

January 17, 1926.

Surgeon General H. S. Cumming,
United States Public Health Service,
Washington, D. C.

Dear Sir:

The committee appointed by you at the request of the conference held in Washington May 20, 1925, was directed to present to you "if possible by January first next, a statement as to the health hazards involved in the retail distribution and general use of tetra-ethyl lead gasoline motor fuel". As soon as practicable after its appointment, the committee met in your office for organization and for discussion of the procedure to be followed in carrying out its instructions.

The members of the committee familiarized themselves, as far as possible, by conferences and by reading, with the existing data bearing upon the subject and upon lead poisoning in general. They had access to the stenographic report (See Public Health Bulletin No. 158) of the addresses and discussions which took place at the conference of May 20, and subsequently they made a personal examination of the plant at Deep Water, N. J. for the manufacture of tetra-ethyl lead, and of one of the stations at which the ethyl fluid is mixed with gasoline.

Ethyl gasoline was first placed on sale February 1, 1923, and its sale was voluntarily discontinued May 5, 1925, about 300,000,000 gallons of ethyl gasoline being distributed during this period. Serious cases of poisoning occurred among men handling lead tetra-ethyl and ethyl fluid in the States of New Jersey and Ohio. As far as the committee is aware these accidents had all occurred in

connection with the manufacture and blending of concentrated tetra-ethyl lead, and threw no direct light upon the problem specifically laid before us--that of the retail distribution and general use of ethyl gasoline. The valuable experiments reported by the U. S. Bureau of Mines and by investigators at Columbia University and others yielded important results, but we felt that the crucial test of the situation must be derived from actual experience in the use of ethyl gasoline under practical conditions of operation.

It was therefore decided that the committee should make a direct investigation of the question submitted to them, planning the work on as extensive a scale as was possible in the time allowed. Fortunately this mode of approach was made feasible by the fact that ethyl gasoline has been in constant use as a motor fuel in certain parts of Ohio for several years; and although the production and distribution of tetra-ethyl lead and ethyl fluid had been suspended by the voluntary action of the manufacturers, pending the present investigation, it was known that in the region indicated, a supply of ethyl fluid was still in the hands of certain consumers and would be continued in use. We were thus presented with an opportunity of studying a fairly large group of individuals who had been using and handling ethyl gasoline and of comparing the findings upon them with the examination of a similar group employing gasoline free from lead.

In several conferences, the committee, with the assistance of Surgeon General Cumming and Surgeon L. R. Thompson, U. S. Public Health Service, in charge of the section of Industrial Hygiene and Sanitation, formulated a general plan of investigation. The actual conduct of the work was entrusted to Doctor J. P. Leake, Surgeon, U. S. Public Health Service, who at once organized a corps of workers

and began observations upon certain groups of individuals in Dayton and Cincinnati. The committee desires to express its appreciation of the cordial cooperation extended to this group of observers by both the employers and workers in the garages selected for the investigations. After all the preliminary arrangements had been completed, the work was pushed with great vigor during the autumn months, and on December 19, Doctor Leake presented to the committee a full report of the results of his study. The committee wishes to express its great satisfaction with the promptness, energy and ability with which these investigations were carried out. The general character and scope of the work may be summarized briefly as follows:

Two hundred and fifty-two individuals were studied. They were all adult males, and fall into five groups.

1. Group A, a control group, consisted of thirty-six men who were employees of the City of Dayton. Their duty was to drive cars during the working day. In these cars the gasoline used contained no lead. The cars were housed in the municipal garage, which in the report is designated as the Dayton Control Garage.
2. Group B, a test group, consisted of seventy-seven men who were employees of a public service corporation in Dayton, and whose duties were similar to those of Group A. The cars that they drove, however, used ethyl gasoline, and this fuel had been in constant use in this service since July, 1923. The garage in which these cars were housed is designated as the Dayton Test Garage.
3. Group C, a control group, consisted of twenty-one men. These were employed as garage workers in the Dayton Control Garage or in a similar control garage in Cincinnati, or as gasoline fillers at service stations or on trucks delivering gasoline in Dayton and the adjoining region. In none of these garages, service stations, or trucks was gasoline containing lead used or handled.

