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REVIEW OF MOTOR VEHICLE AIR POLLUTION RESEARCH

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Increasingly frequent instances of eye irritation and vegetation damage in the Los Angeles basin during the late 1940's led to research which indicated that certain pollutants emitted from industrial plants and transportation vehicles could react in the presence of sunlight to form compounds mainly responsible for these events. Studies showed that hydrocarbons, and oxides of nitrogen would take part in reactions leading to compounds comprising the total entity known as "smog."

Control of industrial pollutants in the Los Angeles area through strict regulations has led to the finding that in a recent sampling 90% (1) of its air contamination could be traced directly to vehicle exhausts. Other cities also report that a substantial portion of pollutants are discharged by vehicles. The transportation unit found responsible for the bulk of the pollutants is the gasoline-powered vehicle. The exhaust from this major means of ground transportation contains contaminants which include a variety of hydrocarbons and partially oxidized hydrocarbons, carbon monoxide, nitrogen oxides, lead and other products from fuel additives, aerosols and small amounts of sulfur dioxide. The hydrocarbons, nitrogen oxides, and carbon monoxide are the principal contaminants. The other pollutants, with the possible exception of lead and aerosols, normally are not considered to be important atmospheric contaminants.

Exhaust concentrations vary widely according to the vehicle, its driving modes, and mechanical conditions. Average hydrocarbons from individual vehicles without control systems may range from 200 ppm to over 5000 ppm. Average carbon monoxide among individual vehicles may range from about 1 percent to 10 percent and oxides of nitrogen from several hundred ppm to over 3000 ppm.

There are two other sources of emissions from the gasoline-powered vehicle, namely crankcase emissions and evaporative losses. Crankcase emissions consist of fuel, additives and some exhaust products. Hydrocarbon concentrations are high and are the only significant pollutants. Evaporative losses occur from vents in the fuel storage and carburetor systems, and consist almost entirely of hydrocarbons.

The California State Department of Public Health has issued the following table showing the relative magnitude of emissions from gasoline-powered vehicles.

Pollutant	Pollutant Source as Percent of Total of Each Pollutant Emitted		
	Exhaust	Crankcase	Evaporative
Hydrocarbons	50-65	25-35	5-15
Carbon Monoxide	98-99	1-2	0
Nitrogen Oxides	98-99	1-2	0

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This table clearly indicates the necessity for control of the exhaust emissions if a definite reduction in motor vehicle pollutants is desired.

Almost all freight and other heavy cargo is transported with vehicles powered by Diesel engines. The Diesel engine differs from the gasoline engine in a number of respects that have a marked influence on the contaminants emitted. The fuel is less volatile and the engine normally operates at a higher air-fuel ratio. Therefore, carbon monoxide concentrations are markedly lower than from gasoline engines. The quantity of nitrogen oxides appears to be about the same as gasoline engines. However, Diesel emissions do create problems from smoke and odor.

In summary, the gasoline-powered vehicle produces the bulk of emissions which create serious air pollution problems. Hydrocarbons and nitrogen oxides from the exhaust react in the presence of sunlight to produce numerous chemical compounds which grouped together have been labeled "smog." Carbon monoxide is also liberated in large amounts from the exhaust. Carbon monoxide does not enter into photochemical reactions producing "smog", but by itself and in proper concentration is a very dangerous toxic gas.

Air must be considered as an important natural resource vital to animals and plants for their life processes. J. R. Goldsmith in "Effects of Air Pollution on Human Health" (2) states, "The average adult male requires about 30 pounds of air each day compared with less than 3 pounds of food and 4-1/2 pounds of water. Compared with other necessities of life, obligatory continuous consumption is a unique property of air. The insensible, intimate interpenetration of air which courses in and out from the lungs gives to air pollution its essential importance."

Although there are many arguments on the potential damage to human health by photochemical "smog", there is little argument, any longer, concerning damage to plant growth and development. E. F. Darley (3) of the Statewide Air Pollution Research Center at the University of California, Riverside, states that gases related to the photochemical process, with the automobile being the principal source of the raw materials, cause serious plant damage and death. In fact, it was damage to vegetation that first indicated a new air pollution problem existed in Los Angeles. Vegetation surveys revealed a gradual spread in the Los Angeles basin and occurrence in other principal population centers of the state. The problem according to Darley now exists in 29 other states of the United States.

