U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45202

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 73-158-162

N.L. INDUSTRIES (HOYT PLANT)
GRANITE CITY, ILLINOIS

NOVEMBER 1974

I. TOXICITY DETERMINATION

The request for the Health Hazard Evaluation specified the substance in question as calcium disodium versenate which is also known as edathamil, calcium disodium edetate, and calcium ethylenediamine tetraacetic acid (CaEDTA). For more than a decade it has been the medical policy within the Hoyt Plant to administer oral CaEDTA to numerous employees as a routine prophylactic method in attempting to control the potential effects of overexposure to lead within the facility. While this practice is depreciated as a control measure, no serious health effects resulting from the prolonged administration of this compound were identified during the survey.

Lead was not specified in the Health Hazard Evaluation request but the potential health effects of this substance could not be ignored since its potential toxicity is great and resulted in the practice of CaEDTA administration. As a result of this survey, it is concluded that lead exposure is toxic for employees of the Hoyt Plant of N.L. Industries. This determination is based upon (1) blood lead analyses demonstrating excessive blood lead elevations in a significant number of employees, (2) environmental measurements which frequently exceeded the U.S. Department of Labor Standards for lead, (3) medical interviews with exposed employees, (4) review of plant medical records, and (5) available literature regarding the toxicity of lead.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are available upon request from the Hazard Evaluation Services Branch, NIOSH, U.S. Post Office Building, Room 508, 5th and Walnut Streets, Cincinnati, Ohio 45202. Copies have been sent to:

a. N.L. Industries (Hoyt Plant), Granite City, Illinois

b. Authorized Representative of Employees

c. U.S. Department of Labor - Region V

d. NIOSH - Region V

For the purposes of informing the affected employees, the employer will promptly "post" the Determination Report in a prominent place(s) near where exposed employees work for a period of 30 calendar days.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of employees of N.L. Industries. The requester sought to determine if the on-the-job oral administration of calcium disodium versenate (CaEDTA) is potentially toxic as used at the Hoyt Plant.

IV. HEALTH HAZARD EVALUATION

A. Description of Process

Approximately 170 hourly and 80 salaried persons are employed at the Hoyt Plant of N.L. Industries. Much of the physical structure of the plant buildings and equipment appears to date back a half century or more, but the actual age of the facility could not be determined.

The plant produces lead shot, rolled sheet lead, solder (lead-tin) wire and bar, lead pipe, and various other lead products.

Batteries serve as the major source of the lead used but some virgin lead is purchased from primary lead refineries. Some lead is also reclaimed from used lead coated copper wire which is obtained from utility companies.

A description of the various work areas is included in Appendix A.

B. Worksite Evaluation

A meeting of NIOSH, Company, and Union representatives was held on March 12, 1974, at N.L. Industries (Hoyt Plant) to discuss the purpose of the survey and the survey procedures.

A worksite walk-through evaluation was then conducted to determine areas of potential exposure to air contaminants.

During the remainder of the week, air and blood samples were collected and medical interviews conducted with 27 employees. Plant medical records were also evaluated.

The Metal Mix A Building was not included in the hazard evaluation request. However, the Company and Union asked NIOSH to extend their evaluation to this area. Work areas in the Metal Mix A Building appeared very dusty, especially in the cable lead burning area.

C. Evaluation Methods

1. Evaluation of environmental lead, cadmium, copper, iron, tin and antimony exposures.

Lead in air concentrations were determined for most plant areas. Both personal and area samples were collected on AA millipore filters.

The U.S. Department of Labor occupational health standard of 0.2 mg/M^3 for inorganic lead is based on a total gross airborne lead determination from samples obtained from the breathing zone of the worker.

To provide the NIOSH physician information concerning the type of lead exposure to aid him with his determination of the potential toxicity of CaEDTA, both total and respirable lead exposures were determined for some employees. Dorr-Oliver cyclone seperators operating at 1.7 liters per minute were used to determine the respirable fraction of atmospheric lead. The respirable samples give an estimate of the lead existing as a fume, whereas the total gross airborne samples represent the lead present as fume and lead dust.

Though the U.S. Department of Labor requires that the total lead in air concentrations be reduced by engineering methods, where feasible, to no greater than 0.2 mg/M^3, other information is necessary for the research oriented activities of NIOSH. For example, blood lead determinations are useful to NIOSH for evaluating lead absorption by the employee. Though neither NIOSH or OSHA recognizes respirators as an acceptable method for controlling lead exposure, where respirators are used their effect on the absorption of lead must be considered. Where respirators are used a characterization of the lead contaminant is useful in determining

whether the right type of respirator is being used. Characterization of the lead contaminant is also useful in selecting sampling methods. For example, a portable sampling instrument for lead may determine lead fume concentrations, but completely miss the lead particulate exposure.

It is emphasized that no standard exists for evaluating respirable lead exposures. Undoubtedly, were such a standard available, the permissible level would be much lower than the present standard for lead based on a gross airborne sample (total). The respirable samples were obtained for the purposes mentioned in the preceding paragraphs.

Two-hour sequential area samples were taken at the south end of the blast furnace and in the Metal Mix A Building. In addition to lead, these samples were also analyzed for cadmium, copper, iron, tin, and antimony. Area samples may not represent a worker's exposure but are useful in evaluating fluctuations in concentrations of air contaminants throughout the sampling period.

