Committee on Air Pollution from
Automotive Engine Exhaust
City of Cincinnati

REPORT TO THE CITY MANAGER

from

COMMITTEE ON AIR POLLUTION
from AUTOMOTIVE EXHAUSTS

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REPORT TO THE CITY MANAGER

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I INTRODUCTION:

On April 9, 1956 the Committee submitted to the City Manager a report with recommendation for actions aimed at eliminating the more obvious automotive exhaust nuisances and containing the suggestion for periodic review of the problem as follows:

> "Provide for review of the local problems of air pollution, presented by automotive vehicles, every two years, in the interest of timely action to protect the health and comfort of the citizens of Cincinnati".

After submission of the 1956 Report, the Committee met several times and then on January 17, 1957 adjourned until such a time as called together by the chairman.

On January 14, 1959, City Council adopted the following motion, presented by Councilwoman Dorothy N. Dolbey:

> "I move that the City Manager be requested to investigate the recent suggestion of two District Government Public Health Officials, for a full scale testing of new gasoline additives to determine their effect in exhaust fumes on humans.
>
> Further that he report on the advisability of enactment of legislation governing the inclusion of such new additives."

Following the City Council action, several committee members requested the City Manager and the Committee Chairman to re-activate the committee for the "review" as recommended in the 1956 Report and to consider the Council motion.

On January 28, 1959, the City Manager requested the committee review both matters and to make appropriate recommendations.

II ORGANIZATION OF INQUIRY

In order to accomplish its purpose the committee first reviewed the 1956 Report and inquired into the action taken by the city to implement the recommendations and the results of such action. The committee then inquired into the status of the development and availability of control devices for automotive engines and the problems associated with the increasing use of gasoline additives.

After hearing various authorities the committee formulated a set of findings and recommendations.

III SUMMARY OF FINDINGS:

A. Review of 1956 Summary Report

1. Composition and Effects of Automobile Exhaust

The composition of automotive exhausts and the health and nuisance aspects as set forth in Section I, II and III of the 1956 Report are found to substantially represent the situation as it is today.

Since the 1956 Report, there have been extensive studies of reaction products from automotive exhaust and their physiological effect. Although, in the west coast area, evidence is at hand to support a strong interest in legislation to limit the emission from automotive engines, the findings of the research studies are not yet considered to be sufficiently definitive to constitute a basis for additional control regulation in the Cincinnati area beyond those of Ordinance 275-1957 (Enacted July 3, 1957).

2. Magnitude of the Problem

Analysis of the available data on registration of automotive vehicles in Cincinnati and Hamilton County, and on automotive fuel consumption, indicates that approximately 221,000 vehicles burn about 439,000 gallons of gasoline and 49,000 gallons of diesel fuel daily in the City. The estimated change from 1954 to 1959 is as follows:

a) Number of Vehicles Registered

Passenger	20% increase
Trucks	10% "
Buses	no change

b) Mileage

Passenger	20% increase
Trucks	10% "
Buses	10% decrease

c) Fuel Consumption

Gasoline	18% increase
Diesel Fuel	7% "

3. Ordinance 275-1957

In order to implement Recommendations 1 through 4 of the 1956 Report, City Council on July 3, 1957 enacted Ordinance No. 275-1957 to prohibit the operation of motor vehicles in such a manner as to emit unreasonable or unnecessary smoke or vapors. This ordinance empowers a police officer to give notice to the owner of a vehicle when such vehicle emits unreasonable, excessive or unnecessary smoke, obnoxious or noxious gases or vapors. When such notice is given, the operation of such vehicle is unlawful unless said vehicle is tested at an inspection station within seventy-two hours. This ordinance also prohibits the operation of a motor bus or truck engine while the vehicle is stationary for more than three minutes except under certain special conditions.

4. Inspection Lane Rejections

On the basis of the foregoing ordinance, the Cincinnati Inspection Lane is now rejecting vehicles for unreasonable, excessive or unnecessary smoke. The following are the number of vehicles rejected:

1957 - 111	vehicles	or	.1%	of	all	cars	inspected
1958 - 124	"	"	.1%	"	"	"	"
1959 (1st 4 mo) 89	"		.23%	"	"	"	"

It was reported that the Norwood Inspection Lane rejects an estimated 30 vehicles a month for excessive smoking although no specific record of such rejections is maintained.

5. Mechanical Maintenance and Proper Fuel in Relation to Excessive Exhaust

The importance of good mechanical maintenance, use of appropriate fuels, and skillful operation as major factors in minimizing excessive exhaust are well known in the public transport and trucking industries. The pressure of economic operation works with the pressure of public opinion to motivate fleet operators to increasingly better performance. However, the small fleet operator or the owners of individual vehicles are not subject to these same compulsions and will require a different approach to bring about the desired results.

Odors cannot always be minimized by good maintenance. New approaches such as additives to the fuel or the injection of chemical agents into the exhaust are under investigation. Although several reports indicate promise, the evidence thus far has been inconclusive. There is real need for fundamental investigation of the chemical factors responsible for odors and eye irritation from diesel engine exhaust.

6. Diesel Fuel Investigation

Recommendation No. 5 of the 1956 Report suggested that the City consider appropriate action to require use by diesel powered automotive vehicles within the city, of diesel fuels meeting reasonable minimal quality specifications.

A survey was conducted by the City Bureau of Air Pollution Control in July and August 1957 by sampling from the tanks of four bus and truck companies. The samples were then analyzed against the fuel specifications of the engine manufacturer and the fuel vendor.

