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CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
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HAZARD EVALUATION AND TECHNICAL ASSISTANCE
REPORT NO. TA 76-100

ASARCO
EAST HELENA, MONTANA

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16. Abstracts: A Hazard Evaluation and Technical Assistance investigation was performed by NIOSH on February 1-4, 1977, at ASARCO, East Helena, Montana, a facility engaged in lead smelting. The survey was prompted by a request from the Regional OSHA Director in reference to exposure to excessive amounts of inorganic lead of the approximately 250 employees. Medical interviews and physical examination of a sample of 31 employees lead to the conclustion that a hazard potentially existed at the time of survey. Several workers had blood lead values exceeding 60 micrograms per deciliter. In addition about 50% of the workers had free erythrocyte protoporphyrin levels higher than expected from their corresponding blood lead levels. Since the presence of protoporphyrin is more a measure of past rather than current exposure, this finding suggests that blood levels in the recent past (about 4 months) were substantially higher than those recorded during the survey. A mandatory respiratory program started about 3 months prior to the NIOSH study could account for the differences. Recommendations for improving environmental, working and sanitary conditions are outlined.

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I. SUMMARY

Based on the data collected during the February 1st - 4th, 1977, evaluation at ASARCO, East Helena, Montana, it is the opinion of the NIOSH Medical Investigators that a potentially toxic situation existed at the time of this study. Several workers had blood lead values exceeding 60 micrograms per deciliter (ug/DL WB). In addition, about one-half the workers had free erthrocyte protoporphyrin (FEP) levels higher than one would expect for their corresponding blood lead levels. This suggests (since FEP is more a measure of past exposure than current exposure) that blood lead levels in the recent past (< 4 months) were substantially higher than those collected during this visit. It should be noted that a mandatory respiratory program was begun about 3 months prior to the NIOSH study and could account for the differences.

II. INTRODUCTION

The National Institute for Occupational Safety and Health received a request for a technical assistance evaluation from the Regional OSHA director in reference to exposure to excessive amounts of inorganic lead at the ASARCO Plant, East Helena, Montana. The plant is currently under abatement period as a result of an OSHA Survey. The plant is a lead smelting operation employing approximately 250 persons.

III. EVALUATION

A. Study Design and Analytical Methods

Approximately ninety persons were asked to participate in this study, from five areas consisting of 1) Maintenance Welding, 2) Zinc Fume Loading, 3) Dross and Reverb Operation, 4) Blast Area, and 5) D and L Sintering Operation. The Maintenance Welding and Zinc Fume Loading areas responded almost completely, but response from the other three areas was very low, resulting in a final cohort of thirty-one employees. Each person was questioned, using a lead questionnaire which included an occupational history as well as specific symptoms known to be associated with lead toxicity. The questionnaire also included such information as smoking histories, eating and smoking habits on the job, potential outside the job exposures to lead, as well as symptomatology that the individuals thought may be job related.

In addition to the questionnaire, duplicate blood samples for lead determination were obtained by standard vena puncture techniques and were collected in commercially available tubes. One duplicate sample was given the ASARCO Industrial Hygienist in a non-identifiable manner for each person tested. ASARCO did this so they might evaluate their laboratory source and compare their results with those by the NIOSH contract laboratory, Medical Diagnostic Services Laboratories (MDS) in Cincinnati, Ohio. In addition, two control and seven split samples were submitted to MDS to insure laboratory reliability.

In addition to blood leads NIOSH analyzed blood for free erythrocyte protoporphyrin, blood urea nitrogen, creatinine and hemoglobin content. A urine sample was also obtained at this time for urinary lead, urinary creatinine and a standard urinalysis determination. These samples were also submitted to Medical Diagnostic Services Laboratories for analysis. Methodology and technique data is submitted separately and may be found in Appendix A.

Brief physical examinations were also given at the time of testing consisting of 1) Biceps, tendon and/or brachioradialis reflexes, 2) Tremor (outstretched hands, 3) wrist strength, 4) ankle strength, and 5) other abnormalities or comments.

