LEAD

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Contents

The color of this cover duplicates that of standard lead chromate yellow paints used everywhere for traffic marking and other safety applications.

Introduction

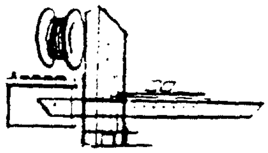
Industry and government, together with medical and research science, are today joining in a new massive effort to learn more about the myriad substances in the air around us and what they mean to our health and well being.

Lead is one of those many substances. This basic element is present in the air in extremely small quantities, usually in the form of inorganic salts. All studies conducted by government, university, or other research groups have shown that the levels of lead in the general or ambient air are low and do not constitute a health hazard.

Nevertheless, certain pertinent questions have been raised and studied. How much lead is in the air? How do the concentrations vary from place to place and time to time? Where does it come from? Does it contribute to "smog" formation? How much lead does man breathe in? What happens to this? What proportion of lead in the general environment comes from the air? What part comes from liquids? From foods? What does research science know about effects of lead on man? What effect does lead, in the air or elsewhere, have on man? What researches are now being conducted? These and other questions will be discussed in this booklet.

From existing research data and other information, it will be seen that lead in the air does not pose a problem for the public under present conditions or in the foreseeable future. Yet careful attention is being given and will continue to be given to all aspects of lead in the environment, including air-borne lead.

The Lead Industries Association is constantly seeking to develop, assemble and disseminate factual information on the many aspects of lead and its uses in society today and to provide guidance on proper safeguards to be exercised. This booklet on "Lead and the Atmosphere" is one in a series being issued by the Lead Industries Association. Readers are referred to the booklet, "Facts About Lead and Industrial Hygiene," for a discussion of the control of lead in occupational exposures.



Lead: An Essential Metal

Lead is everywhere. In the soil, in the air, in the sea. It is in the bodies of city dwellers and in the bodies of natives deep in New Guinea's wilds, one of the most remote areas in the world, thousands of miles from modern civilization.

Lead is the basic ingredient in the solder that binds together our electronic miracles and is the sheath that protects our intercontinental communication system. It is the barrier that confines dangerous x-rays and atomic radiation. It is sound-proofing for buildings and ships and jet planes. It is the major component in the batteries that start our cars and it is in the gasoline that runs our cars. It is an essential metal that is too commonly taken for granted by the public. Because lead is widely and essentially used in modern civilization, there has been scientific interest in watching trends of lead in the environment and in people. Several recent studies, both in the United States and in other countries, have confirmed that lead in the general atmosphere is at extremely low average levels, about one-hundredth of the concentrations safe for workers in lead industries. These studies also checked lead levels in people from several population groups and found no indication of increasing body burdens of lead in the general public.

Some Pertinent Observations

These studies will be discussed in greater detail in later sections, but the following observations are particularly pertinent:

From the American Medical Association's Committee on Occupational Toxicology (1966):

> "The Committee feels obliged to point out that as a result of years of careful clinical study in workers in the lead industry significant, subtle, and unrecognized or 'unrecognizable' changes are not occurring in the general population as a result of its exposure to environmental lead. In fact, this vast clinical evidence, evaluated by a great number of clinically trained scientists, suggests that the general public is not now, nor in the immediate future, facing a lead hazard." (1)

From the U.S. Public Health Service publication, "Survey of Lead in the Atmosphere of Three Urban Communities" (1965):

> "Data from (air samplings) show no consistent trend in the concentrations of lead in the atmosphere of the three cities during the past 5 years . . . (Blood lead levels) are well within the presently accepted range of lead levels for humans and are not significant in terms of a threat of the occurrence of lead intoxication within the groups." (2)

From the World Health Organization (1965):

> "There has been no increase in lead contamination in the last two decades . . . If there has been any change, it would appear that at present man is exposed on the whole to less lead in his environment than he was 20 years ago . . . There is however no cause for complacency . . . " (3)

Recognized Facts About Lead

Lead in the ambient air would be of little interest and of no consequence if it were not for several recognized facts:

- People in general normally have small amounts of lead in their bodies and each day they take in and excrete tiny amounts of lead they get from food, beverage and air. The body is in "lead balance" unless an individual is subjected to an unusually high exposure for a continued period of time. (4)
- Over-exposure to lead can result in lead intoxication, or plumbism, a condition which is becoming increasingly rare, mainly because of the protective measures in lead-producing-and-using industries, where over-exposure is most likely to occur. Other than infrequent occupational exposure, cases of lead intoxication are rare and are considered accidental. (Cases of childhood lead intoxication occur chiefly among children in slum areas who sometimes eat leaded paint chips from old buildings. This type of abnormal situation does not involve air-borne lead and is being brought under control by two courses of action: Non-leaded paints are standard for building interiors, and urban renewal and rehabilitation programs are becoming more widespread.)
- Lead particles, in varying sizes and quantities, can get into the air from various sources, including natural soil disturbances, the burning of certain fuels, burning of waste materials containing lead, some lead-using industries, and the combustion of automobile gasoline.

The majority of lead in the daily intake of man comes from food and drink, with a much smaller percentage coming from the air. Studies have shown, however, that the actual quantity of lead absorbed from the normal atmosphere is so small as to be virtually undetectable and constitutes no hazard.

The question therefore is not whether there is lead in the environment or in the air or in people. The questions are whether the lead that is present is of any significance to the health or welfare of people, and whether there is any likelihood that an increase in lead exposure is possible and potentially harmful.

Fortunately, much authentic data exist to deal with these questions, and more research is in progress to increase our present knowledge.

Measurements in Man

Only in the past few decades has it been possible to obtain sound information about lead in man and about lead in the environment. This is because of the development of the sensitive techniques of measurement and identification that are required to establish reliable information. Armed with the necessary technology, medical and research investigators are able to determine how much lead an average man takes in, how much he excretes, how much he retains in his bones and various organs, how much is in his blood and his urine.

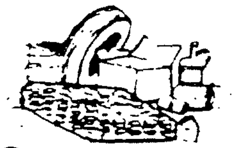
These latter two measurements—in blood and urine—are the critical indicators because it has been shown that an increase of lead in the blood or urine signals an increased intake of lead in the body from some abnormal exposure. Industrial experience has shown that a massive increase in intake is required to elevate blood levels significantly, because the body retains little of the lead taken in. It has also been found that removal of an individual from such exposures will bring his blood level back to a normal range. (5) As a result of increasing knowledge concerning the effects of lead, and the use of proper controls in industry, there has been a marked decrease in the incidence of industrial lead intoxications over the past 50 years.

Data from Many Studies

Careful studies over a long period have produced the following facts pertinent to further discussion of lead in the air: (4, 8)

- The normal person takes in, excretes and retains some of practically every known element in his eating, drinking and breathing.
- American adults take in an average of about 330 micrograms of lead daily and excrete this same amount through normal body functions: thus the body remains in what is called "lead balance." There is no increase in lead in the normal body with age.
- Most of the lead intake comes from food and drink; a very small percentage from air.
- Lead entering the body from the air ranges from about 15 to 90 micrograms per day, depending upon a number of factors, including occupation, place of residence and type of lead in the air.
- Amount of lead in blood of the average person will range from a low of about 10 to a high of about 50 micrograms of lead in 100 grams of blood.
- Most lead intoxication cases studied show a range from 150 to 800 micrograms of lead per 100 grams of blood, and the lowest blood lead level associated with illness has been put at 80 micrograms, for either adults or children. This latter figure is usually taken as an indication that lead levels are getting too high.
- An increase in lead found in the urine is also an indication of greater intake of lead, indicating need for further checking, usually of the blood levels.

The above facts have relevance in connection with studies which have measured the amount of lead in the atmosphere of American cities and in the blood of a number of selected population groups.



Society Creates Wastes

Since the beginning of time, both nature and man have sent gases and dusts into the air, which retains a remarkable facility for disposing of or dispersing them—most of the time, in most places. But this ancient problem has acquired a new intensity because of man's constant crowding into city areas, his demand for the products of modern industry, and his society's creating more wastes than it is now prepared to dispose of readily.

