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 NO. 76-49-312

JAY INSTRUMENTS AND SPECIALTY COMPANY
CINCINNATI, OHIO

JULY 1976

I. TOXICITY DETERMINATION

It has been determined that employees in the Thermometer Manufacturing Area of Jay Instruments and Specialty Company were exposed to toxic concentrations of inorganic mercury.

This determination is based on an environmental/medical evaluation conducted on April 9, 1976, urine samples collected on April 11-12 and April 28-29, and an environmental evaluation conducted on May 19, 1976.

It should be noted that environmental conditions have changed considerably as a result of recommendations instituted after the initial survey had been completed.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. Copies have been sent to:

a) Jay Instruments and Specialty Company, Cincinnati, Ohio
b) Authorized Representative of Employees
c) U. S. Department of Labor - Region V
d) NIOSH - Region V

For the purpose of informing the approximately nine "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 received such a request from an employer representative regarding employees' exposure to mercury. The request was initiated when the periodic urine analysis resulted in high mercury levels in some of the employees, indicating systemic absorption of mercury. The employer requested that NIOSH determine the source of mercury contamination and provide guidance as to how to correct the problem.

IV. HEALTH HAZARD EVALUATION

A. Plant Process - Conditions of Use

Jay Instruments and Specialty Company is primarily engaged in sales; however, it does manufacture industrial thermometers on a small scale. This operation is conducted in one large room. The room was arbitrarily sectioned off into the fabrication, assembly, and shipping and receiving areas.

In the Fabrication Area three employees identified as "glass blowers" fabricate the thermometers; this includes cutting the glass, fire polishing the rod, forming the bubble chamber, filling the thermometer with mercury, calibrating them and reworking any that have to be reworked. Since the fabrication is on a small scale, each of the glass blowers may conduct any one of the operations, depending on the need at the time.

Upon receipt of a shipment of mercury it is stored in wooden cabinets as received (10 pounds of mercury in each polyethylene bottle). Mercury is then prepared for use as needed; it is first poured into an "oxifier", filtered and then used to fill the thermometers in a vacuum chamber. Two hot oil baths and one hot water bath are used to drive excess mercury from the thermometers and to calibrate them. Dry ice and alcohol (in small containers) also are used for calibration of the thermometers. Gas fired Bunsen burners are used to provide the heat for the glass work.

During the initial survey, local exhaust was not available for any of the above mentioned operations nor was there any personal protective equipment available.

Mercury droplets were visible throughout the fabrication area, storage cabinets and even in the assembly area. In addition, several poor work practices were observed; theseincluded the practice of brushing off excess mercury from open end thermometers into the oil baths; the practice of storing mercury contaminated trash in containers without any provisions for control of mercury vapors, and the practice of sweeping mercury.

It should be noted that since the time of the initial survey, environmental working conditions have improved because of engineering controls installed, protective equipment provided and improved work practices instituted These improvements were a result of the recommendations made after the initial survey.

In the Assembly Area, two employees assembled the various components to produce specifically requested industrial thermometers.

Exposure to mercury in this area was through both inhalation of and contact with mercury from thermometers broken during assembly. No local exhaust was present at this work bench and mercury droplets were visible on the bench. Also, both of the assemblers were smoking on the job.

There was one employee in the Shipping and Receiving Area. His job consisted of simply packaging the product for shipment and unpacking and storing materials needed to produce the thermometers.

In addition to those employees already mentioned, there was a foreman who also did some work in the fabrication area, a supervisor, and one additional employee who worked in a small dark room contained within this room.

B. Evaluation Progress

An initial environmental/medical evaluation was conducted on April 9, 1976. This consisted of meeting with the requestor and explaining our proposed evaluation method and the rules and regulations governing the Health Hazard Evaluation Program. The environmental portion of the evaluation consisted of using a J-W Lamaire Mercury Vapor "sniffer" to measure mercury vapor concentration, observing work practices, evaluating general housekeeping and cleanup practices, and obtaining a complete process description. The medical portion of the evaluation consisted of interviewing and examining all employees in the work area. Biological samples were collected on April 12, 1976 and on April 29, 1976. An additional environmental evaluation was conducted on May 19, 1976.

