INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION, INC.

292 MADISON AVENUE, NEW YORK, N.Y. 10017
TELEPHONE 679-6020 (AREA CODE 212)
CABLE ADDRESS: NYILZRO NEW YORK

January 11, 1967

To: All ILZRO Member Representatives, Directors, Lead Program Review Committee, Lead Environmental Health Committee and Lead Chemical Committee

From: A. L. Ponikvar

Subject: Part VI, Environmental Health Research Digest

Enclosed is a copy of Environmental Health, Part VI of ILZRO Research Digest No. 18. This is the first publication of this book, recommended last fall by our Executive Committee and the Health and Safety Committee.

While we consider Part VI to be a positive and forthright statement of lead's relationship to environmental health, we also believe it only realistic to note that portions of these summaries can be read out of context, to the detriment of the lead industry, by those who are ever ready to point an accusing finger. It was for this reason that both committees recommended that distribution of this book be made on a restricted and controlled basis.

ILZRO, therefore, is mailing the Environmental Health Digest on a confidential basis only to its members and member representatives serving on committees. Other distribution is to be effected under the control of ILZRO members. The potential use and audience for this Digest will vary greatly from country to country, depending on the degree of concern on toxicity prevailing in those countries. In view of these differing needs, we are now in the process of establishing proper distribution in each country through the ILZRO membership in those countries.

We feel that this Digest can be a very effective tool for the lead industry in combatting negative forces, provided the contents are utilized with discretion. We feel that the methods of distribution outlined above will effect the necessary control.

If members would like additional copies for internal circulation, they may be obtained from ILZRO.

A. L. Ponikvar

N11696

INTERNATIONAL LEAD ZINC

RESEARCH ORGANIZATION, INC.

PART VI ENVIRONMENTAL HEALTH

ILZRO RESEARCH DIGEST NO. 18

OCTOBER, 1966

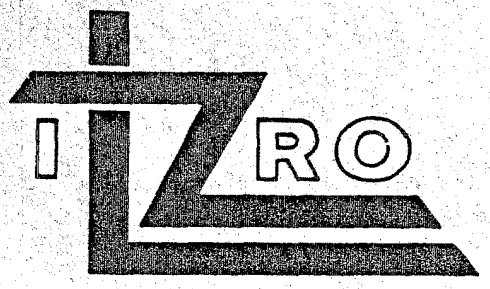
INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION, INC.

292 MADISON AVENUE, NEW YORK, N. Y. 10017
TELEPHONE 532-2373 (AREA CODE 212)
CABLE ADDRESS: NYILZRO NEW YORK

Dr. Schrade F. Radtke
Executive Vice President, Director of Research

Staff

Samuel E. Eck — Assistant Director of Research
Albert R. Cook — Project Manager Electrochemistry
Dodd S. Carr — Project Manager Chemistry
Donald C. Herrschaft — Project Manager Metallurgy
Kenneth J. Altorfer — Project Manager Engineering Economics
Don G. Fowler — Project Manager Health and Safety
Adolph L. Ponikvar — Manager Technical Publications



Printed in U.S.A.

FOREWORD

This first edition of Environmental Health is part of the continuing effort by the lead industry to fill gaps in knowledge concerning the effects of lead on man and his world. The industry is convinced that while the research reported herein will contribute to the welfare of the public, it will also contribute to the continued soundness and further growth in the use of lead in many basic applications.

The information contained in this inaugural venture is based on various research programs conducted under the direction of the International Lead Zinc Research Organization, Inc. (ILZRO), on behalf of leading lead and zinc producers throughout the world.

Many of these environmental health research programs have been under way for several years. The lead industry, however, is aware of the growing public interest in air and water pollution as well as other public health matters. It has, therefore, taken steps in the past year to expand sharply its efforts in these areas. This brochure is one of those steps. But the greatest emphasis is being put on the research projects themselves.

The lead industry is not alone in its work to establish the truth about this metal and its relation to environmental health. Several research programs are being conducted cooperatively with such groups as the U.S. Public Health Service and the American Petroleum Institute.

The research program described in this brochure deals with many areas of immediate public interest such as the effects on humans of particulate lead compounds in the air under experimental conditions, plus measurements of the amount of lead in the air and in the human body. Another project involves the study of the relationship between the lead in motor vehicle exhaust and that on vegetation adjacent to public highways. A new use for the various isotopes of lead present in all lead from whatever source is being developed by one of our contractors in order to trace the lead in a particular sample from its source. Another interesting project has already shown that lead has no specific effect on the central nervous system tissue in the mouse.

It is interesting to note that a recent study showed that levels of lead in the bodies of New Guinea aborigines, living in one of the most remote and primitive areas of the world, completely apart from civilization, are comparable with those obtained in industrialized countries. This particular evaluation of health effects of air pollution was reported at an American Public Health Association meeting in San Francisco in early November, 1966, by Dr. Leonard J. Goldwater, Professor of Occupational Medicine, and Dr. A. Walter Hoover, both of Columbia University School of Public Health and Administrative Medicine. Their study of people in 16 countries concluded that despite increased burning of gasoline and wider use of lead in industry, there has been no significant change in lead levels of the blood and urine in the last three decades.

We have also included reference to other ILZRO research projects conducted under other classifications but having direct or indirect relationship to

environmental health. An outstanding example of this is the LC-18 project on Organolead Compounds. This program, conducted in The Netherlands under ILZRO sponsorship, is devoted to exploratory research in organolead chemistry and to the synthesis of new compounds to be studied in applied fields. One result of these efforts has been the development of organolead compounds that may have a tremendous impact on world health in that the compounds have shown promise in the fight against bilharzia, a debilitating disease that affects perhaps 600 million persons throughout the world.