The conclusions reached by the Bureau at the end of this study are:

> "The overall results of this survey indicate that some companies are not adhering strictly to the specifications of the engine manufacturers. Whether these deviations are the result of economy or practicability is not known. It should be noted, however, that the fuels sampled were within the minimum quality specifications of the vendors."

B. New Inquiries Made by the Committee

1. Status of Exhaust Control Devices

Devices to reduce air pollution from automotive engine exhaust fall into three general classifications, namely, deceleration devices, catalytic afterburners and direct-flame afterburners. They are found to be in various states of development.

a) Deceleration Devices

Interest in deceleration devices is lagging. Contrary to early work, it is now generally conceded that the deceleration cycle contributes approximately 30% of the overall driving emissions. Therefore, dealing with the deceleration cycle only will bring about little improvement.

b) Catalytic Afterburners

1. A unit, under development by the Ford Motor Company, is described as a low temperature catalytic afterburner using vandium pentoxide as the catalytic material. This device is reported to have an efficient selective oxidizing property. Hand built research units are reported to have withstood up to 12,000 miles of road test with an average hydrocarbon reduction of 60 to 73%. This device is reported to produce an unpleasant exhaust odor on start-up. Ref. No 8, Appendix II.

2. A device described as a high temperature catalytic afterburner is under development by the Oxy-Catalyst Corporation in conjunction with the General Motors Corporation. From results of tests on hand built units it is estimated that the useful life of the catalyst would be about 12,000 miles and the efficiency of the hydrocarbon and carbon monoxide removed after warm-up would be about 75%. Ref. No. 6, Appendix II.

Both catalytic units described above will require long warm-up time and will present substantial engineering problems of size, noise reduction, insulation, durability, maintenance cost and first cost limitation.

c) Direct Flame Afterburners

1. The Clayton afterburner has been installed in the Los Angeles area on 24 metropolitan buses. With this device, there appears to be effective control of exhaust gases under idle and deceleration condition, but under acceleration and cruise conditions the device fails to function. There has been no recent reports of improvement or further development on the Clayton Unit.

2. The Thompson Ramo Woolridge unit is a high temperature direct-flame device which is reported to remove approximately 90% of the hydrocarbons during normal traffic operation. However, temperatures are reported to be in the neighborhood of 1500°F presenting difficult problems of size, materials of construction, dependability, heat dissipation, price and maintenance cost. Ref. No. 10, Appendix II.

2. <u>Committee Findings With Respect to Control Devices</u>

The Committee finds that there is no device commercially available today which has been proven to be significantly effective in the overall reduction of the exhaust products from the gasoline engine. An analysis of state of development would indicate that a commercial device is at least several years away.

When such a device becomes available, it appears likely that its application will be made to original or new vehicles only. The problem of incorporating related auxiliary equipment and the re-arrangement of the underside of the present-day passenger vehicle to accomodate the space requirements for such a device makes its application to existing vehicles extremely difficult.

The committee further finds that heavy pressures from the West Coast area and the high profit reward for achievement are strong motivating forces toward ultimate success in this field.

3. <u>Gasoline Additives</u>

Gasoline additives are generally known as anti-knock compounds such as tetraethyl lead, and anti-oxidant compounds such as phosphorus and boron compounds. So far as atmospheric contamination is concerned, tetraethyl lead is much more important than the known anti-oxidant compounds. In general the oxidant compounds are more completely consumed within the engine and do not find their way into the atmosphere in the same degree as does lead.

Tetraethyl lead has been used as a gasoline additive since 1923. Its consumption expanded from less than 1 million pounds in 1926 to over 400 million pounds in 1958. The inevitable increase of lead in the atmosphere from this source, has however, been offset in Cincinnati by an appreciable decrease in lead from other sources so that the total concentration of lead in the atmosphere is now lower than it was in 1941. (See Appendix I).

The lead content of Cincinnati's atmosphere in 1955 varied from .1 to 9.2 micrograms per cubic meter of air, the average being 1.8 micrograms per cubic meter. Measurements of lead in the atmosphere in the County of Los Angeles from August to November 1954, showed the lead content to range from 1 to 16 micrograms per cubic meter with an average of 6.75 micrograms per cubic meter of air.

Continuing research into the response of human beings to exposure to lead compounds has been carried on for a great many years in the Kettering Laboratory, Department of Preventive Medicine and Industrial Health, College of Medicine, University of Cincinnati. From the results of such research, it can be said that the contamination of the atmospheres of American Cities, including Cincinnati, with lead derived from all sources, including that from automotive exhausts, is not sufficient at this time to be regarded as a threat to the public health.

IV RECOMMENDATIONS:

A. Gasoline additives:

Based on information available at this time, the Committee feels it would not be advisable for the City of Cincinnati to consider legislation regulating the use of gasoline additives.

New additives are under development and as they appear on the market they should be scrutinized for possible adverse effect on health through contamination of the atmosphere. The Committee recommends continuing attention to the use of additives. Such matters are under the scrutiny of the U.S. Public Health Service on a country wide bases, but the information provided from this and other sources is readily available for local consideration and application.

B. Automotive Engine Exhaust

The committee recommends that the city should gather and maintain full information concerning the general development in the field of air pollution from automotive exhausts. The city should also take steps to obtain information as to the nature and extent of the problem in Cincinnati. The implementation of these recommendations would seem to require some or all of the following measures.

1. To continue an advisory committee comparable to the present committee.

2. To develope and maintain a moderate and economical program ,through appropriate local agencies,of sampling and analysis of specific constituents of the atmosphere derived from automotive exhausts.

