture of NO<sub>x</sub> and olefin (at trace concentrations in air) accelerates the conversion of SO<sub>2</sub> to sulfate.

(2) The presence of a reaction mixture of ozone and olefin (at trace concentrations) causes conversion of sulfur dioxide to sulfate.

(3) The presence of water droplets (very small) containing certain metals in solution promotes the conversion to sulfate.

(4) The presence of water droplets with dissolved ammonia promotes conversion by atmospheric oxygen.

(5) If water droplets are highly acidic, the  $\text{SO}_2$  oxidation by  $\text{O}_2$  is inhibited.

(6) Sulfur dioxide alone in air is photochemically oxidized at too slow a rate to be significant for urban pollution.

At present, opinion in certain quarters is leaning toward the concept that heterogeneous conversion is the dominant process. This is hypothesized to be the ammonia-promoted process in aqueous droplets.

This concept raises a chicken and egg paradox. Aqueous droplets at humidities less than 100% are not possible unless there is some hydrophilic strong electrolyte present. Of the constituents found in photochemical aerosol, the most likely candidates for stabilizing electrolytes are sulfuric acid and its salts. How does the initial haze of aqueous sulfate droplets get formed? Is there enough primary emission of sulfuric acid or its anhydride to provide the initial aqueous nuclei for appreciable heterogeneous conversion?

*My opinion on this subject is:* There are several alternative paths for sulfate formation, all of which are sufficiently rapid to be significant in urban pollution given the right conditions. Since the polluted atmosphere is not homogeneous, the conditions vary from place to place and time to time, so that one of the paths may be dominant at one point in space time and another at second point and so forth.

$\text{NO}_x$  promoted photo-oxidations will be important to an appreciable extent when averaged over a large area like Los Angeles. It will be dominant in regions where there are few primary hygroscopic nuclei of any great size and little ammonia.

In places having high ammonia and little primary sulfate emissions the photochemical route will provide the initial large nuclei of high pH necessary to initiate the heterogeneous process.

I wish to point out that our knowledge of sulfur compound reactions with intermediates of the  $\text{NO}_x$ -promoted photochemical photo-oxidation is incomplete. At present, only an unknown intermediate in the relatively slow ozone-olefin reaction is definitely implicated. It may be found that some other intermediate is more effective in this conversion. Some of the more reactive intermediates have been ruled out as too slow, e.g.,  $\text{O}(^3\text{P})$  and  $\text{OH}$  at least as far as homogeneous processes are concerned.

*The final opinion:*  $\text{NO}_x$  control will inhibit sulfate formation, but not proportionally or completely.

*Answer. Comments by Dr. Stephens:* The conversion of sulfur dioxide to sulfate by atmospheric reactions has been demonstrated in a variety of government, university, foundation, and industrial laboratories. It is clearly an important atmospheric process. The exact mechanism by which this conversion takes place is still uncertain, because it occurs in a complex mixture undergoing complex chemistry. It is not possible to say just which components cause the oxidation of the sulfur dioxide. There are several different theories to account for it, none of which have been conclusively demonstrated. One of these theories is the oxidation by  $\text{NO}_x$ , a reactive species formed from the reaction ozone and  $\text{NO}_x$ . Another is oxidation by peroxy radicals which would be derived from the organic material. A third is the one mentioned in the testimony; the reaction of ozone with olefins. A fourth is catalytic oxidation in the water droplets involving perhaps heavy metals or even ammonia. One mechanism which does *not* work is direct reaction of ozone with  $\text{SO}_2$  or direct reaction of PAN with  $\text{SO}_2$ .

Studies at Franklin Institute, Stanford Research Institute, Battelle, and General Motors have shown that in photochemical mixtures containing  $\text{SO}_2$ , hydrocarbons, and nitric oxide, the formation of sulfate aerosol is delayed until the  $\text{NO}$  is completely converted to  $\text{NO}_2$ . Aerosol then forms at the same time as ozone is formed. This does not mean that ozone is directly responsible for the oxidation of  $\text{SO}_2$ ; it only means that the  $\text{SO}_2$  oxidizer is not formed until  $\text{NO}$  conversion is complete. Since increasing  $\text{NO}$  concentration delays the formation of ozone, I think it is probable that it would also delay formation of aerosol, although this has not been as widely studied as the formation of oxidant. Likewise, increasing hydrocarbon promotes formation of ozone, therefore, I believe would promote the formation of sulfate aerosol. Following this argument, I think that the formation of sulfate would follow the same pattern as the formation of ozone, and therefore, the best means of control would be to control hydrocarbons rather than  $\text{NO}_x$ , even though  $\text{NO}_x$  may well be involved in the oxidation of  $\text{SO}_2$  to  $\text{SO}_3$ . These ideas are set forth in more detail in a National Academy of Sciences Report which has just been issued as a part of the work of the Committee on Motor Vehicle Emissions.

**Question 3.** At page 6, you recommend a "major expansion in the program for monitoring particulate sulfate in the ambient air." How many state, local, or federal stations currently monitor sulfates?

Answer. I have been unable to come up with a precise number of actual monitoring stations where sulfates are measured in ambient air. However, it has been reported to me that there are approximately 17 stations throughout the U.S. In any case, data are being taken from the U.S. National Surveillance Network (NASN), and it was these data that Dr. Altshuler of the EPA used in his paper "Atmospheric Sulfur Dioxide and Sulfate." This paper is referenced in my written statement.

Since my written testimony, two pertinent articles have appeared. One, entitled "Ambient Air Monitoring for Sulfur Compounds: A Critical Review," has appeared in the Journal of the Air Pollution Control Association, Vol. 23, page 761, September 1973. This article by Joseph Forrest and Leonard Newman, along with Dr. Altshuler's article provides what should be the most up-to-date information on ambient SO<sub>2</sub> and particulate sulfate levels. The second article, by P. O. Warner and L. Stevens, is entitled "Reevaluation of the 'Chattanooga School Children Study' in the Light of Other Contemporary Governmental Studies" [J. Air Poll. Control Assoc., 23, 769 (1973)]. The authors suggest that interferences, such as sulfuric and nitric acid vapors, "be considered detrimental to the formulation of a valid air quality standard for nitrogen dioxide."

In a rebuttal to the article, Dr. Carl Shy of the EPA [JAPCA, 23, 771 (1973)] defends the present air quality standard for NO<sub>2</sub> and points out that the National Academy of Sciences will undertake a critical review of nitrogen oxide criteria in the calendar year 1974. In Dr. Shy's rebuttal, there is a particularly interesting table that gives annual average NO<sub>2</sub> concentrations, and annual average suspended particulates in the form of nitrates, sulfates, and the sum of the two for seven U.S. cities. I am including the table for your information.

TABLE 1.—COMPARISON OF AIR POLLUTANT LEVELS IN THE VICINITY OF THE CHATTANOOGA TNT PLANT WITH THOSE OF SELECTED U.S. CITIES<sup>1</sup>

Location of monitoring station	Annual average NO <sub>2</sub> (µg/MP)	Annual average suspended particulates—µg/MP		
		Nitrates	Sulfates	Nitrates plus sulfates
Chattanooga <sup>2</sup> .....	276	5.7	11.5	17.3
Los Angeles.....	185	12.6	13.2	25.3
Chicago.....	120	4.2	15.7	19.9
New York.....	102	2.7	22.2	24.9
Philadelphia.....	84	3.6	21.9	25.5
Detroit.....	80	4.5	14.5	19.0
San Diego.....	64	5.4	7.7	13.1

<sup>1</sup> NO<sub>2</sub> data, except for Chattanooga, was obtained in 1972 by the arsenite bubbler method. Nitrate and sulfate levels from all cities except Chattanooga were obtained in 1970 by the National Air Surveillance Network.

<sup>2</sup> Data for Chattanooga collected in 1968-69; NO<sub>2</sub> data obtained in 1967-68 by the continuous Griess-Saltzman method.

It is interesting that Los Angeles has a high nitrate level, but also appears to have a relatively high particulate sulfate level, even though the ambient levels of gaseous SO<sub>2</sub> have been quite low.

**Question 4.** At page 7, you recommend plans to develop progressive increments of pollution control toward the health standard. Could you explain a little more fully what you have in mind?

Answer. My point in Section V, Implementation Plans, is basically that in areas suffering from serious air pollution, such as the Los Angeles Basin, the public and its officials have been presented with "all-or-nothing"-type implementation plans, some of which appear to them to be either Utopian and/or disastrous. Indeed, to effect drastic cutbacks in photochemical oxidant, completely impractical measures (such as over 80% gas rationing) were proposed.

Unfortunately, the public has not been presented with sound *interim* strategies designed so that smog control would advance toward the desired long-term goals in some reasonable fashion—(1) scientifically and technically, (2) from a cost effectiveness viewpoint, and (3) furthermore, as being practical in that it could actually be carried out without seriously disrupting the life-style of the people.

For example, a legitimate first-stage goal of an implementation plan in southern California might be to reduce photochemical oxidant to levels in the

South Coast Air Basin where they do not exceed the proposed California Advisory health alert of 0.2 ppm for one hour for more than five days per year. The questions could be asked of the EPA: "What measures would have to be taken to achieve this specific goal? What steps would have to be taken to reduce it to no more than one day a year? When could such an improvement be realistically expected?"

*Question 5. At page 8, you note that EPA now says that NO<sub>x</sub> levels in major cities are fairly safe. Yesterday's witness—Mr. Sprey—disagreed. He argued that in effect, EPA had doubled the standard by leaving the number at 100 micrograms but changing the method of measurement to one that would register only half as much NO<sub>x</sub> in the air. What is your opinion about this dispute?*

Answer. It is very unfortunate that the shortcomings in the method for measurement of nitrogen dioxide in polluted air have caused so much confusion. We will never get out of the confusion if we continue to accept the incorrect measurements, which is apparently what the other witness, Mr. Sprey, recommended. The EPA makes a good case for believing that their ambient air NO<sub>x</sub> measurements were in error because of the use of a faulty correction factor. If we accept the EPA's view, and I have no reason to doubt it, it is scientifically sound to correct the NO<sub>x</sub> values according to the best judgment currently available to give proper NO<sub>x</sub> concentrations and not fictitiously high ones. The fact that this error in the ambient air measurement is on record in the Federal Register as an EPA Statement must, of course, be recognized in the standards-setting process. Failure to recognize it would provide an opening for challenge of whatever standard is established, and whatever control measures are based on that standard. This would be an untenable position, both scientifically and legally.

*Question 6. Could you elaborate on your statement at page 12 that one of the exhaust emission control devices scheduled for use in 1975 or 1976 may produce significant quantities of aldehydes?*

*(a) Which system?*

Answer. I would prefer not to disclose the specific system at this time because my source of information requested that it be kept confidential. I would only like to indicate that it is a system that involves a thermal reactor.

*(b) How serious are aldehydes from a health standpoint?*

Answer. Certain aldehydes are major eye irritants. These include acrolein and formaldehyde. They also may have other effects on our respiratory system, but I am not sure whether these are important at ambient levels. This is a good question to address to a pulmonary physiologist.

*(c) Won't control of all hydrocarbons equally control aldehydes?*

Answer. Not necessarily. For example, most catalytic converters in good operating condition will indeed control aldehydes as well as hydrocarbons, perhaps even better because aldehydes are partially oxidized hydrocarbons. The question arises, however, when one considers aged catalyst systems which have lost much of their activity; concern has been raised in some quarters that their loss in efficiency might be such that a significant fraction of the hydrocarbons entering the catalysts would not be completely oxidized to carbon dioxide and water, but would form aldehydes on the catalysts. Recent data suggest this is not a problem with present catalyst systems currently being tested and used by a major motor company. I trust this is the case, but it is a point worth seriously discussing with the automobile manufacturers who use catalyst systems. Furthermore, as indicated above, it appears that some control systems using thermal reactors may indeed reduce hydrocarbons, but in part at the expense of producing significant amounts of aldehydes.

*Question 7. Dr. Pitts could you summarize for us what you believe would be the best overall control strategy for new cars, stationary sources, and transportation controls at this time to get the most health protection for a reasonable cost?*

Answer. This is a highly pertinent, but very broad, question that would be difficult to answer in detail at this time. I would respectfully request that my staff at the Statewide Air Pollution Research Center and I consider this question at some length and communicate directly with the Subcommittee when our ideas have crystallized and can be formulated in some reasonably concise fashion.

Mr. PREYER. We have two more witnesses, Dr. Stewart and Dr. Ayres. Are they here?

Dr. STEWART. I am Dr. Stewart.

Mr. PREYER. Dr. Stewart, you are the first on the list here.

We will ask you to testify at this time. You have submitted your written statement.

You may read your statement or we could put it in the record and have you summarize it.

**STATEMENT OF DR. RICHARD D. STEWART, DEPARTMENT OF ENVIRONMENTAL MEDICINE, MEDICAL COLLEGE OF WISCONSIN**

Dr. STEWART. Mr. Chairman, I was asked to prepare a brief critique of the air quality standards [see p. 296] even though my area of expertise is carbon monoxide (CO).

So I have asked Dr. Jack Peterson, chief of environmental engineering at our medical school, to help in the preparation of this brief critique.

I was also asked to concentrate on carbon monoxide, and had requested that a slide projector be made available because, with a few teaching slides, I could cover the subject more thoroughly in the brief amount of time allotted.

But I haven't seen a slide projector arrive so I am assuming now that we do not have it. Is that right?

Mr. PREYER. We'll check.

Dr. STEWART. My apologies, Mr. Chairman, because I could have brought a projector along.

We would save an immense amount of precious time if we had one.

I would like to give a quick summary of the critique which Dr. Peterson and I prepared.

Section 109 of the Clean Air Act, as amended in 1970, called for the setting of national primary and secondary ambient air quality standards by the Environmental Protection Agency. Standards for sulfur oxides, particulate matter, carbon monoxide, photochemical oxidants, hydrocarbons, and nitrogen dioxide were published in the Federal Register in April and November 1971.

These standards were based on criteria documents published by EPA in January 1969 (sulfur oxides and particulate matter), March 1970 (hydrocarbons, carbon monoxide, and photochemical oxidants), and January 1971 (nitrogen oxides).

A thorough review of the criteria documents and of the resulting ambient air quality standards reveals that:

(1) Each criteria document was based upon a thorough search of the literature available prior to the document's publication.

(2) Very little quantitative, uncontroversial data on the health effects of air pollutants was found.

(3) Although other effects of air pollution were considered in the preparation of the criteria documents, information relating to health effects was emphasized.

(4) In judging the worth of data for the purpose of setting air quality standards, there was an obvious emphasis on data which would support a conservative standard in each case.

(5) With the exception of sulfur oxides little thought was given to the economic impact upon the United States of any of the air quality standards—EPA had no legal obligation to consider economic aspects.

(6) Under a legal obligation to promulgate air quality standards whether or not adequate data existed upon which to base these standards, EPA did a remarkably good and conscientious job.

The controversy which has arisen in the scientific community subsequent to the publication of criteria documents and the promulgation of ambient air quality standards has been based either upon the examination of new data or upon a different interpretation of the originally cited data. The EPA is in the unfortunate position of having to defend its prior judgments in the face of mounting criticism. While advocacy may be the basis of good law, it is not necessarily the basis of good science which, instead, should be based upon the best available facts.

The task set by Congress for the EPA to accomplish was herculean and almost literally impossible. Adequate data did not exist in the 1969-71 period for the establishment of unassailably good ambient air quality standards.

In fact, adequate data for the setting of such standards does not exist today.

Furthermore, if the present trend continues, with the EPA defiantly defending its original standards, the acquisition of adequate data for the establishment of scientifically unassailable standards will be unduly delayed. Arbitration between the EPA and her critics in scientific community is necessary.

Basic to the kind of arbitration necessary is a reassessment of the ambient air quality standards in the light of new data, new thoughts, and perhaps new view points. To that end each of the standards will be examined.

That is why I have come today to tell you how I happen to feel about it.

I would like to state that my personal philosophy is that we should allow no contaminants in our ambient air, absolutely none. The rate at which we achieve this goal though I think should be dictated by our scientific data base.

If our data base is sufficient we can promptly go to completely uncontaminated air but we should not rush pellmell into that situation based upon an inadequate data base which could produce grave economic repercussions.

When we review the six air quality standards I think there are three comments which, in retrospect, one would like to make.

First, the original six standards adopted outmoded names with which to describe the air pollutants. With the exception of carbon monoxide the rest of the names are really outmoded.

A term like "suspended particulates" I think is a very cumbersome term with which to deal. The term "particulates" means no more than dirt. The specific suspended particulates should be identified and for those which have health impact, criteria documents and air quality standards should be provided.

I think even more important than doing away with the outmoded, traditional names and recognizing the real culprits in our air which have their untoward effect on health is the absolute necessity to have a periodic review of the air quality standards. In the industrial setting air quality standards are referred to as the threshold limit values.

Mr. PREYER. Excuse me, Dr. Stewart, we do have a slide projector here at this time. Perhaps you could submit your statement for the record and make your presentation with the slides.

Dr. STEWART. Before going to the slides, I wish to make two recommendations. First, some provision for periodic review of the air quality

standards is necessary. In the industrial setting, as I mentioned, the threshold limit values which are the counterpart in industry for the air quality standards for the rest of the Nation, do have careful annual review and are either lowered or raised based upon the best available scientific data. I think our air quality standards require no less.

These data are being generated daily and the standards need to be modified up or down based upon what the new data dictate.

The second recommendation is that I think any time air quality standards are set forth consideration of the economic and environmental impact of such standards needs to be clearly defined.

I was asked to concentrate on carbon monoxide and it is a good air quality standard to look at because it is controversial and some of the problems which gave birth to the controversies are inherent in the other air quality standards.

Carbon monoxide is one of the major air pollutants which can adversely affect human health. The Clean Air Act's air quality standards for 1971 limit CO exposure. If one adheres to the 8-hour standard, carboxyhemoglobin saturations above 1.5 percent will not occur in active nonsmokers.

The first slide will illustrate this point rather well.

[Slide.]

Mr. Chairman, what I propose to do is use as a basis for the discussion on carbon monoxide a series of slides with which we teach the sophomore medical students in our medical school because there are some very basic points about carbon monoxide that once understood I think enable us to evaluate the scientific literature.

[Slide.]

Listed here are the names of the key participants who gathered the data that I would like to present.

[Slide.]

All of us are aware that each manufactures within his body a certain quantity of carbon monoxide. Thus, man's oldest poison really is something that he has produced within his being from the early periods of time. The carbon monoxide which we make within our body comes from the breakdown of the red blood cells. If we were breathing completely clean air with no carbon monoxide contaminant, if we were in good health and had nothing wrong with our red blood cells, we would have about four-tenths of 1 percent of our blood saturated with carbon monoxide. Four-tenths of 1 percent of our oxygen carrying capacity would have been lost as a result of this CO combining with the red blood cells.

[Slide.]

Here is shown the increase in carboxyhemoglobin saturation when a person is exposed to different CO concentrations. The lowermost line shows the effect of 8.7 parts per million exposure to CO. This is the 8-hour standard. One can see there that exposure to 8.7 parts per million will result in a maximum bloodstream concentration, of 1.3 to 1.5 percent saturation.

The original criteria document based that figure of 8.7 upon three pillars of evidence available at that time which will get to in a moment.

What I wanted to point out is that the current industrial standard is 50 parts per million and strong consideration is being given to

reducing it to 35 parts per million. You can see this will result in a maximum saturation of less than 5 percent carboxyhemoglobin. To put it in proper perspective, one should mention that an individual who smokes a pack of cigarettes per day will be around the 5-percent saturation level. Five percent of his oxygen-carrying capacity will have been lost.

The average person will develop symptoms of carbon monoxide poisoning at 20 percent carboxyhemoglobin saturation: Headaches, nausea, and vomiting. At 35 to 40 percent carboxyhemoglobin, the ability to turn a car key off and on will be impaired. At 67 percent saturation for 10 minutes, man will die if he is not appropriately treated with oxygen. You can see that for each of these various ambient air CO concentrations, there is a maximum carboxyhemoglobin saturation which one can achieve.

[Slide.]

Now we have for carbon monoxide what we don't have for any of the air quality standard situations, and that is we have equations, mathematical expressions, which allow us to very accurately predict for a given CO exposure exactly how much CO will be absorbed by man. I show you this to illustrate that in an experimental situation one can very accurately achieve the predicted carboxyhemoglobin value. I show it also to illustrate that the analytical method on which some of my conclusions are based are accurate over the range that we are most concerned with, that range from our background carboxyhemoglobin of four-tenths of 1 percent on up to levels of five- to six-parts saturation.

[Slide.]

To quickly answer some of the questions that came up about carbon monoxide's effect upon human health one has available a most valuable tool—a controlled-environment chamber in which the response of human volunteers to various pollutants can be studied.

[Slide.]

Now in this environmental chamber you are looking through a large picture window at the exposed volunteers. In this setting one very accurately can control the concentration of carbon monoxide with great accuracy while having absolute control over temperature and humidity. Here one can study the precise effect of this gas upon man and not therefore have to extrapolate from experimental animal data. In the far corner there is a closed circuit TV to permanently record the day's events.

[Slide.]

In the attached report I have listed the references to the scientific articles which describe the technical aspects of this type of research. We use two separate analytical methods [slide] to monitor the concentration of the gas in the chamber: The gas chromatograph and infrared. We use two independent analytical methods any time we deliberately expose human subjects to a gas.

We use a minicomputer to collect all of the analytical data. This is a readout on the screen during exposure to CO. You can see every second the minicomputer presents exactly what has been in the chamber and what the cumulative exposure has been. With this computerized chamber one has finger tip control of the environment.

The subjects who have been used are healthy adults who are technically capable of understanding the risk involved. The philosophy at

our school has been not to subject human volunteers to more than a negligible risk.

[Slide.]

We place the volunteers in a very comprehensive medical surveillance program, with all of the usual clinical laboratory determinations done to insure that the individuals are enjoying good health before, during, and following the carbon monoxide exposure.

[Slide.]

Prior to every exposure a very thorough repeat medical examination is done on the volunteers. Here a EKG is being taken. Because carbon monoxide exerts its primary effect on the cardiovascular system we utilize various techniques for monitoring the heart continuously. With this apparatus, similar to that in the space program we look at the electrical and chemical activity of the heart during a known exposure to carbon monoxide.

[Slide.]

A physician in attendance always watches the cardiac monitor.

[Slide.]

In the chamber setting we can exercise people to see what effect rapid increase in carboxyhemoglobin would produce.

[Slide.]

We study people in this chamber for days. This shows some medical students who volunteered to stay in for a protracted period of time, having an early morning breakfast. They also sleep in this chamber which has its own toilet facility.

[Slide.]

Most important of all, at strategic points in the experiment one can have the subject put this arm out through a bloodport, get a blood sample, and then measure the carbon monoxide concentration in the blood for correlation with test performance.

[Slide.]

This, again, is a repeat of the original slide which shows our experimental data points plotted on top of a series of curves that were originally derived at the University of Pennsylvania by a very brilliant group of researchers showing that in the chamber setting one can beautifully reproduce the theoretical CO absorption curves.

[Slide.]

This shows the relationship between the increase in carboxyhemoglobin and the increase in cardiac output. This I would like to emphasize. The primary effect of carbon monoxide on man is a result of the decrease in oxygen carrying capacity that it produces. So, if you saturate 5 percent of the blood with CO the heart must compensate and will do so by increasing its blood output by 5 to 6 percent.

[Slide.]

Then using the same type of minicomputer we can collect the physiological response data.

[Slide.]

Now the original air quality standards were based upon cognitive tasks decrements. In other words, man's brain was reported to have been affected by carbon monoxide.

[Slide.]

It had been reported by a group at Stanford that man's ability to estimate 30 seconds, or to distinguish between short intervals of time

was severely impaired at levels as low as 2 percent carboxyhemoglobin, levels above which the cigarette smoker is to be found continuously, and levels around which a good 30 percent of our population is today.

[Slide.]

This shows our attempts over the past 5 years to corroborate that original finding. Our initial attempts were exactly that, to corroborate. These studies were conducted in a double blind setting. This is critical to obtaining valid data. Neither the subject nor the investigator giving the test may know whether or not carbon monoxide is in the chamber because such knowledge could influence the test result. If I were told that I was being exposed to an excessive amount of carbon monoxide prior to coming to testify to this committee, I am sure my performance would be impaired. So, the subject is not allowed to know, nor the investigator, whether or not exposure is actually occurring. This precaution is essential, yet it was ignored by Dr. Beard in his original study.

[Slide.]

Then you review the data on closed circuit TV once the experiment is finished.

[Slide.]

Dr. Beard at Stanford U. was the one who announced the time perception defect and it was a dramatic defect. An individual exposed to low levels of carbon monoxide to produce 2-percent carboxyhemoglobin, when asked to discriminate between short intervals of time had a dramatic impairment. When asked to estimate 30 seconds he would count in slow motion. This would mean that a symphony orchestra in L.A. could never play together and that a Hank Aaron in such a setting would never surpass Babe Ruth's home run record, the time impairment being so dramatically great.

[Slide.]

So, using the same sort of small enclosure as Dr. Beard, but additionally exposing individuals isolated in large chamber, and in a group setting in the chamber over a 4-year period we found there was no impairment in time discrimination, and no impairment in the 30-second time estimation test.

So this put us in a position of disagreeing with Dr. Beard. This didn't end up in a big debate as to whom was right. The scientific groups got together, compared notes as to how the experiments had been done. Dr. Beard tried to reproduce his original study, using the double blind technique which he had not used originally, and was unable to repeat his findings.

It still didn't mean that we had resolved the issue until a second independent group, the Air Force group, came along and did similar studies and obtained essentially the same results as had we. We went one step further. We took faculty, not volunteers, but faculty, up to a 35-percent carboxyhemoglobin saturation, a saturation at which all were made quite ill by the carbon monoxide.

We checked time perception at that concentration and found that while response was slower because faculty were poisoned, time perception was not affected. Then these faculty were promptly treated in a hyperbaric chamber.

Therefore, we feel that time perception is one of the most resistant human effects, one of the most resistant of our human modalities to carbon monoxide effect. This has been published in the open literature I referred to. The unfortunate thing is that in spite of its being scientifically refuted, the acting administrator for the EPA on June 14 of this year in an open letter to the public still cites this work as one of the primary reasons for the current CO air quality standards.

[Slide]

The second pillar was the inability of middle-age firemen to do arithmetic, again in a single blind situation. Four years of work here with a great variety of subjects have shown that man does arithmetic well.

As we went on over this 4-year period and monitored some 30,000 individuals in various blind banks around the Nation to see actually what was their carboxyhemoglobin, we found this sort of relationship. It showed that as the carboxyhemoglobin went up, either as a result of exposure to the gas from automobile sources or from exposure to the CO that is found in cigarettes, man compensates for this loss in oxygen carrying capacity by increasing the number of red cells.

This indicates man has a partial ability to compensate and this is what one would anticipate to be the case. So, from the standpoint of the cognitive tasks, we feel that man's mind is not the most sensitive target to carbon monoxide and that the air quality standards should legitimately be set based upon their effect on the cardiovascular system.

I cited in our little review the two pertinent articles in the literature regarding two studies showing what does happen when man is exposed to low levels of carbon monoxide, a man who is crippled by having advanced heart disease.

Now, my only criticism of the way in which the EPA has used these data is that they have looked at the data and assigned what they call safety factors. They feel that the current standards provide a safety factor of between 0 and 100 percent, depending on the group which you are looking at.

Unfortunately, the research has not gone quite far enough. When you review the original articles you will see that the individuals tested were already in badly polluted areas and that we do not know from these people with advanced coronary disease what would have been their performance had their base line testing been done in an uncontaminated zone.

The majority of the subjects tested were already at carboxyhemoglobin levels in excess of that now permitted, that 1.5 percent. Hence, we do not have true base lines. All we know is that when they were exposed to this level and then reexposed to take them to a higher carboxyhemoglobin level, that their disease was worsened, their response to exercise less tolerant.

So, it is my contention that for certain air pollutants, specifically carbon monoxide, there will be no safety margin for people with advanced heart disease. What needs to be assigned by EPA is the risk factor if you set a certain standard. I think when the standard is set, it should be recognized that if you allow one molecule of carbon monoxide into the atmosphere, that one molecule will have a potential for shortening by a fraction of a second the life of a little old lady with advanced congestive heart failure.

So, there is no safe level of carbon monoxide so far as the entire population with disease is concerned. One has to then look to a reasonable level. I have suggested in our little paper what I would consider to be a reasonable level of carbon monoxide in the air. I would not induce any more strain on a little old lady with advanced heart disease whom I feel must be protected, no more strain than if she were to eat a hamburger.

I think if you set an air quality standard more stringent than at this point in our economic history that the damage could be very great indeed. Ultimately, it would be very nice to have that little old lady to be able to eat her hamburger without worrying about whether she was in Milwaukee or Los Angeles, but I think the standard needs to be reasonable.

The other point that I did not make in the little handout that we prepared for you, on too short notice really to have done as scholarly a job as we would have liked, is the fact that you gentlemen need to know at this point in history what percent of the American population in the major metropolitan areas currently exceed the air quality standards.

We found in a national survey conducted in 1969 through 1971 that 45 percent of the blood donors in the United States had carboxyhemoglobin, the nonsmoking segment, ignoring completely the smoking segment of the population, the nonsmoking segment, 45 percent in the major metropolitan areas investigated had carboxyhemoglobin in excess of 1.5 percent and these data have been published and we have cited them in this document.

So we do have a major problem with the air quality standards for carbon monoxide. I think we have to look very realistically at our current air levels and see whether or not the present standard would be acceptable to us. It is my personal feeling, after reviewing the data, that I probably would do nothing about the other air quality standards. The only one that I would consider holding in abeyance or gradually taken down to a zero background level and that is where I think carbon monoxide should be, at a zero level, I would set a realistic goal that we could achieve in this Nation.

I would not set a standard where the current one is, at a level that I do not believe that we can achieve in the immediate future. I would probably set a 24-hour standard rather than an 8-hour because, one, we found in rural areas in the United States, in rural Vermont and Connecticut, New Hampshire, that in these areas, there were still significant portions of blood donors that had elevated carboxyhemoglobin levels above the air quality standards.

I would probably go for a 15-parts-per-million, 24-hour standard. I would attempt to keep carboxyhemoglobins below a 2-percent level. This would place people with advanced coronary disease in about the same jeopardy that they would be if they walked briskly around this table, ate a hamburger, or went out on a cold winter day. Then, as technology was available and we had a solid data base, I would go then as rapidly as I could feasibly do it to a zero level. Thank you.

[Testimony resumes on p. 300.]

[The critique referred to follows:]

## CRITIQUE OF AIR QUALITY STANDARDS

(By Richard D. Stewart, M.D., M.P.H., Professor and Chairman Jack E. Peterson, Ph. D., Chief, Environmental Health Engineering)

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## CRITIQUE OF AIR QUALITY STANDARDS

Section 109 of the Clean Air Act as amended in 1970 called for the setting of national primary and secondary ambient air quality standards by the Environmental Protection Agency. Standards for sulfur oxides, particulate matter, carbon monoxide, photochemical oxidants, hydrocarbons and nitrogen dioxide were published in the Federal Register in April and November 1971. These standards were based on criteria documents published by EPA in January 1969 (sulfur oxides and particulate matter), March, 1970 (hydrocarbons, carbon monoxide, and photochemical oxidants), and January 1971 (nitrogen oxides).

A thorough review of the criteria documents and of the resulting ambient air quality standards reveals that:

(1) Each criteria document was based upon a thorough search of the literature available prior to the document's publication.

(2) Very little quantitative, uncontroversial data on the health effects of air pollutants was found.

(3) Although other effects of air pollution were considered in the preparation of the criteria documents, information relating to health effects was emphasized.

(4) In judging the worth of data for the purpose of setting air quality standards, there was an obvious emphasis on data which would support a conservative standard in each case.

(5) With the exception of sulfur oxides little thought was given to the economic impact upon the U.S. of any of the air quality standards (EPA had not legal obligation to consider economic aspects).

(6) Under a legal obligation to promulgate air quality standards whether or not adequate data existed upon which to base these standards, EPA did a remarkably good and conscientious job.

The controversy which has arisen in the scientific community subsequent to the publication of criteria documents and the promulgation of ambient air quality standards has been based either upon the revelation of new data or upon a different interpretation of the originally cited data. The EPA is in the unfortunate position of having to defend its prior judgments in the face of mounting criticism. While advocacy may be the basis of good law, it is not necessarily the basis of good science which, instead, should be based upon the best available facts.

The task set by Congress for the EPA to accomplish was herculean and almost literally impossible. Adequate data did not exist in the 1969-1971 period for the establishment of unassailably good ambient air quality standards. In fact, adequate data for the setting of such standards does not exist today. Furthermore, if the present trend continues, with the EPA defiantly defending its original standards, the acquisition of adequate data for the establishment of scientifically unassailable standards will be unduly delayed. Arbitration between the EPA and critics in the scientific community is necessary.

Basic to the kind of arbitration necessary is a reassessment of the ambient air quality standards in the light of new data, new thoughts, and perhaps new viewpoints. To that end each of the standards will be examined.

*Carbon Monoxide*

Carbon monoxide (CO) is one of the major air pollutants which has the potential for adversely affecting human health. To protect the public, the Clean Air Act's air quality standards of 1971 limit CO exposure. Compliance with the 8-hour standard would prevent excursion of blood carboxyhemoglobin (COHb) above 1.5% saturation in active non-smokers.

At the time the air quality standards were promulgated, three pieces of scientific evidence were at hand which indicated that exposure to low concentrations of CO could exert a detrimental effect upon man's ability to perform

cognitive tasks. The human response in the published literature reported to be most sensitive to CO was time perception.<sup>1</sup> Beard and Wertheim had reported that exposure to CO concentrations as low as 50 ppm for a period as short as 90 minutes would seriously impair man's ability to discriminate between short intervals of time or to estimate 30 seconds. This decrement in time perception was reported to occur at COHb saturations as low as 2%, a saturation we now know is frequently encountered by non-smokers, a saturation consistently exceeded by the majority of the smoking population. Ignored by the EPA was the work of two other research groups who, working independently, had failed to corroborate the time perception decrement reported by Beard and Wertheim<sup>2,4</sup>. Of importance is the fact that Dr. Beard was unable to reproduce his original findings when following a better experimental design.

In the face of this refutation, it is troublesome to the scientific community that the Acting Administrator of the EPA on June 14, 1973 cited the Beard-Wertheim work as supporting evidence for the current CO air quality standards in his "Statement to the Public on Clean Air and the Automobile."

The most sensitive decrement in cognitive task performance had been reported by Schulte, et al.<sup>5</sup> Exposure to CO, 100 ppm. for periods of time sufficient to elevate the COHb saturation to 4%, decreased the accuracy with which middle-aged firemen could perform simple arithmetic and inspection tests. Again, the conflicting research of other laboratories was ignored by the EPA<sup>2,3</sup>.

The third piece of evidence cited was the work of McFarland<sup>6</sup> in which he indicated that slight changes in man's ability to detect minute changes in light intensity were impaired when COHb is rapidly elevated to 5% saturation. However, at the 5% COHb level, the cardiovascular response becomes the dominant toxic effect of exposure, and few scientists would wish to risk the hazard of exposing persons with advanced heart or lung disease to CO sufficient to elevate the COHb above 5% saturation.

Therefore, the best available scientific data, observations confirmed by a second independent research group, indicates that COHb saturations less than 5% exert little influence upon the performance of cognitive tasks.

Two recent studies indicate that persons with advanced coronary artery disease are adversely affected by exposure to CO sufficient to increase their COHb to the 3% level<sup>7,8</sup>. This cardiovascular stress is of the same order of magnitude as would be caused by exposure to cold weather or to eating a heavy meal or to walking briskly down the street. This segment of the population probably would be adversely affected by any exposure to CO, no matter how minute. Research is desperately needed to confirm this assumption. Therefore, we are of the opinion that it will be impossible to establish a no-effect CO standard so far as those individuals with significant heart and lung disease are concerned. The CO air quality standard should be set at a reasonable level, not to exceed the cardiovascular stress of eating for example, so that the most susceptible to CO exposure may be afforded reasonable protection. Additional research will be required before the margin of risk of the current CO standards can be ascertained.

### Particulate Matter

Air pollution "incidents" or "disasters" where many people died and many more became ill during a period of obviously polluted, stagnant air have occurred at intervals around the world since 1880. Serious investigation of these incidents began with the one that occurred in the Meuse Valley in Belgium in December, 1930. Investigators listed several hundred materials thought to be in the air during the incident and concluded that the cause of the deaths was probably sulfur compounds acting alone or in combination with liquids and solids

<sup>1</sup> Beard, R. R., and G. A. Wertheim: Behavioral Impairment Associated with Small Doses of Carbon Monoxide. *Amer. J. Public Health*, 57: 2012-2022, 1967.

<sup>2</sup> O'Donnell, R. D., P. Chikos, and J. Theodore: Effect of CO Exposure on Human Sleep and Psychomotor Performance. *J. Appl. Physiol.* 31: 513-518, 1971.

<sup>3</sup> Stewart, R. D., J. E. Peterson, and E. D. Baretta, et al.: Experimental Human Exposure to Carbon Monoxide. *Arch. Environ. Health*, 21: 154-164, 1970.

<sup>4</sup> Stewart, R. D., Newton, P. E., Hosko, M. J., and Peterson, J. E.: Effect of Carbon Monoxide on Time Perception. *Arch. Environ. Health*, 27: 155-160, 1973.

<sup>5</sup> Schulte, J. H.: Effects of Mild Carbon Monoxide Intoxication. *Arch. Environ. Health*, 7: 524-530, 1963.

<sup>6</sup> McFarland, R. A., Roughton, F. J. W., Hnlperin, M. H., et al.: The Effects of Carbon Monoxide and Altitude on Visual Thresholds. *J. Aviation Med.* 15: 381-384, 1944.

<sup>7</sup> Aronow, W. S., Harris, C. N., Isbell, M. W., et al.: Effect of Freeway Travel on Angina Pectoris. *Ann. Intern. Med.* 77: 669-676, 1972.

<sup>8</sup> Anderson, E. W., Anselman, R. J., Strauch, J. M., et al.: Effect of Low-Level Carbon Monoxide Exposure on Onset and Duration of Angina Pectoris. *Ann. Intern. Med.* 79: 46-50, 1973.

suspended in the air which were then, and later, loosely grouped into a term "particulate matter." Almost identical conclusions were reached after the incident in Donora, Pennsylvania in October, 1948 and after the incident in London in December, 1952 which took several thousand lives. In all cases, the term "particulate matter" was used because no one knew exactly what killed the people who died. The term was coined in ignorance and perpetuated by sloth.

Recent research has begun to indicate that the cause of death in the "incidents" was probably one or more water soluble salts. In particular, salts of sulfuric acid (sulfates) have been incriminated. There is good evidence that regardless of other considerations, the lethal material probably existed as droplets in humid air and these droplets must have been small enough to have been inhaled and to have reached the deep lung areas. Present evidence indicates, therefore, that the "particulate matter" in the air needs to be identified chemically and by particle size at high (greater than 70% rh) humidity. There are no data relating health effects to particulate air pollutants thus characterized in the ambient air.

Most of the data on the health effects of particulate matter cited in the criteria document are attempts to correlate untoward health effects with the mass per unit volume of air of solids suspended in that air, the kind of information obtained with the ubiquitous "hi-voi" air sampler. A small amount of data was available on the proportion of metals in these samples, but no attempt was made to relate that information to any effects of air pollution. The other kind of data cited in the particulate matter criteria document is that obtained by a "paper tape" air sampler where the concentration of pollutant is indicated by the darkness of a spot on a filter paper tape. The units of this measurement are "COH's per 1000 feet of air." Only a small amount of this kind of data was available prior to 1969.

Neither mass per unit volume from the "hi-voi" sampler nor "COH's per 1000 feet" from the paper tape sampler can be logically related to health effects of air pollution. To use either measurement is to violate several of the basic principles of toxicology and medicine. And yet, because these were the only kinds of data available upon which to base ambient air quality standards, they were used.

Ambient air sampling for particulates with more sophisticated tools has begun. Attempts are being made to characterize these materials suspended in the ambient air by particle size and by chemical composition. However, until relatively large quantities of such data are available and are correlated with effects of one kind or another, rational, scientifically unassailable standards are impossible to set. Any thing done in the meantime must be considered a stop-gap, temporary measure to be superseded as soon as possible by standards based on better information. More research is an absolute necessity.

### *Sulfur Oxides*

When a material containing sulfur is burned in air most of that sulfur is converted to the gaseous form, sulfur dioxide. Sulfur dioxide, in turn, slowly oxidizes in air to sulfur trioxide, which, in turn, combines with water to form sulfuric acid. The sulfuric acid droplets grow in size by attracting more water vapor, occasionally to the point where a blue haze is formed in the air in sufficient concentrations to interfere with vision.

Animal and human experimentation with sulfur dioxide has been quite extensive. This information combined with data on sulfur dioxide levels found during air pollution "disasters" indicates almost irrevocably that sulfur dioxide *per se* cannot have been the lethal agent. Recent evidence indicates that instead, the culprit is one or more metallic sulfates, materials which exist as particulates in the air, not as gases. Nevertheless, a great deal of ambient air sampling is done to characterize sulfur dioxide levels and a standard exists for sulfur oxides in the air, but not for sulfates.

High sulfur dioxide concentrations (on the order of a few tenths of a ppm) can be tasted and smelled. In concentrations over a few ppm, sulfur dioxide can be irritating to breathe. These effects are good, and perhaps adequate reasons to control concentrations of sulfur dioxide in the ambient air. If so, the ambient air quality standard should probably be aimed more directly at reducing peak concentrations than it is presently, and probably could be relaxed by a factor of from 2 to 5 without endangering health from sulfur dioxide itself. This should not be done, however, until research has better characterized potentially lethal air pollutants and has shown the way to monitor and control them. The secondary reaction products of sulfur dioxide appear to play a major role in

disasters, but present knowledge is not adequate to delineate that role. Much more research is obviously needed.

#### THE AUTOMOBILE-RELATED POLLUTANTS

All of the remaining air quality criteria and standards are concerned with materials in the air which have the automobile as their ultimate source. The standards for nitrogen oxides, photochemical oxidants, and hydrocarbons are all aimed at reducing the concentrations and effects of photochemical "smog". The standard for CO appears to have been set mainly because CO is the largest easily-characterized air pollutant by weight, using untoward health effects as the basis.

##### *Photochemical Oxidants*

Under most circumstances, the class of materials called "photochemical oxidants" appears to consist mainly of ozone (up to 95%) along with a great variety of much-less-well characterized materials. Ozone enjoys the distinction of being by far the most toxic of materials for which air quality criteria and standards exist. As the reference method of sampling air for this class of materials is calibrated with ozone and is sensitive mainly to ozone, the generic name should be changed and ozone should be designated as the material of interest in this case.

Toxicity to people as well as effects on vegetation and rubber products amply justify a strict air quality standard for ozone. Unfortunately, ozone is not directly associated with the most annoying effects of photochemical smog, namely eye irritation and visibility reduction. There is absolutely no assurance that reducing ozone to concentrations below the ambient air quality standards will have any effect at all on eye irritation or visibility reduction. Of course, all concerned hope that these other effects will be controlled if ozone concentrations are controlled, but no one can say for certain that they will be.

Peroxyacetyl nitrate is another secondary air pollutant, formed by reactions similar to those which cause the formation of ozone. Indications are that this material is more toxic than ozone to vegetation as well as people and may be more directly related to eye irritation than is ozone. However, there exists insufficient information as yet upon which to base an ambient air quality standard for this material.

##### *Nitrogen Oxides*

Earlier this year EPA officially recognized the fact that much of the information in the air quality criteria document for nitrogen oxides was based upon a faulty analytical method. There appears to be very little justification for continuing an ambient air quality standard for which the main basis has been removed. Until more data based upon good analytical methods are available relating nitrogen dioxide concentrations to effects, the standard should be officially labeled "provisional" or "temporary" and it should be treated as such.

The main justification for controlling nitric oxide emission from automobiles is to control the secondary formation of ozone, peroxyacetyl nitrate, nitrogen dioxide, and the materials which cause eye irritation and visibility reduction in photochemical smogs. An ambient air quality standard is not necessary for this purpose.

##### *Hydrocarbons*

Recognizing the fact that methane does not participate in the formation of photochemical smog and that methane concentrations in most areas are higher than the concentrations of any other hydrocarbon, the ambient air quality standard is restricted to "non-methane hydrocarbons."

None of the hydrocarbons to which the standard refers have any significant effect on human or animal health, or upon materials of construction even in concentrations several multiples of those found in our urban environment. In general, the standard exists simply because some of these materials are capable of reacting with other constituents of the atmosphere to form the components of photochemical smog. One exception to this generalization is that ethylene acts somewhat as a plant hormone and in concentrations that may be approached in urban environments, can injure some kinds of vegetation.

To combine all non-methane hydrocarbons into one ambient air quality standard violates almost as many principles as does the combining of solids and liquids in the air into a "particulate matter" standard. Many hydrocarbons which have the automobile as their ultimate source (either from fuel evaporation or from

the tail pipe) participate very slowly in photochemical smog formation. Examples of these nearly unreactive materials are the saturated alkanes such as ethane, propane, and butane, and an aromatic, benzene. The reference analytical method for hydrocarbons cannot distinguish those materials which readily participate in the formation of photochemical smog from those which do not. If control of hydrocarbons is necessary through the use of an ambient air quality standard, that standard should be particularized at least to the extent of being specific for classes of hydrocarbons. It should not encompass all hydrocarbons.

There is evidence in the scientific literature for and against the concept that hydrocarbon control is necessary. Some authors have indicated that adequate control of either nitric oxide or hydrocarbons (but not necessarily both) would adequately reduce photochemical smog formation. On the other hand, evidence also exists to show that control of both kinds of material is necessary.

With the exception of ethylene for which an ambient air quality standard is justified because of its potential to cause vegetation damage, there appears to be little justification for an ambient air quality standard for "non-methane hydrocarbons." Instead, emission standards related to the photoreactivity of classes of hydrocarbons appear to be considerably more rational. Even for that, however, much more research is necessary.

#### CONCLUSIONS

The most basic error committed by the Environmental Protection Agency in its writing the air quality criteria documents, control documents, and its promulgation of air quality standards was the adoption of outmoded names for the air pollutants of concern. Of the six criteria documents and standards, only one was written for an easily characterized chemical compound (carbon monoxide). "Particulate matter" has been shown to be no more meaningful than "dirt". "Hydrocarbons" is a term which embraces several million materials ranging from saturated aliphatics such as ethane to the carcinogen, benzpyrene. "Photochemical oxidants" appears to relate mainly to ozone, but apparently attempts to catch other materials under a broad umbrella. "Nitrogen oxides" is accepted by nearly everyone concerned to really mean "nitrogen dioxide." Although "sulfur oxides" is the title used, every effort is made in air sampling to determine either sulfur dioxide alone or to differentiate between sulfur dioxide and sulfur trioxide.

Rather than better characterizing air pollution by using broad categorical terms for air pollutants, EPA has perpetuated an outmoded terminology, creating unnecessary confusion. Particularly in the area of health effects or toxicology, categories of materials do not cause problems; individual materials do. Every effort should be made to put criteria and standards on a scientific, rational basis. These documents and standards should not be written except for individual chemical compounds and on the basis of good chemical and epidemiological evidence for their effects.

In retrospect, a most serious flaw in the law is that of not providing a mechanism for the mandatory periodic review and updating of previously-written criteria and standards. Information on air pollutants and their effects is accumulating rapidly in this country and abroad. New information should undergird the actions of EPA in its attempts to monitor and control air pollution. Currently, EPA is allowed to review and revise criteria at its discretion. Review and revision should be mandatory at intervals of no greater than five years for at least the first ten or twenty years of the existence of a criteria document. Unless the review is made mandatory, review at reasonable intervals of time appears to be extremely unlikely.

Another mistake which has been made in the name of air pollution control is to speak of regulations and controls without considering cost. This is not to say that cost should be a major determinant in the setting of standards, but to promulgate primary and, especially, secondary air quality standards without having some idea of the overall cost to the nation of those standards is irrational and irresponsible. Assessment of the economic impact of all actions of the EPA should be mandatory.

Mr. PREYER. Thank you very much, Dr. Stewart, for some very interesting testimony. I have a series of questions here also arising from from your testimony and again in the interest of time, I would like to

submit them to you and ask if you would give us some written answers. I think you have answered some of them in your testimony.

Dr. STEWART. I would be very happy to.

[The following questions and answers were received for the record:]

QUESTIONS SUBMITTED BY CONGRESSMAN RICHARDSON PREYER AND ANSWERS  
SUPPLIED BY DR. RICHARD D. STEWART

*Question No. 1. From your statement it appears that you believe that air quality standards should be set to protect the most susceptible groups in the society, not merely the average normal adult. Is that correct?*

Answer. Your understanding of my statement is correct. I firmly believe that the Air Quality Standards must be set to provide protection for the most susceptible persons in our society.

*Question No. 2. Your statement also suggests that there may not be any safe threshold for CO exposures.*

(a) *Are you recommending that economics should be considered in setting air quality standards?*

(b) *Would it make more sense to set the standards simply on the basis of protection of health—even if that means a background level is set—and let the time for attainment reflect the economic considerations, as Dr. Pitts recommends?*

(c) *Are there any other pollutants besides CO for which there may be no safe levels?*

Answer. Since carbon monoxide exerts its effect on man by reducing the oxygen carrying capacity of the blood, any amount of the gas which is absorbed, no matter how small a quantity, will represent a measurable body burden. There is a measurable response to any carbon monoxide exposure. In the majority, that response is simply an increase in cardiac output (volume of blood from the heart per unit time) to compensate for the reduction in oxygen available from the blood. Individuals with advanced disease of heart and blood vessels may not be able to completely compensate for carbon monoxide burdens which pose no problem for healthy individuals. Carried to the extreme, one can postulate then that a person dying with advanced heart disease could have his limited life span further shortened by seconds to minutes following the absorption of a single molecule of carbon monoxide. Therefore, I believe that there is no safe threshold for carbon monoxide which would be applicable to each person in the total population.

In my opinion, ozone is a compound like carbon monoxide for which no safe threshold exists.

I do not wish to enter into the debate regarding the economics involved in setting air quality standards. I believe our goal should be to have completely uncontaminated air. The rate at which we proceed to achieve this goal must be dictated by the best available scientific information.

*Question No. 3. Is it your understanding that control of NO and NO<sub>2</sub> emissions is necessary for control of oxidants?*

*Question No. 4. If so, what degree of control of new car emissions is necessary for this purpose?*

Answer to Q 3 and Q 4. I am unaware of anyone who has the answers to these two questions.

"Oxidants" as explained previously is an ambiguous term. However, formation of the secondary components of photochemical smog such as nitrogen dioxide, peroxyacetyl nitrate, ozone, formaldehyde, other aldehydes, ketones, acids, etc. is dependent on an adequate concentration of both nitric oxide and photochemically reactive hydrocarbons as well as sunlight.

If, for any reason, the concentration of the reactants is too low, or there is insufficient sunlight, the resulting concentration of the components of photochemical smog will be so low as to produce no deleterious effects. The necessary degree of nitric oxide emission control to adequately retard the development of photochemical smog is dependent on several factors. Regardless of other considerations, if the concentration of photochemically reactive hydrocarbons is too low or if there is insufficient sunlight (either in prevalence or intensity), photochemical smog will not develop in excessive concentrations. Furthermore, the amount of control of nitric oxide required per vehicle obviously depends on the number of vehicles contributing nitric oxide to the volume of air under considera-

tion. The smaller the number of vehicles or the larger the volume of air, the less control of nitric oxide necessary for each vehicle.

To the best of our knowledge, no one has yet determined how to balance these various factors to result in a rationally determined "degree of control" for either nitric oxide or photochemically reactive hydrocarbons. More research coupled with mathematical modeling of the formation of secondary air pollutants is necessary before scientifically sound standards can be developed. In the interim, control of photochemically reactive hydrocarbon emissions may prove to be the most economical route to control of photochemical smog.

*Question No. 5. Are you recommending deletion of the ambient standard for hydrocarbons? Please explain.*

Answer. Yes, the ambient standard for hydrocarbons should be deleted.

As previously explained, in the context of an air quality standard, the word "hydrocarbons" is meaningless. An ambient air quality standard for ethylene, however, appears to be warranted based upon injury and damage to vegetation.

Except for ethylene, none of the hydrocarbons associated with gasoline evaporation and tall pipe emissions has been shown to be a threat to health, vegetation, materials of construction, or visibility. On this basis, none of these materials warrants the imposition of an ambient air quality standard. Instead, unless nitric oxide emissions are controlled to the point where photochemical smog does not take place, the *emission of photochemically reactive hydrocarbons* should be controlled.

Several recent papers have indicated that a consensus of scientific opinion about the photochemical reactivity classes of hydrocarbons could occur in the near future. Once this has been achieved, emissions of hydrocarbons based on photochemical reactivity class set on the basis of the mathematical model of photochemical smog formation previously discussed appears to be a rational approach to the problem.

*Question No. 6. Are you recommending relaxing the SO<sub>2</sub> standards by two-to-five times?*

*Question No. 7. If so, how can sulfates be adequately controlled? Should other pollutants be controlled more stringently than presently in order to prevent sulfates from forming at hazardous levels?*

Answer to Q 6 and Q 7. No, we do not recommend relaxing the SO<sub>2</sub> standard.

We recommend that the ambient air quality standard be retained, but that it be renamed "sulfur dioxide". At such time in the future when the materials which react with sulfur dioxide to form harmful air pollutants are known and controlled, the primary air quality standards for sulfur dioxide could probably be relaxed. That is, sulfur dioxide alone is probably not capable of serious health effects in doses two to five times greater than those indicated by the present primary air quality standards.

Neither we, nor anyone else so far as we know, are yet capable of specifying which sulfates must be "adequately controlled". Research in this area is promising, but more work on this problem is desperately needed.

Mr. PREYER. Mr. Heinz?

Mr. HEINZ. Mr. Chairman, I would like to take a minute to compliment the witness, Dr. Stewart, on an extremely well-prepared, very learned and most useful testimony.

Dr. STEWART. Thank you very much.

Mr. PREYER. May I just ask one question that you can answer very quickly. Is there any other pollutant besides carbon monoxide for which there may be no safe level?

Dr. STEWART. My own feeling is, and again this just has to be a scientific guess, based upon what we have observed in experimental animals, I have a feeling that in addition to carbon monoxide, when we develop sensitive enough tools, we will find certain people with pulmonary disease probably will not tolerate, we won't be able to find a no-effect level for ozone. I think that is one chemical which has the potential when it enters the lungs, to produce a permanent damage and that when we finally have techniques sensitive to detect this, ozone will be another compound where we will not be able to define a no-effect level.

Mr. PREYER. The work you are doing in your laboratory, as shown by your slides, is very interesting and impressive. I am sure the committee and the country will be very interested in your further results. I hope you will keep us informed.

Dr. STEWART. I will be very happy to, sir.

Mr. PREYER. Thank you very much, Dr. Stewart.

Because of the floor schedule this afternoon, we will not be able to resume until 10 o'clock tomorrow morning. The testimony of Dr. Stephen Ayres will be submitted for the record. We will have some copies available for anyone in the audience who would like to have them.

[Dr. Stephen M. Ayres' statement and attachments follows:]

STATEMENT OF DR. STEPHEN M. AYRES, PHYSICIAN IN CHIEF, ST. VINCENT HOSPITAL, WORCESTER, MASS., AND PROFESSOR OF MEDICINE, UNIVERSITY OF MASSACHUSETTS SCHOOL OF MEDICINE

I am Dr. Stephen M. Ayres, Physician in Chief of St. Vincent Hospital in Worcester, Massachusetts, and Professor of Medicine at the University of Massachusetts School of Medicine. Until June 1st of this year, I was Director of the Cardiopulmonary Laboratory at St. Vincent's Hospital in New York City. Much of the material presented in this testimony is based on research performed during my ten years in New York City.

This testimony is being presented by my associate, Mr. Robert Evans, who has been closely involved with these environmental studies during the past three years.

Automotive pollution produced by uncontrolled emissions from multiple mobile sources has rapidly become the major air pollution problem in most urban areas. Carbon monoxide, nitrogen oxides, hydrocarbons, particulates, lead and oxidants are generated in large volume by the internal combustion engine and are all potentially hazardous to human health. Figure 1 shows hourly concentrations for five automotive pollutants. They were obtained in a highly polluted site in New York City—the toll plaza of the Queens Midtown Tunnel. This data demonstrates two important points: (1) Pollutant concentrations in certain urban areas greatly exceed recommended standards (dotted lines). (2) Carbon monoxide concentrations rise and fall with the concentrations of other automotive pollutants and may be used as an estimate of the dose of automotive pollution. A corollary to this is that blood carboxyhemoglobin concentrations may be used as an index of exposure to automotive pollution and to cigarette smoke.

Most of our estimates regarding the level of air pollution in a given region are based on data obtained from monitoring stations remote from congested city streets. These data provide some idea of the average pollution experience by an area but do not indicate the actual pollution delivered to various members of the population within that area. Figure 2 shows the yearly trends for average pollution within the New York City area. These measurements were made by the New York City Department of Air Resources at their monitoring station located at 121st Street in Manhattan. Note that particulate and sulfur pollution has declined, largely due to the imposition of stringent controls regulating incineration and the combustion of fossil fuels. In contrast, carbon monoxide and oxidant pollution have been relatively untouched because of the difficulty in controlling emissions from most vehicles operated within the city.

Although the average measurements indicate that automotive pollution levels have changed little in the period 1965-1972, they reveal little of the actual pollution delivered to the breathing zone of the mobile New Yorker. Figure 3 compares the hourly carbon monoxide concentrations measured at the Queens Midtown Toll Plaza with concentrations measured at the Air Resources station at 121st Street. Note that levels in congested traffic are from five to twelve times higher than those recorded at the station. An hourly average of 125 ppm in traffic was recorded when the level was but 5 ppm in the remote sampling station at 121st Street.

Ambient air carbon monoxide concentrations provide rough estimates of automotive pollution but frequently underestimate actual contamination because of the multiple mobile sources producing pollutant substances. A high concentra-

tion existing at street level may be so diluted that a low concentration is recorded at a remote monitoring site. This difference between actual breathing zone and monitoring station pollution is less marked with fossil fuel pollutants such as sulfur oxides and particulates because they are emitted from high level stacks and mix with the atmosphere before entering either breathing zone or monitoring probe. For this reason, the extent of automotive pollution is better estimated by either breathing zone measurements or actual measurements of blood carbon monoxide (carboxyhemoglobin). Since most city dwellers move rapidly from high level street pollution to low level remote areas, blood levels give the most accurate index of human exposure to carbon monoxide and other automotive pollutants.

#### THE BODY BURDEN OF AUTOMOTIVE POLLUTION IN URBAN AREAS

We have performed a relatively large series of blood carboxyhemoglobin measurements among different groups of New Yorkers. The most accurate technique is direct blood sampling and analysis by gas chromatography. This technique may be extended to larger groups of individuals by analyzing a breath-holding sample of lung air. Carbon monoxide concentrations in breath-hold samples are very similar to those in actual blood and may be used for large scale epidemiologic studies. In this regard, the method is similar to the use of breath alcohol studies to indicate blood levels of alcohol to individuals suspected of operating a motor vehicle of alcohol in individuals suspected of operating a motor vehicle while intoxicated. Our conclusions are based on both blood and breath-hold data.

The following table gives the average blood carboxyhemoglobin levels for smokers and non-smokers in various groups studied within the city. The higher figure given in parentheses is one standard deviation greater than the mean value. Statistically, about fifteen percent of individuals might be expected to have carboxyhemoglobin concentrations greater than this value.

#### NONSMOKERS

Group	Number of subjects	Average (percent)	Average plus 1 standard deviation
Hospitalized, resting patients.....	200	1.56	1.91
Walking New Yorkers studied out of doors.....	313	1.93	2.53
Group of New Yorkers who had traveled in car or bus prior to testing....	100	2.28	3.08
Bridge workers.....	38	2.12	3.30
Tunnel workers.....	38	2.93	4.29
New York City policemen:			
Congested precincts.....	53	3.14	3.85
Less congested precincts.....	83	2.28	2.85

A more than 24 fold difference separate the lowest value in a non-smoking hospitalized patient from the highest value in a non-smoking policeman emphasizing the importance of regional differences within the city.

Carboxyhemoglobin concentrations in smokers are substantially higher than those in non-smokers. While this double burden imposes an important health hazard on this group, the data is more difficult to interpret because it reflects contributions from both automotive and tobacco pollution. Carboxyhemoglobin in the smoking tunnel worker averaged 5.01 percent for example; about fifteen percent of the group had levels in excess of 7.26 percent. Carboxyhemoglobin in the walking smoking New Yorker averaged 3.89 percent with about fifteen percent having values greater than 5.95 percent.

#### EFFECTS OF CARBON MONOXIDE ON THE HEART

Carbon monoxide in sufficiently high concentrations produces weakness of the heart and ultimate death but these effects are not seen in healthy individuals until the blood carboxyhemoglobin concentration exceeds 30-40 percent saturation. We presented data several years ago that much lower concentrations of carbon monoxide might injure the heart in patients with coronary artery disease. Over 500,000 Americans die from coronary artery disease each year—a disease which injures the heart muscle by reducing its supply of oxygen. Since carbon monoxide also reduces the supply of available oxygen, we reasoned that the

combination of carbon monoxide and coronary artery disease might be particularly lethal.

