On The Potential Hazard Associated With The Introduction Of Tetramethyllead As An Antiknock Agent Into Commercial Motor Gasoline, With Respect To The Absorption Of Lead By The Handlers Of Such Gasoline.

- An Interm Report Made After Nine Months of Distribution -

by

Robert A. Kehoe, M.D., and J. Cholak Ch.E.

From The Kettering Laboratory in the Department of Preventive Medicine and Industrial Health, College of Medicine, University of Cincinnati.

Introductory

Certain questions arose initially concerning the potential hazard of lead absorption in connection with the distribution and use of gasoline containing the antiknock agent, tetramethyllead. The primary factor which might give rise to hazard through the substitution of this compound for tetraethyl lead in equivalent concentration in gasoline (equivalent in terms of the proportional representation of lead in the molecule, whereby, at the maximum, 2.03 ml. of TML are equivalent to 3.00 ml. of TEL), was that of the appreciably greater volatility of tetramethyl lead. The practical question revolved around the extent to which this higher volatility might operate with significant affect to contaminate the air with tetramethyl lead, or whether this factor would be offset sufficiently by the high dilution of the tetramethyllead in the gasoline, and, additionally and more pointedly, by the movement of currents of air in diluting any such volatilized lead to insignificant levels of concentration in the air breathed by those who would handle the gasoline under the ordinary, as well as the possibly extraordinary (from time to time), conditions of the commercial handling of the gasoline.

This question, in so far as a comparatively short period of time and a specific set of conditions (regarded as uncommonly severe) of use were concerned, had been answered in the negative (See Report of The Kettering Laboratory of November 10, 1959). It was believed, however, that the matter was of sufficient importance

The essential principle of the experimental approach was that of feeding a suspension of the plastic material in a soup to a human ~~volunteer~~ Subject who had been under continuous observation for some months for the purpose of determining the pattern of his metabolism of lead, in preparation for a more elaborate experiment. (It was anticipated that participation of the Subject in this brief experiment would not disrupt his routine manner of living.) This subject carried on ~~an essentially normal routine of living~~ the activities of ordinary life and was not exposed to any unusual source of lead in his home or working environment.

The schedule of this experiment included nine days of ~~control~~ preliminary (control) observations, during the first five days of which he adapted his dietary routine to the extent of including the specific kind and quantity of soup in which the plastic material was to be suspended. After the preliminary period of nine days, a second (control) period of five days followed, during which time his diet included the same soup containing 0.25 grams of a lead-free glazed paper which simulated in appearance and texture the ~~coating~~ material used as a coating. An initial dose of 0.25 grams of the coating material was ingested with the soup on the fifteenth day of the experiment, after which from the sixteenth to the twenty-eighth day, the control diet (containing the soup and the lead-free glazed paper) was resumed. During this entire period, the output of lead in the urine and feces were being observed, as indeed, they had been in the entire preceding period during which the subject

had been under investigation.

From the twenty-ninth through the thirty-third day, the plastic coating of the lamp was ingested by the subject in the amount of 0.25 gram per day, after which the subject returned to the control diet from the thirty-fourth through the thirty-eighth day. The determinations of the lead in the urine and feces were continued. The analytical results on the food, feces and urine, covering the entire period represented above, and continuing through forty-one days, have been assembled in a form convenient for examination, in three tables.

Experimental Results

The results referred to above, with the exception of those obtained in the course of the first day, are set forth in Table 1. It may be seen that the quantities of lead in the food, feces and urine, during the first nine days of this period, were essentially the same as those in the subsequent five days. The initial period of fourteen days may, therefore, be taken together to be the control period. The relationships of the findings, in terms of the degree of balance between the intake and output of lead during this control period, are shown in Table 2.

With the first feeding of plastic on the fifteenth day, the subject ingested 30 milligrams of lead in the plastic. The output of lead in the feces, on the sixteenth, seventeenth, and eighteenth days, exceeded by 29.82 milligrams that which would have been expected had the 30 milligrams

lead not been ingested. The average quantity of lead excreted in the urine, during the same three-day period, was 0.019 milligrams, which was essentially the same as, actually slightly lower than, the average quantity excreted daily during the control period.