3. To recognize that the availability and excellence of the Cincinnati Safety Lane provides an unparalleled opportunity for Cincinnati to pioneer means of using its inspection system in improving those forms of improper maintenance and adjustment that contribute to air pollution. The management of the Lane cooperated last year with the U. S. Public Health Service and the Chrysler Corporation in testing the exhaust emissions of a random group of cars through the Lane. It has been proposed by these groups that a more extensive series of tests along these same lines be undertaken. It is recommended that the city arrange to continue this type of activity to determine how best the Safety Lane may be used to reduce automotive air pollution.

4. To be prepared to take appropriate action should satisfactory devices for the reduction of the air pollutants from automotive exhaust be made available and their use become necessary.

APPENDIX I

The Effects of Gasoline Additives

The General Problem

In view of the importance of motor fuels in the American economy, it is not surprising that much attention has been given to the technology of such fuels in the past three decades, and that various materials have been added to petroleum products for the purpose of influencing their chemical and physical properties, and their performance in the internal combustion engine. "Antiknock" agents were among the first additives to achieve prominence in petroleum technology, and of them tetraethyl lead, the first and most successful of the materials to be employed on a commercial basis, has been the most important, both in relation to petroleum technology, and from the aspect of potential hazard to the public health. Other materials, less important in the latter sense, certainly, have been those introduced to maintain the stability of gasoline in storage (antioxidents, in the main), those added to control pre-ignition, those used to prevent the fouling of spark plugs, those designed to reduce various deposits within internal combustion engines, and dyes for purposes of differential identification. It may be expected that a variety of new materials will be developed for these purposes, and that other substances will be added to various "tailored fuels" in substitution for materials now in use, in augmentation of their beneficial effects (technologically), and in fulfilling various other roles indicated by research. Many of these materials, now and in the future, will pose questions in the fields of occupational and public health, and, in the spirit of the times, as reflected by the growth in the responsibility of industry for industrial and public safety, as well as the development of public concern and of legislation toward these ends, the potential hazards associated with the use of these materials will be investigated by private and public agencies, in varying degrees as circumstances appear to require.

Tetraethyl Lead

Of materials now in use, as indicated above, tetraethyl lead is now the most important, because of the extent and virtual universality of its use, and because of the significance that has been attached to the toxic properties of lead compounds for centuries.

This product, first introduced into experimental use, in Dayton, Ohio, in 1923, after a decade of technologic investigation (which has continued in various ways, since that time), was expanded into wide commercial use in the motor and aviation gasoline of the world market, beginning in 1926, and continuing progressively since that time. Antiknock fluids containing tetraethyl lead are now produced in at least six major nations, but their volume is greatest in the United States, in which after a modest beginning, prior to and during 1926, the manufacture of the principal ingredient, tetraethyl lead, exceeded 400 million pounds in 1958.

The hygienic aspects of the use of tetraethyl lead as an antiknock agent have been investigated almost continuously since 1924. An investigation of the United States Public Health Service described in Bulletin No. 163, U. S. P. H. S. (1926), was carried out in 1925, but the bulk of the work has been carried out (before 1925 and since) in the College of Medicine of the University of Cincinnati (in the Kettering Laboratory, since its founding in December, 1930), and a series of publications on the subject have reported the results of these investigations, which are continuing at this time and are expected to continue indefinitely. Other investigations have been carried out under the authority of the governments of Great Britain (1930) and France (1932) and, by less formal means, those of several other countries. Far from having been allowed to lapse, after the early and somewhat stormy period following on the heels of the introduction of the product into commercial use, these investigations have been extended into a detailed examination of the occurrence of lead in nature and in the food and drink of animals and man, and on into the basic metabolism of lead compounds in the animal and human organisms. Contrary to the statements credited to William H. Cary, Jr., and Frederick H. Goldman, of the U. S. Bureau of Food and Public Health Engineering, which would seem to have indicated that this problem has not been followed since the initial investigation of the Public Health Service, the contribution made by the use of tetraethyl lead to the absorption of lead on the part of various occupational groups in the automotive, aeronautical and petroleum industries in the United States (and to a lesser extent elsewhere), has been investigated in greater detail and with more definitive results than almost any other kindred problem of national scope that comes to mind. Moreover, its impact on air pollution, as the latter affects the general public in the United States, has been determined in a fairly comprehensive manner, and is still under satisfactory observation on a continuing basis.

A normal base line for the estimation of the hygienic significance of human exposure to lead in industry and in the community at large, has been provided by detailed observations on human subjects in The Kettering Laboratory during the last twenty-five years. Since 1950, these observations have been concentrated on the inhalation of lead compounds dispersed in finely divided form in the air, in an effort to establish, once and for all, the physiological mechanisms involved, and the standards of safety (in terms of the quantities that can be dealt with indefinitely by the human organism) which should be maintained in industry and in ordinary life, with respect to the total human intake of lead from all sources, including that in the air.

Along with these experiments, field investigations have been carried out, periodically, in order to determine the facts concerning the lead contained in the food and beverages of the country, and the lead content of the air in various parts of various American cities at various seasons of the year. Cincinnati has been the site of the most comprehensive observations, for reasons of convenience, and these observations have served as pilot studies, for application, on a less elaborate basis, to other cities, and for purposes of comparison.

