HEALTH & SAFETY REPORT

From the Director of Health and Safety
Lead Industries Association, Inc.
292 Madison Ave.
New York 17, N. Y.

Look Ahead with Lead

February 11, 1964

LEAD HYGIENE AND SAFETY BULLETIN
No. 156

To Members of the Lead Industries Association, Inc.:

Attached for your information are copies of two excellent papers which were given at the last meeting of the Association of American Battery Manufacturers, Inc. in Chicago. We think you will find the ideas expressed to be up to date and practical.

Extra copies are available from this office if you need them.

Don G. Fowler

Don G. Fowler

DGF:md
Enc. (2)

METHODS FOR THE PREVENTION OF LEAD POISONING IN INDUSTRY
by
Robert A. Kehoe, M. D. *

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

Introduction

The poisonous properties of lead and many of its common inorganic compounds have been known with varying degrees of understanding and misunderstanding for centuries. This situation persists, for the growth of new knowledge has been associated with a tremendous lag in its dissemination, and with a still greater delay in its application in clinical medicine and industrial hygiene. Since almost everyone has heard or read something about lead poisoning, it is assumed by many people, and especially by physicians, generally, that they know a great deal about it. The facts are that laymen, as a group, know virtually nothing about it that is of value to them, and that comparatively few physicians on the outside of industry have had any contact with persons who were suffering from lead poisoning, or any experience that would qualify them to diagnose or treat this ailment, much less to make a valid appraisal of the conditions under which the disease occurs. It is not surprising, therefore, that many cases of lead poisoning, especially those which occur among very young children, or among adults who have no obvious exposure to lead, should go unrecognized. Still less surprising, and actually of common occurrence, is the opposite situation - that of cases of other types of illness, especially those of somewhat obscure character, being diagnosed as lead poisoning, merely because the patient who presents himself to a physician is found or said to be "working with lead," or is employed in a shop or industrial plant in which lead is used. It is cause for much more surprise and indeed for great concern, that in a country in which technical knowledge and skill have reached a very high point - in which research and development in industry have become magic words and deeds in our productive, competitive economy - we should find so great a lag and such striking ineptitude in the application of the available technical knowledge in providing conditions in which the uniquely useful physical and chemical properties of metallic lead and its compounds can be utilized to the full, without exacting an unduly high toll in sickness and disability from the men and women who work with these materials. Much of a congratulatory nature has been said, in many places, of the progress that has been made in industrial medicine and hygiene in the United States. Some of this is valid, especially that which has been limited to the contributions to our knowledge which have been made in the past forty years through research in laboratories of industrial toxicology and hygiene, and through surveys and persistent medical and hygienic supervision and investigation in various industrial plants. Out of these have come the basic information and the practical methods whereby familiar types of industrial intoxication have been brought under satisfactory control in some industrial establishments in some areas of the country. There are, for example, industries in which large quantities of lead and its compounds are being used in potentially dangerous operations, in which no cases of lead poisoning, even of the mildest type, have occurred for many years, and in which the risk of lead poisoning is under complete control.

In contrast to this are industrial plants, usually, but not always, small, in which occupational exposure to lead, in operations that are well-known to be dangerous, occurs practically without control, and in utter disregard of any

* Presentation made at the 1963 Fall Meeting of The Association of American Battery Manufacturers, Inc., November 14, 1963, Chicago.

principles and practices of industrial hygiene. It is equally true that, as the utility of lead and its compounds in modern technology have taken these materials into a large number of highly varied types of industry, many of those who are responsible for production, in their preoccupation with the technology of production, have had no thought for hygienic technology, lacking familiarity with these matters, themselves, and having no experienced or trained technical or medical representatives of industrial hygiene in their organizations. Thus it transpires that the incidence of lead poisoning in American industry is high, and while most of the cases of poisoning are comparatively mild, we still see, from time to time, cases that compare in severity and in their capacity for producing permanent disability, with those which occurred in the darkest periods of industrial history. In bringing these dreary facts home to this audience, I must also emphasize the fact that the manufacture of electrical storage batteries is responsible for a large number of cases of lead poisoning in the United States - probably a larger number than any other one industry - and that to my personal knowledge there have been cases, within the present year, of a type that occur only as the consequence of massive, essentially uncontrolled exposure to lead in the form of dust and fume.

These things are occurring in this industry at a time when there is ample information with respect to both the methods of control and the criteria of human safety, whereby lead poisoning can be eliminated completely from among the occupational diseases.

It is my purpose to bring to you the evidence in proof of the latter statement, and to discuss with you the basic reasons for the failure, in present-day America, to apply well established methods of industrial hygiene to the protection of the health of workmen and the preservation of their ability to earn a living for themselves and their families.

Hygienic Standards for the Appraisal of Exposure to Lead

Let us first consider the results of certain precise observations that have been made over long periods of time in various lead-using industries in this country, whereby occupational conditions which are dangerous can be differentiated from those which are safe. In obtaining such results one cannot have failed to perceive the major features of the industrial operations and of the conditions under which they are carried out, which have rendered them dangerous on the one hand, and safe on the other. These conditions will be dealt with at greater length, separately.

