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SOURCES OF AIR POLLUTION

Transportation (Petroleum)

By: C. A. Jones

Wilmington, California

Executive Secretary
Smoke and Fumes Committee
American Petroleum Institute

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Transportation sources of air pollution include aircraft, boats and ships, trains, trucks, and busses, as well as automobiles. Aircraft and ships operate primarily in unpopulated areas, and their contribution to urban air pollution is relatively insignificant. Trains, trucks, and busses are, in a great many instances, diesel propelled, and the average citizen is, from time to time, aware of pollution in the form of odors and smoke. However, diesel exhaust is only a very small fraction of the total air pollution from transportation, and because it is a relatively minor source, little work has been done to control it. Diesel engines properly operated and properly maintained produce a minimum of smoke and odors. Research organizations and individuals studying air pollution problems are aware of the contribution to air pollution from diesel exhaust, and research in this field is contemplated or is under way in several instances.

Since the major source of pollution from transportation is the exhaust from the gasoline-powered automobile, my remarks will be confined to a study of this problem.

If a gasoline engine could be operated to produce complete combustion, the exhaust products would be carbon dioxide, water, and oxides of nitrogen. Unfortunately the combustion process is not complete in any practical engine, and the resulting exhaust contains hydrocarbons, oxygenated products, carbon monoxide, soot, and smoke, as well as carbon dioxide, water, and oxides of nitrogen.

Carbon monoxide is a toxic constituent of exhaust, and, as such, may in certain instances be a health hazard. Oxygenated products produce annoying odors, and smoke from exhausts contributes to visibility reduction and general soiling of the surroundings. The hydrocarbons and the oxides of nitrogen react in the presence of air and sunlight to produce the manifestations known in Los Angeles as "smog", characterized by eye irritation, the formation of aerosols, damage to vegetation, and increased concentration of oxidant, principally ozone, in the atmosphere. Automobile exhaust contains something of the order of 300 to 5,000 parts per million hydrocarbons, depending upon the driving cycle. In Los Angeles County, about 2-3/4 million cars consume an estimated 6 million gallons of gasoline daily, so it is readily apparent that in this area at least, automobile exhaust is a primary source of air pollution. It is estimated that hydrocarbon emissions from automobiles in Los Angeles County amount to about 1,000 tons per day. This is ten times the hydrocarbon emission from all the refineries operating in the area.

The petroleum industry supplies the fuel used by the automobile, and thus has a sincere interest in the solution to the problem of pollution from automobile exhaust. The stated objective of the Smoke and Fumes Committee of the American

Petroleum Institute is "to determine the causes and methods of control of objectionable atmospheric pollution resulting from the production, manufacture, transportation, sale, and use of petroleum and its products."

Several laboratories have repeatedly demonstrated that ozone, eye-irritating materials, and aerosols are formed when hydrocarbons and oxides of nitrogen in concentrations in the parts per million range are mixed with air and irradiated with artificial sunlight. The ability to produce and control this reaction in the laboratory has made possible a study of many of the variables suspected to influence "smog" formation.

Motor gasoline is a complex mixture of hydrocarbons wtih a wide range of chemical and physical properties. To insure that automobiles will respond satisfactorily under all conditions of operation, the fuel must be properly balanced. The driver expects his car to start easily, warm up fast, and respond instantly when he steps on the accelerator. In addition, he demands good mileage and a gasoline free from knock. To meet all these requirements, refiners blend gasoline to take into account the geographical location and the season of the year as well as the characteristics of the motor car itself.

The knowledge that trace quantities of hydrocarbons present in automobile exhaust play a critical role in the smog-forming reactions has led to the suggestion that some modification in fuel composition might produce an exhaust with less air pollution potential than motor fuels presently in use. Changes in fuel composition could not be expected to reduce the total amount of hydrocarbon present in automobile exhaust; the only possibility would be to change the type of hydrocarbons emitted.