The appended article entitled "Carboxyhemoglobinemia: An Example of Counterrevolution" reviews the development of this concept. Our early work suggested that concentrations in excess of five percent saturation could aggravate coronary artery disease and this observation was used to develop air quality criteria designed to keep carboxyhemoglobin concentrations below that level. Although we suspected that concentrations below 5 percent saturation might be dangerous to certain individuals, data were not available which supported the adoption of more restrictive air quality criteria. Three recent studies have confirmed our findings of the relationships between exposure to carbon monoxide and the aggravation of coronary artery disease. Aronow and associates exposed patients with angina pectoris to 90 minutes of travel on Los Angeles freeways and observed aggravation of symptomatology at carboxyhemoglobin levels close to 3 percent. This was later confirmed by exposure studies conducted by both Anderson and associates and Aronow and associates. These latter two studies were double blind in design—neither the investigator nor the subjects knew when they were exposed to carbon monoxide—and abnormalities were seen at levels as low as 3 percent carboxyhemoglobin saturation. Our earlier findings had been confirmed but even lower levels were found to be hazardous.

#### EFFECTS OF AUTOMOTIVE POLLUTION ON THE LUNG

Many of the other components of automotive exhaust—particulates, oxidants, and the oxides of nitrogen—are capable of irritating the lung in experimental situations. Epidemiologic studies have shown a relationship between chronic bronchitis and air pollution in many populations and it is likely that automotive pollution is the responsible agent. We have recently completed two years of a three year study into the health of workers in and around the bridges and tunnels operated by the Triborough Bridge and Tunnel Authority in New York City.

A complete report, "The Health Effects of Exposure to High Concentrations of Automotive Emissions" is appended to this report. A high percentage of workers had evidence of chronic bronchitis. One quarter of the subjects coughed up phlegm during the daytime, one quarter experienced the symptom of wheezing, many had reduction in expiratory flow rates, and three quarters of the workers had increased closing volumes. These studies suggested that there was an extraordinarily high frequency of pulmonary disease in subjects exposed to automotive pollution.

Cigarette smoking is generally accepted as a major cause of bronchitis and emphysema. In our study, however, bronchitis was present in both smokers and non-smokers. This observation does not minimize the importance of cigarette smoking but indicates that, in certain situations, the burden of air pollution may be greater than the effect of cigarette smoke on the lungs.

We found certain differences in lung function between men who worked in bridges and men who worked in the more heavily polluted tunnels. Carboxyhemoglobin concentration averaged 2.1 percent in bridge workers and 2.9 percent in tunnel workers; expiratory flow rates were one-third lower in the latter group. This data can be used to develop some idea of dose-response relationships. Automotive pollution sufficient to raise carboxyhemoglobin from 2 to 3 percent apparently decrease lung function by one-third. The change in carboxyhemoglobin is an indicator of the intensity of exposure. It itself is not responsible since carbon monoxide is not irritating but is indicative of the body burden of other automotive pollutants.

## EVALUATION OF AIR QUALITY CRITERIA

Air quality criteria for automotive pollutants must be based on the following observations.

1. Automotive pollution associated with carboxyhemoglobin levels above 3 percent appears to produce lung disease in a high percentage of individuals.

2. Carboxyhemoglobin concentrations in excess of 3 percent appear to aggravate heart disease in patients with coronary artery disease. Since at least half of all Americans have unsuspected coronary disease, this means that these level of carbon monoxide are potentially harmful to many individuals.

3. Ambient air concentrations are at best a crude indicator of breathing zone concentrations of automotive pollutants.

4. A significant number of New Yorkers, both smokers and non-smokers, have carboxyhemoglobin concentrations in excess of 3 percent saturation.

We have recently studied the relationship between 24 hourly averages for carbon monoxide and blood carboxyhemoglobin concentration in subjects resting in a hospital bed. A highly significant regression relationship was established: an ambient air concentration of 9 ppm was associated with 2.2 percent carboxyhemoglobin saturation and 5 ppm was associated with 1.7 percent carboxyhemoglobin. When the same approach was applied to walking New Yorkers exposed to out of doors conditions, substantially higher carboxyhemoglobin concentrations were observed with the same ambient air concentrations.

It is important to note that accumulating scientific evidence has resulted in a progressive reduction of levels of carbon monoxide thought to be safe. Our early studies suggested 5 percent carboxyhemoglobin as the desirable maximum level. Aronow's and Anderson's studies suggested 3 percent as a potentially harmful level. Our most recent study suggested that somewhere between 2 and 3 percent increased the incidence of chronic bronchitis. Our observations that ambient air concentrations of 9 ppm may produce carboxyhemoglobin concentrations between 2 and 2.5 percent in non-smokers and the increasing recognition that the automotive pollution associated with these levels of carboxyhemoglobin may produce damage of heart and lung lead us to conclude that the present air quality criteria are reasonable and necessary. If anything, they should be strengthened by the development of additional street level and blood carboxyhemoglobin criteria.

# Health Effects of Exposure to High Concentrations of Automotive Emissions

Studies in Bridge and Tunnel Workers in New York City

Stephen M. Ayres, MD, Robert Evans; David Licht; Jane Griesbach; Felicity Renold; Edward F. Ferrand, PhD; Antoinette Criscitiello, RN, MA, New York

On-site and remote health evaluations were performed on 550 employees of the Triborough Bridge and Tunnel Authority in New York City. Extremely high ambient air pollution was observed. Carbon monoxide averaged 63 ppm over a 30-day period with a maximum hourly concentration of 217 ppm in one facility. Eighty-five percent of the smoking and 47% of the nonsmoking tunnel workers had carboxyhemoglobin saturations in excess of 3%. A high percentage of the group had symptoms suggestive of chronic bronchitis; airway resistance was elevated in one third and almost all bridge and tunnel workers had an increase in closing volume, suggesting small airway disease.

Automotive pollution produced by uncontrolled emissions from multiple mobile sources has rapidly become the major air pollution problem in most urban areas. Carbon monoxide, nitrogen oxides, hydrocarbons, and oxidants are generated in large volume by the internal combustion engine and are all potentially hazardous to human health. The lack

of systematic epidemiological observations and the ethical difficulty associated with large scale experimental exposure have prevented identification of precise dose-response relationships. A group of recent studies has suggested that carboxyhemoglobin concentrations in excess of 5% may induce myocardial ischemia in subjects with coronary artery disease<sup>1-3</sup> and long-term breathing of nitrogen dioxide concentrations averaging 2.9 ppm has been shown to produce significant pulmonary abnormalities in laboratory animals.<sup>4</sup> The aggregate effect of automotive pollution on human health was clearly demonstrated by Aronow et al<sup>5</sup> who exposed ten patients with angina pectoris to 90 minutes of Los Angeles freeway traffic. Carboxyhemoglobin saturation rose from 1.12% to 5.08%, four of the subjects developed electrocardiographic abnormalities, and the average time to develop angina with treadmill exercise fell from 249.4 to 174.3 seconds. The amount of exercise required to produce angina was significantly lower than control two hours later, when carboxyhemoglobin concentration had fallen to 2.91% saturation.

Bridge and tunnel workers, policemen, taxi drivers, and others comprise an unwitting but useful test population. Exposed daily to high

concentrations of automotive pollutants, they might be considered an exaggerated model of the environmental stresses experienced by many other city dwellers. Differences between industrial and community air pollution exposures blend as the commuter travels each day through congested tunnels and highways. While an eight-hour tour of duty is considered an occupational exposure to the tunnel workers, a two-hour daily traffic period for the New Yorkers is generally considered a problem of community air pollution. Obviously, rigid distinctions between occupational and community exposures are arbitrary, and it is likely that environmental and occupational air quality standards will ultimately be similar.

The interest of the Bridge and Tunnel Officers Union and the Triborough Bridge and Tunnel Authority in the problem of automotive pollution has provided a unique opportunity to study the effects of automotive pollutants on human health. A three-year study of all nonadministrative employees of the Authority was initiated in 1970; this article details information collected during the first two years of observation. An extensive program of toll booth air purification was completed during the early months of the second year of study.

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and subsequent studies should permit examination of the effect of sudden decreases in automotive pollution on human health.

### Methods

**Design of the Study.**—Two types of health effects were evaluated: acute responses to high concentrations of automotive pollutants and chronic changes in pulmonary and cardiac function. Acute responses were evaluated by on-site measurements of pulmonary function, carboxyhemoglobin concentrations, and (in some instances) methemoglobin and erythrocyte concentration of 2,3-diphosphoglycerate during, or immediately following, a tour of duty in either bridge or tunnel. Chronic changes were evaluated by means of complete physical examination and laboratory analysis, including serum lead and detailed pulmonary function evaluations, chest roentgenogram, and exercise electrocardiogram, all obtained on a day off from work in a laboratory setting remote from the bridge or tunnel.

All measurements reported in this article were made during the first year of study, except for detailed pulmonary function evaluation and measurement of erythrocyte 2,3-diphosphoglycerate and methemoglobin. These evaluations were made during the second year, a difference which may be important because toll booths were equipped with individual air filtration devices during the second year.

**Description of Population.**—All non-administrative employees of the Triborough Bridge and Tunnel Authority, an organization responsible for the operation of two tunnels and seven bridges within New York City, were invited to participate in the study. Five hundred and fifty employees (70% of the total number of employees) were studied. Eighty percent of the Bridge and Tunnel Officers Union were studied, and this report is limited to these 440 men. This group is responsible for toll collection and traffic control, and is believed to have a higher exposure to automotive pollution than the other groups of employees studied. The tunnel employees work both in the tunnels and toll plaza area. The bridge employees spend their working hours in the toll plaza area.

Typical tunnel booths during the first year of this study had little forced ventilation. They are constructed somewhat below grade while large structures located around them provide little chance for adequate ventilation. Each booth is 0.9 meters wide and 1.8 meters long, with sliding doors on both sides. Tolls are collected through a half door provided with a Plexi-

glass shield that is seldom used. The toll booths at the bridges have better ventilation since the plazas are usually elevated and have no large structures adjacent to them.

Each toll booth was equipped with air filtration equipment early in the second year of study. Air was introduced into the booth from a remote source at a rate of 33.6 cu m/min following passage through high efficiency particulate filters. For this reason, studies obtained during the second year of study reflect exposure to significantly lower levels of pollution than in the initial year.

**Methods of Study.**—The on-site studies were conducted in an air conditioned van equipped with an interview area and pulmonary function equipment. Pulmonary function studies were performed with a waterless spirometer and an electronic XYY recorder. All tests were performed by a single trained technician. Standard ventilatory tests included a forced vital capacity (FVC), forced expiratory volume at one second (FEV<sub>1</sub>), maximum expiratory flow rate (MEFR), and maximum midexpiratory flow rate (MMFR). A forced expiratory maneuver was performed at least five times, and frequently more tries were needed for maximal effort. If necessary, the subjects were permitted to rest between trials. Half the trials were recorded as flow-volume curves and half as volume-time curves. A maximal effort was required for each test procedure and the best effort was selected. Lung volumes were corrected to body temperature, pressure, saturated with water (BTPS). Maximum expiratory flow rate was read as the peak flow on the flow-volume curve. Weight and standing height were measured. The Medical Research Council (MRC) short questionnaire was used to record respiratory symptoms. A smoking and work history was also taken. During the course of the study, two trained technicians administered the questionnaire. This questionnaire was employed so that results could be compared with those of other surveys using similar procedures. For this reason, the technicians were trained to conform to the British recommendations for proper administration of the questionnaire. The project administrator trained the technicians and periodically checked for accuracy and reliability of their technique.

At each of the nine facilities, the mobile van was parked for a prescribed period of time over a nine-month period. The workers reported to the van either before or after work or during a work break. The van was at each facility long enough to afford all men the opportunity to be tested. Parti-

cipation was on a voluntary basis, but full support was given by both Local 1396 of the AFL-CIO and the management of the Triborough Bridge and Tunnel Authority.

The concentration of alveolar carbon monoxide was determined in each man by analysis of the terminal 200 ml of expired air after a 15-second period of breath-holding. The sample was analyzed with a gas chromatograph equipped with a 2.4-meter molecular sieve column and a helium ionization detector system. Data have been converted to percent carboxyhemoglobin saturation by means of a standard regression equation.<sup>8</sup>

During the second year of the study, blood was analyzed by standard methods<sup>14</sup> for erythrocyte 2,3-diphosphoglycerate concentration and methemoglobin.

Chronic health effects were evaluated by routine techniques. A complete history and physical examination was obtained. Evidence of absence from work because of respiratory illness was determined from examination of official company records. Complete blood cell count, fasting blood glucose, cholesterol, triglycerides, and plasma protein levels were measured by standard techniques. Serum lead was measured by a fluorometric technique. In addition, a chest radiograph, resting ECG and Masters two-step ECG were obtained for all subjects.

During the second year of the study, a detailed pulmonary function evaluation was obtained in 179 of the subjects. Flow-volume curves were measured with a waterless spirometer and an oscillographic XY recorder. Airway resistance was measured in a body plethysmograph after the methods of DuBois et al.<sup>9</sup> Closing volumes were measured by means of a mass spectrometer with argon as a tracer gas.<sup>10</sup>

**Aerometric Studies.**—Air was continuously sampled for 38 days at two toll plazas in the Triborough Bridge and Tunnel Authority System. One sampling station was at the Triborough Bridge, the other at the Queens Midtown Tunnel. During an eight-day period, air was also continuously sampled from an observation booth within the Queens Midtown Tunnel.

The analyses performed included: (1) carbon monoxide (nondiapherous infrared analyzer), (2) total hydrocarbons (flame ionization detector), (3) total oxidants (microcoulombic sensor), (4) total nitrogen oxides and nitrogen dioxide (sequential sampler using Saltzman methods), (5) total aldehydes (sequential sampler using MBTH method), (6) acrolein (sequential sampler using 4-hexylresorcinol method), (7) lead (tape sampler and atomic absorption), (8) respirable and nonrespirable particulates and lead (two-stage Andersen

Table 1. - Pollutant Concentrations in a Toll Booth at Queens Midtown Tunnel\*

Pollutant Measured	CO, ppm	THC, ppm	TOx, ppm	NOx, ppm	NO <sub>2</sub> , ppm	ALD, ppm	ACR, ppm	COH, Units	Pb, $\mu\text{g}/\text{cu m}$	Ni, $\mu\text{g}/\text{cu m}$	Total Weight, $\mu\text{g}/\text{cu m}$
Average per 30-day period	63	7.9	0	1.38	0.07	0.05	0.003	1.7	30.9	0	
Maximum hourly reading	217	29.6	0	6.13	0.32	0.16	0.012	3.8	98.0	0	
Average particulates per 30-day period (collected over 72-hour intervals)											
Respirable									10.6		64
Nonrespirable									4.4		69
High volume									35.6		200

\*CO represents carbon monoxide; THC, total hydrocarbons; TOx, total oxides; NOx, nitrogen oxides; NO<sub>2</sub>, nitrogen dioxide; ALD, aldehyde; ACR, acrolein; COH, coefficient of haze; Pb, lead; Ni, nickel.

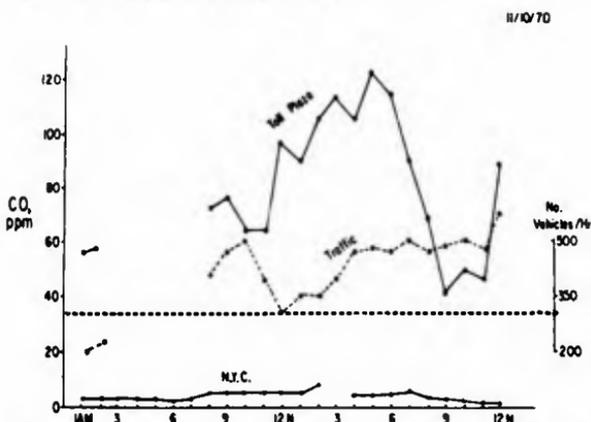


Fig. 1. - Hourly changes in carbon monoxide concentration in toll booth adjacent to Queens Midtown Tunnel. Hourly averages reported by New York City Department of Air Resources (bottom of graph) were obtained 7.6 meters above ground at 121st Street station in Manhattan. Hourly maximum of 35 ppm (dotted line) is suggested by Federal Environmental Control Agency as level to be exceeded only once each year.

dry impactor and atomic absorption spectrometry), and (9) high volume particulates, lead and nickel (high volume sampler and atomic absorption spectrometry).

## Results

**Aerometric Data.** - Thirty-day averages and maximum hourly readings at the Queens Midtown Tunnel for the measured pollutants are shown in Table 1. Carbon monoxide concentration averaged 63 ppm for the 30-day period; a maximum hourly concentration of 217 ppm was recorded. Lead concentrations averaged  $30.9 \mu\text{g}/\text{cu m}$  with a maximum hourly concentration of  $98 \mu\text{g}/\text{cu m}$ . Concentrations of total oxides of nitrogen averaged 1.38 ppm; only 0.07 ppm were nitrogen dioxide, a finding that

suggests the presence of high concentrations of nitric oxide. Concentrations of total suspended particulates, measured by high volume sampling, averaged  $200 \mu\text{g}/\text{cu m}$ ; concentrations of respirable particulates averaged  $64 \mu\text{g}/\text{cu m}$ .

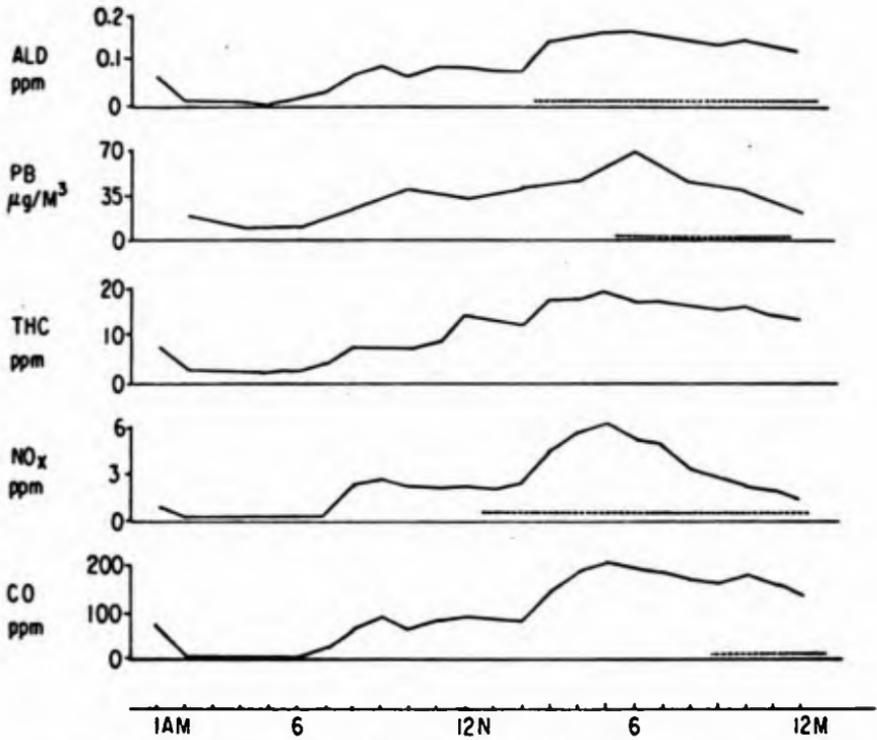
The hourly changes in carbon monoxide concentration are shown in Fig 1. Changes in vehicular traffic are closely related to rises and falls in pollutant concentrations. The concentrations are lower during the morning rush hour than the evening rush hour because the toll booth was closed during the morning hours. That carbon monoxide is a useful indicator of automotive pollution is shown in Fig 2, which compares the concentrations of carbon monoxide, oxides of nitro-

gen, total hydrocarbons, lead, and aldehydes during a 24-hour period.

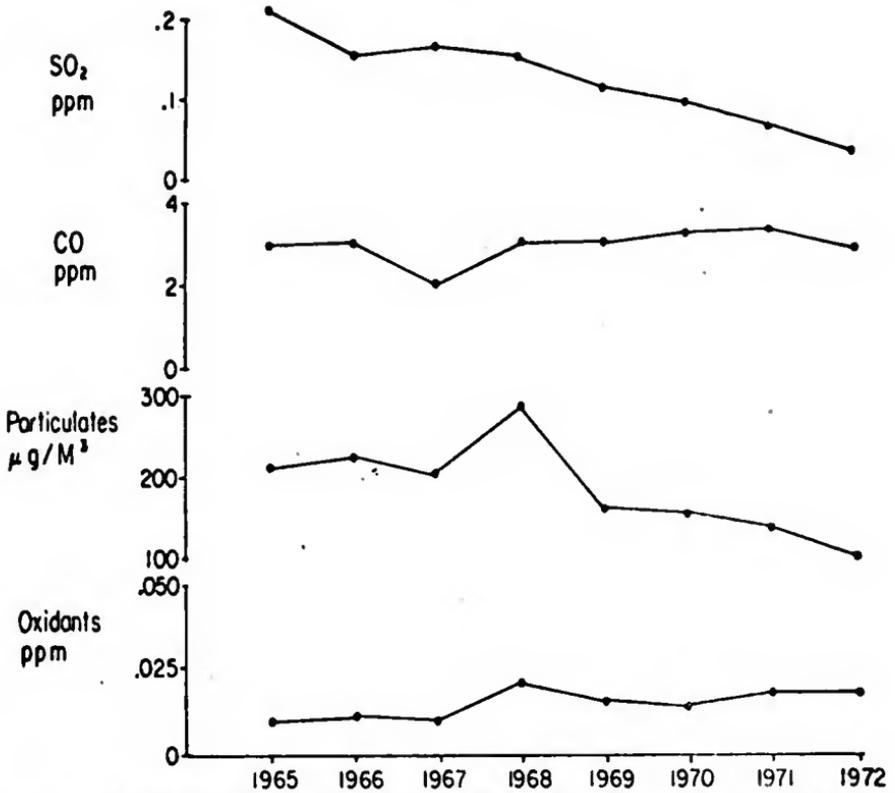
**On-Site Measurements of Blood Carboxyhemoglobin.** - Table 2 lists carboxyhemoglobin concentrations for bridge and tunnel workers. Shown for comparison are carboxyhemoglobin concentrations in a group of 619 subjects studied in Union Square in Lower Manhattan. Carboxyhemoglobin concentrations averaged  $2.93 \pm 1.36\%$ ,  $2.12 \pm 1.08\%$ , and  $1.94 \pm 0.62\%$  in nonsmoking tunnel workers, bridge workers, and Union Square subjects, respectively. Carboxyhemoglobin concentrations for the smokers in the same groups were  $5.01 \pm 2.25\%$ ,  $3.90 \pm 2.13\%$ , and  $3.84 \pm 2.06\%$ . The distribution of carboxyhemoglobin concentrations in New Yorkers is shown in Fig 3; the highest concentrations are found in the tunnel workers who smoke, the lowest concentrations in the nonsmoking subjects examined in Union Square.

**On-Site Measurements of 2,3-Diphosphoglycerate and Methemoglobin.** - Red blood cell concentrations of 2,3-diphosphoglycerate were measured during the second year of study after air filtration equipment had been installed. The concentration of this glycolytic intermediate averaged  $14.50 \pm 1.46 \mu\text{mol}/100 \text{ gm}$  in 39 tunnel workers and  $14.08 \pm 2.06 \mu\text{mol}/100 \text{ gm}$  in 25 bridge workers. Twelve percent of the group had values greater than two standard deviations from the mean of  $13.2 \pm 1.73 \mu\text{mol}/100 \text{ gm}$  measured in non-exposed subjects (Fig 4).

Methemoglobin averaged  $0.43 \pm 0.13 \text{ gm}/100 \text{ ml}$  in the tunnel workers. This level was significantly higher than the level of  $0.34 \pm 0.09$

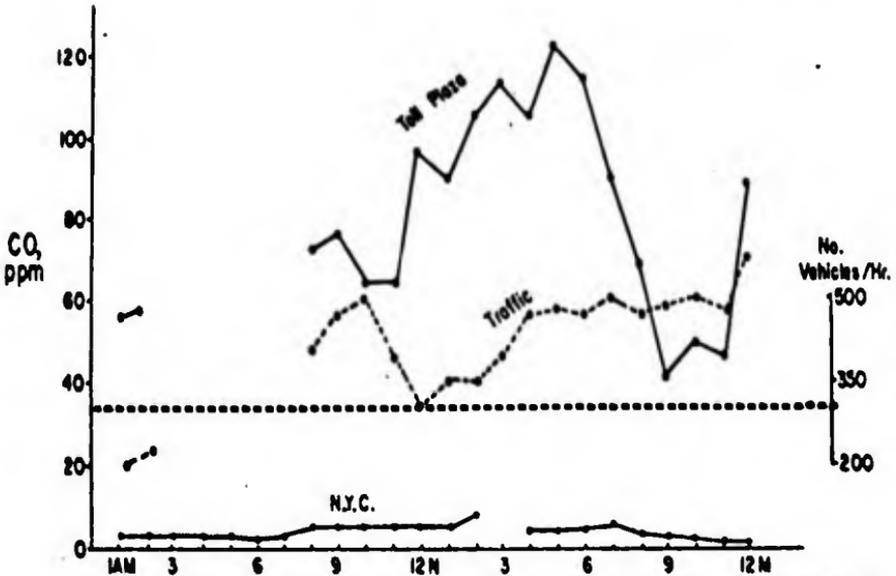


- Relationships among aldehydes (ALD), lead (PB), total hydrocarbons (THC), oxides of nitrogen ( $\text{NO}_x$ ), and carbon monoxide (CO) in monitoring station in Queens Midtown Tunnel toll booth. Dotted lines are 24-hour air quality limits suggested for each pollutant.



— Annual New York City means for sulfur dioxide (SO<sub>2</sub>), carbon monoxide (CO), particulates, and oxidants from 1965 to 1972.

11/10/70



— Hourly changes in carbon monoxide concentration in toll booth adjacent to Queens Midtown Tunnel. Hourly averages reported by New York City Department of Air Resources (bottom of graph) were obtained 7.6 meters above ground at 121st Street station in Manhattan. Hourly maximum of 35 ppm (dotted line) is suggested by Federal Environmental Control Agency as level to be exceeded only once each year.

**Mr. PREYER.** The committee will adjourn until 10 o'clock tomorrow morning.

[Whereupon, at 12:10 p.m., the committee adjourned, to reconvene at 10 a.m., Thursday, September 18, 1978.]



## CLEAN AIR ACT OVERSIGHT—1973

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THURSDAY, SEPTEMBER 13, 1973

HOUSE OF REPRESENTATIVES,  
SUBCOMMITTEE ON PUBLIC HEALTH AND ENVIRONMENT,  
COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE,  
*Washington, D.C.*

The subcommittee met at 10 a.m., pursuant to notice, in room 2123, Rayburn House Office Building, Hon. Paul G. Rogers, chairman, presiding.

Mr. ROGERS. The subcommittee will come to order, please.

We are continuing our hearings on the oversight of the Clean Air Act.

We are very pleased to have as the first witness this morning Mr. Herbert L. Misch, vice president, environmental and safety engineering, Ford Motor Co.

We welcome you back to the committee again. Your testimony was helpful in the writing of the law. Now I think your testimony will be most helpful in giving us ideas how the law is working, what is happening, and Ford's reaction to the law.

We welcome you to the committee, and we will be pleased to receive your testimony.

### **STATEMENT OF HERBERT L. MISCH, VICE PRESIDENT, ENVIRONMENTAL AND SAFETY ENGINEERING, FORD MOTOR CO.**

Mr. MISCH. Thank you, Mr. Chairman, and members of the committee.

My name is Herbert L. Misch. I am vice president, environmental and safety engineering, Ford Motor Co. I appreciate this opportunity to discuss the Clean Air Amendments of 1970 and to suggest some important revisions for your consideration.

When we testified before Congress in the spring of 1970, the amendments then being considered did not include specific vehicle emission requirements. When the provisions requiring 90-percent reductions in vehicle emissions were incorporated in the amendments, we objected but had no opportunity to state our case publicly before committees of Congress.

As you know, the 1970 amendments passed both Houses of Congress by nearly unanimous votes and were signed into law on December 31, 1970. There are many ways to demonstrate the scope and intensity of Ford's effort since 1970 to meet the requirements of the law. Ford's total emissions-related expenditures have grown to a level of \$340 million this year and we have 6,500 Ford people working full time at the task. In March of this year, EPA determined from data sub-

mitted to them that Ford was spending more on vehicle emissions per car sold than any other American manufacturer. EPA also found that the percentage of our engineering budget dedicated to emissions research and development was greater than that of any of our domestic competitors. This is not the complete story, but it does provide some measure of our effort to meet the vehicle emission standards established by law for 1975 and 1976 models.

In spite of these efforts, we did not quite succeed in developing technology that would enable us to meet the statutory 1975 standards. We did make a lot of progress. For example, we will be able to build 1975 cars for California that will reduce hydrocarbon emissions by 94 percent from uncontrolled levels. But the law calls for 97 percent control on all 1975 cars, and that we can't do.

It has been charged by some critics that the auto manufacturers failed to meet the statutory requirements because they tried to clean up the conventional internal combustion engine instead of adopting newer and better approaches. The fact of the matter is that the only conceivable way to meet the requirements on schedule was to use the short time allowed us by the law to try to minimize emissions from the existing internal combustion engine.

Although the 1975 requirements were enacted in 1970, we had less than 3 years to get ready—from December 31, 1970, until this month, when we will start certification tests for 1975 models. Even with an engine that was familiar to us, that looked like an almost impossible deadline. It would have been totally impossible to perfect a new engine, package it in our cars, and convert our manufacturing facilities in time for 1975 model production.

We were also forced to conclude that we had very little chance of meeting the 1976 standards for oxides of nitrogen. The possibility of developing a method of achieving the 1976  $\text{NO}_x$  standard on schedule seemed, in itself, to be very remote. On top of this, we could see no way to meet all three standards for 1976 because the known methods of reducing HC and CO emissions lead to higher  $\text{NO}_x$  emissions, and vice versa.

Even though we knew we would have to rely on modifications of the existing internal combustion engine for some years to come, we nevertheless intensified our efforts on other power sources that might have some potential. These included our PROCOCO stratified-charge engine, prechamber engines, the gas turbine, the diesel, the Rankine and the Stirling engine. Some of these like diesel and prechamber, had the ability or the potential ability to meet the 1975 requirements but offered little hope of also meeting the 1976 requirements. We could not, of course, consider making the massive effort and investment necessary to convert to a different power source if the new approach would have to be abandoned after a single year.

The only new approaches that offered some hope of meeting all three standards—such as the Stirling—were at such an early stage of development that they could not possibly be considered as candidates for mass production during the 1970's.

Late last year, after almost 2 years of intensive efforts to meet the demands of the Clean Air Amendments, Ford's management faced a very serious dilemma. We knew that we would be unable to meet either the 1975 or the 1976 requirements. Even if EPA were eventually

to exercise its full authority to suspend each set of requirements for 1 year and to establish feasible interim standards, we still saw no way to meet the statutory requirements in 1977. But the time had come when we had to commit massive funds to provide production capability for 1975 emission control systems.

At its meeting in November 1972, the Ford board of directors reviewed program expenditures of approximately \$400 million to prepare for production of the best emission control system we had developed for the 1975 model year—even though that system failed to meet the requirements of the law.

Because of the enormous legal and financial risks involved in this unavoidable decision, Ford's management also decided to tell Ford's side of the story to the public.

Since that time we have conducted a grassroots effort to explain our position to community leaders in many urban areas in the United States. Many of these presentations were made to your constituents. We have tried to be constructive and factual in our statements. We have not criticized the Clean Air Act—in fact, we have praised its major accomplishments. But we have tried to stimulate support for a reconsideration of the specific vehicle emission standards in the law in the light of the most recent medical and scientific research.

If you wish, I will be glad to supply for the record a copy of the statement I made in St. Louis. It is typical of many others made by different members of our management throughout the country.

Mr. ROGERS. Without objection, that will be helpful.

It will be received for the record. [See p. 338.]

Mr. MISCHE. Thank you.

Apparently we were not alone in our belief that a reevaluation was needed. The House Appropriations Committee, in its 1973 report on the EPA budget, called for studies under contract with the National Academy of Sciences which would include "the degree to which environmental regulations have contributed or will contribute to the current and the long-term energy crises; the effect of emission control standards on the cost and performance of automobiles, including the cost/benefit implications of present standards."

As you know, Senate Resolution 135, adopted on August 2, 1973, provides for a thorough review by the National Academy of Sciences of both the health effects of the three automotive pollutants and cost-benefit considerations. Under the arrangements worked out with NAS, the final report on the levels of emission reduction required for health reasons is to be completed by July 1974, and the final report on cost-benefit considerations by August 1974.

Ford Motor Co. has been calling for this kind of objective study because without it no one is in a position to say what levels of control are really needed. We trust that the NAS study not only will reassess fully the ambient air quality required to protect public health, but will also review thoroughly the question of how permissible atmospheric concentrations should translate into specific automotive pollution standards within a realistic time frame.

While NAS will present certain interim reports, it is important to emphasize that Congress will have no definitive recommendations from the NAS until completion of the full study next summer. The president of the National Academy, Dr. Philip Handler, made clear the lim-

itations of what could be developed in the early phases of the study in his letter of July 18, 1973, to Senator Jennings Randolph, as follows:

There is considerable doubt that useful conclusions concerning the social and economic impact of implementation of the Clean Air Amendments of 1970 could be reached in the 90-day study. It is probable that, at most, within that time, such an effort could only identify and clarify relevant questions which require answers, establish a schedule of priorities for assessment, and assemble the more readily available pertinent information.

Since the Academy's final report will not be issued until next August, Congress may not be able to study the findings and adopt revised emission standards based on the latest information on need, benefits, and costs until late 1974 or early 1975. By that time, emission certification testing of 1976 models will have to be well along. Consequently, any revisions of the standards based on NAS findings presumably could not become effective prior to the 1977 model year at the earliest.

Meanwhile, if Congress takes no further action, the standards presently scheduled for 1975 and 1976 will go into effect. For 1975, as you know, EPA has established interim standards for HC and CO and the present NO<sub>x</sub> standard will be carried over. For 1976, the statutory HC and CO standards will be enforced, along with an interim NO<sub>x</sub> standard established by EPA.

In our judgment, these requirements will turn out to be, at least in some respect, more stringent than necessary and not cost-effective. In any event, the 1976 requirements will probably prove to be beyond the technical capabilities of the manufacturers.

We should like to suggest that it would be appropriate, in these circumstances, for Congress to consider freezing emission standards through the 1976 model year either at the 1974 levels or at the interim 1975 levels.

Such a freeze could be instituted without significantly delaying progress toward clean air.

In the first place, even with a freeze, the manufacturers would still have the strongest of incentives to continue their efforts to develop more effective emission control technology. At Ford, for example, we could not know in advance what levels of control NAS might recommend and Congress might adopt for 1977 and beyond. But we do know that Congress is determined to require whatever levels are needed to protect health.

We also know that consumers will favor control systems that offer the lowest cost, the best driveability, and the best fuel economy. We would, therefore, continue to have powerful business incentives to develop control systems that meet all of these demands, hopefully without the use of costly catalysts.

In the second place, even with a brief freeze of emission standards, the air will continue to get cleaner. California authorities have measured and reported generally cleaner air year by year since emission controls were introduced. EPA has published data showing that emissions from automotive sources have decreased and will continue to decrease as older, higher polluting vehicles are replaced by the much cleaner vehicles now being produced. Our own calculations show that by mid-1974, total HC emissions will be down by 37.2 percent and CO will be down by 30.4 percent compared to mid-1970, when the Clean Air Act Amendments were being considered.

Because of the steps taken to control HC and CO, only NO<sub>x</sub> has increased somewhat during this period, but it is now also starting down because of the introduction of NO<sub>x</sub> controls on 1973 models. Therefore, a delay of a year or two in further tightening of the standards would not mean a year or two of no progress toward cleaner air.

When the 1970 Clean Air Amendments were adopted, there was considerable discussion about whether or not they represented regulatory "overkill" with respect to the vehicle emission standards which mandated, for example, 97 percent reduction of hydrocarbons from uncontrolled levels. At that time, the question of whether or not Congress had gone too far was not as important as it is today. Clearly, Congress wanted to establish the toughest kinds of targets so as to insure that automobile manufacturers would make maximum efforts to clean up their new vehicles. If the targets turned out to be more stringent than necessary, or impossible to reach, there was time to reconsider.

Today, as that reconsideration is being launched, the national energy crisis provides a new and extremely important reason for avoiding emission control overkill. A Ford scientist presented a technical paper to the Society of Automotive Engineers earlier this week which reported that 1973 emission controls, including the use of 91 octane fuel and lowered compression ratios, have already resulted in a loss of more than 13 percent in fuel economy.

It is clear that any further tightening of the standards could increase that loss. If vehicle emission standards need to be more stringent, then we must face that issue and resolve the energy crisis in other ways. It is imperative, however, not to proceed with an emission control "overkill" that would not be cost effective, would further compound the Nation's energy problems, and would go beyond reasonable public health requirements.

There is another important reason, in our judgment, why Congress should act quickly to freeze emission standards while the NAS study proceeds. We are now engaged in the final stages of trying to develop 1976 model emission control systems. Our present estimate is that the best we can do will not meet the presently scheduled requirements for 1976.

If we do fail in this effort, Congress will have to face the choice, in the near future, of modifying the presently scheduled 1976 requirements, or closing down a substantial portion of the American automobile industry. We think that choice should be faced now, to reduce the waste of money and engineering resources inherent in the futile pursuit of unreachable goals.

If the choice is delayed much longer, there is a substantial risk that it will be impossible to complete certification testing of 1976 models in time for the beginning of 1976 model production. This, in turn, could make it necessary to close some plants and idle their employees until the tests are completed. These risks can be avoided by freezing emission standards until Congress has had a chance to review and act upon the findings of the NAS study.

Whether the freeze should begin with 1975 models, at 1974 levels, or with 1976 models, at the interim 1975 levels, is a question that we think Congress should consider very carefully.

Keeping the 1974 standards for 2 more years would have many advantages. It would avoid the commitment, for 1975, to the use of expensive and unproven catalytic converters in a substantial fraction of vehicles produced for all States but California. Catalysts could still be required in California if that State pursues its right under the Clean Air Act to establish technically feasible standards more stringent than the national standards with EPA approval.

Avoiding the use of catalysts in the other 49 States could save many customers at least \$100 in new car cost. There would also be substantial savings in operating costs. These customers would not need to use unleaded fuel, which means that they could save about 2 cents per gallon, and more gasoline could be obtained from each barrel of crude oil.

The potential durability problems of catalysts in customer use could be avoided, at least temporarily, in the 49 States other than California, pending reconsideration of the need for standards that would require catalyst usage.

Finally, as we have explained on previous occasions, it will be impossible to take advantage of California experience with catalysts in developing improved catalyst systems for the rest of the Nation, unless catalysts are used for at least 2 years in California before they are required elsewhere.

Clearly, we think that carryover of the 1974 standards through the 1976 model year would have many advantages. On the other hand, we can meet the very stringent interim standards set by EPA for the 1975 model year if Congress considers the gains to be worth the costs and risks.

Ford believes the choice should be made by Congress after carefully balancing environmental, energy, and consumer interests. In our view, because the air is already getting cleaner and will continue to get cleaner regardless of the specific standards implemented for 1975 and 1976, the Nation clearly does not face a short-term environmental health crisis. A temporary suspension of any further automotive emission reduction may well be an appropriate redirection of national priorities pending completion of the NAS study. We urge only that the Congress carefully weigh the issue from the standpoint of overall national interest.

There is one further point that I should also discuss. On May 28, 1978, Mr. Lee Iacocca, president of Ford Motor Co., testified before the Senate Subcommittee on Air and Water Pollution regarding alternatives to the conventional piston engine. He emphasized Ford's concern over a law which forces us to demonstrate a "good faith effort" to meet an NO<sub>x</sub> standard which EPA has said is not needed and which is so low as to rule out potential alternate engine concepts. He asked for congressional action before the end of this year to establish an NO<sub>x</sub> standard of 2 grams per mile for the 1977 model year and beyond, as opposed to the 0.4 gram per mile standard now in the law.

At that time, Mr. Iacocca said:

We will make a commitment right now that if this standard is changed by the end of the year and if we meet our development goals, we will put an alternate engine into production as soon as possible—hopefully for the 1977 model year. This will be a priority effort, and we will start with one engine line with capacity of about 500,000 engines a year.

In support of that commitment, we have entered a contract with Honda that allows us access to its "CVCC" engine developments. Further, we are continuing work on our own stratified charge concept (which we call Proco, or programed combustion), and on other promising concepts. The problem is that most of these promising alternate engine approaches cannot be pursued intelligently until we have a firm, long-range target for NO<sub>x</sub> control.

For example, Ford cannot set a target of two grams per mile for NO<sub>x</sub> and concentrate major resources on developing an engine to meet that target when the law contains a standard of 0.4 gram per mile and requires all "good faith efforts" by an automobile manufacturer to meet that level.

Thus, we would also suggest to this committee, that without waiting for the results of NAS study, immediate action should be taken, based upon the evidence already developed by EPA and others, to correct the oxides of nitrogen vehicle emission standard. NO<sub>x</sub> is without question the most difficult vehicle pollutant to control because its control is essentially based on inefficient combustion. The more efficient a car's combustion, the more oxides of nitrogen it creates.

Because of the energy crisis, it is especially important that Congress establish a realistic, long-range NO<sub>x</sub> target. There seems to be nearly universal agreement that the statutory requirement of 0.4 gram per mile for NO<sub>x</sub> is not valid. I understand that EPA Deputy Administrator Quarles testified before this subcommittee earlier this week that EPA did not believe that an NO<sub>x</sub> standard below 2 grams per mile would be feasible at the present time.

Mr. Chairman, I have covered a great many subjects today and I should like to conclude by summarizing Ford Motor Co.'s position on the Clean Air Act.

There is no doubt that the act has already produced and will continue to produce improved air quality for the public. We believe the Act will be strengthened by the decision to ask the National Academy of Sciences to reevaluate three basic questions. First, are the present ambient air quality goals the correct ones to protect the public health? Second, what vehicle emission control levels are required to achieve appropriate air quality within a realistic time frame? Finally, how much will these controls cost the Nation, in terms of both dollars and fuel consumption?

Until the results of the NAS study can be evaluated and acted upon by Congress, we believe the public interest would be served by congressional action this year to freeze emission standards at either the 1974 level or the 1975 interim level established by EPA.

Such a freeze would have no effect on Ford's commitment to devote maximum effort to the development of improved emission control technology, and no perceptible effect on the Nation's progress toward cleaner air.

We also urge that Congress take action before it adjourns this year to review the long-term level of vehicle NO<sub>x</sub> control. We do not presume to know what maximum level of NO<sub>x</sub> in the atmosphere is necessary to protect health. But we do know that a vehicle emission standard for NO<sub>x</sub> of approximately 2 grams per mile or higher is necessary to enable us and others to direct our development efforts toward realistic engineering goals.

For us, these goals are to continue to improve our present engines and develop an alternate engine that will have good fuel economy and will meet stringent emission standards without the use of catalytic converters.

Thank you.

[Mr. Misch's St. Louis speech, referred to, follows:]

TEXT OF REMARKS BY HERBERT L. MISCH, VICE PRESIDENT, ENVIRONMENTAL AND SAFETY ENGINEERING, FORD MOTOR CO., BEFORE A LUNCHEON MEETING OF CIVIC AND BUSINESS LEADERS, ST. LOUIS, MO., APRIL 23, 1973

You may well wonder why we came to St. Louis today in view of the recent front-page news that EPA Administrator William Ruckelshaus has granted the auto companies' request for a one-year suspension of the 1975 Clean Air standards.

Under the law, Mr. Ruckelshaus was empowered to grant a one-year suspension of the standards. He also was authorized to set interim levels to take the place of those fixed by law. He has now done both of these things.

Mr. Ruckelshaus obviously agreed with us that we simply had to have more time, because the alternative could have been to shut down much if not all of the U.S. auto industry. But in granting the one-year suspension we requested, he has set some *very tough* interim standards for control of automotive emissions. And frankly, we don't know whether we can meet those new 1975 standards or not. We probably won't know for several weeks. We need to see the fine print in the test procedures before we can make a further judgment.

In any event, the auto industry has been granted 12 more months to meet the 1975 standards, which now become effective with 1976-model production. The result, you may conclude, is that the heat is off. That we can relax. You might also ask, "What more do you guys from Detroit want, anyway?"

Well, that's a fair question. And I'm going to take the next 25 minutes to try to answer it.

It is important for you to understand right off that the basic problem with the Federal emissions-control program has not been changed by the Ruckelshaus decision. The real issue is the Clean Air Act itself. The standards which Mr. Ruckelshaus has deferred for one year remain in the law. The serious question as to the validity of those standards also remains. Only Congress can correct what's wrong with the law. Beyond granting the one-year suspension and setting interim standards for that year, the Environmental Protection Agency has absolutely no authority to change the standards or the timetable in the law.

Therefore, the reason we have come to St. Louis today is to discuss the urgent need for Congress—in the public interest—to re-examine the emissions-control program in the light of new technical and scientific developments and data.

Mr. Ruckelshaus himself recently called upon the Congress to re-examine the law. The National Academy of Sciences in February also recommended that Congress take a new look at the law.

So, it is not just Detroit that questions the validity of the control levels and timetable in the law.

At Ford, our engineers will use the 12 months' added time to go all-out to develop and perfect the best possible emissions-control systems. But we think there should be equal awareness of the need for Congress to use this 12 months to re-appraise the flaws in the law and correct them.

On the surface, this may appear to be a squabble between the government and the auto industry. But there is someone else who also has a big stake in this whole matter. And that's you.

We believe the automotive-emissions standards set in the law are unrealistic, unnecessarily costly to car buyers and are not justified by need.

We think compliance with the statutory standards, as now required, could turn out to be a bad bargain for you—the American public.

Before we go any further, let me tell you what comes out of an automobile's tail pipe. There are three engine emissions subject to control—hydrocarbons, carbon monoxide and oxides of nitrogen (which we call NO<sub>x</sub>). Hydrocarbons and carbon monoxide are produced by incomplete burning of the gasoline. NO<sub>x</sub>, on the other hand, is produced by the high temperature combination of oxygen and nitrogen. It is the product of complete, efficient combustion. Unfortunately, what you do in an engine to reduce HC and CO emissions increases NO<sub>x</sub> emissions and vice versa.

You may not realize it, but all three auto pollutants are now on the decline. America's air is getting cleaner. And it will keep on getting cleaner—month by month—as new cars with emissions controls replace older cars without them.

So there's no question that automotive emissions are rapidly being eliminated as a significant factor in air pollution—a goal we all want to achieve. Yet, here we are, challenging the law that has the very same objective.

Well, let me tell you why—but first let me sketch in some quick background. Congress first wrote automotive-emissions controls into the Clean Air Act in 1965. We did not oppose that bill. It was an important piece of legislation. Congress correctly realized that only through Federal action could an effective nationwide campaign be waged against air pollution. The law has produced impressive results.

The 1965 law gave the Environmental Protection Agency's predecessor (HEW) discretion to set the emissions levels it considered necessary and feasible. And, virtually each year the auto companies have met progressively stricter standards set by the EPA. The 1973 models—and most people seem surprised to know this—produce, on the average, 85 per cent less hydrocarbons, 69 per cent less carbon monoxide and 48 per cent less oxides of nitrogen than uncontrolled cars.

The problem we face today really started when Congress—without benefit of meaningful public hearings, incidentally—amended the Clean Air Act in 1970. We strongly opposed some of those amendments, because they took away from EPA its discretionary authority to set controls, and instead required the administrator to establish emissions levels specified in the law itself, with rigid time-tables for their achievement. In effect, the emissions levels that the administration had originally targeted for 1980 were written into the law for 1975.

As a result of the Clean Air Amendments of 1970, hydrocarbons must be reduced by 97 per cent, carbon monoxide by 96 per cent, and  $\text{NO}_x$  by 93 per cent compared to uncontrolled cars.

To give you an idea of just how stringent the law's requirements are, more hydrocarbons will escape into the air through evaporation when you have your gas tank filled once at a service station, than your car would emit while using up the whole tankful on the road—under the statutory standards!

If that comparison surprises you, consider that for every gallon of oil-base paint you put on your house with a brush, you add as many pounds of hydrocarbons to the atmosphere as you would by driving your car 8,000 miles—under the statutory standards!

Do you have a fireplace? When you burn one seven-inch-thick log in the fireplace, you contribute as much CO to the atmosphere as you would by driving your car all day—under the statutory standards!

It's true, of course, that heavy concentrations of cars in urban areas create a unique problem, and that's why reducing automotive emissions is essential. But our concern is that the standards in the law could well constitute overkill.

We started working on emissions back in the 1950's, when the problem first came into focus in California. With the 20-20 vision that only hindsight affords, I think it fair to say that we now wish we had done even more than we did—and sooner. But the effort was sharply stepped up over the years, and we really have been going all-out on the problem. We now have more than 5,000 technical people working on emissions. In 1973 alone, Ford has budgeted \$350 million on emissions-related expenditures.

We have considered every emission-control system that we thought might work and could be available for the 1975 models. Frankly, timing limitations precluded consideration of completely new engine concepts for 1975. It is our present judgment—as well as EPA's—that the best approach is the addition of a catalytic converter system to a conventional engine. The catalytic converter looks something like a small stainless-steel muffler. It has a ceramic core that is coated with platinum. The platinum metal acts as a catalyst to stimulate a chemical reaction that converts carbon monoxide and hydrocarbons into harmless carbon dioxide and water vapor.

Development work has progressed well, but we still have a number of problems with catalysts. Until solutions to these problems were found, we were reluctant to schedule this system for nationwide application. Recognizing these problems, Mr. Ruckelshaus adopted a phase-in policy on catalytic converters, requiring them to be installed first on 1975 models in California. However, his tough interim standards may force us to use catalysts on cars outside of California as well.

This brings us to something everyone naturally asks—what about a whole new kind of engine? I assure you we have been conducting an aggressive search for

alternate power sources that might meet the emissions standards and still have satisfactory operating characteristics. Multi-million-dollar research and development programs are well along on the Wankel and the stratified-charge and gas turbine engines, as well as on both Rankine cycle and Stirling cycle external-combustion engines. Some of these—particularly the stratified-charge, the turbine and the Stirling cycle engines—appear to offer real promise for the future. But there simply is no way these can be developed, tooled and put into large-scale production before 1980.

There has been a lot of publicity lately about three foreign cars which, according to EPA, can meet the statutory standards. The obvious question is: Why can't U.S. manufacturers do the same?

The three cars involved are the Honda stratified-charge, the Mazda rotary, and the small Mercedes diesel. Despite what you may have heard, none of these vehicles actually has been certified for 1975. The EPA and the manufacturers have stated that they expect the cars will be able to meet the 1975 standards. But let me make just a few comments about these engine designs.

Take the diesel. We don't think it's an acceptable solution. It smokes, it smells, it is hard to start in cold weather, it has fuel-availability problems and it has poor acceleration characteristics. Mercedes sells about 6,000 diesel-equipped passenger cars per year in this country, and has said it doesn't believe Americans will buy many more than that.

The Honda stratified-charge engine may well represent a promising power plant for the future. This engine is very small, powering a car substantially smaller than the Pinto. Ford has been working with the U.S. Army on a stratified-charge engine for a number of years. We have prototypes running and they look good on both emissions and fuel economy. However, our designs are not yet ready for production. Honda, which doesn't share our problem of having to certify all of its engines for a full line of cars and trucks, has concentrated its total emissions effort on this one design.

Now, with regard to the Mazda rotary engine—this design presents some challenging problems. One of these problems is its present cost to consumers—Mazda charges several hundred dollars more for the rotary-equipped model compared to a piston-engine model. It also has a going-in handicap of a 30 per cent penalty in fuel economy.

But, for the sake of argument, let's assume that a few specialized vehicles—like the Honda, Mazda rotary or Mercedes diesel—could meet the statutory standards. As Mr. Ruckelshaus recognized, this was not a satisfactory solution to the need for 12 million cars and trucks of all sizes to meet the market demand for 1975. Also, the machine tool industry has reported to the EPA that it would take 12 years to retool all the U.S. engine manufacturing capacity for a new-concept engine. The idea that this could be done in two years because foreign manufacturers can produce a few thousand new-concept engines, is unrealistic.

Now to get back to the main point . . .

Mr. Ruckelshaus' decision dealt strictly with the question of technical capacity to meet the standards. He wasn't empowered to decide whether the standards in the law make sense—or to recognize new technical information and data that have become available since 1970, even though this information suggests that Congress went overboard in the emissions levels established in the 1970 Clean Air Amendments. Here are some examples:

On April 10, Mr. Ruckelshaus told a Congressional subcommittee that NO<sub>x</sub> levels for 1976 should be eased because major cutbacks are not necessary in most areas.

Other studies suggest that the threat of carbon monoxide to human health may not be as serious as was thought back in 1970.

Erroneous assumptions as to vehicle population and mileage projections in urban areas substantially overstated the prospective contribution of automobiles to air pollution.

These are some of the important reasons we think Congress should take another look at the provisions of the Clean Air Act.

The important thing to remember is that as tough as the interim standards are, the original even-tighter standards they replace for one year are still on the books, and it literally will take an act of Congress to modify them.

Let me depart from automotive emissions for a moment to mention another aspect of the 1970 Clean Air Act. As a part of that law, the EPA established ambient air quality standards that must be met in all major cities in the country by July, 1975. These standards establish maximum allowable atmospheric concentrations of six specific pollutants from all stationary and mobile sources.

The allowable concentrations were set at levels believed at that time to be necessary to protect public health.

However, recently developed medical data suggest that these standards may be overly stringent. Admittedly, there was little information available in 1970 concerning the effect of air pollution on public health. Even today, few people realize that man-made pollution—from all sources—contributes only a little over 10 percent of all the HC/CO/NO<sub>x</sub> pollutants in the atmosphere. Nature produces the rest.

To give you an idea of how tough the ambient air standards are, the standard for carbon monoxide would have shut down Williamsburg in George Washington's day because of all the wood they burned. And to meet the 1975 standards for hydrocarbons in Gatlinburg, Tennessee, would require cutting down all the pine trees in the Smoky Mountains.

The stringency of the air-quality standards is further illustrated by the fact that at least 85 cities have indicated they will have to limit traffic flow—perhaps by gasoline rationing—to even hope to meet the ambient air standards. In Los Angeles, some guesses are that all cars would have to be eliminated, and even the EPA has acknowledged that more than an 80 percent reduction in car use—with gas rationing—would be required in the Los Angeles Basin. Can you imagine Los Angeles—or St. Louis—getting by on 20 percent of its normal gasoline allotment?

We seriously question whether the ambient air quality standards need to be that stringent to protect the health of the nation, and this is another part of the 1970 Clean Air Amendments that needs re-examination.

Ford Motor Company certainly is not suggesting a stand-pat policy. Major Cities in particular have an air pollution problem, and the automobile is a major part of it. Continued progress is required, and we believe that with time automobile emissions can be eliminated as a major source of air pollution without unreasonable cost to the consumer.

Months ago, we proposed our own set of interim standards which were substantially tighter than present levels. These are now superseded by the interim standards EPA has set. Ford also proposed use of catalyst systems in California first and nationwide later, if the systems proved out in California. This, of course, is akin to the plan EPA has adopted.

The one thing I haven't gone into much is what automotive emission controls may cost the consumer in the next few years. Controls on our 1973 models cost you, the buyer, about \$80—and we think that's a good buy.

Let me remind you what your \$80 buys. Hydrocarbon emissions, compared with an uncontrolled car, are down, on the average, by 85 percent, carbon monoxide by 69 percent and oxides of nitrogen by 48 percent.

But further reductions are going to cost more money—whether controls go to the unnecessarily tough levels prescribed by the Clean Air Act or to the extremely stringent interim levels EPA has set for the suspension year. For example, we think a control system in which we would use catalytic converters to try to meet the standards in the law on hydrocarbons and carbon monoxide will cost an additional \$300. Now, I'm not proposing that the standards be eased just because car prices could go up by \$300. We charge more than that for an air conditioner!

The present law calls for a 98 per cent cut in NO<sub>x</sub> emissions in 1976—compared to a 48 per cent reduction now. No one really knows how to meet the 1976 NO<sub>x</sub> standard or, for that matter, what it will cost. But if it includes a second catalyst, as we think it will, it's not going to be cheap.

But the big thing to consider in trying to control NO<sub>x</sub> down to 0.4 grams per mile is the fuel penalty. It looks like this could cause another 10-20 per cent increase in gasoline consumption. And that would be in addition to today's fuel economy penalty—which is in the area of 10-15 per cent worse than an uncontrolled car.

With cost and gas mileage implications like that, we think it just plain makes good sense to be extra certain the standards in the law are right. The fact is, no one is sure they are right. And, as we have said, there are pretty good indications they are wrong.

If it turns out that it actually is necessary to raise car prices by \$300 or more and to take additional severe fuel penalties to protect the nation's health . . . then, of course, that's what we ought to do. But let's first find out.

What I am saying is that we as manufacturers—and you as buyers—should urge the government to come to a well-reasoned, emotion-free decision as to exactly what degree of automotive-emissions control really is necessary to protect

the nation's health. Based on the new technical information that has become available since 1970, we think the levels Congress has set are now unrealistic. We don't know what the optimum levels should be, but we're fairly certain that they would be less than the present law calls for.

So we make just one recommendation—that Congress order a thorough study of the emissions standards and timetable in the law by a component and objective organization. The single objective would be either to confirm the need for the standards now in the law, or to change them. We hope that Congress will move promptly.

As I've said, this is not just a request from Detroit. Both Mr. Ruckelshaus and the National Academy of Sciences have called for a Congressional review of the standards, also.

It is going to take a real show of support from all over the country to get Congress to do it.

We at Ford are not trying to put a dollar sign on clean air. All we are asking—and we hope you will ask it, too—is that a reasonable balance be struck between further emissions reductions and the cost of achieving these reductions.

If you think we've made a good case today—or if I have done no more than raise doubts in your mind—I hope you will ask just one thing of your U.S. senators and representatives—that they support a prompt and objective re-examination of the law.

Mr. ROGERS. Thank you very much for an excellent statement and for your thinking on the best way to bring about continued progress.

Mr. Satterfield.

Mr. SATTERFIELD. Thank you, Mr. Chairman.

Mr. ROGERS. I might say, if we can, on this first go-around keep to your most important questions, if possible, because we will have to go into a full committee meeting at 11, as I am sure the members will recall.

Mr. SATTERFIELD. One of the things that bothers me a little bit is the apparent decision which has been made in some quarters to proceed with the employment of catalytic devices on automobiles in an effort to meet the standards that have been set.

I was interested to note in two places in your statement on page 8 and page 10, you referred to these catalytic devices as being costly and unproven.

Mr. MISCH. Yes, sir.

Mr. SATTERFIELD. I wonder if you could expand on that just briefly.

Mr. MISCH. We chose the catalyst because of the time constraints of the law and the need to pursue those systems that had shown the greatest promise and had shown the greatest ability to meet the lowest possible emission levels even though they didn't meet the statutory requirements.

When we realized that we couldn't meet those requirements for 1975, we applied for suspension of the 1975 standards which, as you probably know, was denied. We applied through the courts and on remand new hearings were held and, as a result of the material given there, a suspension was granted.

Now, the material basically was this: We in Ford Motor Co. suggested that there was no experience with catalytic systems in the hands of the public and since it was obvious our best good faith effort was the catalyst system we should have an opportunity to get experience in the field on a partial basis.

For that reason, we proposed a two-tier system: One for California and one for the other 49 States, thinking that the California problem was the most acute and severe from the timing standpoint and, second,

because it provided almost all the geographical and atmospheric implications of a trial of such a system.

So, we are in the same position today.

We have added it to a 450-car fleet in California and we are following it very carefully and trying to gain what experience we can, but we have to say they are unproven although we are finding problems and finding solutions to those problems.

Our greatest fears are the fears of the unknown, these things we have not run into, because so many of the problems that develop cause customers to do things to their vehicles.

Mr. SATTERFIELD. Certainly the application of this act is confined only to the manufacturers' level and once an automobile, with whatever device or whatever has been done to its engine to reduce its pollution, is delivered into the hands of the owner-operator, we have no further means of control or check on it.

I think you said that we might get a pretty good reading with the experience in California. Yet, I have a degree of doubt of how valid that reading is going to be in terms of whether or not we have the capability to determine the results of these devices in the hands of the operator.

Do you think we have the technology and capability to get that kind of reading?

Mr. MISCH. I think we certainly can get reasonable experience on what failures might occur in the hands of the customers.

Frankly, in order to know how these devices are working in large quantities in the hands of the consumers, it is going to be necessary that we have some sort of mandatory inspection. I think that the only way we will really know is through a mandatory inspection and maintenance program.

Mr. SATTERFIELD. Is there a technological capability today to set up inspection stations for a rapid readout of the exhaust of an automobile engine and technological capability to correct whatever needs to be corrected?

Mr. MISCH. Not specifically, no, there isn't the capability of noting specifically what the problem might be.

We do think that it might be possible to make gross determinations. In other words, if the catalyst disappeared or was completely ineffective, there would be a way of determining that, either by a temperature sensor or other quick means.

But to be able to determine specifically the level of performance, there is no technology known that would make it practical in the field.