B. Toxic Substance Medical Data

Prolonged absorption of lead or its inorganic compounds from inhalation of vapor, fume or dust, as well as from oral ingestion can result in severe gastro-intestinal disturbances and anemia. With more serious intoxication, neuromuscular dysfunction may occur, and severe exposure may result in encephalopathy. Presenting symptoms are often weakness, weight loss, lassitude insomnia, hypertension, and joint pain. Usually associated with this, there aredisturbance of the gastro-intestinal tract, which include constipation, anorexia, and abdominal pain described as colicky. The physical findings although occurring late usually consist of facial pallor, malnutrition, abdominal tenderness, and pallor of the grounds. The anemia associated with lead poisoning is of the hypochromic, microcytic type with basophilic stippling of the red cells occasionally being present. A lead line may appear on gingival tissues, and in severe cases of poisoning, paralysis of the extensor muscles of the wrist, and less often of the ankles, can occur. Encephalopathy while common in children is unusual in adults.

Nephropathy can also result from prolonged exposure to lead or its inorganic compounds. These may be a progressive and irreversible loss of kidney function, with progressive azotemia, and occasionally hyperuricemia with or without gout. Lead is teratogenic in mammals, so it is advised that exposure of women in the child bearing age to lead should be carefully monitored. Health information related to lead suggests that blood lead levels in individual workers should be kept at values less than 60 micrograms per 100 ml whole blood (WB). It also should be noted that persons with existing anemia or sickle cell trait may be at increased risk from exposure to lead. At the present time NIOSH recommends the levels of 0 to 40 micrograms per ml (WB) to be the range for adults. The levels of 40 to 60 micrograms per 100 ml (WB) to indicate increased absorption and levels above 60 micrograms per 100 ml (WB) to be unacceptable. This is in accordance with the current OSHA proposed lead standard.

C. Results

A total of 31 workers were evaluated during this study. All were male Caucasions. The average age was 33.7 years with a range of 21-60 years. The mean duration of employment at ASARCO was 7.5 years with a range of 0.25-28.0 years.

Only 7 of 31 workers (22%) thought they had symptoms related to work. The most commonly reported symptoms were joint pain (29%), fatigue (25%), metallic taste in mouth (25%), poor memory (16%). There were 16 smokers and 15 non-smokers in the group. One-hundred percent said they washed before eating. However, only 18% of the smokers washed before smoking. Exposure to non-occupational lead sources was negligible (See Table I for complete symptoms by history).

Physical examination revealed 4 of 31 (12%) to have tremor, 3 of 31 (9%) to have decreased wrist strength and 5 of 31 (16%) to have decreased ankle strength on physical examination. No significant abnormalities in deep tendon reflexes were noted (See Table II).

Table III shows the results of the blood lead determinations and the free erythrocyte protoporphyrin (FEP) results. Worker blood leads ranged from 34 to 69 ug/DL whole blood with 7 of the 31 workers having blood leads of 60 ug/DL or higher. NIOSH controls (2) showed values of 14 and 18 ug/DL. FEP values ranged from 25 ug/DL whole blood to 615 ug/DL whole blood. NIOSH controls (2) showed values of 22 and 35 ug/DL whole blood. Analysis for blood urea nitrogen, serum creatinine, and hemoglobin on each worker revealed no significant abnormalities (See Table IV).

Urine samples (spot samples) revealed 22 of 31 to contain greater than 100 ug lead/L urine corrected to specific gravity (sp GR) 1.024. Urine creatinines and lead/creatinine ratios showed wide variation (See Table V). Urinalysis on each worker revealed two workers with significant findings (one with albuminuria, one with abnormal number of white blood cells), the occupational significance being unknown.

D. Discussion

Results of the medical interviews and physical examinations were relatively unremarkable. A bothersome fact revealed by history is that only 18% of the smokers washed before smoking. Over an extended period of time, this may result in increased lead absorption.

Bloods for blood urea nitrogen, serum creatinine and hemoglobin revealed no cases of anemia or severe renal abnormalities.

Urinalysis showed only 2 significant abnormalities, both of which could not be directly related to occupational exposure. Urine leads were elevated in some cases (samples 4, 43, 69, 72, 73, 76) to a higher degree than would have been expected for corresponding blood leads[2]. Urine creatinines and lead/creatinine ratios were unremakrable and showed no significant correlations with any other parameter (employee age, years at plant, etc.).