Swipe samples were also obtained in the lunchroom and locker room. Bulk samples were obtained in the lunchroom and Cable Burning areas.

All samples were analyzed using the atomic absorption method by NIOSH laboratories in Salt Lake City, Utah.

2. Medical Evaluation Methods

a. Background Information

Calcium disodium ethylene diaminetetraacetic acid (CaEDTA) is classed as a complex or coordination compound, i.e., one in which a metal ion, in this case--calcium--and an organic molecule are bound together by a coordinate valence. In chemical compounds of this type, the metal loses its original characteristics as an ion and will no longer exert its usual physiologic or toxicologic effects. When a complexing compound combines with a metal ion with the formation of one or more ring structures, the resulting compound is known as a chelate. Chelates often have properties quite different from the parent metallic ion and organic compounds. Many chelates have biologic activity. Familiar examples being hemoglobin and various enzymes such as carbonic anhydrase, cytochrome oxidase, etc. Many chelates are somewhat unstable and the metallic ion may be displaced by different metallic ions if this leads to the formation of more stable compounds. Thus the calcium ion in CaEDTA will be replaced preferentially by lead leading to the excretion of Pb EDTA by the kidneys. In this manner, large amounts of lead can be effectively removed from the body.

CaEDTA has been approved for two decades by the Food and Drug Administration for use, both as a food additive and as a human therapeutic agent. Small amounts are added to many foods to inactivate trace metals having an adverse effect on food characteristics such as color stability and clarity. Iron and copper are the usual undesirable metals. CaEDTA is permitted in many foods at levels ranging from 75-275 ppm.

Medicinally, CaEDTA is approved for use in the reduction of blood levels and depot stores of lead. Depending upon severity, two forms of the medication are available--a solution for intravenous use and tablets for oral administration. The official FDA approved package circular for either of the medication forms carries the following warning" "Calcium Disodium Edetate is capable of producing toxic and potentially fatal effects. The dosage schedule should be followed and at no time should the recommended daily dose be exceeded." This warning stems from several fatal cases of toxic nephritis observed shortly after the drug was introduced and before the need to limit dosage and monitor kidney function were appreciated. All of these cases had received therapy with the intravenous form and no such effects have been noted by numerous medical researchers who have studied the oral form.

In addition to the severe renal (kidney) manifestations, certain other side effects of CaEDTA are known. Most commonly encountered are nausea, vomiting, abdominal cramps and diarrhea. Muscle cramps, especially involving the leg musculature, are also common. Both the musculosketal and gastrointestional symptoms appear to be dose related, i.e., dose reduction often prevents the symptom. Dermatitis has also been reported on rarer occasions.

The package circular for CaEDTA tablets also contains the following warnings: "Chronic oral use of Versenate (calcium disodium versenate) should not be used as a substitute for adequate measures to avoid undue exposures to lead. Because Versenate chelates other metals, e.g., zinc, copper, etc., the possibility of depletion of such metals in persons taking Versenate on a long-term basis should be considered, and steps taken to avoid such deficiencies." This latter warning may have arisen from early biochemical, clinical, and pharmacologic studies which suggested that in large enough dosage, CaEDTA might interfere with the absorption of mineral elements or reduce the body stores of these elements.

The role of trace metals in human metabolism is still poorly known. Most of what is known has come from studying animals placed on diets deficient in the metal or by providing excessive dietary quantities. In this way a number of deficiency diseases have been identified and the toxic potential of excesses delineated. Counterparts for those animal effects have in some cases been later identified among ill humans. Since the diet is normally rich in many of these elements, deficiency states do not normally occur in humans and for some elements have never been observed. Others only have been observed in delimited geographic areas where soils, and hence plants, are naturally low in certain elements. While large differences in soil and food content are common on a geographic basis, human deficiencies still tend to be rare because of the tiny amount required.

Many trace metals are required as components of various enzyme systems and very large deficiencies would be required to produce a clinical illness, particularly in fully grown adults in which the metabolic demands of growth have been met. Table I gives the physiologic function, daily requirement, and deficiency states associated with some valence two metals. Only metals of this valency are capable of forming chelates with EDTA.

Table 1

Element	Physiologic Function(s)	Daily Requirement	Deficiency Disease(s)
Iron (Fe^{++})*	Component of Hemoglobin, Myoglobin, many oxidation reduction enzymes	10-18 mg	Anemia
Nickel (Ni^{++})	?	?	Decreased growth?
Zinc (Zn^{++})	?	10-15 mg	Short stature, hypogonadism, hepatosplenomegaly, delayed healing.
Copper (Cu^{++})*	Elastin synthesis oxidative deamination	1-3.8 mg	Anemia
Molybdenum (Mo^{++})*	Xanthine Oxidose	0.1 mg	?
Chromium (Cr^{++})*	?	?	Cr^{+++} deficiency is associated with impaired glucose metabolism
Cobalt (Co^{++})*	Vitamin B_{12}	.015-0.160 mg	Anemia
Manganese (Mn^{++})*	Activates many enzymes	1.25-6.5 mg	
Calcium (Ca^{++})*	Bone metabolism, blood coagulation	800 mg	Tetany
Magnesium (Mg^{++})*	Neuromuscular conduction bone and muscle metabolism	300 mg	Senicoma, tremor, tetany

* Considered absolutely or probably essential dietary constituents.

