REPORT

SURGEON GENERAL'S AD HOC COMMITTEE

ON

TETRAETHYL LEAD

January 8-9, 1959
Washington, D. C.

U. S. Department of Health, Education, and Welfare
Public Health Service
Division of Special Health Services
Occupational Health Program
Washington, D. C.

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March 30, 1959

Surgeon General Leroy E. Burney
United States Public Health Service
Washington, D. C.

Sir:

The Committee appointed at your request to consider the public health hazard resulting from the proposed increase of tetraethyl lead from a maximum of three to a maximum of four cc per gallon of motor fuel met in Washington on January 8 and 9, 1959. Dr. H. J. Magnuson, Chief, Occupational Health Program, Public Health Service, served as chairman. Mr. Henry N. Doyle, Assistant Chief, Occupational Health Program, acted as reporter.

Prior to the meeting, the Committee members reviewed Public Health Bulletin 158 "Proceedings of a Conference to Determine Whether or Not There Is a Public Health Question in the Manufacture, Distribution or Use of Tetraethyl Lead Gasoline" (1925), and Bulletin 163 "The Use of Tetraethyl Lead Gasoline in its Relation to Public Health" (1926) and other related scientific publications made available by the Occupational Health Program. Additional background information was provided by one of the Committee members, Dr. William P. Yant, who had participated in the 1925 and 1926 conferences called by the Public Health Service to consider the health problem related to tetraethyl lead. These two previous conferences had also been attended by Dr. Robert A. Kehoe who participated in the first day of the present meeting as medical consultant to the Ethyl Corporation.

On January 8, the Public Health Service representatives defined the scope of the Committee's responsibilities and reviewed the history of the tetraethyl lead problem and the relationship of the Public Health Service to the manufacturers and distributors of tetraethyl lead.

Representatives of the Ethyl Corporation and the E. I. duPont de Nemours & Company presented technical and medical data relating to the proposed increase. The Ethyl Corporation estimates that should the recommended increase be effected, the concentration of tetraethyl lead in gasoline by 1963 would be 0.4 cc per gallon greater than would be the concentration if the 3 cc limit were continued. Without the increase, it was estimated that the tetraethyl lead in the U. S. pool gasoline would rise from 2.09 cc to 2.70 cc, and with the increase, to 3.07 cc per gallon. Estimates by the duPont Company were slightly lower than those offered by the Ethyl Corporation.

On January 9, the Committee met in executive session with technical representatives of the Public Health Service. The proceedings of the meeting and a summary of the data presented to the Committee are contained in the attached report.

The Committee wishes to point out that a conclusive answer is impossible at the present time because of the lack of medical data. While the data available to the present Committee are far more complete than those on which the 1926 Committee had to make its decision, the present group is concerned about the inadequacy of medical data on which to base a conclusive answer to the problem. It is regrettable that the investigations recommended by the Surgeon General's Committee in 1926 were not carried out. If data were now available on body lead burdens, with 1926 as a baseline, a more objective decision would have been possible. Such studies should be undertaken without further delay to assure the validity of the present decision and to guide future committees, particularly since some authorities believe that we are now close to the tolerable limits of lead absorption.

The Committee recognizes that the permissive amount of lead in drinking water may be lowered in the near future. Such action can be taken in view of the improvement in treatment methods for the removal of lead from water. The Committee would welcome similar efforts to reduce the amounts of lead in the atmosphere and was particularly interested in the reported research on the filtration of lead compounds from automobile exhaust in connection with studies of catalytic oxidizers.

The Committee concluded that (1) a change in the maximum concentration of tetraethyl lead in motor fuel from 3.0 to 4.00 cc would not increase the hazards involved in the manufacture and distribution of leaded gasoline and (2) available data do not indicate that such change would significantly increase the hazard to public health from air pollution.

Should the industry increase the concentration of TEL in gasoline, it is the recommendation of your Committee that:

1. The industry proceed cautiously with the increase so that the increase in any one year in the tetraethyl lead content of U. S. pool gasoline not exceed 0.25 cc, and the concentration of tetraethyl lead in U. S. pool

gasoline not be more than 3.2 cc per gallon at the end of five years.

2. The industry supply annually to the Public Health Service the domestic consumption figures for tetraethyl lead.

3. The Public Health Service, in collaboration with the manufacturers of tetraethyl lead, the petroleum industry and other appropriate organizations conduct studies to provide more definitive data on levels and trends of atmospheric lead contamination in selected urban areas and of the body burden of lead of selected population groups. If these studies should bring to light new data of significance, you may wish to reconsider the recommendation of this Committee.

Respectfully,

Leonard Greenburg, M.D.

H. H. Schrenk, Ph.D.

J. H. Sterner, M.D.

W. P. Yant, D.Sc.

S. H. Osborn, M.D.

Henry N. Doyle, Recorder

Harold J. Magnuson, M.D., Chairman

Enclosure

REPORT OF SURGEON GENERAL'S AD HOC COMMITTEE ON TETRAETHYL LEAD

JANUARY 8 & 9, 1959

INTRODUCTION

Early in 1923 tetraethyl lead (TEL) began to be used commercially as a gasoline additive to increase the efficiency of internal combustion motors. The possible dangers of such wide distribution of a very toxic lead compound aroused fear on the part of public health officials which was intensified when a number of fatal poisonings occurred in the manufacture and mixing of TEL. At the suggestion of the Surgeon General the distribution of TEL and the sale of leaded gasoline was temporarily discontinued on May 5, 1925.

On May 20, 1925, the Surgeon General called a conference of public health and interested authorities for "the determination of such facts and to the reporting of such investigations and experiences as may lead to a definite determination as to the hazards, if any, which follow the manufacture, distribution, and use of TEL and similar substances, not only to those who are engaged in the manufacture and distribution of the compound, but more particularly to the public at large." (1) From reports given at the conference on research conducted by the U. S. Bureau of Mines, Department of Interior, Department of Industrial Medicine, Columbia University, and the Medical College, University of Cincinnati as well as clinical observation it was concluded that TEL was a highly toxic industrial compound but that little or nothing was known of the public health hazard which would result from its use as a gasoline additive. In view of these findings the Conference adopted the following resolution:

"It is the sense of this conference that the Surgeon General of the United States Public Health Service appoint a committee of seven recognized authorities in clinical medicine, physiology, and industrial hygiene, to present to him, if possible, by January next, a statement as to the health hazards involved in the retail distribution and general use of TEL gasoline motor fluid; and that this conference indorse as wise the decision of the Ethyl Corporation to discontinue temporarily the sale of ethyl gas; that this investigation shall be paid for exclusively out of public funds; and the results of this investigation shall be reported back to a public conference called for the purpose by the United States Public Health Service, at which labor shall be represented." (2)

To carry out the mandate of the conference the Surgeon General appointed a working committee consisting of the following persons: Dr. A. J. Chesley, Health Officer, Minnesota State Board of Health; Dr. William H. Howell, Professor of Physiology, Johns Hopkins University; Dr. Reid Hunt, Professor of Pharmacology, Harvard University; Dr. Walter S. Leathers, Professor of Preventive Medicine, Vanderbilt University; Dr. Julius Stieglitz, Professor of Chemistry, University of Chicago; and Dr. C. E. A. Winslow, Professor of Public Health, Yale University. This committee met on June 15 and organized, with Dr. Howell as Chairman. Dr. L. R. Thompson, Chief of the Office of Industrial Hygiene and

Sanitation acted as secretary to the committee. The general scope of the investigation was agreed upon, and at the second meeting of the committee of June 29, 1925, Dr. J. P. Leake was entrusted with direct charge of the investigation. On December 22, 1925, the committee met to consider the full report on the investigation which had been conducted by the Office of Industrial Hygiene and Sanitation. (2)

The last meeting of the committee was on January 17, 1926, when the final report was drafted and signed, and subsequently issued as Bulletin 163, "The Use of Tetraethyl Lead and Its Relation to Public Health." This bulletin gives the results of a clinical study of persons exposed to TEL, a study of laboratory methods, findings of atmospheric and dust studies, and suggested recommendations and regulations. The clinical study did not give any decisive indication of lead poisoning among the chauffeurs or workers in garages where ethyl gasoline was used as a motor fuel.

