Report of An Investigation of the Potential Hazard Associated with Prolonged but Intermittent (Occupational) Contact of the Skin of Workmen with a Commercial Product Designated as a Friction Proofing Compound.

INTRODUCTION

In the course of the exploitation of a Friction Proofing Compound formulated and produced for distribution by Wynn Oil Company, questions had been raised by prospective customers concerning the potential hazard associated with the use of this product as an aid to lubrication in a variety of technical applications which involve contact of the skin of workmen therewith. The principal source of concern, beyond the common and potentially troublesome threat of irritation of the skin, which is afforded by a wide variety of industrial materials, lay in the fact that the formulation included a compound of lead which, conceivably, might be absorbed through the skin of those who would handle the product. The latter possibility appeared to require definitive exploration. Accordingly, a simple but crucial investigation was undertaken.

The most satisfactory manner of answering this question, without doubt, was through the investigation of the extent, if any, of the absorption of lead by persons who had been subjected to contact with the compound in the course of their work over considerable periods of time, if such persons were available.

The Friction Proofing Compound has been manufactured for

some years, and put up in concentrated form, for distribution in cans, by employees of Wynn Oil Company. This concentrated preparation is distributed to customer companies, but is used by them only after being diluted in the intended medium - lubricants, hydraulic fluids or like products - to less than 2 percent by volume. It would seem, therefore, that the effects, if any, of cutaneous contact with the compound should be displayed to a greater extent by the employees of Wynn Oil Company than by any other group of persons. The validity of this view of the matter would depend upon the degree to which the employees of Wynn Oil Company had been (and were being) subjected to contact of their skin with the concentrated form of the product, and the duration of the employment of these men under conditions which had provided such contact.

The additional determinant of the essential method of conducting such an investigation relates to the means of detecting and measuring any absorption of lead which may have occurred under the influence of contact of the skin of men with the compound in question. It has been shown that absorption of lead by individuals or groups of men, in quantities in excess of those which occur regularly in their food and beverages, regardless of the portal of entry into the body (via the alimentary or respiratory tract or through the skin), results in an elevation of the rate of the excretion of lead in their urine (if the renal function is normal), and in an increase in the concentration of lead in their tissues, including the blood. This response on the part of the organism is prompt and effective, so that the absorption of even a small quantity

of lead (in excess of the commonly available quantities), is followed promptly by an increase in the urinary excretion. Moreover, if an abnormal type or degree of absorption of lead continues regularly over any considerable period of time, lead tends to accumulate, to some extent, in the body, and with this there is a corresponding increase in the lead content of the blood, as well as that of the urine.

GENERAL METHODS OF INVESTIGATION

With the foregoing matters in mind, the initial step of this investigation was that of determining the probable severity and the duration of the occupational exposure to lead, by way of cutaneous contact, of a representative group of the employees of Wynn Oil Company, by observing them at work, and by obtaining information concerning the labor turnover among the employees, and the length of employment of the present group in the same job.

A second step was that of establishing by inspection, and by consultation with the physician responsible for their medical supervision, the pertinent facts concerning any current or past illnesses of these employees, including those related to irritation of, or injury to, the skin.

The third and final step was that of obtaining suitable specimens of the urine and blood of a representative group of the employees of this Company, for determinations of their lead content. Through consideration of these analytical findings within the group of men, in search of relationships between the quantities of lead

found and the apparent severity and duration of their occupational exposure, one could expect to find evidence of the percutaneous absorption of lead, if such had occurred. Moreover, through comparison of these findings, as a whole, with those obtained previously in the investigation of many known types and degrees of severity of occupational exposure to lead, one could fit these men, as a group, into their proper rank, with respect to the severity, and hence the significance, of their occupational exposure to lead.

The methods employed in the collection of the specimens of urine and blood, and in the analysis of such samples, have been described in detail elsewhere and need not be repeated. Suffice it here to say that such methods have been developed and perfected in this Laboratory through many years of experience, and that large numbers of comparable data have been obtained from many groups of persons in the general population and in a wide variety of lead trades.