** Major mineral elements and daily requirements are much higher than for the trace elements or micronutrients.

While a deficiency in one or more trace elements may be detected by measuring the levels of enzyme, etc., requiring the element, such measurements require very elaborate biochemical assays. It was felt that the much simpler testing of the blood for the presence of adequate amounts of these metals represents reasonable assurance that body depletion has not occurred and that amounts are present to meet normal body demands. With the advent of atomic absorption analysis, numerous determinations for various elements can be made from a single blood specimen, and obvious advantage to the subjects under investigation.

b. Evaluation Criteria

Since "normal" blood levels for several of the elements under consideration have not been established with great certainty, and reported levels have varied depending upon the analytic method used, area of residence, etc., it was felt necessary to include an adequate number of control specimens. These were obtained from healthy adult males (seven NIOSH employees) known to never have taken Versenate or other chelating agents and approximating in age the worker group under study (Group 1).

Also, since the amounts, frequency, duration and date of last ingestion of Versenate among workers was found to vary, it seemed likely that if any effects upon blood metals were found, that these factors might govern the degree of abnormality encountered.

Using patient interviews and medical records, it was possible to define three worker groups in respect to Versenate therapy. The first group (Group 2) consisted of six workers who had taken no CaEDTA for at least two years. The majority of this group had, in fact, never taken Versenate. Since any Versenate effect on mineral metabolism should have completely dissipated within a two year period, this group represents an internal worker control whose levels should approximate those of the NIOSH group. A second worker group (Group 3) consisted of eight workers who had taken Versenate within two years but none for at least two months. The final group (Group 4) consisted of 13 workers who were currently using Versenate therapy. It was felt that should Versenate lower the blood levels of trace minerals, this latter group would most likely demonstrate this loss with the second group, perhaps showing intermediate levels.

Blood lead levels are a widely accepted index of lead exposure. Levels above 40ug% (40 micrograms of lead per 100 grams of whole blood) are considered to indicate exposure greater than that of the community at large. Such levels are common in lead workers and not considered escessive until a level of 80ug% is reached. Levels above 80µg% are considered evidence of unacceptable absorption and pose a substantial risk of lead poisoning.

D. Environmental Evaluation Criteria

Standards for lead, cadmium, copper, iron, tin, and antimony

Substance	Federal Standard	ACGIH	NIOSH Criteria Document
Lead, inorganic	0.2 mg/m^3*	0.15 mg/m^3	0.15 mg/m^3
Cadmium fume	0.1 mg/m^3	0.05 mg/m^3"C"	
Cadmium dust	0.2 mg/m^3	0.2 mg/m^3	
Copper fume	0.1 mg/m^3	0.2 mg/m^3	
Copper dusts	1.0 mg/m^3	1.0 mg/m^3	
Iron oxide	10.0 mg/m^3	5.0 mg/m^3	
Tin, inorganic	2.0 mg/m^3	2.0 mg/m^3	
Antimony	0.5 mg/m^3	0.5 mg/m^3	

* Approximate milligrams of particulate per cubic meter of air.

The Occupational Health Standards promulgated by the U.S. Department of Labor are taken from the Federal Register, June 27, 1974, Title 29, Chapter XVII, Subpart G, Tables G-1 and G-2.

The ACGIH Standards are taken from the tables of Adopted Values and Notice of Intended Changes (for 1973) appearing in Threshold Limit Values for Chemical Substances in Workroom Air Adopted by ACGIH for 1973. A "C" designation indicates a ceiling level which should never be exceeded even for short periods of time.

It should be noted that these Federal Standards refer to total concentrations in the atmosphere and make no distinction between respirable and non-respirable particulates.

E. Evaluation Results and Discussion

1. Environmental Results

The environmental samples results are found in Tables 5, 6 and 7. While all samples were analyzed for lead, cadmium, copper, iron, antimony and tin, the values for all elements except lead were well below Federal Standards and Threshold Limit Values for these materials.

Atmospheric lead samples collected in the Pipe Department and Lunchroom were all below Federal standards.

Time-weighted average determinations were not made for all employees. It is assumed the sampling period represents a worker's typical eight hour exposure which may not be true in all cases. However, it is obvious that lead values exceeded existing U.S. Department of Labor standards for many work areas. For example, three of five total lead samples from the Shot Department exceeded 0.2 mg/m^3. Fifteen of nineteen (83%) of total lead samples collected in the Battery Breaking and Lead Refining Areas exceeded 0.2 mg/m^3. All ten samples for total lead taken in the Metal Mix A Building exceeded 0.2 mg/m^3 and three of four samples in Metal Mix B Building.

Sequential samples taken at the south end of the Blast Furnace and south of the PTR restroom in the Metal Mix A Building were consistently above 0.2 mg/m^3 except for the time period when work had ceased in the Metal Mix A Building (Table 7).

Concentrations greater than 0.2 mg/m^3 were found inside respiratory protective devices worn by the sweeper and baghouse operator.

All of ten samples for total lead taken in Metal Mix A Building exceeded the Standard as did all three respirable samples. Seven of ten sequential samples collected south of the PTR rest room were also excessive (Table 7). Conditions were somewhat better in Metal Mix B Building where three of four total lead samples were excessive.

Only two swipe samples were obtained (Table 6) and indicate the presence of significant amounts of lead outside of actual work areas. These emphasize the need for rigorous housekeeping in ancillary plant areas since such lead represents a potential source of absorption via ingestion.