Mr. SATTERFIELD. Is it your feeling that perhaps we ought to create more interest in this area and try to stimulate more effort in that direction than we have in the past?

Mr. MISCH. Yes; we do think that we need better inspection techniques and we need mandatory inspection.

Mr. SATTERFIELD. I am not going to take a whole lot of time, but I do have one other question.

You made the suggestion that we should adopt an interim standard of 2 grams a mile for NO<sub>x</sub>. I take it you are suggesting this to permit experimentation with new types of engines and that you are not saying that at some future date if it was found we must reduce it that the

new engine wouldn't have the capacity? You are not writing off a standard below this in the future would be possible?

Mr. MISCH. I am saying that unless the 2-gram  $\text{NO}_x$  standard is established and that, in all good faith, Congress feels there is going to be a continuation of this standard for a reasonable period of time, we wouldn't look at some of these alternate approaches because we do have a threshold capability of around 2 grams per mile, such as the Honda approach, for instance.

Now, the reason that it seems to us to be impractical for such systems to later achieve lower levels is that they are basically lean burn devices precluding the addition of a reducing catalyst to the system at some later date. You would have to have an enriching system to do that.

Mr. SATTERFIELD. From a practical standpoint, we will be establishing some sort of minimum for a pretty good period of time.

Mr. MISCH. That is correct.

Mr. SATTERFIELD. Thank you, sir.

Mr. ROGERS. Do I understand, then, Mr. Misch, that the Honda engine which Ford is now contemplating, if arrangements can be made to convert to it as an alternate power system, will bring about a meeting of the standards?

Mr. MISCH. We hope that it will ultimately meet the hydrocarbon-CO standards but it will not meet the oxides of nitrogen standards as it stands probably.

Mr. ROGERS. How far off on  $\text{NO}_x$ ?

Mr. MISCH. I am saying our best estimate is that its capability is to meet about a 2-gram standard. That does not mean that emission levels in vehicles aren't going to be lower than that. In order to certify and be certain that they will be under 2 grams, we need that kind of standard.

Mr. ROGERS. This means you will have no problem meeting the other two standards?

Mr. MISCH. I wouldn't say there is no problem. But there is a good possibility we can meet the other two standards, HC and CO, with minimum use of catalysts.

Mr. ROGERS. What about mileage?

Mr. MISCH. That is an open issue at the moment.

I think Honda has said that they would not anticipate more than about a 5-percent deterioration in reaching the hydrocarbon-CO standard, with, I believe, the present 3.1  $\text{NO}_x$  standard.

Mr. ROGERS. Does that mean from the 1973 capability?

Mr. MISCH. From the 1973 capability.

Mr. ROGERS. So there still would be a penalty?

Mr. MISCH. Yes, sir.

Mr. ROGERS. I had understood there would be no penalty.

Mr. MISCH. No, sir.

Mr. ROGERS. There will be?

Mr. MISCH. There will be.

There are lots of efforts to try to improve that situation but, as we see it at the moment, there would be a breakeven or slight penalty for such prechamber approaches compared to 1973, as far as fuel economy is concerned.

Mr. ROGERS. Thank you.

Dr. Carter.

Mr. CARTER. Thank you, Mr. Chairman.

In our efforts to clean up the air, I realize that we have really put a great load on the automotive industry. Perhaps we have tried to go too far too fast. I think that is undoubtedly true. Of course, we all want clean air. But, certainly we have to give you time enough to develop the mechanisms necessary.

I notice that in the present car you have retarded the spark. Is that true? And you have lowered the combustion ratio and also you have a leaner mixture; is that correct?

Mr. MISCH. That is correct; yes, sir.

Mr. CARTER. That does injure the driveability of your car, does it not?

Mr. MISCH. Yes.

Mr. CARTER. Or any car, for that matter, not particularly yours.

Mr. MISCH. Yes, sir.

Mr. CARTER. It also increases the gasoline consumption.

Mr. MISCH. That is correct.

Mr. CARTER. About 18 percent, you say, on an average?

Mr. MISCH. Thirteen percent for the Ford car. It varies a little bit from carline to carline but there is a 18 percent average reduction on our line of products.

Mr. CARTER. I noticed an improvement in the driveability of the 1973 car over the 1972. I happen to have two cars made by your company, one at my home, a 1973, and one here, a 1971. The 1973 car is quite driveable but it does use, I would say more than 18 percent of fuel over the 1971 car.

Mr. MISCH. I want to clear up one thing.

Thirteen percent is due to emission control. In many instances, we have other factors. The vehicles have gotten heavier. Any one line of vehicles has gotten heavier. That will contribute to fuel economy loss. For instance, in tracking from 1965 to 1973 on a full-sized Ford car, we say that we can account for about a 22 percent reduction in fuel economy or increase in fuel use, 13 percent of which is for emission controls and the remainder is for other things, possibly weight.

Mr. CARTER. A 22-percent increase in the use of gasoline?

Mr. MISCH. Yes.

So, you would be noticing something part way in between that because you are comparing a 1971 to a 1973. You are not going quite so far back. Part of that weight increase is because of product elections we have made. A significant part of it, maybe almost half of the weight increase, is due to those things that were required to make the vehicle comply with Federal safety and damageability regulations, as well, heavier bumper systems and so on.

Mr. CARTER. Yes, sir.

I would say that there has been an improvement in the strength of the body and so on in the past few years.

Mr. MISCH. Yes.

Mr. CARTER. Do you see the use of the catalytic converter in the next year or so? Do you think that you will go that way?

Mr. MISCH. For 1975, our present program is to meet the interim standard. In California, the interim standard there will require a 100-percent catalyst system in all of our cars and in the other 49 States

we are estimating that somewhere between 15 and 50 percent—and I can't give it to you any closer than that at the moment—will require catalysts.

A minimum of 15 percent and as high as 50 percent will require the catalysts in the 49 States.

Mr. CARTER. In case you go to catalytic converters, have you checked the emissions from them, the changes in your  $\text{NO}_x$  and in your hydrocarbons and your carbon monoxide? Have you checked those emissions to see if they are toxic or not?

Mr. MISCH. No; we have not noticed any difference in the hydrocarbons. Of course, basically, the hydrocarbons that the catalytic converter does not change are the nonreactive ones, methane and so on. A high percentage of the total would be methane coming out. Carbon monoxide, of course, changes to carbon dioxide-water.

We have noted as a result of some work first done by Dow Chemical Co. and analyzed by Ford Motor Co. and we since that time have been working with EPA in determining the extent to which sulfur in the fuel may be oxidized to  $\text{SO}_3$ , and with water comes out as a sulfuric acid mist or a particulate. It is early work at the moment. We don't know how to quantify it. As soon as I knew about it, I wrote to the Environmental Protection Agency and disclosed the work we had done and the data we had and we have been working with them ever since in evaluating it.

None of us knows what level of such particulate matter would be of concern.

Mr. CARTER. You wouldn't know the level of emissions of sulfuric acid mist,  $\text{H}_2\text{SO}_4$ ; is that correct?

Mr. MISCH. That is correct.

Mr. CARTER. It might even approach the weight of  $\text{NO}_x$  per mile; is that correct or not?

Mr. MISCH. I can't answer that, Doctor. I really don't know. It is only small quantities that we have measured and all of our work has been done at a steady state, 30 miles an hour steady speed, 60 miles an hour steady speed.

We have been trying to determine whether or not there is any difference in the amount of mist that is formed through time. But it is very early work and I am sure we couldn't quantify it to the point of saying whether there should be or should not be concern.

Mr. CARTER. Would you want to estimate the relative bad effects of  $\text{NO}_x$  and sulfuric acid mist on human health?

Mr. MISCH. Pardon?

Mr. CARTER. Would you like to compare the effect of  $\text{NO}_x$  and sulfuric acid mist on human health?

Mr. MISCH. Yes; I would think that if there is a concern that a threshold should be established below which we would control; that is correct.

Mr. CARTER. Since we don't know what the catalytic converter does emit—there have been studies, some of which I have read, but they have not been made in depth—we might really be trading a devil for a witch is that correct?

Mr. MISCH. There is always that possibility. I don't know how probable it is.

Mr. CARTER. What is the meaning of NIH?

I don't mean the National Institutes of Health.

Mr. MISCH. I am sorry; I didn't hear.

Mr. CARTER. What is the meaning of NIH as used in the automotive industry?

Mr. MISCH. We use it around our shop as indicating "not invented here."

Mr. CARTER. Are you adverse to using inventions which are not conceived at Ford?

Mr. MISCH. No way. As a matter of fact, we have the latch spring handy and the door standing wide open for any ideas. We look at thousands of them continually. I think as evidence is the fact that we didn't invent the Honda approach but we did hurry to get a business and license arrangement with them so that we could take advantage of whatever they know as quickly as possible.

We also, at the same time, announced that we have signed a license agreement with Dresser Industries who have an approach to a fuel handling system that we think might have some merit. We are anxious to look at things that come from elsewhere.

Mr. CARTER. Have you considered the use of an afterburner? Have you given much study to that?

Mr. MISCH. We have done a little work in the past on afterburners; yes, sir.

Mr. CARTER. I would like to ask you the test results from the certified laboratory. If you have your pad there, you might want to write these figures down.

The weighted mass emissions on the 1975 CBS test procedure: Hydrocarbons, 0.62 grams per mile; carbon monoxide, 18.34 grams per mile; oxides of nitrogen, 1.18 grams per mile.

Second, the cold stabilized emissions from the same test: Hydrocarbons, 0.04 grams per mile; carbon monoxide, 0.72 grams per mile; oxides of nitrogen, 0.70 grams per mile.

My first questions is this: Do these results equal or better the standards recommended to this committee by Ford?

Mr. MISCH. The 0.62 on hydrocarbons does.

The 18.34 would meet the 1974 carryover. It would not meet the 1975 interim.

The  $\text{NO}_x$  level certainly would meet what we are recommending; yes, sir.

Mr. CARTER. Let me have your answer again, please, sir.

Mr. MISCH. The 0.62 hydrocarbons would meet what we are recommending, which would be either a 1974 carryover or 1975 interim, whether it be 49 States or California.

The 18.34 would not meet either the 49 States or California for 1975. The  $\text{NO}_x$  would meet it.

Mr. CARTER. Would not?

Mr. MISCH. The  $\text{NO}_x$  would meet what we are proposing.  $\text{NO}_x$  would and hydrocarbons would and the CO would not—of the numbers you just gave me.

Mr. CARTER. Do you think you can match these results at your company?

Mr. MISCH. You are talking about matching them with an afterburner?

Mr. CARTER. No; in any way.

Mr. MISCH. In any way?

Mr. CARTER. Yes, sir.

Mr. MISCH. Well, on a single car, no question about it.

Mr. CARTER. You can do that?

Mr. MISCH. Yes; we have done that. We have presented data to EPA that we have done it on many different approaches.

Mr. CARTER. What would be the cost of doing this, say, on a 1965 model engine which, I believe, is about the most efficient or next most efficient engine you produced, 1965 or 1966. Is that correct?

Mr. MISCH. I don't think I can give you cost.

At this oxides of nitrogen level, we would have been using a reducing catalyst to get to that level. I don't have the cost of such a system available.

Mr. CARTER. Could you do it for \$40?

Mr. MISCH. No, sir.

Mr. CARTER. It would cost in the neighborhood of at least \$300; is that correct?

Mr. MISCH. That is right.

Mr. CARTER. Some people state that this can be done for that low a cost with an afterburner.

Mr. MISCH. We have the latchstring out.

Mr. CARTER. All right, sir. I am glad to hear that.

Thank you, Mr. Chairman.

Mr. ROGERS. Mr. Misch, have you given any thought to the reduction of the weight of the automobiles? Is Ford considering reducing the weight of the automobile?

Mr. MISCH. Yes; we are. Fuel economy is becoming more and more important. So, we have mounted programs to look at all of the factors that influence fuel economy. We know that in the marketplace it is becoming a very strong buying motive and we have to address ourselves to it. It is not only weight reductions; we are looking at programs in axle selections, matching of engines to transmissions; the whole thing.

Mr. ROGERS. We may want to go into that a little bit this afternoon.

The full committee is going to meet very shortly.

Mr. KYROS.

Mr. KYROS. Thank you, Mr. Chairman.

I have only two very short questions.

First, will you briefly describe for the record what this stratified charge engine is?

Mr. MISCH. There are many forms of stratified charge engines but primarily I think you can generalize by saying the concept is to provide a cloud of combustible mixture of fuel and air, a cloud within the combustion chamber that can be ignited, although the surrounding gas, which may be air, is not combustible.

The fact that you maintain a combustible cloud is where the term stratification comes in.

Mr. KYROS. In other words, two levels of combustion. One is combustible and one is not?

Mr. MISCH. That is correct.

Mr. KYROS. You talk about freezing the standards for 1975 at the level of 1974 or interim 1975 standards. You suggested that Congress might do this.

Wouldn't this necessitate a further increase in the stringency of some transportation controls where they are presently required and imposition of new transportation controls where they are not presently required?

Mr. MISCH. I don't know that anyone can calculate that carefully enough to be certain.

I say it for this reason: We are talking about a 2-year period in which you would replace one given control for another. Now, the degradation in control is very slight. That contribution of new cars only in the total population of a given airshed area is going to be very, very small. I, personally, really question whether you can calculate these things closely enough to indicate what the effect would be on transportation controls.

Mr. KYROS. You are not asking for relaxation of health standards in these areas?

Mr. MISCH. No, sir.

Mr. KYROS. Wouldn't this disrupt the plan that EPA has already set up in some areas?

Mr. MISCH. For controls?

Mr. KYROS. Yes.

Mr. MISCH. They would have to say but I rather doubt whether they are sophisticated enough to tell the difference.

In the first place, regardless of what we put out in 1975 and 1976—in the Los Angeles Basin, for instance—new cars replacing the old is going to be a small part of the total. In total, that is not going to allow them to get even close to the ambient air quality standards, anyhow. So, it is a matter of time, I frankly feel.

Mr. KYROS. Thank you, Mr. Misch.

Thank you, Mr. Chairman.

Mr. ROGERS. Mr. Misch, I am sorry we have to interrupt you and ask you to be kind enough to come back at 2 p.m., but the full committee is to meet now and I am sure you will understand our situation.

The committee stands adjourned until 2 o'clock this afternoon.

[Whereupon, at 11 a.m., the committee adjourned, to reconvene at 2 p.m. of the same day.]

#### AFTER RECESS

[The subcommittee reconvened at 2 p.m., Hon. Paul G. Rogers, chairman, presiding.]

Mr. ROGERS. The subcommittee will come to order, please, continuing hearings on the Clean Air Act.

We were in the process of asking some questions of Mr. Misch. We will continue.

Mr. NELSEN.

Mr. NELSEN. I have no questions.

Mr. ROGERS. Mr. Misch, I would like to get a few questions here just to build the record. I know you have commented on this in your statement.

Can the Ford Motor Co. comply with the nationwide 1975 interim standards by EPA after it granted a 1-year delay of the statutory 1975 standards?

Mr. MISCH. Yes; we can.

Mr. ROGERS. Can Ford comply with the 1975 interim standard for California?

Mr. MISCH. Yes; we can.

Mr. ROGERS. In order to comply with these standards, what percent of Ford's 1975 vehicles will have to use catalysts in California and what percent will have to use catalysts in the rest of the country?

Mr. MISCH. One hundred percent of our passenger cars in California and somewhere between 15 and 50 percent of the passenger cars in 49 States. There is still some question with regard to the requirements for trucks in California.

Mr. ROGERS. Now, in your testimony you mentioned some major concerns about the use of catalysts, the cost, the need to purchase the more costly unleaded fuel, the need for more crude oil to produce unleaded fuel and potential durability problems.

It is my understanding that General Motors, who will testify next, feel their catalysts will last 50,000 miles and yet you have had problems with yours; is that correct?

Mr. MISCH. I am not at all sure that our design objectives aren't similar. Our design objectives have been since the outset of the program a 50,000-mile catalyst. In the main, we are experiencing 50,000-mile durability safely.

Our concern really is the frequency of failure that might prevail in the hands of customers. This is the part that we have no great amount of evidence on one way or the other. I am not sure whether General Motors has or not.

Mr. ROGERS. We will get into that.

I had understood, they felt that their catalyst would bring about a 20-percent improvement in economy. This has not been demonstrated in any of your catalysts?

Mr. MISCH. We can't categorically say we can get anything like a 20-percent improvement in fuel economy by the addition of catalysts to, we will say, the 1974 level of vehicle. We have some test data that would indicate as a 15-percent fuel economy improvement. On other models, we have zero improvement and in some instances we have had a loss in economy.

So, it is somewhat a mixed bag. We cannot predict a 20-percent improvement.

I want to make it clear when we are talking about the effect on fuel economy we are talking only with regard to the emission control systems, themselves, not the other things we might be doing. For example, we have been using steel-belted radial ply tires to a high degree and increasing the installation rate of their use on our vehicles. That does improve fuel economy.

We are making air dynamic changes in some instances.

These things add up to fuel economy improvement.

With regard to catalysts, we don't see a 20-percent improvement.

Mr. ROGERS. Do you foresee any other problems with the use of catalysts?

Mr. MISCH. We do see a problem in considering the tourist problems, going to border countries, whether or not, unleaded fuel will be available and, if it is, whether or not the filter device that is needed to cooperate with the filter neck on the catalyst-equipped vehicle will also be available in Canada, Mexico, and so on. We see this as a problem, not insurmountable, but certainly a problem that has to be dealt with.

Mr. ROGERS. Has your company done any research on the extent to which the catalytic converter in meeting these standards may cause harmful unregulated pollutants?

Mr. MISCH. We have done some work identifying the levels of sulfuric acid that might be created. Beyond that, we have done very little.

In the earlier days of evaluating the vanadium pentoxide catalyst, we recognized attrition and that distribution of vanadium in the atmosphere would be deleterious. We have not used that approach.

We have not evaluated in our own research the level of other pollutants such as platinum, palladium, and what-not. We have not evaluated it. However, we are using a monolithic substrate for the catalyst as compared to pellets and we experience no attrition, no rubbing together, so we would not expect to be contributing particulate matter.

Mr. ROGERS. I notice your statement says:

Our present estimate is that the best we can do, will not meet the presently scheduled requirements for 1976.

Now, that is on the NO<sub>x</sub>, I think.

Mr. MISCH. No, sir. That is in 1976 because EPA has the authority to delay the hydrocarbon-CO standards just 1 year; in 1976, with the interim standard of NO<sub>x</sub> of 2 grams they now have combined the statutory requirement of 1.4 grams of hydrocarbons and 3.6 grams of CO. It is this combination of the three that we are saying we can't meet.

Mr. ROGERS. Is there any system that you know of which will reduce all three pollutants?

Mr. MISCH. We don't know of a way of getting there for 1976.

Mr. ROGERS. But you do have a system that reduces all three by when?

Mr. MISCH. We are very hopeful, for instance, that if we have a 2-gram NO<sub>x</sub> level established, we may have one engine family, one engine line of an alternate engine that might meet these levels in 1977.

Mr. ROGERS. That would be the next year, then?

Mr. MISCH. That would be the next year.

Mr. ROGERS. Would it be your intention if that is done that you would then convert all of your automobiles to the alternative engine?

Mr. MISCH. I think in the main, yes, if it is successful that is the intention.

Mr. ROGERS. It is your intention to completely shift over that in a progressive way?

Mr. MISCH. As we see it today, we would. We would have to weigh the economics very carefully. That is on the assumption that what we come up with is a more attractive product for the consumer than the catalyst-equipped vehicle. If that continued to be the case, we certainly would shift over as rapidly as possible.

Mr. ROGERS. Here is what I am wondering: If you are only going to do one line of this, what will happen? You said, I think, you used the figure of 500,000, and you produce how many cars?

Mr. MISCH. About 3 million.

Mr. ROGERS. What happens to the other 2,500,000?

Mr. MISCH. They would be continuing at whatever level we could reach with the catalyst-equipped system.

Mr. ROGERS. How long would it take you to shift the rest of the cars over to it; I think you called it the Honda engine approach, the stratified charger?

Mr. MISCH. It is a little hard to say. It depends entirely on what the condition of the industry was as far as the machine tool industry, what capacity there was there, what changes other companies were making that would load that industry, plus our capability financially to be able to afford to make the shift.

All these things would have to be taken into account in determining the time to do it.

Now, I want to make it clear that we wouldn't expect our 1976 capability on catalyst-equipped cars to be the end-all, be all. We would expect to be making improvements and probably would be meeting the same level with the catalyst cars as we are hoping to do with an alternate engine.

Mr. ROGERS. So, your current plans are simply to produce the 500,000?

Mr. MISCH. Certainly at first we would start with one engine line which is a very, very major commitment.

Mr. ROGERS. Yes; it is.

You think, though, you might want to shift over if that is shown to meet standards and it is accepted?

Mr. MISCH. Exactly.

I don't think we would go with one engine line unless we thought it was going to continue on and would be adaptable to subsequent engines, as well.

Mr. ROGERS. Dr. Carter.

Mr. CARTER. Thank you, Mr. Chairman.

I just would like to know about what would be the cost for you to make a complete changeover to the stratified charge engines by 1975 or 1976. Could you give us an estimate of the amount that it would cost your company? You are not thinking of doing that until 1977, I think you said.

Mr. MISCH. The first engine line we would hope would be by 1977. I am sorry; I can't even give you an intelligent figure for one engine line, let alone the conversion of all of them.

Mr. CARTER. Or for 500,000?

Mr. MISCH. That is one engine line of 500,000. I don't have that figure.

Mr. ROGERS. You could furnish that for the record?

Mr. MISCH. We can do that.

[The information requested was not available to the committee at the time of printing—March 1974.]

Mr. CARTER. Would it be feasible to use this particular engine in one of your charter cars?

Mr. MISCH. As we see the concept, it is not necessarily limited to any size. We are evaluating these alternate engine concepts in all ranges of engine size that we currently produce.

Mr. CARTER. Thank you, Mr. Chairman.

Mr. ROGERS. I was wondering if you are still planning to have a major part of your production still on the catalyst. I wondered about calling a complete halt on increased standards. I think maybe you suggested we hold them up until 1977?

Mr. MISCH. We suggested that you should hold up any more stringent standards until you have an opportunity to study the results of the NAS study and then, based upon the August date next year when that study is to be completed, we are assuming that it would be impractical if not impossible for Congress to establish new regulations that could be effective before the 1977 model.

Mr. ROGERS. I think your paper also talked about a Ford scientist indicated that 1973 emission controls have resulted in a 13-percent loss of fuel economy.

Mr. MISCH. Yes, sir.

Mr. ROGERS. Is this due primarily to the use of exhaust gas recycling to control  $\text{NO}_x$ ?

Mr. MISCH. It is partly that. It is made up of several things. It is made up of the fact we have reduced complex ratios in order to tolerate 91 octane fuel, in order to control unburned hydrocarbons with retarded spark; the exhaust gas recirculation for the control of oxides of nitrogen adds significantly, also. So, it is made up of several actions.

Mr. ROGERS. Have you considered the use of  $\text{NO}_x$  catalysts to restore fuel economy?

Mr. MISCH. The only experience we have had with the  $\text{NO}_x$  catalysts that do not depreciate fuel economy is called a three-way catalyst where hydrocarbons, carbon monoxide, and oxide of nitrogen are controlled simultaneously.

The infirmity of that approach has been that one must obtain a very narrow range of fuel ratios in order to cause the phenomenon to occur. That has been beyond our capability in an air-fuel system until we can develop a feed-back system that actually senses what is coming out the exhaust, if you will, and corrects the air-fuel mixture to these limitations. We don't have a feedback control system as yet that will maintain itself over a reasonable mileage.

Every other oxide of nitrogen catalyst approach that we have taken has depreciated fuel economy because it basically operates on the rich side.

Mr. ROGERS. Now, if we were to freeze the standards, say at the 1974 levels—you said either that or the interim 1975?

Mr. MISCH. Yes, sir.

Mr. ROGERS. Wouldn't that in effect be freezing in the 13-percent fuel loss?

Mr. MISCH. Yes; basically, it would, unless there was a reason to believe that the freeze would be of such duration that we could go back and revisit the 91 octane fuel and complex ratio. There would be the one opportunity to look at the complex ratio to see if we could get some of the fuel economy back. We could get fuel economy faster than we would harm oxides of nitrogen by going back up to the complex ratio.

Mr. ROGERS. What is Honda's estimate of the stratified charged engine, the CCBC stratified engine  $\text{NO}_x$  control capability?

Mr. MISCH. I would prefer to stay with data that they put into the public record.

Mr. ROGERS. I think we are having Honda later.

We will take that up with Honda.

Dr. Carter.

Mr. CARTER. No further questions; thank you, sir.

Mr. ROGERS. Mr. Heinz.

Mr. HEINZ. Thank you, Mr. Chairman. And thank you, Mr. Misch, for appearing before this committee. I do have one or two questions.

On page 7 of your statement this morning, you indicated or you said that the levels required by EPA and the Clean Air Act were not cost effective. What do you mean?

Mr. MISCH. What we mean is that as you incrementally increase the control of hydrocarbons, CO and NO<sub>x</sub> in an automobile, you disproportionately increase the cost of the equipment or system that is required to provide that increment, so that theoretically, at least, you approach perfection at infinity, costwise.

Mr. HEINZ. Let me examine that, if I may, a little further. You say that disproportionate amount of cost. What would be a proportionate amount of cost?

Mr. MISCH. More nearly a linear relationship. Let me remind you that we have said there is about \$80 of cost to the consumer for emission controls in our 1973-74 vehicles and that \$80 has purchased 69-percent reduction in carbon monoxide and 85-percent reduction from an uncontrolled state of hydrocarbons and a 48-percent reduction in oxides of nitrogen.

Now, in going from this level to the 1975 level of 96 percent—let me take the interim standard—of 9 grams of CO, for instance, which would be the California standard for CO, that is 90 percent control instead of 69 percent, and 1 gram roughly of hydrocarbons is 93 percent as compared to 85. Controlling those two constituents to those levels is going to cost not \$80 but somewhere around \$316.

Mr. HEINZ. Mr. Misch let me break in, if I may, and just indicate that, to me, cost effectiveness has always been relating benefits to cost and you have to quantify the benefits. The percentage reduction in the amount of pollution per se is not a measurable benefit as a dollar figure; it is a percentage.

I think in order to reach meaningful cost-effectiveness numbers, one has to make an attempt to quantify, extremely difficult at times, the dollar benefit to the public health, to the public welfare, or other forms of social accounting.

I am not asking you to do that. I am asking you to indicate whether you have some specific numbers in terms of dollar benefits paid and in dollar benefits received and how you would estimate them.

Mr. MISCH. We don't have and we doubt seriously if such numbers could be developed. That is the reason I avoided saying cost benefit but said cost effectiveness, because, with the exception of carbon monoxide, I think the automobile as a source must be compared to other sources. Certainly, as far as hydrocarbon and oxides of nitrogen are concerned. The cost of controlling the other sources versus the cost of controlling automobiles should be taken into account.

It would be my supposition as an engineer that when we start getting on the very steep portion of the cost-effectiveness curve for automobiles, we probably have other ways of treating those particular pollutants to do what we want in the abstract.

Mr. HEINZ. I think that comment is very aptly made.

Let me just continue.

On page 7, I believe you recommended that Congress consider freezing emission standards through the 1976 model year, using the 1974 or 1975 interim levels. By that, did you mean that you are pro-

posing to freeze them only through the 1976 model year, or were you proposing that such freeze might extend beyond the 1976 model year?

Mr. MISCII. We were proposing that the freeze be identified as through the 1976 model year on the assumption that the NAS report and any other information would have been revisited by that time and ongoing, more permanent standards would be established. They may be a continuation of the freeze level of the facts support that or they may be some other levels.

As I said in my statement, I didn't believe that Congress could review these data in time to make an effective judgment prior to 1977. That is the reason for freezing through 1976.

Mr. HEINZ. With respect to the NAS study, you indicate that would be a new study, not one that is ongoing as yet?

Mr. MISCII. It supposedly is ongoing. The one I am referring to is one just commissioned by Congress and funded by Congress to be completed and reported on as of August of next year.

Mr. HEINZ. Based on some testimony we took from EPA earlier this week, the indications were that every piece of new research we do on the health effects of pollutants has generally tended to indicate that we were worse off than we thought we were.

Why would you be optimistic that the NAS study would reverse what is the apparent trend in the pollution research that relates to health?

Mr. MISCII. For this reason we don't have the data to take issue with the ambient standards that have been established to protect health.

I don't know that EPA has indicated that there is data that would tell them that the ambient standard should be more stringent. I think they have said the data as developed would tend to support the standards as they are.

But I would hope, as a result of studies that we have made, when NAS looks at the methods that must be employed to roll back to that level and from these calculations determine the control levels for vehicles and other sources, they will come up with different numbers than we have today.

Mr. HEINZ. Mr. Chairman, we have a quorum call. Could I continue after I return?

Mr. ROGERS. We will recess for about 5 minutes, if we may. We will come right back and try not to delay you.

The committee will be in recess for 5 minutes.

[Brief recess.]

Mr. ROGERS. The subcommittee will come to order, please, for the hearings on the Clean Air Act.

Mr. Heinz?

Mr. HEINZ. Thank you, Mr. Chairman.

Mr. MISCII. Mr. Heinz, perhaps I should correct one statement. I referred to the NAS study as being a study ordered by Congress.

It is really the study as indicated in my statement that was approved by the Senate.

Mr. HEINZ. Maybe we will have the wisdom to consider that legislation ourselves.

I take it then one of the recommendations is that this committee consider that legislation; is that correct?

Mr. MISCH. We would certainly recommend it highly.

Mr. HEINZ. I believe the chairman touched on this point briefly with respect to the fuel penalty the 1973 models now incur due to the emission devices.

I have a 1973 model and it is one of the big ones. It is not a Ford Motor product, I am sorry to say, although our next witness may be more pleased with my car, but it does eat up a great deal of gas.

It is tough getting from one filling station to another. You have in effect proposed that the technology now in effect for 1973, and I suppose for 1974, if I understand you correctly, since the 1974 model year is upon us, be frozen and along with the existing fuel penalties.

What do your studies show would be the improvement versus the existing 1973 technology of the kind of technology you would have to adopt if we did not change the act in order to give the automobile companies more time to come into compliance and EPA did not change their ambient air quality standards?

Mr. MISCH. For 1975 I think I indicated before, considering the 1974 California vehicle to 1975 California vehicle as we are presently planning it, with no change in the current interim standards, we anticipate that there will be the same fuel economy.

We are going from a noncatalyst car to a catalyst car and we are maintaining the same level of oxides of nitrogen control but we are significantly lowering levels of hydrocarbon and CO with the use of catalysts.

We anticipate that that would be a wash.

Mr. HEINZ. Are you saying that cars will consume just about as much gas for their weight?

Mr. MISCH. Yes.

Mr. HEINZ. For the number of accessories they have in 1975 as they do in 1973?

Mr. MISCH. 1975 as in 1973.

Mr. HEINZ. Now, you make a distinction between 1975 and 1976?

Mr. MISCH. Yes, because in 1976 the legal standard as a result of suspending the No. standard is 2 grams nationwide in 1976 but the statutory limits on hydrocarbon-CO come into effect and they are significantly lower.

I would anticipate that we would sacrifice additional fuel economy to reach those lower levels of hydrocarbons.

Mr. HEINZ. Now EPA has said on several occasions where I have been present that they felt the adoption of some of the future pollution control technology, such as the catalytic converter, would reduce the fuel penalty that the 1973 technology brings about.

Why would they say that or why would there be such a discrepancy in their opinion and in your opinion?

Mr. MISCH. We are, of course, constrained to base our opinion on the test data we have available and have actually experienced.

I don't know what they are basing theirs on. I will say that there is an opportunity for improving the fuel economy with the use of catalysts if you consider increasing the Federal gas levels to the catalyst.

If your catalyst efficiency is high enough so that you allow the Federal gas levels to go up, it is possible that on many of the combinations of engines and vehicles, through the enriching process, you

are getting away from the limit farther and you can improve fuel economy.

Up until now it has been our practice and our plan to avoid excessive Federal gas levels simply because we as yet do not know how well these catalysts are going to work in the hands of the consumer.

If we increase the Federal gas level and the catalyst was nonoperative on a vehicle, we would have a deteriorating effect rather than an improvement.

Mr. HEINZ. I understand what you are saying.

Can I turn now to the question of certification tests?

I don't believe we have talked much about it today. I just wanted to clarify one aspect of the way automobile production is judged to be either in compliance or not in compliance.

I am sure when you produce 100,000 cars they are not all exactly alike.

You in effect get some kind of distribution, possibly a skewed normal curve.

The way the law reads or the way EPA has implemented the regulation of the law, what are you allowed, if anything, in terms of the meeting of an  $\text{NO}_x$  of 2 grams per mile?

Does every single car have to be at or below that standard? Is there 1 or 2 percent of the cars out of that 100,000 that could exceed it?

What is the interpretation that your lawyers tell you you must live with?

Mr. MISCH. It is not absolutely clear. However, the process that is employed in the certification ascribed in EPA regulations describes a process that would indicate that the average production vehicle would meet the standards for 50,000 miles.

The certification process starts by saying that we must demonstrate a capability of that engine family system running for 50,000 miles and throughout the 50,000 miles that prototype must operate below the standards.

Mr. HEINZ. On the average?

Mr. MISCH. It must operate below. That test vehicle must stay below the standards in order to be considered a valid vehicle to determine the deterioration factor of the engine family and system.

Then the next part of the certification process is to have a fleet picked of vehicles that represent the various combinations and permutations of our engine and vehicle weights and so on, axle ratios.

These are called certification data cars. They must be run to 4,000 miles and they must be sufficiently below the standards at the completion of 4,000 miles so that when multiplied by the deterioration factor they still remain below the standards.

That is a certification process.

When EPA has determined that they have selected and we have complied with a representative prototype fleet, then they certify us and this I contend would then indicate that we have the constraint of building the vehicles in production.

I can't quote the exact terms, but to all intents and purposes mechanically the same as the vehicles which we certify.

That is what we hold to.

Now, there is one difference and that is in California. California has an end-of-the-line production line test in which we must run the

full CVS test on a 2-percent sample of our production in California and 90 percent of that sample must meet the standards.

Mr. HEINZ. I thank you for your explanation.

At the bottom of page 2 of your testimony, I take the thrust of your comments to be that if the auto manufacturers had more time that they might develop better technological approaches, either in engine design or other auxiliary equipment to meet pollution standards.

Beyond the suggestion you have given us today of essentially extending the interim standards and awaiting the NAS study, are there any more positive steps that this committee or the Congress should be taking to encourage or challenge the auto industry to develop better technology rather than just waiting?

Mr. MISCH. I can't think of any other positive steps that should be taken because if and when we have the definitive targets identified and we know that they are going to stay put, we have all the motivation that is necessary to develop the best means, the best product to meet those standards.

It is a competitive business and we don't talk flippantly about \$300 increases in product costs. Certainly the motivation is there to get lower cost, better operating systems and beat our competitors to the marketplace.

Mr. HEINZ. I think that is the best and most appropriate attitude for you to have.

I certainly commend you on it. It is the heart of our free enterprise system.

I am very pleased about your appearing with us.

I certainly thank you, Mr. Chairman.

Mr. ROGERS. Mr. Symington?

Mr. SYMINGTON. Thank you, Mr. Chairman.

I would like to compliment Mr. Misch on the statement which I have read, although I missed your presentation of it.

Mr. MISCH. Thank you.

Mr. SYMINGTON. We had testimony from the EPA witnesses that overall there was a 7-percent fuel economy penalty through the use of emission control devices.

You use a figure here of 13 percent. Now they claim that in the case of small cars some of these devices actually benefited the fuel economy.

Perhaps that is how they got their seven. Would you like to comment on that or explain what you think might be the reason for the difference in these two?

Mr. MISCH. I haven't personally studied in any detail that report except in a rather cursory examination it would appear to me that EPA developed their data on vehicles on the basis of finding cars in service back in 1964, 1965, 1966, 1967, and so on, and testing them for fuel economy.

Now I am not at all certain that they would contend that they knew the service condition of each vehicle and whether they were comparing apples and apples as they went from year to year.

As a matter of fact, looking at some of the scatter of the data I would strongly suspect there may have been gross differences in the conditions of these vehicles.

I am talking about data that basically is new car data properly broken, developed at the point in time the vehicles were built, whether it was 1965, 1966 or 1967 through 1973.

Now, in respect to the 13 percent I did say there was one specific car line tracked through those years but generally it represented the average as we see it.

One other thing is that the data we are talking about is developed on our own method of testing for fuel economy which we have over the time determined could relate reasonably well with what our customers perceive.

It includes a city and suburban mixture of evaluation, measuring the fuel economy in fact as you go through those cycles.

If I understand correctly, EPA is reporting fuel economy that was developed during the CVS emissions test on dynamometer roles.

In the main there seems to be some concern about the correlation between that fuel economy and what the customer might get.

I do not know of anyone who has yet proved that the EPA, so-called carbon balance method of determining fuel economy does or does not correlate with the customer experience.

Mr. SYMINGTON. You testify that you are concerned that a label based on any test might be more confusing than informative but you feel that the test that you have adopted roughly gives the same experience as the consumer, himself.

Would it not be possible to develop a label along those lines?

Mr. MISCH. We say that it gives an indication of what the consumer will expect but we are talking about the average consumer.

Unfortunately, you know, everyone out there is either below or above average. So, as an individual when he evaluates this compared to his own experience, it may very well be misleading.

We use fuel economy data of this sort to give us a relative measure and a trend from model to model or size to size and so on.

Mr. SYMINGTON. I think that would be generally understood, if you selected some arbitrary speed and some duration with a particular engine and then pointed out in a footnote that this is subject to variances depending on start, stop, and speed and suburban versus urban driving, that would not be too difficult to do but it would give a reasonably accurate indicia of the overall variances one might expect between cars of different sizes and power, would you not think so?

Mr. MISCH. We think so. We think it is necessary that we collectively devise some means that most accurately portrays the fuel economy to the prospective consumer, yes.

We don't think we have it yet. I might say that the Environmental Protection Agency has requested of the Society of Automotive Engineers to develop a test procedure that might be considered as a common or standardized approach to this sort of data.

Mr. SYMINGTON. One other question.

Air-conditioning consumes a good deal of fuel, does it not?

Mr. MISCH. When it is operating and on; yes, sir.

Mr. SYMINGTON. What is that figure? Can you give us that figure?

Mr. MISCH. I don't have it.

Mr. SYMINGTON. Out in St. Louis there was a Ford meeting. I think they tossed the figure out of 20 percent.

Mr. MISCH. It is between 10 and 20, perhaps, when it is operating. Certainly, in hot weather when the head pressures of the compressors are high.

Mr. SYMINGTON. Is there any work going on to reduce that?

Mr. MISCH. Yes, there is quite a lot of work going on. We don't have any revolutionary approaches yet, but we are looking at what can be done to reduce these energy demands from all the accessories, as for example, power steering, air-conditioning, power brakes, or anything that might make an energy demand. We are looking at ways and means of optimizing them so that we can reduce it.

Mr. SYMINGTON. Thank you, Mr. Chairman.

Mr. ROGERS. Dr. Carter, I believe you had a question.

Mr. CARTER. Thank you, Mr. Chairman.

I have just one question. Are you familiar with any apparatus which would lower the emissions, say, of hydrocarbons, could transient at 2.80 grams per mile, 75.10 of carbon monoxide per mile, 1.67 of oxides of nitrogen per mile and carbon dioxide 769.34, any device or afterburner if you would call it that, that would lower the care emissions that much?

Mr. MISCH. I am sorry, I would have to write those numbers down. Are they different numbers than we talked about this morning?

Mr. CARTER. Somewhat like them; yes, sir. These apply to the tests of cars for 1975 and 1976, meeting those standards. Cold transient for hydrocarbons, 2.80. Carbon monoxide, 75.10; oxides of nitrogen, 1.67; carbon dioxide, 769.34.

Mr. MISCH. You say "cold transient"?

Mr. CARTER. And "cold stabilized." I have those figures, too.

Mr. MISCH. I am told Dr. Carter that the cold transient is the first bag collected in the CVS test. Frankly, I can't respond—that is a portion of the total test.

Mr. CARTER. Yes, I want to give you the rest of it.

Mr. MISCH. Perhaps I have it here.

Mr. CARTER. Cold stabilized, if you want to write that down. This is for 1975, 1976. Cold stabilized, 0.04 for hydrocarbons. Carbon monoxide, 0.72; oxides of nitrogen, 0.70; carbon dioxide, 869.25. Then if we go into the third class, the hot transients, 0.08 hydrocarbons grams. Carbon monoxide, 9.19; oxides of nitrogen, 1.73; and carbon dioxide, 708.10. Are you aware that cars have been tested with a mechanism that would produce such emissions?

Mr. MISCH. If I understand this correctly, Dr. Carter, those are three ways, three expressions of portions of the CVS test which when combined then give the grams per mile information that we talked about this morning. That is the total test and that is the one we normally talk about.

Mr. CARTER. Each one is a separate part of them?

Mr. MISCH. But it is a total that addresses itself to the standards. In other words, the 0.62, the 18.34, the 1.18. Those are the levels that would represent what is called for in the standards. I think my answer has to be the same as it was this morning, that we have tested systems and have systems that operate at least through a test at these levels.

Mr. CARTER. Of course, we have talked about oxides of nitrogen, particularly the difficulty in reaching that. You say you can reach 2

grams per mile perhaps with ease, but the standard is 0.4 per mile, is that not correct?

Mr. MISCH. Yes, 0.4.

Mr. CARTER. This test states that they reached 1.67, the cold transient part of it, the cold stabilized 0.70 and not transient, 1.73, all of which are below the 2 grams.

Mr. MISCH. Dr. Carter, I said this morning that we have presented EPA with data that would indicate that we have tested individual vehicles that performed at this level and below. When I talk about what we can support in the way of standard, I am talking about what we can certify in terms of all of our vehicles committed to the certification process. The process itself in 1975 in Ford will involve more than 400 vehicles, and they must all perform. As far as one vehicle performing, yes, we have done it.

To be able to say that we as a company can assure you that those standards can be met with all of our products is something entirely different.

Mr. CARTER. I am sure that it will be quite difficult, and I personally want to compliment you on your testimony and your knowledge of these things. I think you have made an excellent witness.

Mr. MISCH. Thank you very much.

Mr. ROGERS. Mr. Nelsen.

Mr. NELSEN. Thank you, Mr. Chairman.

On some of our farm tractors, we use a fuel injector in our diesel engine, the economy is great and I have seen some cars with it on. I am curious if this has been rejected as a fuel economy application that might work?

Mr. MISCH. It is a good fuel economy approach. There is no question about that. Diesel engines just fundamentally give good fuel economy. The greatest problem with increasing their popularity is really two-fold. It is a heavy engine, as you know. It is great for tractors, but for passenger cars it tends to add a lot of weight. The other thing is that for any given size of engine, its output is pretty low. If you just substitute a diesel engine for a gasoline engine for the same size, it does not get out of its own way.

Mr. NELSEN. Can an injector be used either on a gasoline fuel?

Mr. MISCH. We have been using solid injection in some of the stratified charge approaches. Yes, sir, it can be.

Mr. NELSEN. I wonder about export sales. We had quite a little bit of debate about exporting in our conference committee. What do you do on export models to meet the standards of other countries? Are they uniform with what we manufacture in the United States?

Mr. MISCH. We met the standards of the receiving country. We receive a permit to export.

Mr. NELSEN. Thank you.

Mr. ROGERS. I may have to ask some questions that you can reply to on the record, if you will, because I am going to have to answer the call.

What is Ford's feeling about present capability of CVCC engine to control  $\text{NO}_x$ ? What system would be used with the CVCC engine to control  $\text{NO}_x$ ?

What about health effects tests of pollutants from the automobile?

Do you do any health research on that? Do you make that information available to EPA and if you don't, should you?

I introduced a bill, H.R. 10118, to assure that compliance with auto emission standards would not result in fuel penalty and to improve fuel economy performance of vehicles which do not comply. Would you comment on that please?

Mr. ROGERS. Mr. Misch, what would you think simply of authorizing an extension rather than changing the standards for  $\text{NO}_x$ ? You might give that for the record.

Mr. MISCH. I am not sure I understand that.

Mr. ROGERS. In other words, rather than just setting it at .2, leave it where it is, but authorize EPA to give an extension of that.

Mr. MISCH. Fine.

[The information requested was not available to the committee at the time of printing—March 1974.]

Mr. ROGERS. I think you have a supplemental statement and if you would submit that for the record without objection it will be made part of the record at this point.

[Mr. Misch's supplementary statement follows:]

SUPPLEMENTARY STATEMENT OF HERBERT L. MISCH, VICE PRESIDENT, ENVIRONMENTAL AND SAFETY ENGINEERING, FORD MOTOR COMPANY

Last week Congressman Rogers introduced legislation that would give the Environmental Protection Agency authority to deal with motor vehicle fuel economy. We welcome the introduction of this legislation since it highlights the very important relationship between emission control and fuel consumption at a time when U.S. energy problems are becoming more serious.

We support the concept of Section 2(A) of the Bill that deals with fuel economy labeling. Ford Motor Company favors the provision of information that will assist the consumer in making an informed choice of product. However, no representative fuel economy test exists. We are also concerned that a label based on any test that is developed might well be so complex as to be more confusing than informative.

We support Section 2(F) of the Bill that would limit the use of emission control features that impede fuel economy. As I have pointed out earlier, emission controls coupled with the use of 91 octane fuel and reduction in compression ratios have been responsible for a 13 percent fuel economy penalty to date and further penalties would result from imposition of the existing  $\text{NO}_x$  requirements. The nation's current energy problems require a very careful analysis of the tradeoffs between emission control and fuel consumption.

Sections 2(B), (C), (D) and (E) of the proposed Bill would permit the imposition of fuel economy standards, equipment and design limitations, weight limitations and equipment requirements. In our judgment such standards and requirements are unnecessary since market forces, including rising gasoline and car prices, are already moving the new car market and automobile manufacturers rapidly in the direction of smaller cars and improved fuel economy.

This trend has accelerated within the last several months. We expect the small car segments of the new car market to reach at least 45% during the 1974 model year. Moreover, this trend is certain to continue because gasoline and car prices will have to reflect continuing increases in costs.

Ford Motor Company is moving as fast as possible to stay ahead of this rapid change in consumer preferences. Our Board of Directors is acting today on programs to convert two assembly plants from big car to small and mid-size car production. We have recently approved programs to expand capacity at two small car assembly plants, and we anticipate additional similar actions in the near future. Our new four-cylinder engine line at Lima, Ohio, will relieve shortages of small engines formerly imported from Europe. Our new Mustang II is responsive to the shift in consumer demand and our planned production mix for 1974 calls for as many small cars as we can manufacture.

While our primary engineering efforts have been devoted to safety and auto emissions for the past several years, Ford Motor Company has developed a number of forward product improvement programs designed to reduce fuel consumption through car and truck component innovations, weight reductions and new small

vehicle programs. A large number of fuel economy-related engine, tire, axle, transmission and carburetor actions are planned or under investigation for the 1975, 1976 and 1977 model years.

These changes are occurring rapidly as a voluntary manufacturer response to consumer concerns about gasoline prices and shortages. We see no need, therefore, for legislation that would attempt either to force a shift from larger to smaller cars or to increase the emphasis on fuel economy in all cars. Moreover, if Congress should attempt to force this shift at a rate beyond the domestic automobile industry's ability to convert its production facilities, the consequences would be to idle plants and workers in plants producing larger cars and to encourage imports of small cars at a time when the dollar and the trade balance are already precarious.

If Congress should nevertheless decide that it should take action to improve motor vehicle fuel economy, we feel that the Department of Transportation would be the appropriate agency to deal with overall fuel economy measures in order to assure that the tradeoffs with safety and damageability are properly considered. The Environmental Protection Agency should continue to be responsible for the emissions control aspects of fuel consumption. The most important consideration, however, is that the authority to determine whether any measures are needed and, if so, to establish and administer such measures should be delegated, as provided in this bill, to an administrative agency. In our judgment, it would be a mistake for Congress to enact rigid standards that could not be modified—even if they were later found to be impractical, inappropriate, or unnecessary—except by amending the law.

Mr. ROGERS. Thank you for being here. I am sorry for having detained you. I apologize to those coming up. We will be right back and then receive the testimony of General Motors.

Thank you, Mr. Misch, you and your associates.

The committee stands in recess for 5 minutes.

[Brief recess.]

Mr. KYROS [presiding]. The committee will come to order.

At this time, our witness will be Mr. Ernest S. Starkman, vice president, environmental activities staff, General Motors Corp.

Welcome to the committee, Mr. Starkman.

**STATEMENT OF ERNEST S. STARKMAN, VICE PRESIDENT, ENVIRONMENTAL ACTIVITIES STAFF, GENERAL MOTORS CORP.; ACCOMPANIED BY DR. FREDERICK W. BOWDITCH, EXECUTIVE ASSISTANT FOR VEHICLE EMISSIONS; ROBERT C. STEMPEL, SPECIAL ASSISTANT TO THE PRESIDENT FOR ENGINEERING AND PRODUCT; WILLIAM L. WEBER, GENERAL MOTORS LEGAL STAFF; AND DR. CHARLES TUESDAY, HEAD, ENVIRONMENTAL SCIENCES DEPARTMENT OF GENERAL MOTORS RESEARCH**

Mr. STARKMAN. Mr. Chairman and members of the committee, my name is Ernest Starkman. I am vice president, environmental activities staff, General Motors Corp. With me today are Dr. Frederick W. Bowditch, who is my executive assistant for vehicle emissions; Robert C. Stempel, special assistant to the president for engineering and product; and William L. Weber, General Motors legal staff.

Mr. KYROS. We welcome all you gentlemen to the committee.

Mr. STARKMAN. We are pleased to respond to the invitation of your committee, and offer testimony regarding automotive emissions at these oversight hearings on the Clean Air Act. We are submitting a formal written statement, along with a number of documents which we think are pertinent to the subject matter before your committee, and respectfully request that they be included in the record.

Mr. KYROS. Without objection, they will be placed in the committee's files.

Mr. STARKMAN. The principal subjects we wish to discuss today include:

Changes which should be made to the Clean Air Amendments of 1970;

The need for more stability in the vehicle emission standards, rules, and regulations;

The technical basis for modifying the control requirements for carbon monoxide and hydrocarbons as well as oxides of nitrogen;

The benefits to be derived from universal availability of unleaded motor fuel; and

General Motors progress in developing low emission automobile engines.

General Motors is faced with some critical leadtime and production decisions in the immediate future.

Most importantly, we are not certain at this point what the future standards will be when we have to select hardware for controls.

First, as to the time problems we face. As you know, the existing emission standards were established by Government authority for model rather than calendar years. Thus, the 1975 requirements must be met in models which we begin assembling in August of 1974. Component manufacturers must begin even earlier. To meet these requirements, we will begin certification testing within 30 days. This timetable is essential in order to meet the specifications and durability requirements of the Federal test procedure.

The same thing is true of models which go into production in August 1975. They must meet the 1976 interim standards. Testing to certify these models must begin in the fall of 1974, only a year from now.

However, before testing can begin, we must be committed to a system which we feel confident can meet the interim standards for that 1976 model, including the 5-year, 50,000-mile durability requirements.

We must plan for making our 1975 control systems compatible with the most promising way to meet the 1976-77 requirements. Failure to do this would impose an extreme cost burden on the consumer.

Unfortunately, we presently do not have a control system which will meet all the requirements of the law now applicable to these 1976 models, particularly those of durability and 100 percent conformity. We are desperately trying to develop such capability.

I must emphasize that while we can build some experimental models which will meet the numerical standards, production variances will not permit us to declare that each and every car off the assembly line will also meet them. This is because of the unavoidable consequence of the mass production process, which we call manufacturing variances.

To offset these variances, we must be able to develop an emissions control system which will meet manufacturing goals substantially more stringent than the Government standard.

With these facts in mind, here is our problem: The EPA has stated at Senate hearings earlier this year that it would recommend moderating the statutory 1976 NO<sub>x</sub> standard. Earlier this week, the EPA submitted a recommendation to this subcommittee that the level be changed from 0.4 gpm to "near" 2 gpm. This recommendation is now

to be reviewed by the National Academy of Sciences (NAS) in the study it is making for Congress. We certainly agree that the NAS study is most appropriate at this time. After the NAS files its report, legislative action by Congress would be necessary before any proposed changes could become effective.

At this point, we have no way of knowing:

(1) Whether Congress will take any action, prior to receiving the results of the NAS studies, not due until it will be too late, or,

(2) If Congress does take action, whether it will amend only the statutory provisions and leave untouched the interim EPA standards applicable to 1976 models, or,

(3) Whether Congress will amend the statutory (90 percent) levels and provide new interim levels to replace those now promulgated for 1976 and subsequent model years.

Thus, General Motors may well face the impossible situation of not knowing what the actual standards for its 1976 models will be until the time has arrived in 1974 for it to begin certification testing of those models.

If we endeavor to prepare for the most stringent possibility—and the standards subsequently are moderated by Congress—we will have incurred substantial expense for a product which may not be cost/beneficial to the public and may not be competitively priced. We submit that this is an unreasonable situation.

Thus, we urge your committees, as we did the Senate in May, to move immediately and freeze the national standards. We believe that the public interest would be best served by freezing the standards at a level no more stringent than the 1975 California interim level. We urge that this be done for a 3-year period.

This action will not sacrifice progress in achieving clean air. It will, however, give Congress an opportunity to receive and review the recommendations of the EPA and the NAS; to set the revised requirements, and to give the auto industry sufficient leadtime to meet those standards.

Mr. KYROS. Is this the same kind of freeze proposed by the Ford Motor Co.?

Mr. STARKMAN. I don't believe so.

The 3 years, I believe, runs 1 year further than I heard Mr. Misch refer to.

Mr. KYROS. Thank you.

#### AMBIENT AIR QUALITY STANDARDS AND AUTOMOTIVE STANDARDS

Mr. STARKMAN. There is a significant disparity between the extremely low levels of automotive emission control requirements by the Clean Air Amendments of 1970 and the less stringent levels that subsequent data and experience have shown are adequate for protection of health and the environment.

We are convinced that the original automotive standards prescribed in the Clean Air Act (a) are unnecessary to achieve reasonable air quality standards by 1986; (b) are a dissipation of our natural resources; and (c) are an unnecessary financial burden to place upon the American public, even for such highly affected areas as Los Angeles.

In our full statement, we present the reasons why ultimately any attempt to reduce automotive emissions beyond that of 1gpm HC, 17 gpm CO, and 1.5 gpm NO<sub>x</sub> for California and 1.7 gpm HC, 17 gpm CO, and 3.1 gpm NO<sub>x</sub> for the rest of the Nation, seem unwarranted on any technological or health grounds.

#### ERRORS IN ESTABLISHING ORIGINAL NO<sub>x</sub> STANDARD

Perhaps the best example of the need for the NAS study of the automotive standards and quick followup action by Congress in the acknowledged twofold error in developing the automotive oxides of nitrogen (NO<sub>x</sub>) standard prior to enactment of the Clean Air Amendments of 1970.

These errors are: The current atmospheric level of oxides of nitrogen in the most polluted areas of the country; and the desired level necessary to avoid unnecessary health hazards. In other words, we must find out where we are, and where we are going in order to know what to do to get there.

The EPA has shown that the original NAPCA determinations on these points made in 1970 were both substantially overstated.

First, as EPA recently testified before a Senate subcommittee, the current levels of oxides of nitrogen in the atmosphere are actually much lower than they were originally thought to be.

Second, as far as determining of where we are going is concerned, the original NAPCA advice to Congress in 1970 assumed the value for this level. Later, when EPA promulgated the NO<sub>2</sub> air quality standard, it was several times less stringent than the originally assumed values. By that time, however, the 90-percent automotive reduction in NO<sub>x</sub> emissions was frozen into the Clean Air Amendments of 1970.

The 0.4 gpm NO<sub>x</sub> standard is the result of these errors.

Until Congress acts on EPA's recommendation, the entire auto industry emission research and development program must be based on the assumption that this level for NO<sub>x</sub> remains in effect.

The expenditure of resources and manpower in the direction of control of NO<sub>x</sub> is far from trivial. A significant portion of General Motors' effort is unfortunately keyed to this problem. We should be turning our attention to means for conserving energy rather than continuing to pursue the unjustified NO<sub>x</sub> standard which takes us in the opposite direction.

Because alternate powerplants which yield promising HC and CO levels do not meet the 0.4 gpm NO<sub>x</sub> standard, their development is also restricted. This further underscores the urgent need to resolve the NO<sub>x</sub> question.

#### ERRORS IN INTERPRETING VALIDITY OF ORIGINAL AND CO STANDARDS

In recommending the General Motors 1 gpm HC and 17 gpm CO standards as adequate protection to clean air, it might appear that General Motors is at variance with the conclusion of EPA on these standards in its recent publication entitled "Clean Air and the Automobile." (June 22, 1973.)<sup>1</sup>

<sup>1</sup>The major claim of this statement is that even with statutory 1976 HC and CO automotive standards of 0.41 and 3.4 gpm, respectively several air quality regions will not meet national clean air requirements.

This is not really the case. Two factors explain the apparent difference.

The first factor is that EPA, in its latest analysis of the necessary levels for automotive emission standards, has assumed that no significant increased control over stationary sources in urban areas will be affected during the period between now and 1985-86. It is not justifiable, either from the standpoint of cost/benefit, or from the standpoint of realistic approach to cleaning up our air, that the contributors of controls on nonvehicular sources be ignored in such analysis. This is particularly true since serious transportation controls, such as large-scale gas rationing, are proposed as a consequence of applying such an unreasonable effective date for the ambient air quality standards.

I would like to say at this point, Mr. Chairman, that, as one example of the effort that General Motors is making to clean up stationary sources, we have taken the liberty of including with our formal presentation a pamphlet on stack gas sulfur dioxide control. I think you will find this enclosed with the material we have submitted.

Now getting back to the second factor, the apparent disparity between EPA and ourselves, this has to do with the lack of correlation of effective dates for compliance between different control programs under the act. In the 1970 amendments to the Clean Air Act, it was provided that EPA must require urban areas to comply with air quality standards by the year 1975, or 1977, if a delay is granted. The year 1975 is the same compliance date that applies to new automobiles indicating when their most sophisticated control systems must be installed.

While this duplication of compliance dates may sound immaterial to the casual observer, it is completely illogical to experts in the field. In other words, what justification is there for requiring ambient air to achieve its desired degree of purity before the sophisticated emission control systems required on automobiles will have any significant impact on ambient air quality?

By 1985, most vehicles will be equipped with advanced control systems so that the atmosphere in even the most highly stressed urban areas of our country would be in conformity with what the EPA has chosen to define as acceptable air quality. However, this assumes there is at least reasonable control of stationary source pollution.

#### NEED FOR UNLEADED GASOLINE

General Motors believes that unleaded fuel is necessary for both the current emission levels and for the proposed 1975-76 standards, for a number of reasons.

In the absence of a catalytic converter there is ample evidence that unleaded fuel results in:

- Reduced hydrocarbon emissions.
- Reduced particulates emissions.
- Lower engine deterioration rates.
- Improved spark plug life.
- Reduced owner maintenance.
- Elimination of possible toxicity problems.

With catalytic aftertreatment of the exhaust, which in any circumstance will provide for better driveability and fuel economy, the avail-

ability of unleaded gasoline is absolutely required. As will be shown later in this statement, the return to the consumer in terms of fuel economy will more than offset the added cost of the catalytic converter, and usually in the first year of operation.

#### OTHER PROBLEMS RELATED TO THE CLEAN AIR ACT

The issue of "averaging" of emissions of vehicles on the assembly line and in the field has been discussed many times. It bears repeating because of its extreme importance to the mass production concept. Despite continuing progress in quality control, we have no reason to believe that every one of our production vehicles can meet the extremely low emission standards imposed by the 90 percent reductions of the Clean Air Amendments of 1970.

Perhaps more importantly, there is no need for each car to meet the standards. The atmosphere responds to the average emissions from all the vehicles and most control theory and technology applicable to ambient air, historically, has been based upon this very practical reality.

The averaging concept is not an antipollution control concept at all. It merely says that because of unavoidable variance in mass production of engines and components, production of a system designed to meet a standard will result in enough variances on the low emission side to compensate for all variances on the high emission side with the vast preponderance of production being at or below the prescribed legal level.

There is good reason to believe that there is now a way to provide a better check on production vehicle compliance than through use of the preproduction test and certification process. This might well be studied along with other problems and if true, as we believe, certification could be eliminated in favor of the superior method of testing of emissions at the end of the assembly line, through statistically adequate sampling.

#### DECLINE IN AUTOMOTIVE EMISSIONS

While we are making several recommendations with respect to standards and compliance procedures under the Clean Air Act, air quality would not suffer measurably by the adoption of these statutory recommendations. Our cars produced during this time will continue to contribute to the reduction in automotive emissions to the atmosphere. In our statement submitted for the record are projections, prepared by General Motors Research Laboratories, of ambient air quality in 16 cities under the proposed interim standards as compared to the original 1976 Federal emission standards.

#### ACTION WHILE THE NAS STUDY PROCEEDS

Furthermore, through the NAS study, Congress has an opportunity to review the problems we've discussed and at the same time permit, (1) a test of what catalytic converter technology can accomplish in mass field use and (2) time to proceed with further development of other possible powerplant or control concepts.

In response to such congressional action, General Motors pledges to make every constructive effort we can to look for any feasible solution that will do the emissions control job better than the catalytic converter system.