Because man creates wastes in almost everything he does, the complexities of dealing with the problems of air, water, and solid waste pollution are being increasingly recognized.

Efforts to control and reduce man-made contributions to air pollution in the United States are beginning to show results, according to data from the U. S. Department of Health, Education and Welfare's National Air Sampling Network (NASN), which checks the air in some 200 stations located in different parts of the country.

The latest reported figures show that there was a slight, though significant, decrease in the average levels of particulates in the air measured from 1957 through 1963. (6) Also listed are some of the things found among the suspended particulates, including such metals as arsenic, chromium, copper, iron, lead, manganese, nickel, tin, titanium, vanadium, and zinc. Of lead, the NASN report said: "At most locations less than 1% of the particulate matter is lead." This indicates the relative quantitative role of lead in the overall air pollution picture.

It has been demonstrated that lead has no role in the formation of photochemical smog, which is one of the undesirable manifestations of air pollution. (7)

Neither NASN nor any other data show any general increase in atmospheric lead in recent years. Currently, there is much interest in the fact that about 99 percent of the gasoline used in automobiles in this country contains varying amounts of lead antiknock compounds. When combustion engines operate on leaded gasoline, some of the lead is exhausted into the air. Cars, of course, are not the only source. Others are: Lead-using industrial processes; burning of waste materials containing lead; lead smelting and refining; and burning of fossil fuels. Also, some natural sources contribute to lead in the air. (8)

Modern Gasolines Need Lead

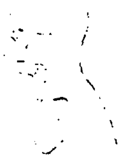
The use of lead is highly important to the efficient and economic production and consumption of the high octane fuels required by modern engines. Lead conserves the amount of crude petroleum required to make the gasolines which assure smooth performance of automotive engines and improve mileage. Despite continued research and the testing of many other substances, no other material has been found as effective.

Lead anti-knock compounds were first added to automotive gasoline in 1923 as a climax to a long and intensive search for ways to make a more efficient fuel that would eliminate harmful engine knock. The public health aspects of the use of leaded gasoline were investigated, and a committee appointed by the U.S. Surgeon General reported in 1926 that no hazard to the public health was indicated from the use of leaded gasoline. (9) A similar committee in England reported essentially the same in 1930. (10)

As a result of technological and economic developments in the automotive and petroleum industries, it was proposed in 1958 that the maximum amount of lead anti-knock additives used per gallon of gasoline be increased from three milliliters (about a teaspoonful) per gallon to four milliliters. The then U.S. Surgeon General named a committee to study the question, and in 1959 this committee concurred in the increase. (11) However, the maximum is used in only a small amount of all gasolines, and the average amount of lead in U.S. gasoline in 1967 is around 2.5 milliliters per gallon.

What happens to the lead in the automobile's gasoline depends largely on the driving pattern and speeds followed, and the condition and design of the car's engine and exhaust system. (12)

During combustion of gasoline in the automobile engine, the lead anti-knock compounds change to inorganic salts, part of which are discharged in the exhaust. In addition exceedingly small amounts of these lead alkyl compounds in organic form may reach the atmosphere through the escape of fuel vapors. Still more are displaced from the tank during refueling, but these amounts are so small they almost defy measurement in the air. (12)



How the Body Handles Inhaled Lead

Studies to determine the size and chemical composition of lead in the atmosphere have shown that a considerable percentage of the lead exhausted by automobiles settles quickly to the ground and is carried off by water or sweepings. Since most of these particles are non-soluble, those which go into water settle down rapidly and do not become waterborne, while others become part of the soil. Air disturbances, caused by winds, storms or autos, may stir up some of these particles from time to time. The finer particles become part of the particulate matter in the ambient air, and are the ones to which people are most likely to be exposed. (13, 14, 15)

However, man's breathing defense mechanisms prevent the majority of dust particles, whether carrying lead or not, from reaching or remaining in the lungs.