In summary, the majority of areas sampled were found to contain excessive atmospheric lead concentrations. Every effort should be made by N.L. Industries to identify areas of high lead exposure and to use engineering methods to control such exposures. It is essential that equipment or procedures used to determine lead in air concentrations be capable of measuring both fume and lead dross exposure.

2. Medical Evaluation Results

a. Results of Blood Analysis for Trace Metals and Lead

Whole blood levels were determined for lead, cobalt, iron, zinc, calcium, magnesium, copper, nickel, manganese, chromium and molybdenum using atomic absorption analysis. The mean and range of values for all elements (except lead, chromium, and molybdenum) by population group are found in Table 2.

Table 2

Mean Values and Ranges By Group for Eight Mineral Elements

(ug/gm Whole Blood)

Group	ELEMENT Co	Fe	Zn	Ca	Mg	Cu	Ni	Mn
1	1.09 0.91-1.32	0.53 0.49-0.55	12.7 11.1-15.0	42.8 35.4-49.7	31.9 27.7-37.6	0.40 0.33-0.47	0.50 0.25-0.72	0.018 0.00-0.039
2	1.17 0.95-1.35	0.52 0.45-0.57	8.5 5.1-11.8	45.4 38.6-48.9,	33.9 31.4-35.3	0.52 0.50-0.64	0.25 0.00-0.48	0.024 0.00-0.034
3	1.18 0.93-1.61	0.47 0.40-0.55	11.6 6.1-17.7	46.3 38.0-53.9	29.9 25.7-33.2	0.53 0.41-0.70	0.43 0.15-0.84	0.027 0.012-0.039
4	1.16 0.89-1.28	0.48 0.35-0.56	10.5 5.7-15.3	50.1 38.6-65.1	30.5 28.1-35.7	0.57 0.44-0.71	0.38 0.07-0.62	0.019 0.00-0.040

Intragroup statistical comparisons for each element were made using the Analysis of Variance (ANOVA) and Student T Test methods to determine if significant differences between the groups existed. The results for chromium and molybdenum were all less than 0.15 and 0.30 ug per gm. of whole blood, respectively, the detection limit of the analytic method. Therefore, no comparison with respect to these two elements was possible.

No significant statistical differences between the four groups of individuals were found with respect to blood content of cobalt, zinc, nickel, and manganese. Iron was found to be significantly lower in groups 3 and 4 than in groups 1 and 2 ($P < .04$). This difference did not seem to be attributable to CaEDTA since group 3 was actually lower than group 4. It, therefore, seemed likely that the lower values for iron might be due to the disturbed porphorin metabolism and resulting anemia associated with plumbism. To test this hypothesis, a correlation coefficient was computed to determine if an association between blood lead and iron levels existed. A correlation coefficient of 0.353 was found. The probability that this correlation is significant was found to be 0.041, i.e., it is statistically significant. It is, therefore, concluded that lead, not CaEDTA, was primarily responsible for the lower iron levels observed.

Calcium levels were noted to increase progressively in groups 1 through 4 and a significant difference was found between the combined mean for groups 1 and 2 and the mean for group 4 ($P < .01$). No other significant differences between the groups were noted. This increase in calcium probably simply reflects the additional intake of this element in the form CaEDTA. As lead replaces calcium in the chelate, this calcium becomes available for various metabolic uses. Since calcium is lost from the body by a number of routes (urine, sweat,feces), it is unlikely that the extra amount associated with the ingestion of 3.0 grams daily of CaEDTA might result in hypercalcemia in normal individuals. However, men who regularly take alkali therapy (usually for peptic ulcer) in addition to CaEDTA might run a risk of developing the symptoms of the milkalkali syndrome. This condition is characterized by an excess of calcium in the blood and soft tissues, by vomiting, gastrointestional bleeding, and high blood pressure. This syndrome usually has been reported in patients who have peptic ulcers and who have used excessive alkali therapy in conjunction with large amounts of milk. It would seem prudent not to place men with ulcer histories on prolonged CaEDTA therapy.

Magnesium levels were noted to be lower in groups 3 and 4 than in either control group. A significant difference was found between the mean for group 2 and group 3 ($P < .005$), and between group 2 and group 4 ($P < .02$). Little is known about the factors regulating magnesium levels in blood. Again, however, CaEDTA does not seem to be responsible since group 4 actually had slightly higher levels of magnesium than group 3. It seems more likely that the levels in these two groups actually are a reflection of the often observed reciprocal relationship between serum calcium and serum magnesium levels. Magnesium also bears a similar relationship with serum phosphate. Unfortunately, this could not be studied since the atomic absorption method does not have sufficient sensitivity for this element.

Copper levels resembled calcium, the mean value increasing steadily in groups 1 through 4. The difference between group 1 and groups 2, 3 or 4 is significant at the $P < .0005$ level. However, group 2 does not differ significantly from either 3 or 4. These observations cannot be due to CaEDTA since this drug should have lowered the copper levels instead of increasing them. It is possible that these levels reflect regional differences in copper dietary intake or environmental exposure. Certainly copper is present in various plant areas and this may account for differences observed. It was noted particularly in Metal Mix B where lead was recovered from copper wire and is, of course, present in batteries. The fact that group copper levels tend to correspond to group lead values suggest that similar inplant type exposures may be occurring. To test this hypothesis, a correlation coefficient between lead and copper was

computed and found to be 0.574. The probability of this being due to chance was calculated as being only 0.0004. Unfortunately, only very limited atmospheric sampling for copper was carried out during the survey preventing substantiation of this conjecture. In any event, copper is without known health effects at the levels observed.