4. Group D, a test group, consisted of fifty-seven men. These were employed as garage workers in the Dayton Test Garage or in a similar test garage in Cincinnati, or as gasoline fillers at service stations, wholesale gasoline plants, or on trucks delivering gasoline in Dayton, Cincinnati, and vicinity. The duties of these men were similar to those of Group C except that ethyl gasoline was handled in the garages, stations, and trucks.
5. Group E, a control group, consisted of sixty-one men employed in two industrial plants of entirely different character from the foregoing in which there was known to be a serious exposure to lead dust. Numerous cases of lead poisoning had occurred in these plants. This group was selected to serve for what might be called a positive control or check in regard to the validity of the clinical and analytical methods used in the study of the individuals of Groups A, B, C, and D.

Methods used:

Each individual was subjected to a careful clinical examination, and in addition, smears were made from his blood and a specimen of his feces was collected. The blood smears and the fecal specimens were sent to Washington to be examined by trained experts for stippling of the red cells and for content in lead. The examination of the feces for lead was made by chemists who had been especially trained in the technique of the method. The blood examinations were made by a group of skilled observers, and were arranged so that the counts in each case were checked by several workers.

The clinical examination was conducted by four physicians. The first of these took a careful industrial history of each subject, and assigned to him a certain number. These numbers were taken at random. Thereafter this individual was recorded by his number, and none of those making the subsequent examinations or the laboratory tests knew whether or not the individual had been exposed to ethyl gasoline; nor, in fact, did any examiner, except the one who took the industrial history, know to which

group the individual belonged.

After taking the industrial history, other examiners made a thorough medical examination, including a medical history, hemoglobin estimation, red-cell count, blood pressure records, visual acuity tests, urine examinations, etc.; and finally a determination, by a special method devised for the occasion, of the muscular strength of the extensor and flexor muscles of the forearm.

While all of the examinations were made with as much care as possible, special attention was given to three methods which, it was hoped, would yield quantitative data of an objective character. These were, first, the determination of the amount of lead in the feces, as an index of lead ingestion or absorption; second, the estimation of the number of stippled red cells, which, in the absence of other causes, might also be considered as an index of lead absorption; third, measurements of the strength of the extensor muscles of the forearm, as an index of lead poisoning. The two first methods yielded results of positive value, but the last was practically negative so far as the present investigation is concerned.

When all the data had been collected, they were submitted to study and statistical analysis by Doctor Leake and his collaborators, and the results were presented to the committee in the form of a detailed report containing a description of the methods used, tabular summaries of results, and protocols of the findings for each individual studied. This report will be published in full by the Public Health Service. So far as the clinical examinations are concerned, it may be said that they failed to give any decisive indication of lead poisoning among the chauffeurs or workers in garages in which ethyl gasoline was used as a motor fuel (Groups B and D)..

(Footnote follows)

* Footnote to page 5.

The only injury observed was acute irritation of the eyes in a few cases, due to getting gasoline into the eyes. This occurred both with ordinary gasoline and with ethyl gasoline but was perhaps more severe in one case due to the latter. This case is mentioned specifically in the full report.

The median time of potential exposure among these men approximated two years, and this negative result, therefore, holds good only for a period of this duration. It should be added that in Group, E, comprising workers in industrial plants in which there was a known and serious exposure to lead dust, definite clinical symptoms of lead poisoning were revealed, although these workers had been exposed for shorter periods of time.

More significant results were obtained from the analysis of the feces and from the microscopic examination of the blood smears. These results are presented in condensed form in the accompanying graphs, and tables. (Graphs 1 to 4 and Tables A, B, C and D.)