The proposed regulations included:

I. Proposed regulations for the manufacture of TEL and the blending of the latter to make ethyl fluid.

II. Proposed regulations for mixing.

III. Proposed regulations for distribution of ethyl gasoline.

IV. Proposed recommendations for automobile garages, repair shops, service stations, and filling stations.

The complete regulations are contained in Appendix C of this report. These were presented to and approved by the Conference of State and Territorial Health Officers on May 25, 1926. It was proposed that these regulations be adopted by the several states in order to secure uniformity of control. The restriction on the sale and distribution of ethyl gasoline was removed shortly thereafter.

Following the 1926 Conference of State and Territorial Health Officers, the President, Ethyl Corporation agreed voluntarily to manufacture, blend, and market TEL and leaded gasoline in accordance with the intent of the recommended regulations. Apparently, this statement of intent removed the pressure for state regulations and established standardized nation-wide safety procedures. No state adopted these or modified regulations. In fact at the present there are no state or federal laws pertaining to the hygienic aspects of TEL. However, these recommended regulations were adopted as understandings by many national governments. Only one country, Venezuela, has adopted legislation regarding the safe handling of TEL. The recommended regulations have, however, been the basis for world-wide health and safety procedures on the part of TEL manufacturers and petroleum refiners.

When the E. I. duPont de Nemours Company began marketing TEL in 1946 the company indicated, by letter to the Surgeon General, its intention to abide by the intent of the recommended regulations.

Since 1926 it has been necessary to make several minor recommended revisions to the recommended regulations. These have been published in Public Health Reports, Vol. 43 (Nov. 1929, page 3147 and Vol. 61, Oct. 1946, page 1487). More recently a color system for aviation gasoline of various octane ranges was recommended for the U. S. Air Force. This system was adopted later as a standard by the

American Petroleum Institute.

In July and August, 1958, a representative of the Public Health Service (H. N. Doyle) visited the Baton Rouge plant of the Ethyl Corporation, the mixing plant of the Esso Standard Oil Company of Louisiana, and the Deepwater, Delaware plant of the DuPont Company. From these visits and interviews with technical and medical officials of these companies it was apparent that very high hygienic standards were being used in the manufacture, transportation, mixing and marketing of TEL and leaded gasoline.

In 1954 information furnished by the Bureau of Standards indicated that no sample of commercial gasoline analysed by the Bureau during the 1953 calendar year contained TEL in excess of 3.0 cc per gallon.

PURPOSE OF 1959 AD HOC COMMITTEE

The 1925 committee concluded "that 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 uses are controlled by proper regulations." This conclusion was qualified by stating that although the study was a most careful and conscientious investigation it was subject to criticism because of the relatively small number of individuals exposed to the effects of ethyl gasoline for a comparatively brief period of time. The committee also noted "It remains possible that, if the use of leaded gasoline 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." (2) In view of this the committee recommended that the study be continued to determine whether or not the use of tetraethyl lead in motor fuel may constitute a menace to the health of the general public after prolonged use or under conditions not now foreseen.

The recommendation of the committee that the amount of TEL be limited to 1 part in 1260 parts of gasoline (approximately 3 cc per gallon of gasoline) was not based on hygienic considerations but on the basis of commercial practice at the time of the study. This concentration has been adhered to by the industry. However, in 1934, after consultation with the Surgeon General, the TEL content of gasoline used solely for aviation purposes was increased to 4.5 cc per gallon.

On November 26, 1958, Mr. B. S. Turner, President, Ethyl Corporation, in a conference with the Surgeon General, sought the advice and guidance [illegible] the Public Health Service relative to increasing the maximum concentration of tetraethyl lead in automotive gasoline from 3.0 to 4.0 cc per gallon. Although the Public Health Service has no legal authority to control the amount of TEL in gasoline the Surgeon General stated that he would have an ad hoc committee appointed to advise if the proposed increase might represent a public health hazard.

At the request of the Surgeon General the following specialists in occupational health and toxicology were appointed by the Chief, Occupational Health Program as members of the Ad Hoc Committee on Tetraethyl Lead: Leonard Greenburg, M.D., Commissioner, Department of Air Pollution Control, City of New York; H. H. Schrenk, Ph.D., Managing Director, Industrial Hygiene Foundation, Mellon Institute; J. H. Sterner, M.D., Medical Director, Eastman Kodak Company; W. P. Yant, D.Sc., Director of Research, Mine Safety Appliances Co.; and Stanley H. Osborn, M.D., Commissioner of Health, Connecticut State Department of Health, representing the State and Territorial Health Officers' Association.

The Committee met on January 8 and 9, 1959, in Washington. The meeting was chaired by Dr. H. J. Magnuson, Chief of the Occupational Health Program, PHS, and Mr. H. N. Doyle, Assistant Chief of the Occupational Health Program, PHS, acted as reporter. In a liaison or technical capacity, the following individuals attended the meeting, in whole or in part: Ethyl Corporation: Dr. George Kirby, Vice President for Research; Dr. Robert A. Kehoe, Medical Consultant; and Mr. Richard Scales, Director of Research, Detroit Laboratory. E. I. duPont de Nemours and Company: Mr. J. R. Sabina, Assistant Planning Manager, Division of Petroleum Chemicals and Dr. John A. Zapp, Director of Haskell Laboratory. Public Health Service: D. J. Birmingham, M.D., Chief, Clinical Services, Occupational Health Field Headquarters; H. E. Stokinger, Ph.D., Chief, Toxicologic Services, Occupational Health Field Headquarters; W. M. Gafafer, D.Sc., Technical Adviser, Occupational Health Program; V. G. MacKenzie, Assistant Chief, Division of Sanitary Engineering Services; H. E. Heimann, M.D., Assistant Chief, Air Pollution Medical Program. Department of Health, Education and Welfare: S. Edelman, Assistant Chief, Public Health Division, Office of the General Counsel.

The Committee was in session from 10:00 a.m. to 4:30 p.m. on January 8, during which time the history of the relationship between the PHS and the manufacturers of TEL was presented by the PHS (contained in the Introduction); data on the technical reasons for the increase, the results of certain research studies, the consumption of TEL by year, and a review of the medical problem were presented by representatives of the Ethyl Corporation. Representatives of the DuPont Company made no formal presentation but did supply the committee with production figures and information on actual and estimated TEL demand on U. S. producers and aided in the clarification of technical points.

The Committee met in executive session with technical representatives of the PHS from 10:00 a.m. to 12:30 p.m. on January 9, 1959. The procedures of the Committee were in accordance with a Department of Justice directive dated October 19, 1950 of which the participants were so advised by the chairman. The agenda of the Committee is Appendix A.

CONSUMPTION OF TEL

The domestic consumption of TEL has shown a dramatic increase since it was first introduced in 1923 from 700,000 pounds to a high of 510,000,000 pounds in 1956 with a slight decrease in 1957 and 1958. The estimated domestic TEL consumption is shown in Table 1. Table 2 shows the average TEL content of domestic gasoline by year from 1924-1958. Table 3 gives the estimated projected consumption of TEL through 1963 based on both a 3 and 4 cc limit and Table 4 projects the estimated TEL content of gasoline for the period 1959-1963 on the same

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basis. The projections offered by the DuPont Company are slightly lower than those submitted by the Ethyl Corporation both in total demand for TEL and its concentration of gasoline. See Table 5 and Figure 1. Based on data supplied by the DuPont Company lead used in the production of TEL represents 15 percent of the over-all U. S. lead consumption.

