U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION REPORT
HE 78-26-560

MALLORY BATTERY COMPANY
LEXINGTON, NORTH CAROLINA

FEBRUARY 1979

I. TOXICITY DETERMINATION

A Health Hazard Evaluation was conducted by the National Institute for Occupational Safety and Health (NIOSH) on January 10 and February 13-15, 1978 at Mallory Battery Company, Lexington, North Carolina. The working environment was evaluated for airborne levels of inorganic mercury, both particulate and elemental. All personal breathing zone samples exceeded the NIOSH criteria document recommendation of 0.05 mg/M^3. The average exposures of the employees in the three areas of the plant evaluated ranged from 4 to 13 times the recommended criteria. The personal respiratory protection program was inadequate.

There is evidence of increased absorption of mercury (Hg), particularly among employees in the Oxide Plant and Depolarizer Room (D.P. Room) where 70% and 58% respectively of the participants had urine Hg levels greater than 0.3 mg/l. There were 9 workers among 104 with known, suspected or formerly high mercury exposure who had a combination of observed tremor plus 2 or more of the following: observed gingivitis, motor coordination disturbance other than tremor, mood change, irritability or temper outbursts, insomnia, weight loss and poor memory. The distribution of these 9 participants was as follows: Oxide Plant - 3; D.P. Room - 2; miscellaneous, suspect high exposure - 3; and, former high exposure-1.* The semen analysis results did not support the original suggestion of a relationship between decreased sperm count and Hg exposure.

Recommendations are presented to monitor and to help reduce employee exposure to inorganic mercury.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding

*Categories of exposure explained in Table I.

its availability through NTIS can be obtained from NIOSH, Publications Office at the Cincinnati address.

Copies of this report have been sent to:

a) Mallory Battery Company, Lexington, North Carolina
b) U. S. Department of Labor, Region IV
c) NIOSH, Region IV

For the purpose of informing the approximately 100 "affected employees" the employer shall promptly "post" for a period of 30 calendar days the Determination Report in a prominent place(s) near where exposed employees work.

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 an 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 the employer to evaluate the potential for exposure of his employees to inorganic mercury. In April 1977, two Mallory employees developed a syndrome which was initially diagnosed as amyotrophic lateral sclerosis (ALS). Removal of these employees from mercury exposure resulted in eventual cessation of symptoms. Further study by the company revealed nineteen additional workers with complaints of backache, muscle weakness, insomnia and weight loss. These symptoms were also reversible upon removal from exposure. Concurrently, concern was expressed by several employees regarding the possibility of decreased fertility among the Oxide Plant employees. Results of a subsequent investigation by the company (sperm count analysis) suggested that there may be a greater than expected number of "low" sperm counts among D.P. Room and Oxide Plant employees. As a result, the company also requested that NIOSH evaluate the possible reproductive system effects of mercury exposure.

IV. HEALTH HAZARD EVALUATION

A. Description of Facilities/Operation

Mallory Battery Company, a subsidiary of P. R. Mallory and Company, produces dry cell mercury batteries. Mallory has operated the Lexington plant since 1960. Mercury usage is approximately 50,000 pounds per year. There are approximately 700 people employed in the areas of concern at Mallory, 205 male and 498 female. The operations of concern in this study take place in four main areas of the plant.

1. Oxide Plant

In a building separate from the rest of the plant, elemental mercury is cleaned and combined with chlorine and sodium hydroxide to make mercuric oxide. There are approximately 34 employees in the Oxide Plant, all males. The job classifications in the Oxide Plant are mercury handlers, process operators, mechanics, lab technicians, baggers and material handlers. There are two shifts. The reactions to make mercuric oxide are performed in reaction chambers; the newly formed oxide is then dried and packaged for use in the Depolarizer Room or for use outside Mallory.

2. Anode Room

A zinc/mercury amalgam is formulated, dried, blended and pressed into pellets which will form the anode of the battery. There are approximately 11 employees in the Anode Room, 5 males and 6 females over two shifts. The job classifications in the Anode Room are amalgam blenders, press operators, inspectors and mechanics.

3. Depolarizer (DP) Room

The Depolarizer Room consists of two rooms - the smaller two-level Slugger Room and the larger press area. In the slugger room mercuric oxide is blended with manganese oxide, graphite and cadmium. This mixture is then brought into the press area where it is pressed by automatic presses into different sized canisters. These canisters make the cathode of the battery. There are approximately 73 people employed in the DP room - 27 males and 46 females - over three shifts. The job classifications in the DP room are press operators, slugger operators, inspectors, supervisors, and mechanics.

4. Cell Assembly Area

The anodes and cathodes, along with appropriate spacers, absorbers and electrolytic solution, are assembled into batteries of the proper voltage. The exposure of employees to mercury in this area is not considered hazardous. To reach this conclusion, an instrument to measure airborne mercury levels - a Bacharach Mercury Vapor Sniffer* was used to preliminarily assess the mercury levels in this area. Values were below criteria recommended for this study; this was consistent with air monitoring conducted by Mallory in the past. Therefore no further sampling was performed and this area will not be discussed in the evaluation.

*Use of trade name information does not constitute an endorsement by NIOSH.

B. Medical Surveillance Program

Under the current medical surveillance program at Mallory (in effect since the summer of 1977), employees receive a pre-employment physical examination, a urinalysis and a base-line urine mercury level.

Mallory presently has a full-time consultant physician who is responsible for their on-going medical surveillance program. Employees in high-exposure areas have their urine mercury levels measured at least once a month. They have at least one physical examination per year. Employees are transferred from high-exposure areas at the discretion of the physician. Transfer is automatic if the urine mercury level exceeds 0.50 mg/l. The transferred employee is not allowed to return to a high-exposure area until his urine mercury level has dropped to at least 0.30 mg/l and the physician has determined the person to be asymptomatic. This program is designed based on the personal experience of the consultant physician as well as on the experiences of others as indicated by personal communication[6] and reports in the literature.[8,11]

The medical surveillance program is supported by an industrial hygiene monitoring program whose goal is to identify, by means of monthly air monitoring, the high-exposure work areas, and where feasible, to reduce mercury exposure through use of appropriate engineering measures.

C. Evaluation Design and Criteria

A preliminary survey was performed on January 10, 1978. The purpose of this initial study was to determine the areas of highest mercury contamination, obtain an understanding of the plant and its operations and to explain to company officials the medical and environmental aspects of the follow-up survey. Area samples for particulate mercury compounds and Sniffer measurements for elemental vapor confirmed Mallory's belief that the areas of highest contamination were the Oxide Plant, the Anode Room and the DP Room. It was decided that medical and environmental data would be gathered from these three areas.