Blood lead measurements showed the following distribution by lead levels:

>60 ug/DL	7 workers
50 - 59 ug/DL	12 Workers
40 - 49 ug/DL	6 workers
30 - 39 ug/DL	6 workers
<30 ug/DL	2 NIOSH controls

Seven workers are above the current NIOSH recommended lead limit of 60 ug/DL. The rest are greater than 30 ug/DL with most being in the 40-59 ug/DL range.

Blood FEP values showed the following distribution:

0 - 100 ug FEP/DL whole blood	4 workers, 2 NIOSH controls
100 - 200 ug FEP/DL Whole Blood	3 workers
200 - 300 ug FEP/DL Whole Blood	11 workers
>300 ug FEP/DL Whole Blood	15 workers

A total of 26 workers had FEP values that were above 200 ug FEP 100cc whole blood. More than 50% of workers had higher FEP values than would have been expected for the corresponding blood leads. For a comparison with a previous NIOSH study see Table VI.

IV. CONCLUSIONS

After review of the data and statistical analysis, several conclusions are apparent:

1) A significant number (23%) of the workers tested had blood lead values above the current NIOSH and OSHA recommended level. (60 ug Pb/DL WB).

2) A significant number (71%) of the workers tested had levels of lead in their urine that are above the current upper limits of normal by the contract laboratory. (100 ug Pb/L corrected to Sp gr 1.024)

3) A significant number (50%) of workers had FEP values higher than would be expected for their corresponding blood lead levels.

In view of the medical data, especially blood Pb and FEP, and the knowledge that the company put into effect a mandatory respirator program in the recent past, it is reasonable to assume that past blood lead values have been higher than those presently measured.

V. RECOMMENDATIONS

Despite the evidence of recent drop in blood lead values, there are still several workers with unacceptable lead values. In order to remedy this in the future NIOSH suggests the following measures.

1) Engineering improvements be instituted to reduce lead exposure. These should be directed toward improving ventilation.

2) Until ventilation is modified, the program of mandatory respirators should remain in effect.

3) Blood leads should be monitored on at least a quarterly basis. Anyone with a blood lead of 60 ug/DL should have the test repeated within 2 weeks and if still elevated be removed to an area of lower lead exposure.

4) Workers should be educated as to the potential dangers of overexposure to lead, especially those resulting from poor work practices and poor personal hygiene.

5) Employees should be informed not to carry their cigarettes or other smoking materials into the work area.

6) Employees should be prohibited from eating, drinking, or smoking in the work area.

7) Employees should be instructed to wash their hands prior to eating, drinking, or smoking.

8) In situations where workers are exposed to lead, work clothing should be provided. The employee should change into work clothing before starting work and should remove clothing before departing. Work clothing should be cleaned and provided on a regular basis.

VI. REFERENCES

1) Chisolm, J.J.; Brown, D.H. Microscale Photoflurometric Determination of Free Erythrocyte Protoporphyrin (Protoporphyrin IX) Clinical Chemistry Vol 21 No. II 1975.

2) NIOSH Criteria for Recommended Standard . . . .Occupational Exposure to Inorganic Lead Pub. No. 73-11010

3) Hazard Evaluation and Technical Assistance, Health Hazard Evaluation No. 77-40, Keystone Resources.

APPENDIX A

LABORATORY METHODS USED IN ANALYSIS OF ASARCO DATA

Laboratory Results From ASARCO Company Employees, East Helena, Montana
TA 76-100 (Technical Assistance to OSHA)

Samples of blood and urine from 31 workers were analyzed by Medical Diagnostic Services, Cincinnati, Ohio, A GSA Contract Laboratory.

Normal values established by the contract laboratory can be found in the Tables reporting the laboratory data. Note that there are no normals supplied for urine creatinine or urine lead. The proposed lead standard recommends a ceiling urine lead of 100 ug per liter of urine corrected to a specific gravity of 1.024. The contract laboratory has supplied uncorrected and corrected urine lead data.

Blood lead and urine lead were determined by the Delves cup atomic absorption method. Blood lead normals were reported as 0-40 ug lead/100 ml whole blood. The proposed lead standard uses 60 ug lead/100 grams of whole blood as the cutoff value.