Lead is a well known toxic substance and its effects have been observed and documented for several centuries. Common signs and symptoms include loss of appetite, constipation, anemia, weakness, insomnia, headache, nervous irritability, muscle and joint pain, tremor, encephalopathy, and abdominal colic. In lead induced colic, the abdominal pain may be very severe. In workers who have had repeated attacks of colic, there is a tendency towards weakness of extensor muscle groups resulting in progressive paralysis most frequently manifested as wrist or foot "drop." Both ingestion and inhalation are important routes of absorption.

Biologic monitoring is essential to assure that workmen exposed to inorganic lead are not absorbing unacceptable amounts. The analysis of whole blood provides a widely accepted parameter of absorption. Blood levels in the normal non-occupationally exposed population rarely exceed 40 µg%, but levels among lead workers commonly are in excess of that value. There is now a worldwide concensus that blood lead levels exceeding 80 µg% represent unacceptable occupational exposure. Below this level no cases of even mild poisoning should occur. The higher the blood lead above this level, the greater is the likelihood of lead poisoning although higher concentrations do not necessarily mean poisoning in all persons since considerable individual variations in susceptibility occur.

The mean lead levels and range of values for groups 1 through 4 were 27(2335); 57(2377); 73(56110); and 79(52124) µg%, respectively. The difference between group 1 and groups 2, 3, and 4, were all statistically highly significant varying from $P < .01$ for groups 1 and 2 to $P < .0001$ for the comparison between groups 1 and 4. Table 3 provides a distribution of values for blood lead by group.

Table 3

Whole Blood Lead

(µg/100 gm)

Group	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	120+	Totals
1	4	3										7
2	1	1		1		4						7
3				1	4	1	1			1		8
4		1		3		2	2	3	1		1	13
TOTALS	5	5		5	4	7	3	3	1	1	1	35

From this table it is noted that nine of the 27 employees studies had lead values exceeding 80 µg%.

From Table 4 it is observed that the highest blood lead levels were detected in the Dross Department workmen (97 µg%) average, with all values above 80 µg%.

Table 4

Blood Lead Levels by Plant Area

	Department					
	Dross	Shot	Metal Mix A	Metal Mix B	Battery Breaking	Pipe
Individual Blood Lead Levels (µg%)	82	68	57	110	107	33
	93	75	77	52	87	52
	95	70	78	56	77	23
	124	67		67		67
	91	81		57		
				75		
Average	97	72*	71	70	90	44

*Excludes one foreman who had a level of 36.

The number of men studied from each department was small and therefore not studied statistically although casual differences are obvious.

In conclusion, no obvious detrimental effect upon trace element blood levels from the chronic administration of CaEDTA was found. However, some variation between various worker groups and controls were noted in respect to the blood levels for iron, calcium, magnesium, and copper. These variations were not thought to reflect adverse effects of CaEDTA as previously discussed.

One-third of the twenty-seven workmen sampled were found to have blood lead values exceeding 80 ug%, a level above which some effects of lead poisoning may be anticipated. The highest levels were found among workmen in the Dross Department (including battery breaking operations) although not exclusively so. Based on this evidence and upon environmental observations and measurements, it is concluded that toxic exposures to lead are occurring within the facility studied.

b. Results of Medical Interviews and Record Reviews

Twenty-seven men were interviewed during the study to ascertain possible side effects from CaEDTA administration and to determine their past and present status in regard to the medication. Only five men reported never having taken any CaEDTA. Of these, two had worked six months or less and the remaining three worked in the Pipe Department.

The usual practice has been to prescribe two tablets three times daily for two weeks followed by a two to four week rest period. After being placed on the medication, blood lead was to be re-checked in a one to two month interval. In actual practice this was rarely done and the worker remained on the medication until re-checked in six months. At that time the medication was generally continued. In many instances the medication had been given for periods of at least 5-8 years (medical records were incomplete prior to that time). It was also impossible to determine what the clinical or lead level criteria were for beginning therapy.

Essentially, no medical control was imposed upon the worker once the medication had been prescribed. Refills are provided upon request. Prescribing instructions appeared to have little influence upon what was actually taken. In general, fewer tablets were taken than prescribed on a daily basis, but drug free periods were often not observed. One regular user was found for whom the medication was never prescribed. Another reported taking a whole bottle (250 tablets) every two weeks for years.

It was usually impossible to tell from the current record whether or not a man was currently on CaEDTA. Rotation to other plant areas apparently was rarely practiced except in some instances of frank plumbism. Three men reported various genitourinary complaints. In two, this was determined to be the result of prostatic hypertrophy. The third related a history of "kidney trouble" seven years ago. These cases were not thought to represent effects of CaEDTA. During the interviews, very limited physical examinations were made. No cases of paralysis were observed. One individual was noted to have Burtonian lines (lead lines on the ginginal margins). This individual's blood lead level was found to subsequently exceed 100 µg%.

Eight of the 22 current or past users had noted minor but definite gastrointestional side effects. These were eliminated in most individuals by reducing the daily dose. This was usually done without contacting the Medical Department. Muscular cramps were also reported by four individuals, but in only two instances did this appear to be definitely related to CaEDTA. Again dose reduction alleviated the symptom.