1. Environmental

The follow-up survey consisted of personal monitoring for mercury exposure. Personal breathing zone samples for particulate and elemental mercury were obtained from selected employees on all three shifts. The sampling procedure consisted of the following: MSA Model G personal sampling pumps calibrated to pull 1.0 liter of air per minute (lpm) were connected via tygon tubing to an iodine-impregnated charcoal tube and a 37 mm cassette with AA filter. The tube and filter were arranged so that the air being sampled was pulled through the filter first (to capture particulate mercury) and then the tube (for elemental mercury). This sampling train was placed on the employee for a period of time approximating the entire shift. The filter samples were analyzed by flameless atomic absorption spectrophotometry and the charcoal tube samples were analyzed by flame atomic absorption spectrophotometry. In addition, smear tab samples were taken to document the extent of mercury contamination within the plant. These samples were taken in areas of known mercury contamination and in areas in which mercury contamination would not be expected. This investigative procedure does not give quantitative results.

In order to evaluate a worker's exposure to substances found in the workplace, values have been derived, based on the best available information from industrial experience and human and animal toxicity studies, which refer to airborne concentrations of the substances to which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect.

There are three sources of exposure criteria used in this study; 1) NIOSH criteria document[5] for a recommended standard "Occupational Exposure to Inorganic Mercury" (1973); 2) Threshold Limit Values (TLV's)[15] and their supporting documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH) (1977), and 3) Occupational Health Standards[12] as promulgated by the U.S. Department of Labor (29 CFR 1910.1000).

The ACGIH and NIOSH both recommend that employee exposure be limited to concentrations of mercury below 0.05 milligrams of mercury per cubic meter of air (mg/M^3), based on an 8 - 10 hour Time Weighted Average (TWA). This level includes all forms of mercury with the exception of organomercury. The current OSHA standard for all forms of mercury except organic is 0.1 mg/M^3 - 8 hour TWA. The ACGIH and NIOSH recommendation is not to be considered as a fine line between safe and unsafe conditions but rather as a guideline for the improvement of occupational health and safety in the workplace. Reference to the OSHA Standards is made for

information only, not to determine the state of compliance or noncompliance with Federal Regulations.

2. Medical

The initial study was designed to evaluate all Oxide Plant employees (all of whom were men) and all (male) Depolarizer Room employees, however, participation in the study was offered to all (male) employees. Only male workers were evaluated as the primary area of concern focused on the possible relationship between high Hg exposure and alleged decreased "fertility" as manifested by low sperm counts. A "control" group was sought from among non-exposed employees such as office and administrative personnel. The final criteria for inclusion in each exposure category is described in Table I.

The study protocol included the following: 1) a medical questionnaire 2) a limited physical examination, 3) semen analysis (count and morphology), 4) analysis of the urine for mercury content and beta-2-microglobulin (B_2M), and 4) analysis of the blood for blood urea nitrogen (BUN), creatinine, follicle-stimulating hormone (FSH), luteinizing hormone (LH) and testosterone.

The medical questionnaire was directed toward revealing occupational history, work practices, pertinent past medical history (particularly as related to the reproductive system) and symptoms associated with mercurialism - constitutional, neurologic and oral. The physical examination focused on an evaluation of constitutional, neurologic and oral signs consistent with mercurialism. Dermatologic and reproductive system abnormalities were also sought.

The following laboratory criteria were used in evaluating results:

a. Semen analysis: reported as number of sperm per ml of fluid. What constitutes a "normal" sperm count is not well understood. It is generally considered that a man whose count is greater than 40 million per ml (and if an adequate proportion of the sperm cells is normal) will not have difficulty fathering children. Men whose sperm counts are less than 40 million per ml have a somewhat decreased chance of inducing pregnancy while those whose counts are less than 20 million have an even lesser chance.

The semen specimen was obtained by giving each participant a sterile plastic cup to take home with him with instructions to produce the specimen by masturbation (after a period of at least 48 hours sexual abstinence). The specimen was to be produced just prior to leaving for work and then brought directly to the NIOSH laboratory technician. Specimens were allowed to coagulate and reliquefy. Slides were made for cytology and the remainder of the specimen placed in transfer containers, frozen and then transported to the analyzing laboratory.

Evaluation of sperm morphology was performed by Professor John MacLeod, Male Infertility Consultant, The New York Hospital (Cornell). Sperm counts were done by National Health Laboratories.

b. Urine mercury and B_2M - Urine Hg levels were reported as mg of mercury per liter of urine (mg Hg/l). Although present evidence indicates that there is poor correlation between individual urine Hg levels, Hg exposure, and signs and symptoms of mercurialism, it remains the best available indicator of Hg absorption. Although there are no official standards for urine mercury levels, a general guideline which has been used in the past is as follows:[3]

	Urine Hg level (mgHg/l)
Non-occupationally exposed	0.03 or less
Increased absorption but no known hazard	0.05-0.1
Hazardous Level-Remove from further exposure	above 0.2
Symptoms of Hg toxicity may occur	0.3 or more

A 12-hour urine specimen, collected at home, was obtained. Such a pooled specimen was considered desirable in order to overcome some of the variability that can be seen in "spot" urine samples, as the excretion of mercury can fluctuate widely from hour to hour and day to day independently of exposure. Levels were corrected to a specific gravity of 1.024 by use of the following formula:

$$\text{Corrected mgHg/liter} = \text{mgHg/liter} \times \frac{0.024}{\text{Observed Specific Gravity} - 1.000}$$

Analysis of the urine for mercury was performed by Utah Biomedical Test Laboratory, Salt Lake City, Utah.

Urinary B_2M (beta-2-microglobulin) is a test of kidney function. The upper limit of "normal" value used was less than 250 mg/gm creatinine. B_2M concentration was measured by the NIOSH laboratory in Cincinnati, Ohio.

c. Blood Analyses

(1) BUN - blood urea nitrogen (10-25 mg/dl*), a test of kidney function. High values may be associated with kidney dysfunction.

(2) SERUM CREATININE - (0.7 - 1.4 mg/dl), a test of kidney function. High values may be indicative of kidney dysfunction.

(3) FSH - follicle-stimulating hormone, (5-25 mIU**/ml) & LH luteinizing hormone, (5-20 mU***/ml), hormones which regulate the production of sperm and testosterone - both very high and very low values can indicate dysfunction.

* milligrams/deciliter
** milli international units
*** milli units

(4) TESTOSTERONE - (300-1200 ng/dl***), a male hormone which is involved in sperm production but is primarily responsible for development of male characteristics such as facial hair and muscle development - both very high and very low values can be indicative of dysfunction.

D. Toxicology of (Inorganic) Mercury[1,2,9]

Mercury (Hg) is a heavy metal which is liquid and volatile at room temperature. Mercuric oxide (HgO) is a poorly soluble inorganic compound of mercury. Little has been published concerning the toxic effects of HgO. The toxicology of metallic Hg vapor, however, has been fairly well documented in the literature.

The primary route of entry of Hg vapor or dust is via inhalation. It may also enter the body through ingestion (especially with poor work practices) and through skin absorption. If inhaled, mercury vapor is readily absorbed into the bloodstream through the lungs.