Table 1. --Estimated domestic TEL consumption* ($\overline{M}$ lbs.)

Year	Automotive	Aviation	Total
1924	0.7	-	0.7
1925	0.3	-	0.3
1926	1.0	-	1.0
1927	1.9	-	1.9
1928	3.1	-	3.1
1929	8.5	-	8.5
1930	14.5	-	14.5
1931	15.8	0.2	16.0
1932	10.2	0.3	10.5
1933	19.1	0.4	19.5
1934	34.0	0.6	34.6
1935	38.2	0.8	39.0
1936	45.2	0.7	45.9
1937	56.6	1.2	57.8
1938	59.4	1.5	60.9
1939	79.8	1.5	81.3
1940	113.6	3.1	116.7
1941	138.0	7.4	145.4
1942	77.3	25.2	102.5
1943	90.5	62.5	153.0
1944	92.7	129.6	222.3
1945	126.6	91.6	218.2
1946	134.8	6.4	141.2
1947	154.7	13.9	168.6
1948	191	24	215
1949	210	24	234
1950	285	27	312
1951	261	43	304
1952	305	52	357
1953	365	58	423
1954	388	51	439
1955	432	55	487
1956	451	59	510
1957	440	58	498
1958	396	59	455

* Data supplied by Ethyl Corporation. Figures prior to 1945 include both domestic consumption and export, aviation figures include all U. S. military use regardless of site of operation.

Table 2.--Average TEL content of domestic automotive gasoline based on 3 cc limits*

Year	ml/gal.
1924	0.03
1925	0.01
1926	0.03
1927	0.04
1928	0.06
1929	0.15
1930	0.25
1931	0.26
1932	0.18
1933	0.33
1934	0.55
1935	0.58
1936	0.62
1937	0.72
1938	0.76
1939	0.96
1940	1.30
1941	1.40
1942	0.92
1943	1.25
1944	1.25
1945	1.48
1946	1.25
1947	1.34
1948	1.53
1949	1.59
1950	2.00
1951	1.69
1952	1.89
1953	2.15
1954	2.22
1955	2.28
1956	2.32
1957	2.22
1958	1.98

* Data furnished by the Ethyl Corporation.

* Table 3. --The Projected average TEL content of domestic automobile gasoline based on 3 and 4 cc limits

Year	3 ml.	4 ml.
1959	2.09	2.19
1960	2.29	2.40
1961	2.46	2.62
1962	2.60	2.84
1963	2.70	3.07

* Data furnished by Ethyl Corporation.

* Table 4. --Estimated TEL consumption 1959-63 in M lbs. for 3 and 4 cc limits

	Automotive			Total	
Year	3 ml.	4 ml.	Aviation	3 ml.	4 ml.
1959	423	443	59	482	502
1960	477	500	59	536	559
1961	530	565	58	588	623
1962	576	630	56	632	686
1963	615	700	54	669	754

* Data furnished by Ethyl Corporation.

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Table 5.--Tetraethyl lead demand on United States producers*

	Domestic Motor Gasoline			
	3 cc Limit		4 cc Limit	
Year	TEL Conc. cc/gal. Pool	TEL Demand MM lbs.	TEL Conc. cc/gal. Pool	TEL Demand MM lbs.
1958	2.00	376	2.00	388
1959	2.10	418	2.10	418
1960	2.10	436	2.13	441
1961	2.20	473	2.23	480
1962	2.20	492	2.26	505
1963	2.25	524	2.30	532
1964	2.25	543	2.39	577
1965	2.25	560	2.42	605
1966	2.25	580	2.52	650
1967	2.25	601	2.55	680

Note: 30% Premium, 70% Regular ratio assumed.

	1958	Premium	TEL Content	2.5 cc/gal.
		Regular	" "	1.8 "
3 cc Limit	1967	Premium	" "	2.75 "
		Regular	" "	2.05 "
4 cc Limit	1967	Premium	" "	3.6 "
		Regular	" "	2.2 "

* Data by E. I. du Pont-de Nemours & Co. (Inc.)

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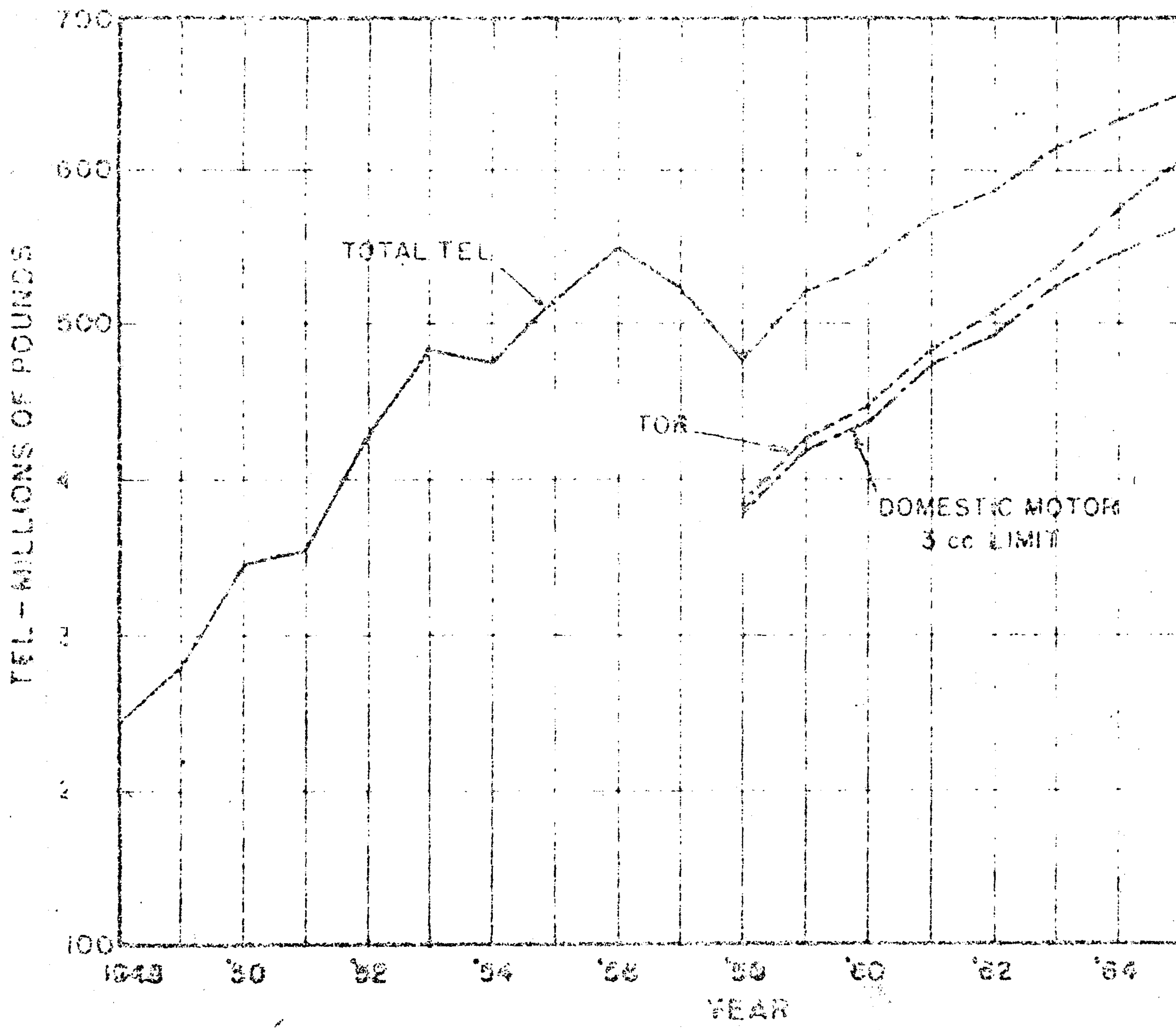
ACTUAL AND ESTIMATED TEL DEMAND ON US PROD



(1) Furnished by E. I. DuPont de Nemours & Company, Inc.

