September 16,1939

Mr. C. S. Anderson
President
Belle City Malleable Iron Company
Racine Steel Castings Company
Racine, Wisconsin

Dear Mr. Anderson:-

In pursuance to our conversation, I am sending you herewith a memorandum giving you the detailed instructions with respect to the collection of the samples which are required for our study, and giving a general summary of my observations at your plant together with a statement of what we hope to accomplish by means of the analyses.

I attach one copy of the instructions which should be issued to the men as written instructions. In as much as you have indicated that you do not want any identification of these instructions as having come from me, I suggest that you have the necessary number copied for distribution to the men. I will not send instructions with the containers as is our usual practice, in accordance with this plan.

If you will survey your situation in line with our conversation and with the memorandum which I am sending you, you should be able to decide promptly the approximate number of men on whom you will wish to have samples obtained. If you will let me have this information, I will have the necessary containers shipped to you as promptly as possible. In as much as these are gallon jugs and since we do not have any very large supply of such jugs which are not in use, I shall not make any attempt to send any containers until I hear from you as to the number that will be required.

For the sake of my own convenience in not maintaining any account, I am sending you herewith a bill which covers the expense of my trip and my fee bill which is in accord with the proportion of time which I spent in your behalf. Any other bills which are the result of analyses or other work, will be sent to you when the work has been completed and reported.

Expense Account and Fee Bill

of Dr. Robert A. Kehoe

For Trip and consultation at Belle City Malleable Iron Company plant at Racine, Wisconsin, on September 14th, 1939.

R.R. (Cincinnati to Racine and return to Milwaukee)	$13.60
Taxi, breakfast and incidentals	4.00
Total (Portion of expense allocated to another consultation)	$17.60
Fee on basis of 1/2 day at $100.00 per day	50.00
	$67.60

Average lead content of tinplate scrap { Kents mech Eng Handbk / Wiley Handbk / Serpe

4 to 6 lbs per ton

Variable with thickness of plate and also, obviously, the thickness of the tin-lead surface.

Composition of surface coat — 20 to 25% tin
80 to 75% lead

Tinplate scrap has been secretly introduced into scrap-iron by the junk dealers, incorporating it into the waste of the scrap handlers, where it is sometimes found by the steel mill people. When business is good and production is high much less precaution is used in inspection

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Product emerges with 0.05 (0.03 to 0.06 %) per cent of lead retained.—

Dilution factor (40% tinplate maximum mixed ≥ 60% non-lead metal

Points of Hazard (outside plant, setting of exclusion fence)
Concentration to be determined

① Charging
② Pouring from ladle into smaller ladles
③ Pouring castings
④ Oxy-acetylene torch work - cutting off gates and feeders
5 Grinding operations - to smoothen surface

Memorandum on the Lead Exposure Associated With the Production of Malleable Iron Containing Lead, at the Racine, Wisconsin Plant of the Belle City Malleable Iron Co.

Certain General Considerations

The Significance of the Analysis of Air for Lead Content

The estimation of the significance of occupational lead exposure by determining the lead content of the air, is based on the generally accepted principle that lead poisoning in industry occurs largely as the result of the inhalation of dangerous quantities of particulate lead which are present in the atmosphere of workrooms. It has been observed that if the concentration of lead particles in the atmosphere does not exceed certain levels, cases of poisoning either do not occur or are so mild as to be of little or no consequence. By reason of variations in the methods of collecting and analyzing air samples, and because of variation in such factors as the type of lead compound and its degree of dispersion in the air, and because of many associated occupational conditions such as prevailing temperatures, length of the working day, and steadiness of employment, the threshold values for dangerous lead exposure have been set at different levels by different hygienic workers. At present it can be said that the general consensus of opinion, as well as certain official and semi-official agencies, favors a permissible concentration somewhere between 1 milligram and 2 milligrams of finely particulate lead per 10 cubic meters of air. My experience has indicated that the higher figure, i.e. 2 mg/10 M³, is a safe one, regardless of the type and subdivision of the lead compound, provided general hygienic conditions are maintained in a

satisfactory state in industrial plants, and provided medical supervision serves to eliminate the definitely unfit worker from the plant population.

The Difficulties and Inadequacies of Air Analysis as a Mode of Estimating the Significance of Le Exposure.