The work of The Kettering Laboratory on lead and its significance in relation to the public health, has been one of the major activities of this Laboratory for many years, and the published (and unpublished) articles on the subject provide a voluminous literature, which need not be cited here. Suffice it to say, briefly, for present purposes, that lead is a normal constituent of every article of food and drink, and that it occurs normally in the air in small amounts. Many activities of modern life contribute some small quantities of lead to the food and beverages of the nation and to its atmospheric envelope. The quantities now involved under the ordinary conditions of human life, those derived from artificial, as well as natural sources, are small and are well handled by the animal organism throughout its lifetime. The quantities (now capable of being defined in precise terms) required to cause human poisoning are very much larger than those to which we are exposed under ordinary conditions, and the problem of public health that lies in the increasing use of lead compounds for a wide variety of purposes - including its use in gasoline - is that of keeping a sharp eye on the sources of contamination of food, beverages and air, so as to make sure that these remain within safe limits. The problem of industrial health, in relation to lead poisoning, has been solved, so far as the specifications for safety are concerned. The unsolved problem in industry lies in the development of means for the uniform application of present knowledge to industrial situations; in adherence to the known specifications as to the concentration of lead which is permitted to occur in the air of work rooms and work areas, and in the medical supervision of the people at work, so as to maintain the lead content of their body fluids and excreta (by analytical means) within known, safe limits. With respect to the safe limits of the content of lead in the air of work rooms and areas, it is generally agreed that the breathing of air containing concentrations below 0.20 mg. of lead (as metal) per cubic meter of air, will not, in itself, cause lead poisoning. This relates to an eight-hour per day and a five-day per week working schedule. Appropriate allowance must be made for air which is breathed for twenty-four hours per day on every day of the week. It is not known, at present, just what the threshold level is in the atmosphere of an entire community indoors and out (experiments are under way in The Kettering Laboratory to determine the facts in this regard). Some grasp of the margin of safety which exists in the atmosphere of the community may be obtained, however, by taking account of the fact that the average concentration of lead in the atmosphere of Cincinnati (a fairly representative American city) is of the order of 2.0 micrograms per cubic meter. This concentration, expressed in the same terms as the standard for industrial safety (0.20 milligrams per cubic meter) is .002 milligrams per cubic meter, or one hundred times less than the industrial standard. These considerations provide little basis for apprehension in the minds of generally intelligent and sensible people, and still less concern among those with a background of physiological knowledge.

The principal factor concerned with the limitation of occupational and public exposure to lead in gasoline is the low concentration of tetraethyl lead in the gasoline. This concentration varies in accordance with the qualities of the base gasoline, but it may not exceed 3 ml. per American gallon in automobile gasoline, or 4.6 ml. per American gallon in aviation gasoline. In practice, the concentration of tetraethyl lead in either type of gasoline rarely reaches the maximum, the average being considerably lower.

Another factor in the limitation of the pollution of atmosphere with lead from the exhausts of automobiles, especially within city limits, is the deposition of lead within the exhaust system of the automobile. The exhaust system acts as a partial condenser of the vaporized lead compounds in the exhaust gases under the conditions of low speed operation, whereby a third to a half of the lead is deposited on the inside surfaces of the exhaust pipes. On the other hand, under the conditions of cross country driving at high speeds, these deposits (carbon, lead etc) are stripped off in flakes, most of which settle out of the air promptly. Because of this intermittent action the lead discharged from motor cars in congested traffic is considerably lower than it would be expected to be.

The prime factor in maintaining the lead from these and other sources in low concentration in the air is the remarkable capacity of the atmosphere to dilute gaseous and particulate substances which are discharged into it at or near the surface of the earth. While the factors which influence the speed and extent of this dilution operate in an extremely variable manner, so that the atmosphere is now "still", and then moving with violent turbulence, the currents of air created by moving objects, such as vehicles, and those generated by differences in the temperature of the atmosphere in various areas and strata, even under the quietest of conditions, result in a remarkably effective dissipation of atmospheric contaminants from their points of origin into broader space. Nothing could illustrate this effect more strikingly than the observations made on carbon monoxide in the streets of a modern city. This gas is discharged in large volume, comprising somewhat more than 5 percent of the total volume of the exhaust gas of the average automobile. Yet in the height of the traffic, determinations of the carbon monoxide content of the atmosphere on the sidewalks of a city street, at the breathing zone of pedestrians, rarely exceeds 100 parts per million, and is usually considerably less. It is evident that if this insidiously dangerous component of the exhaust gas of the automobile is diluted so effectively, even under adverse conditions, the smaller and less dangerous quantity of particulate lead will be dissipated equally as well. Many critical observations have shown that this is true.

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APPENDIX II

AUTOMOBILE EXHAUST CONTROL DEVICES

An Outline of the Presentation before

the Committee on March 4, 1959

Composition of Automobile Exhaust

The composition of the gases issuing from the tailpipe of an automobile engine is extremely variable and dependent upon many factors. These include:

1. Type of operation - idling, acceleration, cruising, and deceleration.
2. Engine condition - carburetor, ignition system, valves, and rings.
3. Engine design factors - induction system, compression ratio, and ignition timing.
4. Drive train - automatic or syncromesh transmission and axle ratio.
5. Fuel composition - to a minor extent.

The major components of automobile exhaust in approximate order of their concentrations are as follows: nitrogen, carbon dioxide, water, carbon monoxide, unburned hydrocarbons, partially burned hydrocarbons, oxides of nitrogen, oxygen, hydrogen, and particulate matter resulting from the decomposition products of fuel and lubricant additives. These components will vary over a many-fold range depending upon the variables mentioned earlier. Those components which are known to be factors in

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the photochemical reaction typical of the Los Angeles smog situation are: unburned hydrocarbons (which can range from 100 to 17,000 p.p.m.), partially burned hydrocarbons (on which insufficient data are available to show the approximate concentrations), and oxides of nitrogen (which can range from 20 to 5,000 p.p.m.).[1,2]

The measurement of the concentration of components of automotive exhaust is extremely difficult. Known analytical techniques for carbon monoxide, carbon dioxide, and oxygen have been applied, but it has been necessary to develop totally new instrumental techniques for the determination of unburned hydrocarbons. The most commonly acceptable method to-date is that developed by co-operative effort within the Coordinating Research Council.[3,4]

Control of Automobile Exhaust

Control devices may generally be divided into two categories. The first includes those devices intended to reduce unburned hydrocarbon emission during deceleration of a vehicle. While these devices have been developed to the point where they can do an excellent job, they have some operational drawbacks, and it is currently estimated that they would only reduce total vehicle hydrocarbon emissions by about 15%.[5]

The second category of control devices includes units installed in the exhaust system to complete the combustion of unburned or partially burned exhaust products. These units operate on either the catalytic or the direct-flame principle.