HEALTH AND ENVIRONMENTAL DATA

The Public Health Service has no knowledge of any cases of clinical lead poisoning having occurred in the manufacture, blending, mixing, or use of TEL and leaded gasoline since the adoption of the recommended regulations of the 1925 Committee. There have been, however, some deaths and clinical cases reported due to the cleaning of tanks which contained leaded gasoline. Tank cleaning was outside the scope of recommended regulations but safety procedures which have been taken by the manufacturers of TEL and the petroleum companies should prevent further disability.

There have been no studies on large population groups to follow up the 1925 investigation which would indicate the effect that the addition of TEL to gasoline has had on the total body burden of lead. This is information which is vitally needed by the present committee. It is known, however, that in addition to lead discharged by motor vehicles the population is exposed to other sources of lead in the atmosphere and that the body accumulates lead through food, water, and tobacco. Research has shown that for individuals with no industrial lead exposure blood lead concentrations range from 0.01 to 0.06 mg. per 100 grams of whole blood and urine lead ranges from 0.01 to 0.08 mg. per liter. It would be fallacious to compare these values with similar values obtained before the widespread use of TEL because of the vastly improved microanalytical methods for determining lead. Kehoe reports having found measurable amounts of lead in clinical specimens of a remote Central American tribe whose only source of lead was that inherent in the food and water supply and that which may have been present in the atmosphere. (3) On the other hand a considerable body of information is available on the concentration of lead in the atmospheres of metropolitan areas. A 5- year atmospheric pollution study of Cincinnati, Ohio found atmospheric lead values ranging from 0.1 to 11.5 micrograms per cubic meter of air with an average of 1.2 micrograms in rural area, 2.0 in residential area, 3.2 in industrial area and an average of 2.7 micrograms for all areas. (4) The most comprehensive data comes from the National Air Sampling Network of the Public Health Service. (5) From values obtained in 15 U. S. cities the atmospheric lead values ranged from a high of 9.5 micrograms in Philadelphia to a low of 0.5 micrograms per cubic meter in Minneapolis. (Table 6) These do not necessarily represent maximum concentrations or comparable values as the sampling site varied from city to city and was seldom in the heaviest traffic or industrial area.

Table 6.--Particulate atmospheric lead concentrations in selected cities

City	Average values, micrograms per cubic meter
Over 2,000,000 population	
Los Angeles	5.2
Detroit	2.9
Philadelphia	9.5
Chicago	2.8
New York	2.8
From 500,000 to 2,000,000	
Cincinnati	1.6
Kansas City	1.0
Portland	1.2
Atlanta	1.8
San Francisco	2.4
Minneapolis	0.5
Less than 500,000	
Fort Worth	0.8
Charlestown	1.1
Louisville	0.6

Values obtained in nonurban areas in the vicinity of certain cities range from 0.1 - 0.9 micrograms per cubic meter. A more recent report of the Public Health Service gives maximum, minimum, average lead concentrations and monthly averages in 30 cities participating in the national air sampling network. Average values ranged from 1 - 57 micrograms of lead per cubic meter and pronounced seasonal variations are apparent. (6)

The generally accepted Maximum Allowable Concentration for industrial exposure based on an 8 hour workday is 200 micrograms per cubic meter.

- Pages 22 to 47 and Pages 61 to 64 -

The following reports and technical data were supplied by the Ethyl Corporation to the Ad Hoc Committee. Since there are copies in the Ethyl Corporation's files, they are merely listed by name below and not reproduced in full.

(1) "Technical Aspects of Increasing the Limit on Tetraethyl Lead Concentration", presented by Dr. George F. Kirby, Vice President, Research and Development, Ethyl Corporation, January 8, 1959.

(2) Ethyl Corporation Research Laboratories memorandum, January 14, 1959, Subject: "Lead Concentration in Undiluted Exhaust Gas", by D. A. Hirschler.

(3) Ethyl Corporation Research Laboratories memorandum, January 14, 1959, Subject: "Lead Retained by Automobiles", by D. A. Hirschler.

(4) Ethyl Corporation Research Laboratories memorandum, January 14, 1959, Subject: "The Influence of Compression Ratio and Fuel Tetraethyllead Content on Oxides of Nitrogen Concentration in Automotive Exhaust", by H. E. Hesselberg.

(5) Ethyl Corporation Research Laboratories memorandum, January 14, 1959, Subject: "The Influence of Tetraethyllead Concentration on Catalytic Converters", by H. E. Hesselberg.

(6) Abstracts of Special Reports Furnished by Ethyl Corporation

  (a) "Oxides of Nitrogen in Engine Exhaust Gas", by Gilbert, Hirschler and Getoor. Presented at 132nd meeting, A. C. S., September 9, 1957.

  (b) "Particulate Lead Compounds in Automobile Exhaust Gas", by Hirschler, Gilbert, Lamb and Niebylski. Reprinted from I&EC, July 1957.

(c) "Filtration of Particulate Lead Compounds from Automobile Exhaust Gas", by Gilbert. Project No. 8U5-M, Research Memorandum No. 209. January 13, 1959. Restricted Release.

(d) "Catalytic Oxidation of Automobile Exhaust Gases--An Evaluation of the Houdry Catalyst", by Nebel and Bishop. Preprint of paper for presentation at SAE Annual Meeting, Detroit, Michigan, January 12-16, 1959.

The Hygienic Aspects of a Proposed Increase in the Maximum Limit of the Concentration of Tetraethyl Lead in Motor Gasoline to Four Milliliters per American Gallon. A memorandum prepared by Robert A. Kehoe, M.D., Medical Consultant, Ethyl Corporation. (Abstracted by H. N. Doyle. Full memorandum issued as a supplement to this report).

Dr. Kehoe's report, an expansion of his remarks to the committee, is divided into two sections: -- (1) the consideration of health hazards involved under present conditions and under those projected on the basis of an elevated limit; and (2) consideration of the public health hazard involved under present conditions and under those projected on the basis of an elevated concentration of TEL gasoline.

In Section 1, Dr. Kehoe treats, in considerable detail, the hazard to workers involved in the manufacture, blending, transportation, storage and use of TEL and leaded gasoline. He points out rather clearly that increasing the concentration of TEL from 3 to 4 milliliters per American gallon would not increase the hazard to the worker under any conditions of use or transportation of TEL or leaded gasoline. The hazard due to manufacture and storage may be magnified due to the larger amounts of TEL involved, but there is no reason to suspect that this could not be adequately controlled.

Since adequate hygienic precautions were instituted in the manufacture, transportation and use of TEL, there have been no significant cases of lead intoxication in exposed personnel. The first warning of the existence of a special problem in connection with the storage of leaded gasoline came in 1928 when a small group of men registered certain unusual complaints of illness in connection with the cleaning of tanks that had been out of service for several months following a period of extended use for storage of leaded gasoline.

By 1940, there had been 80 well documented cases of poisoning in the continental U. S. in connection with the tank cleaning and repair operations, with about 15 fatalities. It was apparent by this time that drastic measures had to be taken to secure complete compliance with the precautions. Accordingly, the Ethyl Corporation (at that time the only distributor of TEL) decided to use the members of its technical and sales field staff for the supervision of all tank cleaning operations in the U. S. Since the institution of these safety precautions (also adopted by the Dupont Company) the incidence of poisoning in the U. S. resulting from tank cleaning operations has been essentially nonexistent.