Graph 1 and Table A represent the amount of lead found in the feces of the individuals of Groups A, B, C, D, and E. The figures along the abscissa of the graph give the amount of lead in milligrams per gram of ash of the feces, from 0.1 mgm. to 3 mgm. The ordinates represent percentages of the workers in each group. It will be seen that in Groups A and B, representing drivers of cars, one using gasoline without lead and the other the ethyl gasoline, the amount of lead in the feces was practically identical. The exposure of these men was mainly to the exhaust gas from the motors, and it would appear that in Group B, using the ethyl gasoline, there was no positive indication of increased absorption of lead. The fact that in Group A, some lead was also found in the feces, shows that these men were exposed to lead from some other undetermined source. In this connection it is to be noted that twenty examinations were made in Washington by the same methods of the feces of ten of the workers in the Hygienic Laboratory of the U. S. Public Health Service. These workers had had no known exposures to lead but their feces showed at each examination small amounts of lead ranging from 0.047 mgm. to 0.290

mgn. per gram of ash of the feces. In what might be called normal feces, therefore, lead may be present, from accidental exposures of one kind or another, in concentrations not differing materially from those found in Groups A and B.

In Group C, representing the garage workers and gasoline handlers not exposed to ethyl gasoline, there is an indication of a slightly greater excretion of lead. In the control garages and repair shops, as will be shown later, there was a perceptible amount of lead in the dust upon the floors and benches.

In Group D, representing the garage workers and gasoline handlers using ethyl gasoline, there is a still further increase in the amount of lead excreted, although the number who showed excretion of as much as 0.1 mgn. per gram of ash is small (15 per cent). It seems probable that this increase was due to the use of ethyl gasoline, since subdivision of this group into two classes, those with a lesser exposure to ethyl gasoline, as regards time and intensity, D1 & 2, and those with a greater exposure, D3 and 4, indicates that in the latter there was greater excretion, as is shown in Graph 2 and Table B.

In Group E, as would be expected, there is evidence of much greater ingestion or absorption. Over 80 per cent showed more than 0.3 mgn. of lead for each gram of ash of the feces, and in some cases the lead was present in concentrations as great as 3 mgns. per gram of ash.

Graph 3 (see Table C) gives curves indicating the number of stippled cells found in the blood of the workers in Groups A, B, C, D, and E. The abscissa in this case represents the number of definitely stippled cells per 100,000; the curves are plotted for the values 1 to 2 per 100,000, 3 to 6, 7 to 20, 21 to 100.

Here again the results for Groups A and B are practically identical.

In each group a small number, twelve per cent, showed definite stippling. No examinations of persons who are neither drivers of cars nor garage workers are available, carried out by the same observers using the same method. It is not possible to say whether the slight degree of stippling observed with Groups A and B possesses any significance, but it seems to be clear that the members of Group B, exposed to the exhaust gases from engines using ethyl gasoline, showed no noticeable increase in stippling as compared with Group A.

In Group C there is a distinct increase in the percentage of workers showing stippling, and this increase is more marked in the workers of Group D. These results, therefore, corroborate the findings from the analysis of the feces in suggesting a beginning storage of lead in these two groups. That the greater indicated storage in Group D is connected with the use of ethyl gasoline seems to be borne out by the curves shown in Graph 4, (Table D), in which the curves are plotted for the two classes of D referred to above, the workers with the greater exposure showing a very slight increase in the percentage of those exhibiting definite stippling. The curve for the workers in Group E is of an entirely different character. Over 90 per cent showed distinct stippling, and in most of these cases the stippling was relatively very abundant.

Inquiry into reported cases of injury resulting from the use of ethyl gasoline.