The two catalytic units which have shown the greatest promise are still in the developmental stage, but prototype units have been quite extensively evaluated.[6,7,8]

One direct-flame afterburner shows promise and is undergoing continued development. (9)

In addition to the devices described in the reference papers, it is known that the Clayton Corporation is working on the development of a direct-flame afterburner type unit. In the Los Angeles area there are about 24 Clayton direct-flame afterburners installed on busses. It has been reported by the Air Pollution Foundation that while these devices do an effective job under idling and decelerating conditions, there are problems in maintaining combustion during accelerating and cruising conditions.

It is also known that the Norris-Thermador Corporation has under evaluation a catalytic type converter designed for operation on leaded fuel.

As regards the reduction of oxides of nitrogen in automotive exhaust, the only reported procedure having shown significant reduction is one employing extremely rich carburetion to reduce the amount of oxygen available for the high temperature fixation of atmospheric nitrogen. (5)

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March 4, 1959

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<u>Note</u>: Reprints of above can be obtained from the Society of Automotive Engineers, 485 Lexington Avenue, New York 17, New York.

APPENDIX III

MAGNITUDE OF THE PROBLEM

The following estimate of vehicular registration, mileage and fuel consumption was compiled by the Cincinnati Traffic Engineer in a special report to the Committee.

TABLE 1

	Daily Mileage		Daily Fuel Consumption: Gasoline		Daily Fuel Consumption: Diesel	
Type Vehicle	1957	1959	1957	1959	1957	1959
Passenger	3,680,000	3,840,000	368,000	384,000		
Trucks-Gasoline	210,000	220,000	52,000	55,000		
Buses-Gasoline	3,000	3,000	500	500		
Trucks-Diesel	210,000	220,000			42,000	44,000
Buses-Diesel	36,000	33,000			6,000	5,400
TOTAL	4,139,000	4,316,000	420,500	439,500	48,000	49,400

TABLE 2

	(1957) (Actual)		(1959) (Estimated)	
	Hamilton Co.	Cincinnati (est)	Hamilton Co.	Cincinnati
Passenger cars	263,476	184,400	272,915	191,000
Trucks	25,059	18,221	25,950	18,898
Buses	462	400	500	410
Church Buses	43	30	50	35
Farm Trucks	1,239	239	1,200	200
Trailers	10,226	7,175	10,600	7,430
House Trailers	285	85	300	90
Motorcycles	1,413	1,000	1,465	1,025
Dealers	357	250	360	252
Public owned	2,566	1,800	2,660	1,860
TOTAL	305,126	213,600	316,000	221,200

TABLE 3

Estimate of Change 1954 to 1959

Mileage

Passenger	20% increase
Trucks	10% increase
Buses	10% decrease

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Fuel Consumption

Gasoline	18% increase
Diesel Fuel	7% increase

Number of Vehicles Registered

Passenger	20% increase
Trucks	10% increase
Buses	-

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APPENDIX IV

Report To: CITY MANAGER'S COMMITTEE ON AIR POLLUTION

AUTOMOTIVE ENGINE EXHAUST

April 23, 1959

This report is in response to a request during the Committee Meeting of March 25, 1959, for information which will update Appendix IV of the April 9, 1956, report to the City Manager.

At the present time we know of no fundamental changes in diesel engine design or fuel which introduce new factors not previously covered in APPENDIX IV of the April 9, 1956 report.

Engine refinements have been made since April, 1956, which together with operating and maintenance improvements have minimized the total problem of smoke and odor from diesel bus engines.

I. CAPACITY

Carrying capacity has been increased from 15 to 30 per cent by the replacement of smaller buses with 51 seat buses using the same basic, but improved, diesel engine.

This results in fewer units being operated and less fuel being consumed per unit to carry the same number of passengers in rush periods.

II. MAINTENANCE

Instruction and experience with diesel engine maintenance has better qualified more men to keep engines in progressively better condition. Properly maintained engines emit less smoke and odor through better combustion.

III. ENGINE REFINEMENTS

Engine manufacturer has made improvements involving cylinder sleeves, piston rings, exhaust manifold system, ratio of blower speed and radiator cooling fan operation which improve combustion and reduce fuel consumption.

Improved combustion minimizes the smoke and odor in a given amount of exhaust emission and at the same time reduces the total volume of emissions as less fuel is required.

IV. HANDLING OF ROAD FAILURES

Infrequently some part of an engine fails or gets out of adjustment while a bus is in service, causing it to smoke excessively until repairs can be made.

Improved reporting of such instances by Company personnel and prompt handling of reports from other sources reduce the period between failure and repair.

V. OPERATION

Instructions to operators, based on IV, A., 3. "The Driving Habits of the Vehicle Operator" in Appendix IV, are included in our training program and in our Group Meetings where all aspects of Safety and Community Relations are discussed. Particular emphasis is placed on unnecessary idling.