The format of this brochure on Environmental Health generally follows that established by the other five volumes, or parts, of DIGEST 18. The complete breakdown of DIGEST 18, by parts, is now as follows:

PART I	DIE CAST AND WROUGHT ZINC
PART II	ZINC FOR CORROSION PROTECTION
PART III	ZINC CHEMISTRY
PART IV	LEAD METALLURGY
PART V	LEAD CHEMISTRY
PART VI	ENVIRONMENTAL HEALTH

The six volumes review progress from April through October, 1966, on the various lead and zinc research and development programs conducted under the direction of ILZRO. The projects reported in these separately bound sections are grouped under specific headings which most closely describe their primary engineering characteristics or area of application. These headings provide a ready index as to published data on specific topics. Appendices include completed programs, other active programs, published articles, and patents.

Attention is directed to the abstracting service of lead and zinc literature conducted by the Zinc Development Association - Lead Development Association in England and also sponsored by Lead Industries Association, Inc., American Zinc Institute, Inc., and ILZRO. Two companion publications, ZINC ABSTRACTS and LEAD ABSTRACTS, are issued monthly and are available on request through the appropriate development association.

Additional copies of the DIGEST or further information on ILZRO work can be obtained from the appropriate lead or zinc development associations in your country. In Japan, the DIGEST may be obtained, in the Japanese language, from Mitsui Mining & Smelting Co., Ltd. or from Mitsubishi Metal Mining Co., Ltd. In Italy, an Italian edition is available from Monteponi & Montevecchio.

For further reference, detailed contractors' reports are available in the U.S. and Canada from ILZRO, AZI, or LIA; in Australia, from the Australian Lead and Zinc Development Associations; in Great Britain, from the ZDA or LDA; in Italy, from Monteponi & Montevecchio; in Japan, from Mitsui and Mitsubishi; and in India, from the Indian Lead Zinc Information Centre. In other countries, requests for these reports shall be referred to ILZRO.

We believe that PART VI, Environmental Health, will be a most valuable addition to the ILZRO RESEARCH DIGEST. We are confident it will become a useful reference for the public, industry, and government in the United States and throughout the world.

Schrade F. Radtke

PART VI ENVIRONMENTAL HEALTH

ILZRO RESEARCH DIGEST NO. 18

TABLE OF CONTENTS

IV. APPENDICES

ILZRO RESEARCH DIGEST NO. 18

PART VI ENVIRONMENTAL HEALTH

I. ACTIVE PROJECTS

LH-75 Human Exposure to Particulate Lead Compounds in the Air Under Experimental Conditions, Univ. of Cincinnati, Robert A. Kehoe, M.D.

The purpose of this study is to determine the maximum amount of inorganic lead that can be inhaled continuously throughout a lifetime by normal people without a demonstrably progressive accumulation of lead in body tissues.

The investigation is limited to inhaled lead particles so as to establish its relevance to ambient air quality criteria. This is done technically by controlling the particle size of the inhaled material within limits of less than 2 microns. Previously work in the Kettering Laboratory has established the fact that particles in excess of 2 microns in size are likely to be trapped in the upper respiratory tract and either swallowed or excreted without being absorbed in body tissues.

A brief outline of the methodology used in these studies will be of interest. Since lead is present in all food, beverages, as well as the air we breathe, it is necessary to measure the intake in the human body from all sources and to differentiate that intake by means of balance measurements. This is accomplished in these studies by measuring the lead content of all food and drink consumed by the experimental subjects, together with the lead content of the air they breathe and the balance measurement is obtained by a continuous and complete measurement of all excreted lead in the urine and feces with supplementary measurements of the lead remaining in the body by means of determination of lead in the blood.

Previous work has shown that by far the greatest amount of lead is taken into the human body through ingestion of food and drink. Therefore, in order to set up a true balance experiment a base line must be established on each experimental subject, and this base line is determined usually as follows: the subject is required to purchase or prepare, duplicated samples of everything he eats and drinks. For instance, if he eats in a restaurant he orders two complete meals, one of which is carried in a special container provided by the Kettering Laboratory. If he orders a drink in a bar, he purchases two - one for analysis. These requirements are maintained throughout the course of the experiment.

Similar requirements apply to all of his body excretions, and these are saved, in special containers, which are provided by the laboratory and the contents of which are analyzed in the laboratory. This procedure is carried on for a period of one year before any exposure to extra amounts of lead is initiated and thus provides a base line for the particular individual.

At the end of the pre-exposure period the subject spends the required amount of time every day in specially built exposure chambers which are large enough for comfortable activities, such as study. In these exposure chambers

known amounts of inorganic lead of known particle size are introduced to provide a continuous exposure for the subject.

Of course, the previously described analyses of food and beverages, plus bodily excretions, are maintained throughout the course of the exposure phase of the experiment, as this is necessary to differentiate the relative contribution from food, beverages, and air. Upon termination of the exposure phase of the experiment the subject is followed again for a period of sufficient length for all of his measurements to return to his "normal" or base line value.

This is a very brief outline of the methodology that has been used for the past 30 years at the Kettering Laboratory for human exposure studies.

The manner of generating the lead particles used in the exposure phase is of interest. A specially designed propane fired bunsen burner is used to which is monitored a controlled amount of tetraethyllead which, when burned, generates lead sesquioxide of the required particle size. The lead particles are dispersed throughout the chamber in a homogeneous concentration and periodic sampling of the air inside the chamber is made as a monitor of this concentration. Particle size determinations are also regularly performed.

The present experiment is designed to provide a study of continuous exposure to air-borne lead and involves a new technical approach due to the recognizable difficulty, or impossibility, involved in finding a human subject who would remain in an exposure chamber 24 hours a day, seven days a week for a period of a year or more.

The experiment outline was evolved to study whether or not a progressive increase in time would provide enough points on a curve so that extrapolation out to 24 hours a day was possible. This experimental outline was as follows: the human subject remained in exposure chambers first for three hours a day, every other day for 16 weeks; then six hours a day, every other day for 16 weeks; then for 9 hours a day every other day for 16 weeks; and finally for 12 hours a day every other day for 16 weeks.