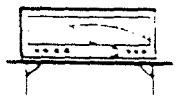
Small dust particles (below 0.5 microns in size; 1 micron equals 1/1000 of a millimeter and is invisible) tend to remain suspended in the respired air and many are exhaled. Larger particles are filtered out in the nose. Approximately 90 percent of particles having an average size of 10 microns or larger are removed in the nasal air passages. (16)

Still other particles are cleaned out by the respiratory system's network of cilia—fine, hair-like structures which constantly sweep out the trachea (windpipe) and bronchi (air tubes) leading to the lungs.

Any particles (including lead) that do reach the small air sacs in the lungs are partially removed by scavenger cells called phagocytes. These engulf the particles and carry them to a moving mucous layer by which they are moved upward by the cilia to the mouth.

The quantity of lead inhaled ranges from less than 15 to 90 micrograms per day (no doubt being closer to the lower figure, according to a long-time researcher in the field). (8) Of the lead inhaled from the air, about 45 percent is exhaled immediately. The lung clearance defense mechanisms carry another 45 percent of the total inhaled to the gastrointestinal tract for eventual elimination. The remaining 10 percent is absorbed into the blood, according to data derived from a lung dynamics task group of the International Commission for Radiation Protection. (23)

Thus, in considering the effect of lead in the air on man, the amount of lead found in the air has to be weighed against the amount that a man may actually breathe in, retain and absorb. This is very much less than the amounts in the air.



Atmospheric Lead Measurements

Measurements of atmospheric lead in cities during the past 20 years have shown low levels on the average and no definite trend upward or downward.

In considering figures on lead in the ambient air, it should be noted that the present accepted safe level for industrial exposure to lead in air is 200 micrograms of lead per cubic meter of air measured over an eight-hour day, i.e., when the air of workrooms contains regularly not more than 200 micrograms of inorganic lead per cubic meter of air, as measured by prescribed methods, cases of lead intoxication do not occur. (25)

In Cincinnati, Ohio, reliable measurements of lead in the air in different parts of the city have been made since 1946. These measurements showed a downward trend in the main residential and basic basin areas from 1946 to 1954. Since then they have stayed relatively steady at below two micrograms of lead per cubic meter of air. Lead concentrations in the commercial area also show a downtrend from about four to two micrograms per cubic meter of air from 1955 to 1962.

Reasons given for this decline since 1946 are the diminishing uses of solid fuel, better collection and removal of the dusts and smoke from industrial operations, better enforcement of smoke-abatement laws, and changes in traffic flow and land use in the metropolitan area. (17)

This decline took place during a period when there was about a two-fold increase in the amount of motor fuel used in the Cincinnati (Hamilton County) area and a nearly doubling in the number of cars.

During 1954-55 an examination of lead-in-air data from 24 U.S. cities was made with the following observations: (17)

In cities up to 2,000,000 population, relatively low lead concentrations from 1.5 to 2 micrograms per cubic meter of air were found.

In cities over 2,000,000 population, the ranges of lead concentrations and the average amounts of lead ran higher, with Los Angeles at an average (median) of five micrograms per cubic meter the highest.

The Three Cities Survey

A detailed report on an extensive program of lead-in-air measurements in three major cities was published by the Public Health Service in 1965. (2) The cities were Los Angeles, Cincinnati and Philadelphia, and the report is commonly known as the "Three Cities Survey."

The lead measurements were made from 3,400 samples collected from the atmosphere regularly over the course of a year (from June 1961 through May 1962) from 20 different sites in the three cities.

The findings were summarized in the report as follows:

"1. The annual average concentration of lead in the atmosphere ranged from about 2 micrograms per cubic meter of air in the downtown and industrial area of Cincinnati, to about 1 in the outlying areas of that city. The values in corresponding areas in Philadelphia ranged from 3 to 1, and in Los Angeles from 3 to 2.

"2. The average concentration of lead in all of the samples obtained in each city was 1.4 micrograms per cubic meter in Cincinnati, 1.6 in Philadelphia, and 2.5 in Los Angeles.

"3. The highest concentrations of lead were found in the air during autumn and winter. The highest seasonal concentrations of lead at any station was 2.4 micrograms per cubic meter in Cincinnati, 3.8 in Philadelphia, and 4.1 in Los Angeles.