VI. MOTOR BUS MILES OPERATED

		Miles
	1956	12,834,869
	1957	12,211,070
	1958	11,495,204
REDUCTION 1956 --	1958	1,339,665 Miles

Most of this reduction is in diesel mileage. Obviously this reduces the total diesel bus engine exhaust problem by a like amount.

VII. ODOR CONTROL

To date no odor control additive or device that has come to our attention has proven effective.

Mr. Gruber calls attention to an additive which I understand is scheduled for extensive testing through the joint effort of an engine manufacturer, a major oil company and a large city transit operator of diesel equipment. I have no details for this report but will obtain further information and report to the Committee as soon as possible.

We have experimented with one device which added what it's developer claimed was a "deodorant and freshener" near the end of the exhaust pipe. We equipped two vehicles with the device and tested them by sense of smell in close quarters and by following buses in regular service very closely. Our installation included a valve to turn the device on or off for testing and comparison.

While we could detect a faint odor, other than diesel exhaust, we could also smell the exhaust to the same degree whether the device was operating or not.

Cost of the device and installation was about $75 per bus. We could not develop a cost on material as it was not possible to determine when the effective element was used up and only the water carrier remained.

We will cooperate in investigation and reasonable testing of any device or additive which comes to our attention.

SUMMARY

Actual benefit of this activity in any particular situation is impossible to measure and it is recognized that none of the foregoing will satisfy an individual who particularly dislikes or fears diesel engine exhaust when he is directly exposed to it.

It is offered as information to the Committee as a basis for evaluating the benefit of changes in engines, maintenance and operations since April, 1956.

RECOMMENDATION

By way of recommendation for additional minimizing of smoke and odor from diesel bus operation I can only suggest that as a Committee we:

Keep informed of progress.

Exchange information

Consider the problem and its solution from

a health, legal and economic standpoint

according to each member's understanding

and bring our conclusions to the Committee

for discussion and study and such action

as it considers proper.

Prepared by:

Mr. Herbert L. Miller
The Cincinnati Transit Company
April 23, 1959

APPENDIX V-A

DIESEL ENGINES AND AIR POLLUTION

1. Factors involved in the problem.

   A. Grade and quality of fuel - Use of low gravity fuel or fuels with a higher percentage of low end causes heavier exhaust smoking.

   B. Maintenance of engine.

   C. Proper air fuel ratio.

   D. Rapid acceleration.

   E. Grades, elevations, and weather conditions.- At high elevations or high air temperatures, the air is thinner, thus reducing the amount of air that the engine gets, upsetting the air fuel ratio.

   F. Warm up when first starting engine and proper operating temperatures. There are two kinds of exhaust smoke expelled from a diesel engine. A black colored smoke is an indication of an excessive amount of fuel for the amount of air the engine is receiving. A white colored smoke results from insufficient combustion temperatures and therefore, occurs normally when the engine operating temperature is low. Diesel develops so little pollutant, it is too trivial to even measure.

   According to reports of Standard Research Institute, (1950) page 45, table XV, diesel fuel is least potent of twelve materials tested;

   Tons of pollutant emitted daily to Los Angeles atmosphere by combustion processes.

   1. Refuse burning - 567.0 tons per day.
   2. Automobile (gasoline) exhaust - 557.0 tons per day.
   3. Gasoline evaporation - 400.0 tons per day.
   4. Fuel oil (all other industries) - 200.0 tons per day.
   5. Fuel gas (petroleum industry) - 182.5 tons per day.
   6. Fuel oil (petroleum industry) - 139 tons per day.
   7. Fuel oil (general public, heating and cooking) - 127 tons per day.
   8. Fuel oil (general public, heating and cooking) - 72.5 tons per day.
   9. Refuse wood (all other industries) - 59.7 tons per day.
   10. Fuel gas (all other industries) - 49.5 tons per day.

11. Catalytic cracking - 14.0 tons per day.

12. Diesel engines (trucks, buses, etc.). ANALYSIS NOT MADE BECAUSE OF SMALL QUANTITY OF FUELS BURNED IN THIS CATEGORY.

Before condemning diesel trucks and buses, there are eleven more potent items more seriously affecting the air pollution problems.

3. Hydro carbon emissions into the atmosphere for diesel is nil.

The second report of the Air Pollution Control district of Los Angeles (1950) shows hydro carbon emissions from diesels as nil. Diesel fuel is much heavier than gasoline, and is much less volatile. Therefore, a negligible amount of evaporation loss comes from diesel equipment.

Normal diesel combustion is always with an excess of air, then hydro carbon as a result of rich mixture ratios are practically nil with diesels.

Table XVII, in the report of the APCD, page 37, shows the following hydrocarbon losses:

Automobile Exhaust	Pounds Hydrocarbon Exhausted Per Barrel of Fuel
Idling	29.6
Cruising	2.1
Acceleration, Deceleration	34.3
Diesel Bus Exhaust	Trace

4. Diesels have less noxious and toxic gases in the exhaust.

A. Carbon dioxide (CO^2) is a colorless and odorless gas formed by complete combustion of the carbon in the fuel.

Tests show diesel exhaust to have six to 7% carbon dioxide under full throttle operation. This gas is considered harmless.

NOTE: It was pointed out during the meeting that carbon dioxide gas is not completely harmless, and that it would be lethal in high percentages. The comment was made that percentages of 30% or above may be injurious. However, in this connection, carbon dioxide gas is generally considered to be much less dangerous or toxic than carbon monoxide. Certainly it would have to be present in much higher percentage than carbon monoxide to cause a measurable amount of injury.

B. Carbon monoxide (CO) is a colorless and odorless gas, but is dangerous to breathe. A concentration of .20% to .25% will cause unconsciousness in one-half an hour. This gas is the result of incomplete combustion.