From the medical records it was impossible to judge the effectiveness of the medication in lowering blood lead levels. This was because of the long term administration, failure to reduce or terminate lead exposure, infrequent follow-up blood leads, the lack of definite information regarding what was actually being taken by the man. Several men apparently developed frank lead colic while on the medication and received intravenous CaEDTA on a hospital outpatient basis. In numerous instances, blood leads rose, sometimes to very high levels exceeding 150-200 µg%, while on the medication.

OSHA Form 102 was reviewed with the plant nurse. Two injuries with a total of 56 days lost and twenty-three cases without time loss were recorded. Seven cases of poisoning were noted. These apparently were instances of lead poisoning. The basis for these diagnoses was not clear, but these apparently were cases requiring intravenous CaEDTA therapy at the local hospital. Three cases of illness due to physical agents were recorded. It could not be determined what the diagnoses were in this category.

V. RECOMMENDATIONS

Every effort should be made by N.L. Industries to identify areas of high lead exposure. Engineering methods should be used or instituted to reduce airborne lead concentrations to levels no greater than 0.2 mg/m3.

Respiratory protection should not be accepted as a satisfactory method for reducing exposure to lead on a permanent basis.

Medical evaluation, personal hygiene and administrative controls are also necessary for monitoring and prevention of absorption of lead compounds into the body. Medical therapy is not an acceptable form of control.

The following additional recommendations should also aid in controlling lead exposures. These recommendations reflect the severity of employee exposures and the need for rigorous monitoring and control.

1. A preemployment blood lead level should be obtained on each prospective employee. An elevated level, reluctance to have repeated tests, or anatomical variations which present difficulties in obtaining blood specimens all comprise potential reasons for rejection.

2. Following employment, new employees should be tested monthly for three months and then every three months for the initial year of employment. Thereafter, every employee should be tested at six month intervals.

3. If blood levels exceeding 80 µg% (0.080 mg/100 gms) are found, these should be repeated within one week of receipt to confirm the original finding.

4. Workers with confirmed blood lead elevations exceeding 80 µg% should be immediately transferred to plant areas posing minimal exposure and referred to the plant or other consultant physician for medical evaluation. If medical evaluation confirms the need for therapy treatment medications may be prescribed on an outpatient or inpatient basis as circumstances dictate. These medications when prescribed for on an outpatient basis should be given daily by the nurse in charge.

5. A blood lead level should be obtained approximately one month following transfer and medical evaluation and repeated at monthly intervals until a significant decline (<70 ug%) in blood lead is obtained. When this has been achieved, the worker may be returned to his previous work site.

6. Following the return of the worker, his job should be evaluated by a competent industrial hygienist who can observe the on site work practices of the individual and the need for improved environmental controls. This is essential to prevent repeated elevations of blood lead.

7. While respirators are required in most plant areas, casual inspection revealed that many were poorly maintained. It is currently left to the employee to exchange his respirator when the filter appears sufficiently dirty. This policy is insufficient to maximize the benefit of respiratory protection. One individual should be made responsible for the maintenance, cleansing, and issuance of approved respirators. This person should be given the authority to see that used respirators are exchanged at proper intervals. This should be daily in areas of greatest lead exposure. Respiratory protection is discussed in detail in HSM 73-11010 (Criteria for a Recommended Standard--Occupational Exposure to Inorganic Lead). .

8. Ingestion is an important route of lead absorption. Smoking, drinking, and eating should be permitted only in areas in which adequate hand washing facilities exist. Orange sticks and scrub hand brushes should be provided at all Bradley basins and their use encouraged. A double locker set-up to avoid contamination of clothing to be worn home is also regarded as minimal in the industry today and should be promptly installed.

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Acknowledgment

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TABLE 5

LEAD IN AIR CONCENTRATIONS

Date	Sampling Period	Job Description	Total Pb Conc mg/m^3	Respirable Pb conc mg/m^3
		PIPE DEPARTMENT		
3-13-74	9:45AM - 3:20PM	Press Operator Pipe Dept.	.02	
"	9:50AM - 4:06PM	" " " "	.03	
"	9:57AM - 4:07PM	Pipe Change Operator Pipe Dept.	.01	.01
		SHOT DEPARTMENT		
3-13-74	8:50AM - 4:08PM	Buck Shot Kettle Operator	.26	.01
"	8:37AM - 4:02PM	Lead Man in Shot Bldg.	.03	
3-12-74	4:22AM - 10:40PM	Lead Man in Shot Bldg.	.23	.03
3-13-74	8:56AM - 4:10PM	Shot Drop Operator	.02	.03
"	4:30PM - 10:25PM	" " "	.25	.03
Shot Drop Operation - Average			.14	.03
		LUNCH ROOM SAMPLES		
3-13-74	10:45AM - 4"45PM	Lunch room at Guard Desk	.03	
"	" "	Center of Lunch Room	.06	
		BATTERY BREAKING AND LEAD REFINING AREA		
3-12-74	4:47PM - 10:20PM	Bumper Operator	0.51	
"	5:12PM - 10:25PM	" "	0.26	0.04
3-13-74	9:10AM - 3:11PM	" "	0.14	
"	9:45AM - 3:00PM	" "	0.30	
Bumper Operator - Average			0.31	0.04

Note: The Federal Standard for lead of $0.2mg/m^3$ refers to total lead.

