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RECOMMENDED AIR QUALITY STANDARD FOR LEAD

Introduction

At the time the Department of Public Health first considered setting air quality standards, in 1959, the manufacturers of tetra-ethyl lead were in the process of requesting a Public Health Service Committee to review the possible importance of increasing the maximal amount of tetra-ethyl lead in motor fuel from 3 to 4 milliliters per gallon. In connection with this review, data were first made available concerning the proportional absorption of lead in the small particle size range which is now known to be characteristic of motor vehicle exhaust pollution of the community's atmosphere. Prolonged experimental human studies using lead sesquioxide for 8 hours a day for 5 days a week, gave evidence of absorption of 35 to 50 percent, the higher value associated with particles having a mean diameter of 0.75 microns, the lower one with the particles having a mean diameter of 0.05 microns. At that time it was the view of Dr. Kehoe that about 60 micrograms of lead per day were absorbed from the alimentary tract with safety, while the absorption of double that amount is potentially dangerous. In view of the number of other sources of exposure, it seemed reasonable to use half of the allowable body burden, or about 45 micrograms per day to be adsorbed from atmospheric exposure, in addition to that absorbed from food and water. On the assumption that 15 cubic meters of ventilation per day occurred, the air pollution exposure which could produce this allowable amount would have been 6 micrograms of lead per cubic meter; and in subjects with intensive exercise or possibly infants with a high respiratory exchange in relationship to total body metabolic pool, a lower value could reasonably have

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At that time among the research topics needed for future air quality standards setting was the statement: "There is suggestive evidence that [illegible] amino acids. Lead also appears to react with intact red blood cells. Since the enzymatic basis for hemoglobin synthesis is rapidly being established, the opportunity to identify the nature of lead damage may become available." Also recommended were studies of the lead content of human organs, of the particle size distribution of atmospheric lead, of the estimation of lead levels in blood and urine, and of the proportion of lead absorbed from cigarette smoking.

In the 11 years since this report has been issued, there has been a distinct advance in our fund of knowledge concerning lead occurrence, lead toxicity, and particle sizes. In the so-called "Three Cities Study", lead content of blood and urine for 2,342 individuals was obtained along with atmospheric sampling in Cincinnati, Philadelphia, and Los Angeles. Smoking histories and occupational histories were obtained, the latter in order to assure the investigators that individuals who had any industrial exposure to this substance were not included. Taken as a whole, the data suggested that with increasing atmospheric exposures there was increasing storage of lead in the body, as reflected in blood lead levels: Men had higher blood lead levels than women, cigarette smokers had slightly higher blood and urine lead levels than nonsmokers or pipe and cigar smokers, urban dwellers had higher blood and urine lead levels than suburban dwellers, and rural residents had the lowest levels of any populations.

In 1966, the Department undertook a study, in cooperation with the Los Angeles County Health Department, to determine whether people living

near a freeway had higher concentrations of blood lead than people living at some distance from a freeway. The population living at some distance from the freeway had decidedly lower levels than the population living near the freeway, but the population living near the freeway had comparable levels to the population previously studied in the "Three Cities Study". The population not living near the freeway happened to have been chosen from among those people living along the sea coast in Venice and Santa Monica, in California and they had statistically and consistently lower blood lead levels within all age, sex, smoking and other possible groups. These data, therefore, suggested that the population generally exposed to air which had not traversed the metropolitan area of Los Angeles, had a lower body burden of lead as reflected in the blood lead levels.

Lead in the Environment and its Effects on Humans - March 1967

In March of 1967, a report "Lead in the Environment and its Effects on Humans" was prepared at the request of the Governor's Office and carefully reviewed by outside reviewers. It said, among other things, "the deposition of lead in the body is related to the intake by inhalation of airborne lead and the ingestion of lead in foods, beverages, and water". (THE SUMMARY ON PAGES 4 and 5 of that report are attached). It was shown that compared to other cities where lead has been measured, Los Angeles consistently had the highest atmospheric lead concentrations. For example, the average concentration at 8 stationary sampling sites in the "Three City Study" of 1961-62 was 2.5 micrograms per cubic meter, but higher values were observed during the fall and winter. The report included an extensive review of the effect of lead on one of the essential steps in the synthesis of hemoglobin, the step affected by the enzyme

delta amino levulinic acid dehydrase. The delta amino levulinic acid levels in urine were reported from many countries and were being used to provide a guide to the possible hazards of lead under occupationally circumstances. Shortly after the material for this report was prepared, human experimental studies using 10 micrograms per cubic meter from 10.5 to 73.5 hours per week, and 150 micrograms from 10.5 to 42 hours per week were published. Average respiratory exposures were calculated on the basis of the reported background level in the community, Cincinnati, where these studies were conducted. It was possible from the regression obtained from the epidemiologic data already compiled to calculate the expected value of blood lead.