The provisional character of the statement above suggests that air analyses as the sole method of evaluating occupational lead exposure leave something to be desired. Such, unfortunately, is the case. The difficulties of sampling the air of workrooms are considerable, in that variability and periodicity in the operations, changes in plant equipment and ventilation, and shifting weather conditions introduce many factors which must be checked; the methods of analysis of samples must be of the utmost precision, and such precision is not easily obtained around industrial plants with contaminated atmosphere. Add to these technical difficulties the fact that the lead absorption of workmen under a given set of atmospheric conditions is determined by the length of their working hours in a specific area and by the character of their respiration during that period. The rate of pulmonary ventilation varies from 5 liters per minute to 35 liters per minute, i.e. from 2.4 cubic meters to 12 cubic meters per 8 hour working day, dependent upon the degree of exertion required by the occupation. Add the additional variable that relatively coarse particles never reach the lung tissue but are trapped in the upper respiratory tract and are subsequently swallowed (and partly absorbed in the alimentary tract), while finely divided particles may be so small as to behave like a gas and so be breathed out in large part after once having been inhaled. Thus the problem can be seen to become a complex one, with

considerations, which can be covered by introducing a large factor of safety into the level accepted as permissible (as some have done by urging the adoption of the concentration of 1 mg/10 M^3 as the safe level), there is the problem of organic disease among the workmen as a factor in susceptibility to lead exposure. It is well known that general vascular disease, and especially liver disease are important factors in susceptibility to lead poisoning, while certain other types of illness are so difficult to differentiate clinically from the effects of lead absorption as to provide cases which must be handled as though they were lead poisoning, if once the possibility of lead intoxication be recognized or believed to be present. There is always the problem of deciding

which condition is responsible for illness or disability, and when this decision has been made, the other is likely to be regarded as contributory.

Adjuncts to Air Analyses

It must be apparent, therefore, that some additional measures of hygienic control must be exercised, not only to avoid hazardous lead exposure, but to obtain more or less continual proof that such exposure is being currently avoided. This can be done in the opinion of the writer only by means of regular and adequate medical supervision of workmen. Such supervision must (1) exclude the physically unfit, i.e. those to whom the lead exposure of the occupation will probably be hazardous; (2) make such observations on the exposed as to determine whether or not they are actually absorbing significant quantities of lead: (3) maintain such records as will prove the adequacy of the supervision; (4) check carefully every case of illness so as to exclude lead as

a factor when it is not, by arriving at an acceptable diagnosis of the actual nature of the illness. Not to go into the details of procedures to accomplish the above purposes, suffice it to say here that preemployment and periodic physical examinations of a fairly comprehensive type are required, and that blood examinations of a standard type must be made and recorded. In addition, the urinary and fecal lead excretion of at least a few representative workmen should be determined at intervals, and, in cases simulating plumbism, study of the lead excretion should be made promptly.

The above regime is predicated, of course, upon the existence of hazardous lead exposure, or upon the existence of lead exposure which has not been proved to be harmless, and which, therefore, may be under suspicion. In a new industry, or in a new procedure involving lead in an old industry, lead exposure will usually be regarded as hazardous for purposes of compensation or litigation, until it has been proved otherwise. The problem in the present case is to determine, with as little inconvenience as possible, whether or not there is any significant hazard in the present operations. It is understood that if such hazard actually exists now, or if it would be caused to exist, if the use of lead-containing scrap were expanded to its logical degree, then the use of such scrap would be discontinued, in all probability, instead of resorting to the measures of hygienic control which have been outlined above. Accordingly it is the purpose of this memorandum to indicate the most adequate and at the same time the least expensive means of measuring the present lead exposure in the plant. As indicated in later paragraphs, it is believed that the most direct and effective means of accomplishing this purpose is to

study the lead excretion of the men who have been exposed to the conditions which have prevailed in this plant over the past several months, rather than to study the lead content of the atmosphere in various parts of the plant. The latter to be useful at all would have to be done systematically and comprehensively and would then lack something of the definiteness of the information obtainable through analysis of the excreta of a representative group of the workmen.