RELEVANT FACTS AND FINDINGS

Thirteen of the 35 employees of Wynn Oil Company were included in the observations. These were so selected as to include 3 persons who were regarded as having had no occupational exposure to lead - 1 was concerned with the direction of general research, 1 was a technician in the Laboratory, and 1 was employed in the shipping department.

The extent of the exposure of 5 other men was somewhat

difficult to estimate, but could not be assumed to be negligible. One of these was a process engineer, whose exposure was certainly slight; 2 were maintenance men, whose exposure, while irregular, was potentially severe at times; 1 was engaged in the mechanical handling of the concentrate in bulk, with but little opportunity, seemingly, for contact of his skin with the product; and 1 was a "line workman" (can-filling line) whose exposure was probably appreciable but indefinable.

Five of the men were engaged regularly in production. They were regarded as being the most likely, as a group, to portray the degree of absorption of lead, if any, associated with regular contact of their skin, during their hours of work, with the concentrated product. By reason of the variability in the intensity of the exposure of these individuals to contact with lead in their occupations, one might expect to find their response to be variable, if indeed, there should be any response in the form of the absorption of lead.

The duration of the employment of the men under investigation ranged from 1 year to 11.5 years; these periods, among the 5 men engaged in regular production, were 1.1, 1.5, 2.2, 6.8, and 8.7 years respectively. (In view of the fact that the excretory (urinary) response to a fairly uniform type and degree of exposure to lead on the part of men employed in a regular industrial schedule (approximately 40 hours per week) reaches its peak well within the first year, the factor of length

of employment beyond that period cannot be expected to play any very significant part in the excretory rate. On the other hand, any considerable degree of progressive accumulation of lead in the body which might occur under these conditions, may be demonstrated by a gradually increasing concentration of lead in the blood. For these reasons, the data as to the lead content of the urine and blood, considered separately and then jointly, provide important indices of the overall severity of occupational exposure to lead.)

The analytical data are assembled in a single table (Table 1) which follows, since their limited numbers lend themselves well to this detailed manner of presentation. They are arranged according to the occupations represented, in the increasing order, downward, of the apparent significance of the exposure, except that the data provided by the 3 men whose exposure could not be estimated, are listed last.

DISCUSSION

The inspection of the data of Table 1 may yield the impression that there is a real difference between the first group and certain of those that follow; that the group of 5 men engaged in "production", in particular, is differentiated from the first group of 3 men by the analytical findings. These differences are more apparent than real, since the data are few in number and are inadequate in the statistical sense. Moreover, the individual findings, without exception, are well within the range of the variability which

Table 1

THE CONCENTRATION OF LEAD IN THE URINE AND BLOOD OF THIRTEEN EMPLOYEES OF WYNN OIL COMPANY, SELECTED TO PORTRAY THE EXTENT, IF ANY, OF THE ABSORPTION OF LEAD BEYOND THAT ASSOCIATED WITH NON-OCCUPATIONAL LEVELS

Identification by Occupation	Potential* Significance of Exposure	Concentration of Lead		
		Mg. per liter in Urine	Mg. per 100 gms in Blood	
			S**	D***
Research	None	0.02	0.04	0.02
Laboratory	"	0.02	0.03	0.02
Shipping	"	0.02	0.03	0.03
	Averages:	0.02	0.028	
Maintenance	Severe but inconstant	0.04	0.03	0.02
"	"	0.03	0.03	0.02
	Averages:	0.035	0.025	
Production	Appreciable daily on workdays	0.04	0.04	0.03
"	"	0.03	0.04	0.03
"	"	0.03	0.04	0.03
"	"	0.03	0.05	0.04
"	"	0.05	0.03	0.02
	Averages:	0.036	0.042	
Line workman	Appreciable but inconstant	0.03	0.03	0.02
	Averages:	0.03	0.025	
Process engineer	Questionable	0.02	0.04	0.02
Bulk handling	"	0.03	0.03	0.02
	Averages:	0.025	0.028	
	Composite Averages:	0.03	0.03	

* "Potential" in the sense of being the subject of the investigation.
** By spectrographic method of analysis
*** By dithizone method of analysis

characterizes a representative normal population, i.e., a sizable group of individuals in a satisfactory state of health, whose exposure to lead has been limited to that which is associated with the consumption of ordinary food and beverages and the breathing of the ordinary ambient air of their surroundings.