Both the experimental and epidemiologic data were very similar in their relationship to the regression line calculated from the epidemiologic data. On the basis of this relationship, Goldsmith and Hexter, reported (Science, vol. 158, page 132, 1967), "epidemiologic studies of blood lead levels in general and occupational groups show a logarithmic regression on estimated atmospheric exposure. Experimental results at the same and higher levels show a dose response relationship which fits the same regression. The data imply that long-term increases in atmospheric lead will result in predictably higher blood lead levels in exposed populations". In a supplementary communication, the data for the freeway study in Los Angeles were noted to fit the regression very closely. In their discussion the authors state, "it seems clear that for many urban residents the total quantity of lead absorbed from the respiratory tract is of the same order of magnitude as that absorbed from the gastrointestinal tract, that increased respiratory exposure within the range observed in community pollution is capable of producing

materially increased storage of lead in the body, as reflected in the blood lead levels, and that further increase in atmospheric lead will result in higher blood lead levels in the population in a predictable relationship. "Effects on health of this increased storage may or may not be present." Table I from the paper in Science gives the estimated atmospheric exposure and mean blood lead levels, the attached notes indicate where the specific items of data have been drawn from.

The 1969 annual meeting of the Air Pollution Control Association included a Symposium on Toxicologic and Epidemiologic Bases for Air Quality Criteria". (The data and discussion regarding lead appears in the Journal of the Air Pollution Control Association, vol. 19, No. 9, pages 684 through 703 and pages 714 through 732.) This symposium included reference to, and discussion of the data of Tipton and Schroeder, which strongly indicate an increased storage of lead in the organs of adult subjects in the United States with increasing age. Goldsmith recommended using the four categories for air quality criteria suggested by the World Health Organization. It was suggested that Level I, the lowest level, might be amended by adding, "significantly increased storage in the body of potentially toxic materials as an example of the direct or indirect effect". In view of the available data, it was suggested that "a reasonable numerical guide for a Level I criterion would be a long-term average exposure to 2.0 micrograms of lead per cubic meter of air, where pollution is largely from motor vehicular sources". The 2.0 micrograms per cubic meter represents the nearest integral of value to the atmospheric exposure at which the regression on the estimated respiratory exposure has a significant regression on the mean blood level. The actual maximal 2.2 micrograms of lead per cubic meter is associated with 19 micrograms of lead per 100 grams of blood.

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On the basis of these data and their review by Departmental consultants, along with suggestive evidence that lead makes a measurable contribution to visibility reduction associated with motor vehicle exhaust, and the suggestive evidence of ecologic effects of lead, the Department concluded that lead is a public health hazard in Los Angeles, and that the reduction and ultimate removal of lead from motor fuel additives would be an important contribution to public health. The Department's position was stated before the Subcommittee on Air Pollution of the Assembly Committee on Transportation on December 4, 1969.

On January 10, 1970 the distinguished British Medical Journal, the Lancet, carried an article entitled "Enzyme Inhibition by Lead under Normal Urban Conditions" by Hernberg and Nikkanen, which stated that a close negative correlation was found between the concentration of lead in blood and the activity of erythrocyte delta amino levulinic acid dehydrogenase in 26 health individuals never occupationally exposed to lead. Virtually an identical regression was found in 142 workers with various degrees of occupational exposure to lead. This covered a range of blood lead values of from 4 micrograms to 94 micrograms per 100 milliliters. The authors conclude,"the results indicate that present levels of environmental contamination with lead can produce a measurable biochemical alteration in man". They comment, "the finding that ALA dehydrogenase is partly inhibited in the 'normal' urban population cannot be considered as proof of an effect on the health, since its significance is unknown as yet, but it demonstrates that even the comparatively low exposure to lead, prevailing today, interferes with metabolism. Without taking any standpoint on this question, it may be assumed from the Goldsmith-Hexter regression that this and other possible effects will

become more pronounced if contamination becomes heavier in the future". (NOTE TO DR. MILBY: A COPY OF THE ARTICLE BY HERNBERG AND NIKKONEN SHOULD BE APPENDED OR THE EQUATION OR FIGURE COULD BE INCLUDED AT YOUR DISCRETION).

Summary

The Department has evidence that as a result of the use of leaded fuel, atmospheric pollution in Los Angeles is making a contribution to the body burden of lead, and that reputable investigators have shown that this increased body burden is associated with an impairment in the activity of an enzyme, the full consequences of which are not known. What is known is that the enzyme is necessary in the synthesis of hemoglobin and other similar materials.

The Department therefore feels that it has sufficient evidence to recommend an air-quality standard for lead which should be not greater than 2 micrograms per cubic meter as a 30-day average for general community exposure using standardized methods of sampling and analysis. Such a level is frequently exceeded in Los Angeles County and other Southern California communities, but not in other locations in California.