Excessive exposures to mercury can produce mercury poisoning or mercurialism, either acute (short-term, intensive exposure) or chronic (usually long-term, lower level exposure). Chronic mercurialism is the type most frequently seen in industrial settings and results from a slow accumulation of Hg in the body over a period of time. The symptoms of chronic mercury poisoning may include the following:

Behavorial or Psychic Changes: Irritability, depression, moodiness, nervousness, headache, insomnia, poor memory, shyness, quarrelsomeness, and neglect of family and job.

Neurologic Changes: Tremor (shakiness), muscle weakness, unsteady walk, lack of coordination, muscle twitching or jumping.

Gastrointestinal/Oral Changes: Tender, swollen gums which may bleed easily or show a dark line or spots. Metallic taste, excessive salivation, loose teeth, sore mouth, upset stomach, diarrhea or constipation, loss of appetite and weight.

General: Nosebleeds, muscle ache or cramps.

Mercury has a cumulative effect but does not remain in the body indefinitely; it is gradually eliminated over a period of time - primarily via the urine. Small amounts are also excreted in feces, sweat and saliva.

Biological monitoring for mercury exposure is generally done by urinalysis. It has been found that within a single individual the excretion of Hg can vary unpredictably from hour to hour and day to day. In spite of this variability, urine Hg levels are still the best available indicator of Hg absorption, especially on a group basis.

***nanograms/deciliter

For the purposes of this study, mercurialism (clinical mercury poisoning) is defined as observed tremor plus 2 or more of the following: gingivitis, abnormal neurologic signs other than tremor, mood change, irritability or temper outbursts, insomnia, weight loss and poor memory.

E. Evaluation Results

1. Environmental

Table II shows the levels of environmental mercury exposures documented on February 13-15, 1978. The values have been divided into three groups per sample - particulate mercury, elemental mercury and a sum of the preceding two, total mercury exposure. This was done in order to determine what fraction of the total mercury exposure was the greatest and to relate that to the area in which the sample was obtained.

A total of forty-seven employees were monitored resulting in 94 separate samples. Five sets of data were not used in the statistical analysis for the reasons listed in Table II. Of the 42 sample sets retained (one sample set represents one employee's total mercury exposure), all exceeded the NIOSH criteria of 0.05 mg/M^3. These values are indicated in the column headed "Total Hg Exposure." Also, 34 of 42 samples for particulate mercury alone exceeded the NIOSH criteria. All samples for elemental mercury alone exceeded the NIOSH criteria.

A statistical analysis was performed to determine the range of exposure values for employees within a particular job classification in a certain area, and for all employees, regardless of job classification, in a certain area. This data is shown in Table III. The two-tailed test to determine the 95 percent confidence limits of exposures among job classifications is indicated in column 5. The 95 percent confidence range for exposures among the three areas is in column 8. (For job classifications with only one sample, the mean and range are shown by a blank line, indicating too small a sample set for calculation.)

A one-way analysis of variance was performed to determine if there was any significant difference, at the 95 percent confidence level, between the average exposure of employees in the Oxide Plant versus the DP Room versus the Anode Room. At the 95 percent confidence level, there is a significant difference between the average mercury exposure in the Anode Room and that in either the DP Room or the Oxide Plant. There is no significifant difference between average mercury exposures in the DP Room and the Oxide Plant. In other words, average exposure to Oxide Plant employees is not significantly different from employees' exposure in the DP Room. There is a statistical difference in exposure of the Oxide Plant and DP Room employees to exposure of employees in the Anode Room.

The respiratory protection program at Mallory consists of disposable mercury vapor masks. Since mercury has poor warning properties (nothing to indicate to the employee when breakthrough occurs) and this respirator

has no end-of-life indicator (to show when air-purifying properties are exhausted), this respirator is not approved by NIOSH. Even if this respirator were approved, it still would not provide adequate protection to Mallory employees. The manufacturer of this respirator states that it provides protection against mercury concentrations up to 5 times the TLV (.05 mgHg/M^3), or 0.25 mgHg/M^3. Table II indicates 27 of 42 employees were exposed to concentrations equal to or greater than 0.25 mg/M^3 on the days sampled. Currently, the only respirators approved by NIOSH are either supplied air or self-contained air, positive pressure, full facepiece. Clearly, the potential exists for all employees in any of the sampled areas of the plant to be exposed in excess of the manufacturer's specifications.

2. Medical

The total number of participants in the medical evaluation was 139, which represented 68% (139/205) of the male employees. After reviewing the occupational histories of the participants, it was necessary to form several additional exposure categories: (1) former Oxide Plant, (2) former Depolarizer Room and (3) miscellaneous, suspect high-exposure group. The control group (with no known exposure to mercury) was expanded to include those workers with past and/or current low mercury exposure.

a. Summary of findings from questionnaires and physical examinations

All participants were examined and interviewed by one of 4 NIOSH physicians. The medical findings for all participants are summarized in Tables IV and V. The percentage occurrence of selected signs and symptoms associated with clinical mercurialism among the 2 known high exposure areas (Oxide Plant and D.P. Room) and the control group is shown in Figure 1. Those signs and symptoms which were reported significantly more frequently than in the control group were irritability, backache, reported muscle twitch ($p \leq .01$*), mood change, poor memory and reported muscle weakness ($p = .02$-$.05$*). There was no apparent correlation between signs and symptoms of mercurialism and urine mercury levels. There were 9 employees (from among 104 with known-high, suspected-high or formerly-high mercury exposure) who had a combination of signs and symptoms suggestive of mercurialism. These 9 participants were distributed as follows: Oxide Plant - 3, D.P. Room - 2, miscellaneous, suspect high exposure - 3, and former high exposure - 1. The urine Hg levels of these individuals ranged from 0.17 to 0.69 mg Hg/l (3 participants did not submit a specimen).

There was an additional participant from the D.P. Room who did not have tremor, but who did, however, exhibit signs of abnormal coordination. He also reported symptoms of irritability and temper outbursts, insomnia,

*Fisher's Exact test or Chi-Square

tremor, fatigue, muscle weakness and metallic taste. His past medical history was non-contributory. His urine Hg level was 0.37 mg Hg/l.

A reproductive history which included questions concerning number of children fathered, number of miscarriages, stillbirths, birth defects and complaints of "fertility problems" was obtained from all participants. Table VI summarizes the information obtained from the Oxide Plant, Depolarizer Room and Control groups. It appeared that there was a higher rate of miscarriage after starting to work at Mallory among the Oxide Plant (2 of 5 pregnancies or 40%) and D.P. Room participants (2/7 or 29%) as compared to prior to starting work there - 1/22 (4.5%) and 2/27 (7%) respectively (see Table VI). The difference was not statistically significant, however, (Oxide Plant: p=0.078, Depolarizer Room: p=0.179, Fisher's Exact test).

