ETHYL CORPORATION

INTER-OFFICE CORRESPONDENCE

TO	Dr. R. A. Kehoe	**ADDRESS**	Cincinnati
FROM	J. E. Boudreau	**ADDRESS**	New York
SUBJECT		**DATE**	April 18, 1966

Dear Bob:

I have your letter regarding the White Horses. Please have no fear that you are in any way being a nuisance to me.

In view of the fact that my contacts are in Washington and your date isn't until September, I am going to see my friends there when I am down for the lead investigation in May. This will still give ample time.

If that falls through, I now have another lead. On Saturday we invited some new neighbors to the house for a drink. Both the man and his wife are Swiss and he is a doctor with the Rockefeller Foundation. He is quite an avid horseman, and both he and his wife keep horses at the Hunt Club in Darien. In the course of the conversation he mentioned that they were going to Vienna next month and were particularly interested in the White Horses. I remarked that this was rather a tight proposition with all the tourists today. He said that he had no problem because the head of the Spanish Riding School was a very close friend of his and he has visited them a number of times. So I am sure that one way or the other, I can get you, your wife and Kathleen in.

I talked with Dick Scales this morning and he said he had outlined to you the nature of our appearance on the 26th. In view of the fact that on that same day they are throwing in sulfur, boron and a number of other things, I am very hopeful that we will be lost in the shuffle.

One of the remarks dropped was that all presentations should not be longer than 10 minutes. I don't think that should cause you too much concern for I am sure that George Kirby will be glad to relinquish part of his time if it is necessary.

I am attaching a copy of the boiled down version of your original paper. Although I understand you are working on a new version, I think that the attached version, which can in turn be greatly reduced, might give a very good overall background of the situation. At any rate, I would be most happy to work with you as soon as you let me know.

With the kindest regards,

Sincerely,

James E. Boudreau

JEB:w

STATEMENT

Concerning the Hygienic Aspects of Lead in the Human Environment

by

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It is the purpose of this statement to present in brief form the salient facts concerning the hygienic aspects of the occurrence and distribution of lead in the environment with particular reference to the contribution made by the use of gasoline containing lead antiknock compounds.

The impression has existed in certain circles that little information is available on this subject, especially as to matters that relate to the

safety of the public.

The fact is, however, that no other hygienic problem in the field of air pollution has been investigated so intensively, over such a prolonged period of time, and with such definitive results. This is not to claim that there are no significant voids in the available information, nor that all of the ultimate answers are at hand. Nevertheless, it is clear that this specific set of problems has been brought to such a point of understanding, in relation to the public health, as to remove it from the realm of urgency and to consign it into that group of hygienic problems on which an effective surveillance should be kept. A considerable measure of assurance for the future may also be derived from the fact that methods of surveillance have been developed, over the years, which are characterized by a high degree of technical precision and physiological relevance.

The results of all these investigations to date, which extend back over the past forty years, have consistently demonstrated that:

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lead compounds discharged from the exhausts of automobiles have not created a hazard to the health of the public.

2. The concentrations of lead from all sources found generally in the air of American cities are low.

3. The amounts of lead to which the general population are exposed - from all sources, including foods and beverages - are below hazardous limits.

4. During the past twenty-odd years, there has been little change, on the part of the "average," adult American, either in his intake and output of lead, or in the amounts of lead retained in his body. Such slight change as has been observed has moved in the direction of a decrease in both intake and output, but it is not certain that this apparent trend is real in the sense of being a representation of a general situation.

The bulk of the investigative work which bears on lead in the environment of man has been carried out in the Kettering Laboratory in the College of Medicine of the University of Cincinnati, under the financial sponsorship of the manufacturers of lead-containing antiknock compounds.

When this work first began in the nineteen-hundred-twenties, there was an appalling lack of facilities for research in these fields, in universities, in governmental circles, and in industry.

In this extremity, certain industries, including the antiknock industry, turned to the University of Cincinnati for toxicological information and medical advice on which to design hygienic measures in their complex and rapidly expanding technology. Thus, the antiknock industry provided the financial support that led to the establishment of the Kettering Laboratory, through agreements with the Board of Directors of the University and with primary respect to the policies of the University.