Potential public health problems result from the use of tank cars in which leaded gasoline has been shipped for cargoes of edible oils and other foodstuffs, the use of leaded gasoline in gasoline lanterns, and the practice, especially in foreign countries, of using small leaded gasoline containers for household purposes. There has been no evidence at this time to indicate that these procedures have represented any hazard to the general public. Should these in fact be problems, the increase of 1 cc per gallon of TEL would hardly intensify the public health problem due to the misuse of leaded gasoline or the transportation of foodstuffs in tank cars which have contained leaded gasoline. This latter practice is discouraged but cannot be entirely prevented, especially in emergency periods when there is a shortage of tank cars.

Section 2 of Dr. Kehoe's report deals with the potential hazard to the general public resulting from the use of lead in internal combustion engines and has a comprehensive discussion of the metabolism of lead by the human body.

(1) Lead in the atmosphere of American cities with special reference to that derived from the exhaust of motor vehicles.--TEL is decomposed to inorganic lead compounds in the combustion chambers of internal combustion engines. Under present conditions, a large proportion of the exhausted lead is the double salt lead chlor-bromide. It is possible that minute quantity of TEL escapes combustion, but under ordinary circumstances, little opportunity is afforded for TEL to escape from the exhaust system. The metabolism of lead in an internal combustion engine has been thoroughly studied. It has been determined that a large percentage of the lead accumulates in the motor and exhaust system. Under conditions of high speed driving and rapid acceleration, the internal combustion engine discharges more lead into the atmosphere than it accumulates. The lead discharged under these conditions is in the form of scale and shreds, although some of it is volitalized. Under usual conditions of city driving, the discharge of lead into the air is low because of the relatively low consumption of fuel, and the condensing effect of the exhaust system. The same is true to a greater or lesser degree when driving in congested areas of a city. Because of the prominence of small size lead particles in the exhaust during slow speed driving, the lead so discharged is readily dissipated by air currents. In whatever dilution it occurs in the breathing zone of man, the lead is respired and absorbed readily.

(2) The source of lead in urban atmospheres.--It appears to

have been assumed by many persons and even by some investigators that the lead found in the atmosphere of cities and in the open countryside is derived from the combustion of leaded gasoline. There were few recorded determinations of atmospheric lead concentrations prior to 1924 when TEL was introduced as a gasoline additive. A few early observers, however, found lead and many other elements in the atmosphere but these were found in traces by the available methods. These values were of scientific interest, but of little hygienic importance, according to the usual view. These studies are complicated by the further fact that precise measurements of lead in the atmosphere have been made possible only by the technicological developments of fairly recent years and only since TEL came into use as a motor fuel. There are many sources of atmospheric lead contamination in addition to TEL. These include the combustion of wood and other vegetation, the finely divided soil in the atmosphere as well as dust and fumes from a multiplicity of sources, including the stacks of industry.

The extent of the contribution made to the lead content of the atmosphere by the combustion of TEL in automotive fuels has been difficult to determine or even to approximate. Measurement of the lead in the air along the course of certain streets and highways has shown significant quantitative variation in correlation with wide variations in the density of motor traffic, but the actual proportion or quantities derived from the exhaust of the motors cannot be estimated from the data so gathered. These statements are made not to minimize the importance of the problem but only to emphasize its complexity and to direct the discussion to its essential point, namely, that we are concerned now and in the future with the total quantity of lead in the atmosphere and not solely with the atmospheric lead derived from automobile exhaust.

(3) The quantities of lead in the urban atmospheres.--The most comprehensive information on the quantity of lead in urban atmospheres has been obtained in Cincinnati and its environs. Data obtained in Los Angeles and Pasadena in 1954 as well as data gathered from other cities, are especially useful in revealing maximum and minimum values. In Cincinnati, the concentration of lead in the atmosphere varies widely according to the sampling spot from somewhat less than one to more than six micrograms per cubic meter of air. These values increase as one goes from rural zones outside the city to suburban, business and industrial areas. There were also variations according to the seasons, the lower values being obtained in warm weather, and the higher values in cold. The average concentration in Cincinnati was somewhat less than 2 micrograms per cubic meter.

Surveys made in other Eastern and Middle Western cities are in harmony with observations made in Cincinnati. Relatively low but not remarkably divergent results have been obtained in Minneapolis and Louisville while higher but again not grossly divergent values have been observed in such areas as Los Angeles and Philadelphia.

Considering the variability of lead in the atmosphere of our cities, as well as other variable circumstances, it is impossible to arrive at any precise estimate of the quantity of lead which is inhaled by the "average" person in the course of an "average" day. It is even more difficult to estimate the largest quantity to which any person may be exposed in this manner over a period of months without sustaining a significant increase in the lead content of the body. On the basis of certain assumptions, it is possible that the average man may absorb a quantity of lead in the order of 0.038 milligrams per day. Inasmuch as the assumptions made in this calculation are believed to err on the high side, this figure should not be taken too literally. The quantity may be nearer to half this value and other observations to be discussed later indicated that it may not be far from 0.02 milligrams per day on the average over a period of years.

(4) The general sources of human exposure to lead and the approximate contribution made by each source to the total exposure.-- The average adult North American takes in approximately 0.33 milligrams of lead per day in food and beverages. The quantities of lead in the daily food intake vary from somewhat less than 0.1 milligrams to 4.0 milligrams, but the mean daily intake is quite stable and the pattern has repeated itself regularly over a considerable period of time. Of this quantity, 0.01 to 0.03 milligrams per day are derived from water used for cooking and as a beverage. The remainder is distributed in fairly small quantities over a wide variety of foods and beverages which contain lead from both natural and artificial sources. The quantities of lead evacuated in the feces of the average North American adult are approximately equivalent to those ingested with his food and beverage. This information, gained in a variety of experimental approaches to the question, indicates that somewhat less than 10% of the lead ingested in these small quantities is absorbed. That some alimentary absorption of lead occurs can be

demonstrated more readily and more certainly through observations made on the excretion of lead in the urine from day to day. It is evident that the daily urinary output of lead varies with the alimentary intake of lead and thus it may be ascertained that lead is absorbed regularly from the alimentary tract. Such absorption under normal conditions is nearer to 5% of the daily alimentary intake than it is to 10%, but there are variations in this respect which would be extremely difficult to describe or explain in detail.

The excretion of lead in the urine of the average normal North American adult amounts to about 0.03 milligrams per day when the urinary output averages about 1 liter per day. The lead content of blood of normal healthy American adults is much less variable than that of the urine, ranging from 0.02 milligrams to 0.06 milligrams per 100 grams of whole blood and averaging somewhat less than 0.03 milligrams. The mean lead content of other body tissues varies widely from 0.01 milligrams per 100 grams of fresh muscle tissue to 1.50 milligrams per 100 grams of rib and long bone. The variation from individual to individual is appreciable but is not remarkable in view of the variations in height and weight, occupations, length of life and in dietary habits. In balanced experiments in which normal healthy North American subjects were followed for 13 and 18 months respectively during which the daily intake of lead in food and beverages was determined by the analysis of duplicate samples of everything eaten and drunk and the dail output in the feces and urine, it was determined th... put of lead was found to exceed the intake systematically by about 8 milligrams per year or by calculation, about

0.02 milligrams per day. This metabolic discrepancy whereby the output of lead exceeded the intake can only be an expression of a source of lead absorption which was not accounted for in the design of the balance experiments. Such a source existed without doubt in the air inhaled by the experimental subject.

The capacity of the tissues for accumulating lead is considerable, and if progressive accumulation does not occur under normal conditions, it must be because the human body once in equilibrium with its environment at a low level of lead intake and absorption is able to maintain itself in an essentially steady state with reference to its lead content through excretionary loss. The excretionary processes are highly responsive to variations in the absorption of lead and they appear to be entirely capable of eliminating the regular stream of absorbed lead [illegible] to day so long as this stream varies reasonably within normal limits.