Tests show diesel exhaust to have up to .06% by volume of carbon monoxide. Gasoline engine exhaust, on the other hand, contains up to .12%.

5. Diesel powered vehicles in Ohio comprise only a very small percentage of the total number of vehicles.

According to the U.S. Department of Commerce, Bureau of Public Roads, motor vehicle registrations in Ohio in 1957 were as follows:

Ohio Registrations - 1957

Automobiles	3,350,063
Buses	
Gasoline	13,569
Diesel	1,368
Trucks	
Gasoline	427,329
Diesel	1,370

There is only one diesel powered vehicle for every 1,400 gasoline powered vehicles in Ohio.

6. What the Cummins Engine Company is doing to eliminate air pollution.

A. Development of the aneroid control. This is a device incorporated in the fuel system to prevent overfueling during acceleration, changing gears, and at full throttle conditions at very low r.p.m. It is actuated by air pressure in the intake manifold, and acts to reduce the fuel delivery to the engine when the engine is not receiving sufficient air to burn the fuel properly.

B. Turbochargers and superchargers - These are devices for increasing the quantity air pumped into the engine improving combustion by making it more complete, and reducing the amount of fuel required by the engine. There is constant and diligent research in progress at all times directed toward improving the engines so that they burn less fuel, produce more power, with cleaner exhaust.

Prepared by:

Mr. H. O'Brien
Technical Service Manager
Cummins Engine Company, Inc.
Columbus, Indiana
April 23, 1959

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Prepared by:

Mr. H. O'Brien
Technical Service Manager
Cummins Engine Company, Inc.
Columbus, Indiana
April 23, 1959

APPENDIX V

SUMMARY OF REPORT PRESENTED BEFORE

THE CITY MANAGER'S COMMITTEE ON AIR POLLUTION

April 23, 1959

The following report is a summary of the statements of Norman V. Beatty, President of the Cincinnati Motor Transportation Association, presented before the City Manager's Committee on Air Pollution:

"In dealing with the request of Mr. Gruber that the trucking industry present a statement on their efforts in controlling or reducing smoke and odor from Diesel operation, we would like to first remind the Committee of a few basic facts.

1. Only a small amount of Diesel equipment is used in Cincinnati by the trucking industry and this equipment is used in their "over-the-road operations."

2. The trucks used in and about the city picking up and delivering freight are powered by gasoline engines. The Committee should therefore remember that less than 10% of the industry's fleet as a whole is Diesel.

Whether a vehicle be gas or Diesel, economic necessity requires the industry to maintain their engines as close as possible to the manufacturers recommended standards or they suddenly find themselves faced with a run-down fleet, and an enormous expense to bring it back to efficient operation. The Committee can see that any operator with a considerable investment in Diesel powered vehicles cannot afford to be slack with their maintenance standards.

By following the rigid standards that the manufacturer recommends, we feel that this is all we should and can do. Our driver-training and education programs are in constant operation instructing in the operation of the company equipment.

In conclusion we wish to state that oil companies construct the best fuels possible to fit the engines. The builders construct the best engine that engineers can devise. The owners maintain their Diesels or quickly suffer excessive loss of their service. . . . aside from our deep concern for public relations, we cannot afford poor Diesel equipment."

Prepared by:
Mr. Norman V. Beatty
President
The Cincinnati Motor Transportation Assoc.
April 23, 1959

APPRENDIX VI

PRACTICAL CONTROL OF DIESEL EXHAUST IN METROPOLITAN AREAS

April 23, 1959

The Cincinnati Committee on exhaust was called into session on February 4, 1959, to comply with their own recommendation of April 9, 1956 (see attached) for a two year review of the subject. In addition, the Council of Cincinnati had resolved the City Manager be requested to have the effect of additives on humans investigated.

This paper is concerned with control of diesel exhaust, and the control of diesel smoke and fumes. There are two basic causes of visible diesel exhaust. The first is caused by crowding oil to the engine during acceleration, without sufficient air to get complete combustion. The second is the greyish exhaust that persists over a distance, caused by incomplete combustion, and the condensate cooled after contact with the open atmosphere.

The acceleration period problem has two basic causes. The first and most important is the design of the engine, and the grade of fuel used in that particular engine. Remembering that a diesel engine has no ignition system, and depends on the heat of compression to fire the fuel, it is evident the engine builder's problem is to have a slight excess of air present under all conditions to insure complete combustion. This can be done under most conditions, but sudden acceleration can disturb this ratio, so that excess fuel can not be burned and passes out the exhaust as smoke.

The second acceleration problem can be helped by an operator, who realizes the capacity of the engine to properly burn fuel, and gives the engine just as much fuel as it can properly burn without over crowding and causing smoke.

The greyish continuous exhaust is more complex. It is concerned with the basic construction of the engine, the timing of injection, the grade of oil used in the particular engine, and the current general mechanical condition of the engine. Of course, the engine could be placed under constant overload, but this is closely related to the acceleration problem.

The writer has checked with a number of large diesel operators, and found that economical necessity requires them to maintain their engines close to manufacturers recommended standards. They have all been through the cycle of converting to diesel engines, and then running them far beyond the recommended time or mileage, then suddenly find themselves faced with a run-down fleet, and enormous expense to bring it back to efficient operation. Today, no one with a considerable investment in diesel powered vehicles can afford to tamper with maintenance standards.