Plant Conditions as Observed

On the basis of the observations made, the potential lead hazards seem to range themselves in order of decreasing importance as follows: (1) exposure to fumes during the pouring from small ladles into casting moulds; (2) exposure to fumes in emptying the furnace into large ladles, transporting ladles to the casting site, and remaining nearby while casting; (3) the crane operator may be exposed to as much fume as anyone in the plant, for short periods of time, by reason of his position near the roof; (4) exposure to fumes emerging from the open doors of the furnace while charging (at times the fumes here are of considerable density, and they may be quite high in lead content by reason of the large surface of lead exposed to the heat at this time; (5) exposure to lead fumes in burning off the gates and feeders of the castings, both large and small; (6) exposure to lead-containing dusts (probably in low concentration) in grinding off the rough spots of castings, the small ones in partially hooded and ventilated grinders, the large ones by a portable grinder.

(There is an additional question which needs to be settled by air analyses, and which can be done later. The fumes

reliability and willingness to follow the instructions given them. At least one man from each site, but preferably two or more should be requested to cooperate. (The cross-sectional character of the results will be enhanced in proportion to the number studied). Each employee so selected should be provided with a container for the collection of his urine and should be carefully instructed verbally and in writing, as to the means of collecting the sample. The container, sealed in its paper bag, should be delivered to the home of the employee and when the sample has been collected it should be collected from his home and re-sealed in its paper bag, (or in a new one if needed) before it is returned to the plant for packing and shipment. The samples should be obtained as promptly as possible, within the limits of the instructions, so as not to allo the containers to remain long in the hands of the employee. Each sample should be labeled carefully with the name of the employee

above the roof of the building. These fumes are carried upward to some degree and then laterally in the direction determined by the wind, and to such distance as the wind velocity will carry it. The degree of contamination of the atmosphere should be determined in various directions and distances.)

Recommendations

In recognition of the fact that whatever exposure has existed within the plant over the past several months will have left its record in the form of lead absorbed by exposed workmen, it is recommended that a group of workmen be examined as to their lead excretion. Men who have encountered the exposures

[illegible] of the duration and severity of these exposures and their

The name, age, period of employment in this plant, the exact character of the work done, and the length of time engaged in such work should be reported to us, together with any additional facts that might be factors in determining the duration and the severity of the exposure to lead, i.e. such as vacations, lay-offs illnesses etc. This should be accompanied by a brief statement of the facts with reference to the exposure, such as the date on which this type of exposure was introduced into the plant, and the changes in operation which have since occurred and which have influenced the opportunities for exposure, such as, for example, the hooding of the furnace and the extent of the production of lead-containing metal during the past several months.

The information obtained by the analysis of the samples referred to above, and by the study of the available facts will determine whether or not any further steps should be taken.

and with the date on which the sample was started and completed. The samples should be packed carefully to avoid breakage and sent by express to this laboratory, addressed to Dr. Robert A. Kehoe, Kettering Laboratory, College of Medicine, Eden Avenue, Cincinnati, Ohio.

t has been suggested that an additional group of dings in which no lead exposure occurs, be added to the group to be studied. Such a procedure may well be quite useful apart from the primary reason for carrying it out, in that the results on such men will provide contrast and will reveal the general opportunities for lead exposure which are afforded by the operation of the plant.)

It is necessary that information be supplied, so far as it is available, on each man on whom samples are obtained.

the plant, it may well be that no further tests will be required to determine what should be done at this time. If they are questionable in their meaning, by indicating the existence of an exposure, but one that seems only slight or moderate in magnitude, or if the results on the samples are conflicting as they might be by reason of a spotty or irregular exposure, some further observations may be needed. The nature and scope of such additional tests can only be determined later. Suffice it here to say that several avenues of approach are available. Certain additional analyses on the feces as well as the urine of workmen might be required in order to give a cross-sectional picture. Certain clinical and laboratory examinations on the men might be necessary

to determine whether or not any exposure, if present, is of actual hygienic importance. Air analyses of a comprehensive type may be indicated to localise the lead exposure and to aid in its elimination. In any case it should be possible, from the results of these first analyses, to visualise the general scope and magnitude of the problem, and so to provide a basis for a decision as to the advisability or inadvisability of further procedure.

In order that there may be no misunderstanding as to
e expense associated with the carrying out of the analyses
vised at this time, it should be pointed out that a charge of
.00 per analysis (i.e. per sample) will be made. This charge
merely covers the average cost per sample (salaries, materials,
and overhead expense) of carrying out the analyses. Shipping
expense will be added. Any subsequent work which may be agre d

Table 2 illustrates the results of slight occupational exposures to finely divided lead compounds suspended in the atmosphere of work-rooms. Exposures which do not result in higher urinary lead excretion than is shown here do not cause lead intoxication.