(5) <u>The metabolism of lead under abnormal conditions</u>.--Investigations of occupational conditions and personnel as well as experimental subjects have provided evidence as to the limits of safe levels of exposure on the basis of physiologic criteria. The general rate of urinary excretion of lead by workmen without renal impairment who have been exposed to lead under reasonably uniform occupational conditions for long periods of time gives a valid clue to the severity and hygienic significance of the exposure.

When the mean level of concentration of lead in the urine does not exceed 0.1 milligrams per liter, the conditions of exposure are safe or have been within the limits of safe exposure during the period preceding the time of sampling. When this value exceeds 0.15 milligrams of lead per liter, occasional case [illegible] soning may occur in the group. As the excretion exceeds 0.15 milligrams per liter, cases of poisoning among the group increase both in number and severity.

The blood may also be used as an index of exposure, but the blood level lags somewhat behind the excretionary level. Experiments have shown that when blood levels do not exceed 0.07 milligrams per 100 grams of blood, the occupational conditions are safe or have been within the limits of safety preceding the time of sampling. Blood lead concentrations in excess of 0.08 milligrams per 100 grams indicates that the individual has sustained a dangerous level of lead absorption and retention and may develop symptoms of lead intoxication. The extent that the level exceeds 0.08 milligrams per 100 grams of blood evidences an increasing incidence and severity of lead intoxication.

The rate of urinary excretion of lead increases stepwise over a period of several months until it reaches a peak which then stabilizes at a level characteristic of the level of lead exposure associated with the occupation. After this stabilization, any significant trend either upward or downward may be regarded as an expression of the deterioration or improvement in the occupational conditions. Lead levels in the range 0.01 to 0.06 milligrams per 100 grams of blood are indicative of safe occupational exposures. Levels between 0.06 and 0.08 per 100 grams are abnormal and indicate definite lead absorption but within safe limits. Values above 0.08 milligrams per 100 grams point to the necessity of terminating the occupational exposure to lead either temporarily or permanently as the circumstances may dictate.

[illegible] possible to express the sev[illegible]
occupational exposure to lead compounds in terms of environmental measurements with anything like the precision represented by the physiologic measurements referred to above.

The daily addition of a soluble salt of lead in a quantity in the order of 0.03 milligrams (thereby doubling the daily alimentary intake of lead) over a period of a year resulted in a slight but significant and progressive increase in the retention of lead in the body, a very slight progressive increase in the urinary output of lead but no measurable increase in the concentration of lead in blood. The addition of larger quantities of soluble lead in the diets of three other experimental subjects in order to provide a total mean intake of lead in the order of 1.3, 2.3 and 3.3 milligrams per day resulted in a prompt and progressive increase in the output of urinary lead, which varied directly with the magnitude of the increased lead input. The rates of accumulation of lead in the bodies of the subjects as well as the rate of increase in the concentration of lead in their urine and blood did not diminish as time passed. The increase persisted apparently at an undiminished annual rate for as long as two years in one experiment and four years in another. However, none of the human subjects sustained any injurious effects or any deviation from good health or well being during any part of the experimental regimen.

It would appear that the absorption of lead from the alimentary tract is within the limits of safety when the average amount available for absorption is on the order of 0.6 milligrams per day. It seems likely that an alimentary intake of about twice this amount, while devoid of danger over a period of 4 or 5 years, would not be tolerated without significant probability of an injurious effect over a period of 10 or more years. It appears that about 60 micrograms of lead can be absorbed daily from the alimentary tract with safety while the absorption of 120 micrograms per day is potentially dangerous. If this be a reasonably valid conclusion, it follows that an incremental increase in any type of human exposure to lead that would result in the additional absorption of about 30 micrograms of lead per day would be within the limits of safety, while an increase in absorption on the order of 90 or more micrograms per day may be harmful.

To determine the response of human experimental subjects to the inhalation of abnormal quantities of lead, a series of balance experiments have been under way. Healthy human subjects have been followed before, during and after prolonged periods (2 years or more) of exposure in a chamber for 7.5 hours per day, 5 days per week, to air containing dispersed lead sesquioxide in concentrations equivalent to 0.075 milligrams (one experiment) and 0.15 milligrams (5 experiments) of lead per cubic meter. Mean diameters of the particle size were 0.05, 0.75 and 1.2 microns. When the concentration of lead sesquioxide in the chamber was equivalent to 0.075 milligrams of lead per cubic meter of air, the blood stabilized in about six months at 0.04 milligrams per 100 grams of whole blood. At the exposure level, equivalent of 0.15 milligrams of lead per cubic meter, the stabilized level of 0.045 milligrams per 100 grams of whole blood was reached after about eight months. The mean urinary excretion level paralleled that in the blood levelling off at about 0.06 milligrams per liter in the first experiment and at about 0.08 milligrams per liter in the second experiment. Thus, it is evident that ... 16.5 hours per day of freedom from experimental exposure ... 5 days of the week together with the complete lack of experimental exposure on 2 days was sufficient after some lead had accumulated in the body to counterbalance the effects of the experimental exposure. An approximate equilibrium was established in the body between the weekly absorption and weekly excretion of lead. The breathing of air containing lead in the concentration of 0.15 milligrams per cubic meter with a mean particle diameter of 0.05 microns did not induce a dangerous level of lead absorption in the body of the experimental subject after more than two years of exposure. In view of the mean concentration of lead found in the urine and blood of the subject at the termination of the experiment, the margin of safety of the experimental condition was large. The determination of the extent of the alveolar retention of lead under the experimental conditions demonstrated that this was in the order of 35 to 50%. These levels would not simulate the exposure of an urban population to lead derived from the exhaust of automobiles or other sources of atmospheric pollution. The results, therefore, do not define the margin of safety of the general population in terms of any presently known or calculable maximum allowable concentration of lead in the general urban atmosphere. There can be little question, moreover, as to the adequacy of the presently accepted standard of safety for respiratory occupational exposure in which the lead compounds are dispersed in a comparable state of subdivision in the atmosphere.

(6) <u>The significance of lead in the atmosphere of cities at the present time and the outlook for the future from the aspect of an increase in the discharge of lead compounds from the exhaust of motor vehicles.</u>--The evidence demonstrates conclusively that the contribution made by the TEL contamination of the atmosphere to the total absorption of lead by the American population has been remarkably small in either relative or absolute terms and that it has been minute physiologically and insignificant hygienically, despite the gross increase in the use of TEL from a few hundred thousand pounds in 1926 to four hundred million pounds in 1958. During the past eleven years, during which the greatest expansion of TEL has occurred, there has been no sign that the average individual in the U. S. has sustained any measurable increase in the concentration of lead in his blood or in the daily output of lead in his urine. In detailed and prolonged study of experimental subjects within the Kettering Laboratory, no evidence has been seen of any quantitative alteration in the normal metabolism of lead nor has there been any suggestion of an increase in the levels of lead concentration in the urine and blood of normal individuals from many walks of life and many areas of the country.

On the other hand, time is the important factor in the development of a physiologic response to the absorption of minute quantities of lead. It may be that the influence of this factor is yet to be recognized fully in relation to this problem. Should this be true, further investigations will reveal its influence long before any harmful effects will have been induced unless there is deleterious effect as yet unsuspected of prolonged exposure to slightly larger quantities of lead than those present in the normal environment of man. Our concern over the hygienic effect of an increase in the permissive amount of lead in gasoline has been replaced by the assurance that the effects of the proposed changes could be established in advance of any harmful consequences by applying the methods of investigation that have provided the present background of information.

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3. Kehoe, R. A., F. Thamann, and J. Cholak: Normal absorption and excretion of lead. J.A.M.A. 104: 90-92 (January 12) 1935.