A concentration of lead in the chambers during this phase of the experiment was maintained at 150 micrograms per cubic meter of air. This value was deliberately selected as providing an amount of lead which could be measured by its increase in blood and urine. The results of this experiment provided a validation of the method and gave values on the curve of blood and urine of 4 points which increased stepwise and which showed comparable values for each subject during the exposure time. Extrapolation from the 4 points on the curve to the 24 hour per day time showed that both subjects would have reached the same level of lead in the blood at about the same time as if they had been exposed during a 24 hour a day continuous exposure.

At the present time there are two subjects being exposed in parallel chambers to similar concentrations of lead in air for the purpose of this experiment. The preliminary phase of this experiment was started in 1963 and the exposure phase of the experiment is now being carried on.

LH-86 Lead Glazes for Dinnerware, School of Ceramics, Rutgers, The State University, John H. Koenig

The objective of this program is to further the understanding of the manufacturing parameters which must be controlled in order to avoid the misuse and improper application of lead glazes.

The operation of a pottery represents the use of knowledge gained by men during the past 25,000 years. Many, if not most, of the techniques and procedures used are of a strictly empiric nature. In the glazing of pottery for dinnerware empirical guides are not sufficient to provide good quality control and a product that is reproducible in nature. Because all good glazes require a certain amount of lead in their composition to provide the necessary plasticity, freedom from crazing, and ease and economy in manufacturing, ILZRO and the U.S. Potters Association decided to investigate the parameters involved in providing satisfactory and inert-in-use glazes.

The inert quality of the glaze is tested by means of a determination of the leachability, or release, of lead from the finished product during normal use. A test was devised and proposed to ASTM for this purpose. This test has been accepted by American Society of Testing Materials (ASTM) and is now designated as "Tentative Method of Determination of Lead Extracted from Glazed Ceramic Surfaces" (ASTM Designation: C 555-64 T, Issued, 1964).

With this test as a tool for the determination of the adequacy of firing temperatures, glaze composition, furnace holding time and other necessary manufacturing parameters, the research was begun. All of the foregoing listed parameters must be under control to provide a properly fired product.

The investigation has been underway for the past two years and is expected to be completed about the middle of 1967. It will be followed by the preparation of a manual or guide for potteries and should be of interest to all those engaged in the manufacture not only of dinnerware but of ceramics in general. An investigation of this kind has not been made before and the information that is being developed is not available elsewhere.

LH-94 Study of the Biological Basis for Lead Intoxication, Harvard Medical School, Bert L. Vallee, M.D.

The biochemical behavior of lead in the human body has not been studied in a definitive manner and it is the purpose of this investigation to provide a fundamental research study of lead in biochemical systems. This work will involve not only chemistry of enzymes and investigations of other body tissues and fluids but will attempt to follow pathways of lead metabolism.

The first general area of approach has been into analytical chemistry in trace amounts. A heavy emphasis in this phase of the program has been on atomic absorption spectroscopy and direct methods which would provide the required sensitivity without time consuming separations and destruction of organic matter and concentration by ashing. Investigation in this area has been interesting and fruitful and is continuing with many different reagents, absorption tubes and varying spectral absorption lines. Fundamental investigations

of various burner designs for the atomic absorption equipment have also been made.

Next a study of the interference by lead with heme synthesis has been approached by investigating the metal binding propensities of serum transferrin. This work is now underway.

Other studies have been initiated along these same lines using the related metal binding protein conalbumin.

Of great interest is the investigation of metallothionein, which is a small molecular weight protein that has been isolated from horse kidney cortex. It has been shown that cadmium and zinc are influential in this system and tend to compete with the sulphur in metallothionein during normal metabolism.

Another promising model for work on heme synthesis and one which has been previously studied in connection with porphyrin synthesis, is the use of Rhodopseudomonas spheroides, which is a phytosynthetic microorganism that may be grown in the light and which has shown a definite sensitivity to lead.

Investigation of similar systems has shown that E. coli is affected by the presence of lead in the growth media and work on this will serve to compare the effects of lead in a different microbiological system.

All of these lines of approach are being followed at the present time.

LH-106 The Kettering Abstracts of available literature on the Biological and Related Aspects of Lead and Its Compounds, College of Medicine, University of Cincinnati, Irene R. Campbell

The Kettering Abstracts of the world medical literature on lead are published quarterly by the Lead Industries Association for the use of the medical and allied professions under the joint financial sponsorship of the Lead Industries Association of New York, the Lead Development Association of London, and the International Lead Zinc Research Organization, Inc., of New York.

LH-109 Study of the Relationship between the Lead from Motor Vehicle Exhaust and that in Consumer Crops, Statewide Air Pollution Research Center, University of California, John T. Middleton

There have been a few studies reported in the literature on the extent of contamination of the soil and crops near highways by exhausted lead products from internal combustion engines. Most of these studies have not provided quantitative knowledge of the extent of the contamination, the distance that it travels, and the indication of its effect on soil and crops.

The University of California has one of the foremost laboratories in this country for making this type of investigation and has begun a study which will take into account vehicular traffic, highway design parameters, air borne lead, amount of lead normally present in the soil along highways, additional lead

added from contamination, and its effect on various fruit, leafy vegetable and root vegetable crops as grown, as harvested, and as sold. In addition, all of these parameters will be measured at various distances from heavily traveled main highways and secondary roads.

A mobile laboratory has been designed and built which will enable complete freedom in the selection of sampling sites for air-borne lead compounds. A special motor generator set is included in this laboratory which will be fueled with white gasoline. At the present time work on the analytical phase of this project is under way.

LH-110 Continuous Inhalation of Lead by Rats, University of Cincinnati, College of Medicine, Emil A. Pfitzer.