C. Evaluation Method

1. Environmental

A Mercury Vapor "sniffer" was used during both environmental evaluations. The "sniffer" served to detect Mercury Vapor sources and to compare concentrations measured during the first environmental evaluation with those measured during the second environmental evaluation.

2. Medical

The nine employees in the thermometer fabrication and assembly areas were interviewed and examined. Questions focused on past occupational history, eating, smoking, and changing clothes at work, a past medical history, and a series of questions about the development of any symptoms or signs suggestive of mercury intoxication. A physical examination with emphasis on

neurological evaluation, was performed. This consisted of observation for any tremor in the upper or lower extremities, deep tendon reflexes, finger-to-nose test, rapid alternating movement, Romberg test, gait disturbances, heel-to-toe gait walking, and a specimen of each individual's handwriting. Gums were examined for gingivitis and mercury lines.

A "spot" urine sample for mercury was collected prior to the collection of a timed sample. A 24-hour urine collection for mercury and creatinine excretion and a simultaneous blood sample for serum creatinine determination were obtained. Creatinine clearance was carried out to evaluate glomerular filtration rate.

Eleven (11) "spot" urine collections were obtained from members of the households of the employees. Three households did not participate. Urine specimens were collected from 12 office workers who served as controls since they have no known present or past occupational exposure to mercury other than occasionally walking through the thermometer department. None of the controls ever worked in the thermometer department. All past urine mercury determinations done by the Kettering Laboratory, University of Cincinnati were reviewed by the NIOSH medical investigator.

D. Evaluation Criteria

a. Environmental Standard

The primary sources of environmental criteria considered are (1) an article entitled "Effects of Exposure to Mercury in the Manufacturing of Chlorine" by R.G. Smith, et. al. which appeared in the November-December issue of the American Industrial Hygiene Association Journal, Vol. 31, pages 687-700, 1970; (2) the NIOSH Criteria Document for a recommended standard...Occupational Exposure to Inorganic Mercury and; (3) Federal Occupational Health Standards Promulgated by the U.S. Department of Labor (CFR Part 1910.1000).

The NIOSH recommended standard for occupational exposure to mercury is 0.05 milligrams of mercury per cubic meter of air determined as a time-weighted average (TWA) exposure for an 8-hour work day. The Federal Standard for occupational exposure to mercury is a ceiling value of 1 mg of mercury per 10 cubic meters of air (0.1 mg/m3). The data presented by Smith shows "no significant signs or symptoms in persons exposed to mercury vapor at or below level of 0.1 mg/M^3. However, the data do raise a question regarding the adequacy of the safety factor provided by a TLV of this magnitude."

b. Medical

Brief Description of Known Pathophysiologic Effects of Suspected Agents:[1,2]
The classical symptoms of chronic intoxication of mercury (mercurialism) consists of excessive salivation and gingivitis, a metallic taste in the mouth, erethism, and a tremor of the upper and/or lower extremity. Erethism is a syndrome that consists of the following symptoms: nervousness, irritability, hyperexcitability and easy loss of temper. However, mercurialism has been associated with other signs and/or symptoms which include:

depression, headache, fatigue, insomnia, impaired memory, anorexia, weight loss, loose teeth, bleeding gums, sore throat, black line on gums (mercury line), various gastrointestinal disturbances, dermatitis, stomatitis, tingling sensation of the tongue, "shaky" legs, intention tremor of lips, hands or feet, loss of muscle strength in arms and legs, disturbances of gait, and nephrotic syndrome with edema, proteinuria and casts in the urinary sediment.

The kidney accumulates the highest concentrations of mercury compared to the other organs. The principal routes of excretion of mercury are through the urine and feces, with the bulk of the excretion in the urine. However, the rate of excretion of mercury fluctuates considerably, independently of exposure, resulting in wide day-to-day and diurnal variations. The complexities of renal excretory mechanisms for mercury lend support to the observed difficulties in relating urine mercury levels of exposure, absorption, and the imminence of toxic accumulations in the critical organs. Such difficulties are evident in the case of "spot" urine samples as opposed to 24-hour samples. These discrepancies could be one explanation for the reason for the high urine mercury levels in workers who show no signs or symptoms of illness from mercury while low levels may be found in some workers with symptoms.