It is impossible in the time available for the discussion of this subject even to mention the principal investigations from which our present knowledge of the behavior of lead in the human body has been derived. Suffice it to say that on the bases of such physiologic facts, the determination of the rate of the excretion of lead in the urine and the measurement of the concentration of lead in the blood provide definitive means for establishing, indirectly, the approximate level of the absorption of lead into the body, under appropriate conditions, and for estimating the severity and the hygienic significance of an occupational exposure to lead. By carrying out analytical surveys of workmen at suitable intervals over a sufficient period of time, one can demonstrate the fluctuations and the general trends in their current rate of absorbing lead, and thus establish the quality of the conditions under which these men work, with respect to the relative severity of their exposure to lead. By maintaining an adequate medical supervision of such workmen, in concurrence with the analytical regimen, one can also determine, in an entirely factual manner, whether the analytical findings both in individuals and also in the group, and hence the individual or collective occupational exposure to lead, is associated with the occurrence of lead poisoning. By means of systematic observations of this type, carried out over periods of years in a wide variety of lead-using industries, it has been possible to develop criteria by which dangerous occupational conditions can certainly be distinguished from those which are safe. Moreover, varying degrees of hazard can clearly be protrayed, in terms of the physiological and clinical responses of workmen to the conditions under which they work.

There are tremendous advantages in having information at hand which demonstrates the extent of the absorption of lead by individuals in a group, and by the group as the composite representation of a specific industrial plant. For one thing, it is no longer necessary to speculate as to the extent and the significance of the exposure of the workmen to lead. This is revealed as clearly and as meaningfully, by analytical means, as are the dimensions of an article in production, by instrumental measurements. As for another gain in reasonable certainty, in contrast with the general fuzziness of former lay and medical opinion, the factor of individual susceptibility to the absorption of lead, which has been one of the potent obstacles to sound environmental control of lead exposure, has been reduced to a level of practical insignificance. One need not concern or delude himself with the idea that this, that or the other set of conditions is not dangerous, or that this specific compound or mixture of compounds in the form and manner in which it is being handled, is not absorbable. The fact of absorption cannot be missed, provided established methods of investigation are employed with sufficient skill and care, and if the analytical results are interpreted on the basis of sound physiologic facts and principles. The latter reservation calls for a word of caution. The development of methods of analysis which cannot be employed successfully in ordinary clinical diagnostic laboratories or in the usual quality control laboratories of industry, has placed this analytical service in the hands of highly competent chemists in specially designed laboratories. So far so good, in insuring the validity of the analytical results. The problem of obtaining satisfactory samples of blood, and especially of urine, however, is up to the physician, as is also the responsibility for interpreting the results and acting upon them. By no stretching of his function can the chemist or industrial hygiene engineer properly assume these responsibilities. The handling and supervision of men who are threatened by disease is a medical function, both by tradition and law, and since the satisfactory placement or displacement of workmen often arises out of these analytical results, such results should be dealth with as the confidential data of medical records. When they are made available to, and discussed with, non-medical personnel, especially workmen, through other than confidential medical consultations with individual workmen, they create situations which are often fraught with grave difficulties, including misunderstanding, apprehension, gossip, and labor-management controversies. (It is fairly obvious that medical matters are often involved in collective bargaining, but it is equally evident that this is not the desirable method of arriving at sound medical policies in industry.)

It may be noted, with some surprise or concern, that the discussion of standards of safety has not included, thus far, reference to the tolerable limit (or limits) of the concentration of lead and its compounds in the atmosphere of industrial establishments. It might have been supposed, for reasons of convenience and economy, as well as historical sequence, that such a standard (or standards) of safety would have been considered herein in advance of any other. It is not through accident or prejudice, however, that this matter has been relegated to a secondary position in its relation to human safety with respect to the absorption of lead. The fact is that the measurement of the concentration of lead in the atmosphere affords many practical advantages in connection with the operation of a plant in which lead is being used, and specifically in the appraisal of the efficacy of the measures for controlling the lead content of the atmosphere. At best, however, one is dealing here with "rules of thumb," in relation to degrees of hazard. The latter vary with the physical and chemical characteristics of the particles dispersed in the air, and, therefore, unless these characteristics (i.e. the nature of the specific compound (or compounds) in the atmosphere, and the distribution of the particles as to size, shape and mass) are ascertained and are interpreted in terms of their potential absorbability, they provide little more than an educated guess as to the severity of the overall hazard sustained by men who work in the tested areas of the plant. The mention of "tested areas" should bring to the mind of the experienced industrial hygiene engineer the problems presented by the many operations which are carried out in many different areas of an industrial plant, and by the manifold variations in the volume of these operations from day to day, month to month, or year to year. The adequacy of the sampling program, as to methods and the satisfactory coverage of such variables as changes in the overall or localized volume of production, deterioration of production and control equipment, and many others, is always open to question and is subject to budgetary, as well as technical, obstacles.