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The Kettering Laboratory has since grown to maturity physically and professionally, and over the years has guided several hundred industrial organizations ~~more than 100 industries~~ in the country and industries as well as governmental agencies in foreign countries; in relation related to the health and well being of employees, customers, and the public generally.

From the earliest use of tetraethyllead as an antiknock agent, it was recognized that the discharge of lead from the tail pipes of motor vehicles might present a serious hygienic problem. On this account, an investigation of the hazard of airborne lead from this source was initiated in 1923, in the Bureau of Mines Experimental Station. About two years later, the first of a series of field investigations of the environmental conditions and the personnel involved was designed and carried out by investigators in the University of Cincinnati. Later in 1925, a more elaborate investigation was made by a group in the United States Public Health Service. Others followed in 1927, 1928, 1932, 1950, and 1955-56, through the efforts of the group in the University of Cincinnati. Through these investigations, the observations were extended to include men engaged in the repair and maintenance of motor vehicles in the shops and garages of motor fleets and individually owned motor cars, as well as the employees of car parks and parking garages, traffic officers, and taxicab and delivery truck drivers, who are believed to have been subjected to maximum exposure to the exhausted effluents of motor vehicles.

Various surveys concerned only with the concentration of lead in the atmosphere of Cincinnati, Los Angeles and Pasadena were carried out in 1950, 1952, 1955, and 1961, by technical members of the staff of the Kettering Laboratory.

Outside the United States, further investigations have been made, in Great Britain and Switzerland, which confirm the findings of the Kettering Laboratory.

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The latest field survey was initiated in 1961, in Philadelphia, Cincinnati, and Los Angeles, by a group of investigators from the Public Health Service, the Philadelphia Health Department, the California State Department of Health, and the Kettering Laboratory, under the general guidance of a Working Group made up of representatives of the American Petroleum Institute, the Automobile Manufacturers Association, the California State Department of Health, the du Pont Company, Ethyl Corporation, Kettering Laboratory, and the Public Health Service. Their report was issued as a publication of the Public Health Service in January of 1965.

As long ago as the early nineteen hundred thirties, the staff of the Kettering Laboratory concluded that the potential hazards of lead could not be visualized or appraised by anything short of comprehensive information concerning the sources of lead in the general environment, and the reaction of man thereto. Accordingly they began a series of investigations which culminated in two series of "balance experiments," of which the first, in 1937, involved human subjects to whom lead, in aqueous solution, was administered, by mouth, in carefully graded dosages, over periods ranging from several months to four years. In 1950, these experiments concerned with the ingestion of lead, gave way to observations as to the behavior of finely divided inorganic compounds of lead dispersed in the air breathed by human subjects. The experiments concerned with the inhalation of lead are still in progress, and are being conducted to demonstrate the maximum level of the concentration of respirable lead which is compatible with the safety of normal healthy persons.

While these investigations were finan[illegible] solely by the antiknock industry in the United States, they a[illegible] with the financial support of these and other industrial[illegible] together with

an abbreviated "monograph" was issued in 1961, in the form of reprints of three lectures, the Harben Lectures of the Royal Society of Public Health and Hygiene, given in London in 1960.

Tetraethyllead has been used since 1923, while tetramethyllead and certain other alkyls came into use in 1960. The average concentration of lead in gasoline in the United States during 1965 was 2.43 grams per gallon. This concentration may be expressed for simplicity as 1 part by volume of tetraethyllead in 1600 parts of gasoline.

These compounds of lead are burned with the gasoline in the engine, and their combustion products appear in the exhaust gas as inorganic compounds of lead. Only minute amounts of the lead alkyls escape combustion in the engine so as to be discharged into the atmosphere.

Only a portion, ranging from 25 per cent. upward to 75 per cent. of the lead which enters the engine in the fuel, is discharged from the tailpipe of the automobile. Of the lead which condenses out in the exhaust system of the engine at low speeds of operation, much is discharged in some later period of accelerated operation, in flakes and chunks too large to become airborne. These may be pulverized to some presently unknown extent and redispersed in the air, by the tires of subsequent vehicles, but most of them continue as particles too large for such dispersion.