There was, however, a statistically significant difference between the reported rate of miscarriages (after starting to work at Mallory) in the Oxide Plant, Depolarizer Room, combined Oxide Plant/D.P. Room employees (40%, 29% and 33% respectively) when compared to the control group rate of 0% [p=0.26 (Oxide Plant); p=0.048 (D.P. Room); p=.009 (combined group), Fisher's Exact Test]. There were 3 participants who gave histories suggestive of decreased "fertility" (one each from the Oxide plant, former Oxide Plant and the Control group).

b. Semen analysis

A total of 121 semen specimens were submitted. Preliminary analysis of the data indicated that there was a greater number of "low" (<20 million) sperm counts among the Oxide Plant employees compared to other areas of the plant. Further examination revealed that 5 Oxide Plant participants with low sperm counts had a history of recent high fever, a condition which in itself could be responsible for a temporarily reduced sperm count.* It was considered necessary therefore, to obtain a second semen specimen from the Oxide Plant employees to allow for evaluation of what, if any, influence these prior episodes of fever had. These repeat specimens were obtained during a follow-up visit in April. The distribution of the original and follow-up sperm counts of the Oxide Plant participants is shown in Table VII. The mean and median values were not appreciably different from those of participants from other areas of the plant (see Table VIII). Each employee with a history of fever and who submitted a second specimen demonstrated an increased sperm count.

The sperm counts of a number of participants (see Table IX) were excluded from statistical analysis because of the presence of specific medical conditions which could likely result in a reduced sperm count. In addition to fever, these conditions included known "fertility" problems prior to starting at Mallory - vasectomy, cryptorchidism (undescended testis) and genitourinary surgery. In addition, it was later found that several current Oxide Plant workers did not meet the exposure-time

*Two of these 5 subsequently had to be excluded from statistical analysis because they did not meet exposure-time criteria for the Oxide Plant as previously described in Table I.

criteria for Category I (Oxide Plant) because of recent transfers. Accordingly, only 15 of the original 29 Oxide Plant participants were included for statistical analysis.

Individual sperm counts with the range and distribution for all the participants (excluding the Oxide Plant which is listed separately) are included in Table X.

Results of the sperm morphology data did not appear to show any deleterious effects(see Table XI).

c, Urine Hg and B_2M

A total of 126 workers submitted urine specimens. The urine Hg levels ranged from less than 0.02 to 1.17 mg/l.* There was evidence of increased absorption of Hg among the participants as indicated by the urine Hg levels. The distribution of urine Hg values for all participants (n=126) was as follows:

Urine Hg level (mgHg/L)	No. of Participants (n=126)	% of total
0-0.03	7	6
>0.03-0.1	10	8
>0.1 -0.3	53	42
>0.3 -0.5	26	21
>0.5	30	24

From the above table, it can be seen that 44% (56/126) of the total participants had urine Hg levels greater than 0.3 mg/l**- the level at which symptoms of mercurialism may occur.

The highest levels of urine Hg were found among the Oxide Plant workers where the mean concentration was 0.51 mg/l, (range 0.17-1.17) mg/l. Seventy percent (19/27) of this group had levels greater than 0.3 mg/l.

Urine Hg level mgHg/l	No. of Oxide Plant Participants (n=27)	% of total
0-0.03	--	--
>0.03-0.1	--	--
>0.1 -0.3	8	30
>0.3 -0.5	9	33
>0.5	10	37

Among the D.P. room participants, 58% (14/24) had urine Hg levels greater than 0.3 mg/l. The range and distribution of urine Hg levels for all participants is shown in Table XII. The mean urine Hg level of both the Oxide Plant and the D.P. Room workers was significantly higher than the control group ($P < 0.01$, Student's t-test).

*Corrected to specific gravity 1.024

**Due to the inherent error in the correction formula used, correction of specimens with low specific gravity (here, <1.012) may have resulted in falsely elevated (>0.3 mgHg/l) urine Hg levels. Thus, 5 individuals may have been incorrectly classified as elevated.

The range and distribution of urinary beta-2-microglobulin levels was not unusual (see Table XII).

d. Blood Analyses

The range and distribution of BUN, serum creatinine and gonadotropins* was not unusual (see Table XII). There did not appear to be any correlation between sperm counts and gonadotropins.

V. CONCLUSIONS AND DISCUSSION

1. Environmental

There is biologically significant mercury exposure, from both particulate and elemental forms, to almost all employees in the Oxide Plant, DP Room and Anode Room. If a combined total exposure is considered, all employees in these areas are overexposed. NIOSH defines exposure to inorganic mercury as "exposure to a concentration of inorganic mercury greater than 40 percent of the recommended level in the workplace"; i.e. any level over 0.02 mg/M^3.

An average of 71 percent of the total mercury exposure in the DP Room is attributable to particulate mercury, 86 percent of the total mercury exposure in the Anode Room is attributable to elemental mercury. In the Oxide Plant, mercury exposure is about evenly divided, 48 percent particulate and 52 percent elemental.

The respiratory protection program provided by the company is inadequate. This conclusion is based on the high Hg exposures documented on the survey dates.

2. Medical

There is evidence of increased absorption of Hg among employees in areas of known or suspected-high Hg exposure, particularly the Oxide Plant and D.P. Room where 70% and 58% respectively of the participants had urine Hg levels greater than 0.3 mg/l. As revealed by results of the questionnaires and review of company records, there have been numerous transfers (prior to the Feburary NIOSH visit) of employees from high to low Hg exposure areas due to high urine Hg levels. There was a variety of reported symptoms among participants, and some were more prevalent among employees with high Hg exposure. There was no apparent correlation between urine Hg levels and symptomatology. This finding is consistent with other reports.[2,7]

In interpreting the data concerning symptomatology there are several potential confounding factors: 1) Many of the symptoms are non-specific; 2) There may have been heightened awareness with a subsequent possibility

*Substances (in this case, FSH, LH and Testosterone) which stimulate sexual glands

of biased reporting among employees who were aware that they were working in a high-exposure area; and 3) the psychophysiologic effect of increased working hours - as much as 60-80 hours/week in some cases - may have contributed to an unusually high rate of reporting of some symptoms.

The early manifestations of mercurialism are non-specific and often overlooked. The classic triad of tremor, gingivitis and psychic changes may be present in varying patterns and degrees, i.e., all 3 may not be apparent in the presence of mercury poisoning. Urine Hg levels, currently the best biologic indicator of exposure and absorption, are known to be poorly correlated with symptomatology on an individual basis. Jacobs et al.[7] made a positive diagnosis of mercurialism if..."tremor and at least two of the following manifestations were present: gingivitis, exaggerated tendon reflexes, jerky handwriting, salivation, personality changes, irritability or disturbed sleep...". Other early symptoms which have been reported include loss of appetite, weight loss, insomnia and poor memory.[13]

Nine participants exhibited a combination of signs and symptoms compatible with a diagnosis of mercurialism (using criteria described on p. 8, See C of this report). Five (5) worked in known high-mercury-exposure areas (D.P. Room or Oxide Plant); 3 in suspected high exposure areas and one had previously worked in a high-exposure area. Urine Hg levels in six individuals ranged from 0.17 - 0.69 mg Hg/l. (Three employees did not provide specimens). There was no apparent correlation between urine Hg levels, severity of symptoms or sperm count in these individuals.