The data of Table 3 were obtained on a group of men whose lead exposure is just on the borderline of danger. Mild and fleeting intoxication is seen in an occasional man, especially where some additional factor of exposure or illness is brought to bear upon the situation. The basic exposure, here, is fairly uniform and is well regulated by strict hygienic control.

Table 4 shows the results of dangerous lead exposure. Cases of poisoning occur from time to time in the population of these plants, and the labor turnover is maintained at a relatively high level.

upon as necessary will be undertaken on the basis of the cost to the laboratory in terms of the time spent by the staff and the expense for materials and overhead.

Interpretations

The type of information which may be obtained by a study such as is advised here is illustrated in the following tables.

Table I gives the analytical data on groups of persons with no occupational exposure to lead compounds. The individuals here represented were normal healthy men on normal diets of their own choosing. The values for the lead excretion expressed in milligrams of lead per liter of urine are such as are generally found in the normal population

On the basis of such observations in a considerable number of industries, we can now determine the significance of a given type of lead exposure, if a sufficient number of samples is obtained to provide a cross-sectional picture of the occupational conditions.

Robert A. Kehoe, M.D.
Director
Kettering Laboratory of
Applied Physiology

Table 1

Lead Concentration in Urine of Persons with No Occupational Lead Exposure

Lead in Mgs per Liter of Urine	Frequency	
	Random Samples on Medical Students	Repeated Samples on Three Normal Subjects
0.000 - 0.009		17
0.01	7	334
0.02	6	145
0.03	8	111
0.04	5	19
0.05	3	6
0.06	1	1
0.08		1
0.10		1
Totals	30	635
Mean and Probable Error	0.029 ± 0.002	0.022 ± 0.0003
Standard Deviation	± 0.016	± 0.011

Table 2

Lead Concentration in Urine of Persons with Safe Occupational Lead Exposure

Lead in Mgs per Liter of Urine	Frequency		
	Random Samples from Workmen - Industry E.P.	Repeated Samples from Nine Men Industry D.P.	Random Samples from Workmen - Industry H.R.
0.0 - 0.019	8	3	0
0.02 - 0.039	8	110	5
0.04 - 0.059	3	239	6
0.06 - 0.079	3	104	11
0.08 - 0.099	2	15	5
0.10 - 0.119			2
0.12 - 0.139			4
0.14			3
Total	24	471	36
Mean	0.037 ± 0.004	0.051 ± 0.0005	0.079 ± 0.004
Standard Deviation	± 0.025	± 0.016	± 0.04

Table 3

Lead Concentration in Urine of Persons with Occupational Lead Exposure Maintained for Years Near Threshold of Toxicity

Lead in Mgs per Liter	Results Obtained on Single Samples from Representative Workmen
0.000 - 0.019	
0.020	3
0.040	14
0.060	17
0.080	10
0.100	9
0.120	6
0.140	9
0.160	4
0.200	1
0.220	1
Total	74
Mean and Probable Error	0.097 ± 0.004
Standard Deviation	± 0.045

Table 4

Lead Concentration in the Urine of Persons with Demonstrably Dangerous Occupational Lead Exposure

Lead in Mgs per Liter of Urine	Frequency		
	Random Samples from Workmen - Industry C.S.B.	Random Samples from Workmen - Industry S.B.	Random Samples from Workmen - Industry E.P.
0 - 0.07	11	4	6
0.08 - 0.15	31	27	28
0.16 - 0.23	14	17	20
0.24 - 0.31	6	7	13
0.32 - 0.39	2	1	3
0.40 - 0.47	1	2	5
0.48 - 0.55	1		4
0.56 - 0.63		2	3
0.64 - 0.71			2
0.72 - 0.79			1
0.80 - 0.87	1	1	
0.88 - 0.95	1		
0.96	3	1	1
Total	73	62	86
Mean	0.155 ± 0.0071	0.172 ± 0.0075	0.194 ± 0.0079
Standard Deviation	± 0.087	± 0.085	± 0.102

*Mean calculated on results above the dotted line.