Free erythrocyte protoporphyrin was determined by the method of Chisolm and Brown "Micro-Scale Photofluorometric Determination of 'Free Erythrocyte Porphyrin' (Protoporphyrin IX)," a Selected Method, Clinical Chemistry 21, 1669 (1975); a copy of this procedure is attached. The normal range reported by the method is 220-870 ug FEP/liter of erythrocytes. All anaylses were done in duplicate using zinc protoporphyrin as a standard. The reported normal range was confirmed by analysis of six laboratory workers giving a range of 214-642 ug FEP/liter of erythrocytes.

There is a great deal of confusion in the literature regarding reporting units for FEP. Some investigators, including CDC and the Mt. Sinai group, report FEP as ug FEP/100 ml whole blood with no regard for hematocrit. Others report FEP as ug FEP/100 ml erythrocytes.

The units used by the contract laboratory are expressed as SI (System International) units as ug FEP/liter of erythrocytes. Table III shows FEP data as reported by the contract laboratory and converted to ug FEP/100 ml erythrocytes, and ug FEP/100cc whole blood, more familiar units. Blood leads are also shown in Table II. Cutoff values have been suggested by Piomelli to be $\leq$160 ug FEP/100 ml erythrocytes and can be used as a guide for interpreting these data (Piomelli, S. "Free Erythrocyte Porphyrins in the Detection of Undue Absorption of Pb and of Fe Deficiency," Clinical Chemistry 23, 264 (Feb. 1977). These cutoff values correspond to 60 ug FEP/100 ml whole blood and roughly correlate to a blood lead of 30 ug/100 ml according to Piomelli and CDC.

Other data were generated using standard clinical chemistry methods and require no special comments.

TABLE I

MEDICAL HISTORIES
ASARCO, EAST HELENA, MONTANA
TA 76-100

FEBRUARY 1-4, 1977

31 Total Workers

	SYMPTOM	YES	NO	% AFFIRMATIVE
1.	Job related health Problems	7	24	22
2.	Treatment for Lead Poisoning or Anemia	1	30	3
3.	Pill to prevent poisoning	1	30	3
4.	Difficulty Sleeping	4	27	12
5.	Fatigue	8	23	25
6.	Dizziness	4	27	12
7.	Irritability	2	29	6
8.	Poor memory	5	26	16
9.	Headache	3	28	9
10.	Muscle Weakness	2	29	6
11.	Muscle Cramps	3	28	9
12.	Tremor	5	26	16
13.	Joint Pain	9	22	29
14.	Poor Appetite	0	31	0
15.	Weight Loss	2	29	6
16.	Abdominal Cramps	2	29	6
17.	Nausea	0	31	0
18.	Vomiting	0	31	0
19.	Diarrhea	1	30	3
20.	Constipation	2	29	6
21.	Metallic Taste in Mouth	8	23	25
22.	Cough	5	26	16
23.	Smokers	16	15	51
24.	Smoke at Work	16	0	100
25.	Wash Before Smoking	3	13	18
26.	Wash Before Eating	31	0	100
27.	Change Clothes Before Going Home	12	19	63
28.	Change Clothes Immediately After Going Home	16	19	84
29.	Respirator Required on Job	31	0	100
30.	Respirator Used as Required	24	7	77
31.	Shower After Work	30	1	96
32.	Hobbies With Lead	1	30	3
33.	Drink Moonshine	1	30	3
34.	Make or Use Pottery	3	28	9

TABLE II

PHYSICAL EXAMINATION
RESULTS

ASARCO, FEBRUARY 1-4, 1977

DEEP TENDON REFLEXS	NORMAL	ABNORMAL	% ABNORMAL
Biceps	31	0	0
Patellar	31	0	0
Tremor	27	4	12
Wrist Strength	28	3	9
Ankle Strength	26	5	16