Date	Sampling Period	Job Description	Total Pb conc mg/m^3	Respirable Pb conc mg/m^3
3-12-74	4:45PM - 10:25PM	Feeder - Battery Breaking	0.14	
"	4:45PM - 10:32PM	" " "	0.19	
Feeder - Battery Breaking - Average			0.17	
3-12-74	3:44PM - 10:20PM	Tapper - Dross Department	0.52	0.38
3-13-74	9:32AM - 3:00PM	" " "	0.62	0.36
Tapper - Dross Dept. - Average			0.57	0.37
3-13-74	9:45AM - 3:20PM	Foreman - Dross Department	0.13	
3-12-74	3:55PM - 10:20PM	Utility Man	0.37	0.13
3-13-74	8:47AM - 3:00PM	" "	1.08	
Utility Man - Average			0.73	0.13
3-12-74	3:57PM - 10:25PM	Charger - Dross Department	0.36	0.08
3-13-74	9:33AM - 3:00Pm	" " "	0.79	0.23
Charger - Dross Dept. - Average			0.58	0.16
3-12-74	4:17Pm - 10:33PM	Sweeper Outside White-Cap Respirator	3.07	
"	" "	" Inside " " "	0.67	
3-13-74	8:53AM - 3:07PM	Baghouse Operator (Inside Airline Respirator)	0.75	
"	4:25PM - 10:34PM	" " " "	0.54	
Baghouse Operator - Average			0.65	
3-13-74	9:45AM - 3:00PM	Lead Man	0.32	0.12
		METAL MIX A BUILDING		
3-12-74	4:43PM - 10:42PM	Laborer - Metal Mix A	0.26	
"	5:30PM - 10:38PM	" " " "	1.4	
"	5:30PM - 10:39PM	" " " "	1.5	0.51
Laborer - Metal Mix A - Average			1.05	0.51
3-12-74	4:48PM - 10:55PM	Charging Kettles Metal Mix A	0.49	
"	5:00PM - 10:54PM	Lead Man Metal Mix A	0.40	0.32
"	5:05PM - 10:40PM	P.T.R. Metal Mix A	1.3	
3-12-74	5:25PM - 10:36PM	Cable Lead Burner MMA	2.1	
"	5:25PM - 10:35PM	" " "	2.3	0.68

Date	Sample Period	Job Description	Total Pb conc mg/m^3	Total Pb conc mg/m^3
3-12-74	5:25PM - 10:37PM	Cable Lead Burner MMA	0.80	
"	5:25PM - 10:38PM	" " " "	1.5	
Cable Lead Burner - Average			1.7	0.68
3-13-74	10:00AM - 4:00PM	Caster - Metal Mix B	0.15	0.03
"	10:28AM - 3:36PM	" " " "	1.10	0.03
Caster - Metal Mix B - Average			0.63	0.03
*3-13-74	10:35AM - 4:17PM	Pouring Slugs Metal Mix B	0.28	0.04

*Pump had stopped running when this sample was taken off the worker.

NOTE: All personal samples were analyzed for cadmium, copper, iron, lead, antimony, and tin. Values for all samples (except for lead as reported above) were below DOL Standards and Threshold Limit Values for these materials.

TABLE 6

METAL COMPOSITION OF BULK AND SWIPE SAMPLES BY PERCENT

Settled Dust Cable Lead Burning Area		Settled Dust Lunch Room	
Cd	<0.01%	Cd	0.01%
Cu	4.5%	Cu	0.2%
Fe	17.0%	Fe	3.3%
Pb	26.0%	Pb	20.0%
Sb	1.2%	Sb	0.4%
Sn	<1.0%	Sn	<0.5%

Swipe sample above towel dispenser in locker room - 1.2 mg lead total

Swipe sample top edge of bulletin board containing OSHA Form 102 - 0.5 mg lead total.

TABLE 7

SEQUENTIAL SAMPLES - SOUTH END OF BLAST FURNACE

Air Concentrations mg/M^3

Sampling Period		Cd	Cu	Fe	Pb	Sb	Sn
6:20PM - 8:40PM	3/12/74	<0.01	<0.1	<0.1	.21	<0.1	<0.01
8:40PM - 11:08PM	"	<0.01	<0.1	<0.1	.63	<0.1	<0.01
11:08PM - 9:27AM*	3/13/74	<0.01	<0.1	<0.1	.64	<0.1	<0.01
5:00PM - 7:00PM	"	<0.01	<0.1	<0.1	1.1	<0.1	<0.01
7:00PM - 9:00PM	"	<0.01	<0.1	<0.1	1.3	<0.1	<0.01
9:00PM - 11:00PM	"	<0.01	<0.1	<0.1	.72	<0.1	<0.01
11:00PM - 1:00AM	3/14/74	<0.01	<0.1	<0.1	1.2	<0.1	<0.01
1:00AM - 3:00AM	"	<0.01	<0.1	<0.1	.84	<0.1	<0.01
3:00AM - 5:00AM	"	<0.01	<0.1	<0.1	.35	<0.1	<0.01
5:00AM - 7:00AM	"	<0.01	<0.1	<0.1	1.1	<0.1	<0.01

*NOTE: Sampler did not sequence - changed manually - power had shorted out and power was off when sampling was discontinued at 9:25AM 3/13/74 - therefore, this is a minumum value for this sample.