The significance of the concentration of lead in the air in the vicinity of workmen, even if it is so determined as to relate only to respirable lead, is still an incomplete expression of the occupational exposure to lead, for this is not the only source of significant exposure. Unless care is taken to limit the introduction of lead into the digestive tract, through the promotion of habits of cleanliness on the part of the men, and through provision of comfortable and attractive wash-room, "change-house" and lunch-room facilities, the lead that is swallowed daily continues as a source of absorption throughout the 24 hours of the day and over the week-end (since the alimentary tract is not emptied of its residual contents at the termination of the day's work). It is true, of course, that the absorption of lead from the alimentary tract is slow and incomplete under the most favorable conditions, but it is also true that lead poisoning may result solely from such absorption, if the quantity ingested is sufficient. Since it is fairly easy, under suitable conditions, for the workman to avoid the ingestion of lead in the course of his work, it is obvious that this contribution to that which he inhales from the air, under much less easily avoidable circumstances, should be kept at the absolute minimum. In this connection it is a fact of considerable importance that the large particles of lead-bearing materials (those in excess of 2 to 10 microns in diameter, or of even larger dimensions) which may remain airborne, in the immediate vicinity of a workman's nostrils, long enough to be inhaled, are deposited for the most part in the nasal and tracheobronchial passages, and that large numbers of them reach the nasopharynx and are swallowed. Thus it happens that the alimentary tract may contain from a few to many milligrams of lead every day, which are derived from the dust-laden atmosphere of a plant. Therefore, the use of an air-sampling device which excludes the larger particles — even those which fall out of the air rapidly--may fail to reveal the true significance of the exposure of workmen to airborne lead.

For all of the foregoing reasons, and for others as well, the sampling and analysis of the air, as the sole or principal means of measuring occupational lead hazards, may fail partially or utterly to reveal the true state of the industrial environment, and it can never (or hardly ever) be expected to disclose the probably or actual hazard of the workmen, especially that of the group of workmen (such for example, as the maintenance and housecleaning personnel) whose work does not fit into the usual patterns of production operations.

Other criteria have been and are being used to maintain a check upon the status of workmen in the lead trades. These range from some form of periodic physical examination to the use of procedures of the clinical laboratory (either as supplements to physical examinations or as the sole measures of medical examination), from which conclusions are drawn as to the likelihood of the onset of lead intoxication in a specific workman or among certain occupational groups of workmen. The strictly clinical examinations are intended to pick out the individuals in a group of men who are threatened by lead intoxication, or, more realistically, to discover incipient intoxication before it has reached a serious or disabling stage. Certain laboratory tests, among which the commonest, the microscopic examination of the blood for "stipping" of the erythrocytes (these tests are often extended to include other changes in the formed elements in the blood, such as reduction in the numbers and in the hemoglobin content of the erythrocytes) and, more recently, the examination of the urine for the presence of abnormal quantities of porphyrins, are being employed as means of appraising the state of health of the workmen, or in reverse, the extent of the hazard of lead absorption to which they are being subjected.

Without entering upon an ill-timed discussion, here, of the relative value of these criteria for diagnostic purposes or for revealing certain non-disabling effects of the absorption of abnormal quantities of lead, it is sufficient for present purposes, to say that none of them, singly or in combination with any or all of the others, is satisfactory. In order to put this fact in perspective in the present state of preventive medicine, I trust that I may, without impropriety, take a firm professional position. I would not be willing to accept the responsibility for the safety of a group of workmen in an industry in which there is an actual hazard of lead poisoning, if I had to rely solely upon any one or any combination of these clinical procedures. In the light of present knowledge, these are not adequate as procedures of preventive medicine in the lead-using industries. In an earlier period of occupational medical practice, they were the best means available; they are now but makeshifts. Their only justification is that they are easier and less costly in their performance. Let me hasten to say that, in lead-using industries in which time and experience have demonstrated that the exposure of workmen to lead in current, stable operations is being so controlled as to be without hazard, it will not be necessary to resort to precise measurement of the rate of the absorption of lead. Even in such industries, however, some of which are known to exist, any important change in the type or method of the operations must be reexamined for its effects upon the absorption of lead by the relevant group (or groups) of workmen, if the health of the latter is to be adequately protected. Moreover, the equipment of the operations, as well as that of industrial hygiene (ventilation, filtration, electrostatic precipitation) undergoes deterioration and must be tested and maintained at a higher level of efficiency, if satisfactory environmental conditions are to persist.