The concentration of lead in the atmosphere of cities varies from city to city, from one area to another in a city, and from time to time during the day, week, month or year. In Cincinnati, where information has been obtained from 1946 through 1962, the concentration ranges from 1 microgram to

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somewhat more than 6 micrograms per cubic meter of air, increasing as one goes from rural to suburban areas, and to business and industrial areas. The values are lower in warm weather and the highest results are found in the industrial areas of the city. Significant differences have also been found at individual sampling sites along arterial highways, in correlation with the varying density of traffic.

It is of some importance to note that there has been a downward trend in the concentrations of lead in the atmosphere in Cincinnati over a period of years since the middle forties, in association with successful efforts in the abatement of coal smoke and fly-ash, as well as changes in housing and traffic patterns. This has occurred despite a progressive increase in general motor traffic.

The same method of observation has been extended in the "Survey of Lead in the Atmosphere of Three Urban Communities", so as to portray, on a broad base, the general characteristics of lead in the atmosphere of our cities, and to confirm the reliability of results that have been obtained over the past twenty years. The expanded information of this survey has demonstrated that, while the average concentration of lead in the atmosphere varies from 1.4 micrograms per cubic meter in Cincinnati to 2.5 micrograms in Los Angeles, no difference has been reflected in public health.

The combined experience of investigators of this matter has demonstrated clearly that the sampling and analysis of the atmosphere with respect to lead must be carried out widely and systematically under all kinds of conditions, in order to provide comprehensive information. The composite picture with respect to the sources of lead, and the rate and direction of their spread and dissipation are by no means simple, and, therefore, assumptions made from scattered and sporadic data are likely to be grossly in error.

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A few widely aberrant results have been obtained from time to time, and excessive significance has been attached to them. Extraordinarily high values may be the result of the concurrence of unusual conditions, but they are more likely to be the result of error, through some fault in the procedures of sampling or analysis. Of much greater significance, both statistically and physiologically, is the prevalence of results of a low order of magnitude over prolonged periods of time.

Actually all of the observed high results have been far below the range that is capable of causing lead intoxication in any individual, even after many months of exposure.

It is often assumed that the great preponderance of the lead in the atmosphere, especially that of cities, is derived from the combustion of leaded gasoline, but the matter is not that simple. The facts are that there are many sources from which lead is distributed into the atmosphere, and while most of these result from the activities of man which are concentrated in urban areas, some are to be found in relatively isolated and sparsely populated places.

Moreover, current investigation has failed to determi[illegible]he rela magnitude of the contributions made by the combustion of coal, wood, and other vegetation, by dust from the surface of the earth, by the stack and burning grounds of industry, and by the incineration of waste materials[illegible] inquiring novice tends to make assumptions on the basis of the gross weig[illegible] lead-bearing materials that seem to be subject to distribution in the atmosp[illegible] taking strict account of the multiple sources, and the factors the dispersion of air-borne solids.

Fortunately, the hygienic issue relates to the total concentration of lead in the atmosphere from all sources, in conjunction with that which is

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in the food and beverages and in any other material that may be swallowed. This issue may be restated as follows: - Any threat posed, to the people, by lead in the air which they breathe, is dependent not only upon the abundance of lead in their entire environment, but also upon the extent to which such lead gains entrance to the internal medium of their tissues. It is not only the lead which enters the respiratory tract, for much of this is carried out again in the exhaled air, and it is not the lead which enters the stomach and intestines, but that which is absorbed therefrom.

The mere abundance of lead in the human environment and in the body is not, of itself, a threat to mankind. Abundance is a relative term. The outcome of the absorption of lead into the human body depends upon its rate and extent, and upon the physiological mechanisms of distribution, and in the metabolic processes and the extent of the accumulation, if any, in the body with time. These are matters which must be known and understood before one speaks of danger.