So far as the committee could ascertain, all the reported cases of fatalities and serious injuries in connection with the use of tetra-ethyl lead have occurred either in the process of manufacture of this substance or in the procedures of blending and ethylizing. It seemed desirable to institute an inquiry in the region where this investigation was made, and where ethyl gasoline had been employed as a motor fuel for

the longest time as to possible cases of injury resulting from its use. All the workers examined were questioned, therefore, in regard to their knowledge of cases of possible injury, and inquiries were made in the Dayton and Cincinnati districts among local health officers, physicians, public health workers, and labor leaders. The few clues obtained from this inquiry were investigated in detail, but the results were negative. No positive evidence could be obtained of harmful effects attributable to the use of ethyl gasoline.

Observations upon the lead in the dust and air of the garages investigated and upon the amount of carbon monoxide.

In addition to the examinations made upon the workers themselves, some data were collected in regard to the amount of lead in the air and dust of the garages and work rooms, and also in regard to the concentration of carbon monoxide. These observations were made during October, 1925, and owing to the unusually cool weather prevailing during that month, the doors and windows were closed during most of the day. The conditions regarding ventilation were those to be expected for winter rather than summer weather. The several methods employed in this part of the investigation are given in detail in the full report. The findings obtained are summarized in the accompanying tabular statements for the several garages investigated as well as for the industrial plants in which there was a serious exposure to lead dusts. This part of the investigation was not so extensive as was desired, owing to the shortness of the time allowed, but it is evident from the results obtained that some lead was present in the air of the garages and work rooms whether the gasoline used contained lead or not; and in the sweepings of dust from the floors and benches there was a distinct amount of lead present, the figures running

from 0.82 mgms. to 22.31 mgms. per gram of dust, according to the time and place of the gathering of the sample. It would seem probable, therefore, that in all garages in which automobiles are being handled and repaired, the workers are constantly exposed to certain amounts of lead dust, and this fact would tend to emphasize the importance of providing such rooms with adequate ventilation, and of keeping both the floors and the benches as free as possible from the accumulation of dust. Owing to the incompleteness of the data, it is not possible to say definitely whether the exposure to lead dust was greater in those garages in which ethyl gasoline was used. It is very desirable that these investigations should be continued.

On the basis of this investigation, the committee feels that the following general conclusions are justified:

1. Drivers of cars using ethyl gasoline as a fuel and in which the concentration of tetraethyl lead was not greater than one part to 1500 parts by volume of gasoline, showed no definite signs of lead absorption after exposures approximating two years.
2. Employees of garages engaged in the handling and repairing of automobiles and employees of automobile service stations may show evidence of lead absorption and storage, as indicated by the lead content of the feces and the appearance of stippled cells in the blood. In garages and stations in which ethyl gasoline was used, the amount of apparent absorption and storage was somewhat increased, but the effect was slight in comparison with that shown by workers in other industries when there was a severe lead hazard (Group E) and for the periods of exposures studied was not sufficient to produce detectible symptoms of lead poisoning.

3. In the regions in which ethyl gasoline has been used to the greatest extent as a motor fuel for a period of between two and three years, no definite cases have been discovered of recognizable lead poisoning or other disease resulting from the use of ethyl gasoline.

In view of these conclusions your committee begs to report that in their opinion there are at present no good grounds for prohibiting the use of ethyl gasoline of the composition specified, as a motor fuel, provided that its distribution and use are controlled by proper regulations. The committee feels that the formulation of specific regulations in regard to the manufacture, distribution and use of tetraethyl lead, ethyl fluid, and ethyl gasoline for adoption and enforcement by the several States belongs properly to the office of the Surgeon General of the Public Health Service. In an appendix to this report, attention is called to certain suggestions which have been made in the course of the discussions of this committee and which it is believed should be taken into consideration in making such regulations.