"4. The highest monthly concentration of any site was 3.1 micrograms per cubic meter in Cincinnati (October), 4.4 in Philadelphia (October), and 6.4 in Los Angeles (December).

"5. The highest concentration of lead in any one sample was 6.4 micrograms per cubic meter in Cincinnati, 7.6 in Philadelphia, and 11.4 in Los Angeles.

"6. The mean concentration of lead found in heavy traffic ranged from about 14 micrograms per cubic meter on Cincinnati streets through approximately 25 on Los Angeles Freeways, to 44 in a vehicular tunnel." (Ed. note: This particular finding refers not to the regular monitoring work of the Three Cities survey but to special studies, using mobile samplers, in or near heavy traffic streams in Cincinnati and Los Angeles, and to measurements from another study done in Boston.)

"7. The average content of lead in particulate matter for all samples was 1.7 percent in Cincinnati, 1.5 in Philadelphia, and 2.3 in Los Angeles.

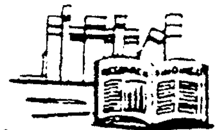
"8. Atmospheric lead concentrations varied during the day; highest concentrations occurred in the early morning.

"The concentrations of lead found in the atmosphere in this study were consistent with those obtained during the same period by the National Air Sampling Network (NASN) of the Public Health Service. Data from the NASN show no consistent trend in the concentrations of lead in the atmospheres of the three cities during the past 5 years. Data obtained by the Kettering Laboratory indicate that in Cincinnati the trend has been downward since 1946."

Though these data showed no trends in accumulation of lead in the air or of lead levels that would affect the health of the public exposed to the air, it is significant that the report indicates that such studies should be continued, saying that the results "have established a baseline for future investigations of these types."

The study itself was prompted by a recommendation of the Surgeon General's committee, previously referred to, which in 1959 concurred in the increase in the maximum lead content of gasoline. This committee recommended that the Public Health Service, in cooperation with industries, carry out:

". . . 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 in selected population groups." (11)



Recent Research Findings

In accordance with the latter part of this recommendation from the Surgeon General's 1959 committee, the Three Cities Survey in Los Angeles, Cincinnati and Philadelphia involved analyses of blood of approximately 2,300 persons and the urine of nearly 1,700 males within the same groups. (2)

The persons examined were selected from groups such as policemen on traffic beats, service station and garage workers, commuters to and from suburbs as well as non-commuters, and some persons with chronic illnesses.

The results of this study showed many gradations in lead levels but no excessive levels of lead in the blood or urine of those examined.

Among the findings reported were:

- No relationship was found between blood lead levels and age.
- In a group of selected chronic dis-

ease patients afflicted with respiratory, kidney or bone conditions neither the range of values nor the mean lead concentrations in the blood or urine differed from the general population. These data showed neither unusually high nor low levels of lead in any of these diseased groups.

- Out of the 2,342 people studied, only 11 showed blood lead levels equal to or higher than 60 micrograms per 100 grams of blood, and these 11 were from groups which probably had an occupational exposure to lead — garage mechanics, traffic policemen, aircraft workers, etc. "A few values in excess of 0.06 (60 micrograms) are to be expected in a large sample of individuals representing a variety of exposures to lead," the report observed. (A subsequent follow-up on 7 of the 11 who could be rechecked showed that the lead levels on second measurement had fallen into the normal range.)
- Urine lead levels fell within the fairly narrow range that is defined as "normal."
- The mean blood lead levels reported ranged from 11 micrograms (per 100 grams of blood) among suburban non-smokers in Philadelphia to 38 micrograms among garage mechanics in Cincinnati (checked previously in 1956). "It is important to recognize that the differences between the lowest and highest of the groups, while relatively large, are well within the presently accepted range of lead levels for humans and are not significant in terms of a threat of the occurrence of lead intoxication within the groups," the Public Health Service report said.
- The mean concentration of blood lead in smokers was slightly higher than that of non-smokers.
- Lead levels in blood of women ran slightly lower than for males and the difference was "remarkably consistent." No explanation for this was noted and the report suggests that special studies on this question "would be desirable."