This is a study using laboratory animals in an exposure to air-borne concentrations of finely divided lead oxide to provide a further test of the study procedure used in project LH-75, where men are being exposed to similar concentrations of lead oxide.

This study will be helpful, especially since animals may be exposed continuously, whereas men must be given time off. In other words, the research is designed to establish several more points on a continuous exposure curve to help substantiate the human exposure curve.

LH-111 Continuous vs Intermittent Inhalation of Lead by Rats, University of Cincinnati, College of Medicine, Emil A. Pfitzer

This study is really a part of LH-110 in which rats are being used to check the LH-75 project. In LH-75, men must be given time off from the exposure. It is the purpose of this program, therefore, to compare these intermittent exposures with continuous inhalations.

LH-117 Effects of Lead on Tissue Cultures of the Central Nervous System, College of Physicians and Surgeons of Columbia University, Margaret R. Murray.

Scientists at Columbia University have described the technique of providing a viable culture of mouse central nervous system tissue and of maintaining the growth of this tissue in appropriate nutrient solutions for extended periods of time. This technique has been successfully used to evaluate the effects on such tissues of various metallic ions by incorporating such ions in the nutrient solutions.

An extensive study of various concentrations of soluble lead added to the nutrient solution is now being made and initial research indicates that lead has very little effect on the growth and health of these in vitro cultures. A complete report of this study will be available for inclusion in the next issue of this digest.

LH-118 Study of Lead Burdens in Laboratory Animals, School of Medicine, Wayne State University, Ralph G. Smith

The objective of this program is to study the effects on animals of exposure to ambient levels of urban air pollution.

About three years ago Wayne State University set up a series of parallel exposure chambers, which could house mice, rats, and other laboratory animals and expose parallel groups of the animals to air drawn from over a busy street in Detroit. At the same time, equal groups of similar animals were exposed to clean filtered air as controls. The exposure of these animals was not originally intended as a lead experiment. However, after the animal exposures were completed, this project was set up to measure the amounts of lead picked up during the life cycle by the exposed animals and to compare these with the amount picked up by the control animals breathing filtered air. The analytical work is being done now.

LH-119 The Use of Lead Isotope Composition as an Environmental Tracer, Isotopes, Inc., D. F. Schutz

The objective of this project is to use the most advanced techniques to attempt a measurement and documentation of the amounts of lead contributed to animal and plant systems from various sources, both natural and man made.

Many studies have been made in the past on the amounts of lead present in our environment, including that in air, food, water and soil. It would be of great interest to be able to determine the source of the lead in a particular sample. This has not been possible previously. For instance, the particle size of air-borne lead is so low that identification of the compound is impossible. In analyzing lead in food and water, usual analytical techniques merely identify and quantify lead as lead. It is the purpose of this particular study to examine the use of isotopic measurements as a device to trace the source of lead in a particular sample. This would help evaluate the quantitative relationship between the lead found in a food item and its source, for example, whether the source was from soil or water or air.

Lead found in mines and soils exists as a composite of the several isotopes and it has been found that the isotopic distribution in a particular sample of lead is characteristic of its source. Sensitive measuring techniques have been devised to characterize lead isotopically and it is proposed that these techniques be used in this study. Because these techniques are extremely sensitive, it has been necessary to provide a special laboratory arrangement for the centralization of all lead sample analyses. This laboratory has been activated and work is now underway on a preliminary evaluation of the techniques as they apply to environmental measurements. It is proposed that some of the first measurements to be made will include filter paper samples obtained from the National Air Sampling Network, samples of drinking water, common foods, and representative soil samples. There are catalogs containing the isotopic distribution of lead obtained from mines throughout the world. These can be compared with so-called "natural" lead samples, which exist in many soils and which have been obtained from sources such as meteorites.

LC-18 Organolead Chemistry, Organisch Chemisch Instituut, T.N.O., Utrecht, The Netherlands, L.C. Willemsens, G.J.M. van der Kerk

This program is devoted to exploratory research in organolead chemistry and to the synthesis of new compounds to be studied in applied field. One such field is the control of Bilharzia, an extremely debilitating disease of man and animal which is of great social and economic importance in tropical areas, particularly where rice is a principal crop.

Bilharzia, named for a German physician, Theodore Bilharz, who described the disease in 1851, is caused by small parasitic worms that live in the bodies of water snails. It has been traced as far back as 5,000 B.C. Some cases have been reported in recent years in New York City hospitals among immigrants from Puerto Rico and servicemen who had been stationed in the Middle East and Africa.

Prophylaxis for bilharzia has been widely investigated by the medical profession and the World Health Organization has set up a special study group. No success has been reported in this endeavor. It has seemed, therefore, a wise move to attempt a vector control program similar to that which was so successful against the mosquito for malaria control. In this case, however, such a control program would be directed against the snail, which is the host for the disease-causing parasite.

As a result of screening several organolead compounds, based on their broad biocidal and biostatic activity, triphenyllead acetate was found to be an active molluscicide. Not only does it kill snails, which act as intermediate hosts for the causative parasite, but it is also effective in destroying snail eggs.

Based on its relative selectivity to snails and snail eggs, triphenyllead acetate is less toxic to rice seedlings, by a factor of 10 or more, than other molluscicides. Field trials are underway to evaluate this organolead compound as a means of controlling Bilharzia by interrupting the life cycle of the snail.

The research is being conducted at the Tropical Pesticides Research Headquarters and Information Unit, London, England; at the Tropical Research Institute at Mwanga, Tanzania, utilizing various organolead compounds prepared under the LC-18 program.

Various organolead compounds also have exhibited high anthelmintic activity against tapeworms, which infect economically important animals, such as chickens, turkeys, goats, sheep, and cows, as well as man. The dose required to rid animals of these parasites is very low as compared with the toxic level for such animals, making organolead compounds valuable chemotherapeutic agents. Screening tests of 1 di-n-butyllead diacetate with mice have been completed and show marked improvement over tin compounds used for this purpose.