Methods for the Control of Exposure to Lead in Industry

The principle that develops from the general consideration of the preceding discussion, is that the principal functions of the physician in the lead-using industries are those of recognizing the existence of the danger of lead poisoning therein, when it exists, and of estimating the extent and the significance of this danger, and of providing suitable specifications for its elimination. It is clear then, that the actual prevention of occupational lead poisoning, in all but secondary matters, resides in the control of the inherent opportunities for exposure to lead which derive from the industrial operations. The responsibility for such control lies in technical, not medical, hands, and is, fundamentally, a function of management. This function, however, in our day, may properly be delegated to the industrial hygiene engineer, provided the efforts of the latter are implemented adequately by management, either directly or through the medical department. It is not wise nor realistic to assign such responsibility to a physician, nor is the physician true to his humane role in society, if he accepts such responsibility. There is no drug nor medicine--no chelating agent, no food nor drink, such as milk or lemonade--whereby men who are absorbing dangerous quantities of lead may now be shielded from the harmful effects of such absorption. The time may come when medical research will have brought forth medication that will serve this purpose, but this has not been accomplished, and until such a time, the responsibility for the occurrence of occupational lead poisoning rests heavily upon the management of the lead-using industries.

There are certain measures which can be employed usefully and effectively for short periods of time, or in unusual situations or emergencies, whereby the medical guidance of the management in the disposition of workmen can be used for the protection of the latter in obviously dangerous situations. Such conditions should not be tolerated longer than is required to arrive at a sound conclusion as to the nature of the existing situation and the proper means of dealing with it over the long pull.

The specific methodology of environmental control in lead-using industries need not and should not be spelled out in this discussion. Suffice it here to say that technical experience and expertness are involved in the location and design of an industrial plant, its operations and its equipment, to meet the requirements of production, along with those of industrial hygiene and public health. (The mere mention of appropriate methods for the disposal of airborne and waterborne wastes is sufficient, for present purposes, to justify considerations of public health.) Obviously, it is much more difficult to achieve satisfactory results in the conversion of an old plant to a new or revised use. This is a matter which should be considered expertly in the hygienic appraisal of an industrial project of this type. It is not an uncommon experience to find that a new plant has been designed to achieve certain advantages in production, in disregard of the requirements of industrial hygiene. Almost equally disconcerting is the outcome of the attempt to utilize an available or conveniently acquired building (or group of buildings), only to find, too late, that the cost of remodeling, without achieving a satisfactory result, was greater than that of constructing a new, properly designed and safe plant.

Before concluding these brief comments on the methods of environmental control in the lead trades of the present and future, at least one other general principle should be enunciated, this time from the point of view of the physician in industry, whose duty, among others, is to cultivate among workmen the utmost in knowledgeable compliance with the requirements in personal performance. These requirements must be reasonable in their demands upon both the understanding and the behavior of the workmen. One cannot make light of the hazards of the day's work, and at the same time put the responsibility for meticulous care in the avoidance of hazard upon the uninstructed workman. The intelligent and effective use of a dust respirator is indeed a matter which requires both understanding and meticulous care. Moreover, if the requirement of the use of the dust respirator is to be more than a gesture of piety, against the overwhelming probability that it will not be used effectively by untrained and unsupervised workmen, the respirator will have to be selected, inspected, cleansed and fitted to the workman by an appropriately trained representative of the management, and its proper use will have to be assured by an effective system of supervision. As the preceding comments suggest, there are situations which require the use of personal respiratory protective equipment from time to time and there are a few jobs which, it seems, cannot be carried out with safety without continuous use of such equipment. This is rare, fortunately, and each instance must be accepted as a real challenge to the ingenuity of the designers of processes and equipment, since it is the persistent, nagging evidence of a departure from sound principles of both industrial engineering and environmental hygiene. It is a function of the process engineer to design the equipment of production to secure the maximum in efficiency and economy of production, consistent with the safety of those who carry out the operations. The contribution of the environmental (industrial) hygiene engineer, in this relationship is to secure the safety and the maximum of convenience and comfort of the workmen, to the end that they shall sustain no impairment of their capacity to work because of potential dangers of their occupation.

<u>The Basis for the Present Position of the Lead-Using Industries in Matters of Industrial Medicine and Hygiene</u>

In the preceding discussion it has been pointed out, with some emphasis, that there are now satisfactory criteria for the identification and appraisal of dangerous occupational conditions, with respect to occupational exposure to lead, and that there are methods for the complete elimination of the danger of lead poisoning from industry. The proof of the correctness of these statements has been furnished by those who have made effective use of the criteria for the differentiation of safe from dangerous conditions, and have employed methods of environmental control through which these criteria have been met over periods of years. The bald fact which emerges from these statements is that despite the availability of adequate means for the prevention of lead poisoning, the industrial users of lead and its compounds in this country now permit the occurrence of lead poisoning among their employees, while our society is willing to accept a certain toll of illness, and a shortening of human life, while reaping the benefits of a large series of industrial products.

The question with which all gentle and responsible people are confronted at this juncture is--Why should these things be? Some partial answers to this question are worthy of consideration, not so much for the appeasement of our collective guilt, as for a clearer view of the way which lies ahead.