TABLE III

Blood FEP and Blood Lead

ASARCO, EAST HELENA, MONTANA
FEBRUARY 1-4, 1977

TA 76-100

Specimen Number		ug FEP/DL erythrocytes	ug FEP/DL Whole Blood	Blood Lead ug/DL ml whole blood
01		154	75	38
02		367	171	35
03		796	357	34
04		848	412	58
05	Split 04	810	390	54
06		155	82	36
07		677	304	37
08		509	274	64
09		284	146	46
10		446	219	59
11	Split 10	412	202	53
12		705	348	60
13		50	25	35
14		472	236	43
35		1,176	615	69
36		436	222	66
36		477	234	65
38		456	223	63
39		495	259	54
40		746	343	46
41	Split 40	779	350	48
42		700	328	50
43		302	135	38
44A		146	73	44
44B	Split 44A	150	73	39
46	NIOSH Control	76	35	18
47	Split 46	60	27	18
48		585	317	50
49	Split 48	534	292	44
69		1,087	522	59
70		574	292	41
71		757	409	50
72		1,053	518	58
73		526	266	55
74		672	310	60
75		472	241	44
76		905	449	54
77		1,101	538	53
78		562	276	53
15	NIOSH Control	58	22	14
Blank Tube	G-1	-		4
	G-2	-		3
	G-3	-		3
	G-1	-		4
	L-2	-		4
	L-3	-		3
MEAN		585		50.4
STD. DEV.		±293		±10.5

* Split Sample
** NIOSH Control
*** Incomplete Analysis

TABLE IV

ASARCO BIOMEDICAL DATA

FEBRUARY 1-4, 1977

TA 76-100

SUBJECT #	(5-26) BUN mg/DL	(.5-1.3) CREATININE mg/DL	(14-18) HEMOGLOBIN g/DL
g/DL			
1	20	0.7	16.1
2	17	0.8	15.6
3	22	1.0	14.5
4	18	1.0	16.4
6	19	0.9	18.1
7	23	0.6	14.8
8	14	1.1	17.6
9	17	0.9	16.6
10	16	0.6	16.4
12	17	1.2	16.2
13	19	1.3	16.9
14	22	1.1	17.0
35	26	0.9	17.4
36	27	0.8	16.6
37	18	1.0	15.9
39	21	0.8	17.2
40	20	0.9	15.2
42	27	1.1	15.2
43	21	0.7	14.5
44	23	1.0	16.5
45	17	1.2	16.4
48	16	1.0	18.5
69	16	0.9	15.6
70	22	0.8	16.8
71	11	0.8	17.7
72	20	0.9	16.0
73	22	0.9	17.2
74	26	1.0	15.0
75	19	0.8	16.9
76	19	1.0	16.3
77	23	1.1	16.0
*78	14	1.2	16.5

*Complete Study Not Done

MEAN	19.8	0.93	16.4
STD. DEV.	±3.9	±0.17	±1.00

TABLE V

URINE LEAD DATA
ASARCO, EAST HELENA, MONTANA

FEBRUARY 1-4, 1977

TA 76-100

Sample Number	Urine Lead Corrected to Sp. Gr. 1.024 ug/L	Urine Creatinine mg/DL	Ug Lead in Urine mg Creatinine
01	79	164	.048
02	124	150	.083
03	166	182	.091
04	241	254	.095
06	62	224	.028
07	151	156	.097
08	180	190	.095
09	104	200	.052
10	133	70	.190
12	150	116	.129
13	34	146	.023
14	67	160	.042
35	112	194	.058
36	111	156	.071
37	108	104	.104
39	49	158	.031
40	164	188	.087
42	191	224	.085
43	270	94	.287
44	98	260	.038
48	153	134	.114
69	221	360	.061
70	104	134	.078
71	98	122	.080
72	212	262	.081
73	306	206	.149
74	131	210	.062
75	149	226	.066
76	279	68	.410
77	96	216	.044

Suggested laboratory cutoff value 100 ug lead/liter urine corrected to Sp. gr 1.024

MEAN	145	178	.090
STD. DEV.	±69	±63	±.070

Urine leads show the following breakdown:

100 ug/liter (corrected)	8
100-200	16
200-300	5
300	1

TABLE VI

COMPARISON OF BLOOD LEAD
AND FREE ERYTHROCYTE PROTOPORPHYRIN
AT ASARCO AND A RECENT NIOSH LEAD STUDY[3]

ASARCO			NIOSH STUDY		
Blood Lead Range ug/DL	Mean Blood Lead ug/DL	Mean FEP ug/DL WB	Blood Lead Range ug/DL	Mean Blood Lead ug/DL	Mean FEP ug/DL WB
10-20	0	0	10-20	17	47
21-30	0	0	21-30	25	99
31-40	36	164	31-40	36	189
41-50	46	265	41-50	46	189
51-60	57	374	51-60	55	194
61-70	65	314	61-70	0	0
Mean Age		33.7		36	
Mean Years at Plant		7.5		5.8	
Number Studied		31		37	