The semen analysis data did not appear to show any deleterious effects from exposure to mercury. The reproductive histories revealed a higher rate of reported miscarriages among the high exposure (both Oxide Plant and D.P. Room) groups as compared to the control group (40% and 29% in the Oxide Plant and D.P. rooms respectively compared to 0% among the control group) after starting at Mallory. The reported miscarriage rates prior to starting at Mallory were quite similar. The significance of this finding is not clear. The data must be interpreted with caution because of a number of unanswered questions - factors which could affect both the actual rate of miscarriage and its reporting by employees. These factors include (1) the questionnaire did not elicit information necessary to adjust for years at risk; (2) the history may be somewhat inaccurate because it was obtained from the husbands rather than the wives; (3) there may have been a biased response among the known high-exposure groups; (4) this data was derived from a relatively small sample; and (5) a rate of 0% among the control group is unrealistically low.[4,14]

VI. RECOMMENDATIONS

A. Environmental

1. Unless or until suitable engineering controls can be instituted to reduce employee exposure to below 0.05 mg/M^3 of total inorganic mercury,

a positive pressure supplied air respirator or self-contained breathing apparatus (positive pressure) should be issued to all employees so exposed.

The above recommendation, its costs and logistics, emphasizes the need for engineering control. The following suggestions may be worth considering:

a. Increase the air removal capacity (cfm) of the general room ventilation and the ventilation to the machine enclosures.

b. If available, replace the old presses with newer models that are more efficient (produce less dust).

c. Clean exhaust systems periodically to maintain efficiency.

2. A written respirator program should be developed in accordance with 29 CFR 1910.134 - Respiratory Protection.

3. Continue the training or instructional program, to include the hazards of mercury exposure and the protective procedures within the plant to be administered to all new employees and periodically to all employees as a refresher.

4. Review individual work practices periodically. Careless handling of mercury compounds can contribute significantly to a worker's exposure.

5. Monitor employee exposure to Mercury periodically. Monitoring should be performed on all employees when they are involved in a process change in order to determine if that process change has caused increased mercury exposure.

6. Maintain strict housekeeping rules. Clean up thoroughly all spills immediately.

B. Medical

1. Continue pre-employment and periodic history and physical examination with emphasis on signs and symptoms associated with mercurialism (constitutional, neurological and oral).

2. Continue pre-employment and periodic monitoring of urine-Hg levels in mercury-exposed employees.

3. Women of reproductive age should be closely monitored as mercury in high concentrations is suspected of being a possible cause of birth defects.[10]

4. Continue monitoring of urine Hg levels of persons in high-exposure areas at least monthly. When there is evidence of increased Hg absorption corrective action should be taken to determine the cause. Employees with urine Hg levels of 0.20-0.25 mg/l (repeated once for verification) should be removed from further exposure until the level is at least 0.1 mg/l (and the employee is asymptomatic) in order to provide for an adequate margin of safety.

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TABLE I

Categories of Mercury Exposure

Mallory Battery Company
Lexington, North Carolina
HHE 78-26

February 13-15, 1978

OXIDE PLANT - three months or more since start of exposure (not necessarily continuous)- includes employees who have been out 3 months or less. Employees out for greater than 3 months will be in Former Oxide Plant group.

DEPOLARIZER ROOM - three months or more since start of exposure (not necessarily continuous)- includes workers who have been out for 3 months or less. Employees out for greater than 3 months will be in Former D.P. Room Worker group.

LOW EXPOSURE ("CONTROL") - those who have had not worked in Oxide Plant, D.P. Room or other high Hg Exposure areas and those with miscellaneous, probably low, Hg exposure as indicated by job description.

MISCELLANEOUS, PROBABLY HIGH MERCURY EXPOSURE - workers from various parts of the plant who cannot be classified otherwise but with suspected high exposure because of job description.

FORMER OXIDE PLANT WORKERS - former oxide plant workers out of the area greater than 3 months.

FORMER D.P. ROOM WORKERS - those employees who have been out of the area more than 3 months.