First, what is true of the lead-using industries is true, in greater or lesser degree, of all of the hazardous trades in the United States. The evidence is not as clear, in many of these, as it is in those involved in the use of lead, as to the satisfactory means for controlling the hazard, but the practices of industrial medicine and hygiene are hardly ever on a par with the knowledge that is available, even in the most forward-looking and best informed industrial circles, while, in many others, performance lags far behind knowledge. There is probably no State in the United States in which there is not a very wide difference between those industries in which the practices are good and those in which they are less good or actually bad. If this is the case within certain outstandingly active States, in matters of industrial hygiene, there is an even greater divergence among the States, some of which occupy a primitive place in this setting, and make hardly a gesture toward occupational health. (It is for the latter reason that our society as a whole cannot escape some share in the responsibility for the poor quality of industrial hygiene that is to be found in many areas of the country. If the government of the people is wholly or partially unaware of its obligations, the people too are blind.) It is hardly to be expected, therefore, that the lead-using industries should out-distance industry in general, in its hygienic performance, despite the fact that human experience in the handling of lead is old, even ancient, while that associated with many other materials is in its infancy. There is also, as has been said previously, a very great variation, among the lead-using industries, in their familiarity with the principles and applications of industrial medicine and hygiene. Some have set fine examples in performance, others have resisted successfully every effort to win their adherence to good practices, while still others have engaged in the production (mostly of raw products) without even considering any need to protect their employees against lead poisoning. It is all too evident that the principles of good medical and engineering practice in the American industrial community are extremely spotty in their dissemination and application, and that there cannot be said to be an effective professional representation of industrial medicine and hygiene within the industries of this country. This is almost equally true, at present, of state, county and municipal health departments, despite the existence of notable exceptions to this generalization. Under these circumstances, it is not surprising that there is little by way of effective implementation of state legislation in matters of industrial hygiene in many areas of this increasingly industrialized country.

A second feature, which goes far to explain the laxity of hygienic performance in many lead-using industries, is the insidious and often mild character of the intoxication induced by the absorption of moderate quantities of lead. Men who themselves have worked for many years in lead-using industries, and have supervised other workmen, remember the many men who, seemingly, have escaped illness, or have not been seriously disabled, and forget the smaller number of men who had severe cases of poisoning, as well as the larger number of men who were off work from time to time, but returned again and again to the job with which they were familiar. (It is usually in this latter group--those who have suffered repeated attacks of lead intoxication of varying severity over a period of years, that our cases of severe and often permanent disablement--encephalopathy and palsy--are found. Despite their relative infrequency these cases still occur.) The veterans in the industry, especially foremen and superintendents in the older types of plants and operations, will recount some of their earlier experiences, and insist, with truth, that present conditions are so much improved as to bear little resemblance to those of an earlier day. The fact is that the penalties of compensation costs and the stress of personnel problems, including collective bargaining, have focused an increasing amount of attention upon the hygienic problems of the lead trades, and have resulted in greater and more widespread efforts toward environmental control. Many of these efforts have been poorly directed toward ill-defined goals, however, and have achieved varying degrees of improvement in the occupational conditions, without elimination of the hazard. What has occurred, therefore, has been a fairly general reduction in the severity of the cases of lead poisoning, without a pronounced effect upon the incidence of the disease. Thus it is that cases of lead intoxication still occur in well-established industries. Moreover, as this metal and its compounds find their way steadily into new uses, an increasing number of workmen are being subjected to inadequately controlled occupational exposure, and the decreases in the incidence of lead poisoning, in some segments of industry, are counteracted by increases in others.

A cursory examination of the foregoing statements would seem to face us with an old and frustrating dilemma on which many attempts to solve the lead problem in industry have bogged down--namely an unpredictable variability in human susceptibility to lead poisoning. This, however, is not the case, for something new and decisive has been added to our knowledge in recent years, with the amassing of overwhelming evidence that, when the rate of the absorption of lead by men is kept within certain well-defined limits, no intoxication occurs. It is this fact which sets the standard of industrial medicine and hygiene which is to be achieved in the lead-using industries. It is also this fact which dispels much of the uncertainty which has plagued the physician in the lead trades for so long, as to what to expect of a certain set of occupational conditions. Certainly not all persons who are subjected to a dangerous degree of exposure to lead become ill at the same time or even ultimately, but all are in danger and may become ill at an utterly unpredictable time, and, as the severity of the exposure is found to increase from one occupation to another, the number and severity of cases of poisoning increase. These cases occur within a definite range of ordinary biological variability, fitting therefore into the usual patterns of biological phenomena. Even more importantly, for our professional peace of mind, at a sharply defined point in the progressive decrease in occupational exposure, cases of intoxication no longer occur, and the only evidence of the occupational absorption of lead that can be found is that of some elevation, above that of the ordinary normal individual in the general population, of the concentration of lead in the tissues and body fluids of the workmen.

Summary

The entire substance of the preceding discussion, apart from the presentation of the evidence on which it is based, may be represented briefly in the following summary.