There is no consistent correlation between urinary excretion of mercury and duration of exposure for individuals. The normal range of mercury content in the urine for non-occupationally exposed persons ranges from 1 to 15 ug/l. A suggested guide for interpretation of mercury levels[5] is presented below:

SUGGESTED INTERPRETATION OF INDIVIDUAL URINE MERCURY LEVELS

Guide for Workers Exposed to Inorganic Mercury	Level of Mercury in Urine Micrograms/Liter
Normal Limits	Less than 30
Increased Absorption	above 50
Warning	above 100
Hazardous Level - remove from further exposure	above 200
Symptoms of Mercury Poisoning may occur	above 300

Adapted from Medical Supervision for Employees in Mercury Mines and Mills.[4]

It should be recalled that urinary mercury determinations are not a substitute for a thorough medical history and physical examination. These determinations should be repeated so that a trend may be established for that individual. An individual who shows over 200 ug Hg/L on two successive tests should be removed from further exposure until the level has fallen below 50 ug Hg/L.[4]

In general there is a good correlation between environmental levels of mercury and the levels of urinary excretion of mercury on a group basis. The average urinary mercury excretion for a group of workers is a reliable indicator of the environmental hazard. Group average levels above 50 ug Hg/L of urine should arouse suspicion and levels above 100 ug Hg/L call for correction of the faulty work situation.[4]

E. Evaluation Results and Discussions

1. Environmental

As described earlier, the request had been submitted so that NIOSH could assist in determining the reason for the high urine mercury levels and to provide guidance in correcting the problem. The reasons for the high urinary mercury levels became evident immediately.

Jay Instruments and Specialty Company had purchased the entire operation but apparently had never received any instruction or education on the hazards associated with mercury or safe handling procedures.

There was absolutely no local exhaust available; mercury droplets were visible on every workbench and on the floor; no personal protective clothing or equipment was available; mercury was commonly swept from the bench tops; excess mercury from open end thermometers was brushed into the oil baths; mercury contaminated glass and trash was stored without any controls for mercury vapors; a vacuum pump for the chamber used to fill the glass rods with mercury exhausted into the room. Smoking was permitted in the work area, and until a few months prior to the initial survey, eating was permitted in the work area. Work clothes were worn home and often worn for a considerable amount of time before showering. In brief, mercury was handled without any engineering controls and with poor industrial hygiene work practice. This is evident from the "sniffer" reading during the initial survey; the lowest concentration measured was 0.1 mg of mercury/cubic meter of air (see Table I).

It should be emphasized that working conditions were as described above apparently becuase of lack of knowledge (on both management's and labor's part) and not becuase of delibera te neglect.

Since the initial survey several engineering controls have been installed, personal protective clothing and equipment have been made available, and industrial hygiene work practices have been instituted. These changes were the result of recommendations made upon completion of the initial survey, and the follow-up. Arrangements to comply with the recommendations made during each survey were made immediately; these recommendations included:

1. Install a local exhaust hood to partially enclose the Oxifier, vacuum chamber top, and filtering operation. This would also serve to provide local exhaust during the transfer of mercury.

2. Provide a canopy type hood (with mechanical exhaust) for the oil and water bath; b) refrain from brushing excess mercury off into the baths.

3. Provide local exhaust ventilation at the glass blowers' work stations.

4. Provide a make-up air source for the exhaust fan located on the north-west corner of the building.

5. Submerge mercury contaminated (waste) glass in water.

6. Vacuum mercury spills and droplets instead of sweeping them. The vacuum system should be one that contains a trap for the mercury and should not exhaust mercury vapor into the work environment.

7. Clean troughs along work bench; these are presently a source of mercury vapor and are located directly beneath the glass blowers' respective breathing zone.

8. Provide respirator cartridges approved for mercury vapor; those presently used are not approved for mercury vapor. The respirators should be used during mercury transfer even with the other recommendations in effect.

9. Provide clean protective clothing daily and when contaminated with mercury.

10. Provide appropriate protective shoe covers.

11. Institute an educational program which stresses proper work practices, health hazard of working with mercury, and personal hygiene practices; hand washing should be manditory before breaks, lunch and when leaving the building. The practice of no eating in the work area should be continued; a no smoking policy in this room should be instituted at this time.

During the follow-up it was recommended that a thorough clean-up be undertaken immediately and a regular clean-up policy be instituted thereafter. Arrangement to curtail operation the day of the follow-up were made immediately and the clean-up program instituted.