We are not wedded to any particular form of emissions control. We have been working with the catalytic converter to solve a short term problem. However, this does not mean that we will not try to find solutions in other technologies.

Now, I'd like to discuss our progress and plans for the future.

#### GM PROGRESS AND PLANS FOR MEETING EMISSIONS STANDARDS: 1975-76

During 1972, General Motors spent \$238 million on making emission controls more efficient and effective, on research to develop new emission control systems and for related facilities and tooling. This year, we expect to spend about \$350 million. These expenditures do not include the cost of hardware installed in our manufactured vehicles.

By the end of this year, our cumulative expenditures in these areas for the period 1967-73 will exceed \$1 billion. We are now estimating expenditures of approximately another \$1 billion in this effort during 1974-76.

We now have the equivalent of more than 4,200 full-time scientists, engineers, technicians, and supporting staff committed to the task of removing the automobile from the air pollution problem. We submit that this commitment in money and personnel amply support the EPA Administrator's findings as to GM's good faith.

The 1975 General Motors cars will meet the two sets of standards of emission control established by the EPA—one for California and another for the rest of the Nation.

#### CALIFORNIA 1975 CONTROL SYSTEMS

In California, the system is designed to reduce emissions of hydrocarbons by 94 percent, carbon monoxide by 90 percent, and oxides of nitrogen by 60 percent, compared with uncontrolled cars of 1960.

General Motors will use a catalytic converter either mounted under the car's floor or on the engine for meeting the 1975 interim California standards—incidentally, we have examples of these catalytic converters with us today—and, as we now see it, on probably most of our vehicles for the national interim standards as well.

It is probable that our 1975 California system will also include all the basic components currently on a 1973 vehicle—exhaust gas recirculation, evaporative emission system, PCV valve, spark control system, and air pumps as required.

It is also probable, based on our current planning, that the majority of our 1975 cars will have new carburetion and ignition systems to maintain or improve fuel economy and engine performance; and in most cases—perhaps all—catalytic converters may also be necessary or desirable.

Based on our extensive research and engineering effort, we believe a system which includes a catalytic converter is the best choice of avail-

able alternatives at this time from the standpoint of emission control, durability, low maintenance, drivability, cost to the consumer, and especially fuel economy.

None of the potential alternate powerplants satisfied all of these requirements and at the same time had realistic prospects to meet all requirements of the 1975 and 1976 standards.

#### FORTY-NINE-STATE 1975 CONTROL SYSTEMS

As to the interim 1975 standards in the 49 States other than California, our concern is that trying to meet these tough standards within the time available without catalytic converters might mean, in many cases, further losses in fuel economy and engine performance, and less assurance that the required emission levels could be maintained in the field.

We are doing everything we can to make sure that, if we install catalytic converter systems nationwide, we can do so with a minimum of uncertainty and disruption to our company, our dealers, our customers, and the public.

#### PROGRESS IN CATALYTIC CONVERTER DEVELOPMENT

It has been suggested that the fuel penalty will be excessive, that catalytic converter control systems will be too expensive, and that the U.S. balance of payments will be affected unfavorably.

Without lengthening comments on each of these claims, there are answers available, supplemented by the material in this section of our statement:

First, for 1975 models there will be a saving in fuel consumption through use of the converter.

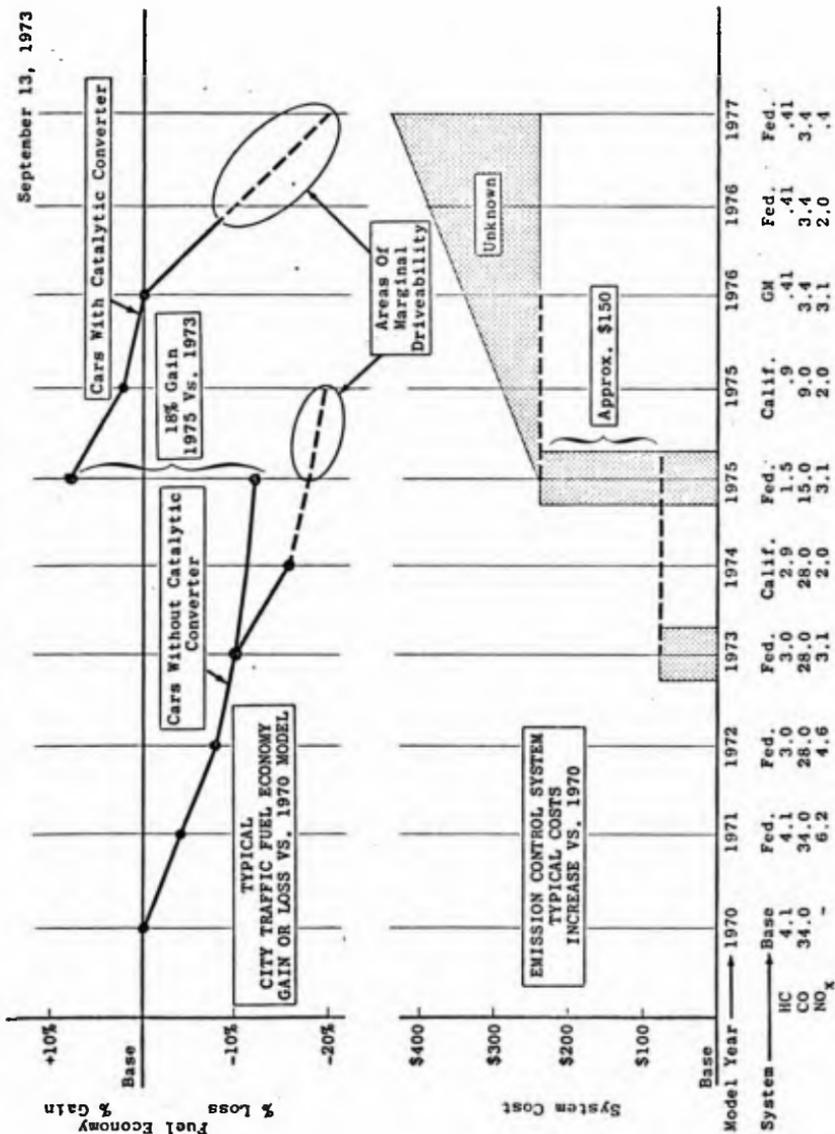
Second, the fuel economies, which our data show are available for 1975 models through use of the catalytic converters will repay new car purchasers for the cost of the system in the first year of use.

Third, there should be no net, overall unfavorable effect on U.S. balance of payments with respect to GM cars when fuel economy is taken into account.

Despite the need to import platinum and palladium, the fuel savings and therefore the reduced need to import foreign oil will offset this disadvantage.

If you will refer to the chart on the following page, you will note that since 1970, I suggest the chart is a little complicated and we can go into explanation after I finish my presentation, if you would like—however emission levels, along with more stringent requirements for certification vehicles have resulted in fuel economy penalties. This is shown by the line marked "Cars without Catalytic Converters."

TRENDS: FUEL ECONOMY VS. EMISSIONS, COST VS. EMISSIONS  
1970 BASE YEAR TO 1977 (PROJECTED)



The installation of catalytic converters, illustrated by the line at the top, will increase the purchase price cost (approximately one-half of the total additional 1975 system cost of \$150). Costs are shown by the bars at the bottom. However, the benefits are clear; a decided improvement in economy, higher than even the base year. Customer benefits also include the advantages of engines optimized for efficiency; better driveability and starting.

As we stated previously, the savings in fuel cost and maintenance more than pay for the 1975 system in the first year—assuming normal mileage accumulation.

We are still concerned over the adequacy of customer vehicle maintenance practices. We are also concerned over the availability of the proper fuel and the measures which must be taken to assure its exclusive use.

We want to emphasize that, on a per-car basis, the cost of the platinum and palladium used in the catalyst will not be exorbitant—about \$6.

We are continuing to make what we believe is every constructive effort to look for any feasible solution that will do the emission control job better than the catalytic converter. We have been working with the catalytic converter to solve a legislated short-term problem, but we are not wedded to it. We will try to find solutions in other technologies. We have a competitive incentive to meet the standards in the most effective and efficient way from the standpoint of our customers.

#### ALTERNATE POWERPLANTS

Other technologies than piston engines have been under development. They have been discussed by many witnesses at previous congressional hearings. The dilute combustion (or stratified charge), rotary, turbine, and diesel powerplants all have had their advocates.

Based on the data presented, various alternate techniques appear to have some promise for small portions of the basic demand of the total U.S. car market.

Indeed, we intend to market a rotary-powered passenger car during the 1975 model year which will be equipped with emission control systems to permit its full compliance with the Clean Air Act. We are actively examining other powerplants to see if any have the best potential for use in GM cars, and we are continuing our research and development on other technologies.

One of these is the dilute combustion engine. This includes the stratified-charge powerplant, or which there are many variations. While we do not know all of its details, Honda's CVCC is one of the variations.

General Motors has not rejected the stratified-charge engine as a possible alternate powerplant in its future model vehicles. On the contrary, in the past year we have expanded our research and development effort in this area.

#### SUMMARY AND CONCLUSION

Summarizing then, we are doing all we can to meet applicable automotive emission standards on our future products. For the immediate future, we will be able to comply. For the 1976 models, due to the

opposing technologies involved and the lack of recognition of averaging of production variances, we are unable to make the same commitment. Rather, we must state today that we do not have the technology to mass produce cars, every one of which will meet the 1976 interim or 1977 standards.

Our most urgent need is for Congress to provide immediate relief from the unnecessarily stringent  $\text{NO}_x$  standard, which was established on a twofold error and is admittedly unsupportable now. This action is essential to permit auto manufacturers their best possibility of achieving alternate powerplant potential or the ultimate automotive emission standards. Due to leadtime problems of our industry, each day this change is delayed can bring unnecessary costs and other problems to the public.

While Congress is undertaking a study of new data on the validity of current legislated auto air quality standards, General Motors has completed its in-depth review and has made recommendations based upon this data. The automotive standards proposed—in grams per mile—by GM to 1.0 HC, 17 CO and 1.5  $\text{NO}_x$  for California, and 1.7 HC, 17 CO and 3.1  $\text{NO}_x$  for all other States are adequate to protect the public health and welfare.

However, until the NAS study can be completed, GM has recommended in testimony before the U.S. Senate, and now before your committee, that standards no more stringent than the EPA 1975 California interim requirements be frozen into law for such time as Congress feels is necessary to permit its analysis and action based upon results of the study.

We have also shown that automotive emissions are being reduced on new cars to a significant degree. These and reductions from previous models of a similar nature are resulting in a cleaner atmosphere—even in California.

In conclusion, you may be assured that General Motors remains committed to completing the job of removing the automobile as a contributor to the Nation's air pollution problem and at the earliest possible time.

Mr. SYMINGTON [presiding]. Thank you, Mr. Starkman, for that thorough statement. I am going to apologize to you for the ingress and egress of members. We have had some votes during the statement. I think most of us have had a chance to read it through.

I would like to ask you what problems are presented by that law that requires that each car be warranted as meeting the 1975-76 standards if in fact you will achieve what you describe as an average standard performance?

Mr. STARKMAN. These problems are substantial, Mr. Chairman. The construction of automobiles has implicit within it, or any other manufactured product, a certain amount of variability. The automobile industry has been able to improve its capability to reduce those variations over the years, in some cases to a remarkable degree, and the interchangeability of parts has been improved as a consequence of reducing those variations. Nevertheless, the complexity of the automobile includes many, many factors contributing to emissions and there are almost a hundred of them. They vary from the rear end or differential system to such things, as you might guess, as the carburetion, timing, and compression ratio. There is a distribution curve of emission

levels in manufacturing cars which otherwise are essentially identical. Some cars provide emission levels that are higher than the average of their counterpart and some produce emissions which are lower.

In the instance where the automobile industry has its target, we will say for purposes of engineering example, that not more than 1 percent of the cars can exceed a given absolute level, we design for something that is about 50 percent of that level in the emissions area. In effect we are saying that the average of all those cars must have an emissions level that is about one-half of what was intended by Congress in designing the law in order that not more than about 1 percent will exceed that level. Even then we cannot guarantee that not more than 1 percent will exceed that level.

This imposes on the automobile industry a very unnecessary constraint. I think more to the point, if I may say so this effectively, if it could be done, would reduce the emissions produced by automobiles by a factor of two greater than was intended.

Mr. SYMINGTON. If I understand you correctly, what you are saying now is that less than 1 percent of the vehicles produced would exceed the emission standard. Is that so?

Mr. STARKMAN. If we made the average of our automobiles meet a standard that is only half of that particular target. This is because of the shape of the distribution curve.

Mr. SYMINGTON. That would be your intention?

Mr. STARKMAN. If we were charged to have to meet any given level, and as a matter of fact that is the way we proceed to meet a production target, we set a target. After we set the target, we determine by how much we must have to go below that given level in order to be assured that we won't exceed the target by more than a very, very small fraction. How do we assure ourselves that we accomplish this? We do it, in this case by measuring those vehicles for emissions on a statistical basis after we produce them.

We now do this for California cars. Two percent of all cars sold in California have a full emission test done on them. It takes 24 hours to carry the test out. So we have some experience with what is happening in California with respect to our capability to build cars to meet such targets.

Mr. SYMINGTON. You are saying, are you not, that while you can be reasonably certain that less than 1 percent or 2 percent of produced vehicles standards you don't know, other than those you have tested, you don't know which ones they are that might?

Mr. STARKMAN. We cannot point a finger to a specific one that might, except by a sampling procedure or testing each one. Don't misunderstand me. Some components we test 100 percent. Right now we test our carburetors 100 percent, every one of them, because the standards we have to apply to the flow rate of gasoline to the carburetor are so extremely exact in order to accommodate the pollution levels we are allowed.

Mr. SYMINGTON. Should we derive from your testimony that it is not feasible to require a warranty on each automobile produced that it meets the standard?

Mr. STARKMAN. At the present moment, it is completely impossible for us to test each and every car for this complete cycle, each and every car that comes off the assembly line, even for California, much less for the whole Nation.

As a consequence, we cannot stand flatfootedly and say each and every car produced at the end of the assembly line falls within this level. We design so that a maximum of them can, and it is a very, very small fraction that does not.

Mr. SYMINGTON. I understand. You say at the present moment you expect to develop such a competency in the future at a cost you can sustain, or do you not expect that?

Mr. STARKMAN. For the purpose of emission control, I don't see any method in sight except by testing the car by a full procedure. Perhaps Mr. Stemple can enlarge on this.

Mr. STEMPLE. With today's 1973 vehicle which is built to a hydrocarbon standard of 3.4 grams per mile, the average vehicle itself, as built, has more in the vicinity of 2 grams per mile, so that the distribution of those cars varying from that norm somewhat is not going to exceed the 3.4. That is Mr. Starkman's point.

Substantially the bulk of our cars built today are significantly below the standard. If we look ahead to the interim 1975 Federal, at 1.5 grams per mile hydrocarbon, the target we are shooting at federally is in the order of point eight to point nine gram per mile. You can see in an attempt to get all the cars within the standard as has generally been the interpretation of the act, the actual design target is significantly less than the statutory limit.

Mr. SYMINGTON. Do you suggest then that the overall requirement should be modified to be one that is of general application to the process itself rather than one which applies to each car produced?

Mr. STARKMAN. We strongly suggest this, Mr. Chairman.

Mr. SYMINGTON. What are some of the requirements subjected to a test that can be made comparable to the type of test you would perform, and if found wanting in this respect would that be a car you would like to have back to work on?

Mr. STARKMAN. A very good example, Mr. Chairman, is in this 2-percent sample for California, we do find cars that exceed and we correct them. If a car does exceed, we can normally determine what the case is and we correct it.

Mr. SYMINGTON. You made a comment about unleaded gasoline, about greater efficiency. Is that true, therefore, energy conserving?

Mr. STARKMAN. What I think we tried to say is, firstly, unleaded gasoline is absolutely necessary for cars with catalytic converters. I tried to say in addition, that for cars which do not have catalytic converters, there are benefits to using unleaded gasoline. These benefits I delineated. The benefits range from lower emissions from a particular car, to longer spark-plug life and less oil deterioration. There are about five factors I recall I delineated.

I tried to say it is not so that the unleaded gasoline is a benefit only in the case of catalytic-equipped cars, it is a benefit otherwise for cars that don't have catalysts.

Mr. SYMINGTON. Isn't it true that to produce unleaded gasoline, more crude is required?

Mr. STARKMAN. This depends. If one assumes that the octane number of the gasoline required by the cars is an octane number which is available by not adding lead to the gasoline, then no more crude is required. Now, in 1970, General Motors stated that it thought unleaded gasoline was a requirement for the future, and as a consequence

it would reduce the compression ratios and do other things to its automobiles in order that all of its automobiles subsequently would run on 91 octane gasolines.

You may ask, why 91 octane gasoline? For the reason that it was General Motors conclusion that 91 octane was very close to what would be the average octane number if you mixed all of the fuels together in the country and didn't add any lead.

Now, the capability from refinery to refinery does vary such that some refineries may have to upgrade their capability. Other refineries can do better than 91.

I have to make an additional point or two here if you will allow me. One is that the unleaded gasoline situation has been a little confused. I believe, in the presumption that perhaps we would have to replace our 100 octane fuel, our 95 octane fuel, and our 91 octane fuel all with unleaded gasoline. Now, if one did indeed have to replace the present mix to take care of the cars that we have built in the past, or what the public has got used to, then I would agree with your statement. Yes, it would take more of a barrel to produce a gallon of gasoline. However, we don't think that this factor is there in the future, and we intend to commit ourselves to producing cars that do not require greater than 91 octane number gas.

Mr. SYMINGTON. Thank you, Mr. Chairman.

Mr. Chairman, I will turn it over to you.

Mr. ROGERS. I presume that could even be less costly to the public. the lower octane gas?

Mr. STARKMAN. We believe it can be, because of the attendant advantages of less maintenance and less deterioration, not just on these components I referred to but on such things as exhaust systems, which suffer from deterioration due to lead components.

Mr. ROGERS. Mr. Nelsen.

Mr. NELSEN. What was the reason for going to a leaded gasoline in the first place, what prompted that change, the higher compression engine and what else?

Mr. STARKMAN. That is correct. The improvement of the anti-knock quality of gasoline in any event is done more effectively at less cost through the use of lead alkyls, such as tetraethyl lead. This is the cheapest way to get antiknock quality.

Mr. NELSEN. Are you able to get the knock out of an engine successfully with different designs now, with nonlead gasoline?

Mr. STARKMAN. So as not to monopolize this area of questioning, and because of Mr. Stempel's background, let me allow him to answer the question.

Mr. STEMPER. We basically have designed the engine to efficiently utilize 91 octane fuel. That has required adjustment of the compression ratio, the chamber design, and at the same time modification of the chamber to avoid problems such as surface to volume ratio. Historically, increasing compression ratio did improve gasoline mileage. At that time, however, gasoline octane was limited and the addition of lead made possible high compression ratios without knocks or detonation.

The thing that has come on us in recent years has been an addition of another parameter, that of hydrocarbon emissions. Eventually, we find as we go on from 1968, 1969, 1970, 1971, that the restrictions

imposed by hydrocarbon control meant that we were no longer operating a high compression engine near the knock limit or near the limit of fuel availability, but rather at the hydrocarbon limit. We were severely detuning. It became apparent to us that the requirement for hydrocarbon was the stricter of the two.

As a result of having to back down it became apparent that we could more efficiently control hydrocarbon and maintain the economy at a lower compression ratio using, as Mr. Starkman has outlined, the 91 octane fuel.

**Mr. NELSEN.** Referring again to the fuel injector, I remember seeing a small automobile with a very small engine, and I am trying to recall where it was, it was at an automobile show. It was not a large engine and it was not a diesel engine. I was curious about the fuel injector thing. You have the injection of the fuel under pressure which would vaporize it more, therefore would create better combustion.

I wondered if you have any comment relative to that?

**Mr. STEMPER.** We have been rather fascinated by fuel injection ourselves. Typically it has always appeared to us that fuel injection should do a better job of metering the fuel to each cylinder. The one thing that has happened, though, in time with the advent of emission controls, and the concentration on trying to keep our vehicles operating as efficiently as possible, has been the parallel program of improvement in carburetion. Fuel injection adapted to a modern V-8 engine has shown to be almost as good as a good carburetor.

What has happened is that the V-8 manifold has been developed for operation in a close space, and therefore it has good air flow characteristic to each cylinder. The carburetor acts as a single mixing chamber, so we have a very homogenous air-fuel mixture with about the same ratio to each cylinder. When we attempt to do that with eight separate injectors, you are correct. We do have a fog of fuel that vaporizes quickly, but minute differences in the control of the time of the injector means that each cylinder can see a different air-fuel ratio. It is difficult to control that.

The case that you make of a smaller engine, for instance, if it was a four cylinder inline engine, the manifolding of those engines is very difficult. It is not quite as nice and compact or flow-tailorable, if you will, as a V-8, but a long skinny manifold with the center cylinders tending to be rich and the ends to be lean. On those engines we do find some gains with fuel injection.

We do hope to have on the market very shortly this year, model year 1974, a four cylinder engine that does utilize an electronic fuel injector system. It is highly sophisticated. We believe we do have precise metering control and it does show us some gain in emission control. We are continuing to work with that.

Experimentally we are looking at that system on V-8's. We may be able to reach the level of sophistication where the carburetor will be replaced. For the time being it appears that the carburetor is still with us for a few years.

**Mr. NELSEN.** I have a complaint with my General Motors car, driving a V-6 Buick, it has 95,000 miles on it, it still doesn't use any oil and I can't wear it out. I think I am entitled to a new car pretty soon.

**Mr. STARKMAN.** I will carry that complaint back to my superiors.

Mr. NELSEN. Thank you.

Mr. HEINZ. I will trade cars with you. I have a 1973 Buick. I would be most pleased to trade my 1973 Buick for yours.

Mr. NELSEN. That is a deal.

Mr. ROGERS. Dr. Carter.

Mr. CARTER. Thank you, Mr. Chairman.

I notice one of you gentlemen is Dr. Bowditch, is that right? I believe I met you before.

Dr. BOWDITCH. Yes.

Mr. CARTER. Are you of the Bowditch navigation family?

Dr. BOWDITCH. That is the one relative we agree we are related to. That is true.

Mr. CARTER. I used that book some years ago in getting my logarithms. Really I think every navigator uses it regularly. Not that I ever navigated.

My son has a Monte Carlo. I have a Ford. Being a political family we have to go around. I have found out that you have improved the driveability of your car in the past few years.

Of course the committee did cause you a great deal of trouble, I realize that, and perhaps we should have gone more slowly. I think most of the people in our country feel that we compressed the time in which you should reach certain goals too much and to your disadvantage. As a result of that we decreased the driveability of some of our cars and increased the gasoline consumption, caused you to do that, rather. Is that correct?

Mr. STARKMAN. That is correct, Dr. Carter. We are obviously unhappy about the consequences of reducing emissions at the expense of some driveability and fuel consumption of our vehicles. We are trying and what we presented here today with respect to what can be accomplished with catalytic converters will indicate an attempt to get back to the kind of driveability that we used to have, and to improve the fuel economy to at least that which we used to enjoy.

Mr. CARTER. I certainly think you are making a great deal of improvement because I have driven my son's car and I have found it much more driveable than one of your cars we previously owned. It is thriftier.

In making a new car you have retarded the spark, is that correct?

Mr. STARKMAN. That is correct.

Mr. CARTER. Lowered the compression ratio.

Mr. STARKMAN. In some cars. We had a number of cars prior to the 1971 models that had compression ratios such that 91 octane fuel was satisfactory. These cars were sufficiently low in oxides of nitrogen emissions that we didn't have to modify them very much, if at all. The other cars we had to modify the compression ratio.

Mr. CARTER. You are using a leaner mixture, is that correct?

Mr. STARKMAN. To date we have gone in the direction of leaning the mixture considerably.

Mr. CARTER. Yes; and that did hurt the drivability. According to your figures, I think you have answered this question though, but a catalytic converter will cost you how much more?

Mr. STARKMAN. \$150 for the complete system. By that we mean all of those components in addition to the catalyst, container, and the

pellets and its attachments. The catalytic converter unit as such we think will cost the consumer about \$75.

Mr. CARTER. Have you checked emissions coming from your cars with a catalytic converter in place?

Mr. STARKMAN. Yes; many, many of them. I perhaps should let Mr. Stempel answer this one. He has had a large part to play in the development of catalyst equipped test vehicles and fleets of catalyst equipped vehicles that we actually have in the field. Maybe he can tell you in a few moments what we are doing by way of checking both prototype and field vehicles with catalyst systems on them.

Mr. STEMPEL. Currently we have in our own development fleet 421 cars with something over 8 million test miles accumulated on catalytic converters. These cars are tested quite often, quite frequently both on a standard cold CBS sampling test for typical emissions of hydrocarbons, CO and NO<sub>x</sub> as well as various studies on the converter, itself, for both particle emissions and other noxious emissions. In addition to that we have several large fleets either started or underway where cars are actually in the hands of typical customers in the field doing a variety of things with automobiles just as they would normally use their cars. We are gaining a lot of knowledge about how these vehicles perform in the hands of customers in the field as well as by prescribed tests on experimental vehicles operated on General Motors proving grounds.

Mr. CARTER. Are many of these emissions toxic that come from the catalytic converter?

Mr. STARKMAN. I think I may, for the answer to that question, call on Dr. Charles Tuesday. He is head of the Environmental Sciences Department of General Motors Research. Dr. Tuesday has been in charge of or closely associated with the work we are doing to make sure that by putting catalysts on we don't worsen a situation rather than improve it.

Dr. TUESDAY. We have a very extensive program with essentially two facets. One facet is to see if anything at all that we don't really want is coming out of a car equipped with a catalytic converter that is operating as it is supposed to, the second facet is to see if there is any way anything can go wrong with the control system or the catalyst (something that could possibly happen in the field) that might produce something that would be obnoxious.

Up to this point in time we have found, as other people have found, oxidation of SO<sub>2</sub> to sulfuric acid. However, it should be remembered that less than 5 percent of the SO<sub>2</sub> in exhaust is oxidized to sulfuric acid. It should also be noted that according to the EPA the exhaust gas of gasoline powered motor vehicles on a national basis contributes only six-tenths of 1 percent of the SO<sub>2</sub> from all sources. Therefore, 99.4 percent of the SO<sub>2</sub> emitted is coming from someplace else.

It is generally agreed that the ultimate fate of all SO<sub>2</sub> is eventually sulfuric acid or other sulfates. Thus all the SO<sub>2</sub> that goes in the air eventually ends up as sulfate. Twenty percent of that happens within the urban area, the other 80 percent perhaps in rural areas.

Mr. CARTER. There will not be enough sulfuric acid formed from the SO<sub>2</sub> to cause difficulty.

Dr. TUESDAY. Not unless there is a significant increase in the sulfur level of gasoline. It is obvious that the sulfur comes from the gasoline.

The automobile manufacturers could do without it entirely. The removal of sulfur will add to the price of gasoline, I am sure. If the levels of sulfur in gas should increase over what they are right now—

Mr. CARTER. They will not, you think, affect the air causing a dangerous level of sulfuric acid mist, is that correct?

Dr. TUESDAY. It is generally agreed that  $\text{SO}_2$  and sulfates are not good. Approximately 99.4 percent of  $\text{SO}_2$  and sulfates now come from sources other than automobiles. So, unless the 99.4 percent of these  $\text{SO}_2$  emissions are eliminated by some control mechanism, the very small amount that comes from sulfur in gasoline is insignificant. If, however, these other sources are controlled so that most of these emissions are eliminated, then the automobile contribution might become significant.

Mr. CARTER. I believe your company manufactures about 3 million cars a year, is that correct?

Mr. STARKMAN. I think about twice that number.

Mr. CARTER. 6 million, excuse me. What is the total output of the automotive industry?

Mr. STARKMAN. Roughly for the past model year I think it will be 14 million automobiles, passenger automobiles, trucks, and buses.

Mr. CARTER. With that number of catalytic converters then in 1975 and thereafter do you still think there will not be enough  $\text{SO}_2$  and from that sulfuric acid mist to affect the health of the people?

Dr. TUESDAY. I would say we could go further. If all automobiles would simultaneously change to these converters the rise in sulfuric acid in the air would be insignificant compared to what is coming from other sources in a typical urban area such as Washington, D.C., for example.

Mr. STARKMAN. Let me take another try at this. What Dr. Tuesday has said is that the contribution of oxides of sulfur from automobiles, whatever the form, is a very, very minor amount of the oxides of sulfur that get into the atmosphere. I think he also said that the oxides of sulfur that get in the atmosphere as  $\text{SO}_2$  are by natural processes converted to  $\text{SO}_3$  anyway and can become  $\text{H}_2\text{SO}_4$ , or sulfuric acid. As a consequence, any modification that takes place in a catalytic converter of a car even if it was significant, which it isn't, would be nothing more than a hastening of the process of oxidation of  $\text{SO}_2$  to  $\text{SO}_3$ , which will take place in the atmosphere in any event.

Mr. CARTER. My interest is that it does not reach dangerous levels. I understand you are experimenting with the rotary or Wankel engine, is that correct?

Mr. STARKMAN. We are doing more than just experimenting. We are in the initial phases of getting ready for production in the 1975 model car. We hope to be able to be marketing a 1975 model with the rotary combustion engine in it.

Mr. CARTER. It uses a considerable amount of oil, is that correct?

Mr. STARKMAN. The experience to date with rotary engines on the road has indicated that in the process of lubrication their oil consumption is higher than the counterpart piston engine. Our effort, of course, is in the direction of reducing that lubricating oil consumption to a level that is no greater, if not less, if we can accomplish it, than its counterpart reciprocating engine.

Mr. Stempel may want to add something to this.

Mr. STEMPEL. Our rotary development should not be confused with other rotary engines. We refer to it as a General Motors rotary engine. The difference is that our approach is somewhat different from the others. We believe very strongly that oil consumption is critical. The more oil that is used requires more to be refined, and made available as a lubricant.

Looking at the oil demand supply curve it is necessary that we conserve it. We have done quite a bit with our piston engine to get into the 2,000 mile quart consumption range. This is considered to be a good oil consumption level. We are attempting to get our rotary engine up in that same range. Currently we are in the 1,500 mile per quart range. We want to get it a little better before we introduce it to production.

We also made other changes in that engine to bring its economy up to where it is equivalent to a piston type engine. We think today if you come on the market with any new engine and alternate powerplant such as a rotary or stratified charge, that it must be at least as good as its equivalent performing piston engine in terms of oil consumption and fuel usage. It could not certainly be worse than that.

Mr. CARTER. What are the toxic products which come from the oil used in this engine?

Mr. STARKMAN. I would presume that the lubricating oil products, whether they be combustion products or otherwise should be no different in character or quantity than one would expect from a reciprocating engine counterpart. I am aware of no special problems as regards toxicity.

Mr. CARTER. I think there is a problem, and I believe it has been stated here, that since this particular engine uses more lubricating oil that there is a problem with the emissions, some toxic substance.

Mr. STEMPEL. If the engine did use more oil the hydrocarbon content would be up. Keep in mind the engine still has a closed crankcase situation here. We are endeavoring to get the oil level to that equivalent to a piston engine. The product of combustion out of the tailpipe will be very similar to that of the piston engine, or we hope in terms of emissions lower than.

Mr. CARTER. How do you define NIH?

Mr. STARKMAN. We heard the discussion this morning and this afternoon with Mr. Misch of Ford and the "not invented here" we have heard before. I presume you are making reference to "not invented here" in quotes.

Mr. CARTER. That is right. I see you are not really adverse to that because you have a rotary engine somewhat like the Wankel anyway. I am happy to know that you are improving on it.

You have a General Motors proving ground at Mesa, Ariz., do you not?

Mr. STARKMAN. That is correct.

Mr. CARTER. Some of your cars, I am sure many of them, have been tested there with many different devices. Have you ever had an afterburner test out there that was quite effective or not?

Mr. STARKMAN. We have had many, many tests. We work with thermal devices as well as catalytic. The afterburner is a form of thermal converter device.

Mr. CARTER. How did you come out with this afterburner?

Mr. STARKMAN. At this point in our development we do not believe that the thermal reactor is the direction in which to go. If there is any one very large reason we believe that the thermal reactor is not as promising as a catalytic converter it is because we have as yet not seen a successful thermal reactor that does not require a very rich mixture to the engine and, therefore, an increase in fuel consumption.

Mr. CARTER. I am referring now to a car which you actually tested there. Some data which I have shows that in grams per mile you got below the 2 grams per mile level with  $\text{NO}_x$ , in fact on one occasion, 0.70 grams of  $\text{NO}_x$  per mile. Is that correct?

Mr. STARKMAN. Let me refer this again to Mr. Stempel. I think that the particular tests you are talking about are ones in which he has been engaged and has been closely associated with. He knows perhaps more about this particular aspect than either Mr. Misch or myself.

Mr. STEMPEL. I believe the test you have reference to refers to a company identified by the name of Vortex conducted at our desert proving ground. We at General Motors did make our desert proving ground available to that company to test its afterburner device. We have made it available to them on many occasions. We have reviewed their device and are interested in any device that shows promise of reducing emissions. You will note from that test on that vehicle that they used, I believe, a 1965 Chevrolet vehicle. It was modified so that they could fit on the afterburner device. Also in some of the correspondence we have had with the company they indicate that the device has a nominal cost.

It should be noted that the car had additional modification such as the air injection reactor pump added to provide a source of air in the afterburner, as well as modifications to the spark control system. It did, however, retain the same 1965 carburetor because it was rich enough to work in conjunction with an afterburner.

The numbers of the data from that vehicle in terms of all three constituents, hydrocarbons, CO and  $\text{NO}_x$ , are not sufficiently promising in terms of the 1975 interim Federal standards of 1.5, 15, and 3.1. The CO number exceeds the Federal standard. Also, the data are not promising in terms of the California  $\text{NO}_x$  standard in light of the low levels for hydrocarbons and CO's required with it.

That system perhaps would have application at the 1973 level for instance, but for the upcoming more stringent combination of hydrocarbon—CO and  $\text{NO}_x$  does not appear to have the ability to meet it. Further, I think if you have the right data sheet there, you will note that the miles per gallon on that particular test were of concern to us because the fuel economy was down.

We have been generally taking the approach with our new lower emission control systems that we should strive to improve fuel economy and that seemed to be at odds with our system.

Mr. CARTER. The 1975 emissions for  $\text{NO}_x$  is 0.41, is that correct?

Mr. STEMPEL. The 1975 interim would be 3.1, 1976 established 2, and 1977 statutorily would be 0.41.

Mr. CARTER. I think all these show less than 2 grams per mile.

Mr. STEMPEL. They have generally been in the range of 2 grams per mile, that is correct. However, that is with CO averages in the neighborhood of 16, 15, 18. I am recalling now but generally in that range.

In conjunction with  $\text{NO}_x$  limits of 2, the maximum CO allowed is 3.4.

Mr. CARTER. I have taken up a lot of time. I want to ask just one other question. When you spoke of the fuel injection, that sort of interested me. I believe you say it is efficient only in small engines, is that correct?

Mr. STEMPER. Currently our best efficiency is arrived at on an engine; for example, a four-cylinder in-line engine. Comparing a carburetor on a long manifold versus fuel injection, we appear to do a better job with a fuel injection. On our experimental V-8 engine, the new carburetors that are part of our 1975 system are doing a better job than fuel injection, but I did indicate we are continuing to work on it. It is a promising development.

Mr. CARTER. You notice the Volkswagen uses that now.

Mr. STEMPER. Yes. And that is a very good application on that engine.

Mr. CARTER. They have had it for some time, is that correct?

Mr. STEMPER. Yes.

Mr. CARTER. On both the six-cylinder and eight-cylinder cars.

Mr. STEMPER. Let us look carefully at the two engines. The Volkswagen is a closed piston engine. The piston is out far. The manifold is very, very long. When we introduce gasoline in that engine and then bring it all the way around the bend to the intake ports, it is difficult to get good mixture in that type of engine. In that case, fuel injection applied to that engine does show improvement. It is a good application.

In the case of the Mercedes in-line-six engine, again with the long manifold, as I said with our in-line four, it does show a very definite improvement there. In terms of wide-open throttle performance fuel injectors are genuinely good. The thrust of our development primarily is in the partial throttle traffic range where both fuel economy and emissions are important.

Mr. CARTER. I understand the Mercedes six electronically or mechanically timed is quite economical in gasoline usage—for my part, I am still going to buy American.

Thank you, gentlemen.

Mr. ROGERS. Mr. Heinz.

Mr. HEINZ. Thank you, Mr. Chairman. Mr. Starkman, on Tuesday we heard some testimony that I thought was quite significant. This is the testimony recommending that standards for auto emissions be frozen at levels no more stringent than the 1975 California interim level. One of the witnesses in his testimony, Mr. Pierre Sprey, testified that admittedly crude and preliminary corrections indicated there are doubts whether the existing ambient air standards for  $\text{NO}_2$  does a sufficient job in protecting human health. He urged further study to confirm or refute these preliminary statistical correlations.

Would you, or would you not, agree that EPA should be most reluctant to weaken  $\text{NO}_x$  standards if it might prove to be that in weakening those standards, we were injuring the public health; that in fact the standards that we now have might not prove to be stringent enough.

Mr. STARKMAN. Well, I think you will find that General Motors has consistently said that where there is a health requirement, we have no question whatsoever with respect to the controls that must be effected to accommodate that health requirement. There is a great difference of

opinion in the medical field with respect to the impact of various kinds of pollution on humans, animal health, or vegetation. The usual way to settle such argument is for an appropriate body of scientists, medical scientists, to study this question and come up with a recommendation.

Often times the opinion of that one individual will prevail if it turns out to be right. Other times it evolves that he is wrong. We believe that appropriate studies by competent bodies to determine what the levels should be is the best way to approach these things. That is why we are encouraged by the Congress having asked the National Academy of Sciences to take another look at the levels of emissions which have been prescribed and to come back with their best opinion of what should be done.

What we are saying is that the preponderance of evidence from all quarters at this point is to the effect that oxides of nitrogen levels for the rest of the country, except Los Angeles, of 3.1 grams per mile by the 1975 procedure, should protect all health so far as we can see. For California, a level of approximately 1.5 or 1.6 should be adequate to protect health, even based upon the kind of air quality standards which the Environmental Protection Agency says we should have.

We have no quarrel at all on going at these things on a rigorous basis. I would like to call on Dr. Bowditch, who follows the details of air quality standards and automotive emission control levels, for any other comments he might have.

Dr. BOWDITCH. I just wanted to add that there is a discussion in our statement, if you look near the back, a section entitled "GM comments—NO<sub>x</sub>," where we have a discussion of ambient air NO<sub>x</sub> requirements. I think perhaps when your staff has an opportunity they might want to examine that in some detail. We encourage a study such as the National Academy of Science in this matter. We certainly don't pretend to be experts in the medical area having to do with the setting of ambient air standards.

Mr. HEINZ. I thank you very much.

Mr. ROGERS. Do you do testing on the health effects of the emissions? What effect does it have on health?

Mr. STARKMAN. I would like to call on Dr. Tuesday for an answer.

Dr. TUESDAY. Currently General Motors does not do anything of its own, but we do support the CRC program which is a combination of the automotive and petroleum industries and EPA. As you are probably aware, EPA has been criticized for joining this program. However, the idea of this group is to try to obtain evidence about the effects of air pollutants so that the standards we are discussing today can be set rationally. We do support that.

Since the level of support is based on size, General Motors is the biggest supporter of these studies with the exception of the Federal Government.

Mr. ROGERS. Who set that up?

Dr. TUESDAY. These studies are monitored by an Air Pollution Research Advisory Committee. It has members on it from the automotive industry, petroleum industry, and EPA. They decide what research is needed and solicit bids from various contract-research organizations. The emphasis is on the kinds of air pollution research that will help to define what air quality should be.

Mr. ROGERS. What have been their findings?

Dr. TUESDAY. Some of the most significant findings were those Dr. Stewart recently testified about here. Most of the work he was talking about was funded by this particular program. There is currently a study going on now in Chattanooga which is a repeat of the previous study in which the Federal Government is doing part of the study and CRC-APRAC is supplying instruments to make sure the atmospheric NO<sub>2</sub> measurements are correct. This is another study that is going to end up with some data. Presumably that is the only way we will be able to tell what the health effects are.

Mr. ROGERS. In the drug industry we require that a drug be proven safe and effective before it can be sold in the market. Would it be fair to require the automobile industry to assume that same burden? In other words, they would have to come in with proof of what the particular catalytic converter may come out with, where you have researched that and show that there are no additional poisonous pollutants or if there are, exactly what the situation is.

Dr. TUESDAY. There is a law, the Clean Air Act, that already says devices put on vehicles to reduce pollutants shall not introduce any other noxious substances. That is already part of the law.

Mr. ROGERS. We have standards too, but that does not mean they are being met. As I understood your testimony, you yourself are not testing this information to furnish it to EPA. What I am saying is, should there be that requirement as we have for the drug industry? Before they can sell their product they must come in with actual clinical tests, proof, as to whether something is safe or whether it isn't.

You see, what we are getting from EPA, and this is why I bring this up, is that it is difficult for us to test everyone. Now should it be on the man who is going to sell it and make the profit to come in and assure the public before it is put on the market that the product is meeting the standard, and it is not bringing in the pollutants. Conversely, if it does have the pollutants, should not the burden be on the man who brings that out to test it and show it and present that evidence to the regulating body?

Mr. STARKMAN. Mr. Chairman, we are doing just precisely that. We are measuring by all the available means as precisely as we are able, what kind of things are going to come out of the tailpipe if we install those systems on our products. I think that there is a difference perhaps between the drug industry and the automobile industry in this particular instance.

Mr. ROGERS. Because you have gasoline as well, I understand that.

Mr. STARKMAN. That is correct. I believe that the area which makes it difficult for the automobile industry to say there will be no harmful effects has to do with the lack of knowledge as to the extent to which the carbon monoxide, hydrocarbons, oxides of nitrogen, and other materials that might come out of the tailpipe, do affect public health.

I make the distinction between public health and the pill that the individual may take. We are trying very hard, the whole community is trying hard—we are part of this activity today—to decide what levels are harmful to human health of those materials that come from the automobile. We are suffering, I think, in part because the assumptions made by the EPA in order to insure that we didn't harm human health were too stringent. By their own admission they now believe

that the NO<sub>x</sub> levels they recommended were too stringent. We covered that in our statement.

Mr. ROGERS. I am not sure they think it is too stringent. I think they felt that their measuring device may have been in error. I think they still feel that the health effects are the same, but as I understand the testimony it was that they felt that their testing device was not correct.

Mr. STARKMAN. Not completely so, Mr. Chairman, if you will allow me. They did in their determinations assume what they thought was a safe level for the atmosphere. As I tried to point out, they have since come to the conclusion that might have been too stringent.

Mr. ROGERS. No. They have not had tests on health effects. What I am saying is, they said so many parts per million is the level for health effects, isn't that correct?

Mr. STARKMAN. That is correct.

Mr. ROGERS. It must be adhered to.

Mr. STARKMAN. That is correct.

Mr. ROGERS. What they are saying is when we tested in certain cities we thought the level was at a different level.

Mr. STARKMAN. That is also correct.

Mr. ROGERS. But I don't think they informed us that they would not say that the health effects are not the same.

Mr. STARKMAN. Let me try again. First, a health level is established. Then a measurement is made in the community to determine what is the level in that community. Now if a level in the community is at a point above the health effects level something must be done to reduce that level.

Mr. ROGERS. How do you find what that level is?

Mr. STARKMAN. You measure.

Mr. ROGERS. Yes. This is where they had the problem.

Mr. STARKMAN. When EPA measured their level in various communities they said, "Oh, my, we exceed that level in over 40 cities. Now what must we do? We must therefore insure that that level be brought down to the safe level designated by our air quality standard by controlling the oxides of nitrogen from automobiles. We have in a given community 1 million automobiles, each of which now emits 4 grams per mile. We must reduce that level to not more than four-tenths grams per mile."

After going through this type of procedure, it evolved that those cars producing 4 grams per mile at the time they made their measurement had not brought the level up to the danger point at all. Those communities were still safe.

For those cars in that community nothing was necessary to be done, nor in the immediate future.

Mr. ROGERS. Except for this. What they did in their testing was that they used a different technique.

Mr. STARKMAN. That is correct.

Mr. ROGERS. There is now some controversy about that testing. So that where they say there are now two cities they really feel we have a problem. When we go into this old testing we may find that the testing has not been properly interpreted, and there still may be 40 cities. They are still saying the health effect of that pollutant on human life is the same. They are not changing the health effect on human life.

Mr. STARKMAN. Their finally adopted level is the same as they now have as far as the health effect is concerned. That is correct.

Mr. ROGERS. But they are simply saying our measurement showed. I am not sure that is a legitimate measurement. In fact, there is some controversy and we might ask you to give us a comment on these two testings both of which I don't think are very good. I don't ask you to do it now, but perhaps for the record. It looks like one simply doubled. Perhaps this is a convenient way of easing a situation which has become something that we need to face up to.

I am not saying that. I am not sure. I think the impression has been given that the health effects are not as severe with that pollutant. But because of a differing technique in measurement that brought that change about, in the 2 cities instead of 40, I believe it is important to consider.

Mr. STARKMAN. Can we have Dr. Bowditch comment briefly?

Mr. ROGERS. Certainly.

Dr. BOWDITCH. When the 1970 amendments were under consideration no ambient air standard for  $\text{NO}_x$  had been determined. What was then part of HEW had the authority to set that number but had not done so. In order for there to be a calculation made, so that a determination could be made as to how much the oxides of nitrogen emissions from automobiles should be reduced, some assumption had to be made back in 1969 and 1970. This was essential in order to furnish Congress with some numbers that could be used in preparing the percentage reductions contained in the Clean Air Amendments of 1970.

However, the number that was assumed at that time, for purposes of the calculation, as a likely air quality standard was a quarter to one-seventh the level, which EPA ultimately established as the health or air quality standard in effect today. In addition to this error, EPA has recognized an error in measuring the amount of  $\text{NO}_x$ . So, really looking all the way back on the way the 1970 Clean Air Act reductions were computed two errors were made on  $\text{NO}_x$  although quite justifiably. One was in estimating where the health standards would be set, and that was made the lower level on our chart on page 22 of our statement. The other was on the ambient, or current atmospheric level, which is the higher point on our chart where EPA says the measurements have been made wrong. So there were errors made both on the top end, where the air is now, and on the bottom end, where we want to go, on the desired air quality.

Mr. ROGERS. Except for the fact we had no definite test on the health effects.

Dr. BOWDITCH. There are medical experiments that have been run and these are cited in great length in the various papers.

Mr. ROGERS. To bring about a change of the level of the pollutant for health effects, they have no studies justifying a change of that. The only thing they have justified is the change in the testing. It may be that the testing is more legitimate with the arsenite test. But I am not sure that is being interpreted correctly. We will go into it and this is what we will furnish you material on and we will ask you to comment.

Now what I am saying is why shouldn't the company that is involved with this problem, with the pollutant coming out, present

health data on what you are doing, at what level it is safe, and at what level it isn't?

Mr. STARKMAN. Mr. Chairman, I think we have an entirely different situation than that of the drug industry.

Mr. ROGERS. I understand that because you also have to deal with gasoline that goes in your product.

Mr. STARKMAN. Of course.

Mr. ROGERS. I can understand that. As I understand it you have a cooperative arrangement where you are both supposedly supporting this type of research but I haven't seen any definitive result come out, nor have I seen EPA request it. So, I am not so sure that we shouldn't consider placing in the law some requirement to this effect. You might, I think, think about this and let us have some comment for the record.

Mr. STARKMAN. All right, we will try to comment on this for the record.

[The information requested was not available to the committee at the time of printing—March 1974.]

Mr. ROGERS. I want to think about this some as to changes in the law.

Now you have felt that the converter is the way to go.

Mr. STARKMAN. The catalytic converter, yes.

Mr. ROGERS. Ford tells us today they believe we should have a change in the power system. Have you had an opportunity to look at this stratified charger?

Mr. STARKMAN. Yes. I would like to call on Mr. Stempel to answer that.

Mr. STEMPEL. Yes, General Motors has looked at the stratified charge concept for many, many years. It has been an ongoing program in our research department. Of course, more recently we have undertaken a more active development of that both in terms of the smaller engines and larger V-8's. It is a very active program as we have previously testified at EPA.

The basic problems with the stratified charge engine are those that we have previously identified, that is the problem of getting the mixture to burn either in an open stratified charge engine or a jet ignition type of engine. They are all dilute charges, and involve problems of getting the right mixture to burn, start rich and burn out lean.

The problems generally occurred during the transient operation. We agree there are many new techniques available to us. We discussed fuel injection, better carburetion, better ignition, better control of chamber shape. All of these are being put into that engine in an effort to see what can be achieved.

One of the things we are noting so far is that it still takes some form of cleanup to totally get the amount of hydrocarbons down to the final very low limit. However, we are continuing to work on that. As such time as that engine shows good promise it certainly will be a candidate as an acceptable alternate powerplant. The catalytic converter, as we have noted in our statement, is simply a device, at this point in time, that appears to have the most promise in terms of controlling emissions, improving economy and drivability for the near term. At such time as an alternate engine, perhaps of a stratified charge type, or other form would be feasible it could obviously supplant the catalytic converter.

**Mr. ROGERS.** But at this stage you don't think it is feasible?

**Mr. STARKMAN.** We are not ready yet to put that into production. It may be that we can get ready to put it into production in the next few years. Right now our answer is the catalytic converter. We think it has additional advantages as I tried to state over and above cleaning up the pollution in the tailpipe.

**Mr. ROGERS.** Let me ask you, are you aware of a report which has just been out recently about the Toyota electronic black box, they call it I think? Are you aware that for traffic it cuts on and off and has a saving supposedly, fuel saving, of more than 12 percent, and reduces emissions by more than 21 percent?

**Mr. STEMPER.** This is a report we have seen in the news media where they have described a system. When a car comes to a stop for longer than a few seconds the engine shuts off. It is automatically restarted when the driver drives away. We have previously looked at the on and off system. We don't know what their basis of comparison was or what their base data were.

It has been our experience that such a system imposes a whole new set of standards on the vehicle such as the amount of electrical energy to restart the car each time, that is the starter motor and the ability to generate it in turn. Also the start up emissions must be reexamined. We typically find that the very first fires of a piston engine are higher on emissions than successive fires. That has to be evaluated in light of the overall picture. At this time we really don't have a full evaluation of the system. We are aware of it, and we obviously are looking at it.

**Mr. ROGERS.** I think it would be helpful to the committee when you make an evaluation if you could let us know.

**Mr. STARKMAN.** Yes. It will take some time to make such an evaluation, but we can. We will keep you or your staff informed.

**Mr. ROGERS.** Thank you.

Are you aware of the work that Dr. William D. Balgord, senior research scientist at the New York State Department of Environmental Conservation has done? He claims that he has developed a way to meet the original 1975-76 emission standard at a cost far below automakers estimates for their systems. Now perhaps you could give us some comment on the record on that.

**Mr. STARKMAN.** We will do that.

**Mr. ROGERS.** I think that would be helpful for us to have.

[The information requested was not available to the committee at the time of printing—March 1974.]

**Mr. ROGERS.** Now when you say that your new catalytic converter will bring a gas premium, what tests have been done? Do you have the results of those in your report here?

**Mr. STARKMAN.** These results have been incorporated in both the spoken statement and the one for the record.

**Mr. ROGERS.** You feel without question this has been proved, that we can expect a gas premium?

**Mr. STARKMAN.** We have no reservations about this effect, none whatever.

**Mr. ROGERS.** It would range in what area?

**Mr. STEMPER.** Mr. Chairman, if we look at the data we submitted for the record we show, and I use the word "trends," that this data represents the average trend of many of our experimental cars encompass-

ing everything from our smaller four cylinder engines up to the large V-8's. That data says up to an 18-percent gain is expected in 1975, versus 1973. That is basically a converter system, converter and all its supporting hardware versus a 1973 car without a catalytic converter. That obviously is an estimate of an average on indicative of a range of economy gains, some higher and some lower. At this point in our testing we are confident enough that all of our cars have shown a gain with a catalytic converter at the 1975 interim standards.

The purpose of including the curve in the report today was to perhaps bring home graphically the difference between the 1975 interim and the low standard that comes on in 1976 and 1977. Even with the catalytic converter at the statutory limit for  $\text{NO}_x$  of 0.41 for hydrocarbons, 3.4 for carbon monoxide, and two for  $\text{NO}_x$ , and for 1977 0.4 for  $\text{NO}_x$ , that system suffers a loss in efficiency and economy.

We are saying the economy gain applies to the 1975 model year. You can see on the chart that at the California levels, slightly less on hydrocarbon and CO, but on an order of magnitude of 2 grams  $\text{NO}_x$ , that the economy is down somewhat. It is still better than a 1973, 1974 system, but not as good as the Federal interim limit.

We have arrived at those numbers over the past year in a series of developmental tests on the cars, we have put together for various demonstrations, for Members of Congress and the Senate and various field test vehicles. As a matter of fact, today we drove to the hearings in such a car. It is available through our Washington office if you would like to drive it sometime. It does have a catalytic converter on it. Perhaps the best way to get the gas mileage is to verify it. We believe it is there. Our test data show this. What we have been doing is simply accumulating this data to satisfy ourselves that in fact we have a real economy gain.

Mr. ROGERS. Thank you. I introduced a bill regarding fuel economy. I don't know if you have seen it yet.

Mr. STARKMAN. Yes, sir, we have seen your draft.

Mr. ROGERS. Could you comment on that for the record? I won't go and ask you to state it now.

Mr. STARKMAN. We will be happy to comment on it for the record. We are not prepared right now, Mr. Chairman.

Mr. ROGERS. Yes. If you could let us have your thinking on that, it would be helpful.

[The information requested was not available to the committee at the time of printing—March 1974.]

Mr. ROGERS. Some have proposed a tax on pollution from motors if extension is granted to create incentive to meet standards. What is your reaction to that?

Mr. STARKMAN. We don't like to see a penalty assessed for the purpose of bringing about punitive effect in an area such as this. We believe rather that there should be other incentives, and particularly, if there are incentives that they have to do with the marketplace. These are better, I think, than taxation or other ways of going about this.

Mr. HEINZ. Mr. Chairman?

Mr. ROGERS. Yes, Mr. Heinz.

Mr. HEINZ. Mr. Chairman, I would like to return quite briefly to an item you touched on with Mr. Starkman a few minutes ago, which is the fact of the questioned basis for Jacobs-Hochheiser method of

measuring NO<sub>x</sub>. I am wondering, Mr. Starkman, if you could tell the committee if you know whether the measurement technique that was used was also used as a means of measuring concentrations of NO<sub>x</sub> in the experiments on the health effects; namely, the epidemiological, toxicological, or clinical studies.

If, in fact, the same measuring technique was used there, of course the errors would cancel out and EPA would not have a very good case for changing the NO<sub>x</sub> standards. Would you comment on that?

Mr. STARKMAN. Of course. Your point is very well stated.

Dr. TUESDAY. I think you will find this is covered in some detail in the part of our statement about nitrogen oxides. They did use the Jacobs-Hochheiser method in the Chattanooga study, but unfortunately, it was another modification of it. A double-bubbler method rather than a single-bubbler method was used. Thus, a straight forward comparison is unfortunately not possible.

The current study that is going on in the same area uses as a method of measurement the chemoluminescent method. It is considered quite reliable. It is also more costly.

Mr. HEINZ. Has anybody ever made a test to correlate or calibrate or otherwise compare the differences between the two, the Jacobs-Hochheiser method?

Dr. TUESDAY. We have, and we supplied this information to EPA in our comments on the original proposal. As near as we can tell, these comments were initially disregarded, but apparently have now been recognized as valid. Direct comparisons have been made, but variations between the two methods are so complicated that you can't go from one to the other, after the fact.

Mr. STARKMAN. Mr. Congressman, I think I should inform you that the research labs are not afraid of anything, including the Jacobs-Hochheiser, except that they call it J-H.

Mr. HEINZ. Mr. Chairman, I thank you for yielding.

Mr. ROGERS. I do want to ask one question because you said you had funded certain work in joint research. I believe Dr. Stewart does some of the funded work. Now, the report we got, a study that he has made, which I guess you have jointly funded, suggests that perhaps there may be no safe threshold for CO or for oxidants. If that research is proved out, what would this mean? What action must we take?

Mr. STARKMAN. I think each of us produces carbon monoxide in our living process. It scares me a little bit to think what might happen if I am told that I can't exhale carbon monoxide. I think I had better not comment beyond that point, Mr. Chairman.

Mr. ROGERS. In other words, we might have to tighten—

Dr. TUESDAY. If you read his testimony, the study he referred to had to do with levels of CO approximately 15 ppm. His recommendations for current air quality was 15 ppm for CO for 24 hours, which is even more lenient than the one proposed in our statement. He also said that ultimately he would like to have not one molecule of CO in the air. That is a very idealistic situation. He was not referring to the results of his study. He was referring to the philosophy that one molecule might make one old lady live 1 minute less.

In the ideal situation, there would be no CO in the air. To do that, of course, would require all of us in this room to stop breathing, cer-

tainly all of us to stop smoking. He held it up as an ultimate goal, but in terms of the lifetime, probably, of most of us here, he was talking about 15 ppm for 24 hours.

Mr. ROGERS. That is not the way I read the testimony.

Dr. TUESDAY. The testimony is a matter of record.

Mr. ROGERS. On his research.

Dr. TUESDAY. The research he did had to do with cognitive skills, basically human ability to figure, to think. He found no effect in those studies that would confirm Beard and Wertheim's work. The study he was talking about had to do with the effect of CO on blood and the cardiovascular system. This is not work he did himself.

Mr. ROGERS. I thought we had the memo here which maybe I completely misread, but I think not.

Dr. TUESDAY. I think he was asked what would be a defensible CO standard today. I think he said 15 ppm, 24-hour average. That is in his testimony.

Mr. ROGERS. I am not sure that he said today we had to do away with it all. I am not saying that. I am saying the suggestion, his research suggested that we might have to tighten rather than relax standards on oxidants and CO. Here is Stewart's testimony :

Therefore we are of the opinion that it will be impossible to establish a no effect CO standard so far as those individuals with significant heart disease are concerned. The CO air quality standard should be set at a reasonable level not to exceed the cardio-vascular stress of eating, for example, so that the most susceptible to CO exposure may be afforded reasonable protection. Additional research will be required before the margin of risk of this current CO standard can be ascertained.

So I think he does make pretty definite statements on this.

Dr. TUESDAY. What he says is that it is not possible to have a zero risk CO level in the air. There is a risk to someone of one even molecule. Someone, presumably the Federal Government has to determine what is an acceptable risk for the general population.

Mr. ROGERS. I understand, but he is saying that we may not be strict enough in our standards.

Dr. TUESDAY. If you read further, he also says that he recommends 15 ppm for 24 hours.

Mr. ROGERS. For the current—

Dr. TUESDAY. As a defensible CO air quality standard, based on today's knowledge.

Mr. ROGERS. That is right.

Mr. STARKMAN. Mr. Chairman, again this is Dr. Stewart's thesis and his opinion. I don't think we should quarrel with it. He is a respected physician and research scientist.

Mr. ROGERS. He said it needs further research. I don't think he said this is all definitive, but he is raising a flag of concern here to which I think we all should be alert.

Mr. STARKMAN. Well, we should. When we are making decisions with respect to what level should be, his and the opinions of others should be taken into account.

Mr. ROGERS. Now let me ask you what do you think this committee should do, just one, two, three.

Mr. STARKMAN. I think this committee should consider three things. The requirement for reduction in the emissions from automobiles. We have stated—

Mr. ROGERS. 1974 or the interim 1975?

Mr. STARKMAN. We think they should not be frozen at a more stringent level than the 1975 California, no more stringent than that.

Mr. ROGERS. What else?

Mr. STARKMAN. I think it is probably not the province of the committee necessarily but perhaps the EPA, we need to assure that there is unleaded fuel available such that we can accomplish two things. One is to provide for low emissions from cars without catalytic converters, plus allowing us or anybody else to be able to apply systems which cannot tolerate lead alkyls which are in leaded fuel.

Mr. ROGERS. How long should these standards be frozen?

Mr. STARKMAN. We have suggested 3 years, Mr. Chairman. I don't want to leave the impression, however, that we are concerned only for oxides of nitrogen. For the immediate future we hope that the Congress, your committee, will consider the matter of carbon monoxide and hydrocarbon standards. That is why I said no more stringent than California.

Mr. ROGERS. Should we simply authorize an extension by EPA, leaving the standard as a goal, but simply authorize the extension if it is necessary.

Mr. STARKMAN. I think we should leave that consideration up to the wisdom of your committee and the Congress as to what should be the vehicle for doing this. I had a couple of other points perhaps I should add.

I believe that the EPA needs aid in recognizing the averaging situation. I think the Senate committee at least has expressed itself rather clearly with respect to the matter of averaging. I believe that the matter of certification of vehicles prior to their production is an unnecessary vehicle in the present context. It might have been a useful vehicle early in the game, but I think now, where we have postaudit for California at least, this postaudit can be accomplished as well for the rest of the vehicles in this country on the same basis, that we can assure that vehicles are going to be built to those requirements that have been established by other than present certification procedure. The present certification procedure has us bound up very tight in the progress we can make.