(1) The means by which dangerous occupational exposure to lead may now be differentiated from that which is harmless, are now available and have been put to the practical test of time and use.

(2) Methods, derived essentially from engineering techniques, are also available whereby occupational exposure to lead can be brought and maintained within the limits of safety. These have proved their adequacy in use and are capable of general application.

(3) The combined modern armamentarium of industrial medicine and hygiene can be so applied as to eliminate lead poisoning from American industry, when the determination to do so has become a general policy of industrial management.

LEAD ABSORPTION CONTROL

by
W. M. Fallies*

The Electric Storage Battery Company, Manager, Industrial Hygiene and Safety, Philadelphia, Pennsylvania

The number 0.2 has a special significance in lead absorption control. It is the Threshold Limit Value (or TLV) for lead. The TLV is the concentration at which a material in the air of the workplace becomes a possible danger to the health of the worker. It is an average value about which the concentration may fluctuate as long as the fluctuations are not excessive and the time weighted average does not exceed the limit over an 8 hour period. What may be considered excessive depends on a number of factors the chief one being the nature of the action which the material has on the body. You may also have heard about Maximum Allowable Concentrations, Maximum Permissible Concentrations, Maximum Acceptable Concentrations, etc. These are attempts to measure the same thing as the TLV but sometimes with a slight difference. The Maximal Acceptable Concentration (as published by the American Standards Assocation) is an upper limit of atmospheric contamination which should not be exceeded. In practice there is very little difference. We try to stay under 0.2 for any length of exposure.

In a discussion of Threshold Limit Values of toxic materials, a toxicologist may set up two classes - self-policing and non-self-policing. Most of you are quite familiar with at least one member of each of these classes. Sulfuric acid mist has a Threshold Limit Value of 1 mg. per cubic meter and exposures to high concentrations can cause inflammation of the upper respiratory tract. But concentrations above the TLV are quite disagreeable and few people will tolerate this exposure. Thus the TLV for sulfuric acid is self-policing.

The situation with lead is quite different. The TLV for lead is 0.2 mg. per cubic meter. Exposures to high concentrations can produce permanent disability and death. Some people claim to taste lead in the air. I cannot, but I understand it is not an unpleasant taste and there is little information available concerning tastable levels. So lead is non-self-policing. The policing must be taken care of by the medical control program.

Our primary control is the determination of the urine lead level. We used to do stippled cell counts, we have checked urinary porphyria levels, others have tried urine delta-amino-levulinic acid levels. All these are affected by lead exposure and can be used to effect some measure of control but they are evidences of interference by lead with the normal functioning of some body processes. We feel that these interferences are things which our control program should prevent. We continue to study the problem but expect to remain with urine leads. Generally urine lead levels less than 0.20 mg/liter of urine are considered to represent non-hazardous exposure.

Every month every employee who has more than a casual contact with lead sends a urine sample to the Industrial Hygiene Laboratory in Philadelphia. The urine lead level tells nothing concerning the condition of a man's health. It cannot be used as evidence of lead poisoning except, possibly, at very high levels. What it does do is reflect a man's exposure. A high urine level does not necessarily indicate lead poisoning but it most assuredly does indicate excessive exposure.

---

* Presentation made at the 1963 Fall Meeting of The Association of American Battery Manufacturers, Inc., November 14, 1963, Chicago.

N 213.02

The ESB program includes air sampling for lead. But with the increase in urine sampling the importance of air sampling has gradually decreased. Most air samples attempt to duplicate as nearly as possible the conditions in the breathing zone of the worker. The results must be extrapolated to cover a full day's work to determine whether the man's entire exposure exceeds the TLV. Even with many samples to cover as much of the job as possible the overall exposure is guess work. With urine sampling the man himself can be looked on as the sampling device. The air sampled is the air actually breathed. The only trouble is that all people don't absorb and excrete lead in exactly the same way. Urine lead concentration under similar exposure conditions varies from person to person and even from day to day for the same person. But in group exposures urine samples and air samples will follow parallel courses and the urine samples will indicate average air concentrations.

It is unfortunate that individual urine levels don't always follow air concentrations but there is one way to compensate for this at least partially. Urine specific gravity measurement gives a rough indication of the way all materials in the urine are being excreted. If the gravity is low it is an indication that the lead excretion rate is reduced. Some laboratories make it a practice to correct urine lead levels to a standard or average, specific gravity. This is usually 1.024. We don't make this correction because there does not appear to be any sound scientific basis for doing it. (Also in our experience 1.024 is too high for an average specific gravity.) To my knowledge the practice of correcting for gravity is not followed for any other substance measured in urine. We do, however, tend to ignore samples with low gravities and the lower they are the less reliance is placed on them. A single low gravity can be ignored but a consistent run of low gravities on one individual means that we get no reliable determination of his lead exposure. The cause of the lack of concentration should be determined to see if there is anything wrong with the man's kidneys but in the meantime we need some measure of his lead absorption. This is one of the situations in which we turn to blood lead analysis. In this case the blood lead is used as a substitute for a urine lead determination.