4. Cholak, J., L. J. Schafer and R. F. Hoffer: Results of a five-year investigation of air pollution in Cincinnati. A.M.A. Arch. Indust. Hyg. and Occup. Med. 6: 314-325 (October) 1952.

5. Chambers, L. A., M. J. Foter and J. Cholak: A comparison of particulate loadings in the atmospheres of certain American cities. Proc. Third Nat. Air Poll. Symp., Pasadena, Calif., April 18-20, 1955.

6. Air pollution measurements of the national air sampling network. Public Health Service Publication No. 637, United States Public Health Service. Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, 1958. (Processed)

Agenda [illegible]

Department of Health, Education, and Welfare
Public Health Service
Bureau of State Services
Division of Special Health Services
Occupational Health Program

Ad Hoc Committee to the Surgeon General
on
Tetraethyl Lead

January 8 and 9, 1959
Room 3652
General Services Administration
Regional Office Building
7th and "D" Streets, S.W.
Washington, D. C.

Subject for discussion: Does the increase from 3 ml to 4 ml of tetraethyl lead per gallon of gasoline represent a public health hazard?

Agenda

1. Introduction	Dr. Magnuson
2. Background	Mr. Doyle
3. Charge to the Committee	Dr. Magnuson
4. Technical and Economic Developments regarding Tetraethyl Lead	Dr. Kirby Ethyl Corp.
5. Remarks for the DuPont Company	Mr. Sabina and Dr. Lapp
6. The Medical Problem regarding Tetraethyl Lead	Dr. Kehoe
7. Committee Discussion	
8. Summary of Action	Dr. Magnuson

Participants and Observers

Committee

Dr. James H. Sterner, Medical Director, Eastman Kodak Co.
Dr. Leonard Greenburg, Commissioner, Department of Air Pollution Control, City of New York
Dr. William P. Yant, Director of Research, Mine Safety Appliances Company
Dr. Helmuth H. Schrenk, Managing Director, Industrial Hygiene Foundation
Dr. Stanley H. Osborn, Commissioner of Health, Connecticut Department of Health

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Ethyl Corporation

Dr. Robert A. Kehoe, Medical Consultant
Dr. George Kirby, Vice President for Research
Mr. Richard Scales, General Manager, Detroit Research Laboratories

E. I. duPont de Nemours & Co. (Inc.)

Mr. J. R. Sabina, Assistant Planning Manager, Division of Petroleum Chemicals
Dr. John A. Zapp, Director, Haskell Laboratory

Department of Health, Education, and Welfare

Mr. Sidney Edelman, Assistant Chief, Public Health Division, Office of the General Counsel

Public Health Service

Dr. A. L. Chapman, Chief, Division of Special Health Services
Dr. H. J. Magnuson, Chief, Occupational Health Program
Mr. H. N. Doyle, Assistant Chief, Occupational Health Program
Dr. D. J. Birmingham, Chief, Clinical Services, Occupational Health Program
Dr. H. E. Stokinger, Chief, Toxicologic Services, Occupational Health Program
Dr. W. M. Gafafer, Technical Adviser, Occupational Health Program
Mr. V. G. MacKenzie, Assistant Chief, Division of Sanitary Engineering Services
Dr. H. E. Heimann, Assistant Chief, Air Pollution Medical Program
Mr. J. M. Horstkamp, Chief, Special Services Branch, Bureau of State Services

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APPENDIX B

List of Materials Furnished Committee Prior to Committee Meeting

Proceedings of a conference to determine whether or not there is a public health question in the manufacture, distribution, or use of tetraethyl lead gasoline. Public Health Bulletin No. 158, United States Public Health Service. Government Printing Office, Washington, 1925.

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Kehoe, R. A., J. Cholak, D. M. Hubbard, K. Bambach, R. R. McNary, and R. V. Story: Experimental studies on the ingestion of lead compounds. J. Indust. Hyg. & Toxicol. 22: 381-400 (Nov.) 1940.

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Kehoe, R. A.: Exposure to lead. Occupational Medicine 3: 156-172 (Feb.) 1947.

Cholak, J.: The nature of atmospheric pollution in a number of industrial communities. Proc. Second Nat. Air Poll. Symp., Pasadena, Calif., May 5-6, 1952.

Cholak, J., L. J. Schafer, and R. F. Hoffer: Results of a five-year investigation of air pollution in Cincinnati. A.M.A. Arch. Indust. Hyg. and Occup. Med. 6: 314-325 (Oct.) 1952.

Abstracts from the Bulletin of Hygiene, 1954-1958, on the health aspects of tetraethyl lead. Abstracts of the following papers were included:

Savicevic, M. (Our first cases of poisoning with lead-tetraethyl) Bull. Inst. Hyg. Belgrade 2: 46-63, 1953. (In Serbian)

Hessmer, H. Zur klinischen Begutachtung gewerblicher Bleivergiftungen. (Clinical assessment of industrial lead poisoning) Med. Klin. 49: 218-223 (Feb. 5) 1954.

Jacklin, L. Bleistaub in der Luft. (Lead dust in the atmosphere) Schweiz. med. Woch. 28: 685-686 (July 9) 1955.

Dattling, J. Zur hygienisch-toxikologischen Bedeutung von Bleistaub aus dem Auspuff von mit bleitetraethylhaltigem Benzin betriebenen Motoren. (Hygienic and toxicological importance of lead dust in exhausts of motors driven by tetraethyl lead petrol) Arch. f. Gewerbepath. u. Gewerbehyg. 13: 624-636, 1955.

Jacklin, L. Untersuchungen uber den Bleigehalt der Auspuffgase beim Benzinmotor. (Investigations of the lead content of exhaust gases from petrol engines) Arch. f. Gewerbepath. u. Gewerbehyg. 14: 626-630, 1956.

Giammarco, E. Importanza dall'avvicendamento mensile nei reparti di produzione del piombotetraetile attraverso l'esperienza di cinque anni di osservazione clinica. (Importance of monthly shifts in lead tetraethyl production departments as seen after five years of clinical examination) Med. d. Lavoro. 47: 539-547 (Oct.) 1956.

Chambers, L. A., M. J. Foter, and J. Cholak: A comparison of particulate loadings in the atmospheres of certain American cities. Proc. Third Nat. Air Poll. Symp., Pasadena, Calif., April 18-20, 1955.

KE 0009386

APPENDIX

Regulations from Public
Health Bulletin 163 (1926)

These regulations have been formulated in accordance with the recommendations of the Surgeon General's committee, under whose direction the investigation into the hazards from tetraethyl lead gasoline was conducted. They are proposed for adoption by the several States in order to secure uniformity of control and were the subject of consideration at the meeting of the State and Territorial health authorities with the Surgeon General on May 25, 1926. These regulations are based upon present conditions and knowledge and it is appreciated that changes may be advisable from time to time.

By the term "tetraethyl lead" is meant the chemical substance $Pb(C_2H_5)_4$ of a commercial grade of purity or higher. Ethyl fluid is the concentrated commercial fluid containing tetraethyl lead and other ingredients, which is to be mixed with gasoline to make ethyl gasoline. The manufacture of ethyl fluid consists in adding these other ingredients to tetraethyl lead and is called "blending." The process of adding the ethyl fluid to gasoline to form ethyl gasoline is called "mixing." In the term "ethyl gasoline" as herein used are included all other motor fluids containing tetraethyl lead.

I. Proposed Regulations for the Manufacture of Tetraethyl Lead and the Blending of the Latter to Make Ethyl Fluid

1. No person shall be employed without adequate instructions as to the nature of the hazard and the precautions to be taken.

2. Each worker shall have a periodical physical examination, which shall consist of such physical and other tests as are indicative of the absorption of tetraethyl lead and shall include, as a minimum, the following items:

(a) Examination of blood for stippling by carefully trained workers, using positive and negative controls, without knowledge of the source of the slides; this examination shall be once a week for the first three weeks and bimonthly thereafter.