II. PLANNED PROJECTS

LH-104 Toxicity Study of Ingested Paint Film

The problem of lead poisoning in children is one involving certain socio-economic groups and almost always exists in older areas of old cities. The children predominantly affected are in the age range from six months to about three years. The source of the lead is almost always from painted wooden interior surfaces, usually window sills. The purpose of this planned study is to evaluate the toxicity of paint films containing no lead and various amounts of lead pigments as well as various kinds of lead pigments.

It is planned to use laboratory animals in this study and to use specially prepared typical dried paint films. Such an investigation has not been done before; all of the information on the toxicity of lead-containing paint comes from investigations of the pure lead pigments. It seemed desirable to investigate the toxicity of the paint film itself and the influence of the film on the toxicity of the lead pigments it contains.

LH-112 Bone Marrow Biopsy as a Measure of Total Body Lead Burden

In the measurement of the body lead burden it is important to medical scientists to determine just what the relationship of a blood lead value is to the total amount of lead present in a particular individual. Numerous autopsy measurements of the lead content of bone and other organs have been made but these measurements generally have not been specifically oriented to answer this question.

This study, therefore, has been designed as an experimental approach using laboratory animals which will be exposed to lead compounds as needed and then sacrificed at various stages of their exposure in order to provide samples of bone, bone marrow, blood, and total bodies for determining the body burden of lead, as well as the distribution of lead in the body.

This work will supplement several other studies which are being made or planned on human autopsy cases. The total effort will help considerably in the understanding of the relationship of total body burden to blood lead content.

LH-113 Lead and Experimental Tumors of the Kidney in Rats

Several reports in the literature indicate that ingestion by laboratory rats of a soluble lead compound, such as lead acetate, will induce a high percentage of tumors of the kidney. All of these studies have used large amounts of lead, always in excess of 1% of the total diet.

This study will use several different amounts of lead in the diet to determine threshhold levels of lead in relation to tumor production and to attempt a quantitative and qualitative relationship establishment.

LH-114 Neurophysiological Effects from Lead Exposure

A small scale study, using techniques as reported in the Russian literature of measurements of conditioned reflex activity, is proposed. This type of investigation will be of interest to those concerned with central nervous system effects.

Several European investigators, notably in Russia, France and Switzerland, have used techniques of exposure evaluation to toxic agents that involve extremely subtle measurements of central nervous system effects. These effects have in many of the studies been related to an evaluation of the toxic nature of the material studied. Examples of these studies are the well-known ones made at the Pavlov Institute in Leningrad.

American toxicologists have not used techniques of this kind very widely and, in general, do not hold to the belief that quantitative relationships to the toxicology of a material can be established in this manner. However, some studies of this nature, using very small or subclinical amounts of lead, would help in future understanding of the nature of the toxic effect.

LH-115 Extension of the "Three Cities Survey"

The "Survey of Lead in the Atmosphere of Three Urban Communities", published by the United States Public Health Service as Public Health Service publication #999-AP-12, set a pattern for environmental measurements. Investigations of this type could well provide prototypes for future evaluations, not only of lead but of other materials found in the environment.

ILZRO has informed the U.S. Public Health Service that it is ready to cooperate in another investigation in which air samples are taken and analyzed for lead and representative samples from the blood and urine of various population groups are measured. This type of investigation can provide a sort of environmental inventory for a continuing surveillance program.

III. COMPLETED PROJECTS

LH-69 Characteristics of Atmospheric Lead Aerosols, Stanford Research Institute

The objective of this research program was to extend the exploratory sampling of atmospheric lead aerosols to all types of environments, to extend the size range of the sampling system for a single sampling period, and to characterize more completely the nature of the lead aerosol.

The results of this research were published in the Air Pollution Control Association Journal, Vol. 15, No. 3, March 1965, 102-105, in an article entitled "Size Distribution Studies with the Aerosol Spectrometer" by F. L. Ludwig and Elmer Robinson of the Stanford Research Institute, Menlo Park, California.

LH-76 The Testing of Organolead Compounds for Possible Endocrinological and Anti-Mammary Tumor Activity, The Worcester Foundation for Experimental Biology

The objective of this project was to study 22 organolead and organotin compounds for various endocrine activities, including anti-estrogenic, anti-mammary tumor, anti-androgenic, estrogenic and thymolytic and anti-inflammatory.

Significant anti-androgenic activity was reported for two of these compounds. The researcher, Ralph I. Dorfman, suggests possible therapeutic value in prostatic cancer, possibly some forms of mammary cancer, and possibly for acne, in a paper entitled "Anti-androgenic Activity of Tetra-N-Butyllead in a Mouse Assay", which appeared in the Proceedings of the Society for Experimental Biology and Medicine, 1964, vol. 116, 1055-1057.

LM-4	A Study of Lead Base Alloys	Armour Research Foundation
LC-10	Lead Chemicals	A.G. Little Company
LC-11	High Emission Lead Compounds	New York University
LM-15	Continuous Extrusion of Cable Sheathing	John Robertson Company
LC-19	Lead Oxide In Low Temperature Vitreous Coatings	University of Illinois
LC-20	Lead Glazes for Ceramic Whiteware Bodies	Ohio State University
LC-22	Fundamental Behavior of Lead in Glasses	Alfred University
LC-23	Study of Ferroelectries Containing Lead Compounds	University of California