One other feature of the individual items of data must be reckoned with, in that the analytical error of each result, as recorded in Table 1, is of the order of $\pm$ 0.01 milligram. The positive and negative deviations can be counted on to cancel out each other in a sufficient number of results, and while the entire group of results may be ample for this purpose, the groups in Table 1, the largest of which is 5 in number,are much too small for this purpose. It is necessary, therefore, to look at these findings with the perspective which is provided by the corresponding data of a larger number of suitable observations. An example of such an assembly of data is afforded in Table 2, by the distribution of the frequencies of the findings obtained by the analysis of sequential daily samples of the urine and blood of one of a series of experimental subjects, a member of the staff of this Laboratory, whose previous and current life and work involved only the normal environmental intake of lead in food, beverages and ambient air. (The distribution of these numerous results, obtained in the investigation of a single individual, differs very little from that which characterizes the array of results obtained from the same numbers of individuals.)

In order to relate the data of Table 1 to the findings which may be obtained by similar means from a group of men whose work

Table 2

DISTRIBUTION OF THE RESULTS OF ANALYSES OF THE URINE FROM DAY-TO-DAY, AND OF THE BLOOD FROM WEEK-TO-WEEK, AS OBTAINED IN THE INVESTIGATION OF THE NORMAL METABOLISM OF LEAD IN A YOUNG, HEALTHY, HUMAN ADULT (SUBJECT F.C.)

Lead in Urine in Mg. per Liter and in Blood in Mg. per 100 Grams	Frequencies of Occurrence of the Values Indicated		
	Urine	Blood	
		Spectrographic	Dithizone
0.01	92	-	-
0.02	279	37	62
0.03	104	24	7
0.04	34	13	5
0.05	17	1	2
0.06	3	-	-
0.07	1	-	-
Mean and Deviation	0.028 + 0.009	0.030 + 0.007	0.023 + 0.005

had resulted in their absorption of significant quantities of lead, Table 3 is introduced. The results tabulated in Table 3 have been displayed in accordance with the frequency of occurrence of certain ranges of the concentration of lead in the urine and blood of men whose collective exposure to lead was known to have been sufficiently hazardous to induce occasional mild cases of lead intoxication among them. It is not to be inferred that all of the men in this group had absorbed or would eventually absorb potentially dangerous quantities of lead. What is meant is that the conditions under which these men worked were such that some members of the group incurred a severity of exposure and a degree of absorption of lead, from time to time (perhaps under unusual circumstances), which threatened to result, or had actually resulted, in mild symptoms of intoxication. The critical point in the absorption of lead, as indicated by the concentration of lead in the urine, or (more precisely) in the blood, beyond which such symptoms can be anticipated (or precipitated, if suitable action is not taken promptly), is indicated in Table 3 by the asterisks and by the respective footnotes. The margins of difference between the normal ranges of the concentration of lead in the urine and blood in Table 2 and those beyond the normal ranges as shown in Table 3, are apparent. In view of the number of findings in Table 3 which are within the normal ranges defined in Table 2, the validity of the differentiation of the two groups may seem to be dubious. Why should there be normal persons within the allegedly dangerous environment of the industrial operations which produced the findings in Table 3? If there is such variability among men

Table 3

DISTRIBUTION OF THE RESULTS OF THE ANALYSIS OF THE URINE AND BLOOD OF A GROUP OF MEN EMPLOYED UNDER CONDITIONS OF EXPOSURE TO LEAD WHICH RESULT OCCASIONALLY IN MILD CASES OF LEAD INTOXICATION

Lead in Urine in mg. per Liter and Lead in Blood in mg. per 100 grams	Frequencies of Occurrence of the Values Indicated	
	Urine	Blood
0.00 - 0.019		
0.02	3	1
0.04		18
0.06	7	21
0.08		6**
0.10	10	6
0.12		1
0.14	14	
0.16		
0.18	11*	
0.20		
22	3	
24		
and over	9	1
Mean and Deviation	0.152 ± 0.124	0.075 ± 0.041

* The threshold value in the concentration of lead in the urine is not a fixed point but a range extending from 0.15 to 0.20 mg. per liter, in recognition of seasonal and other variables.