Mr. ROGERS. Do we need different penalties? For instance, the EPA Administrator was concerned about a lack of good faith effort by one of the companies. Now the alternative seems to have been, as he said, to close them down and put people out of work. Should we have some different penalty for people who would not abide by the law?

Mr. STARKMAN. Again, Mr. Chairman, I think this is the province of others than the industry itself to comment upon. I would say that were we the ones who might be found someday to have made an error—

Mr. ROGERS. Now may be the time to speak up then.

Mr. STARKMAN. If you asked me I would say, therefore, there should be no new penalties whatsoever. The penalties that presently are available are pretty high level penalties. They are rather severe. The capability that the regulatory agency has for imposing rather critical penalties on industry or on individuals in the industry are very, very large weapons. I am not sure that the size of those penalties is justified.

Mr. ROGERS. Thank you so much. We are most grateful to you for your patience and bearing with the committee this afternoon at such a late hour. Thank you for your helpful testimony.

The committee stands adjourned until 10 a.m. tomorrow.

[Whereupon at 5:15 p.m. the subcommittee adjourned to reconvene at 10 a.m., September 14, 1973.]

## CLEAN AIR ACT OVERSIGHT—1973

FRIDAY, SEPTEMBER 14, 1973

HOUSE OF REPRESENTATIVES,  
SUBCOMMITTEE ON PUBLIC HEALTH AND ENVIRONMENT,  
COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE,  
*Washington, D.C.*

The subcommittee met at 10 a.m., pursuant to notice, in room 2123, Rayburn House Office Building, Hon. Paul G. Rogers, chairman, presiding.

Mr. ROGERS. The subcommittee will resume.

We are continuing our hearings on clean air.

We are happy to have as our first witness Mr. Sydney L. Terry, vice president for Environmental and Safety Regulations of the Chrysler Corp.

We welcome you to the committee, and we will be pleased to receive your statement.

**STATEMENT OF SYDNEY L. TERRY, VICE PRESIDENT, ENVIRONMENTAL AND SAFETY RELATIONS, CHRYSLER CORP.; ACCOMPANIED BY CHARLES HEINEN, DIRECTOR, VEHICLE EMISSIONS PLANNING, AND VICTOR C. TOMLINSON, COUNSEL**

Mr. TERRY. Thank you, Mr. Chairman.

I am Sydney L. Terry, vice president, environmental and safety relations, Chrysler Corp.

With me today are Charles Heinen, director, vehicle emissions planning; and Victor C. Tomlinson, of our legal staff.

Mr. ROGERS. We welcome you to the committee.

Mr. TERRY. We certainly appreciate this opportunity to present Chrysler's position on the implementation of the emissions control requirements of the 1970 Clean Air Act.

Let me begin by saying that we at Chrysler are in full support of the need to control automotive emissions. We recognize the need for Federal legislation as a necessary step on the road to clean air. And we are fully dedicated to removing the motor vehicle from the entire air pollution problem.

Our record speaks for itself. We were among the first to recognize the part the automobile played in creating photochemical smog. We developed the instrumentation and information that were a necessary prerequisite to controlling automotive emissions. And our engineers developed the system of emission controls subsequently used by nearly all American and foreign automobile manufacturers, so that today's

cars, using control techniques based on Chrysler designs, emit 70 percent less pollution than a car without controls.

We are concerned that the people of this Nation are not aware of the real progress in emissions control already achieved by the automobile industry. Let there be no misunderstanding. As far as the automobile is concerned, we are going to have clean air—air that protects the public health and that improves the quality of life. The only issue remaining is one of cost—both social and economic. Will we have clean air at a reasonable cost? Or will we have clean air at an exorbitant cost?

The great preponderance of evidence from medical and scientific research supports the position that the automotive standards are more stringent than they need to be for the protection of health. There is no question they are forcing us to the use of catalysts. The evidence shows that health can be protected with standards which do not require costly catalytic systems, and which will not cause a further serious drain on the Nation's energy supplies.

Unfortunately, we are now on a headlong course in the opposite direction. The 1975 interim standards set by the EPA as a test run for full implementation of catalytic systems in 1976, require expensive and unproven catalytic converters on all cars sold in California in 1975, and on many models sold in the rest of the country. These cars will require more expensive lead-free fuel—the kind of fuel which will not be generally available in Mexico and Canada where thousands of Americans normally drive. They will be more expensive to buy and to maintain, and they will use noble metal catalysts made from platinum and palladium, about which we all know far too little at this point.

If we are to turn back from this course which so many independent scientists have said is wrong, to a course which will give us clean air at reasonable cost, the decision has to be made now. Next year, when the health and cost benefit reports requested by Congress start to come in, it will be too late for those car buyers who will already have catalytic systems on their cars.

We are already in the process of gearing up for mass production of catalytic converters for our 1975 models which require them. And, unless Congress acts now, and sets new standards for 1975 and 1976 that can be met without the use of catalysts, the Nation's consumers will have invested hundreds of millions of dollars in a control technology that we believe will be discarded very shortly. From all appearances, we are going to end up in this country with a short term production run of what will soon turn out to be orphan cars—cars for which supporting maintenance for catalysts and unleaded gasoline will have to be kept available for the 10 to 12 years they stay on the road. This has very serious implications for the oil industry which we believe should be spending its efforts on higher priority issues.

Unless we take action now, the Nation's severe energy problems are also going to be intensified even further by a set of standards which will increase fuel consumption by as much as 25 percent. We don't claim that the Clean Air Act caused the fuel shortage. But anyone who looks at the facts has to agree that unless the act is changed now, it will certainly intensify the energy problem. For all those reasons, we urge Congress to act quickly, before it is too late.

Now I would like to review a few points to put our position in perspective. The 1970 Clean Air Act calls for a reduction of 90 percent beyond the reduced levels already achieved in 1970. That is an actual reduction of up to 97 percent from uncontrolled levels. Unlike the law which calls for cleaning up stationary sources, this law does not allow the Administrator of the Environmental Protection Agency to revise the mobile emission standards or delay their implementation when the evidence clearly shows that the control costs far outrun the benefits. Technological feasibility is the only criterion the Administrator can use when deciding if the mobile standards are to be applied on schedule. In our judgment, and the judgment of many others, it is the wrong criterion.

Since the spring of 1972, the Nation has known, through a report to Congress by the EPA, that the estimated cost of meeting the emissions standards for mobile sources would be more than \$8 billion per year, and that the expected benefits in reduced damage to plants and vegetation would be less than \$1 billion per year. Said another way, that's \$8 of cost for \$1 of return.

In the fall of 1972, the Office of Emergency Preparedness issued a report stating that the Government's present policy on emission control is in direct conflict with the country's economic and national security goal of conserving scarce energy. The report pointed out, for example, that a 25-percent loss of efficiency as a result of emission control systems required to meet the 1970 Clean Air Act, "will require an increased purchase of gasoline which over the next 30 years will amount to over 1 trillion gallons—equivalent to some 48 billion barrels of crude oil." The country would need all the production from nearly five Alaskan oil fields just to meet that extra demand. We believe these facts should also be considered when the automotive emissions standards are reexamined.

The question of alternate engines is often raised. However, it is agreed by everyone familiar with this question, including the National Academy of Sciences, the Office of Science and Technology, and the Environmental Protection Agency, that in the time available under the law, we had no choice but to develop add-on devices such as catalysts for our present piston engines.

At my own company, we were forced to curtail some of our work on the gas turbine engine because of this timetable, and also because it does not appear to be possible for the turbine to meet the 0.4 grams per mile oxides of nitrogen standard. Even though we continued research both on our own and under contract with EPA, we had no choice at the time but to concentrate most of our efforts and manpower on developing a new catalytic technology.

Nothing would give us greater pleasure than to report that as a result of those efforts we can meet the emissions standards which are now effective on 1976 and 1977 models. But as you know, that is not the case.

We have made great progress with our catalyst research. Our catalyst technology and the technology of our suppliers is well developed, and we are prepared to match our systems against those of any other manufacturer in the business. But the record established by the recent EPA hearings makes it clear that no manufacturer, including those who are prompting catalytic control systems, can meet the

original standards set by the Clean Air Act and warrant their systems for 5 years or 50,000 miles in customer use.

Despite our intensive efforts in the field of catalyst research, and our large investment in tooling and production facilities, we believe that catalytic converter systems are the least desirable control system. A good number of independent scientists agree with us. Catalysts are subjects to damage or over-heating in many common driving situations. They could add as much as \$1,300 to the cost of owning and operating a motor vehicle for 5 years. They must run on expensive lead-free gasoline which will not be universally available to Americans driving in Canada or Mexico. Their efficiency will be impaired by the use of gasoline containing lead or phosphorus. According to estimates by the Stanford Research Institute, the standards as now written could increase gasoline demand by as much as 25 percent over uncontrolled levels.

We at Chrysler have examined all the possible alternatives to this control strategy which might be used in the longer run. We have explored all the alternates for the internal combustion engine, even though the leadtime for conversion to another engine was clearly inadequate. We have done considerable work with the Wankel, or the rotary engine, beginning as far back as 1962. And to be quite frank, we are not optimistic about that engine because of its high cost, its high fuel consumption, and its high emissions of carbon monoxide and hydrocarbons. The National Academy of Sciences report says that the Wankel suffers a 30-percent fuel penalty compared to an equivalent piston engine.

We have investigated the diesel as a possible alternative. However, even the Daimler-Benz Co., a principal manufacturer of passenger-car diesels, has testified that the diesel is not the answer for the passenger-car need of this country. While its fuel efficiency is good, the diesel is heavy, very expensive, noisy, and smelly. Unless it is carefully maintained, the diesel emits high levels of smoke particulates. And the consensus is that the diesel cannot meet the statutory standard for oxides of nitrogen.

We have worked with various electric systems, the Rankine cycle engine, and all the rest. And none of them satisfies all the requirements for emission controls, cost, driveability, and fuel economy that are required for sale in the U.S. market.

The most promising alternative we have under study is a stratified-charge engine. We have a disclosure agreement with Honda which has developed a version of this engine, and are currently negotiating a licensing agreement with them. We are also conducting our own intensive development program of converting our engines to CVCC technology. This engine shows performance which we all desire, and above all for low levels of emissions without the use of catalysts or lead-free gasoline. We are very optimistic about its possibilities for the future.

Assuming the engine works, and assuming it will meet all the standards, we believe we could convert one engine line to production of a CVCC engine in approximately 3 years.

However, it is important to understand that if we are required to build catalyst-equipped engines in the meantime—with all our efforts devoted toward perfecting new and untried catalytic systems, devel-

oping improved controls on our engines on all the problems of certification, manufacturing, and quality control that the National Academy of Sciences warned of, the stratified-charge engine and any other alternate engine will surely be delayed. We believe that would be a serious setback to the cause of clean air and energy conservation.

The National Academy of Sciences, the RECAT Committee, the Federation of American Scientists, and respected scientific and technical experts agree with us that nationwide conversion to catalytic control systems is not in the country's best interest.

They have all pointed out that we can only meet these standards in the available time at the expense of some other national objective.

Paul McCracken, former chairman of the Council of the Council of Economic Advisors, put the issue this way: "At what point does further improvement in our environmental rules cost so much in terms of what must be given up in other directions that it is not worthwhile? That question must be faced explicitly." And he pointed out that "on general economic principles" one would expect that a 90-percent further reduction of auto emissions from a base already down 70 percent would be overdoing it, requiring resources that could better be used elsewhere.

Now if reductions of up to 97 percent from uncontrolled levels were necessary for full protection of the public health, then this question would never be asked. But the great preponderance of new evidence gathered since the Clean Air Act was passed supports the position that less stringent standards would more than adequately safeguard the health of even those who might be most susceptible to the adverse effects of automotive emissions.

As you know, we at Chrysler have tried to bring this issue to the attention of the public and government. We believe it is important that all the facts be known before the Nation embarks on a control program that will cost eight times more than it will produce in benefit. Many of the facts are already available. I would like to review some of them today as they apply to the three primary automotive emissions.

In the case of oxides of nitrogen, EPA has acknowledged errors in the original measurements of atmospheric concentrations. They have recognized that  $\text{NO}_x$  in most areas of the country is not the health threat once feared, and have reduced the number of cities exceeding the ambient standard from 47 to 2. And one of those is marginal. On the basis of this data, EPA has said the automotive standard should be changed. In fact, Mr. Quarles of the EPA has reiterated before this committee on Monday of this week that a  $\text{NO}_x$  standard of 2.0 grams per mile would satisfy the needs of all areas except Los Angeles into the 1990's.

In the case of the gaseous hydrocarbons from automobile exhaust, there is complete agreement that there is no threat to health at levels found in the atmosphere today. Hydrocarbons are controlled in order to prevent formation of photochemical oxidants—smog. In California, where the problem is most serious, officials recommended a standard of .9 grams per mile. There is no information showing the Federal hydrocarbon standard of .41 gram is needed in California—or anywhere else in the country.

In the case of carbon monoxide, there is of significant effect on any kind until the carboxyhemoglobin level—the level of carbon monoxide in the blood—exceeds 3 percent. A nonsmoker exposed to air with a

concentration of about 9 parts per million for 8 hours, which is the very conservative Federal air quality standard, would have a 1.5 percent carboxyhemoglobin level, which is only half that level.

We hear that CO concentrations in our cities are often as high as 30 parts per million. But a survey of the carbon monoxide blood levels of nearly 30,000 urban Americans shows that the majority of nonsmokers have carboxyhemoglobin levels of 1.5 percent or less already. This raises serious question about the adequacy of atmospheric carbon monoxide measurements as far as health is concerned.

As you know, the carbon monoxide standard for cars set by the act was based on atmospheric readings taken in the city of Chicago, where on 1 day in 1965 the carbon monoxide concentrations averaged 44 parts per million for an 8-hour period. That, incidentally, was considered the worst area for carbon monoxide in the country. Based on that information, it was determined that automotive emissions had to be reduced 90 percent in order to bring the 8-hour CO average down to 9 parts per million.

However, measurements at that same station in Chicago since that time show that carbon monoxide concentrations are decreasing steadily as older vehicles are replaced by cars with present controls. The peak levels of CO at that station are already down to 15 parts per million, and the continuing downward trend is expected to meet the extremely stringent national air quality standard of 9 parts per million at that station in 1974. And this will come about before the standard requiring a 96-percent reduction in carbon monoxide from automobiles becomes effective in even one car.

As new information such as this has become available, a growing number of people, including many Members of Congress, have called for a further study of this whole question before a costly and counter-productive catalytic control system is forced on the driving public.

We are naturally very gratified that the Congress has authorized the National Academy of Sciences to review all the new evidence, to consider the level of control necessary to safeguard health, and to evaluate the costs and benefits of various control levels.

While the Academy is conducting this needed study, we urge the Congress to guarantee a continuation of cleaner air at a reasonable cost by carrying over the strict 1974 standards. The evidence shows that with these standards there will be a continuing improvement in air quality as far as the automobile is concerned.

We believe the Nation has everything to gain and nothing to lose by taking such an action. If we are wrong, and the studies show the standards as now written are in fact necessary, then they can be reinstated. If, on the other hand, we are right—and the great preponderance of evidence shows we are right—then the Nation will save billions of dollars in natural resources, and the consumer will save hundreds of dollars in the purchase price and operating costs of his automobile.

We are meeting the 1974 standards without catalysts and at reasonable cost. By continuing the 1974 emission levels during the study period, we would not have to convert to more expensive lead-free fuel with its inherent high fuel-cost penalties, and we would still be continuing the steady trend toward cleaner air.

Only Congress can prevent this needless and costly commitment to catalysts nationwide—and time is running out. Binding commitments

have already been made for tooling and components for our 1975 models, many of which will require catalysts. We are already receiving the parts required for our 50,000-mile durability emission test. Our final decisions on technology for 1975 must be made this fall.

The Academy's interim report will not be ready until late October or November. We believe enough serious questions have already been raised to justify action now.

The EPA report shows the costs of motor vehicle controls outweigh the benefits.

The Office of Science and Technology says we need answers to more questions before we commit to a new control system.

The Office of Emergency Preparedness says catalysts will aggravate our energy problems.

The National Academy of Sciences has already said that catalysts are the least desirable of all control systems.

The Federation of American Scientists has said catalytic systems are wasteful.

A number of respected individual scientists have said we are on a wasteful course of action under the present law.

In addition, individual members of the automobile industry are developing new engine technology which, if we receive the necessary extra time, could provide a most desirable combination of cleaner air, better fuel economy, improved performance, and lower cost to the consumer.

We urge you not delay this matter, and to act now to carry over the 1974 standards while the National Academy of Sciences completes its full study. By so doing, we can move the country closer to the goal we all support—clean air which the Nation must have, at a cost the Nation can afford.

Thank you, sir.

Mr. ROGERS. Thank you very much for your statement.

Mr. Satterfield.

Mr. SATTERFIELD. Thank you, Mr. Chairman.

Mr. Terry, on page 1 you made the statement: "We developed the instrumentation," and so on, with respect to controlling automotive emissions. By this, do you mean measurement instrumentation?

Mr. TERRY. Yes, sir.

I happen to have with me today Mr. Heinen who started working with Professor Haagen-Smith in California back in 1953, when the automobile companies, Chrysler in the lead, started working with Professor Haagen-Smith and other scientists to try to find out what the automobile role was in this strange chemical reaction taking place in the air.

Mr. SATTERFIELD. How accurate is that instrumentation today?

Mr. HEINEN. Let's define the instrumentation that we are talking about. We are talking about the instrumentation at the exhaust pipe.

Chrysler's paper on this came in 1955 at the Air Pollution Control Association. It dealt with the use of nondispersive infrared technology for CO and hydrocarbons. That was good for roughly plus or minus 5-percent accuracy.

We developed the "rolls technology", the procedure and methods for using dynamometer rolls at Chrysler. That introduces an error of the order of plus or minus 7 percent.

We have several other instruments that are used in exhaust analysis.

We had the first cart put together including all of the instruments, the concept and a number of other things dealing with exhaust analyses. The order of magnitude of the accuracy, or reproducibility of the total system for measuring exhaust, is plus or minus 10 percent at present conditions.

I think the question you are asking deals with atmospheric systems. That is why I differentiated what we did at Chrysler and generally what the industry did in order to establish where we were at the time.

Mr. SATTERFIELD. I was inquiring about the exhaust readings because this leads to my next question.

One of the things that has disturbed me is that we have gone to great lengths to try to control emissions of automobiles, but at best we are only controlling the readings in the manufacturers' hands.

It seems to me at this point we really didn't know what happens.

I am wondering whether or not the instrumentation you helped develop lends itself to portability or perhaps viability at inspection stations, and I would like to know in connection with that if this is economically feasible. Would it require a great deal of expertise for people at inspection stations to read such an instrument and to make the necessary adjustments to bring an automobile back into compliance?

Mr. HEINEN. There are a number of answers to that question. As you can well imagine, it is a very complex question.

The full test procedure takes something of the order of 12 hours. For a yearly inspection, that would be impractical. In addition, similar measurements would be required to adjust a vehicle back into approximate compliance.

Actually, one system which sounds extremely simple, but which has a great deal of effectiveness is measurement of just the idle with fairly straightforward garage-type instrumentation. The State of New Jersey has done quite a bit of work in that area.

We in the Coordinating Research Council which you are apt to hear more about as we go along in that activity because I happen to be chairman, and we are enthusiastic about it. We have spent millions for developing systems in the field for existing devices and which can be used with, I would say, a certainty of about 30 percent of being dead nuts or that much off in either direction. This is pretty good for maintaining a total population because it averages out.

When you are talking about an individual car's certification, the more accurate equipment required for the full test can be extremely expensive.

Mr. SATTERFIELD. What you are saying is that prospects of this kind of inspection and maintaining automobiles operating in connection with the minimums established, is a long ways off?

Mr. HEINEN. At the minimums established, it is almost hopeless—the minimums in the law. That would be almost hopeless.

Mr. SATTERFIELD. Then by control at the manufacturer with no subsequent control, we are in effect fooling ourselves, are we not?

Mr. HEINEN. I suppose actually down at the levels that we are talking about in the standards at the present time, we are fooling ourselves even at the level of the manufacturers.

The accuracy of the equipment at that level is about 50 percent.

Mr. SATTERFIELD. One other question in connection with this, and I think I understood the statement to say this.

Is it your feeling in the absence of owner-operated inspections that the life duration of controls would be better if you achieved those controls at the manufacturers' level by adjustments in the engine or by the addition of devices such as the catalyst?

Mr. HEINEN. Our feeling at Chrysler is adjustments in the engine would be better because of the complete lack of knowledge on anybody's part, and I mean "anybody" all inclusive, as to what happens to catalysts in the field. This is one of the reasons that we are so interested in having more field testing before we expose them to the customers.

One of our men whom I call our professional sadist—he is the chief of our garage—has been 40 years in the business—has now developed a page and a half of different ways that he can fail catalysts completely in the types of operations that consumers are apt to perform. How frequently is this going to happen?

Questions of that type we should know before we expose—

Mr. TERRY. I would like to add something to this.

With our present engine modification system—we have to make sure the car is kept in tune to meet emission levels. Keeping the car in tune involves well-known operations that the garage mechanics know how to do and have been doing for many years. When you add a catalyst to the engine system, you have to keep the engine in tune just as you did before. If it gets out of tune, it is almost a certainty that you will destroy the catalyst if you let it stay out of tune, in which case you have to get a new catalyst and you also have the extra emissions in the meantime because you are not getting any use of the catalyst.

It does not make your problem easier but in many ways it makes it more difficult.

Mr. SATTERFIELD. I think what you say is correct but if I have an automobile with a catalyst in it and if I choose not to put out the money to replace it, there is nothing to make me do so, so we don't have any control, do we?

Mr. TERRY. That is right.

Mr. SATTERFIELD. You stated first on page 2 that the great preponderance of evidence from medical and scientific research supports the position that automotive standards are more stringent than they need to be for the preservation of health and you seem to repeat this on page 9.

Do you have readily at hand a reference to the evidence to which you refer, or can you obtain it?

I think any information you have would be helpful to us as a part of our record.

Mr. TERRY. We collected that information for the counterpart committee in the Senate and we would be happy to submit this to you for the record.

Mr. ROGERS. Without objection, it will be made a part of the record. [The following information was received for the record:]

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23. von Post-Lingen, Marie-Louise, "The Significance of Exposure to Small Concentrations of Carbon Monoxide," Symposium on Air Pollution, Proceedings of the Royal Society of Medicine.
24. W. H. Forbes, "The Influence of Moderate Carbon Monoxide Poisoning Upon the Ability to Drive Automobiles" 1937.
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<sup>1</sup> Copies of the technical papers referred to may be found in the committee's files.

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41. California Air Quality Data, Vol. IV, No. 3 pages 1-7.

42. California Air Resources Board Bulletin, Feb. 1973, page 4.

43. C. M. Heinen, "Some Health and Safety Aspects of the Automotive Exhaust Study Program" Second Highway Safety Research Correlation Conference on "Health, Medical and Drug Factors in Highway Safety" April 5, 1954.

44. John M. Pierrard, Ronald D. Snee and Joseph Zelson Paper No. 73-75, entitled "A New Approach to Setting Vehicle Emission Standards", presented at 66th Annual Meeting of Air Pollution Control Association, June 24-28, 1973 Chicago, Illinois.

Mr. SATTERFIELD. Could we have the same thing with respect to your survey in Chicago where you say the measurements have changed? Is that available?

Mr. HEINEN. That is in the same group.

Mr. TERRY. There is a paper on that, and I have a graph which is part of that paper which shows this trend. I think if somebody can pass it up to you, you can glance at it and see how that trend is going, and this is representative of how automobile emission trends have been going.

[Testimony resumes on p. 435.]

[The following information was received for the record:]

# **A New Approach to Setting Vehicle Emission Standards**

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and Joseph Zelson**

**E. I. du Pont de Nemours & Company, Inc.  
Wilmington, Delaware**

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Air Pollution Control Association  
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## ABSTRACT

Urban ambient air quality trend analysis was evaluated as an alternative to rollback analysis to estimate vehicle emission standards needed to achieve national ambient air quality standards. Examination of the trends of monthly maximum 8-hour average carbon monoxide concentrations, central business district traffic activity, and emission rates from vehicles on the road suggests that the automotive exhaust emission standard for carbon monoxide derived in response to the requirements of the Clean Air Act Amendments of 1970 may be ten times too severe.

The excessive stringency of the vehicle emission standard for carbon monoxide was confirmed by two different analyses of the correlation between annual mean carbon monoxide concentration and frequency of occurrence of carbon monoxide concentrations above the level of the 8-hour standard. One correlation analysis, using all available CAMP data, involved an empirical approach and the other assumed that carbon monoxide concentrations are described by the lognormal distribution.

Based on the analysis of CAMP air quality data, a vehicle carbon monoxide emission standard of approximately 29 grams per mile appears adequate to meet the ambient air quality standard. The large difference between the results of this analysis and the 1976 Federal vehicle carbon monoxide emission standard indicates the advisability of applying this methodology to verification of the standards for hydrocarbons and oxides of nitrogen.

## INTRODUCTION

A crucial step in air resource management is the determination of the reduction of pollutants from various emission sources necessary to meet air quality goals. This determination requires a knowledge of the relationship between pollutant emissions and ambient air quality. Conceptually, the level of allowable emissions consistent with achievement and maintenance of a desired level of air quality can be derived from the information outlined in Figure 1. As shown, the determination of an emission standard consistent with achievement of a given air quality standard involves consideration of existing air quality, background air quality, and source growth trends. The interactions among these factors can be described by a model.

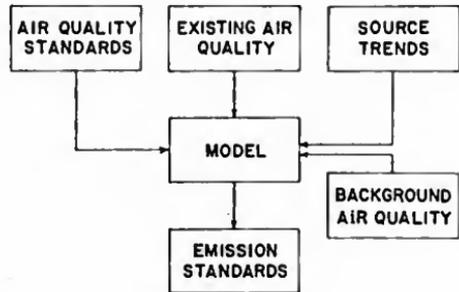


Fig. 1 - Flow Diagram for the Determination of Emission Standards

Air quality standards, to protect the public health and welfare from any known or anticipated adverse effects of air pollution, were promulgated by EPA in April, 1971, as directed by the 1970 Amendments to the Clean Air Act. These air quality standards are shown in Table I for those pollutants associated with automotive use. These standards thus became available to be used with the other data, as outlined in Figure 1, to determine the vehicle exhaust emission standards needed to achieve the specified levels of air quality.

TABLE I

NATIONAL AMBIENT AIR QUALITY STANDARDS  
FOR AUTOMOTIVE POLLUTANTS

Carbon Monoxide	9 ppm	8-Hour Average*
	35 ppm	1-Hour Average*
Hydrocarbons	0.24 ppm C; (6-9 a.m.)	3-Hour Average*
Nitrogen Oxides	0.05 ppm NO <sub>2</sub>	Annual Arithmetic Mean
Oxidant	0.08 ppm	1-Hour Average*

\* Not to be exceeded more than once a year

Another part of the same 1970 Amendments to the Clean Air Act, however, directed EPA to set vehiclc hydrocarbon and carbon monoxide emission standards for 1975 models corresponding to 90 percent reductions from the standards for 1970 models, and to set a vehiclc nitrogen oxides emission standard for 1976 models corresponding to 90 percent reduction from the level of 1971 models. In response to the mandate by Congress, EPA determined 1975 and 1976 emission standards as shown in Table II (1)\*.

TABLE II  
U. S. LIGHT-DUTY VEHICLE EMISSION STANDARDS

	Emission Standards, Grams Per Mile		
	<u>1975 Federal Test Procedure</u>		
	<u>CO</u>	<u>HC</u>	<u>NO<sub>x</sub></u>
1975	3.4	0.41	3.1
1976	3.4	0.41	0.4

Because the percentage emissions reduction was specified first and the air quality standards were established some time later, it is not unlikely that the emission standards resulting from the mandate by Congress might not be consistent with the ambient air quality standards. In the absence of any other considerations it might be desirable to attain the lowest emission levels from automobiles which are technologically achievable. In general, however, the cost of the emission control hardware and fuel consumption increases with the degree of emission control imposed (2). In view of the worsening energy supply situation in this country, it is imperative that an appropriate balance be struck between required emission levels and resulting fuel consumption penalties. It is, therefore, important to make certain that the emission standards are in fact soundly related to the air quality standards, and that we are not paying for more control than is needed to achieve the established air quality standards.

To determine the reduction in vehicle emissions needed to achieve ambient air quality standards a working model relating these variables is needed. Several approaches can be identified

- Diffusion modeling of the urban atmosphere
- "Rollback" analysis
- Air quality trend analysis

\* Numbers in parentheses refer to references

The use of mathematical models of the urban atmosphere for prediction of ambient air quality appears promising. To date, however, this modeling technique has not been developed to the point where it can be used to establish emission standards. Thus, practical technical estimates of needed emissions reductions have been made on the basis of the so-called "rollback" approach (3). This approach assumes that the pollutant concentration is proportional to the emission rate of that pollutant in an air basin, with a small correction for the background level of the pollutant. Using the rollback approach, automotive emission standards required for achievement of ambient air quality standards have been calculated first by the California and later by Federal agencies, for various assumed combinations of implementation dates and air quality standards. These calculations have been made to estimate the emission reduction needed to meet the air quality standard in the most polluted location, which is expected to guarantee achievement in less polluted places.

In the time since the rollback method was first applied, there has been an appreciable reduction of vehicle hydrocarbon and carbon monoxide emission rates. By studying the effect of these reductions on resulting air quality, another way of relating emission standards to air quality is made possible. This air quality trend analysis inherently accounts for the influence of atmospheric processes on the relationship between emissions and air quality.

An important factor in the analysis of emission reductions needed to meet air quality standards is the manner in which the carbon monoxide, hydrocarbon, and photochemical oxidant air quality standards were specified. For example, the ambient air quality standard for carbon monoxide is specified in terms of one-hour average and 8-hour average concentrations which may not be exceeded more than once per year. Evaluation of present air quality and surveillance of progress toward air quality objectives, therefore, requires accurate determination of the levels which are exceeded no more than once per year. The rarity of such extreme values, however, necessarily implies a low degree of reliability of these estimates especially as they must, in many cases, be based on incomplete sampling. If it could be established that a definite relationship exists between the number of times (or the extent) the air quality standard is exceeded and another property of pollutant concentrations (such as the mean over a long period), the requirement for continuous sampling could be relaxed and the degree of reliability of data interpretation improved. Also, extensive data already available giving monthly and annual mean concentrations could be interpreted in terms of frequency of exceedence of the air quality standard concentration.

This paper is a progress report on development of a methodology for estimating required emission standards by analysis of air quality trends. Two techniques of relating long-term average concentrations to progress toward achievement of the air quality standard have been developed. The methodology has been applied to determination of the vehicle carbon monoxide emission rate consistent with maintenance of the air quality standard. The emission standards derived by the methodology developed here are compared with those derived from rollback calculations,

and with those currently imposed as a result of the 90 percent reduction mandated by the 1970 Amendments to the Clean Air Act.

### ROLLBACK MODEL ANALYSIS

The "simple" rollback equation is

$$R = \frac{(GF)(EAQ) - (AQS)}{(GF)(EAQ) - (B)}$$

where

- R = fractional emission rate reduction required to achieve desired air quality
- GF = emission growth factor
- EAQ = existing air quality
- AQS = air quality standard
- B = background air quality

The rationale for this equation and some suggested modifications are discussed by Jensen (4).

To illustrate with a specific example, the national ambient air quality standard for carbon monoxide requires that the 8-hour average concentration not exceed 9 parts per million (ppm) more than once per year. Although the stringency of the standard has been questioned (5), the goal of meeting the standard will be accepted for the purposes of this paper, and only the question of what automotive emission rate is needed to meet this standard will be considered. Carbon monoxide has been chosen as an example because in most large cities, nearly all of it can be ascribed to vehicular activity. Then, the rollback approach would say that if the 8-hour average carbon monoxide concentration exceeded once per year is found to be 18 ppm, a reduction of automotive carbon monoxide emissions to half their current rate would achieve the 9 ppm air quality standard, provided background is negligible.

### EPA Calculations

EPA has applied rollback analysis to emission standard selection based on a worst-case philosophy (6). The needed reduction of emissions to meet the air quality standard in the worst known (or expected) case was calculated, and then applied under the assumption that this is the most effective strategy nationwide. In the case of carbon monoxide, EPA used the worst carbon monoxide event ever observed, which happened at the Chicago CAMP station in December 1965 where an 8-hour average of 46 ppm was measured. A growth factor of 1.54, corresponding to 3 percent annual increase in vehicle population, and at that time considered appropriate to the Chicago metropolitan area, was used. Under these assumptions, the necessary 1975 carbon monoxide emission standard was calculated to be 9.3 g/mile. Similarly, EPA calculated the necessary hydrocarbon and nitrogen oxides emissions standards for the worst locations in the country (Los Angeles for hydrocarbons, and New York for nitrogen oxides). The three resulting emission standards are shown in Table III.

It is clear that the vehicle emission standards calculated by the EPA (shown in the first line of Table III) are generally much higher than the 1975-76 standards derived from the 1970 Amendments to the Clean Air Act (shown in the second line of Table III). The carbon monoxide standard calculated by rollback is almost three times greater and the nitrogen oxides standard is three greater than the 1976 standards which were based solely on the 90 percent reduction formula. Only in the case of the hydrocarbon standard do the calculated standard and the legislated standard agree. If the rollback model analysis is correct, the 1976 standards are more stringent than needed to achieve the ambient air quality standards and, in fact, do not appear to be related to the ambient air quality standards.

TABLE III

VEHICLE EMISSION STANDARDS CALCULATED BY  
EPA USING ROLLBACK MODEL ANALYSIS

	Emission Standards, Grams Per Mile		
	1975 Federal Test Procedure		
	<u>CO</u>	<u>HC</u>	<u>NO<sub>x</sub></u>
EPA Calculation (5)	9.3	0.32	1.2
1976 U.S. Standards	3.4	0.41	0.4

### Alternate Calculations

The rollback model analysis as applied by the EPA was based on two input assumptions which on subsequent analysis do not appear to be correct. These assumptions involve

- (1) The appropriate vehicle or emission source growth factor, and
- (2) The appropriate value of existing air quality.

The first problem in applying rollback methodology is the validity of assuming direct proportionality between emissions totaled over an air shed, and peak concentrations encountered at specific points in the air shed. If this assumption is true, then it would be justifiable to project future air quality at any point in the region on the basis of the anticipated growth of the entire urban complex. This would also imply that ambient pollutant concentrations at all points within an air shed are directly related.

A test of this assumption was made for Chicago, using data from the EPA CAMP station in the central business district, and from outlying air sampling stations operated by the City of Chicago. The Chicago Department of Environmental Control began carbon monoxide measurements at four sites in December, 1970. Two of these sites are in residential areas, and the other two are near expressways, at distances

from 2.5 to 12 miles from the center city CAMP station. Daily average carbon monoxide concentrations at these sites, published in the quarterly Chicago Ambient Air Quality Data summaries, were compared among themselves, and with the values for the CAMP station, computed from a magnetic tape record provided by EPA of hourly average data for the period December 1970 through December 1971.

Correlations of daily average carbon monoxide concentrations for the various pairs of stations, though generally statistically significant, were quite small, as shown in Table IV. The lack of correlation from site to site is consistent with the diffusion model assumed by Johnson, et al (7) and discussed by Chang and Weinstock (8); both groups concluded that the contribution of local street sources to measured carbon monoxide may be dominant in urban situations. Evidently this indicates that ambient atmospheric carbon monoxide air quality data should be related to nearby, not remote, traffic activity. Chicago central business district traffic, rather than metropolitan area traffic, should be considered therefore in attempts to explain air quality measured at the CAMP station. In their analysis of urban air pollution, Ott, et al (9) assumed that traffic in large urban business districts is at its "saturation" level, meaning that no increase of vehicle use can be foreseen.

TABLE IV

CORRELATION OF DAILY AVERAGE CARBON MONOXIDE  
CONCENTRATIONS BETWEEN PAIRS OF CHICAGO  
AEROMETRIC STATIONS, DECEMBER 1970 - DECEMBER 1971

	Correlation Coefficient <sup>a</sup>				Mean of Four City Sites
	<u>Expressway</u>		<u>Residential</u>		
	<u>Cermak</u>	<u>Sunnyside and Knox</u>	<u>Fenger</u>	<u>Stevenson</u>	
CAMP Station	0.30	-0.04 <sup>b</sup>	0.18	0.25	0.24
Cermak		0.24	0.30	0.31	0.74
Sunnyside and Knox			0.15	0.20	0.66
Fenger				0.34	0.61
Stevenson					0.64

<sup>a</sup> Except where noted, all correlation coefficients are significant at the 0.01 probability level

<sup>b</sup> Not significantly different from zero

Cordon traffic counts, provided by the Bureau of Street Traffic of the City of Chicago, verify that traffic saturation exists in the Chicago central business district surrounding the CAMP station. Average traffic for the area bounded by Wacker Drive on the north and west, Roosevelt Road on the south, and Michigan Avenue on the east is shown in Figure 2. These data indicate that traffic has been essentially constant over the decade ending in 1971.

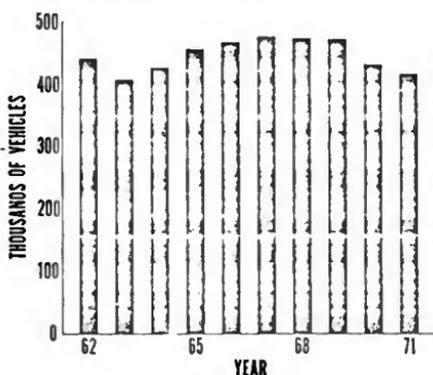


Fig. 2 — Weekday Daytime Traffic in Chicago Central Business District

The required automotive emission standards for 1975 have been recalculated using a growth factor of unity as justified by the traffic data. The same background values and existing ambient air quality levels used by the EPA were employed in these calculations. These alternate standards, given in the second line of Table V, are about 60 percent greater than the values calculated by EPA which are shown in the first line.

TABLE V

ALTERNATE VEHICLE EMISSION STANDARDS  
CALCULATED BY THE ROLLBACK MODEL ANALYSIS

	Emission Standards, Grams Per Mile		
	<u>1975 Federal Test Procedure</u>		
	<u>CO</u>	<u>HC</u>	<u>NO<sub>x</sub></u>
EPA Calculation	9.3	0.32	1.2
Calculation With Unity Growth Factor	15	0.5	1.8
Calculation With Unity Growth Factor and Once-Per-Year Ambient CO Concentration	23		
1976 U. S. Standards	3.4	0.41	0.4

The second questionable input value used in the EPA rollback model analysis is the proper level of the existing air quality. For example, the ambient air quality standard specifies air quality for carbon monoxide based on a value of 9 ppm 8-hour average not to be exceeded more than once per year. Thus the rollback analysis should use that value which is exceeded once per year rather than the worst value ever seen over a sampling period of almost ten years as was done in the EPA calculations.

A copy of the magnetic tape data file for all CAMP sampling locations, through 1971, was provided by EPA. The distributions of the 8-hour average carbon monoxide concentration were generated from these basic data. Analysis of the distribution of 8-hour average carbon monoxide concentrations disclosed that the value exceeded once per year in Chicago was 38 ppm. Hence, the emission standard for carbon monoxide was calculated by the rollback model using the once-per-year 38 ppm concentration consistent with the occurrence frequency specified by the air quality standard rather than the once-in-ten-year 46 ppm concentration used by EPA. This calculation yields a value of 23 g/mile as the carbon monoxide standard needed for achievement of the air quality standard, some two-and one-half times the 9.3 g/mile value calculated originally by EPA.

Once again, it is clear that the vehicle emission standards calculated by the alternative rollback model analysis are much greater than the 1975-76 U.S. standards set in accordance with the direction of the 1970 Amendments to the Clean Air Act. The carbon monoxide standard based on actual vehicle growth rates and observed existing ambient air quality levels is almost seven times the current 1976 standard. The nitrogen oxides standard is better than four times as great as the legislated standard while again the hydrocarbon standard and the legislated standard are in generally good agreement.

It can be argued that the rollback calculation using the observed once-per-year carbon monoxide value does not allow a safety margin, and that use of a growth factor greater than the observed unity growth factor is needed to allow for increasing background carbon monoxide advected to the measurement area as the surroundings develop. The desirable safety margin is a matter of judgment which is inappropriate to discuss here, although it can be pointed out that there appears to be a safety factor already included in the choice of the 8-hour average air quality standard level of 9 ppm (5). On the other hand, the use of a larger growth factor than that observed or anticipated for the region near the aerometric station can be questioned.

To quantify the sensitivity of the required fractional emission reduction, as calculated by the simple rollback model, to a change in background value, one can view an urban complex as a central subregion lying entirely within the urban surrounds. Using carbon monoxide for simplicity, the present air quality  $P$  in the central subregion is the sum of a background concentration advected into the central region  $B$  and a concentration produced by emissions from local traffic  $P-B$ . Without emission controls, the future air quality in the central subregion would become  $F$ , with background contribution  $B_f$  and local traffic contribution  $F-B_f$ . But recognizing that

traffic saturation exists in the central subregion, the local vehicular contribution to air quality remains the same, so that

$$F - B_f = P - B \quad (1)$$

Applying the simple rollback model, the fractional reduction of emissions in the traffic-saturated central subregion, required to meet the air quality standard,  $Q$ , is

$$R = \frac{F - Q}{F} \quad (2)$$

If, now, the future background value is expressed as a multiple of current background, by

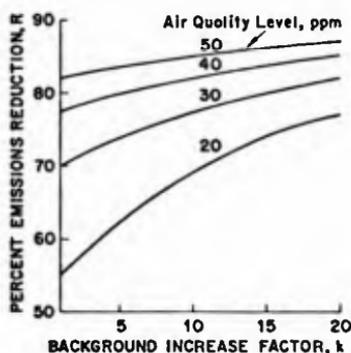
$$B_f = k B \quad (3)$$

and equation (1) is used, the rollback expression becomes

$$R = \frac{P - Q + (k - 1) B}{P + (k - 1) B} \quad (4)$$

The calculated reduction of emission rate depends only weakly on future background levels for the case of high present concentrations, and for reasonable background increase factors, as shown in Figure 3. In this figure, the sensitivity of the computed needed reduction to a background increase is plotted assuming a present background value of 1 ppm, and the air quality standard level of 9 ppm. Even with a tenfold background increase, the error in calculated percent reduction, for an assumed present air quality of 40 ppm, is less than 5 percent.

Fig. 3 - Effect of Future Background Increase on Emission Reduction Requirements Computed by Rollback Method



In summary, the rollback model is sensitive to the assumed existing air quality which must be defined as a value exceeded only once per year but only weakly

dependent on background growth. Further, a growth factor greater than one is not appropriate for traffic-saturated center city areas as determined by analysis of traffic data. Finally, the fundamental assumption of proportionality between emissions over an air shed and absolute peak concentrations does not appear to be justified based on analysis of carbon monoxide daily averages for a 13-month period at five locations in the same city. Uncertainties inherent in the selection of proper values of these variables for use in the rollback calculation have resulted in divergent estimates of needed vehicle emission standards for carbon monoxide ranging from 9.3 to 23 g/mile. The evident shortcomings of the simple rollback equation indicate a need for improved approaches to definition of needed emission standards.

## AIR QUALITY ANALYSIS

An alternative to the simple rollback approach is available which involves analysis of air quality trends. The approach developed in our study and described in this paper is based on an examination of the aerometric data record for cities with long term measurement bases, to evaluate what discernible air quality changes have accompanied changes in pollutant emissions over the years.

The case of carbon monoxide is mostly directly amenable to analysis because two simplifying assumptions can be made:

- Carbon monoxide in urban areas originates exclusively with motor vehicles.
- The half-life of carbon monoxide in the atmosphere is much longer than the air mass exchange period.

### Trend Analysis

There has been a general improvement in carbon monoxide air quality as measured by the percent of the time that the ambient air quality standard was exceeded over the years at the CAMP sampling sites near the centers of six major cities. These exceedence values were computed from the basic magnetic tape data file mentioned earlier and are shown in Table VI. To further examine this trend, a detailed study was made for Chicago, the city cited by EPA as having the worst carbon monoxide pollution problem, and the prototype case used in the EPA rollback calculations of required nationwide carbon monoxide emission rate reductions.

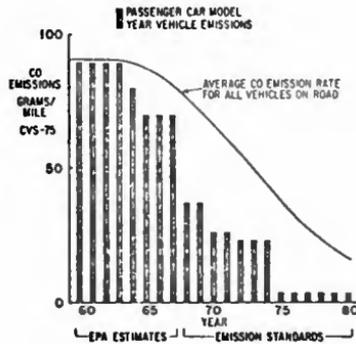
It was noted earlier (Figure 2) that traffic in the Chicago central business district surrounding the CAMP station was approximately constant over the 1962 to 1971 decade. It is thus possible to utilize vehicle population mean carbon monoxide emission rate as an index of total carbon monoxide output in the vicinity of the CAMP station. Figure 4, adapted from an EPA presentation to the RECAT committee (5) depicts both the decrease of light-duty vehicle carbon monoxide emission rates by model year, and the estimated national average carbon monoxide emission rate for the vehicle population as a whole, including heavy-duty vehicles.

TABLE VI

CAMP CITY AMBIENT CARBON MONOXIDE TRENDS

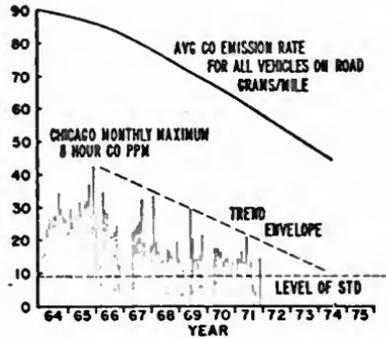
Year	Percent of Time the 8-hour Federal CO Standard Was Exceeded					
	Chicago	Denver	Washington	Cincinnati	St. Louis	Philadelphia
1962			11			
1963			20	29		
1964	67		5	20	16	23
1965	92	26	2	2	21	35
1966	71	34	2	3	12	16
1967	40	30	5	6	7	19
1968	18	11	2	6	2	39
1969	38	5	0	-	1	1
1970	24	16	2	-	0	2
1971	14	19	2	1	1	1

Fig. 4 — Effect of Introduction of CO Emission Controls on Vehicle Population Mean CO Emission Rate



As was already shown in Table VI, the frequency of exceedence of the 8-hour carbon monoxide standard has been decreasing in Chicago since 1964. However, determination of the required emission reduction to meet the air quality standard must include consideration of the amount by which the level of the standard is exceeded. One measure of this is shown in Figure 5, where the highest 8-hour average carbon monoxide in each month of record is plotted. Evidently, the air quality standard will be more than met when the monthly maximum 8-hour average carbon monoxide falls to the air quality standard level of 9 ppm, because the standard permits one exceedence per year of the 9 ppm level, whereas when the monthly maximum reaches this level, and stays below it, there are no exceedences. The curve describing vehicle population mean carbon monoxide emission rate is also shown in Figure 5, along with the apparent trend envelope of maximum monthly 8-hour average carbon monoxide concentrations.

Fig. 5 - Comparison of Vehicle CO Emission Rate and Monthly Maximum CO Values in Chicago



There is a striking parallelism between the downward slope of the trend envelope of peak carbon monoxide values and the curve defining the mean carbon monoxide emissions from the vehicle population. The linear extrapolation of the trend line shown in Figure 5 suggests that the 9 ppm level of the ambient air quality standard will be achieved in mid-1974 in Chicago, the city with the worst ambient carbon monoxide concentrations. The upper curve of Figure 5 shows that the vehicle mean carbon monoxide emission rate at that time is projected to be 40 g/mile.

However, two aspects of the carbon monoxide data suggested the need for further analysis:

- (1) The considerable month-to-month variation in peak carbon monoxide concentrations, presumably due to meteorological factors, and
- (2) The dependence of the trend line in Figure 5 on a few extreme values.

### Effects of Meteorological Variables

An analysis of the association between meteorological factors and peak carbon monoxide values was carried out, to determine whether the departures of monthly peak carbon monoxide values from the trend line could be reduced. Identification of significant meteorological variables would permit compensation for their effects and consequently improve confidence in the trend line.

To explore for relationships of predictive value, hourly weather data (6 a. m. to 12 midnight) at the Chicago lake front airport (Meigs Field), and the concurrent hourly carbon monoxide measurements at the CAMP station, approximately 1.5 miles northwest of Meigs Field and adjacent to the Eisenhower Expressway, and hourly traffic counts on the Eisenhower Expressway at the nearest automatic counter (5.5 miles west) for 1968 and 1969 were analyzed. The analysis employed multiple

TABLE VII  
 VARIABLES IN REGRESSION ANALYSIS<sup>a</sup>

Variable Level	Month	Day	Hour	Wind		Visibility	Stability	Sky		Traffic
				Speed	Direction			Cover	Cover	
1	Jan.	Sun & Hol.	6	0-5	5-44	0-2	1	0.0	0-999	
2	Feb.	Mon	7	6-10	45-84	3-4	2	0.1	1,000-1,999	
3	March	Tues	8	11-15	85-124	5-7	3	0.2	2,000-2,999	
4	April	Wed	9	16-20	125-164	8-10	4	0.3	3,000-3,999	
5	May	Thurs	10	21-25	165-204	12-20	5	0.4	4,000-4,999	
6	June	Fri	11	26-30	205-244	21-30		0.5	5,000-5,999	
7	July	Sat	12		245-284	40		0.6	6,000-6,999	
8	Aug.		13		285-324	50		0.7	7,000-7,999	
9	Sept.		14		325-4	60		0.8	8,000-8,999	
10	Oct.		15			70		0.9		
11	Nov.		16			80		1.0		
12	Dec.		17			100				
13			18			120				
14			19			≥ 150				
15			20							
16			21							
17			22							
18			23							
19			24							
Total No. Levels	12	7	19	6	9	14	5	11	9	

<sup>a</sup> Units: Wind Speed -- knots  
 Wind Direction -- degrees  
 Visibility -- miles  
 Stability -- 1 = extremely unstable, 5 = slightly stable  
 Sky Cover -- fraction  
 Traffic -- vehicles per hour

regression techniques in which the levels of the different variables were represented by dummy variables (0, 1), which eliminated the need to assume an analytic function to describe the relationship between the weather and traffic variables and carbon monoxide. The levels of each variable are shown in Table VII. The resulting 83 term regression equation (additive model) was of the form

$$\hat{y} = b_0 + b_1 X_1 + b_2 X_2 + \dots + b_{83} X_{83}$$

where  $\hat{y}$  is the predicted hourly carbon monoxide concentration, the X's are dummy variables (0, 1) representing the levels of the weather and traffic variables, and the b's are regression coefficients estimated from the data by least squares. For a given variable, each coefficient represents the difference in carbon monoxide concentration between the given level and the first level of the variable (i.e., the first level of each variable is not represented in the equation). Correlations among the predictor variables (X's) were low, hence, it was possible to obtain precise estimates of the coefficients in the additive model. Use of the logarithmic transformation of the carbon monoxide data did not improve the fit.

TABLE VIII  
REGRESSION STATISTICS<sup>a</sup>

	1968				1969			
	df	SS	Rank+	F	df	SS	Rank	F
Month	11	1,282	6	12.59	8	20,634	1	217.70
Day	6	2,284	3	38.84	6	1,626	4	22.87
Hour	18	3,494	2	19.34	18	3,744	3	17.58
Wind Speed	5	527	7	13.32	5	479	7	8.08
Wind Direction	8	6,111	1	74.53	8	7,903	2	83.44
Visibility	13	1,917	5	15.25	13	1,062	6	6.93
Station	4	71	9	5.86	4	230	9	4.84
Temperature	10	490	8	6.36	10	570	8	4.80
Total	8	1,954	4	26.39	8	1,580	5	16.73
Intercept		0.43				0.50		
Total Adj. Sq. Dev.		3.25				3.44		
Total Error								
Total		4,332				4,204		

- All F values are significant at the 0.01 probability level
- Rank of sum of squares (SS) from largest (1) to smallest (9)

The regression statistics summarized in Table VIII indicate that all variables have a significant effect. The F tests of significance were constructed by determining the total sum of squares accounted for when the dummy variables corresponding to each

physical variable were added to the equation last (10). Using the sum of squares as a measure of importance, Table VIII indicates that only wind direction has a major effect in both years studied. Figure 6 illustrates this dependence on wind direction. The tendency toward increased carbon monoxide concentrations with northerly and easterly winds may be a reflection of the lake breeze effect documented by Lyons and Olsson (11) in their study of Chicago mesometeorology, or it may be a peculiarity due to location of the sampling site on the south side of the Eisenhower Expressway.

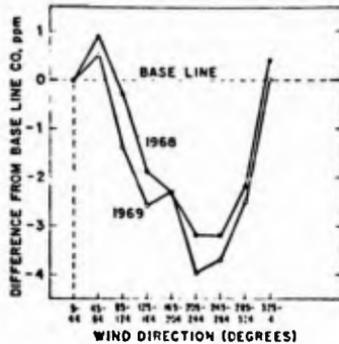


Fig. 6 — Dependence of Chicago Camp Station Hourly CO Values on Wind Direction

While all the meteorological variables included in the model are statistically significant, there is still considerable variability which remains unexplained by the model, as shown by the adjusted  $R^2$  values in Table VIII. Thus, the model was not judged to be adequate at least in its present form, for prediction of the distribution of ambient carbon monoxide concentrations. Although we are continuing to seek improvements in the meteorological model, another approach has also been taken, which does not rely on the dependence of trend line location on extreme values.

### RELATIONSHIP BETWEEN MEAN AND EXTREME VALUES OF AMBIENT POLLUTANT CONCENTRATION

It was pointed out earlier that the air quality standards for carbon monoxide, hydrocarbons, and photochemical oxidants are specified as concentration levels, over given averaging times, not to be exceeded more often than once a year. Therefore, demonstration that the standards are being achieved, or evaluation of progress toward achievement of the standards, requires a high degree of confidence that the air quality measurements used to estimate the frequency distribution of pollutant concentrations are representative. Unless continuous measurements are made, the confidence of an estimate of the occurrence frequency of a rare event, such as is implied by the air quality standards, is degraded.

The work discussed below was undertaken to determine whether a definite relationship exists between exceedences of the standard and the annual mean, which

is less sensitive to missing data. If such a relationship can be shown to exist, then the annual average can be used to determine appropriate emission reductions needed to meet the air quality standards.

Two basic approaches can be considered to relate exceedences to long term averages:

- (1) If the distribution of the pollutant can be adequately described by an analytic function, then the frequency of extremes can be calculated from the parameters of the distribution, and
- (2) If there is a close-fitting empirical relationship between extremes and mean, this relationship can be used to interpret data on means of pollutant concentration.

Both of these approaches were examined for the case of carbon monoxide.

### Lognormal Distribution Approach

Knowledge of the analytic form of the distribution of concentrations would enable calculation of extreme values from incomplete data samples. An argument for use of the lognormal law was presented by Larsen (12), who pooled six years of data from each of the CAMP cities, and showed that for the individual cities, the lognormal law adequately described the distribution of the highest 30 percent of carbon monoxide concentrations. However, if the lognormal law is generally applicable, a relationship should be evident for the pooled data from all cities surveyed.

Proportionality of the standard deviation ( $S$ ) and the mean ( $\bar{X}$ ) is a property of the lognormal distribution. The CAMP data were examined to determine whether this relationship between  $S$  and  $\bar{X}$  held for the pooled carbon monoxide values. From the magnetic tape data file, 8-hour average carbon monoxide concentrations and their standard deviations were computed by year for each city. The corresponding annual mean carbon monoxide values were likewise computed, providing 51 data pairs ( $\bar{X}$ ,  $S$ ) from the pooled file. For the 51 data sets represented by the CAMP carbon monoxide data from 1962 through 1971, the least squares line relating 8-hour average carbon monoxide standard deviation and annual mean carbon monoxide was computed to be

$$S = 0.3 + 0.444 \bar{X}$$

The standard error of the estimated intercept (0.3) was 0.2; hence the intercept was not significantly different from zero. When the curve was forced to pass through the origin, the least squares line was  $S = 0.491 \bar{X}$ . The standard error of the estimated slope (0.011) was 0.011. A good fit to the data is provided by both the regression line ( $S = 0.3 + 0.444 \bar{X}$ ) and the approximation  $S = 0.5 \bar{X}$ , as illustrated in Figure 7. The results that the use of the lognormal law may be justified.

Fig. 7 - Relationship Between Standard Deviation of 8-Hour Average CO Values and Annual Average CO for All CAMP Cities

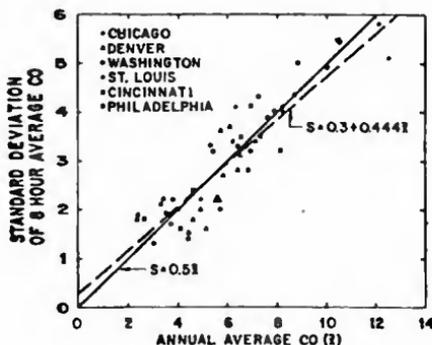
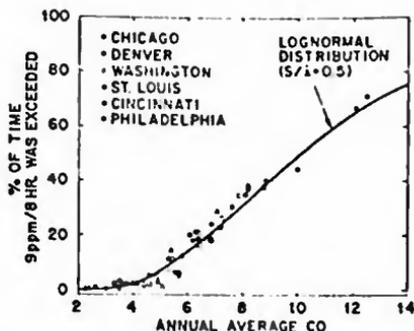


Fig. 8 - Relationship Between Exceedence of Federal 8-Hour Ambient CO Standard and Annual Average CO for All CAMP Cities



The 51 pairs of values of percent exceedence of the 8-hour carbon monoxide standard and annual mean carbon monoxide are plotted in Figure 8. The curve in Figure 8 was computed for the lognormal distribution with coefficient of variation ( $\sigma/\mu$ ) equal to 0.5, and gives a good fit to the whole data set. Using the lognormal frequency distribution, with coefficient of variation = 0.5, the annual average carbon monoxide concentration consistent with one annual occurrence of the 9 ppm 8-hour average carbon monoxide concentration was computed; this value is 2.3 ppm. Moreover, the computed required annual average is not strongly dependent on the value of the coefficient of variation. Using values of 0.45 and 0.55 for the coefficient of variation, the corresponding computed annual average carbon monoxide concentrations become 2.1 and 2.6 ppm, respectively. Thus, the ratio  $\sigma/\mu$  need only be known with moderate accuracy to obtain a useful result.

### Empirical Correlation

Another approach is the empirical one of determining the relationship between exceedences of the ambient air quality standard and annual average concentration. This approach, like the lognormal approach, reduces sensitivity to sampling voids because the estimate of exceedences is based on the annual mean. An additional advantage of the empirical approach is that the confidence limits of the annual mean associated with achievement of the air quality standard can be objectively determined. Linear regression analysis of the 51 pairs of carbon monoxide data (annual mean and percent exceedence) indicated that the annual mean carbon monoxide value associated with achievement of the 8-hour ambient carbon monoxide standard is 3.2 ppm. However, a more accurate estimate of the annual mean required for achievement of the air quality standard can be determined by considering only those data for small exceedence, i.e., where the air quality standard is being met, or nearly so. Therefore, from the 51 CAMP carbon monoxide data sets, only those 23 pairs with less than

7 percent exceedence (PCT) were fitted by least squares to the corresponding annual mean carbon monoxide values ( $\bar{X}$ ). The resulting regression equation was

$$PCT = 2.7 \bar{X} - 8.5$$

with  $R^2 = 0.76$ . Table IX lists the annual mean carbon monoxide values needed to meet the air quality standard, calculated from this relation at various confidence levels. The tabulated carbon monoxide values are the lower limit values of the corresponding confidence bands. These values are in excellent agreement with the 2.3 ppm computed by the lognormal analysis discussed above.

TABLE IX

ANNUAL MEAN CO FOR ACHIEVEMENT  
OF AIR QUALITY STANDARD

<u>Confidence Level, %</u>	<u>Annual Mean CO Concentration, ppm</u>
90	2.6
95	2.5
98	2.4
99	2.2

**CARBON MONOXIDE EMISSION STANDARDS DETERMINED  
BY AIR QUALITY ANALYSIS**

It has been demonstrated above that an annual mean carbon monoxide concentration of 2.3 ppm is consistent with achievement of the 8-hour average ambient air quality standard of 9 ppm for carbon monoxide. Table X shows that Cincinnati and Philadelphia already in 1971 had annual average carbon monoxide values close to the 2.3 ppm annual average which is associated with one occurrence per year of the 9 ppm 8-hour average carbon monoxide level specified by the air quality standard. Thus the downtrend of vehicle carbon monoxide emissions, resulting from replacement of older cars, has been sufficient to improve air quality in these cities essentially to the level of the ambient air quality standard, as is evident from the exceedence experience shown earlier in Table VI. If the worst-case philosophy adopted by EPA for their rollback calculations were applied to the 1971 air quality measurements, Denver would supplant Chicago as the national prototype for determination of the carbon monoxide emission standard. However, the increase of ambient carbon monoxide in Denver since 1969 (Table X) is apparently due to a vehicle population mean carbon monoxide emission rate which is significantly higher than the national mean value. The high vehicle carbon monoxide emission rate is ascribed to the antitampering provision of the law, which has been interpreted to prohibit adjustment of carburetors to compensate for altitude. Thus, a carburetor calibrated for the proper air/fuel ratio at or near sea level runs significantly richer at Denver's 5,000 foot elevation, with resultant excess carbon monoxide emissions (13).