LM-26	Powder Roll Cladding of Lead to Steel	University of British Columbia
LM-31	Mechanism of Lead Fatigue Cracking	University of Queensland
LE-35	Fundamental Study of the Electro-chemical Behavior of Lead in Various Media Including Cyclid Conditions	University of Cambridge
LC-39	The Kinetics of the Reduction of Lead in Ceramic Systems	University of Illinois
LC-40	Ferroelectric Behavior of Lead Hafnate, Barium Hafnate and Lead Hafnate-Strontium Hafnate Systems	University of Illinois
LM-44	Adhesive Joining of Lead	American Smelting & Refining Co.
LM-46	Metallic Lead as Lubricant Additives	Ethyl Corporation
LE-47	Chemical Reduction Plating	Eltex Research Corporation
LC-51	Fast Fire Glazing of Structural Clay Products	Georgia Institute of Technology
LC-54	Thermal Expansion of Lead Containing Glasses	North Carolina State
LC-61	Lead in Plastics	DeBell and Richardson, Inc.
LM-67	Development of the Continuous Sheet Lead Casting Process	The Broken Hill Assoc. Smelters Prop. Ltd.
LE-73	Lead Anodes in the Purification of Domestic and Industrial Effluents	Water Pollution Research Lab., England
LM-90	Application of Lead For Acoustical Use In European Bldg. Partitions	University of Berlin

B. OTHER ACTIVE LEAD PROJECTS

PART IV LEAD METALLURGY

I. ARCHITECTURAL APPLICATIONS

LM-7 Lead Asbestos Pads for Vibration Attenuation
LM-16 Lead for Sound Attenuation
LM-58 Plumbing Applications of Lead
LM-77 Development of Lightweight Lead Sheet Roofing Systems
LC-59 Ceramic Coatings for Cementitious and Metallic Surfaces
LE-83 Lead Coatings for Concrete

II. WROUGHT LEAD APPLICATIONS

LM-45 Conversion of Particulate Lead to Wrought Forms

III. CABLE SHEATHING

LM-55 Lead Composite Cable Sheathing

IV. SOLDERS

LM-97 Commercialization of Lead-Filled Fiber Metal

V. JOINING

LM-44 Adhesive Joining of Lead

VI. LEAD COATED STEEL

LE-36 High Speed Lead Plating on Steel

VII BATTERY APPLICATIONS

LE-82 Application of Powder Metallurgy to Lead Acid Batteries
LE-84 Support of Naval Research on Lead Acid Batteries
LM-85 Joining of Particulate Lead Products

VIII. CORROSION CONTROL

LE-65 Corrosion of Lead in Various Media
LE-70 Electrochemical Corrosion of Lead Alloys

IX. FUNDAMENTAL RESEARCH

LM-8 Lead Powder Metallurgy
LM-64 Properties of Molten Lead and Lead Alloys
LM-80 The Effect of Fatigue Stressing on the Surface Reactions of Lead
LM-91 A Fundamental Study of Some Dynamic Properties of Lead and its Alloys
LE-29 Fundamental Surface Reactions of Lead

PART V LEAD CHEMISTRY

I. LEAD CHEMICALS

LC-18 Organolead Chemistry
LC-28 Organolead Chemistry
LC-49 Lead Compounds as Lubricants and Lubricant Additives
LC-62 Litharge Glycerol Cement Analogues
LC-63 Investigation to Impart Special Properties to Cotton Through Applications of Lead Compounds
LC-89 Lead Compounds, as Wood Impregnants Against Marine Borers

II. PAINTS AND PIGMENTS

LC-34 Lead Pigments in Water Thinnable Metal Primers
LC-50 Lead Pigments in Water - Based Vehicles, Including Paints For Surfaces Other Than Ferrous
LC-81 Antifouling Paint Formulations
LC-95 Lead Pigments in Electrophoretic Paint Deposition Systems

III. LEAD IN CERAMICS

LC-12 Lead Glazes for Fast Firing Bodies
LC-14 Physical Properties of Lead in Electroceramics
LC-21 High Lead Ferrites
LC-37 Physical and Inorganic Chemistry of Important Lead Compounds
LC-74 Mechanical Strength of Glasses
LC-87 Opacification of Lead-Bearing Porcelain Enamels
LC-88 The Crystal Chemistry of Lead-Zinc Compounds
LC-93 Refractories for Manufacturing Lead Glasses
LC-96 Large Scale Triaxial Phase Diagram for $PbO-B_2O_3-SiO_2$
LC-107 Flame Spraying of Low Temperature Leaded Porcelain Enamels
LC-108 Study of Crystal Relation of Lead-Bearing Low Melting Glasses

ARTICLES AND PRESENTATIONS ON LEAD RESEARCH

General

ILZRO SYMPOSIUM ON LEAD-ACID BATTERY, conducted by A.R. Cook, Philadelphia, Pa. October 13, 1966

BASIC RESEARCH IN THE INDUSTRY COOPERATIVE RESEARCH ORGANIZATION, S.E. Eck, presented to American Ordnance Association, Burham, N.C., May 26, 1966

LEAD RESEARCH - KEY TO TOMORROW'S MARKETS, S. F. Radtke, presented at the 38th Annual Meeting of the Lead Industries Association, Inc., St. Louis, Missouri, March 31, 1966.

INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION SPEARHEADS INDUSTRY PRODUCT DEVELOPMENT, American Metal Market, Feb. 16, 1966.

CHEMOTHERAPY OF BILHARZIASIS, World Health Organization, Technical Report Series, No. 317, 1966

ANTHELMINTIC ACTIVITY OF DIBUTYLLEAD DIACETATE, G. Gras, Rev. Elev. Med. Vet. Pays Trop., France, Vol. 19, No. 1, 1966

ILZRO RESEARCH REPORT TO THE INDUSTRY, S.F. Radtke, presented at the ILZRO Incorporation Meeting, Tokyo, Japan, Nov. 2, 1965.

RECENT ILZRO BATTERY RESEARCH, Three Talks: (1) ILZRO Battery Research (2) Developments in ILZRO Lead Cable Sheathing Research and (3) ILZRO Lead Research - Research Seminar, presented by S.E. Eck for S.F. Radtke at the 2nd International Conference on Lead, Arnhem, The Netherlands, October 6, 1965

RESEARCH AND DEVELOPMENT UNDER ILZRO EXPANDING ESTABLISHED MARKETS AND FINDING NEW PRODUCT LINES, American Metal Market's Annual Lead-Zinc Supplement, July 12, 1965.