Differences in the lead levels in the blood among the various groups included in the Three Cities Survey are indicated in the tabulation below:

Mean Blood Lead Levels

(Of Selected Subject Groups in Three Cities Survey)

(In micrograms per 100 grams of blood)

City and Subject Group	*No. Subjects*	*Lead in Blood (Mean)*
Los Angeles:		
Aircraft Employees		
male	291	19
female	87	17
Policemen	155	21
Pasadena City Employees		
male	88	19
female	52	12
Philadelphia:		
Suburban		
male	23	13
female	58	13
Commuter		
male	43	19
female	7	15
Downtown Resident		
male	66	24
female	40	18
Policemen	113	26
Cincinnati		
Policemen		
smokers	107	25
non-smokers	11	23
Firemen		
smokers	163	25
non-smokers	27	24
Post Office Employees		
smokers	118	24
non-smokers	20	22
Health Department Employees		
smokers	30	22
non-smokers	5	16

Other Studies on Lead

The Three Cities Survey findings were consistent with other similar, though less ambitious, studies in the United States as well as in other parts of the world.

In 1943 a study of 188 Mexican and United States subjects showed mean blood levels of 30 micrograms per 100 grams of blood and mean urine levels of 27 micrograms per liter of urine. (18)

In 1960, a study of 970 Americans in six large cities and one rural area gave these findings: the mean for urban blood samples was 20 micrograms of lead per 100 grams of blood as compared to 14 micrograms for the rural blood samples. (19) Pertinent findings from this study are summarized:

Blood Lead Levels

(In micrograms per 100 grams of blood)

City	No. Samples	Mean	Range
New Orleans	130	22	5-50
Dallas	128	18	3-54
Denver	131	19	7-50
Chicago	97	20	5-60
New York	112	20	4-53
Cincinnati	137	20	3-51
Rural	102	14	1-35

An earlier study in Switzerland is of relevance because it included measurements at two periods, one just after the introduction of lead antiknock additives into Swiss commercial gasoline, the other about six years later. (20) The results:

Swiss Study: Blood Lead Levels

Average Values

Micrograms (ug) per 100 grams of blood

	1948-1950 ug	1948-1950 people	1955-1956 ug	1955-1956 people
Medical students (No abnormal lead exposure)	14	19	13	27
Garage personnel	23	40	22	31

Thus, there was no change in lead concentrations in the blood during the first six years following the introduction of leaded gasoline in Switzerland. (The slight decrease shown in the figures is not significant.)

World Survey Findings

The World Health Organization of the United Nations more recently sponsored an international task force study of blood and urine measurements collected from 16 nations of the world. The findings (published July 1967), averaged by country, showed average lead content in blood from a low of 7 micrograms per 100 milliliters of blood among urban Peruvians to a high of 28 micrograms for urban dwellers in Finland. Average levels by residence, including urban and rural, reported in micrograms of lead per 100 milliliters of blood, were: Finland 26; Yugoslavia 24; United Kingdom 23; New Guinea 22; New York City 21; Czechoslovakia, Egypt and Japan 20; Chile and California 17; Ohio 16; Israel and Holland 15; Argentina 14; Italy 13; Poland 12; Sweden 10; and Peru 7. The aggregate average was 17. (21)

According to Drs. Goldwater and Hoover of Columbia University, who reported the results of the WHO survey, these and other recent investigations of "the lead content in human blood do not differ greatly from those shown by older investigations during the past three decades."

The Columbia scientists said that "the lead levels reported in the blood of the New Guinea aborigines are of particular interest in that these natives, living in the hills of New Guinea, away from industrialization and motorization, showed blood lead levels higher in range than urban and rural Californians. The mean figure of 22 micrograms per 100 milliliters of blood was higher than that of samples from 13 other localities, including California, Ohio and New York City. Mean levels from England, Yugoslavia and Finland are slightly higher than the New Guinea mean."

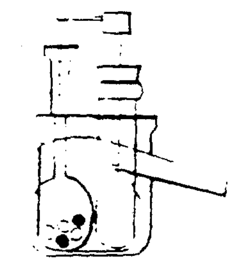
More detailed information from the doctor serving the New Guinea area revealed that the environment is completely non-industrial and free of gasoline fumes. "Cooking is done in utensils made of unfinished bamboo tubes. Other domestic utensils are made mostly of wood. These observations serve to illustrate the difficulties in assuming a simple relationship between residence and body blood lead levels."