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The effects of stationary sources are usually localized, but with mobile sources, such as automobiles, the affected areas may be quite large and may even encompass an entire watershed. According to Darley, losses from acute injury vary with the type of plant. With leafy vegetables or flowers such as orchids or carnations, wherein the saleable portion of the plant is injured, the grower may sustain direct and complete loss. In the case of root crops such as carrots and beets, or those where the fruit is used such as tomatoes and beans, injury to leaves causes an indirect loss due to decreased yields or impaired quality. Annual dollar losses from direct effects of air pollution on plant life in California alone have been estimated at $10-$12 million and from indirect losses at another $100-$115 million.

Therefore, there is ample proof of serious damage to crops and large monetary loss from the effects of photochemical "smog" caused mainly by gasoline-powered vehicles.

Although the evidence that photochemical "smog" causes serious damage to plants is quite definite, one cannot say the same for the effect on human health. Natural variability in responsiveness to air pollution is observed in all populations. Generally speaking, susceptibility is great among premature infants, the newborn, the elderly and the infirm. Those with chronic diseases of the lungs or heart are thought to be a particular risk. J. R. Goldsmith (2) states, "The possible effects of air pollution on personal or community health are:

1. Acute sickness or death.

2. Insidious or chronic disease, shortening of life, or impairment of growth.

3. Alteration of important physiological functions, such as ventilation of the lung, transport of oxygen by hemoglobin, dark adaptation (the ability to adjust eye mechanisms for vision in partial darkness), or other functions of the nervous system."

Statements 2 and 3 are very difficult to assess as some of the chronic diseases take years to develop and many other possible causative factors may simultaneously be producing their impacts. However, Goldsmith (1) states, "Shortening of life has not so far been conclusively related to air pollution exposures, but suggestive evidence has been presented."

A review of the general literature provides good evidence for serious plant damage from photochemical "smog" and sufficient indirect evidence to indicate actual or potential

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damage to human health. There certainly appears to be ample evidence for some form of control of air quality, even though additional research is needed.

Research in the field of air pollution is extensive and varied because of the complex nature of the problem. As an example, a new United States government - industry research program on automotive air pollution has just been announced (4). This program is a three-year, $10 million project and will probably ultimately involve some twenty-five research studies. The first four studies will involve a study of the odor components in Diesel exhausts; a study which will interpret available data concerning the effects on human behavior and performance of chronic exposure to low levels of carbon monoxide; a study to examine the toxicity of aromatic hydrocarbons in the lung; and a study to determine the possible effects of chronic and acute exposure to various combinations of air pollutants peculiar to most urban environments, including carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate sulfate and an organic lead compound.

The nature of the research program indicates that the government is seeking all possible information on the difficult problem of directly connecting human health problems with air pollution.

It has been apparent in California for a number of years that the critical item in the control of air pollution is the control of the emissions from the gasoline-powered vehicle. Through adequate control, photochemical air pollution problems and high concentration of carbon monoxide and nitrogen dioxide in the atmosphere may be materially reduced.

The first laws on motor vehicle emission control were enacted in California in 1959 and 1960. These laws required the California Department of Public Health to establish air quality standards and motor vehicle emission standards and created a Motor Vehicle Pollution Control Board to certify control systems which met the emission standards. The present standards are attached. Congress in 1965 enacted legislation requiring the Secretary of Health, Education and Welfare to establish emission standards for all motor vehicles sold in the United States. The present Federal standards are very similar to those currently in effect in California. Requirements for 1970 models have just been announced in the Federal Register, June 4, 1968. They are the same as the requirements presently set forth for the 1970 models in Assembly Bill No. 357. The attached table presents a comparison of existing State of California and Federal standards together with future Federal and proposed State requirements.

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The history of the development of exhaust control systems can best be summarized by quoting from the interesting report by John A. Maga (5), "Control of Vehicular Emissions":

"Prior to development by the automobile industry of the present exhaust control systems, much work had been done on eliminating hydrocarbons and carbon monoxide by using catalytic and flame afterburners. These devices were in the general shape of mufflers and were to have been installed in the exhaust system of the car. Several of these devices were approved by the California Motor Vehicle Pollution Control Board in 1965, but the automobile industry decided against their use. The future of catalytic and flame afterburners is unclear and little work has been done on such devices since 1964.

"The first exhaust control systems were installed on the 1966 model vehicles made by American manufacturers for sale in California. Federal regulations will require that all 1968 model vehicles sold in the United States have such systems.