The blood determination has another important function - the confirmation of a diagnosis of lead intoxication. As mentioned previously, urine lead levels reflect exposure and absorption but tell very little about its effects in the body. The effects of lead are very much more closely related to the level in the blood. A concentration 0.08 mg. of lead per 100 grams of blood is generally regarded as the danger level. But levels above 0.08 do not automatically mean lead poisoning exists but are referred to as levels compatible with symptoms of lead intoxication.

A single urine lead in excess of 0.20 is not regarded as especially significant. However, a recheck is made and if it checks out at 0.20 or more, two things happen. First, the doctor takes a blood sample for lead analysis. Second, the job is studied (usually by the man's immediate supervisor) to see if the source of the exposure can be determined. Often this added attention from the doctor and the foreman is enough to correct the problem. If it is not corrected, the urine lead will remain above 0.20 and the blood level will rise slowly and eventually exceed 0.08. At this point (when 2 consecutive blood levels have exceeded 0.08) the individual's exposure must be terminated by assignment to non-lead work.

Rare individuals may reach a blood lead level of .08 as soon as or before the urine level reaches 0.20. To detect these people our program includes a periodic blood lead survey of everyone with exposure regardless of urine lead levels.

The blood lead level has a legal significance. Even though a level in excess of 0.08 may not be used medically by itself to make a diagnosis of lead poisoning it will be sufficient to support a workmen's compensation claim for lead poisoning. In such a situation symptoms of almost any illness have been construed to be symptoms of lead poisoning.

The doctor's part in the follow-up of high levels is important but even more important is the follow-up in the plant. The foreman may be able to determine the source of the lead simply by watching the job being performed. People doing the same job don't do the job in exactly the same manner. Plates may be piled on a skid by sliding them together gently or slapping them down one on top of another. Both methods generate dust but the second can generate many times more than the first and the difference can easily be the difference between a normal and expected industrial exposure and a hazardous exposure. In drossing a lead pot, dross can be dropped on the floor or thrown carelessly into a drum or it can be carefully deposited in a drum.

In correcting these things the objection will invariably arise that doing the job carefully means doing the job slowly. This may be true at times and it may be necessary to slow the job down a bit; but I find that the careful worker often has more work done at the end of the day than the fellow who is always in a hurry. What passes for speed is nothing but wasted motion.

In addition to the job itself there are some other factors which should be watched. Personal cleanliness is one of great importance. I have seen reasonably good lead control where men do not take a shower at the end of the shift and where uniforms are not worn on lead jobs. But without these two factors a plant will usually operate so close to the hazardous levels that any changes such as overtime will cause trouble. The ideal would be a clean uniform every day but this should not ordinarily be necessary. On some jobs a weekly change has proved to be sufficient but on others such as paste mixing 2 or 3 changes a week are not common. An important thing in any change schedule is to have provisions for an emergency change in case of accident or unusual conditions.

The institution of daily showers should not be nearly as much trouble as the change of clothes because little expense is involved. Apparently, though, many people do not like taking showers so there is a real problem of enforcement. I know of a number of plants where the daily shower is now a condition of employment. Achieving this can be troublesome but it can be done and is well worth the trouble. Another factor well worth mentioning is housekeeping. The general rules for running a neat and orderly plant, apply in a battery plant. Of special interest is how to keep the floors clean. I have been asked a hundred times what do I think of vacuum cleaners, scrubbers, sweeping compounds, etc. I have seen all of them used and many of them misused or dropped in disgust over the results, but I have also seen most of them do a good job. Certainly plant conditions (e.g. amount of open space, size of aisles) affect the applicability of the various methods. But I have reached the inescapable conclusion that the best method of keeping floors clean in any plant is the one which the plant people will apply diligently and follow religiously. I have seen machines given up in disgust in one plant, while doing an excellent job in another quite similar plant. The difference is, that only a half-hearted effort was made in the first plant.

I believe that all concrete floors should be treated regularly with a sealer and hardner. Dusting concrete is unsightly in any plant but in our business it makes it possible to tell if a floor is clean.

When a study of housekeeping, personal hygiene and other factors reveals no obvious source for lead, two further steps are taken - ventilation velocity measurements are made and air samples are taken. No ventilation system can be expected to run indefinitely without trouble. In adjustable systems gates are opened and closed, drive belts stretch and slip or break, ducts fill with dust, etc. We make an annual check on all ventilation systems whether trouble is suspected or not. Ventilation measurements can be very complex with pitot tubes for measuring duct velocities, measurements of static pressures in ducts, calculations of duct losses and fan horsepower requirements. But most of this can be left to the engineer who designs the system. What is needed is a measurement of velocity at the point at which dust is generated. A small velometer with scales of 0-200 and 0-850 ft/min. is quite satisfactory. After the measurements are made they must be interpreted. There are no exact standards which can be applied. The first thing to look for is any change from past readings. If there had been no trouble with lead on a specific job in the past and if urine and air samples had run low it is a reasonable assumption that the ventilation velocities were satisfactory and any changes now measured should be regarded with suspicion. But this doesn't help when setting up new jobs or in situations where something other than ventilation may be the cause of the trouble.