From these studies and other existing data, it is shown that the quantities of lead detected in the atmosphere are well below concentrations that would present health concern to the public, are not increasing in general, and are not elevating the body burdens of the general public.

In a recent review of research on sources of lead entering the body, the ability of the body to achieve lead balance, and the overall toxicology of lead, a leading toxicologist in California summarized as follows: (22)

"It has been shown that the population of the United States is in lead balance and the old causes of acute and chronic lead intoxication have been reduced to very low levels by changes in technology. Lead body burdens of the population have been maintained at the same level for the past 30 years regardless of the fact that there has been a 2.5-fold increase in the use of leaded gasoline. The bulk of the body burden of lead has been obtained via the food chain and not by inhalation from the environment. Although lead is present in the ambient air, only a small percentage of the inhaled lead is in the correct particle size for pulmonary retention and even that fraction contributes only an extremely small amount to the body lead burden. Body defense mechanisms make it highly unlikely that environmental lead could induce chronic lead insult in the population. Greatly increased exposure to lead slowly increases the body burden but only at levels well above those encountered in the environment. The supposed chronic intoxication from environmental contamination is a myth, not a fact."

Expanded Research Program



Intensive medical studies carried out over a long period of time have established sound criteria for determining safe levels of lead as found in the diet, in industrial atmospheres and in man's system. According to known medical evidence, compiled from a variety of research in the laboratory and on animals and human beings, present levels of lead in the general environment do not present a public health problem.

There remain questions about lead in relation to human beings that should be investigated. The lead industry, which has long promoted and supported such research, is expanding its efforts to study these questions. Research studies into health aspects are included in the program of the International Lead Zinc Research Organization, Inc. (ILZRO), with which the Lead Industries Association is affiliated. ILZRO is now stepping up its efforts concerning investigations into lead and human health.

One research project of immediacy and pertinence is seeking to determine the smallest amount of lead in air which man breathes that would have an effect on the possible accumulation of lead in the blood.

Problem of Ambient Air Standards

The pertinence of such research relates to efforts by some air pollution control authorities to set ambient air standards for certain substances which, in excess in the atmosphere, are considered pollutants. Setting such standards for lead at this time calls for guesswork, when what is needed is solid information based on scientific research. As has been said, in industrial exposures, the accepted safe level for a working lifetime is 200 micrograms per cubic meter of air in the workroom based on an eight-hour day, five-day week. Obviously, this would not necessarily apply to air which people are breathing 24 hours a day, seven days a week. Nor is it scientifically acceptable merely to assume that since a full 168-hour week is roughly four times a 40-hour week, then there would be logic in setting the full-time level at about one-fourth, or 50 micrograms per cubic meter of air. Full-time exposure compared with exposure and withdrawal from exposure poses different problems in elimination of lead.

Tests with Human Subjects

Kettering Laboratory at the University of Cincinnati is carrying on experiments with human subjects that involve nearly full-time exposure to atmospheres with known lead concentrations. The object is to determine what concentration of lead in the air a person breathes may start an upturn in measurable lead in the person's blood. From this work, sponsored in part by the U.S. Public Health Service, it is hoped that a reasonable yardstick can be developed for setting ambient air standards for lead, where desired, as is being done for many other substances found in the air.

The fact that there is no scientific basis now for setting any such figure is conceded by the state of California which has been studying the situation for some years and has not as yet found any acceptable method for determining a lead/air standard, although standards have been set for a number of other substances emitted into the air from various sources.