Lead is taken into the human body in virtually all human food and beverages. The quantities of lead taken into the body in this manner greatly exceed the amounts taken in with the air in breathing.

The quantities taken in daily with the inspired air are not so well defined, since they must be calculated on the basis of the average concentration of lead in the air breathed in by the individual during each period of 24 hours.

The maximum quantities of lead absorbed into the body from that taken into the alimentary and respiratory tracts may be determined with a reasonable accuracy. Experimental evidence shows that somewhat less than 10 per cent. of that ingested (swallowed), and somewhat less than 50 per cent. of that inhaled, are absorbed.

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indirectly, the order of magnitude of that absorbed in the respiratory

Under the conditions that exist at the present time, the quantity of lead absorbed daily by the average adult not subjected to unusual types of lead exposure is balanced for all practical purposes by the excretion of a corresponding quantity of lead. The manipulative error of these experiments is such that the apparent balance between intake and output may not be exact, and, therefore, there may be some slight, progressive accumulation with time. From theoretical considerations this seems likely, but it is certainly small and is believed to be physiologically insignificant.

In seeking to determine the total "body burden" of lead, the difficulty lies in the fact that lead, like certain other mineral elements, is distributed selectively into the skeleton of man, and that the skeleton, although a living part of the human organism, carries on its metabolic activity at a relatively slow rate. However, the mass of the skeleton, relative to other tissues of the body, would seem to reduce the content of lead, under ordinary circumstances to almost negligible proportions. Thus the concentration of lead in the skeleton of the average child or man appears to be of the order of about 20 parts per million, which is not far from the concentration of lead in soil and coal. Thus the overwhelming quantity of the lead in the body of the ordinary adult is sequestered in that part of the body that is least likely to be affected by it, and is in low concentration even there.

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But it is this partial removal of the lead of the body that tends to conceal its presence by reducing its concentration in the soft tissues and body fluids. Lead is distributed in the body in accordance with a regular pattern in which all of the tissues share. It might be supposed, therefore, that the concentration of lead in the fluid and cellular tissue determined through blood analysis, would make it possible to project the concentration which is to be found in all other tissues, to arrive at the total quantity in the entire body. And so it would, but for the fact that the skeleton, itself, is physiologically inhomogeneous, in that the hard shafts of the long bones are extremely limited in their blood supply, and in their consequent share in time in the bodily metabolism. This physiological inhomogeneity poses the obstacle to the determination of the body burden of lead in the living man.

The concentration of lead in the blood, also under ordinary conditions, varies to some extent with the current rate of the absorption of lead, but it tends to represent the approximate state of the body generally, with reference to its over-all burden of lead.

Under the conditions of occupational exposure to lead, it has been possible to develop criteria for the safety of workmen, in terms of the rate of the urinary excretion of lead, on the one hand, and the concentration of lead in the blood, on the other. The threshold values indicative of the dividing line between definitely safe and incipiently dangerous degrees of occupational absorption of lead are, approximately, the concentration of 150 micrograms per liter in the urine, and that of 80 micrograms per 100 grams in the whole blood.

The concentration of lead in the blood of persons of all ages is an adequate criteria to distinguish between those who are threatened with the

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toxic effects of the absorption of lead, and those who are under no such threat. Even in the case of infants and young children, the onset of lead poisoning has not been found to occur in association with levels of lead concentration in the blood under 60 micrograms, per 100 grams, of whole blood. As to what is meant by the term, lead poisoning, or whether there may not be some subtle or occult effect of lower concentrations of lead in the body, generally, or in certain tissues such as the brain, that would not be included among the symptoms of so-called "classical" lead poisoning, no doubt should linger in any mind. On the basis of all accepted evidence there is little justification for apprehension concerning a possible hazard of presently incomprehensible type.

examinat environmental factor as common and variable as that of lead. This metal and its uses need to be kept under surveillance so that they are compatible with human safety, as specified by meaningful criteria. Such criteria are available with respect to food and beverages, and such a criterion is being developed with respect to the atmosphere. It is possible that present and future criteria will need refinement from time to time, and if so, this is an expected product of the extensive research that had to come in the efforts of modern man to understand and to control the environment which he is altering, drastically, to his own ends.