"To date, the control of exhaust emissions has been directed at hydrocarbons and carbon monoxide. Two systems are now in use. The air injection system introduces air into the exhaust manifold at each of the exhaust ports. In the manifold the air combines with the hydrocarbons and carbon monoxide (but not open flame) eliminating a large portion of these compounds. The system requires an air pump and piping.

"The ignition - induction system reduces the hydrocarbons and carbon monoxide by improved combustion efficiency within the engine through a special calibrated carburetor and distributor and related components. The system essentially depends upon careful regulation of ignition, timing, idle speed and idle fuel mixtures."

The performance of these systems is described by W. F. McMichael, et al (6). In a series of road tests involving 1966 model passenger cars from the three major manufacturers, with relatively low mileage on the cars, "Mass emissions of hydrocarbons and carbon monoxide from equipped cars were significantly lower than the 1962-1963 baseline emission values. Except for the Chevrolets in the low-altitude cities, oxides of nitrogen levels from equipped cars were significantly higher than the baseline levels, (+26 to 365%)." In other words, the reduction in hydrocarbons and carbon monoxide by automobile manufacturers was made in such a manner that the required engine operation caused a marked increase in oxides of nitrogen. This pollutant is not presently under control in the standards.

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On this basis, the remarks of W. Hibbard (7) of the Bureau of Mines in testimony before Congress in 1966 appear very significant. Mr. Hibbard suggested that the devices then required for auto exhaust control would not be permanently useful or successful, but would simply afford time to develop more effective solutions. In this connection, the Federal Government is presently sponsoring research on devices for reducing the concentration of nitrogen oxides.

The above remarks agree with those advanced by Assemblyman Hayes in his recent statements to the California Highway Commission. When the present devices reduce one set of contaminants, but in so doing seriously increase another which is known to cause serious damage to plants and possibly to human health, then one concludes that further testing of other devices is of great importance in finding acceptable solutions in the quickest possible time.

On this basis, a very interesting conference was held in Sacramento with Mr. George W. Cornelius on June 13, 1968. Mr. Cornelius is prepared to install his emissions control system on a new car for tests as noted in Assembly Bill No. 690. This unit is capable of markedly reducing the hydrocarbons and carbon monoxide by use of an afterburner and a reduction of nitrogen oxides by recycling exhaust gases with a control device. Mr. Cornelius stated that he had contacted all automobile manufacturers and has received no offers of any kind to this date. He stated the initial cost for a single car would be approximately $25,000. We believe that ultimately a minimum of three cars should be tested. However, it would be expected that the extra cars would cost much less for installation costs providing they were similar.

The certification of a device is a complicated and costly procedure. The procedure for the State of California may be briefly outlined as follows:

1. The device is furnished to an evaluation engineer of the Motor Vehicle Pollution Control Board.

2. The engineer, after evaluation of the possibilities of the device in meeting criteria, may request further data on special laboratory tests and various road tests. This testing will be quite extensive and requires a sizeable expenditure by the developer of the device.

3. After analysis of this data and the finding that the results indicate the positive merits of the device, then the Board may request approximately 25 of the devices for further testing in their own laboratories and on vehicles operating under different conditions.

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4. After completion of this work and analysis of data, the Board may grant a certification.

We have also written a letter requesting information on the availability, cost of installation, etc., to all known producers of experimental devices. These include the following, together with answers received to date:

Company	Reply to Letter
Walker Manufacturing and American Cyanamid Co.	Negative for testing
American Machine and Foundry Chromalloy Corp.	Positive, will supply units for test
Arvin Industries Universal Oil Products	Negative for testing
Norris-Thermador Corp. W. R. Grace & Co.	Negative for testing
Cornelius Research and Development Laboratory	Positive, will supply unit for test
General Motors Corp.	Negative for testing
Arco Chemical Corp.	Positive - Dealing presently directly with Air Resources Board for testing
Ford Motor Co.	Negative for testing
DuPont Laboratories	Negative for testing

This report has presented evidence that emissions from gasoline-powered vehicles may either in their original form or acting as a material source for photochemical conversion into other compounds cause serious damage and large monetary losses to various forms of valuable field crops and to the commercial production of flowers. Also increasing amounts of evidence indicate that serious harm to the health of humans may take place through the breathing of contaminated air.

Tests on present control devices indicate that there has been a definite decrease in hydrocarbons and carbon monoxide emissions. However, this development has caused a marked increase in the production of oxides of nitrogen, a material causing damage to plant life and a potential hazard to human health. It is apparent that further research and development must be expedited.

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