During 1967, however, two states did adopt a figure for lead in the ambient air, despite admitted lack of foundation for these figures. The state of Pennsylvania set a "tentative" limit of five micrograms per cubic meter of air averaged over a 30-day period. Although this figure was said to be derived from preliminary data developed by Dr. Robert Kehoe of Kettering Laboratory, Dr. Kehoe personally appeared before the Pennsylvania Department of Health hearings to dispute the application of his data in this way and to testify that research in its present stage showed the figure to be too low. He added that any figure calculated on present data "is not necessarily or even probably correct." (23)

The state of Montana later adopted this same standard, upon recommendation of the U.S. Public Health Service, even though the PHS spokesman gave no scientific reason for this figure and told the State Board of Health that:

"Information of the effects of lead in the atmosphere is indeed sparse . . . As far as we are aware, there are no cases of clinical lead poisoning that can be attributed to exposure to lead in the ambient atmosphere. The levels present, we found in most places, are thought to be safe, although there are some places where exposures are subject to considerable question . . . Allowing for wide variability among individual persons, and a wide variability of exposures, and injecting a modest factor of safety, we feel that 5 micrograms per cubic meter of lead for monthly average of exposure is probably safe."

But nowhere did this spokeman give any data or backing for this figure as against any other value, whether higher or lower.

The human exposure studies which are continuing at Kettering Laboratory are expected to shed more scientific light on this complex subject when the experiments are completed.

The question of whether the relatively small amounts of lead taken in by the average adult from air would have an effect on those particularly susceptible to disease has been at least partially answered by the Three Cities Survey in its study of patients with diseases affecting liver, kidney, lung or bone. These patients showed no unusual blood lead accumulations.

Study of TEL Workers

Another question that has been raised concerns exposure of long duration to relatively low levels of lead, such as might occur in persons exposed to continued high levels of air pollution. An analysis of the health records of persons occupationally exposed to lead for many years does not indicate a correlation between such exposure and any health problem.

The results of one such thorough analysis was reported at the October 1966 meeting of the Industrial Hygiene Foundation. (24) This was the study of employees in the tetraethyl lead (TEL) production facilities of a major producing company. The TEL group was suitable for this analysis because in addition to their normal exposure to lead, they were subject to some further exposure on their jobs; also, health data existed for the workers over their entire period of employment.

The study covered 1,120 men: 348 currently working in the TEL area who had been there six months or more; 348 men who had not had occupational lead exposure and who served as controls; and 424 men who had formerly worked in the TEL area for at least six months or more in the past. The first two groups were matched according to race, age, and length of service with the company. Measurement of lead in urine excretions for TEL workers was almost double that of controls, showing a significant difference in lead absorption between the exposed and unexposed groups.

Company medical records of the workers were reviewed for information on the following items: history of important chronic disease, height and weight, blood pressures, hemoglobin determinations, white blood cell counts, and electrocardiographic abnormalities.

For the most common chronic diseases, the TEL workers and prior TEL workers both showed lower prevalence than that of the controls, the study found.

The summary of the findings said that though TEL production workers had an average urinary lead excretion more than double that of the general population, "no adverse effect on health of this degree of lead exposure was detected."

Research Will Provide Answers

The need for continuing research was a consensus of the Public Health Service symposium on environmental lead contamination held in December 1965 in Washington. A panel report noted that no explicit evidence was presented that suggested present lead burdens were associated with any major contribution to disease in the population. The report said the possibility could not be excluded that present lead intakes might, in undetected fashion, be related to certain ailments. The panel recommended epidemiological and laboratory studies to find out more about possible effects of present or higher lead levels on man.

Other recommendations included:

More accurate definition of the effective absorption of lead by inhalation; development of techniques for better assessment of body burden of lead, and "the biological mobility of lead in its several biological compartments, and continued, intensified studies on the relative contribution to the biosphere of lead from geological and technological sources."

With these recommendations, the lead industry is in accord. It also expects that the research that it is sponsoring both alone and in participation with other groups, or the work being done by other organizations, will help provide answers to the questions that have been raised.

The lead industry for many years has supported scientific studies of all aspects of the use of lead. New and expanded programs are continuing through the International Lead Zinc Research Organization. These include plans to participate in a major study similar to the Three Cities Survey previously described, but on an expanded basis. Other projects will utilize new techniques, such as isotopic ratios, for measuring sources of lead in the environment, and will open up new avenues for keeping up with information about man's use of lead, especially about lead in the atmosphere.

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