Table II

Environmental Data - Exposure to Mercury Compounds

Mallory Battery Company
Lexington, North Carolina

February 13-15, 1978

HE 78-26

	Time Sampled (min)	Volume Sampled (M^3)	Particulate Hg (mg)	Elemental Hg (mg)	Total Hg (mg)	Particulate Hg Exposure (mg/M^3)	Elemental Hg Exposure (mg/M^3)	Total Hg Exposure (mg/M^3)
Depolarizer Room								
Press Operator	390	0.39	0.210	0.045	0.255	0.54	0.12	0.65
Press Operator	383	0.38	0.045	0.029	0.074	0.12	0.08	0.20
Press Operator	376	0.38	0.270	0.048	0.318	0.71	0.13	0.84
Press Operator	393	0.39	0.200	0.041	0.241	0.51	0.11	0.62
Press Operator	370	0.37	0.160	0.031	0.191	0.43	0.08	0.52
Press Operator	386	0.39	0.350	0.043	0.393	0.90	0.11	1.01
Machine Operator	377	0.38	0.300	0.022	0.322	0.80	0.06	0.85
Machine Operator	380	0.38	0.029	0.028	0.057	0.08	0.07	0.15
Machine Operator	387	0.39	0.180	0.040	0.220	0.46	0.10	0.56
Machine Operator	391	0.39	0.039	0.063	0.102	0.10	0.16	0.26
Machine Operator	380	0.38	0.210	0.041	0.251	0.55	0.11	0.66
Machine Operator	318	0.32	0.034	0.046	0.080	0.11	0.14	0.25
Machine Operator	314	0.31	0.170	0.022	0.192	0.55	0.07	0.62
Machine Operator	393	0.39	0.210	0.049	0.259	0.54	0.13	0.66
Machine Operator	388	0.39	0.290	0.048[2]	0.338	0.74	0.12	0.87
Slugger Operator	415	0.42	0.190	0.059	0.249	0.45	0.14	0.59
Slugger Operator	403	0.40	0.310	0.060	0.370	0.78	0.15	0.93
Slugger Operator	414	0.41	0.280	0.099	0.379	0.68	0.24	0.92
Slugger Operator	399	0.40	0.170	0.076	0.246	0.43	0.19	0.62
Inspector	370	0.37	0.027	0.043[1]	0.070	0.07	0.12	0.19
Supervisor	277	0.28	0.011		0.011	0.04		
Maintenance Man (mechanic)	356	0.37	0.200	0.043	0.243	0.54	0.12	0.66
Maintenance Man (mechanic)	368	0.37	0.170	0.049	0.219	0.46	0.13	0.59
Maintenance Man (mechanic)	374	0.37	0.026	0.044	0.070	0.07	0.12	0.19
Maintenance Man (mechanic)	387	0.39	0.180	0.064	0.244	0.46	0.16	0.63
Maintenance Man (mechanic)	394	0.39	0.220	0.066	0.286	0.56	0.17	0.73
Maintenance Man (mechanic)	388	0.39	0.023	0.053	0.076	0.06	0.14	0.20
Anode Room								
Amalgam Blender	465	0.47	0.004	>0.080	>0.084	0.01	>0.17	>0.18
Amalgam Blender	441	0.44	0.010	>0.100	0.110	0.02	>0.23	>0.25
Amalgam Blender	257	0.26	0.022	0.065	0.087	0.09	0.25	0.34
Press Operator	444	0.44	0.007	0.041	0.048	0.02	0.09	0.11
Press Operator	444	0.44	0.004	0.029	0.033	0.01	0.07	0.08
Press Operator	437	0.44	0.002	0.028	0.030	0.01	0.06	0.07
Oxide Plant								
Process Operator	398	0.04	0.016	0.043	0.059	0.04	0.11	0.15
Process Operator	390	0.39	0.220	0.067	0.287	0.56	0.17	0.74
Process Operator	383	0.38	0.025	0.039	0.064	0.07	0.10	0.17
Process Operator	374	0.37	0.021	0.059	0.080	0.06	0.16	0.22
Process Operator	288	0.29	0.023	0.051	0.074	0.08	0.18	0.26
Process Operator	274	0.27	0.260	0.056	0.316	0.96	0.21	1.17
Material Handler	396	0.40	0.860	0.041	0.901	2.15	0.10	2.25
Material Handler	390	0.39	0.440	0.070	0.510	1.13	0.18	1.31
Material Handler	299	0.30	0.038	0.053	0.091[3]	0.13	0.18	0.30
Material Handler	292	0.29	1.300	0.100	1.400	4.48	0.35	4.83
Engineering Technician	392[4]	0.39	0.009	0.070	0.079	0.02	0.18	0.20
Water Treatment Operator	307[5]	0.31	0.008	0.020	0.028	0.03	0.07	0.09
Maintenance Man (house services)	262	0.26	1.400[6]	0.027	1.427	5.39	0.10	5.49
Laboratory Technician	297	0.30	0.007	0.055	0.062	0.02	0.18	0.21

[1] analytical error - sample lost

[2] possible sampling error

[3] sample possibly tampered with

[4,5] exact time sampled unknown

[6] sample possible tampered with

Table III

Statistical Analysis of Sampling Data

Mallory Battery Company
Lexington, North Carolina

HHE 78-26

Location	Job Classification	Population Size (N)	Average Exposure (mg/M^3)	95% LCL - UCL (mg/M^3)	Population Size (N)	Average Exposure (mg/M^3)	95% LCL - UCL (mg/M^3)
DP Room	Press Operator	14	0.56	0.41 - 0.71			
	Slugger Operator	4	0.77	0.51 - 1.03			
	Inspector	1	--	--			
	Mechanic	6	0.50	0.26 0.72			
	Total				25	0.56	0.45 - 0.67
Anode Room	Amalgam blender	3	0.26	0.11 - 0.41			
	Press Operator	3	0.09	0.05 - 0.13			
	Total				6	0.17	0.06 - 0.28
Oxide Plant	Process Operator	6	0.45	0.04 - 0.96			
	Material Handler	3	1.29	-0.5 - 3.09			
	Engineering tech	1	--	--			
	Lab Technician	1	--	--			
	Total				11	0.63	0.18 - 1.08

Table IV

MEDICAL FINDINGS OF PARTICIPANTS

Results of Oral & Neurologic Examination

Mallory Battery Company
Lexington, North Carolina
HHE 78-26

	Number (%) of Participants with Positive or "Abnormal" Signs					
	Oxide Plant (N=29) No. (%)	D.P.Room (N=27) No. (%)	Control Group (N=35) No. (%)	Miscellaneous Suspect High-Exp. (N=33) No. (%)	Former Oxide Plant (N=6) No. (%)	Former D.P.Room (N=9) No. (%)
Mouth						
Mercury Line	1* (3)	1 (4)	0 -	0 -	1 (17)	0 -
Inflammation of Gums	1 (3)	3 (11)	0 -	0 -	2 (33)	0 -
Inflammation of Mouth	1 (3)	1 (4)	0 -	0 -	0 -	0 -
Neurologic						
Hyperactive Deep Tendon Reflexes	1 (3)	0 -	0 -	0 -	0 -	0 -
Tremor	6 (21)	5 (19)	3 (9)	6 (18)	1 (17)	0 -
Fasciculation	1 (3)	0 -	0 -	0 -	0 -	0 -
Motor & Coordination	1 (3)	1 (4)	0 -	0 -	0 -	0 -
Muscle Strength	0 -	1 (4)	0 -	0 -	0 -	0 -
Finger-to-nose	0 -	0 -	0 -	0 -	0 -	0 -
Romberg	0 -	1 (4)	0 -	0 -	0 -	0 -
Rapid Alternating Movement (RAM)	0 -	1 (4)	0 -	0 -	0 -	0 -