LEAD RESEARCH - FORMULA FOR INDUSTRY PROGRESS, S.F. Radtke, presented at the 37th LIA Annual Meeting, Chicago, Ill., April 28, 1965

SIZE DISTRIBUTION STUDIES WITH THE AEROSOL SPECTROMETER, F.L. Ludwig and E. Robinson, Stanford Research Institute, published in Air Pollution Control Association Journal, Vol. 15, No. 3, March 1965

ANTI-ANDROGENIC ACTIVITY OF TETRA-N-BUTYLLEAD IN A MOUSE ASSAY, R.I. Dorfman, Proceedings of the Society for Experimental Biology and Medicine, 1964, Vol. 116.

CONDUCTING COOPERATIVE RESEARCH PROGRAMS, S.F. Radtke (ILZRO) presented before AMA on August 26, 1964, and published in AMA Bulletin, Dec. 1964.

NEW LEAD-ZINC MARKETS THROUGH RESEARCH S F Radtke, ILZRO, Lead and Zinc (Japan), Sept. 1964.

RESEARCH . . . Rx FOR LEAD-ZINC PROGRESS, E&MJ Metal and Mineral Markets, Sept. 7, 1964.

Lead Chemicals

NEW DEVELOPMENTS IN ORGANOLEAD CHEMISTRY, G. J. van der Kerk, Industrial & Engineering Chemistry, Oct. 1966.

INVESTIGATION OF ORGANOLEAD COMPOUNDS II - THE REACTION OF TRIPHENYLPLUMBYLLITHIUM WITH SMALL-RING HETEROCYCLES: FUNCTIONALLY SUBSTITUTED ORGANOLEAD COMPOUNDS, L. C. Willemsens and G. J. M. van der Kerk, Journal Organometallic Chemistry 4 (1965) 34-42

INVESTIGATION OF ORGANOLEAD COMPOUNDS III - THE REACTION OF ORGANOLEAD COMPOUNDS WITH KETENE (TRIPHENYL PLUMBYL) ACETIC ANHYDRIDE, L. C. Willemsens and G. J. M. van der Kerk, J. Organometallic Chemistry 4 (1965) 241-244

GROUP IV ORGANOMETALLIC SULFUR COMPOUNDS- THIO DERIVATIVES OF PHENYL-GERMANES, -STANNANES AND PLUMBANES, W. E. Davidson, K. Hills and M. C. Henry; Journal Organometallic Chemistry 3 (1965) 285-294.

SOME COMPLEXES OF PHENYLLEAD HALIDES, Kenneth Hills & Malcolm C. Henry, Journal of Organometallic Chemistry, 3, (1965).

XIV. ULTRAVIOLET ABSORPTION DUE TO BONDS BETWEEN IVTH GROUP METALS, W. Drenth, M. J. Janssen, G. J. M. van der Kerk & J. A. Vliegenthart, Journal of Organometallic Chemistry, Vol. 2, 1964.

THERMOCHROMISM OF HEXAPHENYL - AND HEXACYCLOHEXYLDILEAD, Journal of Organometallic Chemistry, Vol. 2, 1964.

INVESTIGATION OF ORGANOLEAD COMPOUNDS. I. A NOVEL RED ORGANOLEAD COMPOUND. A REINVESTIGATION OF KRAUSE'S RED DIPHENYLLEAD, L. C. Willemsens & G. J. M. van der Kerk, Journal of Organometallic Chemistry, Vol. 2, 1964.

STUDIES IN GROUP IV ORGANOMETALLIC CHEMISTRY. XIII. ORGANOMETALLIC COMPOUNDS WITH FIVE METAL ATOMS IN NEOPENTANE CONFIGURATION, J. C. Willemsens and G. J. M. van der Kerk, Journal of Organometallic Chemistry. Vol. 2, 1964.

SOME REACTIONS OF HEXAPHENYLDELEAD, Adolf W. Krebs & Malcolm C. Henry, Quartermaster Research & Engineering Command, Journal of Organic Chemistry, Vol. 28, 1963.

THE SYNTHESIS OF ORGANOLEAD SULFUR COMPOUNDS, M. C. Henry & A. W. Krebs, Quartermaster Research & Engineering Command, Journal of Organic Chemistry, Vol. 28, 1963

Paints and Pigments

ORGANOLEAD COMPOUNDS POTENTIAL RAW MATERIALS FOR SURFACE COATINGS, Paint Manufacture, Feb. 1965.

ANTICORROSIVE LEAD PIGMENTS IN WATER-THINNED FERROUS METAL PRIMERS, Everett J. Ritchie & Howard J. Hughes, Official Digest, Vol. 36, No. 469, Feb. 1964.

WATER-THINNED PRIMERS FOR STEEL SURFACES, Industrial Finishing, Aug. 1963.

INVESTIGATION OF LOW TEMPERATURE VISCOSITIES OF GLASSES IN THE SYSTEM PbO-K_2O-SiO_2 BY THE BEAM BENDING METHOD; A. Yalcinkaya, Alfred University, M. S. Thesis, June 1965.

THE STRENGTH AND WEAKNESS OF BRITTLE MATERIALS, C. J. Phillips, American Scientist, Mar. 1965.

KINETICS OF THE REDUCTION OF LEAD COMPOUNDS AND GIASSES: G. H. Haertling and R. L. Cook, University of Illinois, Journal of American Ceramic Society, Vol. 48, #1, Jan. 1965.

RATE DETERMINANTS FOR FAST-FIRE BODIES, R. A. Pregnall M. S. Thesis, Clemson University, 1965.

CALCULATION OF YOUNG'S MODULUS OF ELASTICITY FROM COMPOSITION OF SIMPLE AND COMPLEX SILICATE GLASSES, C. J. Phillips, Glass Technology, Vol. 5, No. 6, Dec. 1964.