(b) Semimonthly contact with plant physician for informal statement as to general health.

(c) Bimonthly weight, stripped.

(d) Bimonthly systolic and diastolic blood pressure estimation while sitting.

(e) Bimonthly hemoglobin estimation by Dare's hemoglobinometer.

3. Exact records of examinations shall be kept, and persons showing gradually increasing amounts of stippling, sudden development of stippling, or other marked deviation from normal shall be promptly excluded from tetraethyl lead work, irrespective of whether or not such finding may be indicative of lead poisoning. All parts of the plants where lead in any form is used shall be subject to sanitary measures to prevent collection and dissemination of lead dust.

4. Separate ventilation systems shall be provided for the manufacturing apparatus and for the air of the rooms, the outlets of the latter being located near the floor of each room and all external inlets and outlets being so situated as to avoid dustiness and appreciable contamination of the air around the plant.

5. Daily inspection shall cover efficiency of ventilating systems, all joints, valves, and gaskets of manufacturing apparatus, and adequacy of pressure-hose respirators.

6. All containers of ethyl fluid or tetraethyl lead shall be labeled as to exact content and danger and shall conform to the regulations of the Interstate Commerce Commission. These containers shall be carefully tested for leaks and shall bear a plainly legible label stating that they are to be closed tight immediately when emptied, without cleansing, and sent back to the plant.

7. Kerosene or other material used for cleansing the used containers of ethyl fluid or tetraethyl lead shall be placed in the containers by means of a closed system with air vents to outside air and with adequate ventilation.

8. The filling shall be performed by means of a closed system with air vent from the container to the outside air, and with adequate ventilation.

9. A dye shall be added to ethyl fluid in sufficient amount to give staining qualities to the ethyl gasoline to deter individuals from using it for cleansing or other similar purposes.

10. Reports shall be made monthly to the appropriate officer of the State concerned covering the following points:

Number of workers employed at beginning of month.

Number of workers employed at close of month.

Number of new workers.

Number of workers separated from tetraethyl lead work on account of results of examinations.

Number of definite cases of poisoning.

Condition of cases of poisoning previously reported so far as known.

II. Proposed Regulations for Mixing

1. The maximum content of tetraethyl lead in commercial ethyl gasoline shall be in the proportion of 1: 1,260 by volume for commercial tetraethyl lead, or 1: 1,300 for Pb $(C_2H_5)_4$ C.P.

2. Mixing ethyl fluid with gasoline except for certain specific requirements such as research, military and naval use, and air-mail service shall be done only at the main distribution centers and in not less than tank-car lots. Adequate provision shall be made at each such center for thorough mechanical distribution of the ethyl fluid throughout the gasoline, and the efficiency of such distribution shall be controlled by the analysis of samples.

3. The locations of these centers and the names of persons engaged in mixing shall be reported to the State department of health of the State of employment.

4. As few persons at each center as practicable shall be employed for this work.

5. No person shall be engaged for mixing until adequately instructed as to the mechanics of mixing, the dangers, and the precautions to be taken.

6. The distributor of ethyl fluid shall provide a special corps of adequately trained instructors and service men.

7. All mixing shall be done with the maximum ventilation practicable under weather conditions existing at the time.

8. Operation of the pumps shall be instantly stopped at the appearance of a leak or other defect, and no attempt shall be made to repair or disconnect the system until a qualified man takes personal charge of it.

9. Floors of all places where any possibility of spilling is present are to be provided with drains and proper facilities for making possible a complete flushing out of all spilled fluid, or in their absence provision shall be made for chemically neutralizing any spillage as it occurs.

10. No bulk mixing station shall be dismantled or disconnected for repairs except by a qualified man.

11. Kerosene or other efficient means of preventing skin absorption of tetraethyl lead and washing facilities shall always be conveniently available.

12. The rules and instructions affecting the employees shall be posted in a conspicuous place where the ethyl fluid is being handled.

13. The distributor of ethyl fluid shall, with the advice of the United States Public Health Service, select a representative group of at least 40 men exposed to the hazard of mixing, representing the entire area of distribution. This group shall serve as an index of the hazard of mixing. Monthly for the first three months and every four months thereafter this group of employees shall have an examination, which shall consist of:

(a) Examination of blood for stippling, by carefully trained workers, using positive and negative controls, without knowledge of the source of the slides.

(b) Examination of fecal samples of lead.

(c) Report as to general state of health.

(d) Weight, stripped.

(e) Blood-pressure estimation, diastolic and systolic, when sitting.

(f) Hemoglobin estimation by Dare instrument.

Exact records of these examinations shall be kept.

14. The results of the examination shall be reported promptly to the Surgeon General of the Public Health Service.

III. Proposed Regulations for Distribution of Ethyl Gasoline

1. Each filling station shall have prominently displayed at the pump, or in other conspicuous place, the following warning or one of similar effectiveness: "Ethyl gasoline containing tetraethyl lead, to be used as motor fuel only, and not for cleaning or any other purpose."

2. Suitable leaflets shall be available at all filling stations where ethyl gasoline is sold, for distribution on request. These leaflets shall describe the possible dangers and precautions to be taken in the use of ethyl gasoline.

3. Containers of ethyl gasoline sold to the general public shall be labeled: "Ethyl gasoline containing tetraethyl lead. To be used for motor fuel only, and not for cleaning or any other purpose."

IV. Proposed Regulations for Automobile Garages, Repair Shops, Service Stations and Filling Stations

1. Automobile garages or repair shops holding more than five cars and all inclosed public-service stations and inclosed filling stations for automobiles should be registered with the local health department.

2. In addition to doors and to window ventilation in summer, automobile garages, repair shops, inclosed service stations, and inclosed filling stations should have permanently operative ventilation at least equivalent to that given by an opening or openings at ceiling level free to the outside air, but protected from down drafts, with cross-section of 0.2 percent of the floor space available for cars, together with an opening or openings for inlet near floor level of corresponding effectiveness, both arranged to give positive dilution of exhaust gases as generated. This is to be taken as a minimum, special conditions requiring greater permanent ventilation.

3. Automobile garages, repair shops, inclosed service stations, and inclosed filling stations should be kept reasonably clean and free from dust by means of flushing out and moist sweeping or vacuum cleaning.

4. Automobile garages, repair shops, service stations, and filling stations should keep conspicuously posted a copy of these regulations with the following statements in large type:

AUTOMOBILE EXHAUST GAS IS DANGEROUS. MOTORS SHOULD NOT RUN LONGER THAN 30 SECONDS UNLESS THE CAR IS IN MOTION OR THE EXHAUST IS DIRECTLY CONNECTED TO THE OUTSIDE AIR. LIQUIDS SOLD AS MOTOR FUEL, EXCEPT ORDINARY GASOLINE, SHOULD BE USED ONLY AS MOTOR FUEL, AND NOT FOR CLEANING OR OTHER PURPOSES. THE FUMES FROM THE EVAPORATION OF EVEN ORDINARY GASOLINE MAY BE INJURIOUS.

APPENDIX D

Three Reprints Furnished by Ethyl Corporation

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Confidential

Mr. ... Turner
... Kirby

... Warren

Fourth Millilitor

New York
... Ro...

Detroit

June ...

I am forwarding our latest evaluation of the fourth millilitor. The Introduction, Summary, and Figures 1 and 2 can serve as a basis for Dr. ...hoe's meeting with the Surgeon General. The discussion and remaining Tables and Figures are the documentation of our basis and approach.

I will be discussing this subject with Dr. ...hoe in Cincinnati prior to his visit to Washington.

...

cc: Dr. R. ...hoe (...)
... Hales
... Gibson

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