In an effort to provide factual information on the effect of fuel composition on air pollution manifestations from automobile exhaust, the Air Pollution Foundation and the Smoke and Fumes Committee of the American Petroleum Institute entered into a cooperative research program during the period June 1957 to June 1958 to investigate this problem thoroughly. Facilities developed at Stanford Research Institute for the irradiation and study of diluted auto exhaust were provided under APF sponsorship. The Franklin Institute Mobile Air Pollution Laboratory, housing long-path infrared equipment, and the facilities of the University of California at Riverside Air Pollution Research Group were brought into the problem under the sponsorship of the API.

The study was designed primarily to study the manifestations of air pollution such as eye irritation, aerosol formation, ozone formation, plant damage, and various chemical factors from the exhausts from test fuels. It was not the purpose of this project to establish the chemical nature of the manner of formation of theproducts of the photochemical reactions.

The equipment used included a test automobile mounted on a chassis dynamometer and equipped with suitable automatic controls to produce the various phases of automobile operation. The exhaust produced was collected, diluted with purified air, and pumped into a 520 cubic foot chamber where artificial light sources were used to simulate sunlight irradiation. Chemical sampling devices and test instruments were provided to monitor the exhaust mixture, and a panel of male college students was used to measure eye irritation. Four test fuels were used in this study. Three fuels representing extremes in hydrocarbon composition were compared with a blend of commercial gasolines sold in Los Angeles. Four automobiles were selected, representing typical cars found on the road today. The cars were not new, but had indicated mileages from 22,000 to 60,000 miles. These cars were tuned and equipped with new points and plugs before the tests were carried out, but were not otherwise serviced.

In studying automobile exhaust, the operating cycle chosen is an important variable. Under idling and decelerating conditions, the exhaust is high in hydrocarbon content, while under cruising and accelerating conditions, hydrocarbon emission is less and oxides of nitrogen emission increases. Earlier work by the Air Pollution Foundation has shown that eye irritation depends to a large extent upon the concentration of hydrocarbons and the ratio of hydrocarbons to oxides of nitrogen in the exhaust mixture. Thus, it is apparent that a choice of operating cycles is important in a study of this kind. To match the actual situation as closely as possible, the driving cycle used followed a traffic pattern survey conducted by the Automobile Manufacturers Association in Los Angeles.

The results of these experiments have shown that substantial eye irritation was developed from the irradiated exhaust from each of the four fuels tested. The exhaust from the highly olefinic fuel reacted more rapidly under irradiation than exhaust from the other fuels tested. The rate of ozone formation from irradiated exhaust varied with fuel composition, but the quantity of ozone produced was independent of fuel composition. During a number of experiments, plants were exposed to irradiated exhaust with the intention of comparing damage produced by the different samples. None of the exhausts produced more than slight traces of the oxidant-type plant damage characteristic of "smog". Individual automobiles vary markedly in the air polluting potential of their exhausts, and differences in automobiles have as great an effect on the manifestations of air pollution from exhaust as do differences in fuel composition.

A study of a somewhat similar nature is in progress at the Bureau of Mines Petroleum Experiment Station in Bartlesville, Oklahoma. Here the primary emphasis has been on the analysis of exhaust gases to determine the hydrocarbon composition. As a part of this study, many different fuel types have been used in a test engine and the exhaust products analyzed. Results from this study have shown that olefin contents of exhaust hydrocarbons tend to increase with increase in engine severity, regardless of the fuel used. In terms of fuel composition, aromatic compounds in a fuel are heavily reflected in the exhaust products, while olefins in fuel are reflected to a lesser degree in exhaust, but are heavily influenced by the driving cycle.

Thus, it is apparent that while changes in fuel composition do have some effect on the hydrocarbon composition of the exhaust, no appreciable effect on air pollution manifestations can be accomplished by changing fuel composition. As long as there are hydrocarbons and oxides of nitrogen emitted from the tailpipes of automobiles, we can expect to have eye-smarting, visibility-reducing "smog" in areas like Los Angeles where traffic density is high and natural ventilation is poor. The only sound approach to the problem seems to be to add to our automobiles a device to convert the exhaust to that ideal condition mentioned earlier where the products of combustion are harmless carbon dioxide and water.