*Questionable

Table V

MEDICAL FINDINGS OF PARTICIPANTS

Results of Medical Questionnaire

Mallory Battery Company
Lexington, North Carolina
HHE 78-26

Number (%) of Participants Expressing Complaint

	Oxide Plant (N=29) No. (%)	D.P.Room (N=27) No. (%)	Control Group (N=35) No. (%)	Miscellaneous Suspect High-Exp. (N=33) No. (%)	Former Oxide Plant (N=6) No. (%)	Former D.P.Room (N=9) No. (%)
Neuropsychiatric						
Headache	7 (24)	5 (19)	3 (9)	8 (24)	1 (17)	2 (22)
Irritability	16 (55)	11 (41)	7 (20)	16 (48)	3 (50)	2 (22)
Mood Change	7 (24)	9 (33)	5 (14)	7 (21)	1 (17)	1 (11)
Fatigue	16 (55)	8 (30)	11 (31)	14 (42)	3 (50)	2 (22)
Insomnia	8 (26)	6 (21)	6 (17)	13 (39)	3 (50)	4 (44)
Tremor	4 (14)	1 (3)	2 (6)	7 (21)	3 (50)	3 (33)
Poor Memory	5 (17)	5 (19)	1 (3)	8 (24)	0 0	1 (11)
Temper Outbursts	6 (21)	5 (19)	2 (6)	4 (12)	3 (50)	0 (0)
Muscle Twitch	5 (17)	4 (14)	0 (0)	9 (27)	3 (50)	3 (33)
Gastrointestinal						
Loss of Appetite	3 (10)	3 (11)	2 (6)	3 (9)	1 (17)	0 (0)
Weight Loss	5 (17)	2 (7)	1 (3)	1 (3)	1 (17)	0 (0)
Nausea	1 (3)	1 (4)	2 (6)	2 (6)	0 (0)	0 (0)
Vomiting	0 (0)	0 (0)	1 (3)	0 (0)	0 (0)	0 (0)
Diarrhea	0 (0)	3 (11)	1 (3)	2 (6)	0 (0)	0 (0)
Abdominal Cramps	0 (0)	1 (4)	2 (6)	1 (3)	0 (0)	0 (0)
Miscellaneous						
Muscle Weakness	5 (17)	3 (11)	0 (0)	3 (9)	1 (17)	0 (0)
Backache	12 (41)	5 (19)	3 (9)	8 (24)	1 (17)	3 (33)
Muscle Ache/Cramp	4 (14)	4 (14)	4 (11)	3 (9)	3 (50)	0 (0)
Skin Rash	6 (21)	12 (44)	7 (20)	5 (15)	1 (17)	1 (11)
Nosebleeds	0 (0)	2 (7)	3 (9)	3 (9)	0 (0)	0 (0)
Irritated/Sore Mouth	1 (3)	4 (14)	2 (6)	5 (15)	0 (0)	0 (0)
Metallic Taste in Mouth	10(34)	9 (33)	8 (23)	10 (30)	2 (33)	1 (11)
Other*	2 (7)	1 (4)	0 (0)	0 (0)	0 (0)	0 (0)

*1-brown toenails & fingernails; 1-tingling of arms

TABLE VI

Mallory Battery Company
Lexington, North Carolina
HHE 78-26

Reproductive History
of Oxide Plant,
Depolarizer Room and Control Group

	Control	Oxide Plant	Depolarizer Room	Combined D.P. Room & Oxide Plant
Total Pregnancies	(N=35)	(N=29)	(N=27)	(N=56)
Pre-Mallory	33	22	27	49
Post Mallory	23	5	7	12
Live Births				
Pre-Mallory	31	21	25	46
Post Mallory	23	3	5	8
Birth Defects				
Pre-Mallory	0	0	0	0
Post Mallory	2*	0	0	0
Miscarriages				
Pre-Mallory	2 (6%)	1 (4.5%)	2 (7%)	3 (6%)
Post Mallory	0 (0%)	2 (40%)	2 (29%)	4 (33%)
Stillbirths				
Pre-Mallory	0	0	0	0
Post Mallory	0	0	0	0
History Suggestive of Decreased Fertility	1	1**	0	1

*1 with esophageal atresia; 1 with hemiangioma of hand (represents 2 different participants).

**there was also 1 former Oxide Plant employee who had a history suggestive of decreased fertility.

TABLE VII

Comparison of Initial and Follow-Up Sperm Counts of Oxide Plant Participants[1] (millions of cells/ml)

Mallory Battery Company
Lexington, North Carolina
HHE 78-26

FEBRUARY	APRIL
0.6	No Specimen
3.0*	No Specimen
4.0*	60.0
18.0	66.8
38.6	57.2
39.4	No Specimen
40.2*	66.0
43.0	80.0
48.0	41.2
56.8	61.2
56.8	79.2
60.6	29.6
75.6	67.2
81.6	100.2
82.8	80.0
85.2	106.0
86.0	64.8
108.6	66.0
No Specimen	83.0
No Specimen	70.0

*Fever

[1] Including those with fever only but excluding those with additional or other medical conditions which would likely result in a decreased sperm count and those who did not meet exposure-time criteria for Oxide Plant.

TABLE VIII

Comparison of Mean and Median Sperm Counts
of Mallory Participants

Mallory Battery Company
Lexington, North Carolina

HHE 78-26

Category	N	Mean (SEM)* (millions/ml)	Median (millions/ml)
Oxide Plant February	15**	58.8 (7.4)	56.8
(April)	18	68.8 (4.3)	66.4
Depolarizer Room (February)	21	62.28 (5.1)	64.2
Low Exposure (February)	26	60.19 (5.6)	65.0
Misc., probable high exposure (February)	26	58.3 (5.1)	60.8

*Standard error of the mean

**15/29 sperm counts included. The remainder were excluded from statistical analysis for the following reasons: recent transfers from Oxide Plant; no semen specimen submitted; presence of specific medical condition which could likely cause a reduced sperm count;and fever within 3 months prior to testing.

TABLE IX

Sperm Count (millions of cells/ml) of Participants (from all areas of the plant) not included in Statistical Analysis[1]

Mallory Battery Company
Lexington, North Carolina
HHE 78-26

FEBRUARY	APRIL
41.2	15.6
6.0*	NS**
0.2	6.8
40.6	NS
7.6*	NS
70.0	NS
9.2	NS
50.2*	NS
15.8*	NS
37.8	NS
Zero	NS
0.8	NS
1.4	70.0
13.2	NS
18.2	44.4
39.8	60.0
3.0*	NS
4.0*	60.0
40.2*	66.0

High Exposure (Oxide Plant & D.P. Room)	11
Low Exposure ("controls")	4
Misc. Suspect High	3
Former High Exposure	1

[1]Medical reasons for exclusion included history of decreased sperm count prior to starting at Mallory, vasectomy, cryptorchidism, Genito-urinary surge and fever. Included are Oxide Plant employees currently in the area but recently moved either because of a high urine Hg level or decreased sperm count.

*Fever

**No Specimen

TABLE X

Sperm Count Results (millions of cells/ml) of D.P. Room, Miscellaneous, Suspect High Exposure, Controls, and Former D.P. Room & Oxide Plant Employees

Mallory Battery Company
Lexington, North Carolina
HHE 78-26

D.P. Room (N=21)	Miscellaneous Suspect High Exposure (N=26)	Low Exposure "Control" (N=26)	Former D.P. Room Workers and Former Oxide Plant Workers* (N=13)
16.2	1.0	4.4	22.0
18.2	16.0	6.8	22.6
34.4	17.8	16.8	31.4
36.8	24.0	21.0	43.2
40.2	36.6	31.0	45.8
55.6	37.8	35.4	50.2
58.0	40.8	46.0	54.4
59.8	51.8	48.0	57.4
62.2	53.2	48.0	72.6
63.2	55.6	51.8	74.0
64.2	57.0	52.2	83.0
64.8	60.0	55.8	95.2
65.8	60.4	64.8	112.4
67.2	61.2	65.2	
70.8	61.6	66.2	
71.4	62.4	68.8	
82.2	67.8	72.4	
83.8	69.0	74.4	
86.0	70.2	76.8	
102.0	70.4	83.4	
105.0	70.8	86.6	
	75.4	89.8	
	85.8	96.4	
	97.6	96.6	
	102.0	102.8	
	108.8	103.6	
Median 64.2	60.8	65.0	
Mean 62.3	58.3	60.2	
SEM 5.1	5.1	5.6	

*Heterogeneous group, summarization inappropriate.