One way to approach the problem of setting air velocity requirements is to make them so high that they are sure to do the job. This will work but in cooler climates there is a very real problem of heating all the air which the ventilation uses. Also ventilation can be strong enough to suck up heavy objects such as gloves and can affect the flame of a torch so that a proper job of burning cannot be done.

However, there are a few basic principles to remember. 1) A person's movements and open windows can generate air flow velocities of 75 ft/min. or more. This will cause air and dust to be blown out of a hood if the hood velocity is not above this. 2) Velocity must be measured where the dust is generated. If an operation is in front of a hood, the velocity of the hood will not give an accurate indication of its effect because velocity drops off as distance in front of the hood increases. Take the measurement at the job. At times it may be necessary to measure at the hood and guess at its effect where the dust is generated. In making such an estimate it must be remembered that velocities fall off much more rapidly with distance from a small opening than from a large one. 3) Ventilation must be designed so that the air is not carried through the breathing zone of the worker. If a man can put his head in a hood over the work and breathe air coming from the work you might as well not have any ventilation except for the protection it gives others in the area. In general, it might be stated that 200 ft/min. is a good velocity for lead dust and fume control and 150 ft/min. sometimes does a good job but at times a far higher velocity may be needed.

In addition to changing the job method, improving housekeeping and personal hygiene and using ventilation, there is one other way to reduce lead absorption - use a respirator. A suitable respirator properly worn will in most cases terminate the exposure because in battery manufacturing the major part of the lead absorbed enters the body through the lungs. Even in those few cases where a considerable amount of lead is being absorbed by ingestion, the reduction in respired lead may be enough to reduce the exposure to a safe level. Unfortunately, the two conditions of suitability and proper use are not often met. The respirator must be an approved type with an approved filter. The approval is by the Bureau of Mines and it insures that the respirator is suitable for protection against dust not significantly more toxic than lead. This approval is for dust only and extremely fine particles like lead fumes will not be stopped by a dust filter. There are filters available for the removal of fume and in some respirators the fume filter is directly interchangeable with the dust filter. But to filter finer particles the fume filter must have smaller openings so air goes through it with greater difficulty. This results in increased breathing resistence and a greater filter area is needed to keep breathing resistence within acceptable limits. In practice fume filters are used only with respirator face pieces with dual filter holders.

A far more important problem is that of insuring that respirators are worn properly. Every approved respirator is supplied with instructions for its use. These instructions are almost never read by foremen or by the men who wear the respirators. A respirator doesn't fit automatically everytime it is put on. It must be tested for fit (as described in the instructions) and adjusted until it does fit. This takes only seconds.

Gas mask cannisters and chemical respirator cartridges are gradually used up in use and eventually leak. The filter in a dust respirator is never used up in this sense. As it gets dirty the pores fill up and the filter gets better and better but breathing resistence increases. Filters should be changed before breathing resistence increases noticeably not when they begin to look dirty. However, a respirator should be cleaned every day and cleaning time is a good time to change the filter whether it is especially dirty or not. After watching a good many hundreds of men making batteries, I have made the statement that if I could take my pick of these men I would run a battery plant without ventilation and not have any trouble with lead poisoning. I was trying to be dramatic and went a bit overboard but as I think about it, I am not at all sure that it couldn't be done. Some people appear to be able to tolerate lead exposure better than others. With enough of these people all but the worst exposure could be ignored. But there is a better way which is to use people who can work without raising clouds of dust. As I mentioned before, people's work habits vary as much as their sensitivity to lead. We don't know how to change the sensitivity and would be reluctant to experiment with it if we did, but we do know how to change work habits (although with some people it may be difficult).

The way work habits are changed is through training. The man to do this training is the supervisor. If he is going to change the way his people work, he must know how they work and what is wrong with it. It is amazing how little foremen know about the details of the jobs which people are doing under their supervision. I believe that there would be a remarkable improvement in housekeeping and lead absorption if every foreman would, on some periodic basis, watch every detail of every job in his department. Too many foremen think that doing a good job means being in motion all the time. They spend too much time doing things which their employees should be trained to do. They've got to understand that their job is working with people and helping these people to do a better job and the way they do this is through constant instruction and training. If we get this point across, it isn't only health and safety that is going to improve but the whole operation will improve.

In conclusion, I would like to very quickly rate for relative hazard some of the jobs found in a storage battery plant according to my experience with them. Among the worst jobs are making or handling oxide, reclaiming lead in plates by melt-down and most jobs involving handling of plates. Jobs involving molding of parts and such things as post and connector burning in many cases can almost be rated as non-lead jobs. Lead cannot be absorbed through the skin so there is no hazard in handling lead or lead parts.