TABLE X  
CAMP CITY AMBIENT CARBON MONOXIDE TRENDS

Year	Annual Average CO Concentration, ppm					
	Chicago	Denver	Washington	Cincinnati	St. Louis	Philadelphia
1962			5.3			
1963			6.9	7.1		
1964	12.1		5.7	6.1	6.4	7.2
1965	17.1	7.3	3.7	4.0	6.5	8.1
1966	12.5	7.9	3.3	4.9	5.8	6.6
1967	8.8	7.6	4.9	5.6	5.6	6.4
1968	6.2	5.4	3.4	5.7	4.6	8.7
1969	8.2	4.6	3.0	-	5.1	3.5
1970	6.9	6.5	3.8	-	4.4	4.1
1971	5.4	6.7	3.5	2.3	4.4	2.6

A recent survey of exhaust emissions from a total of 1,020 vehicles of the 1957-1971 model years in six cities clearly showed that both hydrocarbons and carbon monoxide emissions in Denver were significantly higher, and oxides of nitrogen significantly lower, than in the other cities studied (14). In each city surveyed in the study cited, the vehicles which were tested were selected to be representative of the vehicle population distribution as of 1971, by make and model year. The automobile population mean carbon monoxide emission rate for calendar year 1971 in each of the cities is shown in the second column of Table XI. The third column of Table XI lists the necessary reduction from the 1971 annual mean ambient carbon monoxide level in each city to reach the annual mean value of 2.3 ppm which is consistent with achievement of the air quality standard. The last column of Table XI shows the carbon monoxide emission standards consistent with achievement of the ambient air quality standard. These emission standards were calculated by applying the percent reduction factors from Column 3 to the 1971 vehicle population mean carbon monoxide emission rates from Column 2, assuming that annual mean carbon monoxide is directly proportional to vehicle population mean carbon monoxide emission rate. The latter assumption implicitly includes the concept of traffic saturation, which is generally accepted to exist in all these cities.

Table XI shows that a vehicle carbon monoxide emission standard no lower than 35 g/mile is adequate for achievement of the air quality standard, except for Chicago. There is very good agreement among the calculated necessary carbon monoxide emission standards for all cities, again excepting Chicago. The more stringent standard calculated to be necessary to meet the air quality standard in Chicago may well be the result of the meteorological peculiarity of that city's pronounced lake breeze effect documented by Lyons and Olsson (11), and discussed earlier. Therefore, using Chicago as the national worst-case prototype, it implies that carbon monoxide emissions should be reduced by 57 percent from their

1971 values to attain the ambient air quality standard. From Table XI, this implies an allowable vehicle carbon monoxide emission rate of 29 g/mile.

TABLE XI  
 VEHICLE CO EMISSION STANDARDS CALCULATED  
 BY AIR QUALITY TREND ANALYSIS, USING MEASURED  
 1971 VEHICLE POPULATION MEAN CO EMISSION RATES

<u>City</u>	<u>1971 Population CO Emission Rate, g/Mile, CVS-75</u>	<u>Decrease of 1971 Annual Mean Ambient CO Required to Achieve Air Quality Standard, Percent</u>	<u>Required CO Emission Standard, g/Mile, CVS-75</u>
Chicago	66.37	57	29
Denver	112.11	66	38
Los Angeles	74.44	52	36
St. Louis	74.81	48	39
Washington, D. C.	61.87	34	41

**COMPARISON OF CARBON MONOXIDE EMISSION STANDARDS  
 AS DERIVED BY AIR QUALITY ANALYSIS AND BY ROLLBACK ANALYSIS,  
 AND AS REQUIRED BY THE CLEAN AIR ACT AMENDMENTS OF 1970**

It is relevant to attempt to reconcile the difference between emissions reductions calculated by the rollback procedure and by the method developed in this paper, and further to compare the corresponding standards with the standards issued by EPA in response to the mandate of Congress as expressed in the Clean Air Act Amendments of 1970. Table XII summarizes the several rollback calculations discussed earlier, all of which are aimed at deriving the carbon monoxide emission standard consistent with achievement of the 8-hour average carbon monoxide standard, and all of which assume implementation of the standard beginning with 1975 model vehicles. The three rollback calculations are based on an assumed carbon monoxide background value of 1 ppm. The linear extrapolation of the trend line of maximum monthly 8-hour average carbon monoxide concentrations shown in Figure 5 indicates achievement of the 9 ppm concentration level in 1974. At this time the vehicle population mean carbon monoxide emission rate would be approximately 40 g/mile, which value is also shown in Table XII. The value found by the two methods of analysis of the relationship between mean and exceedence is 29 g/mile; this is entered in Table XII under the label "mean-exceedence."

The values in Table XII cover the range from 9.3 to 40 g/mile. As was discussed earlier, the rollback calculations which yield the carbon monoxide emission rates of 9.3 and 15 g/mile are not justified. The rollback value based on the correct

growth factor and existing air quality level in Chicago is 23 g/mile. This value appears consistent with the value of 29 g/mile for the national worst-case city, Chicago, as derived from air quality analysis by the two methods developed for relating means and exceedences.

TABLE VII

CO EMISSION STANDARDS FROM CHICAGO CAMP DATA

	<u>CO Emission Rate, g/Mile, CVS-75</u>
Rollback	
46 ppm, GF = 1.54	9.3
46 ppm, GF = 1.00	15
38 ppm, GF = 1.00	23
Mean-Exceedence	29
Trend of Monthly Maxima	40
Clean Air Act	3.4

On the other hand, the value of 40 g/mile derived from extrapolation of the trend of monthly maximum carbon monoxide occurrences in Chicago appears high. As was pointed out earlier, this value was determined by only a few extreme values, and thus was sensitive to errors or anomalies in these extremes.

A number of possible further refinements might be incorporated in the process of determining necessary emission standards by air quality analysis. One major factor may be differences from city to city in actual carbon monoxide output per vehicle mile due to differences in temperature, trip speed, and driving mode mix. Another factor which could alter the resultant emission standard is a difference between vehicle population mean carbon monoxide emission rate in a particular city, and the national average value due to differences in vehicle mix (15). However, such corrections are expected to be small in comparison with the correction which was incorporated in the analysis to account for differences in engine emission rate from one part of the country to another. Most important, such corrections would be insignificant in comparison with the order of magnitude difference between the carbon monoxide emission standard of 29 g/mile derived in this paper, and the 3.4 g/mile standard established by EPA to provide the 90 percent reduction mandated by the Clean Air Act Amendments of 1970.

## APPLICATION OF AIR QUALITY ANALYSIS TO DETERMINATION OF EMISSION STANDARDS FOR NITROGEN OXIDES AND HYDROCARBONS

The air quality data analysis technique described here is applicable to the determination of the permissible vehicular emissions of oxides of nitrogen, although this question is complicated by several factors which are not present in the case of carbon monoxide.

- The accuracy of ambient nitrogen dioxide measurements is highly uncertain
- Nonvehicular sources contribute significantly to nitrogen oxide emissions, and in some cities dominate
- The range of spatial influence of nitrogen oxide emissions from large, single, elevated sources is likely to be much different from that for vehicular ground sources

Work is in progress to apply this methodology for determination of the vehicular  $\text{NO}_x$  emission rate which is consistent with the  $\text{NO}_2$  air quality standard, using ambient air monitoring data. However, the EPA has stated that the ambient levels of  $\text{NO}_2$  were measured incorrectly because of faulty analytical techniques and that they will suggest to Congress that the vehicle  $\text{NO}_x$  emission standard should be revised upward (16). The rollback calculations presented by EPA (6) suggest an  $\text{NO}_x$  emission standard of approximately 1 g/mile, based on the uncorrected ambient  $\text{NO}_2$  measurements. Revision of this standard to, say, 2 or 3 g/mile would significantly alter the choice among options for future vehicle emission control. Relaxation of the 1976  $\text{NO}_x$  control requirement also would permit better system reliability and greatly reduce operation and maintenance costs (6).

Efforts are also under way to adapt the air quality analysis methodology to determination of hydrocarbon emission standards consistent with achievement of the air quality standard for photochemical oxidant. However, because the chemical dynamics connecting hydrocarbons and photochemical oxidant also involve  $\text{NO}_x$  as a reactive species, determination of the hydrocarbon emission standard implies prior determination of the  $\text{NO}_x$  standard. Thus, no results are yet available on the hydrocarbon emission standard.

### IMPLICATIONS OF REVISED EMISSION STANDARDS

The air quality data analysis presented in this paper indicates that relaxation of the 1975 vehicle carbon monoxide emission standard is justified, not from arguments about technical feasibility, nor about economics, but on the fundamental basis of what is necessary to meet the air quality standard. It is important to recognize the implications of this finding in light of the basically conflicting requirements of the

1975-76 standards for simultaneous extreme reductions of emissions of  $\text{NO}_x$  on the one hand, and carbon monoxide and hydrocarbons on the other, along with the necessity for high reliability and ease of maintenance of systems to achieve emission control on vehicles in consumer use (17).

It is not our purpose here to develop quantitative estimates of the effects of a less stringent carbon monoxide standard. The interactive nature of the problem parameters precludes this, in any event. However, one can confidently expect that the less restrictive carbon monoxide standard would result in appreciably improved system reliability and durability, would ease maintenance requirements, and probably would reduce system cost. Still another - and perhaps the most significant - potential advantage to be realized is a reduced fuel economy penalty, which obviously is highly relevant to the national energy resource position (2).

## CONCLUSIONS

A methodology has been developed for determination of emission standards needed to meet air quality standards. This methodology is based on analysis of air quality trends, and reflects the realization that the influence of meteorological and chemical dynamics on pollutant behavior can best be evaluated from measurements in the atmosphere. Since many such measurements are already available, in the form of air quality monitoring records, they should be utilized as fully as possible to determine adequate emission standards.

The air quality trend analysis methodology was applied to the case of carbon monoxide, as part of a continuing study. This analysis of the change of air quality during a period of decreasing vehicular carbon monoxide emissions indicated that an appropriate vehicle carbon monoxide emission standard for the worst urban area would be approximately 29 g/mile, as opposed to the 3.4 g/mile Federal standard applicable to 1976 model year automobiles on a nationwide basis.

The large discrepancy between the carbon monoxide standard established on the basis of the 90 percent reductions mandated by the Clean Air Act Amendments of 1970, and the value derived in this paper by examination of air quality data, emphasizes the need for continuing review of standards.

Based on this experience, vehicle emission standards for  $\text{NO}_x$  and hydrocarbons should also be reexamined, to determine whether similar discrepancies appear.

Because the degree of vehicle emission control needed to meet air quality standards varies widely from one location to another, a continuing commitment to the current strategy of demanding all automobiles to meet the same very stringent standards required for the worst areas in the country should be reconsidered in detail. The advantages of a two-car strategy with respect to  $\text{NO}_x$  control have

aircady been discussed by the RECAT committee. The critical national crude oil supply condition demands prompt development of a strategy for clean air which minimizes waste of our natural resources.

### ACKNOWLEDGMENTS

The extensive analysis which formed the basis for this work was facilitated by the cooperation of representatives of several organizations in providing data. We thank R. Rambo and D. C. Dees, Illinois Department of Transportation, and M. Gross and G. Sachno, Chicago Bureau of Streets, for Chicago traffic data; G. Nehls and G. Akland, EPA-NEEC, for magnetic tape CAMP data; P. Harrison, Chicago Department of Environmental Control, for daily average CO data; V. Hagerty, National Climatic Center, for meteorological data; G. Wood and D. Sorrels, Colorado Department of Health, and J. J. Dolan and B. B. Gerhardt, Colorado Department of Highways for data on Denver traffic and vehicle emissions. We also thank A. J. Pahnke and E. N. Cantwell, Jr. of Du Pont for their valuable contributions.

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Mr. SATTERFIELD. On page 12, you refer to the Office of Science and Technology, saying we need more answers to questions before we commit a new control system, and the Office of Emergency Preparedness says catalysts will aggravate our energy problem.

Do you have reference to those papers, and if you do not have them, could you give us a citation so we can demand them?

Mr. TERRY. The first is from the RECAT report. Those are definite references we would be happy to submit for the record.

Mr. SATTERFIELD. Do you know if there have been a number out of the Office of Science and Technology referring to exhaust and controls?

Mr. TERRY. We referred to the RECAT report which is quite detailed in their treatment of the emission standards and the cost benefits, and there are a number of statements made in that report relative to the wisdom of pursuing with the present stringency of control for automobile emissions.

Mr. SATTERFIELD. You don't have a copy of it?

Mr. TERRY. We did not bring it, but we would be happy to send you one.

Mr. SATTERFIELD. I think it would be well to have that information in our record.

[The following information was received for the record:]

REFERENCES INDICATING SERIOUS QUESTIONS AS TO NEED FOR THE STRINGENT MOTOR VEHICLE EMISSION STANDARDS MANDATED BY THE CLEAN AIR ACT FOR YEARS 1975 AND 1976

The citations requested by Congressman Satterfield for the references in Mr. Terry's statement may be found on page xx of final (RECAT) report of the Office of Science and Technology dated February 28, 1972, pages C11 and C12 of the Staff Study of the Office of Emergency Preparedness entitled "The Potential for Energy Conservation" (October, 1972) and pages 124 and 127 of the Report by the Committee on Motor Vehicle Emissions. These references indicate serious questions exist as to the need for the stringent motor vehicle emission standards mandated by the Clean Air Act for the years 1975 and 1976. Copies of the cited pages follow:

[From Page XX of Cumulative Regulatory Effects on the Cost of Automotive Transportation (RECAT)—Final Report of the Ad Hoc Committee, February 28, 1972 (Prepared for Office of Science and Technology)]

EXECUTIVE SUMMARY

\* \* \* "severity factors," which are ratios of the harmfulness to health of the previously mentioned pollutants. Within the broad limits of this estimate, the total 1969 annual national costs of pollution due solely to gasoline motor vehicles lies between \$2.2 and \$5.7 billion (in 1970 dollars).

The costs of automotive emission control are likewise subject to considerable uncertainty. The best estimate for achieving control at the specified 1976 levels was approximately \$350 per car initial investment cost in excess of the cost of precontrolled cars, with a corresponding additional operating and maintenance cost of \$65 per year. These costs, applicable to the introductory year of 1976, were estimated to decrease with time due to increased production efficiency according to the equations:

$$\text{Investment Cost} = C_1 = 350 - 110(1 - e^{-0.25t})$$

and

$$\text{Operating and Maintenance Cost} = C_2 = 65 - 20(1 - e^{-0.25t})$$

where  $t$  is the time in years after 1976. These equations lead to a predicted ultimate investment cost of \$240 per vehicle and an ultimate operating and maintenance cost of \$45 per car per year.

The relationship of costs of control to the benefit (costs of pollution damages saved) obtained are shown in Table 3 for the decade (1976-1985) which will be required to replace almost all of the pre-1976 cars with vehicles of the 1976 degree of control stringency, and for the post-conversion year. The expected growth and composition of the automotive population have been taken into account in both the costs of pollution damages and the costs of emission control.

From Table 3 it appears that the excess of control costs over benefits for the "conversion decade" will average about \$63 billion, or about \$6.3 billion annualized over the decade. After "conversion," the annual excess of cost over benefits will average about \$3.8 billion.

The Committee's cost/benefit analysis, with all its limitations and uncertainties, raises significant questions concerning the present program of mobile source emission control. In addition to the unfavorable cost/benefit ratio, the analysis reveals major conceptual difficulties and data deficiencies concerning the relative health damages caused by different air pollutants. It appears, therefore, that the nation is embarked on an air-pollution-control program of enormous scope, complexity, and cost with little measure of the relative harmfulness to health of the several pollutants being considered.

[From pages C-11 and C-12 of *The Potential for Energy Conservation—A Staff Study*, October 1972; Executive Office of the President, Office of Emergency Preparedness]

An examination of intercity and urban transportation modal mixes and the energy-efficiency of each of the transportation modes suggests that modest redirection of intercity transportation patterns would be feasible and helpful in lowering overall energy demand. However, urban transportation is the prime candidate for action. A comparison<sup>1</sup> of two futures for transportation, one based on the extrapolation of current trends, the other based on a steady but non-revolutionary shift toward more energy-efficient transportation modes, reveals a possible energy savings of 6,110 trillion BTU's in the year 2000, a 20 percent reduction.

#### CONSERVATION MEASURES

Current government policy is functioning in at least two basic ways to aggravate the energy problem. First, it favors development of air and highway transport. Should these preferential policies continue, automobiles, aircraft and trucks will maintain their high rate of growth. Second, present environmental/national security goals—(1) reduce pollution through mission control and (2) conserve fuel—are in conflict. Reliance, on a pollution control scheme, which requires a fuel penalty estimated to be approximately 15 percent<sup>2</sup> can seriously aggravate fuel reserve and national security problems. Moreover, increased fuel consumption has a proportionally detrimental effect on air pollution. Economic effects of decreasing automobile efficiency are also sizable. For example, a decrease of 25 percent in efficiency will require an increased purchase of gasoline which over the next 30 years will amount to over one trillion gallons (equivalent to some 48 billion barrels of crude oil.)

Another major factor contributing to the enormous growth in transportation fuel consumption is attributable to tastes, habits, and aspirations of the American public. Foremost among those is an almost total disregard of any problem posed by the rate of energy consumption. As a consequence, Americans tend to ignore the tradeoffs between fuel consumption and speed, convenience, safety, and comfort of transportation. Therefore, the trend toward more powerful, larger cars and more cars per family has been persistent. Moreover, low average car occupancy, use of cars for many short trips, and disregard for congestion problems have further aggravated both pollution and fuel consumption problems.

Actions which can reduce transportation energy requirements are :

<sup>1</sup> Hirst, *Energy Consumption for Transportation in the U.S.*, ORNL-NSF Report ED-15, March 1972.

<sup>2</sup> EPA, *The Economics of Clean Air*, February 1972; Private communication with Joseph Somers, May 1972, Mobile Source Pollution Control Program, Office of Air Programs, EPA.

## GENERAL

Enact programs designed to increase public awareness of energy conservation needs and measures.

Inject the energy conservation issue into appropriate national programs (e.g., environmental, health, urban development, safety).

\* \* \* \* \*

[From pages 124 and 127 of Report by the Committee on Motor Vehicle Emissions, National Academy of Sciences]

\* \* \* 70 percent for carbon monoxide, and 50 percent for oxides of nitrogen, all measured in relation to the uncontrolled emissions of pre-1968 vehicles. As seen in the curves, were 1973 standards to remain in force, total emissions of hydrocarbons and carbon monoxide would continue to decline for some years, as would that of NO<sub>x</sub>. Preponderantly, these effects reflect the removal from service of older, uncontrolled, or less-well-controlled automobiles.

#### 7.6 Implementation of 1975 and 1976 Standards and Related Matters

Of two promising candidates for certification and production in 1975 and 1976—the dual-catalyst system and the carbureted stratified-charge engine—only the former is planned for manufacture on a scale commensurate with expected requirements in those years. Even if durable catalysts became available, the dual-catalyst system would still have several undesirable characteristics, the more important of which are listed below.

1. The dual-catalyst system is expected to have poor fuel economy. Improvements in fuel economy could be obtained by the use of proper feedback control mechanisms, but these are unlikely to become available for production in 1975 or even 1976.

2. Dual-catalyst systems will have a higher initial cost, be more difficult to maintain, and be less durable.

3. Manufacture of vehicles equipped with single- or dual-catalyst systems in large numbers before sufficient experience with these devices under actual diverse consumer use is precarious.

\* \* \* \* \*

\* \* \* health effects of individual pollutants, their relation to ambient concentrations, the relationship of total emissions to primary and secondary ambient pollutant levels, the contribution of automobile usage to total emissions, and the possible relative reductions in emissions from stationary and mobile sources. Some of the issues posed by these considerations are resolvable only by further scientific research; all will require the attention of officials concerned with pollution control.

These matters are so complex and important that the Committee strongly urges an early and thorough reexamination by Congress, EPA, and the Academy of all aspects of motor vehicle pollution standards established in the Clean Air Amendments of 1970—their premises, underlying assumptions, the goals that were set, and the interplay among the three pollutants dealt with specifically in the Act. In the light of the material developed in its study, CMVE believes that such a reexamination would be extremely valuable in relating motor vehicle emission control to the many issues relevant to a sound national environmental policy.

\* \* \* \* \*

Mr. SATTERFIELD. Mr. Chairman, I have some other questions, but in the interest of time, I will relinquish the floor.

Mr. ROGERS. Mr. Preyer.

Mr. PREYER. Thank you, Mr. Chairman, and thank you, Mr. Terry. I think you have made a very interesting contribution here. Almost all of our previous witnesses have testified that we ought to stick with our health safety standards but that we should let the time of attainment of those standards reflect the economic and cost-benefit considerations. But you are saying we ought to adjust the standards, themselves; that it is not necessary that they be so stringent?

Mr. TERRY. May I clarify that, Congressman?

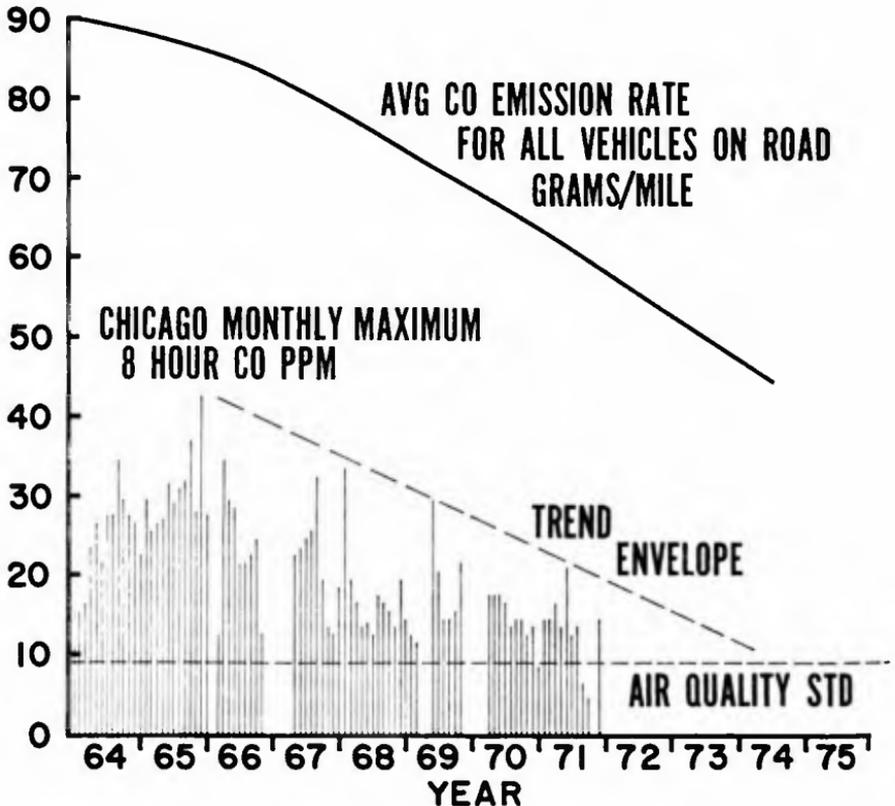
We do not question the primary air quality standards which are the standards that relate to health, at least not in any active way. We feel there is not enough information; from the information we do have, we feel they may be a little more stringent than is required, but we are not questioning that in any major way.

We are questioning the automotive emissions standards that have been determined are necessary to meet these primary air quality standards.

Exhibit A is that graph [see below] which we just handed to Congressman Satterfield which shows what actually is happening in Chicago to the air quality. In the exact station that was used by HEW in the scientific paper that was used for a background in determining the standards in 1970, they said we have measured 44 parts per million and we ought to get down to nine. This will require a 90-percent reduction in CO from new cars. Admittedly, that was a conservative rollback technique. I would like to submit this graph of CO readings in Chicago at this point for the record.

[The graph referred to follows:]

**MAXIMUM CO VALUES ARE DECREASING,  
PARALLELING CO EMISSION RATE DECREASE**



Mr. TERRY. Since then, Ruckelshaus and a number of others in EPA have said we don't know that the rollback technique is correct. We feel it may need some working over.

Until we know how to do it, we have to stick with our present standards. We are saying all you have to do is measure the air quality in some of these areas, and you can see the rollback technique is unduly conservative.

Our point is we are not questioning the health standards or the primary air quality standards to anywhere near the extent that we are criticizing the auto emissions standards that are supposed to be necessary to reach these ambient air health standards.

Mr. PREYER. I am glad Mr. Satterfield asked you for the basis of your statements here about the preponderance of the evidence, and I think that will be very helpful to the committee.

We have heard from a number of people so far who even urged stricter standards. Perhaps we are only hearing one side of the issue. For example, Dr. Stewart said, if I am not oversimplifying his testimony, that any carbon monoxide in the air was dangerous and that we should work overtime to reduce it to zero.

Mr. TERRY. I think both of us want to say something about Dr. Stewart's remarks. I have read them very carefully and also the questioning afterward. Charlie and I have talked about it. I think it is very important that we understand what Dr. Stewart is really saying or what he really means, I think.

Dr. Stewart said in his testimony that—and I am trying to paraphrase it as well as I can—3 percent carboxyhemoglobin was the lowest, measurable effect anyone could determine. He said if you want to take heart patients and people with serious diseases and determine whether there is any possible effect on those people who already have debilitating diseases of some kind, then he said it is possible there may not be any level at which carbon monoxide may not have any effect.

However, he said the carboxyhemoglobin level is a kind of load on the human system like a heavy meal would be. Now we being to see what he really meant.

What he is saying is that nobody can ever say that there is a zero possibility that somebody taking his next-to-last breath will not have one added last breath if there is not some carbon monoxide going to his lungs, but that degree of effect would not seem to be a reasonable health hazard.

I think that is what Dr. Stewart was trying to say but a point misunderstood as he said it.

Mr. HEINEN. I would like to say essentially what you said.

What he was saying is no measurable effect—I could arbitrarily tell you there has to be an effect all the way down to zero that is measurable. Therefore a significant health effect is the thing you have to define and which Stewart defined at roughly 3 percent carboxyhemoglobin.

I might say I have worked with Dr. Stewart very, very closely because through CRC he is handling two pet projects of mine, the carboxyhemoglobin for nonsmokers, which was approximately 1.7 percent the way it is right now. The upper 98 percentile is below 5 percent. It is kind of interesting that the highest value ever recorded

any place for carboxyhemoglobin was in that budding metropolis, Sleetmute, Alaska. The highest was Sleetmute, Alaska. The next was El Toro; another one in northern Vermont.

The point I am making is we sometimes forget there are other sources of carbon monoxide than the automobile.

You will remember that Dr. Stewart said orders of 3 percent are—anything below 3 percent has not been demonstrated as significant health effects. I think that is of considerable importance in studying Stewart's results.

Mr. SATTERFIELD. Do you know what percentage of carbon monoxide is in the blood when your fingernails turn blue?

Mr. HEINEN. It is of the order of 50 percent.

Mr. SATTERFIELD. A few years ago, I flew fighter planes for the Navy and the test then was if your fingernails turn blue, you go home.

Mr. HEINEN. You have the altitude effect and, incidentally, going up 1,000 feet will give you a percent increase in carboxyhemoglobin.

Mr. TERRY. I think this is the simplest way for me to understand it—that carbon monoxide in the air is equivalent to an extra load that a person must bear. A person must bear an extra load when he gets up in the morning, when he takes any kind of physical activity, when he eats a meal, and so on. When you start equating the percent carboxyhemoglobin increase with the other things you do in life, you see what we are talking about when you say it should be 2 or 3 percent. The very normal things you do cost you the equivalent of 2 or 3 percent carboxyhemoglobin in the blood.

Mr. HEINEN. This is very interesting, but what Stewart and Greenfield have said publicly is a very conservative monoxide standard 1.5 of carboxyhemoglobin, we can achieve that without in any way requiring the standards that are written into the law that require catalysts. That is the point we are making.

We are accepting all of the present standards as conservative enough to protect all of our health.

Mr. PREYER. Mr. Satterfield, we will not inquire too closely of our scientific witnesses whether brain damage occurs when your fingernails turn blue.

You mentioned the CRC council. Senator Muskie has raised the question of whether its proper for the EPA to serve on that council or criticize its results when it is basically an oil and automobile industry financed council. The EPA is a relatively small proportion of it.

Do you have any comments to make about that?

Mr. HEINEN. Yes; I am sorry I did not have a chance to hear the Senator or to comment to Senator Muskie. His mother, unfortunately, died at the time we were there. Otherwise, this is basically what I would have told him: The coordinating research council is not set up to do anything other than determine facts.

The way that we proceed in determining facts is to agree cooperatively—EPA, the petroleum industry, ourselves—what areas information is needed in. For example, we decided that information was needed on the population, carboxyhemoglobin level.

Then we set out to find out what contractors in the country had the facilities to perform this kind of work. From those contractors, we jointly took the best proposition for getting the information. We hired them, in essence. The contractors included everybody from Har-

vard, Nebraska, Stanford Research, and so on, the best people we could find in the country. We have guaranteed them that they would publish their results without pressure of any kind from anybody and that we would support them up to the contract level. We have carried this out scrupulously.

We have not, in the CRC, reached any conclusion relative to these data.

Now, as to the thoroughness with which this procedure is carried out, let me cite you the following:

In the years that I have been with this coordinating research council activity and I have been in the council since the beginning, there has never been a project approved that the EPA did not approve of 100 percent. The chairman previous to me was Dr. Ludwig of EPA; the vice chairman at the present time is Dr. Jones of EPA. The vice chairman previously was Charlie Mosier from Texas.

The scientists that we put on this committee operate to develop data, not give opinions on these data. At every phase of the process there are representatives of all three groups.

I speak at this length because I consider that this is one of the most important experiments in industry-Government cooperation that is going on in this country. If there is one thing that we are lacking, in our competition with other countries at the present time, it is the benefit of cooperation between industry and Government.

I have had quite a bit of opportunity in recent months in conferences in England and Mexico and in conferences on technological assessment here in Washington to realize that to compete, we in this country need a procedure by which we can agree on the data. Then we can fight about the data afterward. This is a very important experiment along this line. As you can see, I am highly enthusiastic. I consider this as important as my main job.

Mr. PREYER. I understand EPA is reconsidering its role in the Council, but I gather your opinion is that it is valuable, that it basically finds facts.

Mr. HEINEN. There is one set of facts, not yours or mine, but one set of facts, and that is the way it ought to be.

Mr. TERRY. The facts have to be there and nonarguable. It is very helpful to have the scientific representatives from industry and government work together to determine those facts and argue with each other about whether they have the best contractor or not and so on and so forth, but there is really only one set of facts, and scientific people cannot settle their arguments politically.

What we are trying to do is get a common set of ground rules, and then after the regulations or whatever has to be done about it is a separate thing entirely.

I think this is an extremely important principle to any engineer or any scientific person. There has to be a common research base of information which is agreed upon as being valid information from which to work, both for the guy trying to solve the problem in industry and for the guy trying to decide what to do about it from the standpoint of Government.

Mr. PREYER. I have taken more than my time.

I will say in summing up that it is very difficult in legislation to insist upon strict standards as we are doing in the Clean Air Act when

you cannot justify by scientific evidence whether they are too strict for whether they are not strict enough. That seems to have been my general impression of the evidence.

In that situation, when health is at stake, you would come down on the side of being safe.

But I gather what you are saying to us is the evidence is a little stronger, that we are on a safer side than we may have thought.

Thank you for your testimony.

Mr. ROGERS. Mr. Symington.

Mr. SYMINGTON. Thank you, Mr. Chairman.

Yesterday, Mr. Terry, we had the General Motors representatives here, and I asked them what their view was of the provision of the Clean Air Act that would require that each car manufactured in 1975, I guess, be warranted as meeting the standard. They felt that that was unrealistic, that they would attempt to achieve through stringent, overall efforts an average acceptability, and that probably less than 1 percent of their manufactured vehicles would fall below that average, and that, they felt, was the best anyone could do and they would not know which cars those were, but they would also be willing to bring one up to scratch if it were returned and found to be wanting.

Would that be roughly your testimony with respect to that same provision in the act, or would you have some other approach to that?

Mr. TERRY. I think we agree with the General Motors position. Let me restate what our position is.

The Clean Air Act requires a 90-percent reduction in emissions from 1970 levels for two of the pollutants and from the 1971 levels for one of the other pollutants. Whether averaging is permitted or not is a matter of interpretation. What does a 90-percent reduction mean?

It seems to me what the 90 percent means is you want to have a 90-percent reduction of total new car automotive emissions by 1975 and 1976. So, if that is what you mean, the way you would do that is you would take the average emissions in 1970, taking the highest and the lowest and figuring out what the average was, and then say the average has to be only 10 percent of that in 1975. You would be talking averages in both cases.

On the other hand, you can't take the average emissions in 1970 and then say, now then, we are going to take 10 percent of that, and every car has to be better than that without making a greater than a 90-percent reduction. I think that is what General Motors was saying yesterday in a different way.

You could say let's take a 90-percent reduction in the worst car, and if you say your worst car has to be no more than 10 percent of what your worst car was in 1970, that would be another way of saying it. You could then say all cars have to be better than that level in 1975, but that would be such a high emission level that it would not be a very realistic way to do it.

That is why we think averaging is a very sound and a necessary concept.

You could take the bell-shaped curve you had in 1970 and take that level which 90 percent of the cars met or better in 1970.

You could then use that same method and say the law then requires that by 1975, 90 percent of the cars be better than 10 percent of what the emission level was in 1970. That is another way of doing it. It

is just applying the same ground rules for this 90 percent reduction when you measure for 1975 as you did for 1970. If you did that, everybody would be happy, and this whole averaging thing would be settled.

**Mr. SYMINGTON.** It would still require a lifting of that statutory provision which provides for the warranting of every automobile produced; is that right?

**Mr. TERRY.** What you are going to do about the warranty remains a problem no matter how you measure it, because you still have a part of the curve that is not within the limiting number and you cannot abolish tolerances bylaws.

**Mr. SYMINGTON.** All I am trying to elicit from you is a simple yes-or-no answer. It does not shock me. I just want to hear it.

**Mr. TERRY.** I think the warranty thing should be settled, Congressman Symington, by setting a level in the field which represents something that you would call a gross departure from the standard, and if it is above that the car has to be readjusted and brought within that level of emissions.

That is not near as big a departure from the average or the standard as you might think.

**Mr. SYMINGTON.** To proceed to satisfy the national community that the 1975 cars taken as a whole meet collectively the standard, how can you make that determination until the year has gone by and you measure the air? How do you do it in anticipation?

**Mr. TERRY.** The way we are doing in California and the way General Motors suggested is more than a satisfactory way of determining whether it is below the level, and that is to insist 90 percent of the cars coming down on the line measured on some quick test do meet the standards and the 10 percent that don't meet it are adjusted to meet the standards.

If in addition you take a 2-percent audit of the cars coming down the line and give them the full emissions test, you can be sure that on the average the population is well below the levels set for the standards.

**Mr. SYMINGTON.** I think that is very much parallel to the testimony we had yesterday. Yet, they propose to meet this overall standard through the use of catalytic converters. While they say they have not rejected the stratified charge approach they, nevertheless, feel that human happiness will ensue from the catalytic converter. You disagree with that.

**Mr. TERRY.** When we get to catalytic converters, we are taking some irrevocable steps, in a sense, in that catalytic converters can only operate satisfactorily on lead-free gas, so we have that very expensive step to go through. We have the problems that those owners are always going to have in finding the lead-free gas.

We have the current problems with catalysts which we still find out more about every day. We often get unexplained failures, although our catalysts are improving as our technology improves, but we still feel they are not ready to put in volume production in cars. We are trying to control the engine better so they are less apt to fail catalysts. The whole thing has to be looked on as a system.

The reason we don't want to go to catalysts next year is we just don't feel they are ready for mass production and the customer is going

to have more than his share of problems, judging from our past experience with automobile components.

Mr. SYMINGTON. Would it be your testimony that gasoline which contains lead would be satisfactory in other than a catalytic-protected car?

Mr. TERRY. Yes. In fact, we feel a relatively small amount of lead, and by that I mean 2 or 3 grams at the most, per gallon is an excellent way to conserve oil resources and gasoline. When we go to lead-free gas, no matter how you slice it, you are going to get at least 5 or 6 percent less mileage out of each barrel of oil that you use. There is no way of getting around that.

There are all kinds of ways of saying it is due to the compression ratio, or it is due to the refinery or what-have-you, and different refineries have different octane requirements, but in the end there is no way of refuting the statement that you are going to get 5 to 6 percent less mileage out of a barrel of oil if you take the lead out of gasoline.

Mr. SYMINGTON. The other question that I had went to the labeling of automobiles with respect to their fuel economy.

I think we have had testimony that this is a complicated process, but I wondered yesterday if it would not be possible to select certain arbitrary speeds and duration and give the buying public what they might expect from their car.

Would that be feasible from your point of view?

Mr. TERRY. Congressman Symington, we do not object at all to labeling cars to show their fuel economy. We think information should be given to the consumer, but it should be information that is going to help the consumer.

Now the problem of fuel economy is complex, as you indicated, and the label that we are going to be putting on the cars this year is not going to tell the consumer much of anything because it simply gives a range of fuel economy that all the cars tested by EPA got for each weight and class of car and also it gives an average for that weight of car.

We object to the EPA cycle, in general, for determining fuel economy because it shows generally much poorer figures than people actually get. It is very inefficient, a very inefficient cycle as far as fuel economy is concerned. Certainly this labeling program is not going to be a sales tool. It will show people that the gasoline economy they can expect on the average for this weight car is pretty bad, and therefore it is going to discourage sales.

So, we don't think it is representative and we don't think it is a particularly helpful thing from the consumer's point of view to give them this label. However, we are going along with it because any kind of labeling program has to have a common method of measuring the fuel economy.

What we hope to do is work out with EPA and the Society of Automotive Engineers a fuel economy schedule that will be fair and will

cover all the various kinds of driving in a more or less balanced way that we can all agree on would be a proper, common way of determining fuel economy and then put that on the car.

Mr. SYMINGTON. Is there a fuel penalty with the stratified charge approach that you are interested in?

Mr. TERRY. When you say fuel penalty, you must deal with comparisons.

If we are comparing with 1973 cars we hope to improve the fuel economy with the stratified charge engine. We doubt that we could ever get much better fuel economy—I wouldn't say no better—with the prechamber combustion-type engine than we got with preemission control cars. We doubt that we could improve very much on a standard uncontrolled engine with uncontrolled emissions.

Mr. SYMINGTON. Thank you, Mr. Chairman.

Mr. ROGERS. What is the effort of Chrysler as far as its emission-related expenditures? What would you estimate those to be and how many people do you have working on this problem specifically?

Mr. TERRY. We estimate our emissions experiences, I believe, for 1973, will be \$29 million. We can give you information on that. We have given it to EPA.

Mr. ROGERS. But about \$29 million?

Mr. TERRY. Yes, sir. That is fiscal year 1973.

Mr. ROGERS. Do you have any idea about how many people are devoting their time to it?

Mr. TERRY. It is over 1,000 equivalent people. It is in the information we have submitted.

Mr. ROGERS. What are your total sales?

Mr. TERRY. Around \$9 billion.

Are you talking about dollars or cars?

Mr. ROGERS. Yes, sir.

Mr. TERRY. Yes, sir; \$9.8 billion.

Mr. ROGERS. What was Mr. Ruckelshaus upset about? I saw in the paper he was upset with Chrysler.

Mr. TERRY. You are referring to the good faith issue.

This came up because of a discussion as to whether or not a catalyst manufacturer had been given the proper treatment, or the supply business, in preference to some other catalyst manufacturer, and I think it was most unfortunate that this was taken as being a basis for any good faith discussion.

Actually, the choice of a catalyst manufacturer or any other supplier is certainly, we think, the responsibility of the automobile manufacturer to make, and we certainly have the highest stakes of all, which is our right to stay in business.

If we make the wrong decision, of course, we simply can't manufacture cars. I don't see how we could have any higher stake than that.

To come along after the fact and question whether or not we made the right decision or not does not really seem to be connected to the

good faith issue. So, we think the whole thing was most unfortunate, and I think EPA really felt that way too, before they got done.

Mr. ROGERS. Do you think it would be well to have penalties in the law other than the drastic penalty of just closing down a company? Should there be some interim action that could be taken in areas where there is some determination that the law has not been followed rather than a drastic action of closing down?

Mr. TERRY. I don't see how it would help much to have interim penalties. The penalties certainly, as you indicate, are as severe as they can be. It is like saying if the death penalty is the ultimate, should we fine the victim on the way to the ultimate penalty.

If you were to ask me if it would be helpful to have interim penalties, I might agree with you, but not in addition to the ultimate penalty.

Mr. ROGERS. It seems to me there would be a hesitancy, I would think, in completely closing down. You hate to throw people out of jobs. This is a very difficult decision to make. There might be more of an incentive knowing that penalties could be assessed without having to go to the ultimate where there would be a reluctance to do it. That is what I am saying.

Mr. TERRY. At this point, Mr. Chairman, that particular question of good faith is moot because that was written in as a condition for giving the year's extension one way or the other. Now we have to meet the standards anyway 1 year later unless Congress changes the law.

Mr. ROGERS. I thought you were asking for changes in the law.

Mr. TERRY. The good faith question is moot at this point.

Mr. ROGERS. We may insert it. I am not sure it may be moot. If we give a suspension, we may want a show of good faith that we are still trying to accomplish a goal.

Mr. TERRY. The standard will always be at the end of the rainbow.

Mr. ROGERS. Good faith to get to that standard was the point and whether we should have some interim penalties which are, in other other interim penalty?

Mr. TERRY. Would it mean somebody is looking over our shoulder and saying you have to get there or get the death penalty but you are not going fast enough so we are going to fine you or impose some other interim penalty?

Mr. ROGERS. I presume it would be like saying the penalty is here, but you and I know it is probably not going to be used so somebody in effect could not use good faith and feel that that penalty would never be used.

I question whether it would, in closing down an entire company. I question whether that would be used. I would think you in business would have some feeling of that. I would think if some lesser penalty that could be effectively administered might be used if there is a violation of the law. That is all I am saying.

Mr. TERRY. The way the act actually works now, it does not necessarily completely shut down an automobile company. We have a

great many engines and combinations of engines, and they have to be certified separately. Some do better than others, and we have to change our plans from time to time in order to get a representative line of cars certified. This is all very expensive and in a sense debilitating. Certainly there is no job we extend more time and effort and management surveillance on than emissions control.

The danger of putting in these interim penalties, if you want to describe them in such terms, is that somebody then is trying to second-guess what we are doing to try to meet these emission controls. We hope our judgment is better than somebody that we are giving all the information to, and we question whether he can then come back to us and say we are not doing right.

It seems to me it is not really a case of closing us down anyway as far as enforcement of the emission standards is concerned.

Mr. ROGERS. If they prevent the sale of your automobiles—

Mr. TERRY. Just some of them. It would not happen all of a sudden because we have various ranges of success.

Mr. ROGERS. Have you met any of the 1975 standards yet?

Mr. TERRY. We have met 1975 standards on some cars.

Mr. ROGERS. Not in any of your complete lines, though, I don't believe, have you?

Mr. TERRY. The 1975 standards—we have two sets of standards for 1975: The original statutory standards which are now to be applied in 1976, and we have 1975 interim standards. We have met 1975 interim standards with a lot of cars.

Mr. ROGERS. With the whole line? Do you feel that you can, in other words?

Mr. TERRY. We feel we can meet the 1975 interim standards with a full line of cars, but we will have to use catalysts to do it on all California cars and on some cars in the United States. We are not sure how much or how many. We want to keep the number of catalyst-equipped cars to a minimum.

We think catalyst cars will end up as orphans.

We will come up with a better solution than catalysts, and we want to keep the population of catalyst cars down as low as we can.

Mr. ROGERS. On those standards that you are meeting, have you already arranged to obtain the catalysts? Are you producing them or is someone else?

Mr. TERRY. Universal Oil Products is working with us. It is really almost a joint effort. They are going to supply our catalysts. We may manufacture some ourselves. Complete arrangements have not been finalized.

Mr. ROGERS. I think you said you were entering into the voluntary fuel labeling arrangements.

Mr. TERRY. Yes, sir.

Mr. ROGERS. I would like for the record, and I don't care about your taking time to go into it now, your reaction to a bill we introduced to relate fuel economy with the devices. This is H.R. 10118.

[The information requested was not available to the committee at the time of printing—March 1974.]

Mr. TERRY. I have been down and talked to Senator Hollings and others about standards for fuel economy, as well as various other proposals for decreasing fuel usage.

We feel that using fuel economy standards as a means for controlling the fuel used by cars is not a good way to go because it, again, cuts off on a line—that is, it is a nuclear deterrent type of thing which will regulate off the road certain kinds of cars. We, of course, are always working to try to make sure that all our cars are better. We feel that some kind of a graduated financial incentive would be a much better way of forcing improved fuel economy levels of new cars.

When you talk about really saving fuel, maybe you realize that you don't get much effect from controlling new cars for at least 4 or 5 years. It is the same delayed effect we are getting with our emission control efforts. It takes at least 10 years to get the full effects of regulations on new cars covering the entire population.

For that reason, we think that if the problem is immediate and imminent—and we think it is—that new car fuel economy standards are not going to be very effective and could be counterproductive.

Mr. ROGERS. What about your plans for reducing the weight of your overall 1975 fleet cars? Has any activity taken place there?

Mr. TERRY. Weight control is a very important activity. Charlie Heinen's job involves that.

We have always worked on weight control. Any automotive engineer recognizes the cumulative effect of a pound of weight on many of the components in a car. Weight control is a continuing effort with us, and we have some ways that we think we can do a better job.

Mr. ROGERS. Could you relate for us what is a fuel saving, say, 500-pound weight of a car. If you could reduce it, what would be the fuel saving?

Mr. TERRY. I have an excellent paper on this I would like to enter into the record.

Mr. ROGERS. Without objection, it will be made part of the record.

Mr. TERRY. It covers the fuel penalty for automatic transmissions, power steering, and all that kind of thing.

Mr. ROGERS. That would be helpful.

[Testimony resumes on p. 455.]

[The following information was received for the record:]

# General Factors Affecting Vehicle Fuel Consumption

presented at  
1973 SAE NATIONAL AUTOMOBILE ENGINEERING MEETING  
DETROIT HILTON HOTEL  
TUESDAY, MAY 15, 1973

G. J. Huebner, JR. and D. J. Gasser  
Chrysler Corporation

In recent years, fuel economy and acceleration have worsened. The trend will continue, and we may not be able to work our way out of this problem as the rules are written today.

In the main, the degradation of fuel economy and acceleration from 1968 to 1973 has been brought about by two factors — emissions controls, and weight increases. The primary factor in the weight increase has been the addition of mandated safety equipment.

This paper will briefly review the major factors that influence fuel economy and acceleration. Historically, the vehicle designer has been able to trade one for the other. When both depreciate at the same time, design latitude narrows considerably.

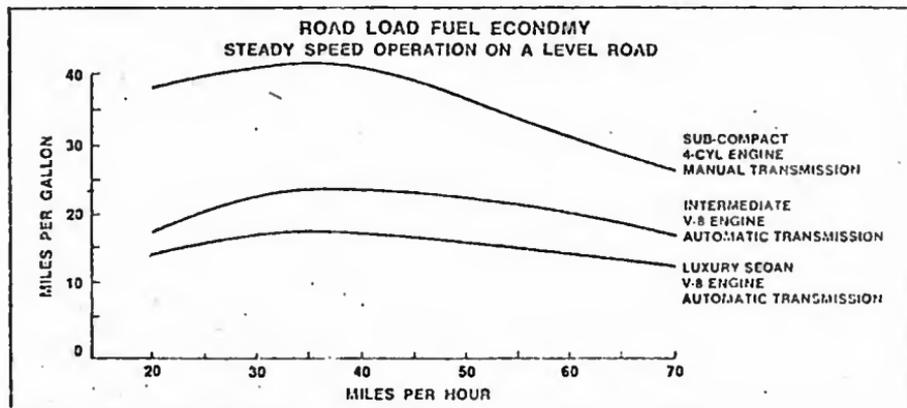
## Measuring Fuel Economy

There are two basic types of fuel economy, road-load and cycle. Road-load economy involves steady-state operation on a level road, a condition seldom attained in normal driving practice. Cycle economy, however, can involve acceleration, deceleration, idling, and road-load operation in various relative amounts — depending upon the cycle. We currently measure

fuel economy under Urban, Freeway, and Interstate cycle conditions. The urban cycle is most often quoted for comparative purposes.

In Figure 1, road-load fuel economy is plotted against car speed for three vehicles. The sub-compact vehicle has a four-cylinder engine and a manual transmission for extremely good economy. The heavy luxury car has a large V-8 engine and automatic transmission. The top and bottom curves illustrate a wide spectrum of fuel economy levels. An "in-between" car, the intermediate vehicle with a V-8 engine and automatic transmission, represents a mid-size car that traditionally provides adequate economy. Because it represents a typical American car, I will use it for evaluating the influence various factors have on its fuel economy and acceleration.

Notice that the peak road-load economy level of each vehicle occurs at about 30-40 mph, and that it drops off rapidly at the higher speeds. While the road-load condition is seldom attained in normal driving practice, its measurement is useful for general fuel economy comparisons. More normal than road-load economy is urban-cycle economy, which consists of ten modes encountered in stop-and-go driving. The percentage



of time spent in each mode of the cycle are: 16% idling, 34% Acceleration, 18% Deceleration, and 35% Road Load. The urban cycle economy levels are similar to those obtained in the current Environmental Protection Agency emissions test cycle.

There are two phases of urban cycle economy operation, cold and warm. The cold phase involves the first five miles of operation, where the choke and lubricant warm-up are major factors. The warm phase involves operation after ten miles, with a significant improvement over the cold.

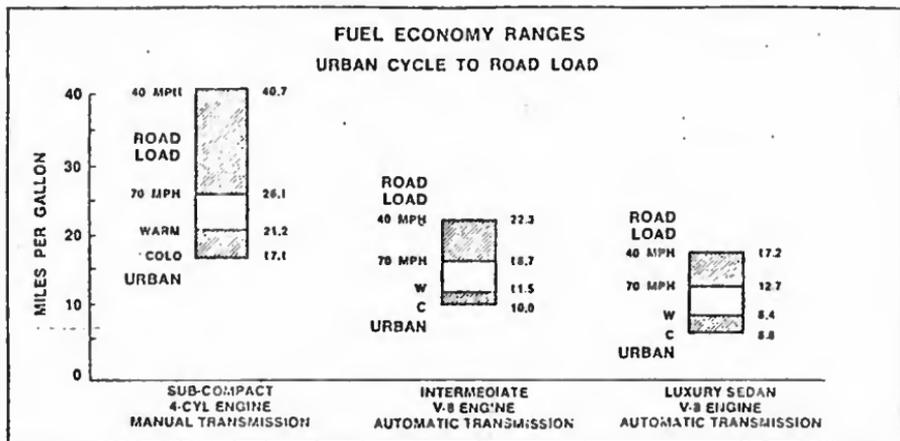


Figure 2

In Figure 2, urban-cycle and road-load economy levels of the three cars have been combined to illustrate the ranges that are possible for each vehicle. As expected, for all three vehicles, the highest attainable economy levels occur in the 40 mph road-load condition, while lowest levels occur in the cold-urban condition. Notice, that under certain unique conditions, these completely different vehicles could conceivably produce the same economy level. This is unlikely, but it is possible in the area of about 17 mpg. The warm-urban and 70 mph road-load economy levels represent more-or-less normal conditions, and they will be used for comparative purposes throughout this discussion.

#### FACTORS AFFECTING FUEL ECONOMY

APPROXIMATE EFFECT OF FACTORS	URBAN CYCLE	70 MPH ROAD LOAD
VEHICLE SIZE AND WEIGHT	80%	80%
TRANSMISSION	15%	5%
ACCESSORIES*	5%	5%

\*AIR CONDITIONING NOT OPERATING

Figure 3

#### Factors Affecting Fuel Economy

There is about a 13 mpg difference in both urban-cycle and 70 mph road-load economy between the luxury and sub-compact cars, while the acceleration levels of these two vehicles are roughly equal. The primary factors contributing to the economy difference are vehicle size and weight, type of transmission, and the car's accessories.

Vehicle size and weight is the most significant factor (see Figure 3). The larger vehicle, at a weight of 5200 lbs., compared to 2100 lbs. for the sub-compact and with a 40 per cent greater body frontal area, requires a large V-8 engine to equal the acceleration level of the small 4-cylinder powerplant in the smaller car. These factors combine to account for 80 to 90 per cent of the economy difference. The transmission effect is primarily due to the fact that the sub-compact is equipped with a manual transmission while the luxury vehicle is equipped with an automatic. The tabulated effect of accessories represents the weight effect of the power steering, power brakes, power windows, and air conditioning which are normally installed on the luxury car but not the sub-compact. This category also includes the power consumption effect of the power steering unit.

The intermediate car has been selected as the sample vehicle for our factor evaluation, because it represents an average American vehicle that provides completely adequate performance. We will look at the effect of engine efficiency and displacement, compression ratio, torque converter, transmission, axle ratio, aerodynamic drag, tires, accessories, vehicle weight, and emissions controls. For the most part, we will investigate ten per cent changes in these factors. It should be noted that the effect of the factors will vary on vehicles other than our average car, but not significantly.

Background information for our factor evaluation is based on a combination of Chelsea Proving Ground test results and performance calculations. The acceleration and torque tests were conducted under established Proving Ground procedures. Historically, the performance calculation technique provides very good agreement with actual test results. It's

acceleration and fuel economy effects quoted in the factor evaluation are therefore based primarily on calculated data which have been confirmed by past and current actual vehicle testing.

ENGINE DISPLACEMENT ✓	
INTERMEDIATE CAR WITH AUTOMATIC TRANSMISSION	
EFFECT OF A 10% ENGINE DISPLACEMENT CHANGE:	
70 MPH ROAD LOAD FUEL ECONOMY	0.1 MPG
URBAN CYCLE FUEL ECONOMY	0.2 MPG
ACCELERATION EFFECT	
12% THROUGH GEARS	19% DIRECT GEAR

Figure 4

Engine displacement is our first factor for evaluation. In general, an engine displacement increase results in economy losses and acceleration gains, while a displacement decrease results in economy gains and acceleration losses. A ten per cent displacement change has only a minor effect upon both 70 mph road-load and urban-cycle fuel economy. Notice however, the major effect of displacement on acceleration. Throughout this summary, "through the gears" is a comparison of acceleration from 0 to 60 through all gears, while "direct gear" is a comparison of 50-70 acceleration in direct gear without using a kickdown to a lower gear.

COMPRESSION RATIO ✓	
INTERMEDIATE CAR WITH AUTOMATIC TRANSMISSION	
EFFECT OF A 10% COMPRESSION RATIO CHANGE:	
70 MPH ROAD LOAD FUEL ECONOMY	0.5 MPG
URBAN CYCLE FUEL ECONOMY	0.3 MPG
OCTANE REQUIREMENTS:	
10% INCREASE (9.5:1 C.R.)	95 *
STANDARD (8.6:1 C.R.)	91
10% DECREASE (7.7:1 C.R.)	88
ACCELERATION EFFECT	
4% THROUGH GEARS	6% DIRECT GEAR

Figure 5

The general effect of an increase in compression ratio is an improvement in both fuel economy and acceleration, while reducing compression ratio produces economy and acceleration losses. A ten per cent compression ratio change has a more significant effect on fuel economy than the previously discussed displacement change. The effect of compression ratio on acceleration, however, is much smaller than the effect of displacement. Note the fuel octane requirement change for the high and low compression ratio engines.

TORQUE CONVERTER	
INTERMEDIATE CAR WITH AUTOMATIC TRANSMISSION	
EFFECT OF A RELATIVELY LOOSE TO TIGHT CONVERTER	
70 MPH ROAD LOAD FUEL ECONOMY	0.2 MPG GAIN
URBAN CYCLE FUEL ECONOMY	0.7 MPH GAIN
ACCELERATION LOSS	
1% THROUGH GEARS	6% DIRECT GEAR

Figure 6

The sample vehicle was tested with two torque converters; one relatively loose, and one relatively tight. The relatively loose converter is a small unit usually used on six-cylinder and small V-8 engines. The relatively tight converter is a larger unit with a primary usage on vehicles with large V-8 engines. The change from the loose to the tight converter showed economy gains and acceleration losses. The gain in 70 mph road-load fuel economy resulting from this change is only minor, due to the small slip differences between the converters at high speed. There is, however, a very beneficial gain in urban-cycle fuel economy. The acceleration loss occurs primarily in direct gear operation.

TRANSMISSION ✓	
INTERMEDIATE CAR AUTOMATIC VERSUS MANUAL TRANSMISSION FUEL ECONOMY LOSSES	
WITH EQUAL AXLE RATIOS (2.71 AUTO. & MAN.)	
70 MPH ROAD LOAD FUEL ECONOMY	1.2 MPG
URBAN CYCLE FUEL ECONOMY	1.8 MPG
WITH "OPTIMIZED" AXLE RATIOS (2.71 AUTO., 2.94 MAN.)	
70 MPH ROAD LOAD FUEL ECONOMY	0.5 MPG
URBAN CYCLE FUEL ECONOMY	1.6 MPG
ACCELERATION GAIN:	
EQUAL AXLES	"OPTIMIZED" AXLES
6% THROUGH GEARS	4% THROUGH GEARS
16% DIRECT GEAR	10% DIRECT GEAR

Figure 7

Changing from a manual to an automatic transmission with equal axle ratios results in very significant economy losses. This car is normally furnished with a 2.94 axle ratio for the manual transmission and the 2.71 for the automatic to optimize gradeability and pulling away from a stop. Figure 7 therefore also includes the effect of the transmission change with the optimum axle ratios. In this case, the economy losses for the automatic transmission are reduced somewhat but remain very significant, although it must be pointed out that the manual transmission results were obtained with a skilled driver.

whereas the automatic can be consistently the same with an unskilled operator. Note that the acceleration gains for the automatic in both axle ratio examples are also major, especially in the direct gear ranges.

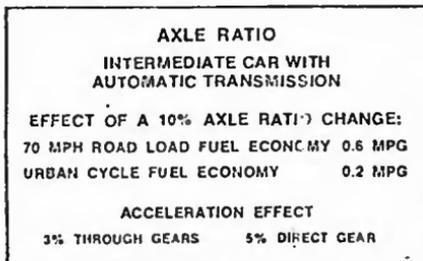


Figure 8

In general, an increase in numerical axle ratio produces economy losses and acceleration gains, while a decrease results in economy gains and acceleration losses. A ten per cent axle ratio change has a significant effect on 70 mph road-load fuel economy. The effect on urban-cycle economy is only minor, however, due primarily to the acceleration and deceleration modes involved in the cycle operation.

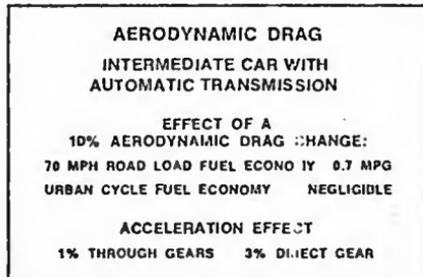


Figure 9

The general effect of an aerodynamic drag increase is loss in both economy and acceleration. Conversely, a drag decrease will produce economy and acceleration gains. A given aerodynamic drag change significantly affects only high-speed operation, since aerodynamic horsepower required varies with the cube of velocity. The effect of a ten per cent aerodynamic drag change on 70 mph road-load economy, is therefore, quite significant due to the speed involved. As expected, the effect on urban cycle economy is negligible because of the low speed involved. The effect of aerodynamic drag on acceleration would be much greater than quoted, if higher speed operational ranges were considered — aerodynamic drag has a very significant effect on top speed.

Rolling resistance is primarily dependent upon tire construction. In general, an increase in rolling resistance produces losses in both fuel economy and acceleration, while decreases result in economy and acceleration gains. At low speeds, rolling resistance forms the major contribution to total force

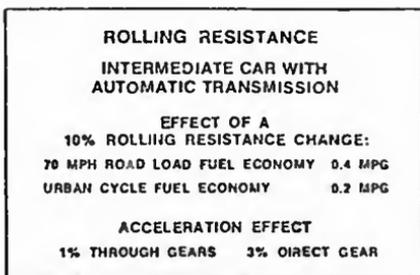


Figure 10

required; the aerodynamic drag is the prime contributor at high speeds. The acceleration effect of a ten per cent rolling resistance change is about equal to that previously quoted for aerodynamic drag.

The 1970 Fiberglas-belted tire was about one mpg poorer than the bias, non-belted polyester cord tire previously used. Improvements in this tire reduced the penalty to 0.3 mpg. Steel-belted radial tires can provide 0.3 mpg advantage over the polyester cord.

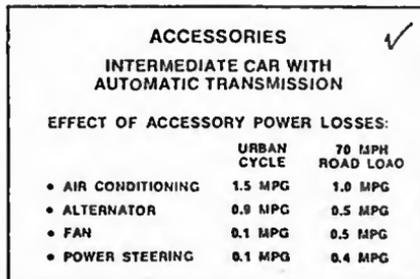


Figure 11

Fuel economy losses for four basic engine accessories are summarized in Figure 11. The effect of air conditioning, which is highly variable with ambient temperature, is quoted at 85°F. Maximum output of about 40 to 50 amperes is reflected in the alternator economy losses. The fan included in this summary is an 18-inch diameter, 7-blade unit. The losses quoted for power steering assume "straight ahead" driving with minor corrections.