Mercury vapor concentrations measured during the follow-up survey, with the sniffer, are presented in Table I.

2. Medical

Employee Profile - There were nine persons, four women and five men, working in this area. The average employee age is 32 years (range, 17 to 56 years for all, 17 to 25 for women, and 19 to 56 for men) and the average length of employment in thermometer fabrication department is 24 months (range, 1 to 72 months). Two persons reported prior employment ranging in duration from 10 to 36 years at another thermometer manufacturing company. Thus the duration of exposure to inorganic mercury ranged from 1 month to 36 years for this population.

All employees interviewed reported that, until several months prior to this investigation, employees were permitted to eat and store food in the thermometer department. They also reported that they are permitted to smoke in the area. Also, they said they changed their work clothes and showered at home <u>after</u> work. Two persons reported prior occupational exposure to

mercury. No person reported using mercury at home in a hobby or other work. All persons reported washing before eating at work. A review of signs and symptoms revealed that 5 persons out of 9 reported the following:

Subject A reported diarrhea, tremor, fatigue, irritability, and an unsteady gait;

Subject B reported a history of anorexia, nausea, irritability, insomnia, and paresthesia - physical examination was within normal limits;

Subject C reported a history of irritability, headache, and fatigue - physical examination was within normal limits;

Subject D reported irritability - physical examination revealed the questionable presence of an intention tremor;

Subject G reported a three-month history of irritability and nervousness - physical examination was within normal limits. The remaining four persons were assymptomatic with normal physical examinations.

Table II summarizes the results of all urine mercury determinations carried out by the University of Cincinnati and NIOSH. While there is great variation in these results, several observations can be made. It is apparent that employees in the thermometer fabrication and assembly areas have increased systemic absorption of inorganic mercury. In addition, the NIOSH data show that "spot" urines mercury determinations generally correlate well with 24-hour results.

The NIOSH data revealed three persons with elevated urine mercury levels. Two were in the hazardous range. For the group as a whole, the mean "spot" urine mercury level was 107 ug/L with a range from 44 to 283 ug/L. The mean 24-hour mercury excretion was 134 ug/L with a range from 12 to 397 ug/L, reflecting total daily excretion of mercury. As can be seen from Table III, the control group and the family member did not differ significantly from each other ($p>0.01$, however, both groups were significantly lower than the exposed group ($p<0.01$). It would therefore seem that family members have not experienced increased absorption of mercury as a result of household contamination by work clothes, shoes, etc. A comparison of urine mercury determinations for symptomatic and assymptomatic workers revealed a statistically significant difference ($p<0.01$). All creatinine clearances save one were either within normal limits or greater than the upper limit of normal. Subject E had a slightly low creatinine clearance. There was no statistically significant difference between mean creatinine clearance for symptomatic versus assymptomatic workers.

Conclusions: Based on mercury vapor concentrations measured, lack of engineering controls, personal protective equipment, work practices observed, medical questionnaires, physical examinations, and multiple urine mercury determinations, it is concluded that employees in the thermometer fabrication and assembly areas were exposed to toxic concentrations of inorganic mercury resulting in systemic absorption of mercury. Furthermore, the urine mercury levels for symptomatic workers was significantly higher than the urine levels for assymptomatic workers. This

finding strongly suggests that unacceptable systemic absorption of mercury may be the cause of these symptoms. Renal function, as measured by creatinine clearance, was within normal limits except for one person. There was no significant difference in creatinine clearance between symptomatic and assymptomatic workers.

Essentially all of the recommendations have already been complied with; therefore, only those not already mentioned are listed here:

1. All persons with a history of symptoms suggestive of mercurialism should be removed from the area until symptomatically improved. In addition, all persons with urine mercury determination above 200 ug Hg/L on two successive occasions should be removed from the work area until the urine mercury level is below 50 ug Hg/L.

2. Urine mercury determinations should be done every other month for as long as the average urine mercury level for all workers in the thermometer department is less than 100 ug/L. Also all new employees should receive a pre-employment history, physical examination, and a urine mercury determination by a competent laboratory.

3. Periodic determination of environmental mercury levels is suggested.

4. There are some data that describe abnormal reproductive or developmental changes in animals associated with mercury exposure. As a precautionary measure, any exposure to mercury should be minimized in women of reproductive age.