In conclusion we beg to say that we are conscious of the fact that the conclusions to which we have come in this report, although based upon most careful and conscientious investigations, are subject to the criticism that they have been derived from the study of a relatively small number of individuals who were exposed to the effects of ethyl gasoline for a period of time comparatively brief when we consider the possibilities in connection with lead poisoning. A more extensive study was not possible on account of the limited time. It remains possible, that if the use of leaded gasolines becomes widespread, conditions may arise very different from those studied by us which would render its use more of a hazard than would

appear to be the case from this investigation. Longer experience may show that even such slight storage of lead as was observed in these studies may lead eventually in susceptible individuals to recognizable lead poisoning or to chronic degenerative diseases of a less obvious character. In view of such possibilities the committee feels that the investigation begun under their direction must not be allowed to lapse. The respective States would be dependent upon the findings of such investigations for changes in their regulations. With the experience obtained and the exact methods now available, it should be possible to follow closely the outcome of a more extended use of this fuel and to determine whether or not it may constitute a menace to the health of the general public after prolonged use or under conditions not now foreseen.

Outside the question of ethyl gasoline it would seem from this investigation that wherever automobiles are housed together, there is an accumulation of lead dust which may prove to be a source of danger to the workers involved, in addition to the hazards arising from the production of carbon monoxide gas. The vast increase in the number of automobiles throughout the country makes the study of all such questions a matter of real importance from the standpoint of public health, and the committee urges strongly that a suitable appropriation be requested from Congress for the continuance of these investigations under the supervision of the Surgeon General of the Public Health Service, and for a study of related problems connected with the use of motor fuels.

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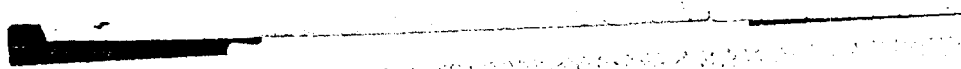


TABLE A -- PERCENTAGE OF PERSONS WITH MORE THAN ONE TENTH MILLIGRAM OF LEAD PER GRAM OF ASH IN FECES IN THE EXPOSURE GROUPS A, B, C, D AND E.

MILLIGRAMS OF LEAD PER GRAM OF ASH				
	.101- .300	.301- 1.000	1.001- 3.000	3.001 & Over
A	29	6	-	-
B	32	2	-	-
C	41	6	-	-
D	56	13	2	-
E	15	49	29	5

TABLE B --- PERCENTAGE OF PERSONS WITH MORE THAN ONE TENTH MILLIGRAM OF LEAD PER GRAM OF ASH IN FECES IN GROUP C AND HALF-GROUPS D1-D2 AND D3-D4.

MILLIGRAMS OF LEAD PER GRAM OF ASH				
	.101- .300	.301- 1.000	1.001- 3.000	3.001 & Over
C	41	6	-	-
D1 and D2 (1)	54	8	-	-
D3 and D4	57	18	4	-

(1) D1 and D2 are the two quarters of exposure group D which had less exposure to ethyl gasoline and ethyl fluid and D3 and D4 are the two quarters which had the greater exposure.

TABLE C -- PERCENTAGE OF PERSONS SHOWING DEFINITE STIPPLING OF
DIFFERENT DEGREES IN EXPOSURE GROUPS A, B, C, D AND E.

STIPPLED CELLS PER 100,000 RED CELLS

	1 - 2	3 - 6	7 - 20	21 - 100	Over 100
A	6	-	3	3	-
B	9	3	-	-	-
C	19	5	-	-	-
D	28	9	9	-	-
E	10	13	13	26	31

TABLE D -- PERCENTAGE OF PERSONS SHOWING DEFINITE STIPPLING OF
DIFFERENT DEGREES IN GROUP C AND HALF-GROUPS D1-D2
AND D3-D4.

STIPPLED CELLS PER 100,000 RED CELLS

	1 - 2	3 - 6	7 - 20	21 - 100	Over 100
C	19	5	-	-	-
D1 and D2 (1)	28	8	10	-	-
D3 and D4	29	11	8	-	-

(1) D1 and D2 are the two quarters of exposure group D which had less exposure to ethyl gasoline and ethyl fluid and D3 and D4 are the two quarters which had the greater exposure.