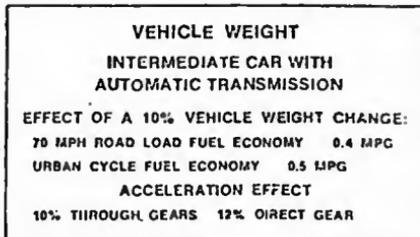


Figure 12

It is interesting to note that, combined, the quoted accessory losses amount to about two-and-a-half miles per gallon.

The general effect of a vehicle weight increase is losses in both economy and acceleration, while a weight decrease

results in economy and acceleration gains. Ten per cent represents a vehicle weight change of about 350 lbs. in an average car. Only major weight changes such as this will significantly affect fuel economy. Note, however, the very significant effect of the ten per cent weight change on acceleration.

1968 TO 1973 PERFORMANCE TREND				
INTERMEDIATE CAR WITH AUTOMATIC TRANSMISSION				
	ACCELERATION TIME (SECONDS)		FUEL ECONOMY (MPG)	
	0-60 THRU	50-70 DIR.	URBAN CYCLE	70 MPH R.L.
1968	11.2	8.2	12.4	17.0
1973	12.6	9.5	10.1	16.1
1968 TO 1973 LOSSES	11%	14%	2.3 (19%)	0.9 (5%)

Figure 13

Both acceleration and fuel economy estimates for the 1973 package are compared to 1968 levels in Figure 13. The losses in acceleration and fuel economy are very significant as you can see.

Emission controls and vehicle weight increases are the prime contributors towards the indicated major economy and acceleration losses.

EMISSION CONTROLS		
INTERMEDIATE CAR WITH AUTOMATIC TRANSMISSION		
LOSS TO EMISSION CONTROLS AND RELATED ENGINE SPECIFICATION CHANGES		
	URBAN CYCLE	70 MPH ROAD LOAD
1968 TO 1973	1.8 MPG (15%)	0.5 MPG (3%)
1972 TO 1973	1.2 MPG (10%)	0.4 MPG (2%)
ACCELERATION LOSS		
1968 TO 1973 =	2% THROUGH GEARS	1972 TO 1973 1%
	3% DIRECT GEAR	

Figure 14

The effect of emission controls on the fuel economy of our "average" car is shown in Figure 14. The major losses occurred in the 1973 changes when exhaust recirculation and delays in spark advance timing were introduced. Acceleration losses related to emissions controls have not been significant during this period.

Vehicle weight is the other prime contributor towards reduced economy and acceleration. Note that the economy losses resulting from the 1968-1973 weight increase are less significant than they were for emission controls. On a percentage basis, however, the acceleration losses are much greater than the economy losses.

VEHICLE WEIGHT—1968 TO 1973	
INTERMEDIATE CAR WITH AUTOMATIC TRANSMISSION	
LOSS TO VEHICLE WEIGHT INCREASES ONLY:	
URBAN CYCLE	70 MPH ROAD LOAD
0.5 MPG (4%)	0.4 MPG (2%)
ACCELERATION LOSS:	
9% THROUGH GEARS	11% DIRECT GEAR

Figure 15

This is an appropriate time to discuss the "double effect of weight". For example, let's suppose we are willing to accept the 1968 to 1973 weight increase with its accompanying economy losses, but we are not willing to accept the eleven per cent direct gear acceleration loss. In order to recover this acceleration loss, we increase displacement and axle ratio. This would result in additional economy losses of 0.2 to 0.3 mpg in the urban cycle, and 0.7 mpg at 70 mph. The economy

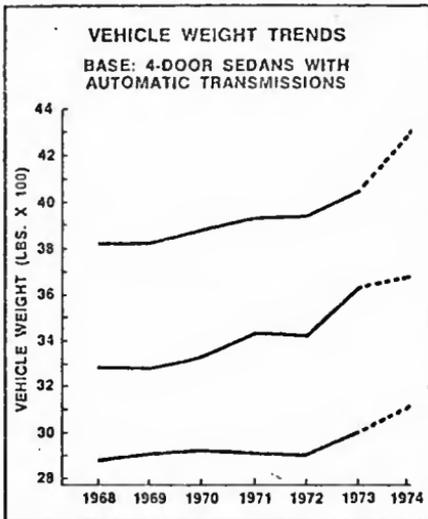


Figure 16

losses due to vehicle weight would now be increased to levels of about 0.8 mpg on the urban cycle and to 1.1 mpg at 70 mph road-load.

While we are on the subject of vehicle weight, a look at the 1968 to 1973 trends of three actual vehicles (Figure 16) proves very interesting.

If the trend continues, it won't be long until the compact weighs as much as the intermediate previously did, and the intermediate weighs as much as the standard formerly did.

There are, however, some long range economy improvement areas that are definitely worth future consideration on all vehicles regardless of their acceleration capability. Improvements of seven per cent may be possible in the area of engine efficiency. We feel that a 0.5 mpg improvement can be reasonably expected. Aerodynamic drag reduction can be obtained. Transmission modifications require extensive changes, but are worth considering. Overdrive or lower numerical axle ratios have a very significant economy effect when combined with a lock-up converter, especially at higher speeds.

#### Conclusions

Since 1968, vehicle weight increases and emissions controls have reduced fuel economy substantially, with the bulk of the loss being due to emissions controls.

An additional loss in economy and acceleration is predicted by 1976. Attempts to regain the acceleration losses by conventional means would probably result in further economy reductions.

The impact of the predicted losses can be lessened by using combinations of the following:

- Improved engine efficiency
- Improved drivetrain efficiency
- Reduced aerodynamic drag
- Reduced tire rolling resistance
- Reduced vehicle size.

Mr. ROGERS. Could you give me, say, just what it would be for 500 pounds?

Mr. TERRY. For a 10-percent vehicle weight change—10 percent—that is 400 pounds for a 4,000-pound vehicle—for 10-percent vehicle weight change, 70 miles per hour fuel load economy would change by four-tenths of a gallon. The urban cycle fuel economy would change by five-tenths of a mile per gallon. In other words, there would be about a half a mile a gallon saving for a 10-percent weight reduction.

Mr. ROGERS. If you changed it 600 or 700, it would be about 20-percent change. Would it still keep that ratio and be about a mile per gallon?

Mr. TERRY. For each 10-percent change, a half mile per gallon change.

Mr. HEINEN. That is one of the targets we are shooting for.

Mr. ROGERS. I presume this would counter any penalty that we might have to take because of control features.

Mr. TERRY. Right now, we are looking at a 25- and 30-percent total fuel economy penalty for the 1977 car, which is newly deferred from 1976 standards. The 1977 standards assuming we figure out how to make them, judging by all the individual cars we have around that have a chance of making the 1977 standards, have substantial overall fuel economy penalties of the order of 25 to 30 percent.

Mr. SYMINGTON. What is the weight difference between your heaviest and your lightest car?

Mr. TERRY. We run from 3,000 to 5,500.

If you have two passengers and gas, then the lightest U.S.-built car goes to 3,500.

Mr. ROGERS. What is the difference in fuel that you average, say, on those two?

Mr. TERRY. From around 8.5 mpg to around 16 mpg, using the EPA cycle.

Mr. ROGERS. I notice General Motors in their testimony said that they felt that they would have a savings with their catalytic converter, as much as 18-percent gain.

Mr. TERRY. I heard that and I am at a complete loss to explain it.

We have no technical data to indicate any appreciable fuel saving for oxidation catalysts. The year talking about the oxidation catalyst, which is the first step, not about the 1977 standards or the NO<sub>x</sub> standards.

We feel the oxidation catalyst will be lucky to break even in fuel economy when we go from a noncatalyst to a catalyst car. We have data both ways.

Mr. ROGERS. I think it would be well to show that for us. I have heard that challenged.

Mr. TERRY. We have cars with and without catalysts, and we can furnish that.

[The following information was received for the record:]

#### FUEL CONSUMPTION INFORMATION

The attached chart provides various fuel consumption comparisons of Chrysler Corporation engines. The two columns at the right of this chart are our 1973 and 1974 fuel economy as derived from the EPA certification values. Although the certification data include truck applications of the various engines, only passenger car values were used because the baseline used for comparison was

the average fuel economy for the 1020 passenger cars involved in the E.P.A. "six cities" study as calculated by Chrysler. The baseline value used was 13.9 miles per gallon which was the average of the years 1968 to 1970.

Shown on the chart are the production weighted averages for all Chrysler engines. As can be seen, in 1973 the certification values are 14.5% below the baseline; for 1974, they were 12.2% below.

In computing the values that represent current device status *all* values from development cars that met the 1975 interim Federal standards were averaged for each car; then the cars, themselves, were averaged by engine types. The results show the following:

	Percent below baseline
Air pump only -----	-8.7
Catalyst plus air pump -----	-9.5
Catalyst only -----	-8.0

Obviously, nothing that we have tried in our development programs indicates the possibility of major fuel consumption saving with or without catalysts. Actually, even the slight improvement indicated over 1974 is doubtful if 1975 interim standards are adopted, since some penalty will be incurred in order to provide a safety factor for production. If the 1974 levels are maintained, this penalty would not be required.

FUEL CONSUMPTION—MILES PER GALLON  
CHRYSLER CORP. ENGINES

Engine	Percent production	1975 development vehicles			1973 certified	1974 certified
		Catalyst, no air pump	Catalyst, with air pump	Engine modification		
198 in. <sup>3</sup> -----	0.63	17.1	19.2	18.1	17.9	15.4
225 in. <sup>3</sup> -----	28.15	16.0	16.3	16.1	16.1	16.5
318 in. <sup>3</sup> -----	15.29	12.3	12.15	12.7	11.4	12.4
360 in. <sup>3</sup> -----	13.79	10.6	10.5	10.8	9.7	10.35
400 in. <sup>3</sup> -----	23.79	11.3	10.9	10.5	9.5	9.0
440 in. <sup>3</sup> -----	6.97	9.2	9.1	9.8	9.4	9.0
Weighted average (miles per gallon) -----		12.8	12.6	12.7	11.9	12.2
Below baseline 1968-70 valve 13.9 miles per gallon -----		8.0	9.5	8.7	14.5	12.2

Note: All tests run by EPA method.

Mr. ROGERS. As I understand it, you plan to move into the Honda engine type and you have some arrangement with Honda already.

Mr. TERRY. We have a disclosure agreement with them.

Mr. ROGERS. About how many cars do you think would be involved?

Mr. TERRY. We have to find out first if the Honda technology will give us the emission levels required as well as the performance and the economy and so on. If it does, we will certainly want to convert just as fast as we can. It depends on what we get out of it.

Mr. ROGERS. In your testimony, I notice that you say it costs \$8 for \$1 of benefits. I think that benefit simply was dated to the effect on crops. It did not go to property damage or man's health? Did it include paint on houses?

I thought your testimony was keyed only to the effect on crops.

Mr. TERRY. Maybe paint on houses was not included but the table attempted to include everything. What they said about the health effects—they had an asterisk in there—this is an EPA report to Congress—was that no figure was given for health effects because there was no data to use.

Mr. ROGERS. I have seen a \$9 billion figure on health and illness.

Mr. TERRY. That is due to control of other emissions—sulfur oxides and particulates. The \$9 billion health savings are not attributed to control of automotive emissions, but to control of stationary sources. I would like to submit for the record table 1-4 taken out of the EPA 1972 annual report to the Congress to clarify further the cost-benefit relationships we have been discussing.

[The table referred to follows:]

TABLE 1-4.—PROJECTED NATIONAL ANNUAL BENEFITS (DAMAGE COST REDUCTION) BY SOURCE CLASS IN FISCAL 1977

[1970 dollars in millions]

Source class	Benefit class			Total benefit	Control cost (table 1-1)
	Health	Residential property	Materials and vegetation		
Mobile.....	(1)	(1)	\$945	\$945	\$8,385
Solid waste.....	172	145	119	436	224
Stationary fuel combustion.....	3,812	3,267	2,366	9,445	2,476
Industrial processes studied.....	1,413	1,302	734	3,350	1,213
Industries not studied.....	0	0	0	0	0
Miscellaneous <sup>4</sup> .....	0	0	0	0	0
Total benefit <sup>4</sup> .....	5,397	4,615	4,164	14,176	12,298

<sup>1</sup> Value of benefits from reducing CO, NO<sub>x</sub>, and HC emissions not available due to lack of data.

<sup>2</sup> Based on alternative 1 in table 3-3 for meeting the 1975 and 1976 vehicle emission standards.

<sup>3</sup> Health damage cost due to NO<sub>x</sub> from stationary fuel combustion not included due to lack of data.

<sup>4</sup> Benefit computation based on proportional reduction of damage costs in table 1-3 excluding "miscellaneous" source damage costs since these are generally not controllable and, therefore, can not become benefits.

Mr. ROGERS. This is changing because now the testimony is that the NO<sub>x</sub> has greater effects on sulfates.

You have seen that testimony, on the oxidizing—in fact, we just received that testimony that they did not realize before.

Mr. TERRY. This was the effect, as I understood it, before, of catalysts on the formation of sulfates. That is another thing entirely, and that effect cannot be very big for automobiles because of the very small amount of sulfur oxides emitted by automobiles.

Mr. ROGERS. Our testimony is that it has quite an effect, and furthermore, I guess you have seen the study showing that some of them think that the automobile, because of the fallout on to the grounds of all of the metal and so on, the pollution, that being taken into the water, we have not checked this all out yet but they claim it is as bad as the sewage. So, I think this all needs to be checked but this theory is not being advanced.

Mr. HEINEN. It needs to be checked. They are talking about nitrates. I calculated that and I assure you it needs to be checked in the worst possible way.

Mr. ROGERS. Thank you so much for your presence here today.

Mr. SATTERFIELD. I listened with great interest to your statement about gas consumption and a saving by weight. Obviously there is a limit. I took my own registration card out and I will not name the model or make, but it weighs 3,713 pounds. It is a 1973 model. I am burning 30 percent more gasoline. I have checked this very carefully.

I did a quick figure. If I were to get back where I was in gasoline consumption with my previous vehicle, I would have to get rid of 3,000 which would probably leave me with no more than a Honda motorcycle.

Mr. TERRY. I don't think we can get back a 30-percent fuel economy loss by weight savings.

Mr. HEINEN. I think Ford said 13, General Motors says as far as I can read their graph they are in the area of 10 percent. That is recoverable, we think, and we are certainly going to try to recover that. We also have weight gains as a result of safety measures, and we are going to try to recover them as much as we can.

Mr. SATTERFIELD. I think this may be apropos of the problem we have testing pollution in the hands of the manufacturer as opposed to pollution in the hands of the operator. Maybe most of us don't know how to operate a vehicle. I have a 30-percent penalty in a 1973 car over a 1971 model and I have talked to a lot of owners, and this seems to be the rule rather than the exception.

Mr. TERRY. We are in a new program now to try to educate our customers as to ways of improving their gas mileage by the way they drive. I was amazed to find out that one of these stop-and-go drivers who is riding at a constant speed of 50 or 60 miles per hour but who alternately speeds up and slows down, always trying to stay at a constant speed, can waste as much as a mile and a half per gallon. That is a lot to waste by a bad driving habit.

Mr. SATTERFIELD. Maybe by education you can do more than just by weight reduction.

Mr. SYMINGTON. You say your fuel percent is roughly 12 percent, 13 for the Ford and 10 for General Motors, or at least that is what they claim. The environmental testimony is the average is 7. It is hard to get 7 out of 12, 13, and 10. Would you say they are using a different system from you?

Mr. HEINEN. It is partly a different point in time. We are talking from the time we started to make these changes. They are talking from the point of 1972-73, I think it was, and the big change that has occurred during that time. The first big change that occurred was the change in compression ratio that we all made and spark timing to accommodate the possibility of 91-octane fuel which is the highest you can get lead free. We made changes to accommodate that.

Then the second big step that occurred in fuel economy loss was the accommodation of the oxides of nitrogen control. All other losses that have occurred are comparatively insignificant.

If I remember correctly, the point in time measurement from EPA accommodates one but not the other.

Mr. TERRY. We lost 3 or 4 percent in fuel economy back in 1971.

Mr. SATTERFIELD. On page 3 of your statement you say there is no question they are forcing us to use catalysts. Who is "they?"

Mr. HEINEN. The action taken in the interim standards, which incidentally, we are not criticizing, because the way the law reads was not their best judgment but what was "technically feasible." There is no question catalysts have to be put on as a result of these standards.

Mr. SATTERFIELD. There was a great deal of talk about catalytic devices and other devices such as reactors and so on.

I asked the question the other day of Mr. Quarles if they were encouraging any work in any device other than a catalyst. Are you telling me there is no such encouragement?

Mr. TERRY. No. For example, catalytic and thermal reactors are a part of a great many emissions systems. They are part of our own.

We do get some conversion in a standard exhaust manifold. Earlier we were talking about the Honda and the Wankel rotary engine. Both of those engines depend very importantly on thermal reactors.

Mr. SATTERFIELD. We have not abandoned that approach?

Mr. TERRY. We have not.

Mr. HEINEN. For example, if the 1974 extensions were to occur and the interim standards were to be set 2 years from now, there is no question in my mind that there would be no catalysts used, but within the time frame it in essence forces catalysts nationwide, as I think the other people have testified. They have all come to the same conclusion that on some cars you are going to have to do it.

Mr. SATTERFIELD. I was interested in the line of questioning by Mr. Symington a little while ago. I was surprised because I did not know it. You made a statement that there is a mileage penalty when you use no-lead or low-lead gasoline.

If we were not using catalytic devices, would there be any justification to remove lead from gasoline?

Mr. TERRY. Not in our opinion. There has been a great deal of discussion as to the health effects of lead in the air and of other possible harmful health defects. We have studied the literature. We don't claim to be experts in this at all because all by itself, it is a controversy that is almost as extreme as the one on the whole Clean Air Act. We don't feel from what we have been able to find out that it would do any harm to maintain a couple of grams of lead in gasoline indefinitely.

Mr. SATTERFIELD. In the medical evidence and scientific research evidence that you referred to earlier, do you recall whether there is anything that specifically deals with the health problem of exhaust in automobiles so far as lead is concerned?

Mr. TERRY. We will be happy to add that.

Mr. SATTERFIELD. If you have such studies, it would be helpful. I understand the main reason to remove lead is to make the catalytic device work.

Mr. TERRY. That is right.

Mr. SATTERFIELD. Is it possible if lead is used in an automobile engine that it can be trapped?

Mr. TERRY. Yes, and I think we would elect to do that on balance in order to gain fuel economy and performance.

Mr. SATTERFIELD. But it can be trapped after it is burned?

Mr. TERRY. Yes, and the technology is improving all the time.

Mr. HEINEN. The medical aspect of lead is the one vehicle emission studied in the literature, and today no Government agency is saying there is a health basis for lead removal. Every time that question is approached results have come out showing there is not a health basis. The conclusion is usually phrased "it cannot be doing any good, but, there is no health basis at present level."

Mr. SATTERFIELD. If you have any such studies, it would be very helpful to have them committed to the committee for the record.

[The following information was reviewed for the record:]

#### REFERENCES ON EFFECT OF LEAD IN GASOLINE<sup>1</sup>

1. Facts About Lead and the Atmosphere, published by the Lead Industries Association, Inc.

<sup>1</sup> The articles referred to may be found in the committee's files.

2. Dr. Edward E. David, Jr., Memorandum on EPA Proposed Regulations Affecting Lead in Gasoline, dated 1 November 1972.
3. Dr. Ronald E. Engel, position paper on "Health Hazards of Environmental Lead" for Bureau of Air Pollution Science, Air Pollution Control Office, EPA, April 29, 1971.
4. D. Hagger, President, Federal Commission for Air Hygiene, Zurich (Switzerland), paper entitled "The Health Implications of Leaded Gasoline" presented at the International Symposium on Environmental Health Aspects of Lead in Amsterdam, October 2-6, 1972.
5. Advance copy of letter from the Secretary of U.S. Department of the Interior to Mr. Weinberger of EPA.
6. Dr. Klaus Schwarz, Acting Associate Professor, School of Medicine, University of California, letter to EPA (March 9, 1973) on subject "Comment on Proposed Regulations for Lead Reduction Schedule and the Health Rationale for this Action (Federal Register Volume 38, No. 6, January 10, 1973)".
7. National Academy of Sciences paper entitled "Lead, Airborne Lead in Perspective" (1972).

Mr. PREYER. Concerning the research studies which you have agreed to furnish us dealing generally with whether or not the auto emissions standards are too stringent, were all or substantially all of those studies funded by the CRC?

Mr. HEINEN. They are a broad cross-section of studies I have been collecting over 20 years. This had been a hobby with me as well as a business. They cover all kinds of investigators.

Mr. PREYER. While I am not so cynical to believe a study funded by the automobile and oil interests or funded by Ralph Nader's interest on the other side are predetermined in their results, there is the old principle of whose bread I eat whose song I sing.

I think it would be helpful if we had some independent information.

Mr. HEINEN. We have picked the most prestigious people in the country, people I am darned sure you can't buy—people like Harvard and Yale and Nebraska, and believe me, there is no pressure at all of any kind put on these people.

Their reputation is the one you have to look at, not whatever you think of ours or the petroleum industry or EPA. It is the reputation of the contractors that you have to consider in the CRC studies.

Mr. PREYER. We will look forward to receiving these studies.

Mr. ROGERS. Thank you so much for your presence here today.

Our next witness today is Dr. Edward David, executive vice president, Gould, Inc.

We welcome you to the committee. We would be pleased to receive your statement.

I might say that Dr. David has been Science Adviser to the President and in a most distinguished position has rendered great service to this Nation and we particularly welcome you again to our committee.

**STATEMENT OF DR. EDWARD E. DAVID, JR., EXECUTIVE VICE  
PRESIDENT, GOULD, INC.**

Dr. DAVID. Thank you, Mr. Chairman.

As you have said, I am Edward E. David, Jr. I am executive vice president for research, development, and planning of Gould, Inc. I am responsible for the overall direction of our company's program to develop a base-metal reduction catalyst for controlling oxides of nitrogen, or NO<sub>x</sub>, in auto exhaust.

For those of you who may not be familiar with our company, Gould is a diversified manufacturer of electrical and automotive products, with annual sales of about \$620 million. Our products include electric motors and generators, industrial and medical instruments, a wide range of batteries, and a variety of engine parts and related automotive products.

I am personally delighted that this committee has decided to take stock of the automobile emission situation, after 3 years under the 1970 amendments to the Clean Air Act. It has been an eventful 3 years on the technological frontier. At the time the amendments were passed, many of us in the scientific community had serious doubts about the wisdom of legislating technology, for clearly technology did not exist to satisfy the 1975-76 emission standards.

In the interim, we have seen this situation change dramatically. We have seen engine concepts which had lain fallow for many years take on new significance. And now both the rotary and the stratified charge engines are actively being marketed. New ignition and fuel systems which give much greater control over combustion, and hence lower emissions, are in the preproduction stage. Durable catalyst systems have been developed and will be applied initially in 1975. These catalysts, rather than being merely add-ons to the internal combustion engine, will be incorporated into the design of the engine itself. Catalysts are rapidly becoming an integral part of the automotive propulsion system. Furthermore, the pace of technology development is still accelerating.

In short, I must admit that many of us in 1970 underestimated the excellence and ingenuity of our community's response to the legislative emission standards, for there is no doubt in my mind that those standards can be achieved, and within the time frame currently contemplated.

Mr. ROGERS. That is 1976 and 1977?

Dr. DAVID. That is right.

On a more philosophical level, these events of the past 3 years are an impressive addition to the remarkable achievements of the Nation's Apollo program. In that program a seemingly improbable task; namely, "man on the Moon within the decade," was achieved against great odds. That goal was set through the political process. Similarly, I believe we will see the goal of clean auto transportation achieved in response to the political process.

Now, I am sure that not everyone will accept my optimism. It is natural that those who must manufacture the cars and accept the performance liability should take a "show me" attitude. They are properly skeptical and wary. But I have confidence that future events will confirm the validity of my viewpoint. I should add, however, that I am concerned about the variability of manufacture and the variability during usage. Averaging in both these dimensions seems justified on basic scientific grounds if the legislated standards are to be met. In my view, averaging is within the original intent of the Clean Air Act amendments, though they have not been so interpreted to date.

Despite my optimism, many people, including some in my former White House office, question whether the effort is "worth the candle"—do the benefits from emission controls offset the costs to the public?

This question, of course, raises the issue of fuel economy, made more immediate by the energy crisis. Comparison of benefits and costs also raises the issue of health effects from auto pollutants.

From a broad point of view, these issues can be addressed candidly. On energy and fuel economy, it is clear that there are many factors other than emission control involved. These include overall design of the car, its weight, accessories, and performance. There is, in addition, the driving style of the operator. The point is clear that increased fuel economy need not imply reduction of emission standards.

On health effects, those who advocate relaxing the standards must necessarily show that any change in the act which would allow a greater level of pollutants would not have adverse health effects. The law should not be amended on inconclusive evidence, if there is any possibility that an error might cause harmful health effects. In other words, any reasonable inference of a harmful health effect is reason enough to set standards as though that effect existed. I believe this philosophy was the congressional intent when the Clean Air Act amendments were passed. And that intent is the driving force behind much current environmental health activity, statements, and proposals on health standards. It is that philosophy which makes today's strict emission standards appropriate.

So much for my personal views on the events of the past 3 years concerning emission control. In the remainder of my testimony, I will recount results achieved by my company to the clean air challenge by developing effective NO<sub>x</sub> emission control for autos. This work supports much of what I have said above. I will divide my comments into four sections: 1. The availability of NO<sub>x</sub> control technology. 2. The cost to the consumer of control installations using this technology. 3. Fuel economy with NO<sub>x</sub> control. 4. A comment on health effects of NO<sub>x</sub>. Let me give a quick summary of my views on these topics.

First, technology is available to achieve the legislated 90-percent reduction in NO<sub>x</sub> emissions. The key to this result is a NO<sub>x</sub> catalyst combined with an appropriately engineered system. This system aspect is critical. The catalyst must be part and parcel of the engine design.

Second, the cost of NO<sub>x</sub> control will add about \$60 to the auto sticker price.

Third, NO<sub>x</sub> control will not cause an unacceptable energy drain. Our studies show that cars equipped with catalyst systems result in a modest improvement in fuel economy comparable to 1973 cars. As technology advances, further gains may be possible.

Fourth, the health effects of NO<sub>x</sub> in the atmosphere cannot be addressed as easily. Recent studies have raised several health effect issues that have not been adequately investigated. I have not seen any results which say that NO<sub>x</sub> is less damaging to health than when the standards were originally set. Thus, it seems to me to be prudent to retain the 0.4 gram per mile standard until there is positive evidence that it is too high. This approach is in line with the "prudent man" philosophy to which I referred earlier.

Now, let me examine each of these areas a little more fully. First, technology.

#### AVAILABILITY OF NO<sub>x</sub> CONTROL TECHNOLOGY

There are essentially two technical alternatives for NO<sub>x</sub> control: exhaust gas recirculation—EGR—and catalysts. EGR has been the

primary means of controlling NO<sub>x</sub> to the levels achieved to date, but has also resulted in much concern over the loss of fuel economy and vehicle performance. With the best available technology, EGR can probably achieve a standard of about 1.0 gram per mile. On the other hand, much greater NO<sub>x</sub> control is possible with catalysts, and without the fuel economy and drivability problems associated with EGR.

As a matter of fact, using an NO<sub>x</sub> catalyst to achieve the statutory 1977 NO<sub>x</sub> level of 0.4 gram per mile will cost the consumer no more over 50,000 miles than the use of EGR to achieve the interim standard set for 1976 of 2.0 gram per mile. The catalyst's slightly higher initial cost is offset by savings in fuel costs.

As we told the Environmental Protection Agency early in July, we expect the catalysts developed by Gould to be capable of meeting or exceeding the 1977 model year standard of 0.4 gram per mile, when used in a properly engineered system. The typical performance of the catalysts is such that for the first few thousand miles, emission levels between 0.1 and 0.2 gram per mile are routine on standard-size U.S. cars. As mileage accumulates, the catalyst becomes less active, until at 25,000 miles it achieves emission levels between 0.35 and 0.55 gram per mile. The effect of very low emission levels during much of the 25,000-mile cycle means that the intent of the Clean Air Act is being met. That is, the average emissions of the vehicle during the typical 25,000-mile test cycle are below 0.4 gram per mile even though at the final testing point of 25,000 miles, some of the catalysts are above the 0.4 level.

Of course, we are working very intensively at perfecting the catalysts so that all of them will meet the 0.4 standard after 25,000 miles. As I indicated earlier, we are confident of being able to achieve that goal.

Our optimism on this score is shared by EPA. As the then Acting Administrator, Robert Fri, said in his decision of July 30: "Reducing catalyst technology has advanced dramatically in the past year and the rate of progress seems to be accelerating. Gould, Inc., has begun to obtain a significant and encouraging body of test results indicating the durability of their system."

#### TYPICAL DEVELOPMENT PATTERN

To some extent, our confidence is based on the typical pattern of development which one experiences with a new technology. We are, in effect, past the preliminary research period, and are well into the development and engineering phase where progress is typically very rapid, as we have been seeing in the past 6 to 12 months. In the months ahead, we expect a similar period of fast-paced developments.

As a case in point, we can look at the development of oxidation catalysts for controlling hydrocarbons and carbon monoxide. Again, as Acting EPA Administrator Fri pointed out in his July 30 decision, at the time of the first EPA suspension hearings in the spring of 1972, only a handful of cars had run more than 20,000 miles and still met the 1975 HC and CO standards. A year later in April 1973 the data were sufficient to predict that 66 percent of the market could meet the 1975 standards in 1975. Durability, fuel economy, and safety problems had been largely solved. And since April of this year, still more progress has been made, to the point where General Motors has said publicly

that it expects its oxidation catalysts to meet the interim 1975 standards for 50,000 miles.

#### SYSTEM COMPATIBILITY

It was brought out regularly during the EPA hearings that performance of catalysts is very much system dependent. Indeed, I cannot stress too strongly that the various techniques and devices we are talking about are not merely add-ons, but must be designed as an integral part of the total internal combustion engine system. In other words, the same catalyst operating in different systems with different specifications may give vastly different results. Poor performance can result from poor carburetor adjustments, improper air bleed to the catalysts, misdirected exhaust flow, and so forth.

Much of the apparent differences between our testimony and that of the auto companies is due to system factors, and should be resolved with time. Gould's promising results, for example, were obtained this spring and only recently have we been able to communicate to the auto firms and conditions necessary for good performance. In the next few months, we expect much improved test results from the auto companies.

In addition, we are pursuing a course whereby independent parties will be able to demonstrate the feasibility of this technology. To date, programs covering at least six cars with New York State and city have been started. As you may have read in *Automotive News* recently, a 3,500-pound Matador has passed 12,000 miles with excellent drivability and fuel economy and with emissions at the last test mileage, 9,000 miles, well below the 1977 levels for CO, HC and NO<sub>x</sub>. Tests are also being performed at the Bureau of Mines and Southwest Research Institute under various Government contracts. We believe that this independent data, to be generated in the next 6 to 9 months, will speak to the soundness of our approach.

Perhaps more importantly, our test programs with the Japanese auto manufacturers are progressing well. We understand that this effort is because the Japanese NO<sub>x</sub> standard of 0.4 grams per mile is scheduled to take effect in April of 1976, about 6 months ahead of the start of the 1977 model year in this country. We have confidence that in Japan we will succeed in meeting both the emission standards and the short timetable.

#### 1. MANUFACTURABILITY

With any new technical device, the question of manufacturing feasibility is foremost. It is naturally a concern of our customers, just as it must be your concern as the representatives of the public. We believe our manufacturing abilities in this particular field give us a unique advantage. The technology required to produce the NO<sub>x</sub> catalyst is a familiar one to Gould. It is similar to the production of automotive bearings and bushings, in which we are a leading high-volume producer and have been for decades. It is also similar to the production of electrolytic metallic foil for electronic printed circuits. We are today the world's leading supplier of this material.

Gearing up to meet the 1977 model year catalyst requirements will not be an easy task, of course. We require a lead time of some 18 months

before commencing delivery of catalysts to meet production requirements.

To sum up the technical picture, we believe the 1977 NO<sub>x</sub> standards can be met. But we believe the likelihood would be enhanced if the auto companies were permitted to average out the variations in manufacturing and during consumer usage. Objections to both sorts of averaging usually center on how to determine if a car, or population of cars, meets the standards. Let me not go into detail on the answer, but merely say that statistical sampling techniques are well adapted to this task.

## 2. COST TO THE CONSUMER

The second area which might bear on a revision of the Clean Air Act concerns cost. We stated at the EPA hearings that we expect to price our catalyst to the auto companies in the neighborhood of \$15 to \$20 each. More recent innovations lead us to believe that a price at the lower end of this range is probably attainable. Two catalysts would be required for a V-8 engine, together with their containers and an air piping system.

Therefore, making the usual assumptions for distribution, tooling costs, dealer markup and so forth, we estimate that the total net cost to the consumer would be approximately \$60 per car for a standard V-8, over and above the emission equipment already installed in 1976 autos.

Such progress in reducing manufacturing costs illustrates the power of engineering to bring the benefits of technology to the consumer. With the rate of progress in the technology and the engineering still to be done, it is entirely possible that stringent NO<sub>x</sub> control with catalysts could be even less costly than this \$60 level.

## 3. FUEL ECONOMY

The third area, fuel consumption, is critical in today's energy-conscious society. As we told the EPA, Gould's fuel economy studies show our catalyst in a dual catalyst system can result in improved gas mileage over 1973 cars. Information presented at the EPA hearings by other witnesses supported this finding.

This has obvious cost benefits to the consumer, of course. But, equally important in light of the present international oil picture, is that the 0.4 gram per mile standard in 1977 will require less fuel than 1973 cars.

## 4. HEALTH EFFECTS

The fourth area that might constitute grounds for easing the NO<sub>x</sub> standards concerns health effects. This is, after all, at the root of the extensive emission control effort which the auto industry has mounted in recent years. The bulk of our testimony has concentrated on the technical aspects of achieving low emissions. But I believe our remarks would not be complete without commenting on the health situation.

Let me start by saying that we certainly are not expert on the health effects of NO<sub>x</sub> or other pollutants. However, it is apparent that there are a large number of open questions in this field. As you have heard earlier in these hearings, there remains much controversy over

the measurement of  $\text{NO}_x$  in the atmosphere. The physiological mechanisms by which  $\text{NO}_x$  might cause serious health effects are not fully understood. We may never be able to isolate the effects of low dosage over long periods of time. And there is the question of the interaction of  $\text{NO}_x$  with other pollutants.

Therefore, in the absence of definitive information in this field from which to draw conclusions, we suggest prudence in recommending less stringent  $\text{NO}_x$  emission standards. A relaxation of the present 0.4 grams per mile standard for 1977 would, in our opinion, be premature at this time, pending more complete data gathering and more exhaustive studies, particularly with respect to  $\text{NO}_x$  and its synergistic effects with other pollutants.

#### FAST-MOVING TECHNOLOGY

In conclusion, Mr. Chairman and members of the subcommittee, I would like to stress that this is an area of fast-moving technology. The progress we have seen in the past year has been extraordinary, and the pace is continuing. For example, in the 2½ months since we testified at the EPA hearings, we have developed a new version of our catalyst which promises much improved results over the data we reported to the EPA. The new catalyst has a lower operating temperature, is less susceptible to variations in carburetion, and promises improved durability. An example of this type of catalyst, is on the table in front of me. It has accumulated 20,000 miles with excellent results.

This rapid technical progress has resulted because the Clean Air Act Amendments created a new market for emission control systems. As I said in my introduction, there now appear to be several different technical roads to achieving the original standards. Which one or ones will win out should rightly be determined by competition. We are seeing now the testing that initiates this competition. Any change in the standards or timing will adversely affect that process.

We at Gould are deeply committed to  $\text{NO}_x$  control research and development. We are presently spending at the rate of about \$1 million per year, with approximately 15 full-time professional people and 20 supporting personnel. We would not be so committed if we saw the market possibilities disappearing or fading into the future.

Let me emphasize then in closing that we have considered the state of technology, the uncertainties of health effects, fuel availability, and cost to the consumer. All considered, we see no compelling reason at the present time to modify the current statute.

Now, we would be happy to answer your questions.

Mr. ROGERS. Thank you very much, Dr. David, for very helpful statement and the conclusion that you think we have no need to modify the statute at this time.

Mr. Satterfield?

Mr. SATTERFIELD. Thank you, Mr. Chairman.

Dr. David, can you tell us whether yours or any other catalytic device has proven test worthy for 50,000 miles?

Dr. DAVID. Our catalyst has not proven test worthy for 50,000 miles. We have demonstrated durability over 25,000 which is compatible with EPA's assumption the catalyst could be replaced once during the 50,000-mile driving cycle.

Mr. SATTERFIELD. What about the test conditions?

Dr. DAVID. Catalysts were tested under both the AMA intermittent driving cycle and in steady freeway driving.

Mr. SATTERFIELD. Is there any bearing upon the effectiveness of a catalyst in the tuning of the engine?

Dr. DAVID. As I indicated in my testimony, the engine has to be designed as part of the catalyst system which means one has to control the combustion rather precisely.

That is an important element in getting results that we do.

Mr. SATTERFIELD. I get back to one thing that has bothered me about our whole effort.

We seem to be controlling the exhaust of an automobile at the manufacturing level and concluding that we are doing a good job and yet we have no way in the world of policing it after it gets in the hands of the operator.

I am assuming your catalyst is predicated upon burning a special type of gasoline?

Dr. DAVID. We are not subject to lead poisoning.

Let me add with respect to your first comment, that we do not foresee a major technical problem in policing emission devices. We have looked into a number of measurement techniques which are being incorporated into small, inexpensive, portable instruments which can determine levels of emissions from autos.

Local service stations—or State inspection stations, depending on the desires of the individual States—could be equipped with such devices to determine whether or not catalyst replacement is required, in much the same manner as other equipment is replaced from time to time.

Mr. SATTERFIELD. You can burn yours with regular gasoline?

Dr. DAVID. That is right.

However, the system requires no lead—low-lead gasoline.

Mr. SATTERFIELD. I notice you say the cost to the owner would be \$60.

I take it you are talking about the add-on price to the auto?

Dr. DAVID. That is right.

Mr. SATTERFIELD. If one drives a car 50,000 miles he will have to replace the converter?

Dr. DAVID. He will have to replace it once. We have not calculated the replacement costs but it would be less than the \$60 because this includes the air pump, plumbing, and canisters which would not have to be replaced.

Mr. SATTERFIELD. With the energy crisis staring us in the face, suppose it is impossible for the owner to buy low-lead gasoline and has to burn leaded gasoline.

Will this destroy the system or require the replacement of the converter?

Dr. DAVID. It would poison the oxidation catalyst that would then have to be replaced. However, it is my understanding that EPA has asked for comments on a regulation that would require all filling stations in the country larger than a certain size to carry nonleaded gasoline by 1975.

I have heard Chairman Train this morning on television say the nonleaded gasoline standards which would be issued within a few weeks.

Mr. SATTERFIELD. I hope we will have him here because I have some questions I want to ask him.

I can understand how you can have two types of gasoline to serve two types of automobiles on the road when you have an adequate supply of the fuel but when you are in a critical shortage period I don't think you can guarantee nor can he that you will have all the gas you need for all the different types of cars on the road.

Dr. DAVID. The need will grow slowly because of the 10-year half-life.

I think the oil companies could respond and make low-leaded gasoline available in the amounts needed.

Mr. SATTERFIELD. Most of the problem is in distribution. When you have a surplus your distribution problem is not very acute but when you have no reserves, that system has to work absolutely perfectly to deliver the type or quantities of the gasoline you need when and where you need it.

Dr. DAVID. I appreciate the point. I tried to drive around Denver this summer and I had my problems.

I might say, Mr. Satterfield, as you know, there are many different brands and octane ratings of gasoline on the market at the present time.

My 1973 car runs better on 91-octane gasoline than others. So, I don't think the situation would be drastically different in the low-lead case.

Mr. SATTERFIELD. To go back to the economy and the energy crisis, does it not take more crude to make low-lead gas than not?

Dr. DAVID. I believe that is true. However, the fact is not really relevant to the energy shortage because the remainder will be used for other applications.

The implication or assumption may be that the rest of the barrel would be wasted, but that is not true.

Mr. SATTERFIELD. With the overall use of the barrel it will not go as far as it does today if you are not making leaded gasoline?

Dr. DAVID. A single barrel would not go as far toward production of gasoline, yes.

Mr. SATTERFIELD. Another point, you indicate that you feel that the standards for exhaust emission of  $\text{NO}_x$  as now constituted, ought to be not changed.

I am not sure that they should, either, but I would be interested in your view in light of the fact that the EPA and everyone recognizes that measurement of  $\text{NO}_x$  in the ambient air is concerned their readings have been wrong.

Do you know whether or not the standards that have been set so far in terms of  $\text{NO}_x$  in the exhaust of an automobile are predicated on those erroneous ambient air standards or requirements?

Dr. DAVID. I think we should say the following things:

There are several ways of measuring  $\text{NO}_x$  in the atmosphere.

The current thought that there has been a two-to-one measurement error is now open to serious doubt. The new and old methods have been compared and our information is that it is very difficult to say how much the error has been.

Mr. SATTERFIELD. Let's assume the first suspicion is correct and that there is not as much  $\text{NO}_x$  in the ambient air as originally thought.

Would this not be justification for changing the standard of NO<sub>x</sub> from an automobile?

Dr. DAVID. I don't think so, Mr. Satterfield, for the following reason:

In addition to the testimony you have heard this week that NO<sub>x</sub> may have effects we are only beginning to understand, there is the point with the restrictive transportation plans that have been put forward by EPA, the lower the emissions, the more automobiles we can have on the road.

Mr. SATTERFIELD. Was this not anticipated with respect to the given number of cars at the time?

Dr. DAVID. I don't know how the standard was calculated but it seems to me with the EPA proposing to restrict the number of cars in the New Jersey area, for example, by 70 percent, that any additional reduction in automobile emissions is going to decrease the impact of that plan on transportation.

Mr. SATTERFIELD. Has your company conducted any studies with respect to the problem EPA is now looking into, the suspicion that there may be additional pollutants given off by catalytic devices?

Dr. DAVID. We have looked into it. We have not made the measurements that would satisfy me as a scientist. However, our information indicates that any emissions from our catalyst would be much less than from an uncontrolled car burning leaded fuel.

Mr. SATTERFIELD. When you were in the Office of Science and Technology, did you have occasion at any time to address the EPA or any other agencies of this Government with respect to information in your hands dealing with pollutants of automobile exhausts?

Dr. DAVID. Yes, we had a dialog with all of these people more or less regularly.

Mr. SATTERFIELD. Would EPA have access to all of these?

Dr. DAVID. Yes, I believe they had access to all of the reports which have been referred to here this morning if that is what you are interested in.

Mr. SATTERFIELD. Would this apply to memorandums also out of your office with respect to studies and views when you were in that office?

Dr. DAVID. Except for personal memoranda between my staff and me.

Mr. SATTERFIELD. So, we could get all of this by making the proper demand upon EPA?

Dr. DAVID. Yes.

Mr. ROGERS. Would your catalyst work with the Honda engine?

Dr. DAVID. Yes, sir, it could work with the Honda engine.

Mr. ROGERS. If they are having problems with NO<sub>x</sub> your catalyst could solve that problem in that field?

Dr. DAVID. That is correct, Mr. Rogers.

[The following letter was subsequently received for the record:]

WINSTON & STRAWN,  
Washington, D.C. September 17, 1973.

Re Correction of Dr. David's Testimony on Friday, September 14, concerning GEM's compatibility with CVCC engines.

PAUL G. ROGERS, *Chairman,*  
*Subcommittee on Public Health and Environment,*  
*U.S. House of Representatives, Washington, D.C.*

DEAR SIR: In the testimony before your Subcommittee, on Friday, September 14, 1973, Dr. Edward stated that Gould's NO<sub>x</sub> catalyst should be compatible

with the Honda type stratified charge engine. This statement was incorrect. The Honda concept for maximum emission control must have a very lean air to fuel ratio. The Gould  $\text{NO}_x$  catalyst is not compatible with any system that operates on the lean side of stoichiometric. The Honda engine runs from 17-20:1 while Gould's  $\text{NO}_x$  catalyst must be run on a richer air to fuel ratio of 15:1 or less. Thus we are not compatible with the Honda type stratified concept; however, we may be compatible with the Honda stratified charge concepts that run at or near stoichiometric carburetion.

Sincerely,

JOHN R. REILLY.

Mr. ROGERS. What do you think the savings in fuel will be with the  $\text{NO}_x$ ?

Do you have any range?

Dr. DAVID. We have done testing with the dual catalyst system and compared it with the 1973 automobiles, the same automobile modified, and we have tested both a Chevrolet and a Ford.

We are finding fuel economics for the dual catalyst system which are in the range of 3 or 4 percent.

Mr. ROGERS. How does your system differ from the two catalyst systems which were strongly criticized, I believe, by NAS earlier this year?

Dr. DAVID. I don't think that there are differences in kind.

There are differences in degree. During the months since the NAS report we arrived at a much better formulation of the dual catalyst system.

In addition, with the help of the automobile companies, we have been able to add, as I indicated to you earlier, better fuel distribution systems and better spark systems so that the entire operation of the engine is much improved.

Mr. ROGERS. I would like for you to comment and can you do it for the record if you prefer on EPA's system of measurement, if it is scientifically done where they took the two systems of measurement, say, in Chattanooga?

Dr. DAVID. I would be glad to do that for the record, Mr. Chairman.

Mr. ROGERS. I think it would be helpful.

Does it not end up in effect doubling the standard?

Dr. DAVID. The information I have seen from EPA with respect to the two-to-one error has that implication, but as I indicated earlier, it seems to me the implied two-to-one error will not hold up under close examination.

Mr. ROGERS. If you could give us your details on that, it would be helpful.

[The following comments were received for the record:]

#### COMMENTS ON EPA'S TWO PRINCIPAL MEASUREMENT TECHNIQUES

(JACOBS-HOCHHEISER AND SALTZMAN)

As you probably know, Mr. Chairman, two principal measurement techniques are in question concerning the Chattanooga Study and  $\text{NO}_x$  in the atmosphere. One is the so-called Jacobs-Hochheiser method (Federal Reference Method), the other is the so-called Saltzman technique.

EPA's present methods for  $\text{NO}_x$  analysis all employ systems whereby ambient air is bubbled through a liquid solution with subsequent chemical reaction (except chemiluminescence). These systems rely on obtaining a reproducible quantity of reaction under all conditions. Unfortunately, this reproducibility is upset by such factors as ambient temperature, the size of the bubbles, and most importantly, the amount of pollutant gas already passed through the solution. The latter problem was in part responsible for the varying results obtained by

using the Jacobs-Hochheiser techniques in Chattanooga. It is believed that non-"wet chemical" techniques should be used instead of the highly variant wet chemical methods (e.g. arsenite, Jacobs-Hochheiser and Saltzman).

As indicated, the Jacobs-Hochheiser method was used in the original studies around Chattanooga, which became the basis on which the present NO<sub>x</sub>-health standard was set. However, the Saltzman method is the more reliable of the two, and an initial examination of the relationship between the two methods indicated that the J-H technique over-stated the amount of NO<sub>x</sub> in the atmosphere around Chattanooga by about a 2 to 1 margin.

More recent results, on the other hand, do not confirm that 2 to 1 relationship. It seems that it is very difficult to relate the data obtained by the J-H method to Saltzman data. Moreover, the large arsenal which had been emitting quantities of NO<sub>x</sub> to the atmosphere in the Chattanooga area is no longer in operation, so any new measurements taken now by more accurate methods could not be correlated to the NO<sub>x</sub> levels and health effects seen in the years when the arsenal was in operation.

The result is that we are almost back at ground zero. We have little confidence that the first measurements by the Jacobs-Hochheiser method were correct. And we also are not sure what the Saltzman or newer techniques would have shown if they had been used in Chattanooga.

Fortunately, however, new measurement techniques are now being developed such as laser spectroscopy, which promise to provide the accuracy this problem demands.

Mr. ROGERS. Thank you very much.

Our last witness this morning is Mr. John Quirk, president, Vortex of Rancho LaCosta, Calif.

We welcome you to the committee and we would be pleased to hear your testimony at this time.

#### STATEMENT OF JOHN QUIRK, PRESIDENT, VORTEX

Mr. QUIRK. Mr. Chairman, when Vortex first spoke out against the catalytic converter 3 years ago, we were a voice in the wilderness. Now the majority opinion is with us and the catalytic converter is championed primarily by the Environmental Protection Agency and General Motors.

The EPA gets there by seeing it as their duty to take an unyielding position for the statutory standards. With the present EPA test procedures, the only way to meet the standards is with the catalysts. I did think they sounded uneasy defending it Tuesday, like an attorney who is not sure his client is innocent.

As for General Motors, they are, of course, like the EPA dedicated to clean air, and the catalyst is the best they have come up with. Also I think it is well known that high placed persons there have put their personal engineering prestige on the line for a "successful" catalytic converter. And commercially, General Motors could believe, with their more advanced converter, that they have Chrysler and Ford between a rock and a hard place. Whatever the motives, the EPA and General Motors have got the juggernaut rolling.

In the 4 days I have attended the hearings, I have heard a constant theme, a question asked over and over. Is there an alternative to the catalytic converter? There is indeed. It is the Vortex Reactor.

What we claim here today is documented. With the chairman's permission, I would like to include in the record certain test results from General Motors and the Environmental Protection Agency [see p. 476]. We ask that anyone who disagrees with our claims be called upon, no matter what their size, to do so with documentation, not conversation.

My name is John Quirk. I am president of Vortex, an independent laboratory, privately funded, trying to do in the emissions business what cannot be done by the giant companies. That is to come up with a smog device that gives low emissions on high performance engines at low cost; to come up with a low cost device which reduces all three pollutants, carbon monoxide, hydrocarbons and NO<sub>x</sub>. We have succeeded, against the odds.

If you wonder what kind of persons find themselves in such an adventure, these are my brief personal credentials. I am a 1942 graduate of the Naval Academy. I was a carrier fighter pilot. For 20 years I had my own company in Detroit selling to the auto industry. I competed successfully. I have also written successfully about the industry. My novel "The Hard Winners" has sold a million copies. I know Detroit and the auto industry and what makes it go.

Our partner in Detroit is Howard McGregor, a well-to-do business executive who likes the excitement of this battle and also believes it is his duty to do this for the country.

Our original inventor, Von Brimer, was a madman. He was a genius. He died in 1971 as much a madman, as much a genius as the day he was born. We believe he will one day be known worldwide for some extraordinary advances in more than one field.

His brother is now the engineer. He was chief of missile launch at the Cape, so he could be called a scientist. But he would rather be called an engineer, and he thinks that any lab that has more than 10 engineers won't turn out anything astounding.

Anybody who thinks this group could not come up with a better smog device than General Motors thinks that General Electric invented the electric light, not Edison.

We have succeeded and then have been frustrated beyond description, that nobody seemed to want to do anything about it. Until we got to the House of Representatives. Three Congressmen have looked and listened, become interested and have showed us how to go forward. Two staff members of this committee have helped a great deal. I tell you this, we came to Washington this time with what we are convinced is the answer to the smog problem and yet were at the end of our line.

This week there has been a dramatic turnaround for us, including urgent new interest in us from an auto company and from a major manufacturer, and for this we are indebted to the House of Representatives. I want to add that not once has anyone here asked about our politics nor we about theirs.

As for the performance credentials of the Vortex reactor, the testimony at these hearings says it best. Dr. Carter read to Mr. Misch, of Ford Motor Co., the test results with our reactor on a 1965 V-8 Chevrolet.

He asked Mr. Misch, "For \$40, on an engine with this high performance, can you duplicate these results?"

Mr. Misch responded, "No, we cannot."

Nor can General Motors. Nor can Chrysler. Vortex, the small laboratory, stands alone in emissions control on the kind of engines the carowner wants and the energy crisis demands. Certified tests at General Motors, Chrysler Olsen Laboratories, the California Air Resources Board, and the Environmental Protection Agency say so.

Mainly we are going to rely, for substantiation of the importance of our claims, on the testimony yesterday of the General Motors engineers, who seemed not convinced of the merits of Vortex. Mr. Ernest Starkman said General Motors was looking for a smog device which would reduce all three pollutants. Vortex reactor reduces all three.

Mr. Starkman said General Motors would continue looking for a smog device which gave better performance and better gasoline mileage than the catalytic converter. He stated that the converter would improve gasoline mileage, but this was only in comparison with 1974 vehicles, not 1965 engines. The Vortex reactor on a 1965 engine burning Ethyl gasoline will get better gas mileage than a 1975 engine of the same horsepower equipped with a catalytic converter. The 1965 engine will also have better drivability and all around performance. These facts should be shouted out loud. Everything which the auto industry has done on emissions control displeases the driver of the car. Everything that Vortex proposes will please the driver.

Mr. Starkman proposed that the emissions standards be set at HC of 1.0 for California; 1.7 for the rest of the country; CO of 17; and NO<sub>x</sub> of 1.5 for California; and 3.1 for the rest of the country. In order to accomplish this, General Motors would need a catalytic converter for California and much of the rest of the country. The \$40 Vortex reactor on the full performance engine would meet these requirements nationwide. I trust this committee will see this as most significant.

It is obvious that none of the auto companies has a device which can do what the Vortex reactor can do, at the low price and with the full engine performance. Otherwise they would surely have it on their 1974 automobiles. Surely, they would not hold it out of production, to use another system which costs \$250 more, has much worse engine performance and fuel economy and much higher emissions. Any member of this committee who wishes direct assurance need only ask the direct question of General Motors and Chrysler, "Can your company match the Vortex emissions levels for \$40 on 1965 engines?" General Motors and Chrysler must answer that they cannot, just as Ford Motor Co. answered.

Then comes the great question. If we have such a winner, why won't anybody pay attention? The answer is NIH—the not invented here philosophy. Anybody who does not believe that NIH has played a major part in the emissions control decisions in Detroit believes the sun does not rise in the east.

Detroit interest in the stratified charge engine and the rotary engine are cited as evidence that NIH does not exist. But the fact is that Honda knew better than to take their engine to Detroit. They took it to Washington and made Detroit come to them. General Motors could have had the rotary engine for \$3 million. They waited until public pressure forced them to take it for \$50 million, and you heard yesterday how carefully they insisted what they now had was the GM rotary engine. Engineering pride is a great thing which has accounted for much of the success of Detroit. Such pride is not all good. We will give you an example of NIH which is so explicit as to be painful. But we choose an example with a Japanese company, because the Detroit engineers can see it more clearly in others than in themselves.

In a head-to-head contest, on an engine chosen at random, in a certified laboratory, a \$30 Vortex reactor had half the emissions of

the \$250 Mazda reactor. I want to make it quite clear, that five Mazda engineers agreed that Vortex would cut their emissions by more than half and save them a very great deal of money. But both here and in Japan they had no interest. Why not? They gave one reason: "Because we have spent 6 years developing our own reactor."

Does that sound like nonsense? If it is not true, Mazda can call our bluff before this or any other panel. It happened exactly as related. This committee now knows that Mazda could have half their present emissions. I think perhaps the American public would like to know that. I would imagine the Mazda stockholders would like to know they could have saved \$200 a car. If such a thing could happen in that auto company, could it happen in another, no matter how incredible a distant observer would think such a thing to be?

I said we are privately funded. Our funds aren't enough. For example, we need more sophisticated test equipment because our latest reactors have such low emissions that our equipment can't read them. We have looked for funding as properly we should, with our success and promise. There were five places we could look.

1. First, was the Small Business Administration. We were quickly advised that those funds were for disadvantaged persons. We could have advised them we were disadvantaged compared to General Motors, but we didn't argue the point.

2. Second was the Environmental Protection Agency. Now that the EPA knows we have something unique, we are getting great cooperation from their Ann Arbor laboratory, as we are from the California Air Resources Board Lab. But, we didn't bother asking for funds because before we could they volunteered that they were funding only those projects on which nobody else would spend any money. I think "spend" in this case is a euphemism for "waste."

3. Third is the oil companies. They are the logical people to back us. Since we use leaded fuel, we are exactly what they want. We are their best and only help. These companies are spending millions of dollars on television and other media advertising telling the public how concerned they are about pollution and the energy crisis. We did ask; several companies. The answer was unanimous. Every one of them said, almost as though it were rehearsed, that they had now decided to leave the hardware to the auto companies, who were best equipped to do that job.

I am anxious to report that Phillips Petroleum Co. has provided us with our laboratory building, as an institutional contribution, and for this we are profoundly grateful. It is a contribution without which we could not have survived, and we think they should be commended for helping us even before we had proved what we had.

4. Fourth is supplier companies to the auto industry. Several have investigated and have believed that the product had great merit. Each in turn has walked away after contacting the auto companies and inquiring as to the possibilities.

5. Fifth is the auto companies themselves. One of these companies, General Motors, has given us two test vehicles. They have given us generous access to their test facility in Mesa, Ariz., and the staff there has not only cooperated beyond the call of duty but has cheered our successes. GM has funded us with \$5,000. Chrysler will now run tests

to confirm the GM and EPA results. This is a total of perhaps \$20,000 out of the \$6 billion which will be spent by 1977.

Yet we have accomplished what they could not accomplish. Are we entitled to wonder? A major Japanese company, one of the giants there, now approaches us and asks if we want them to back our American effort. Is that the way it should be?

To conclude, I have some specific recommendations. They are based as much on commonsense as on "scientific" data, and our first recommendation is that the Committee recognize that not all engineers are wise policymakers. The Congress should trust the commonsense of its Members before trusting the tunnel vision assertions of those of us who are immersed in the battle.

1. First, we can only agree with the auto companies that emission standards should be just stringent enough to meet the health and esthetic requirements. The penalty for "overkill" is too heavy to be disregarded.

Obviously, Vortex would be pleased with the standards recommended by Du Pont, or the State of California, or by GM as cited heretofore. The country would be pleased, too, because of the benefits they would get from the Vortex Reactor or a competitor that performed as well.

2. The test procedures and weighting must be changed, on a commonsense basis. At present there is a premium on passing a test under artificial test conditions rather than building a device which performs in real life. The only emissions figure which counts is the total amount of emissions from a car during the entire life of that car.

The question has been raised this week about the need for constant check on field performance of the catalytic converter. If it isn't functioning, a great deal of money has been spent for nothing. An afterburner functions uniformly all of its life. It usually gets better as the car ages and the engine gets dirtier.

In any event, the whole concept of testing should be restudied to reflect better the actual road conditions in the hands of drivers. Temporary tricks during laboratory tests should not be permitted.

As for weighting, the present CVS test uses a round trip to a shopping center as the average urban driving trip and has weighted the cold start portion accordingly. But in New York City, where smog is a deadly problem, the average trip is a taxi which runs all day, a police car which runs all day, a truck which runs all day, a commuter whose engine is warm by the time he gets there. The cold start is important only for the commuter when he starts up to go home. Thus, the correct figures for New York to use are the cold stabilized figures. With the Vortex Reactor, these are so low that New York smog would be knocked out immediately and would stay knocked out for all time. The same is true for Los Angeles and some other cities.

We recommend, Mr. Chairman, that the committee consider delegating to the various cities authority to handle the matter in accordance with their own particular problems. The averaging system of the EPA will not work.

Mr. Chairman, we would not say that no one will come along with a better device than Vortex. Right now we appear to be the best. The

public would vote for us. We hope this committee will keep an eye on us.

[The test results referred to follows:]

GENERAL MOTORS DESERT PROVING GROUND VEHICLE EMISSIONS LABORATORY, MESA, ARIZ.<sup>1</sup>

RESULTS: 1973 FEDERAL TEST<sup>2</sup>

[In grams per mile]

	Cold start emissions	Expected hot start emissions
Hydrocarbons.....	1.36	0.06
Carbon monoxide.....	36.33	4.77
Oxides of nitrogen.....	1.17	1.20
Carbon dioxide.....	818.71	789.64

<sup>1</sup> Date, August 8, 1973; car No. CH-22327; relative humidity 52.4; odometer, 8,824; inertia weight, 5,000; hot idle, 0; test No., W-3715; actual horsepower, 14.7; cold idle.

<sup>2</sup> Economy during schedule 10.16 miles per gallon.

RESULTS: 1975-76 FEDERAL TEST

[In grams per mile]

	Cold transient	Cold stabilized	Hot transient
Hydrocarbons.....	2.80	0.04	0.08
Carbon monoxide.....	75.10	.72	9.19
Oxides of nitrogen.....	1.67	.70	1.73
Carbon dioxide.....	769.34	869.25	708.10

WEIGHTED MASS EMISSIONS

[In grams per mile]

Hydrocarbons.....	0.62
Carbon monoxide.....	18.34
Oxides of nitrogen.....	1.18
Carbon dioxide.....	804.70

Note: Temporary system data—measurement system being upgraded to meet 1975-76 Federal procedure.

Mr. ROGERS. Thank you very much for your statement. Where have you had tested this Vortex reactor?

Mr. QUIRK. We have tested it at General Motors, Olson Laboratories, Chrysler, the California ARB, and the Environmental Protection Agency.

Mr. ROGERS. Has it been tested for 50,000 miles?

Mr. QUIRK. No, sir, it has not.

Mr. ROGERS. What is the total number of miles?

Mr. QUIRK. We have never run endurance tests because of lack of funds, but I would point out that afterburners as such have been tested in the Mazda and do endure. It is a matter of the temperature versus time, and the metal does not know if it is in a Mazda reactor or in ours. Du Pont has also run endurance tests with afterburners, and thinks that since theirs endure, ours would last 50,000 miles.