TABLE XI

Mallory Battery Company
Lexington, North Carolina
HHE 78-26

Sperm Morphology
(mean percentage cell type)
of Mallory Battery Company Participants[1]

	Oval "normal"	Large	Small	Tapering	Amorphic	Bicephalic	Spermatids
Total Mallory Participants (N=119)	75.1	1.5	9.1	3.8	7.2	1.6	4.0
Control (N=26)	71.4	1.3	12.0	3.8	9.4	0.9	1.6
Oxide Plant (N=15)	79.5	1.4	6.5	3.8	6.7	1.9	3.1
D.P. Room (N=21)	83.2	2.2	6.5	2.8	3.6	1.1	1.5

[1]Excluding those persons with a history of recent fever.

Table XII

Mallory Battery Company
Lexington, North Carolina
HHE 78-26

February 13-17, 1978

Range and Distribution of Laboratory Values for All Participants

	Urine Hg* (mg/l)	FSH "Normal" Range (5-25 mIU/ml)	LH "Normal" Range (5-20 mU/ml)	Testosterone "Normal" Range (300-1200 ng/dl)	BUN "Normal" Range (10-25 mg/dl)	Serum Creatinine "Normal" Range (0.7-1.4 mg/dl)	B_2M (ug/gm Crea)
Oxide Plant							
Mean	0.51	7.4	10.2	462	14	1.0	44
SEM	0.05	0.6	1.5	34	0.6	0.02	9
Range	0.17-1.17	2.0-16.0	1.8-37.0	192-900	8-19	0.8-1.3	<5-244
	(N=29)	(N=27)					N=27
Depolarizer Room							
Mean	0.45	7.3	9.4	490	14	1.1	67.4
SEM	0.06	0.6	0.94	35	0.6	0.02	19.0
Range	0.17-1.04	2.7-16.0	1.8-26.0	220-1020	9-20	0.9-1.3	<5-374
	(N=27)	(N=24)					N=24
Controls							
Mean	0.20	5.9	10.2	427	14	1.1	50
SEM	0.03	0.7	1.0	27	0.51	0.02	7
Range	0.01-0.65	3.8-17.0	2.4-25.0	184-800	8-20	0.9-1.4	<5-165
	(N=35)	(N=31)					N=32
Miscellaneous							
Mean	0.4	8.5	11.6	458	14	1.1	51
SEM	0.06	0.7	1.2	27	0.7	0.02	6
Range	0.11-0.96	2.9-17.0	1.0-28	210-800	6-22	0.8-1.3	< 5-180
	(N=33)	(N=28)					N=28
Former oxide plant							
Mean	0.31	8.6	15.6	500	13	1.1	85
SEM	0.12	2.3	5.2	20	0.8	0.1	32
Range	0.03-0.85	2.7-16.0	2.3-34.0	440-560	10-16	0.9-1.3	31-237
	(N=6)						
Former Depolarizer Room							
Mean	0.12	8.8	6.1	449	13	1.0	35
SEM	0.04	1.7	1.3	20	1	0.1	9
Range	0.03-0.35	2.8-19.0	0-13.0	320-520	9-17	0.7-1.2	<5-76
	(N=9)						

*Corrected to specific gravity 1.024

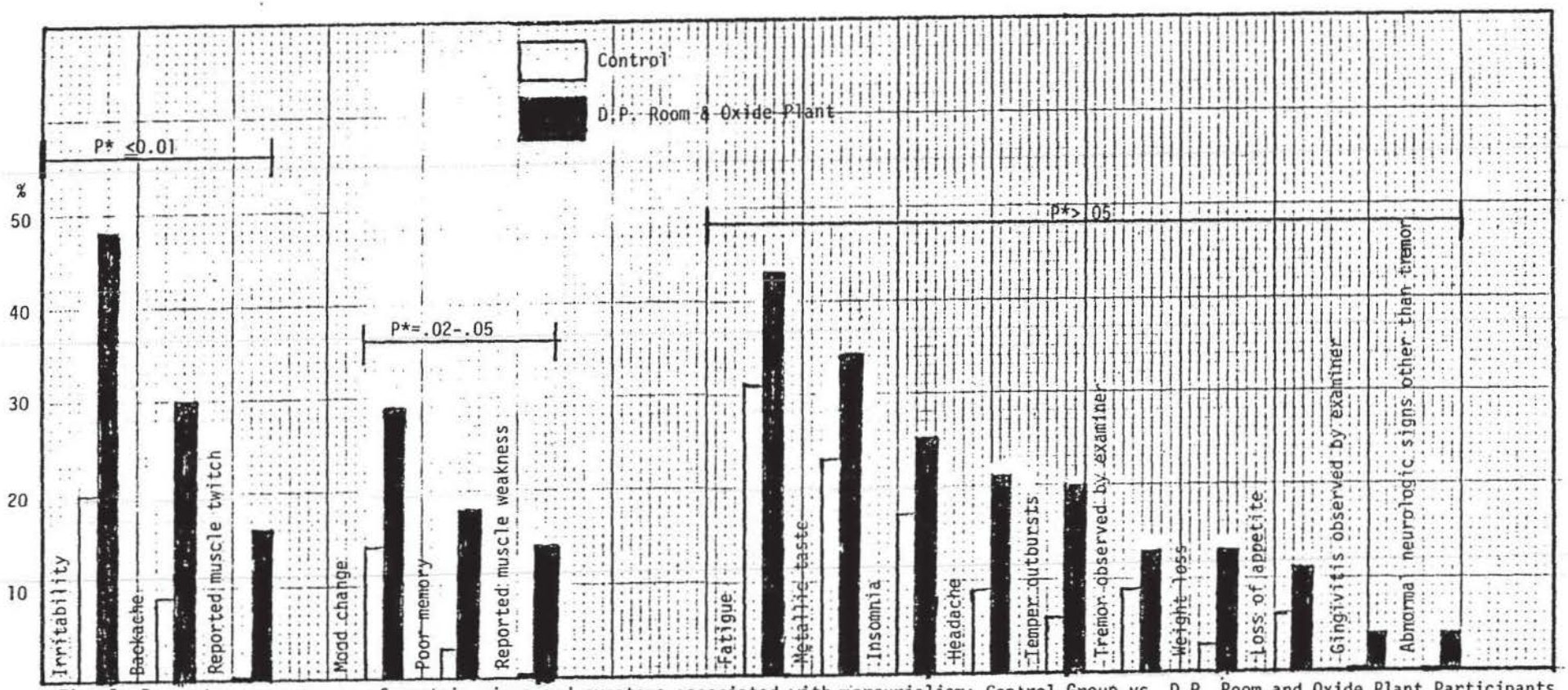

Fig 1. Percentage occurrence of certain signs and symptoms associated with mercurialism: Control Group vs. D.P. Room and Oxide Plant Participants

(*Fisher's Exact Test or Chi-Square)