During the second period in which the plastic coating was being fed, the ~~volunteer~~ Subject ingested 30 milligrams of lead per day in that manner (in addition to that contained in the food itself) each of five days. The feces evacuated during the thirty-first through the thirty-fifth day contained 155.34 milligrams of lead in excess of that which would have been expected had the 150 milligrams of lead in the plastic not been ingested. (The discrepancy here, that is, the apparent excess of output over intake, may be ascribed to small sampling errors (plastic or food or both) which are almost inevitable in an experiment of relatively short duration. The point of importance is that apparently all of the lead ingested in this form is accounted for in the fecal evacuations. The conclusion might be drawn that no lead was absorbed from the plastic during this period. This is not necessarily true, but certainly the quantity absorbed was small.

The data obtained by the analysis of the urine represent the crucial evidence, with reference to the absorption of lead. It may be noted that the urinary output of lead during the pertinent period of seven days (thirtieth through thirty-sixth) appeared to be slightly and persistently elevated. The average for

this ~~period~~ period is, in fact, significantly higher than that of the control period ($t = 4.5$, d.f. = 18, $p \leq 0.01$). The increase was indeed slight, and but for its consistent trend it would have little, if any significance. It is a matter of importance that it increased progressively from the thirtieth to the thirty-third day, when the peak value of 0.033 milligrams was reached, after which it fell off and could not be differentiated from the earlier results after the fortieth day.

The data as to the concentration of lead in the blood of the ~~volunteer~~ Subject, before, during and after the experimental regimen, are given in Table 3. The concentration in the blood was unaffected by the feeding of the plastic.

-- was a large quantity of lead in the alimentary tract over a period of [illegible] was accounted for by a very slight increase in the excretion of lead in the urine. This ~~quantity~~ increase was so minute, however, that it could be considered to be significant only in statistical terms. The lead excreted in the urine during the relevant period never exceeded ~~the~~ quantities that are often found in the urine of ordinary, normal persons, and the slight elevation above the previous (control) level would have had no significance even statistically but for the fact that it ~~was~~ persisted ~~over~~ for several days, and then disappeared just when [illegible] it should have ~~on physiological grounds.~~ ~~This may have been a matter of chance,~~ but it is reasonable, at least, to attribute ~~this temporary elevation of the~~

Table 1

~~TABLE 1~~

The Intake and Output of Lead Before, During and After the Experimental Ingestion of a Plastic Containing Inherent Lead

Day	~~Schedule of Feeding~~ Administration of Plastic	~~mg. per 24 hrs. Lead Content Milligrams~~ Intake of Lead with Food mg. per 24 hrs	Output of Lead mg. per 24 hrs. In Urine	In Feces
1	Control	0.66	0.017	----
2	"	0.30	0.018	0.20
3	"	0.21	0.013	0.27
4	"	3.22	0.025	----
5	"	0.12	0.019	0.21
6	"	0.30	0.023	0.22
7	"	0.12	0.017	0.79
8	"	0.21	0.018	0.47
9	"	0.06	0.014	----
10	"	0.21	0.017	0.17
11	"	0.15	0.021	----
12	"	0.09	0.021	----
13	"	0.27	0.012	0.30
14	"	0.30	0.014	0.02
15	250 mg. of plastic*	0.24	0.017	----
16	Control	0.30	0.019	27.30
17	"	0.09	0.017	----
18	"	0.39	0.011	2.88
19	"	0.15	0.025	----
20	"	0.30	0.025	0.51
21	"	0.27	0.024	0.17
22	"	0.27	0.021	----
23	"	0.03	0.016	0.16
24	"	0.09	0.018	0.18
25	"	0.45	0.017	0.14
26	"	0.06	0.015	0.18
27	"	0.09	0.012	----
28	"	0.06	0.032	1.36
29	250 mg. of plastic*	0.06	0.011	----
30	"	0.06	0.026	----
31	"	0.06	0.027	12.12
32	"	0.06	0.031	45.10
33	"	0.12	0.033	50.80
34	Control	0.12	0.031	39.00
35	"	0.12	0.031	8.32
36	"	0.06	0.024	1.96
37	"	0.09	0.025	----
38	"	0.06	0.026	----
39	Reduction removed	0.18	0.025	0.25