Mr. ROGERS. How many miles have you tested them?

Mr. QUIRK. About 8,000 miles.

Mr. ROGERS. These are the results you got after the 8,000?

Mr. QUIRK. The latest test I just read are after 8,000.

Mr. ROGERS. Does it correct the pollutants to the 1975 and 1976 standards?

Mr. QUIRK. No, sir, we meet the 1975 interim standards.

Mr. ROGERS. So you are meeting the 1975 interim standards.

Mr. QUIRK. We meet all the standards proposed by every witness before this committee.

We feel, Mr. Chairman, that it is possible that we could meet the 1976 standards, but we have not wanted to spend our funds attempting to do that because that would mean perhaps another \$200 in cost on our \$40 device, and if it is not necessary, we don't think the public should be required to do that.

When I was in Detroit, the auto industry used to fight over a 5-cent advantage in a part and now they toss \$50 or \$60 around as if it meant nothing. When you add up what the catalytic converter will cost the customer in the life of the car, it represents billions of dollars overall that would be required.

Mr. ROGERS. On hydrocarbons, you are at 0.62.

Mr. QUIRK. That is on the weighted mass emissions. On the cold stabilized emissions we are at 0.04. This figure is opposed to the 1.5 General Motors recommended yesterday.

Mr. ROGERS. Carbon monoxide.

Mr. QUIRK. 18.34 as opposed to the 17 that General Motors recommended yesterday; the 24 that California air resources board recommends and the 40 that Du Pont recommends.

Mr. ROGERS. The oxides of nitrogen.

Mr. QUIRK. We are 1.18, as opposed to the 1.5 recommended here yesterday, and 2.0 which is now the interim standard.

Mr. ROGERS. The carbon dioxide.

Mr. QUIRK. That is not a factor. That is merely added in determining what your fuel consumption is. That is not a pollutant.

Mr. ROGERS. What is the effect on fuel?

Mr. QUIRK. Substantially we have 1965 fuel economy. We suffer some loss in running an air pump but that is a minimal loss. We are effectively at 1965 levels or very close to that. Our fuel economy is better than the—

Mr. ROGERS. What does EPA say about your device?

Mr. QUIRK. To begin with, they did not think it was possible a company of our size could come up with a better device than the auto companies. They resisted looking at it. Once we showed them enough test data from other laboratories, they tested in their own laboratories and now have enthusiastically offered a full series of tests in their Ann Arbor laboratory.

We have something they are interested in checking and beyond that, they might be able to make some modifications to it that would make it better. They have experiences we don't have.

Mr. ROGERS. Your cost factor was \$40?

Mr. QUIRK. Yes, in the original form we had it costed out at \$28. In its present form, we have made a generous allowance for changing to a stainless steel manifold.

Mr. ROGERS. Would any other device have to be placed on the automobile in connection with this?

Mr. QUIRK. No, sir, none whatsoever.

Mr. ROGERS. Mr. Satterfield?

Mr. SATTERFIELD. Mr. Quirk, I wish to welcome you. I have been concerned about a statement that was made by Mr. Quarles, I think, on Monday. I recall 3 years ago when we were talking about this act, there was a great deal of discussion about going down more than one road; that the catalytic device was one and thermal reactors and other proposed reactors were others.

I was very much concerned when I asked Mr. Quarles exactly what was EPA doing with respect to some of the other alternative devices and I was told they were not doing anything.

I am interested in knowing when EPA became interested in your device?

Mr. QUIRK. We told the EPA about it as long as a year ago. For quite a long period of time, they said verbally and in writing they had no interest in afterburners because of the automobile experience with them and their own experience with them was that no afterburner had merit. Eventually we broke through that barrier by showing them certified tests showing how much better our afterburner was than Dupont's or Mazda's or anybody else's.

Mr. SATTERFIELD. Do you have copies of that correspondence?

Mr. QUIRK. Yes.

Mr. SATTERFIELD. Would you have objection to making that correspondence available.

Mr. QUIRK. I do not want to fight with the EPA, but I want to cooperate.

Mr. SATTERFIELD. I don't want to put you in an unfair position and I think that would help us not in terms of criticizing EPA, but we carefully wrote a provision into the Clean Air Act that EPA must report to Congress once each year. They are supposed to report about what is being done in the whole experimental area, about systems which would affect pollutants as well as the cost and technical feasibility of each.

As I said before, I was disappointed there was no mention of any device, catalytic or otherwise in the report we received. I want to try to impress upon EPA that we are looking for this information and maybe the reasons they expressed to you will help us come to an agreement with EPA.

[Testimony resumes on p. 490.]

[The following correspondence was received for the record:]

CORRESPONDENCE BETWEEN VORTEX AND ENVIRONMENTAL PROTECTION AGENCY

VORTEX,

*Rancho La Costa, Calif., December 12, 1972.*

Mr. WILLIAM RUCKELSHAUS,  
*Environmental Protection Agency,*  
*Washington, D.C.*

DEAR MR. RUCKELSHAUS: Enclosed is a letter to the Air Resources Board concerning the Vortex Reactor. I've sent copies to President Nixon, Governor Reagan, Mr. Cole, Mr. Ricardo, Mr. Ford and others.

If we have the answer to the auto smog problem, as it appears from the test results we do, it is time someone took the initiative.

Proving that we have the best and most sensible answer is simple and straightforward. That's the easy part. Getting someone to do something about it is the hard part. From your own experience in government and with industry, you'll appreciate what we're up against.

We must report to you (with sense of humor and without rancor) that the emissions experts have made a billion dollar vocation out of *searching* for the

answer to the smog problem. Having the answer handed to them needing only implementation is something they're simply not geared for.

Who does something about it?

Respectfully,

JOHN QUIRK,  
*President.*

\* \* \*

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY,  
OFFICE OF AIR AND WATER PROGRAMS,  
*Washington, D.C., January 2, 1973.*

Mr. JOHN QUIRK,  
*President, Vortex  
Rancho LaCosta, Calif.*

DEAR MR. QUIRK: This is in response to your request of December 13, 1972, as to the Federal Government interest in supporting the development of emission control devices suitable for automobiles.

The Environmental Protection Agency is interested in all possible approaches to emission control. Our technical staff analyzes all such proposals to determine whether they show promise for meeting present or future emission control requirements. In some cases, we arrange for testing of such approaches in our laboratory. However, because of the large number of such proposals, we must limit our testing effort to confirming the results that have been obtained from competent independent testing laboratories, at the expense of the developer of the proposal.

At the present time, with the exception of a highly-targeted engine development program that is oriented toward gas turbines, Rankine and stratified charge engines as low emission power systems, we are not in a position to financially support the development of hardware suitable for automotive application. Our role is basically limited to the technological assessment function described in the foregoing paragraph.

If you are interested in having our technical staff evaluate your proposal you should communicate directly with the Director of our Division of Emission Control Technology at our motor vehicle emissions laboratory at 2565 Plymouth Road, Ann Arbor, Michigan 48105. However, it is only fair to caution you that there is so significant likelihood that it will be possible for the EPA to financially support your work, and that our participation in your undertaking will necessarily be limited to a technical evaluation of the results that can be achieved with your approach to emission control.

Sincerely yours,

ERIC O. STORK,  
*Director, Mobile Source Pollution Control Program.*

\* \* \*

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY,  
OFFICE OF AIR AND WATER PROGRAMS,  
DIVISION OF EMISSION CONTROL TECHNOLOGY,  
*Ann Arbor, Mich., January 8, 1973.*

Mr. JOHN QUIRK,  
*Rancho La Costa, Calif.*

DEAR MR. QUIRK: This is in reply to your letter to President Nixon dated December 12, 1972, concerning the results of testing of your Vortex reactor system.

The data provided with your letter is a mix of 7-mode and CVS data. It is not possible to compare the 7-mode results to our Federal standards which utilize a cold-start CVS procedure. The General Motors test of the 1972 Impala equipped with the 1965 engine and your device gave results where carbon monoxide exceeded the 1975 standard by a factor of three. As you are probably aware, one of the reasons for going to the CVS procedure was to get a true mass emission test which includes all starting emissions and more realistically represents the problem of cold start. Your data and our experience with other reactor systems proves that it is very difficult if not impossible to meet the 1975 and 1976 CO standards with a reactor applied to a conventional piston engine. The auto industry has had

to concentrate on catalytic devices or engine redesign as in the Honda compound vortex controlled combustion chamber in order to meet the required levels.

Thank you for bringing your system to our attention.

Sincerely yours,

JOHN P. DEKANY,  
Director.

\* \* \*

VORTEX.

Rancho La Costa, Calif., April 2, 1973.

To: Mr. William Ruckelshaus, Environmental Protection Agency.

This is the report on the Vortex Reactor, as requested by your staff. The report will be plain spoken, because this is no time for parlor talk. The report address itself to two questions:

1. Is an afterburner the correct solution to the automobile emissions problem, as opposed to catalytic converters?

2. Is the Vortex Reactor the best afterburner?

The report will rely on facts as determined by certified private and government laboratories, with surmise kept to a minimum. We expect that any exception to the findings likewise be based on facts, not on wishful thinking of competing emissions engineers, not on industry ego, and not on any instinct on the part of large corporations or government agencies to find it incomprehensible that a small group of individuals might come up with a better answer than the heavily funded industry and government laboratories.

We do not believe even one statement in this report can be challenged. We think the following facts are incontrovertible:

#### *Premise*

Protecting the ecology means more than just reducing auto emissions. The future of the world is made at least as uncertain by the energy crisis as it is by auto pollution.

If the emissions solution costs 25% of the world's oil reserves, it is not a good solution.

If the emissions solution would quickly exhaust the world's known supply of certain rare metals, it is not a good solution.

If the emissions solution would unnecessarily cost car buyers billions of dollars, would drastically cut engine performance and would drastically increase fuel consumption, it is not a good solution.

#### *Statement:*

There are six requirements for the smog device which is the correct solution for the auto emissions problem.

- (a) Low emissions.
- (b) Low cost.
- (c) High engine performance.
- (d) Low fuel consumption.
- (e) Simplicity.
- (f) Durability.

Of all the devices and systems which have received publicity, only Vortex even claims to meet all six requirements.

#### *Brief History of Detroit's Efforts to Control Emissions*

1. Automobile engines reached their peak performance in 1965. Since then, there has been a serious decrease in performance caused directly by the emissions controls chosen by Detroit. Driveability has decreased and fuel consumption has increased.<sup>1</sup>

*Question. Is there not another problem—of having also to recapture the operating efficiency which you sacrificed in order to get the new standards?*

*Answer.* That's exactly right. Also the things that we are doing have adversely affected the fuel consumption. We have to use more fuel for the same result. We hope we can engineer our way out of it, but that still remains to be seen.

2. In the early 1960's, Detroit knew about smog as a complaint from remote Los Angeles, but no one took it as seriously then as in 1973.

In an atmosphere of novelty, relative unconcern and relative lack of knowledge, the auto companies made a multibillion dollar decision on smog control. The

<sup>1</sup>This is so well known that it should need no corroboration, but we quote Mr. James Roche, director and former chairman of General Motors, in an interview April 1, 1973.

question was whether to eliminate the emissions before they were formed (by making engine changes) or after they were formed (by reactors and/or converters.) The industry chose the former, with fateful consequences.<sup>2</sup>

3. The auto industry has spent somewhere between one and three billion dollars (depending on accounting allocation) on emissions control engineering and research. Much if not all of this money has been provided by the car buyers, thus creating an unusual and direct responsibility to the public to use this vast sum of money wisely, in addition to the obvious, inherent responsibility of the automobile industry to preserve the environment. Smog control is a public matter. At no time do the auto companies or their employees have the right to make smog decisions for corporate convenience or personal ego.<sup>3</sup>

4. To reduce emissions, Detroit reduced compression ratio, retarded the spark, leaned the mixture and otherwise decreased engine performance. Partially to overcome this, they increased engine size.

For this drastic loss in performance,<sup>4</sup> they got substantial reductions in emissions on new cars as they left the line. The State of California surveys show the quick upsurge in, emissions after the cars have been on the road only a few thousand miles, so that it might be fairly said that for all the money spent and all the headaches given the driver, the Detroit solution was a partial, short lived fix.<sup>4</sup>

Furthermore, by 1973 this approach had brought emissions to an irreducible minimum.<sup>5</sup>

#### SUMMARY OF DETROIT'S EFFORTS FROM 1965-73

For expenditure of vast sums of the car buyer's money, Detroit has achieved marginal emissions results at the cost of serious decrease in power and drastic increase in fuel consumption.

#### Statement:

It is an incontrovertible fact that if 1973 automobiles were equipped with the Vortex Reactor, the car buyers would *save money* in original purchase price and maintenance, there would be *much better engine performance and driveability*, there would be *much better gas mileage*, and there would be *lower emissions*. It could have been. It can still be for 1975.

#### Where does Detroit go now?

1. Though Detroit had, in the mid 1960's, justifiably downrated catalytic converters, now they have no choice but to talk catalytic converters, starting with the 1973 engines.

2. Mr. John P. DeKany, director of the EPA laboratory at Ann Arbor, says, "It is very difficult if not impossible to meet the 1975 and 1976 standards with a reactor applied to a conventional piston engine. The auto industry has had to concentrate on catalytic devices or engine redesign as in the Honda compound vortex controlled combustion chamber in order to meet the required levels."

3. But the auto industry and Mr. DeKany overlook one fundamental fallacy in their logic. What they should say is, "*Starting with 1973 engines*, the only way we can think of to come anywhere near meeting the 1975 standards is with catalytic converters. We know that this will cost the car buyers billions of dollars. We know this will drastically deplete the fuel reserves of the world, in the midst of the already serious energy crisis. We know that the converters are short lived and inconsistent and that replacement costs alone are prohibitive. We know that there may not be enough rare metal in the world to

<sup>2</sup> There is no point in this report in discussing at length the motivation and rationale for this decision. It was made, and its consequences exist as facts today.

<sup>3</sup> Only a Ralph Nader or a headline hunting politician would charge that the auto industry has acted with deliberate irresponsibility. Vortex holds the industry in high esteem and considers its leaders to be in the forefront of true world citizenship. On the other hand, Vortex knows of no one close to the scene who does not believe that N.I.H. (Not Invented Here) has played a major role in Detroit's decisions. It is entirely clear that the auto industry has been determined to solve the emissions problem in their own laboratories, no matter how much it costs. They could do this with a clear conscience, simply by rationalizing, because of their sublime faith in their own engineering invincibility. They could be lofty minded while they made their decisions and at the same time be dead wrong.

<sup>4</sup> The buyer of new cars doesn't need Mr. Roche to tell him that his car doesn't perform well. Stalling out three times every time he starts the car tells him that.

<sup>5</sup> James Roche: "First we have to engineer our way in to try meet the standards. (Referring to 1975 standards.) We haven't been able to do that yet. Once we do that, we'll have to try to recapture efficiency."

supply the need. We know all that, but starting with the 1973 engines, the only solution we can think of is catalytic converters."

That is where Detroit is now headed.

*Question. But what if Detroit "bit the bullet" and abandoned the direction taken in 1965 and started over again with high performance, efficient 1965 engines?*

Statement:

To the degree that catalytic converters are demanded and required to retrieve the engineering and policy decision made by Detroit in 1965, it is an indefensibly wrong requirement.

*The reason the catalytic converter is the wrong answer*

The reasons are well known:

1. Extreme high cost. Industry estimates have run as high as \$875. A current automotive company estimate is \$275 O.E.M. with an additional \$275 the first year.

2. Short life. Frequent replacement will be required at a prohibitively high cost.

3. Unacceptably high fuel consumption, in the face of the energy crisis. The best the industry even hopes for is 1973 fuel consumption, and that is not good enough.

4. Depletion of rare metals. (Some researchers suggest that base metals will do the job, but that is speculative at best.)

5. Poor engine performance, no better than 1973 at best, and that is not good enough.

Of the six requirements, the catalytic converter fails outright on five of them, low cost, simplicity, durability, engine performance and fuel consumption. It fails on the 6th, emission control. In that it can not consistently meet the standards even under carefully controlled laboratory conditions and quickly fails to meet them after only a few miles on the road.

Statement:

An emissions control system which will unnecessarily deplete oil reserves is obviously the wrong system.

An emissions control system which will unnecessarily deplete rare metals is obviously the wrong system.

An emissions control system which will unnecessarily cost the car buyers billions of dollars and result in cars with poor driveability and uncertain emissions control is obviously the wrong system, particularly if it is required solely to retrieve a wrong decision made in 1965.

*Question. Is there a viable alternative to catalytic converters?*

*Premise*

If the afterburner will save billions of dollars, will give better engine performance, will give better fuel economy and will give acceptable emissions levels which are consistent, it is obviously a better solution than catalytic converters.

*Performance of afterburners*

All afterburners have the obvious ignition problem. In the first three minutes of engine operation, the afterburner is not lighted off. Thereafter, afterburner emissions are lower than with any other system. In assessing the overall performance, the question is how much weight should be given the cold start portion of the standard tests, in comparison with the hot sequences. This and related matters will be discussed specifically in relation to the Vortex Reactor, though the statements in this regard would apply to all afterburners.

*Comparison Between the Vortex Reactor and Other Afterburners*

1. Several companies have built successful afterburners. The Mazda reactor and the duPont afterburner are the best known. duPont, by virtue of its size, reputation and influence, receives the lion's share of cooperation from Detroit.

2. Based on certified tests, the emissions levels with the Vortex Reactor are at least as low as those obtained with any other afterburner.<sup>9</sup>

<sup>9</sup> Certified test results, as will be discussed below say that Vortex results are better, but at this time we will accept the undocumented, verbal assertions by General Motors, Chrysler, du Pont and others that they can "duplicate" the Vortex results. None claim to better the Vortex results with their own afterburners.

3. There is more to judging comparative performance of smog devices than just the bottom line of emissions levels. DuPont claims to match the Vortex results. But Vortex achieves these results with a \$30 device, without air controls, on full performance 1965 engines with complete driveability and excellent fuel economy, and DuPont does none of these things. Therefore DuPont *has not* and *can not* match the Vortex results.

4. This report assumes basic knowledge of emissions controls on the part of the readers. The key question is how does the Vortex Reactor differ from other afterburners and why does it perform better?

(a) It gets lower emissions for a given size and cost because of the vortex path of the emissions, which permits burning at higher pressure and with longer dwell path.

(b) It costs far less, because it is simpler. It consists of a standard General Motors air pump, an igniter and some stainless steel tubing. There are no fair controls. The O.E.M. cost, complete and installed, has been estimated by U.S. Steel and STP as under \$30. In the case of Mazda, the Vortex Reactor would save as much as \$100. DuPont's publicly announced price was about \$350 with all controls and changes considered, though it is now said informally to be much less. In no event is it anywhere near the Vortex Reactor in cost.

(c) Except for power to drive the pump, the Vortex Reactor performs on full performance 1965 engines with 1965 fuel economy.

(d) Because of the longer dwell path, there is excellent sound attenuation, permitting reduction in size or elimination of the muffler. Considering other costly engine changes made since 1965 which could now be removed, it is even conceivable that the engine with Vortex Reactor installed would cost less than the 1973 engine. Vortex believes so.

(e) The Vortex Reactor reduces NO<sub>x</sub>. No other reactor claims this. The Vortex theory of gradual dissociation, as opposed to the present frozen equilibrium, has been proven by tests by General Motors, U.S. Steel and others.

5. Du Pont and many automobile companies have worked on vortex reactors, subsequent to issue of the Vortex patent. The small Vortex laboratory, working with their own invention, have stayed ahead in the development race.

#### COMPARISON BETWEEN THE VORTEX REACTOR AND THE MAZDA REACTOR

*In impact, this section may be the most important in this report, and we urge close attention to it.*

6. Mazda claims to meet the 1975 standards, as announced also by the EPA. But it appears that the correct statement should be that Mazda delivered two carefully prepared cars which passed the tests. Vortex is not alone in cynicism about these results.

James Roche said on April 1, 1973: "Mazda and Honda have built an engine. Building one engine that will do the job is a lot different from building nine million that will have to do the job."

The fact is that Mazda is selling cars today which do not meet the 1973 requirements, let alone the 1975 standards. Vortex believes that the following narrative of relations between Vortex and Mazda is of extreme importance in judging the attitudes of automobile manufacturers towards emission control, and therefore it will be presented in detail.

Vortex purchased a new 1972 Mazda. It did not meet 1972 or 1973 standards, let alone 1975 standards. Vortex removed the complicated and costly Mazda reactor, substituting the simple, inexpensive Vortex Reactor. As tested at General Motors and Olson Laboratories, the engine performance was up substantially and the emissions were cut by more than half.

Vortex then challenged Mazda to a competitive test, which was run February 7 and 9, 1973, at Olson Laboratories, the lab used by Mazda for their certified tests. Let alone 1975 standards. Vortex removed the complicated and costly Mazda emissions. The Vortex NO<sub>x</sub> was higher but comparable. Five Toyo Kogyo engineers observed the test. They agreed that the Vortex Reactor would cut the emissions in half and save as much as \$100 a car.

Nonetheless, Toyo Kogyo stated both in California and then in Japan, on February 21, that they had no interest in the Vortex Reactor. To repeat, they recognized that they could cut the emissions in half and save perhaps \$100 a car. But they were not interested because, "We have spent six years developing our own system."

If Toyo Kogyo now claims they can meet the 1975 standards and that this is why they are not interested in the Vortex Reactor, it would be simple enough for the EPA to take the supposed production device they tested, install it on a 1973 Mazda chosen at random by a United States congressman and determine if Mazda can meet the 1975 standards. Then test a Vortex Reactor on the same car.

Statement:

Vortex states unequivocally that on all competitive tests to day, the Vortex Reactor cuts the Mazda emissions by half.

Statement:

Vortex states unequivocally that based on the six criteria listed above, no other afterburner comes near the Vortex performance. Vortex stands ready to have this contested in neutral vehicles on neutral grounds.

#### THE INEVITABLE CONCLUSION

Based on the six criteria, low emissions, low cost, simplicity, durability, high engine performance and low fuel consumption, afterburners are a better answer to smog control than any other system, and the Vortex Reactor is a better answer than any other afterburner.

#### Key questions

1. How close does the Vortex Reactor come to 1975 standards?

To California 1975 standards, quite close. It is conceivable that with a current igniter program between Vortex and Carborundum, the reactor will meet the Federal HC and CO 1975 standards and come close to the NO<sub>x</sub> standard. Certainly the Vortex Reactor in the field is consistently closer to the 1975 standards than a catalytic converter.

2. Should the 1975 standards be relaxed?

The standards now set are arbitrarily set and represent the *opinions* of EPA experts. There are at least as many experts who have the *opinion* they are set too tough. The point is that there is nothing sacrosanct about these standards. If there is a good reason to change them, they should be changed. Vortex has listed good reasons to change them:

- (a) To conserve fuel in the energy crisis.
- (b) To conserve rare metals.
- (c) To save the car buyers billions of dollars.
- (d) To give the car buyers engines that perform well.

The federal standards need only be relaxed in compromise with California, or the cold start weighting be modified a little, and the Vortex Reactor, with all its advantages to the consumer and the ecology, would be in business.

Statement:

The emissions from the Vortex Reactor are low enough to eliminate smog.

3. Could the auto industry install Vortex Reactors in 1975?

To say this is impractical from a production standpoint is nonsense. To return to 1965 engines would be a much easier job than to destroy them and go backwards from 1965 to 1973.

When it comes to making production changes, the auto industry can (within reason, of course) do what it wants to do.

4. What does a company like Vortex need, if all the above claims are true? Why isn't Vortex off and running, instead of near expiration?

Vortex has looked to major automotive suppliers for backing. It is a fact that all suppliers to the auto industry believe, rightly or wrongly, that there is zero chance that the auto industry will adopt and use an outside solution to the smog problem, no matter what the merits. In that atmosphere, no company wishes to risk one cent on the possibility that the better device will be chosen.

Similarly, tests at the Air Resources Board Laboratory<sup>7</sup> show that Vortex has an excellent retrofit device, low cost and effective, which would appeal to the car owners because it retains driveability and fuel economy. It will cost \$150,000 for the required certification program. No company believes that government will require more than has already been done. Instead, it is unanimously believed, wrongly or rightly, that the government is satisfied with the partial retrofit measures thus far taken for 1966-70 cars and satisfied that the older cars will gradually disappear from the highways and that therefore "the heat is off." In that atmosphere, no company wishes to risk one cent on the possibility that the government will require that smog be eliminated.

<sup>7</sup> Vortex is getting excellent cooperation from the California Air Resources Board Laboratory.

These are facts. That is, the belief is a fact. If the belief is wrong, the auto industry and government must take vigorous steps to dispel the belief. And by actions, not words.

FINAL STATEMENT AND QUESTION BY VORTEX TO THE EPA

The preponderance of evidence is that the afterburner is a better answer for emissions control than the path now pursued by the auto industry. The preponderance of evidence is that the Vortex Reactor is the best afterburner, best for the car buyer, best for the world, best even for the car maker.

But who will do something about it? The EPA? The car makers? The Congress? The President? The Press? The Public?

Vortex says to anyone who is skeptical about this report that it is based on certified tests which are available. The Vortex Reactor wins in head to head contests. Ask Mazda. As for surmise: If \$1 billion had been spent on the Vortex Reactor, how good would it now be?

JOHN QUIRK,  
*President.*

\* \* \*

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY,  
*Washington, D.C., April 27, 1973.*

Mr. JOHN QUIRK,  
*President, Vortex,  
Rancho LaCosta, Calif.*

DEAR MR. QUIRK: This is in response to your letter to Administrator Ruckelshaus of April 2, 1973, in which you discuss the potential of the Vortex Reactor for controlling automotive emissions.

As you know, our technical staff advised you on January 8, 1973, of their evaluation of the test data that you provided on the results obtained with the Vortex Reactor. In that evaluation, they concluded that the emission control results achieved with the Vortex Reactor are significantly lower than the results needed to meet the statutory emission standards. Specifically, the one set of data that was obtained by GM on an Impala equipped with the Vortex Reactor had carbon monoxide emissions that were three times as high as the 1975 standards; that test was made with a hotstart only, and the CO would be expected to be much higher had the test been made with the cold start required by the official test. As you were also advised, these results are consistent with what might be expected from the use of a manifold reactor when applied to a conventional piston engine.

In your letter of April 2, you also ask what the EPA is going to do about the Vortex Reactor. As I advised you in my letter of January 2, 1973, with the exception of a small, highly targeted program to develop alternative power systems, we do not have funds to support the development of emission control systems. All of our development funds are fully committed to the Rankine Cycle and gas turbine engines, which engines are not receiving sufficient attention by the industry; in view of the enormous expenditures being made by the auto industry to control emissions from conventional engines, we withdrew over two years ago from any further support of emission control technology for such engines. Thus, except for the technical evaluation of your work, which has been made, there is nothing further that the EPA can do about the Vortex Reactor. Had that evaluation resulted in a conclusion that the Vortex Reactor is an effective emission control device, we would have publicized that information; but under the circumstances, we see no real purpose to be served by publicizing our conclusion that—on the basis of the data that we have seen—the Vortex Reactor offers no particular promise for widespread application to new cars.

As regards the potential for retrofitting the Vortex Reactor on existing vehicles, we expect at some point in the next year to be in a position to formally evaluate a broad variety of retrofit alternatives that may be considered by the several States for mandatory installation on cars that are already in use. We are not yet in a position to conduct such evaluations because the evaluation criteria and evaluation methodology remain to be developed. When we are ready to make such evaluations, we will be pleased to consider the Vortex Reactor in that context. But even then, it is clear that our role will be limited to testing and evaluation of retrofit alternatives proposed by industry, and to reaching conclusions on the basis of this work. We will not be in a position to financially support the development of retrofit kits which, we believe, will be adequately developed by

those organizations that would stand to gain financially from the sale of their devices if their use is made mandatory by individual States.

Sincerely yours,

ERIC O. STORK,  
Deputy Assistant Administrator  
for Mobile Source Air Pollution Control.

\* \* \*

VORTEX,  
Rancho LaCosta, Calif., May 9, 1973.

Mr. ERIC O. STORK,  
Environmental Protection Agency,  
Washington, D.C.

DEAR MR. STORK: Thank you for your letter of April 27. But you didn't answer any of the questions we asked in our April 2 report to Mr. Ruckelshaus, concerning the energy crisis and the catalytic converter. May we ask for direct answers to the direct questions asked herein?

1. We charged that the catalytic converter is a disaster which will cost the public billions of dollars, will deplete the oil and platinum reserves of the world, and won't do the emissions job in the first place.

This view is also held by Chrysler Corporation, by California Air Resources Board experts, by major oil companies, by emissions scientists in the universities, and by the National Academy of Sciences, which was funded by the EPA itself, to survey and report. In fact, we don't know of anyone who thinks the catalytic converter is the answer.

Yet the EPA and the auto industry plunge ahead on this course, ignoring the energy crisis, each trying to place the blame on the other or on Congress—passing the buck—all this rather than admit a wrong course was chosen a few years ago.

The cost of the catalytic converter can well be \$2700 a car. There's \$500 initial cost, compared to 1965 cars. There \$150 for converter replacement at frequent intervals in the life of the car, at least \$450 in 100,000 miles, probably much more. Since the converters won't work on worn engines, there's upwards of \$1,000 for a new engine at 50,000 or 75,000 miles. There's \$750 in unnecessary gasoline consumption in 100,000 miles, compared to 1965 performance.

We defy anyone in the auto industry or the EPA to stand up and deny these figures. *Direct question* (not just to you, but to all with policy authority at the EPA): Do you think the catalytic converter is economically sound? Ecologically sound? Technically sound? Or are you just going along with Agency policy against your better judgment?

2. Our report stated that the majority of experts in the California ARB, in the universities, in the auto industry and oil industry, and in independent laboratories disagreed with the personal opinions of the EPA experts as to what the 1975-6 standards should be and as to how the emissions tests should be conducted.

It is a fact that if the California standards were accepted or if less weight is given to cold start (as could reasonably be done,) alternative control systems would meet the requirements and make the catalytic converter unnecessary. *Direct question*: Are you confident enough that your personal opinion is correct that you are willing to cost the car owners \$2700 a car (more than three billion dollars a year) and deplete the oil and platinum reserves of the world to support your opinion?

3. We report to you that the auto industry resists outside devices until designs are frozen, and then says it's too late. (We had thought you would be interested in the tactics of this resistance, especially since it directly involves you, but apparently you are not.) There are engines in Detroit on which designs are not yet frozen. Two years from now the industry will say it's too late to consider outside devices on those engines. You say this is none of your business.

We reported to you (and documented) that we could cut Mazda emissions by more than half and, incidentally, save more than \$100 a car, but that Mazda has no interest in outside devices. You say this is none of your business.

*Direct question*: If it is none of your business that the auto industry here and abroad could reduce emissions and save money for the American car buyer, just what is the business of the Environmental Protection Agency?

Sincerely yours,

JOHN QUIRK, President.

U.S. ENVIRONMENTAL PROTECTION AGENCY,  
OFFICE OF AIR AND WATER PROGRAMS,  
EMISSION CONTROL TECHNOLOGY DIVISION,  
Ann Arbor, Mich., June 11, 1973.

Mr. JOHN QUIRK,  
President, Vortex,  
Rancho La Costa, Calif.

DEAR MR. QUIRK: This letter will confirm our verbal discussion during your visit to our laboratory on June 6, 1973. Prior correspondence to you from Mr. Eric Stork and myself did not intend to discourage further development on your or other thermal reactor systems, but, meant to point out that it is extremely difficult to completely control gaseous emissions to Federal statutory emissions levels through the use of thermal reactors alone. The difficulties experienced by companies such as Esso as well documented in the literature. This does not mean that break throughs are not possible as evidenced by the successful application by Toyo Kogyo of the reactor to the Waukel engine.

On the basis of your emissions test data acquired at the GM laboratory and Olson laboratory and the low estimated cost of your design, we believe confirmatory testing of the Vortex thermal reactor in our EPA laboratory would generate useful data for evaluating both retrofit and OEM applications of the Vortex system. Consequently, please implement the test arrangements as we discussed with Mr. Henry Gompf, phone 313-761-5230 X271.

Sincerely yours,

JOHN P. DEKANY,  
Division Director.

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U.S. ENVIRONMENTAL PROTECTION AGENCY,  
OFFICE OF AIR AND WATER PROGRAMS,  
EMISSION CONTROL TECHNOLOGY DIVISION,  
Ann Arbor, Mich., June 26, 1973.

Mr. HERMAN P. ROTH,  
Consultant, Manhattan Beach, Calif.

DEAR MR. ROTH: Thank you for your letter of June 14, 1973. I am also sorry that my absence precluded my discussing thermal reactor technology status with you during your visit to Michigan last month.

I appreciated receiving a copy of your report "Thermal Reactors, the EPA, and the Auto Industry", and your kind invitation to comment on same. While your quotes from the EPA report "Automobile Emission—The State-of-the-Art as of December 1972" and the NAS report are of course accurate I would like to comment upon your interpretative statements accompanying these quotes.

It is inaccurate to state that the two referenced documents provided the primary evidence on which the Administrator based his decision of April 11, 1973 to suspend statutory 1975 standards. The primary evidence consisted of information and data acquired during the public hearings held prior to the decision, such as data contained in suspension applications, oral testimony (including NAS) and written briefs. This material is a matter of public record and EPA evaluations of the material are summarized in the technical appendix to the Administrator's decision. The two referenced documents, however, did provide valuable background for the Administrator and his staff in preparation for the hearings.

The Administrator's statements "The essence of the decision today involves the oxidation catalyst . . ." and ". . . the catalyst is the technology that must be used if statutory standards are to be met by 1975 or 1976" should not be construed as preferential endorsement or backing of the catalyst concept as you have implied in your report. These statements reflect acknowledgement of several facts as substantiated at the hearings:

- (1) The oxidation catalyst is the first choice system of the vast majority of the automobile manufacturers.
- (2) The oxidation catalyst when utilized in conjunction with other engine modifications will be able to meet 1975 statutory emission levels and will permit automobile manufacturers to certify to 1975 statutory standards.
- (3) The costs of catalyst systems are reasonable and fuel economy of a 1975 system will be equal to/better than the fuel economy of a 1975 typical system.
- (4) There is no parallel production experience to predict the problems that might be encountered if catalysts were introduced nation-wide in 1975

thus suggesting the usual risks associated with untested technology when first introduced to the market place.

(5) Non-catalytic technology, namely diesel, stratified charge, and rotary/thermal reactor, was also demonstrated to be able to meet statutory emissions levels—but lead-time considerations precluded significant utilization in 1975 or 1976. Even possibilities for introduction in 1978-79 seemed highly uncertain.

These facts along with other extensive information, provided the basis from which the Administrator made his availability of technology and public interest conclusions that are well documented in his decision of April 11. His decision did not make an "apparent commitment to catalytic systems" as suggested in your paper. On the contrary, the Administrator went to great efforts during the hearings to discuss advanced technology, and to determine what technology improvements (mainly related to alternative systems) would and could be made if he granted a suspension to the industry. Any commitment to catalyst technology has been a unilateral one by the industry, especially since the Clean Air Act does not permit EPA to specify technology. As far as your comment that the merits of catalytic systems are far from conclusive proved I must add that same comment holds equally true for the other alternative systems. In the end only large-scale field demonstration will settle the question of technological superiority.

As a final comment, I must clarify the claim that the Vortex system achieved considerably better emissions reductions than the Mazda reactor in repeated tests on Mazda cars. While the data might indicate this conclusion, it would be fair to point out that the comparisons were to 1972/1973 Mazda production reactors which would not be expected to do significantly better emissions-wise than the 1972/1973 Federal standards levels dictate. Mazda's advanced version reactor when tested in our laboratory did demonstrate an ability to meet 1975 statutory levels both at 4,000 and 50,000 miles. The vortex system must demonstrate the same low emission reduction capability before valid comparisons can be made. These points were discussed with John Quirk during his recent visit.

We agree with the value of the NAS committee studies and my understanding is that EPA will probably extend the contract.

Thank you for the opportunity to comment on your report and I hope that my comments will help to clarify our position on technology which is that in no way does EPA intend to discourage the continued development of advanced concepts.

Sincerely yours,

JOHN P. DEKANY,  
Division Director.

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VORTEX,  
Rancho LaCosta, Calif., July 3, 1973.

Mr. JOHN DEKANY,  
U.S. Environmental Protection Agency,  
Ann Arbor, Mich.

DEAR MR. DEKANY: As you know, we went to du Pont after meeting with you. After extensive technical discussion, including test evaluation, the du Pont engineers concluded that Vortex has a viable answer to the smog problem, provided Congress will adopt the reasonable clean air standards proposed by du Pont. Since du Pont is generally known as the large corporation most deeply involved with afterburners, we think that recommendation is significant. You are welcome to check with Mr. Edward Cantwell, Division Head, Automobile Emissions, for verification.

We are delaying sending you the reactor for your 1962 Chevrolet while our lab tries out some of the cold start techniques proposed by du Pont. We think an unjustified penalty is paid to get cold start, but of course we must give attention to it. We should have the test reactor in your hands within three weeks. Vortex is most appreciative of your interest and of this opportunity.

I want to respond to your June 26 letter to Mr. Roth. Your letter is reasonable and, of course, says many things with which we can only agree. But it also says some things with which we disagree, and I think it's important to tell you exactly where and how we disagree.

In the fourth paragraph, you say, "The Administrator's statements 'The essence of the decision today involves the oxidation catalyst . . .' and ' . . . the catalyst is the technology that must be used if statutory standards are to be met

by 1975 or 1976' should not be construed as preferential endorsement or backing of the catalyst concept."

It doesn't matter what the Administrator meant to convey. He did convey to this reader and many others that the EPA was backing the catalytic converter, and subsequent statements in "clarification" have only served to strengthen that reading. The EPA supports the standards, and when it says the only way to meet the standards is the catalyst converter, the EPA is backing the catalytic converter.

You state (1) The oxidation catalyst is the first choice system of the vast majority of the automobile manufacturers.

That should read: The oxidation catalyst is the first choice at General Motors, whose president is a competent engineer who has made the difficult problem of the converter his personal project. Most other manufacturers have stated their active resistance to the converter but reluctantly agree they will use it to meet certification tests for 1975 and 1976, if that is what the government demands.

You state (2) The oxidation catalyst when utilized in conjunction with other engine modifications will be able to meet the 1975 statutory emission levels and will permit automobile manufacturers to certify to 1975 statutory standards.

That should read: With the present 1973 Poor Performance Engine, an afterburner won't work. An afterburner permits return to high performance 1965 engines. But starting with 1973 engines, an oxidation catalyst must be used to achieve further emissions reductions. It will *not* be able to meet 1975 statutory emission levels, because it will deteriorate quickly in the field and result in higher emissions levels than with an afterburner. It *will* enable manufacturers to *certify* to the standards, for that brief moment when the engine and catalyst are new.

You state (3) The costs of the catalyst systems are reasonable and fuel economy of a 1975 system will be equal to or better than the fuel economy of a 1975 typical system.

That should read: The costs of the catalyst systems are totally unreasonable. In the life of the car, the cost will be more than \$3000. (Fortune says only \$2100 but did not include cost of a new engine, as does Vortex.)

The fuel economy is a disaster. General Motors now says the fuel economy will equal 1973 fuel economy, which is a disaster. Furthermore, this does not take into account at least a 10% fuel loss because the converter requires unleaded fuel, which means less gasoline from a barrel of oil. The fuel economy loss is upwards of 25%. Du Pont sets it at 42%.

You state (4) There is no parallel production experience to predict the problems that might be encountered if catalysts were introduced nation-wide in 1975.

This should read: The National Academy of Sciences, in its report to the EPA, stated what is common knowledge, that the oxidant converter is fragile. Furthermore, the NAS states that the certification and endurance tests are misleading in that they specifically fail to include those factors in real life driving which most affect deterioration of the converter.

You state (5) Non-catalytic technology . . . was also demonstrated to meet statutory emissions levels—but lead time consideration precluded significant utilization in 1975.

This should read: The EPA and Congress now know that the Clean Air Act standards are unnecessarily stringent. But until they are officially changed, the EPA and Congress will demand adherence to them. This precludes consideration of the viable alternatives, such as the Vortex Reactor, which will give high engine performance, outstanding fuel economy, very low cost *and* lower emissions than the catalytic converter over the life of the car. Lead time is not a factor. The industry could more readily install the Vortex Reactor than the catalytic converter. It is self serving nonsense, if the auto industry claims otherwise.

You state: His (the Administrator's) decision did not make an apparent commitment to catalytic systems . . . Any commitment to catalyst technology has been an unilateral one by the industry.

This should read: No matter what the Administrator intended, his decisions and statements can only be interpreted as a commitment to catalytic systems, since he blocked out any other systems from competing. Vortex is not being facetious when it says this is like saying to the victim, "I didn't mean to shoot you dead." Unless and until the EPA, the Congress and the auto industry recognize that they have specifically committed this nation and the world to the disaster of the catalytic converter, when viable alternatives were available, the juggernaut will roll. It is time for the EPA to say, "Apparently we were misunderstood by everybody and apparently some of our actions and state-

ments have backfired. What can we do to rectify this?" Vortex could tell you how to do something great for the people of the world.

You state: (as for alternative systems) . . . in the end only large-scale field demonstration will settle the question of technological superiority.

This should read: It is already well documented that the present auto industry emissions control systems, including the catalytic converter, deteriorate rapidly in field use. On the other hand, it is documented that afterburners function as designed so long as they remain physically intact. In the field, the oxidant converters will cease to function as they did in the certification tests at 4,000, 10,000 or 15,000 miles. The afterburners will function as designed for 50,000 miles. By the time field results proved that the 1968-1973 controls deteriorated rapidly (just as predicted by the afterburners proponents,) it was too late. By the time the field results prove that oxidant converter will deteriorate, as everyone knows it will, it will be too late.

Finally, you state: I must clarify the claim that the Vortex system achieved considerably better emissions reductions than the Mazda reactor in repeated tests on Mazda cars. While the data might indicate this conclusion, it would be fair to point out that the comparisons were to 1972/1973 Mazda production reactors which would not be expected to do . . . better . . . than the 1972/1973 standards. Mazda's advanced version reactor when tested in our laboratory did demonstrate an ability to meet 1975 statutory levels both at 4,000 and 50,000 miles.

This should read: In every competitive test to date, the Vortex Reactor outperforms the Mazda reactor by a wide margin. Tests have proven that the vortex burning chamber is more efficient than the Mazda burning chamber. The Vortex Reactor without air controls performs better than the Mazda reactor with or without air controls. The Vortex reactor with air controls performs better than the Mazda reactor with or without air controls. The Vortex Reactor costs as much as \$200 less than the Mazda reactor and results in better engine performance and fuel economy.

The EPA is aware that the auto manufacturers cull out their best performers for the production certification tests and that cars being sold are significantly worse as to emissions than are the test cars. As for the 1975-6 demonstration tests, the special test vehicles can cost \$100,000 and more. Mazda submitted two special test vehicles. The EPA ran tests under conditions which were specifically different from field conditions. The engine was idled at 3,000 RPM, and this would never be done in the field. There was a special hand choke which even the EPA expert driver had difficulty managing, so that at least one test was aborted.

Thus it can be said that Mazda built two costly, special test vehicles which demonstrated that under unrealistic conditions the 1975 standards could be met. Beyond this, these tests mean nothing at all. Performance in the test laboratories has no significance, when it has already been demonstrated that performance in the field is quite different.

The fact is that it has been demonstrated again and again that under equal conditions the Vortex Reactor costing far less is much more effective than the Mazda reactor. This statement is totally undeniable. It allows no equivocation. The fact exists.

We look forward to our tests with you and repeat our appreciation.

Sincerely yours,

JOHN QUIRK,  
*President.*

P.S.—It is probable that for \$100,000 Mazda could build a special vehicle with a Vortex Reactor and get lower emissions in a 1975-6 test than with their own reactor.

Mr. SATTERFIELD. What about funding from the EPA?

Mr. QUIRK. We are not the type of people who ask the Government for funding.

Mr. SATTERFIELD. I congratulate you for that.

Mr. QUIRK. We intend to make a lot of money on what we have done. But I do think any of that funding that they had spent on us would have been a lot better spent than on Rankine cycle.

Mr. SATTERFIELD. Were there funds from EPA in connection with some part of the emission control devices?

Mr. QUIRK. They had funds available, but their policy was to devote those to devices that nobody else would waste any money on.

Mr. SATTERFIELD. It looks like you are almost in that position.

Mr. QUIRK. That is right.

Mr. SATTERFIELD. As I understand your testimony—

Mr. QUIRK. We spent a considerable amount of money on our own device, but that is all private money.

Mr. SATTERFIELD. A device similar to yours if I read your testimony correctly, would not necessarily be subject to the fuel problems that a catalytic device would be. Yours would burn on any kind of fuel whatsoever.

Mr. QUIRK. Any type.

Mr. SATTERFIELD. There would be no problems with the fuel.

Mr. QUIRK. None whatsoever. If you have a fouled up spark plug that would destroy a catalytic converter, that would have no effect on ours.

Mr. SATTERFIELD. I am very concerned about what I have seen since I have been in Congress and it goes all the way to the cigarette and tobacco hearings we had. It becomes awfully easy for the people in the Federal Government to decide that one thing will solve a problem. In tobacco, they said smoking caused cancer and that is something that has never been established, but the net result of that statement by a Federal official has meant there has been little or no research on experimentation to determine whether it does or not, and we need more research.

About 3 years ago they had a neat little saying, "Get the lead out," and everybody felt if we got the lead out of gasoline we will have solved the problem. Here again it seems there has been a decision to go with a catalytic device which is unproven and this leads to the impression that we have solved the problem when actually we have not.

I think we should have a broader range of experimentation in all these areas.

Mr. QUIRK. I used the word "juggernauts" with respect to giants, whenever the EPA or the auto industry make up their minds they are going in certain directions, in this case, catalytic converters, it is almost as if they defy you to dissuade them from that path.

They promise you if they are successful, they will increase the fuel consumption of this country, place us more at the mercy of the Arab nations, that they will have an adverse effect on our dollars, they will cost the American public as much as \$3,000 a car and this is what they promise.

Opposed to that, we say it will cost the American public \$40 a car and he will have a car with drivability. When he gets in to start his car, it will go like 1965 and not have to restart it five times. At the very least, somebody should take a look at what we have now.

Mr. SATTERFIELD. I would hope we could get our basic idea over to EPA and everybody else involved. We should examine everything that comes down the pike.

Mr. QUIRK. I would point out, probably 13,000 people in the United States are running around claiming they have answers to the smog problem, but what I think the EPA should consider, the thing that sets us apart, is that certified tests results have done all our talking for us.

In line with what you say, I would suggest, as a matter of practicality, anybody who comes to the EPA with certified test results should get a hearing.

Mr. SATTERFIELD. I am inclined to agree with that. Thank you very much.

Mr. ROGERS. I think this is impressive testimony although the testing has not been done for 50,000 miles, you say you are now in the process of doing that?

Mr. QUIRK. We are not in the process of doing it, but afterburners as a class survive 50,000 miles without any difficulty. We would like to do it. We wish we had \$150,000 to run 10 cars on a 50,000-mile test.

Mr. ROGERS. I would like for the committee staff to take this testimony and send it to EPA and to the major automobile companies asking for their comments. I particularly want to know from EPA what they are doing if this seems to prove out to make sure the testing is done quickly and adequately.

Mr. SATTERFIELD. Do I understand you are saying that you really don't have the capability of doing the 50,000 mile test at this point?

Mr. QUIRK. We don't have the money.

Mr. ROGERS. We will ask that that be looked into.

[The following letter from EPA was received for the record:]

ENVIRONMENTAL PROTECTION AGENCY,  
OFFICE OF THE ADMINISTRATOR,  
Washington, D.C., October 19, 1975.

HON. PAUL G. ROGERS,  
*Chairman, Subcommittee on Public Health and Environment, Committee on Interstate and Foreign Commerce, House of Representatives, Washington, D.C.*

DEAR MR. CHAIRMAN: This is in response to your letter in which you ask for a report to the Subcommittee on the Vortex Reactor, as well as for a summary of contacts that the EPA has had with Vortex.

Our files on communications with Vortex go back to last January, when Mr. John Quirk first brought his device to our attention. Since that time we have had extensive correspondence with Mr. Quirk, both direct and through various Senators and Congressmen, as well as through the White House. In August of this year, we made confirmatory emission tests of a vehicle equipped with the Vortex Reactor. A copy of our test report is enclosed.

To summarize, the Vortex Reactor was installed on a 1965 Chevrolet engine by the Vortex Corporation, and the emissions from that vehicle were 0.81 grams per mile hydrocarbon, 22.7 grams per mile carbon monoxide, and 1.43 grams per mile oxides of nitrogen. These emission levels would not allow the vehicle to meet 1975 interim Federal emission standards and certainly not the statutory Federal emission standards; for carbon monoxide, for example, the interim Federal emission standard is 15 grams per mile, and the statutory standard that will apply in the 1975 model year is 3.4 grams per mile. As regards unburned hydrocarbon and oxides of nitrogen, the vehicle equipped with the reactor did a better job, but would still not meet the statutory standards.

The measured emission levels are generally consistent with emission levels that can be expected from thermal reactors, which devices have been extensively explored by a number of companies, including the Chrysler Corporation, the duPont Corporation, and Ethyl Corporation. It is generally agreed that conventional vehicles equipped with thermal reactors are not capable of meeting stringent emission levels, especially carbon monoxide.

The EPA testing showed no fuel economy advantage for the Vortex Reactor over other emission control systems planned for use by auto manufacturers. Fuel economy of the Vortex Reactor-equipped vehicle was 10.8 miles per gallon. This is comparable with the fuel economy of current model automobiles of similar weight. Catalytic emission control systems planned to be used on many 1975 and nearly all 1976 models are expected to achieve somewhat better fuel economy than current values, in addition to emission levels well below those demonstrated with the Vortex Reactor.

On your question as to our intentions for dealing with Vortex in the future, we plan to evaluate an advanced version of the Vortex Reactor in November. In view of the foregoing discussion of the work that has already been done on thermal reactors, however, we have no reason to believe that the Vortex Reactor can be improved to a point where vehicles equipped with it could perform better than vehicles equipped with catalysts, or than inherently low emission engines such as the stratified charge.

As regards financial support for further development of the Vortex Reactor, we cannot be encouraging. The limited resources available to us for research and development on low pollution engines are all devoted to an intensive effort to evaluate the feasibility of Rankine and gas turbine systems. Over two years ago we completely withdrew from the funding of any hardware developments designed to allow today's engines to meet emission standards. This action was taken because the automobile industry, spurred on by the stringent requirements of the Clean Air Act, was investing each year enormous sums of money in their efforts to clean up the conventional internal combustion engine. We concluded that there was no significant likelihood of the small amounts of money that we might be able to devote to such work resulting in a unique development that might be overlooked by the industry. All of our in-depth evaluations of the industry's work in the last two years has confirmed that that was a sound decision, and that putting Federal monies into trying to clean up Detroit's engines would be inappropriate, especially in view of the many competing needs for Federal funds in areas in which Federal expenditures can make a significant impact.

I appreciate this opportunity to provide you this background information on the Vortex Reactor.

Sincerely,

RUSSELL E. TRAIN, *Administrator.*

Enclosure.

#### EVALUATION OF A CHEVROLET FITTED WITH A VORTEX REACTOR—AUGUST 1973

Emission Control Technology Division Office of Air and Water Programs  
Environmental Protection Agency

##### BACKGROUND

The Emission Control Technology Division was contacted by Vortex Inc. of Tucson, Arizona, concerning the possible testing of their test vehicle fitted with a thermal reactor. The vehicle had been recently tested at the General Motors Proving Ground in Mesa, Arizona, and approached the 1975 Federal interim emission levels, being slightly high only in carbon monoxide. The Test and Evaluation Branch agreed to test the vehicle, but because of the heavy work load could only schedule one test. Additional and more complete tests on this system and on a system designed for OEM application are planned in the near future.

##### SYSTEM DESCRIPTION

The thermal reactor was a large cylinder, approximately eight inches in diameter and seven feet long. It was fitted into the exhaust system, about three feet downstream of the exhaust manifold. A spark plug near the upstream end of the reactor was fired by means of a separate coil connected to the regular coil. Air from an air pump could be controlled by the driver to enter either the exhaust manifold or the entrance (before the spark plug) of the reactor.

##### TEST PROGRAM

The vehicle supplied by Vortex was a 1972 Chevrolet Impala. The original engine was replaced with a 1965 Chevrolet 327 CID engine. The test performed was a 1975 FTP as outlined in the November 15, 1972, Federal Register for light duty vehicles. Because of the Vortex representative's concern for back pressure from the standard CVS exhaust hook-up, the dilution box was not used and the exhaust pipe from the vehicle was simply stuck inside the larger inlet pipe to the CVS.

For the first 300 seconds of the test air from the air pump was ported to the exhaust manifold. For the rest of the test it was ported to the reactor.

## TEST RESULTS

The test results are presented below along with calculated fuel economy. Emission are in grams/mile.

Test No	HC	CO	CO <sub>2</sub>	NO <sub>x</sub>	MPG
16-674.....	0.81	22.68	803.5	1.43	10.8
1975 interim standards.....	1.50	15.0	.....	3.1	.....

## CONCLUSIONS

The Vortex system produced much lower emissions than are typical for a 1965 uncontrolled vehicle. However, the vehicle failed to meet 1975 interim levels, HC and NO<sub>x</sub> emissions were about half the limits, but CO emissions were 50% higher.

Mr. ROGERS. Thank you, Mr. Quirk, for your being here and for giving us this testimony.

This concludes our hearings for today, and the committee will stand adjourned until 10 o'clock Monday morning.

[Whereupon, at 12:55 p.m., the hearing was adjourned, to reconvene at 10 a.m., Monday, September 17, 1973.]

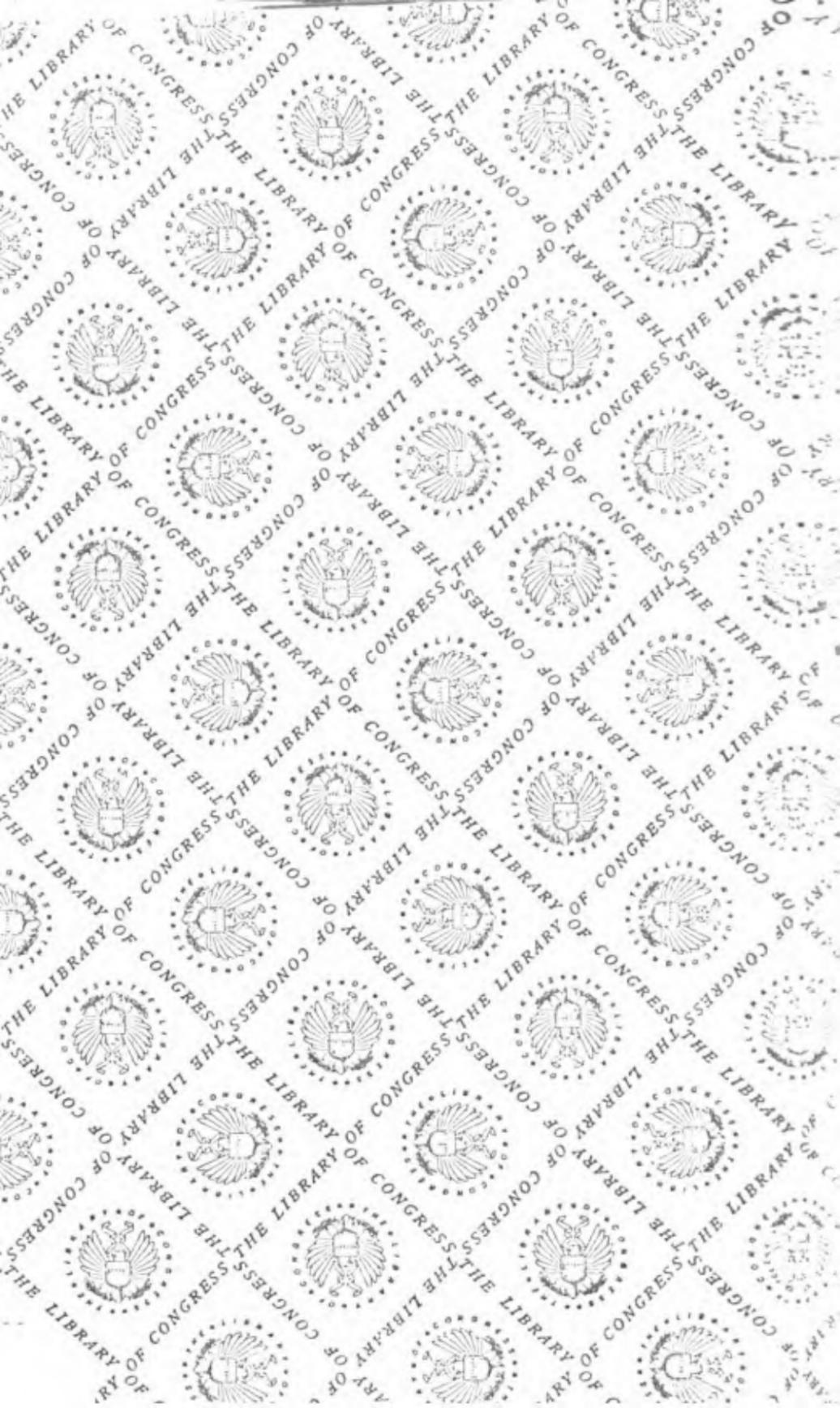


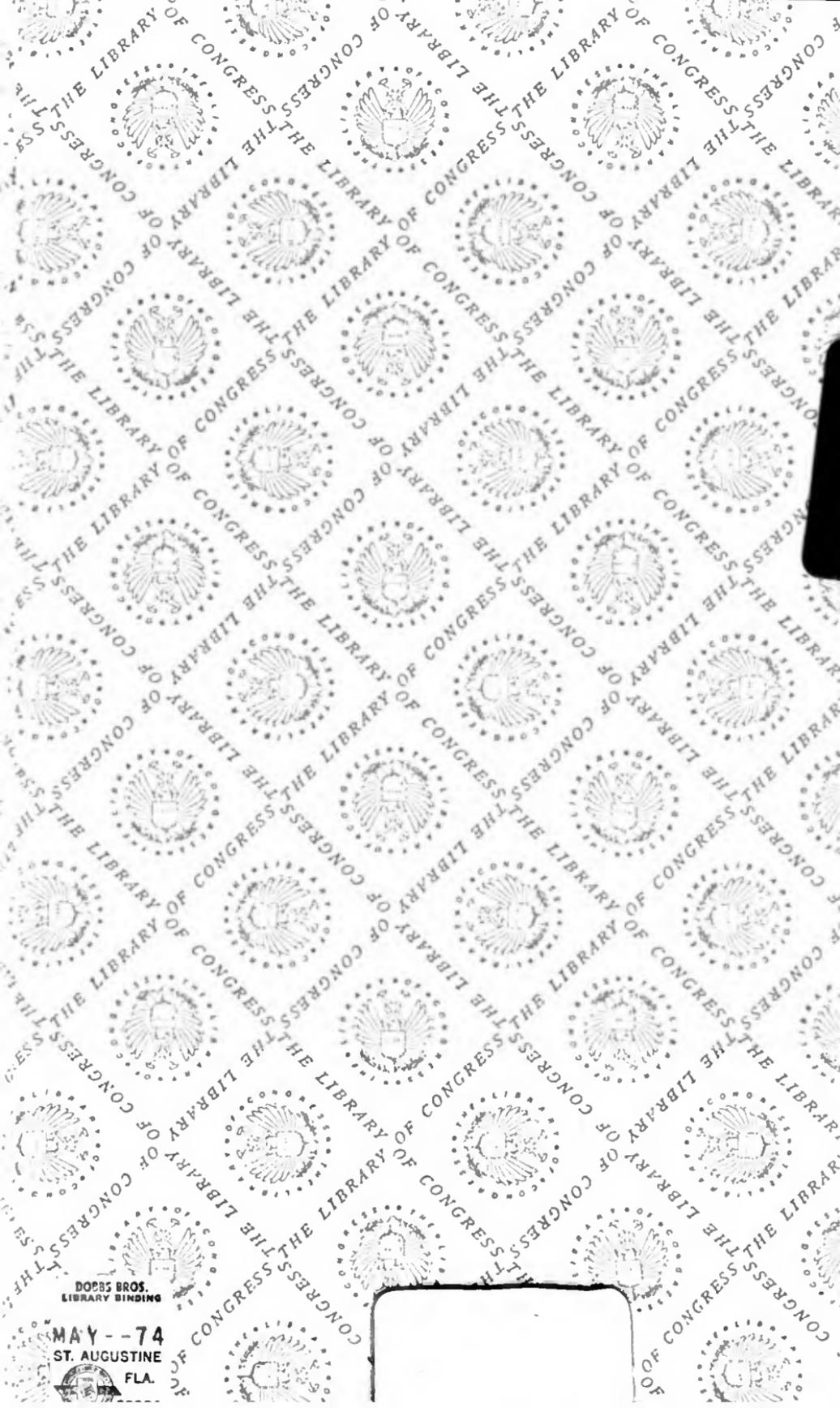
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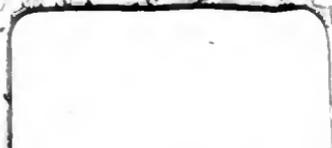






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