PHASE RELATIONS IN THE SYSTEM PbO-CO_2 AND THE DECOMPOSITION OF CERUSSITE, David A. Grisafe & William B. White, The American Mineralogist, Vol. 49, Sept. - October 1964.

RATE DETERMINANTS OF GLAZE FORMATION, M. K. Spear, Jr. M. S. Thesis, Clemson University 1964.

ELECTRICAL RESISTIVITY IN THE POTASH - LEAD - SILICA SYSTEM; A. Micheli, Alfred University, M. S. Thesis, June 1964.

PHASE RELATIONS IN THE SYSTEM LEAD-OXYGEN by W. B. White and R. Roy, Journal of American Ceramic Society 47, 242-249 1964.

PHASE DIAGRAMS, Lead in the Ceramics Industries, LIA, Nov. 1963.

DIELECTRIC BEHAVIOR IN THE SYSTEMS $PbHfO_3$-$BaHfO_3$, David L. Wilcox & Ralph L. Cook, Univ. of Illinois, Journal of the American Ceramic Society, Vol. 46, 47, July 1963.

DILANTOMETRIC AND X-RAY DATA ON LEAD COMPOUNDS, PART 2, J. F. Argyle & F. A. Hummel, Pennsylvania State Univ., Journal of the ACS, Jan. 1963.

PHASE RELATIONS AND STRUCTURES IN THE SYSTEM PbO-Fe_2O_3, A. J. Montvala & S. F. Ravits, Univ. of California, Journal of the ACS, Vol. 45 June 1962.

CRYSTALLIZATION CHARACTERISTICS OF LEAD MOLYBDATE IN LOW TEMPERATURE ENAMELS, R. B. Amin and R. L. Cook, Univ. of Illinois, Journal of American Ceramic Society Bulletin, Vol. 42, #11, Nov. 1963.

Furhter references are listed in Digest 17 or may be obtained from ILZRO

LEAD AND ZINC DEVELOPMENT ORGANIZATIONS

AUSTRALIA

Australian Lead Development Association
Australian Zinc Development Association
95 Collins Street
Melbourne C.1., Australia

GREAT BRITAIN

Lead Development Association
34 Berkeley Square
London W.1, England

Zinc Development Association
34 Berkeley Square
London W.1, England

FRANCE

Centre d'Information du Plomb
10 Place Vendome
Paris 1, France

Chambre Syndicale du Zinc et du Cadmium
39 Rue St. Dominique
Paris 7e, France

Zinc et Alliages
34 Rue Collange
Levallois - Perret (Seine)
Paris, France

GERMANY

Bleiberatung E.V.
Haus der Metalle
Tersteegenstrasse 28
Dusseldorf, Germany

Gemeinschaftsausschuss Verzinken
Beethovenstrasse 12
Dusseldorf 4, Germany
(Hot Galvanizing for Corrosion Protection)

Zinkberatung, E.V.
Friedrich-Ebert-Strasse 37-39
Dusseldorf, Germany

INDIA

Indian Lead Zinc Information Centre
5A, Lord Sinha Road
Calcutta 16, India

ITALY

Istituto Italiano del Piombo e dello Zinco
via Marco de Marchi 7
Milano, Italy

JAPAN

Japan Lead Zinc Development Association
No. 3, 2-Chome Uchisaiwai-cho
Chiyoda-ku
Tokyo, Japan

THE NETHERLANDS

Stichting Doelmatig Verzinken
Jan van Nassaustraat 93
'S-Gravenhage, Holland
(Zinc Coatings for Corrosion Protection)

SPAIN

Centro Nacional de Investigacianes Metalurgicas
Ciudad Universitaria
Madrid 3, Spain

SWEDEN

Scandinavian Lead Zinc Association
Sturegatan 22
Stockholm ö, Sweden

UNITED STATES

American Zinc Institute, Inc.
292 Madison Avenue
New York, New York 10017

Lead Industries Association, Inc.
292 Madison Avenue
New York, New York 10017

CONTRIBUTORS TO THE INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION, INC.

American Metal Climax, Inc.
New York, New York

American Smelting and Refining Co.
New York, New York

American Zinc Lead and Smelting Co.
St. Louis, Missouri

Anaconda Company
New York, New York

Broken Hill Associated Smelters
Proprietary, Ltd.
Melbourne, Australia

The Bunker Hill Company
Kellogg, Idaho

Cerro Sales Corp.
New York, New York

Asarco Mexicana S. A.
Mexico City, Mexico

Cominco Ltd.
Montreal, Quebec, Canada

Eagle-Picher Industries, Inc.
Cincinnati, Ohio

Electrolytic Zinc Co.
of Australasia Ltd.
Melbourne, C.1, Australia

Hudson Bay Mining & Smelting Co. Ltd.
Winnipeg Manitoba, Canada

International Smelting & Refining Co.
New York, New York

Matthiessen & Hegeler Zinc Co.
LaSalle, Illinois

Mitsubishi Metal Mining Co., Ltd.
Tokyo, Japan

Mitsui Mining & Smelting Co., Ltd.
Tokyo, Japan

Monteponi & Montevecchio
Societa Italiana Del Piombo
E Dello Zinco
Milano, Italy

Mt. Isa Mines, Ltd.
Queensland, Australia

National Zinc Co., Inc.
New York, New York

Noranda Sales Corporation Ltd.
Toronto 1, Ontario Canada

The New Jersey Zinc Co.
New York, New York

The Rio-Tinto Zinc Corp., Ltd.
London, England

St. Joseph Lead Company
New York, New York

Sulphide Corporation, Pty., Ltd.
Melbourne C.1, Australia

Tsumeb Mining Corp., Ltd.
Tsumeb, South West Africa

U.S. Smelting Refining & Mining Co.
Boston, Mass.