Table 2

Summary of The Analytical Data Representative of the Control Period

	Lead ingested	Lead eliminated			Balance
	In food (mg)	In urine (mg)	In feces (mg)	Total (mg)	Intake less output
Summation of results obtained during 14 days.	3.23	.25	2.65	2.90	+0.33
Daily average of results obtained during 14 days	.23	.02	.19 (per day) .99 (per evacuation)	.21	+0.02
S.D.	.150	.038	.20		

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TABLE 3

Concentration of Lead in Blood at Various Times

Day of Experiment	Lead in milligrams per 100 grams
1	0.024
6	0.023
13	0.015
19	0.024
24	0.019
32	0.020
37	0.021
43	0.015

COMMENT

The results obtained in this experiment ~~correspond to~~ confirm completely the expectations based on prior experience of experimentalists. The absorption of the inorganic compounds of lead, from the alimentary tract, even at best, when soluble compounds in aqueous solution are ingested, ~~xx~~ occurs to only a modest extent. In this instance, it could be expected confidently that the basic lead carbonate, mixed in ~~the~~ an essentially inert plastic material, would not be accessible to any ~~appreciable degree, for absorption~~ absorption. It was in no sense surprising, therefore, that the alimentary absorption of the ingested lead was negligible, and that the lead which had been swallowed was evacuated in the feces without significant diminution in its quantity.

~~Some~~ a very small amount ~~slight quantity~~ of the ingested lead was absorbed during the period in which there was a large quantity of lead in the alimentary tract over the period of several days, as indicated by a very slight increase in the rate of excretion of lead in the urine. This ~~quantity~~ increase was so minute, however, that it could be considered to be significant only in statistical terms. The lead excreted in the urine during the relevant period never exceeded ~~the~~ quantities that are often found in the urine of ordinary, normal persons, and the slight elevation above the previous (control) level would have had no significance even statistically but for the fact that it ~~exx~~ persisted ~~over~~ for several days, and then disappeared just when it appeared at the outset. Could not reasonably be expected to do so. As we have observed formerly when a person (a person) it should have ~~on physiological grounds.~~ ~~This may have been a matter of chance,~~ has been subjected to a very slight and long-continued measurable degree of exposure to lead, there was no change in the level of lead concentration in the blood the occurrence of the slight elevation but it is reasonable, at least, to attribute ~~this temporary elevation of the~~ the urinary concentration of

~~urinary lead output to the experimental ingestion of the lead-containing plastic~~ it to the presence of the experimental material within the alimentary tract. In any case, the evidence is adequate to demonstrate the complete insignificance of ~~the presence of this lead compound in this form and quantity~~ the potential lead intoxication. in the ~~alimentary tract over the period of some seven days~~, from the aspect of any hazardous degree of absorption of lead.

CONCLUSION

This experiment has demonstrated conclusively that the accidential or intentional ingestion of the lead-containing plastic employed to coat incadescent lamps (bulbs) would be unattended by any hazard ~~of~~ from the absorption of lead from the alimentary tract. The coating material is essentially inert within the alimentary tract, and the lead contained within it is absorbed therefrom only to an entirely negligible extent.

From The Kettering Laboratory in the Department of Preventive Medicine and Industrial Health, College of Medicine, University of Cincinnati.

Observation by A. Davis, M.D.
Lawrence Schafer Ch.E.
J. Cholak, Ch.E.
T. Sterling, Ph.D.

Report by :
A. Davis, M.D.
R.A. Kehoe, M.D.

Approved _____
Robert A. Kehoe, M.D.
Director

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