The amounts of lead ingested with food and beverages and the amount inhaled from the atmosphere constitute the total threat, if any, of lead to a human being. However, since these sources differ in their means and ease of penetration into the body, and, to some slight extent, in their effect upon the distribution and handling of lead in the body, they must be examined,

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separately, as to their significance. Accordingly, the limit of safety, with respect to the absorption of lead from the one, must be established while the other is being held constant, and vice versa. This has been the object of two groups of special experiments at Kettering Laboratory.

In one set of experiments, groups of people were given a measured quantity of lead per day, in simulation of his ingestion of food contaminated with lead. In brief, they have set up the criterion for safety. On the basis of these and other experiments, it is altogether probable that a young, healthy adult can be expected to ingest, regularly, an average quantity of lead somewhat less than 0.6 mg. per day, without any risk of accumulating a significant quantity of lead in a life time.

A different situation arises, however, in measuring the amount of lead absorbed into the body by breathing. This, to begin with, cannot be determined directly, but must be calculated from a number of factors. The most satisfactory physiological criterion lies in the response afforded by the changes in the content of lead in the urine and blood. However, while analyses provide definitive evidence of the safety or the potential risk at the time of the analyses, they cannot yield information on which to predict the probable extent of the absorption that will ultimately occur when lead is being absorbed into the body at a constant, significant rate. This is the difference, and it is a fundamental physiological difference, between occupational exposure on 8 hours a day, 5 days per week, and community exposure, which is continuous through the 24 hours a day on 7 days a week.

These facts make it necessary to approach the criterion of public safety, in relation to lead in the atmosphere, on a different principle than that of the safety of employees in the lead-using industries. It is also necessary to employ a different method of observation from that concerned with the ingestion of lead.

In experiments under way at the Kettering laboratory, two humans have been subjected to atmospheric lead concentrations of 10 micrograms per

been under

the subjects have been spending ... days ...

experimental chamber. ~~They have not~~ ... trable

~~increase in the concentration of lead in their urine~~ ... expected

~~in the blood without some prior change in the urinary output.~~

Since this experiment has very nearly run its course, with negative results thus far, it seems necessary to begin again at a higher level of the concentration of lead in the chamber, so as to obtain barely positive results by which to describe, by extrapolation, conditions which are potentially dangerous. Such conditions will be in advance of the threshold of safety, which then will be located at a lower level. This is ~~a painfully slow process~~ slow work, but through ~~such~~ the results, a satisfactory criterion of public safety can be established on a physiological basis, with such margin of safety ~~as~~ may be considered to be prudent.

Professional men engaged in industrial hygiene and public health must accustom themselves to the quality of negativity in the results of ~~studies~~ ~~and~~ certain investigations. No one is impressed by negative findings, despite the fact that the public health must be described, in practice, in such terms, and that safety must be defined as the absence of hazard.

We are seeking, in this instance, not a disability nor a disease, but a threat. No such threat has been found, although the methods for detecting it have been sharpened in their sensitivity. In terms of present information, which has been sought systematically, the fact is clear.

No present hazard to the public health is represented by the lead dispersed in the air in association with the use of leaded gasoline. No increase

in the total intake of lead by persons in the general population in this country has been found. Moreover, the methods of investigation available at present are such that a sudden or gradually progressive increase in the lead content of the atmosphere, or, for that matter, in the intake and absorption of lead from any and all sources, can be detected before it reaches dangerous proportions.

In addition to this safeguard, it should be possible, before long, to supply criteria for reasonable standards of air quality, with respect to lead content, which will take into account the physical and physiological factors that influence the respirability and the absorbability of the compounds of lead found commonly in the atmosphere. Truly, this is a matter which is complex in itself, and one which must be balanced against the other sources of lead absorption.

A more satisfactory procedure, in relation to public safety, and one which must be employed, is that of making observations from time to time on representative groups in the population, by methods which will indicate the general sources and the order of magnitude of any significant changes in the exposure of the public to lead, and provide intelligent bases for hygienic control.

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