It was this phase of the problem that prompted the writer to invite the members of the Fumes Committee, the City of Cincinnati Air Pollution Bureau, the U. S. Public Health Service, and other interested parties, to visit a Railroad Diesel Shop, to see for themselves that the statements concerning close maintenance is a daily practice and not a white-wash. Mr. H. J. Burkley, Sup't. of Motive Power of the Baltimore & Ohio R.R. gave his assent to our visit, stating he wanted no show put on, but an explanation of actual daily practice. Mr. R. C. Diamond, Sup't. of the Baltimore & Ohio R. R. agreed, as did Mr. H. J. Hofstetter, Master Mechanic.

Mr. J. H. Long, Regional Diesel Supervisor made the step - by - step demonstration of how the Baltimore and Ohio R. R. carefully checks each piece of equipment and the tests on parts before they are put in service.

Demonstration and explanation of maintenance standards - B.& O.R.R. Stock Yards Engine House. 9 A.M. - April 3, 1959.

1. Different types of fuel equipment in use at the present time on B & O

   (a) Unit injector furnished by E.M.D. Co. The B & O is getting ready to equip 1 EMD road engine with EMD injectors that have a special American Bosch modification kit KT 7822.
   (b) Pump and nozzle, These are furnished the company in various designs and size from American Bosch Co., Bendix Co., Demco Co.

2. Overhaul procedures for rebuilding fuel equipment to the manufacturers standard.

   (a) The close tolerances that must be adhered to in rebuilding to these specifications.

3. Equipment used in the inspection of parts.

   (a) Lift gauge used to determine the lift dimensions of needle valve in nozzle tip.
   (b) Otoscope used to make an inspection of the needle valve seat on the inside of the nozzle tip.
   (c) Micro-matic light and optical flat. This is used to check all flat lapped surfaces and be sure that the surface is within 2 micro inches.

4. Machinery used to make precision repairs.

   (a) Shauer lathe
   (b) Nozzle refinishing machine
   (c) Automatic lapping machine

5. An Alco 244 nozzle with a cutaway pump was used to demonstrate the com-fuel set up that is required on a locomotive today.

6. A nozzle was put on the run in test stand and nozzle opening pressure set, and nozzle run in. It was explained that this method of testing is used for the specific purpose of trying to make the nozzle fail, and to observe any defects that might exist, such as:

(a) soft seat in nozzle tip
(b) defects in lapped joints
(c) wet tip
(d) incorrect leak off
(e) correct nozzle firing pressure
(f) correct angle of spray

7. The calibration of a pump was explained and the reason for calibration with master pumps, also why the calibration is more correct if done on a stand that is automatic.
An Alco 244 pump was set up in the full load position and calibrated.

8. Line defects were discussed and the service life of oil condemned due to fuel oil dilution.

9. The savings that can be realized from good fuel equipment were:

(a) reduction in crank shaft failures
(b) reduction in power assemblies pulled
(c) reduction in lubrication oil consumption

10. A Keine test was made of the No. 7 pump and nozzle on locomotive 9374, and the benefits to be derived from this method of testing on form period.

(a) to find and correct fuel leaks
(b) to check the opening pressure of nozzle and insure that fuel equipment is operating correctly
(c) to help prevent dilution of the fuel oil

What conclusions can reasonabl be deduced from the facts? The engine builder is forced by the white heat of competition to build the best engine engineers can devise, to utilize the most work from the fuel burned, and the least energy passing out the exhaust. The oil companies construct the best fuels possible to fit the engines. The owners have to maintain their diesels or quickly suffer excessive loss of their service. Every day a railroad diesel stands idle costs the company five hundred dollars. A major breakdown from poor maintenance runs up to twenty thousand dollars. Aside from our deep concern for public relations, we simply can not afford poor diesels.

There is a far greater consideration than the local problem of smell from a diesel, truck, bus or railroad engine. The whole world is divided in two camps, with incalculable stakes in the world's great oil pool in the Middle East, Europe and other countries use much of the gasoline and lubricating oils, but the United States is the great user of the residue oils, in our diesels and power plants. Our own oil reserves are known and limited. We must use the Middle East oils to bolster their financial status, to keep them out of our enemy's hands, and to conserve our own supplies. We know that in a major conflict, there will be no rationing for the people. There won't be any gasoline at all for them. A high placed Defense Department official told this writer the people would have to walk.

Diesels do smell when one is close to the point of exhaust. The writer is not a doctor or research engineer, but has had first hand knowledge of the effect of concentrated diesel fumes. During World War II, as an Army Railroad officer, I took over the operation of the Main Line between Naples and Rome when the line was repaired and returned to service. There were numerous tunnels on the 90 mile division, and two of them, Etri and Orso, were six miles long with a 1% grade from each end to the middle. The electric locomotives were destroyed, and we had to use diesels. Fumes built up in the middle of the tunnels, and my men complained of headaches. Our Battalion Doctor, Captain Castagno, and I rode daily through the tunnels, and did get headaches, which passed away in about 30 minutes. We had no hospitalizations, and no eye infections. This was a concentration of smoke and fumes penetrable by a strong headlight to a fifty foot distance, endured for about 10 to 12 minutes.

People complain, and their complaints should be considered. An official, elected or appointed, has the responsibility of weighing all of these things, realizing there are minor discomforts we must endure. It is just as great a duty to inform the public as to the necessity of some nuisances, as to try to alleviate real injuries.

The herculean advances of the internal combustion and fuel industries, are not a matter to be regulated by local authority. The recommendations of the 1956 Fumes Committee, as enacted into Law, are sound and reasonable and enforceable. The City has neither the money, equipment, or personnel to compete with the resources at the command of the industries involved. They will find the answers.

Prepared by:

Mr. T. J. Wells
Supervisor of Locomotive Operation
Cincinnati Superintendents Committee
April 23, 1959