** The threshold value in the concentration of lead in the blood is now sharply defined at approximately 0.08 mg. per 100 grams. Any individual whose blood contains lead in excess of this value, as determined by analytical procedures of adequate precision, is in danger of developing symptoms of intoxication.

under comparable occupational conditions, how can the hazard of the occupation be defined? The answer to these questions is not difficult to find if one examines the variability of occupational exposure to lead. Men work for varying periods of time, and with varying degrees of care and skill (in looking after themselves as well as in the performance of their duties), and at widely differing jobs, in industrial plants. Not all of them are employed in hazardous jobs. In a single analytical survey of the population of a small plant, such as that illustrated in Table 3, the widely differing results obtained by the investigation of a stable and representative group of workmen indicate the varied degree of the absorption of lead which is dissociated with the several types of operations in which the workmen have been engaged, currently. The danger to the individual man, as well as the locus of the hazard to which he had been subjected, is revealed thereby. (Periodic surveys of this type also serve to reveal variations in the extent of the exposure of individual workmen and of occupational groups from time to time, and so provide a check on the adequacy of measures of environmental control.)

On the background provided by the data in Table 2 and Table 3, the significance of those presented in Table 1 can be appreciated fully. It is clear that the findings in Table 1, without exception, are within the range which characterizes normal persons who have not been subjected to any unusual, abnormal or occupational exposure to lead. If, by sufficient repetition of the analyses of the urine and blood of the 5 men engaged in "production", one were to establish the fact, on statistical grounds, that these men were absorbing some minute quantity

of lead in the course of their work, the slightness and the hygienic insignificance of such absorption (requiring such an extreme of precision to be brought to light) would still be evident. It is apparent, therefore, that men who handle this concentrated formulation need have no fear of absorbing significant quantities of lead through their skin as the result of contact with the material. The diluted formulation presents even less of a potentiality in that direction. Obviously, a reasonable degree of compliance with the requirements of personal hygiene, in relation to the avoidance of the contamination of food and other articles that may be put in the mouth, should be enjoined upon those who handle this product. That this is not a significant hazard in connection with the day's work of men whose personal habits of cleanliness were not unusual, is well demonstrated by the results displayed in Table 1 of this report.

SUMMARY

1. The employees under investigation were in a satisfactory state of good health and capability for their jobs. No evidence of irritation or damage to the skin of the men was found in either their clinical histories or their physical status.

2. The analytical findings in the blood and urine of the men, without exception, were such as to demonstrate, clearly and unequivocally, that they had not absorbed significant quantities of lead in the course of their extensive occupational contact with the concentrated, lead-containing Friction Proofing Compound. The average concentration of lead in the blood of the men (26 determinations, 2 from each man) were 0.03+mg. per 100 grams, while that in

the urine (13 determinations) was 0.03-mg. per liter. The highest concentration of lead in the blood was 0.045 mg. per 100 grams (average of 2 results), which is well within normal limits, and the highest in the urine was 0.05 mg. per liter, which is in the intermediate normal range only slightly above the mean normal value.

3. The significance of the observations lies in the failure of any of these men to develop signs of cutaneous irritation in consequence of the daily and very frequent contact of their skin with the concentrated formulation, and in their failure to absorb the lead compound through their skin under these same conditions.

4. The conditions of exposure were sufficiently severe to justify the conclusion that there is no occupational hazard, with respect to potential lead absorption in association with the handling of this product, and that the potential hazard of dermatitis in connection with its handling is evidently no greater than that involved in the handling of a variety of commonly used petroleum oils.

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