SEQUENTIAL SAMPLES COLLECTED SOUTH OF PTR RESTROOM METAL MIX A

Air Concentrations mg/M^3

Sampling Period		Cd	Cu	Fe	Pb	Sb	Sn
6:10PM - 8:10PM	3/12/74	<0.01	<0.1	<0.1	1.6	<0.1	<0.01
8:10PM - 10:10PM	"	<0.01	<0.1	<0.1	.42	<0.1	<0.01
10:10PM - 12:10PM	"	<0.01	<0.1	<0.1	.36	<0.1	<0.01
12:10PM - 2:10AM	3/13/74	<0.01	<0.1	<0.1	.22	<0.1	<0.01
2:10AM - 4:10AM	"	<0.01	<0.1	<0.1	.01	<0.1	<0.01
4:10AM - 6:10AM	"	<0.01	<0.1	<0.1	.01	<0.1	<0.01
6:10AM - 8:10AM	"	<0.01	<0.1	<0.1	.11	<0.1	<0.01
8:10AM - 10:10AM	"	<0.01	<0.1	<0.1	.26	<0.1	<0.01
10:10AM - 12:10PM	"	<0.01	<0.1	<0.1	.41	<0.1	<0.01
12:10PM - 2:10AM	"	<0.01	<0.1	<0.1	.29	<0.1	<0.01
2:10PM - 4:10PM	"	<0.01	<0.1	<0.1	.36	<0.1	<0.01

APPENDIX A

PLANT OPERATIONS

The Hoyt Plant is a secondary lead smelter. Lead is obtained from lead storage batteries and from lead coated copper cable.

Metals brought into the plant from the "outside" are tin, antimony, copper, iron, bismuth, and other metals. Lead is also brought in from primary sources. N.L. Industries is not a primary producer of lead.

Battery Breaking Area

Batteries are obtained from various sources and are unloaded onto a conveyor and transferred to the "guillotine" for splitting or go to the saw mill where the battery tops are removed. During our survey on March 13, the old guillotine operation was dismantled and discontinued. The lead plates and acid are removed from the casing and the plates are brought to Dross strage bins prior to smelting. Workers on the saw operation wear protective clothing and ear muffs, as well as cartridge respirators. In addition, all workers (and throughout the plant) are required to wear coveralls.

Dross Department

This is the smelting area of the Hoyt Plant. The blast furnace is charged with lead plates from the batteries, some coke, slag from previous melts, and other materials. The "mix" is melted, the slag is run off, and the almost pure lead (molten) is decanted into a kettle for cooling. Before slag is run off, a local exhaust ventilation " cover" is placed over the slag kettle to attempt to control "emissions." The furnace crew consists of five employees and a foreman per shift. The furnace operates 24 hours per day. A "tap" is made every twenty to thirty minutes. Hoyt Plant management estimates they smelt 78 tons per day of material. The fumes and dust from the blast furnace are exhausted to a dust collector and metallurgical baghouse. The dust which contains lead particles is reused in the blast furnace.

Dust respirators are required in this area by the Company.

Rolling Mill

Lead obtained from the smelting operation is melted and poured into slabs which are 4"-5" thick. The slabs are then passed through a "two-high" rolling mill. The sheet lead is used in door linings, roofing, tank lining, sound attenuation, and for shielding radiation sources. Also made in the department is "lead wool" used by the plumbing trade. This operation runs 2-3 days per month. General ventilation is in operation. No local exhaust ventilation systems are in operation.

Metal Mix A-Cable Lead Department

This department reclaims lead from lead coated copper wire. The wire is obtained from various sources such as utility companies. The wire is heated and molten lead removed by skimming. The copper wire is returned to the supplier. This is a three shift operation. Local exhaust ventilation is in operation over most of the melting kettles, but is not fully effective. Dust respirators are required in this area by the company.

Metal Mix A-Preferential Tin Removal (PTR)

This area contains a chemical process for removing tin from furnace bouillon. The impure tin recovered is shipped out for electrolytic refining. Protective clothing and dust respirators are in use.

Metal Mix A-Solder Manufacture

Metals are alloyed (principally tin and lead mixtures) for internal use by other departments or to customer specification for battery manufacturing. Also, lead is cast into billets to be brought to the Shot Department for fabrication into lead shot.

Metal Mix B

Lead and tin are melted and cast into billets for use by the Pipe Department for pipe and solder wire fabrication. Lead is also alloyed with silver, bismuth, tellurium, tin, copper, and antimony depending upon customer specifications. Virgin lead is used in these applications. Plumbing lead is also cast, principally, but not entirely, from virgin lead.

Plumbers lead is also cast into billets mainly from lead obtained from outside primary sources.

General dilution ventilation is in operation. No local exhaust ventilation is in operation.

Pipe Department

Lead billets obtained from Metal Mix B are extruded into pipe. Tin-lead billets obtained from Metal Mix B are extruded into wire or bar solders. Antimonal lead pipe is also manufactured with the antimony content to customer specification. Respirators are not required by the company in this area.

Shot Department

The Shot Department manufactures varying sized shot for sporting or target use. A conventional shot "tower" is used to form the shot from molten lead. After the newly formed shot is quenched, it is dried. sorted, sized and bagged. Buckshot is also made by utilizing a patented casting machine. Small amounts of arsenic or antimony are usually alloyed with lead to produce a harder shot which is ballastically superior, being less subject to deformation.