V. REFERENCES

1. Patty, FA, ed., Industrial Hygiene and Toxicology, Vol. II. Chapter 26, The Metals (Excluding Lead), pp 1090-1104. New York: Interscience Publishers, 1963.

2. Criteria for a Recommended Standard . . . Occupational Exposure to Inorganic Mercury, NIOSH, 1973.

3. R.G. Smith, Ph.D., A.J. Vowald, M.D., L.S. Patil, M.D., and T.F. Mooney, Jr., Ph.D.: Effects of Exposure to Mercury in the Manufacturing of Chlorine, American Industrial Hygiene Association Journal, Vol. 31, pp. 68-700, 1970.

4. Medical Supervision for Employees in Mercury Mines and Mills. Technical Bulletin for Physicians, August 1967. Bureau of Occupational Health, State of California, Department of Public Health, 2151 Berkeley Way, Berkeley, California 94704.

5. Dividsohn, I. and Henry, J.B., Eds., Todd-Sanford Clinical Diagnosis By Laboratory Methods, Chapter 3, pp 84-100. Philadelphia: W.B. Sanders Co., 1974.

6. Federal Register, June 27, 1974, Vol. 39, No. 125, Title 29, Chapter XVIII, 1910 Subpart G, Table G3.

VI. AUTHORSHIP

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TABLE I

MERCURY VAPOR CONCENTRATIONS MEASURED WITH A
J-W LAMAIRE MERCURY VAPOR "SNIFFER"

JAY INSTRUMENTS AND SPECIALTY COMPANY
CINCINNATI, OHIO

April 9, 1976

	mg/M^3
Glass Blowers' Breathing Zones	0.12 = 0.16
Trash Box (Broken Thermometers)	0.2 - 0.3
Metal Container (Storage of Glass Bulbs Containing Mercury)	0.2 - 0.3
Trough Along Glass Blowers' Work Bench	0.3 - 0.4
Above Oil and Water Bath	0.2 - 0.4
Chamber for Filling Thermometers with Hg (removed lid)	>1.
Glass Blowers' Clothing	0.3
Workers' Shoes	0.6 - 0.8

May 19, 1976

Assembler's Breathing Zone	0.01 - 0.02
Glass Blower's Breathing Zone (#2)	0.02 - 0.03
Glass Blower's Breathing Zone (#2)	0.02 - 0.04
Glass Blower's Breathing Zone (#1)	0.03 - 0.09
Glass Blower's Breathing Zone (#1)	0.02 - 0.04
Near Oxifier	0.03 - 0.04
Near Baths	0.05
Smock (#1) - Glass Blower	0.02 - 0.04
Assemblers Smock	0.01
Supervisors Office	0.01
Glass Blower's Shoes (#1)	0.05
Stockroom - Vapor Dials	<0.01

TABLE II

URINE MERCURY DETERMINATION AND CREATININE CLEARANCE
JAY INSTRUMENT
Cincinnati, Ohio

Urine Mercury Determinations (ug/L)

Kettering Laboratory, University of Cincinnati

Employee & Date of Hire													Urinary Creatinine Clearance (cc/min)*
A[m]	6-10-70	240(3-74)	34(4-74)	53(11-74)	48(3-75)	53(09-75	36(1-76)	57(3-76)			62[a]	12[b]	171
B[m]	8-06-73	106(6-74)	77(7-74)	78(12-74)	94(6-75)	30(12-75)		210(3-76)			151[a]	173[b]	211
C	6-22-73	107(6-74)	104(7-74)	94(12-74)	26(6-75)	138(12-75)					38[a]	76[b]	188
D[m]	5-15-74		173(11-74)	190(12-74)	280(6-75)	84(07-75)	120(1-76)		750(2-76)	43(3-76)	223[a]	355[b]	169
E	8-05-75					20(04-75)	430(1-76)	310(1-76)	750(2-76)	43(3-76)	62[a]	34[b]	78
F[m]	5-05-75					29(12-75)					44[a]	52[b]	202
G	12-16-75							400(3-76)			283[a]	397[b]	95
H	3-03-76										45[a]	46[b]	156
I[m]	1-03-76										58[a]	62[b]	129

m = male

a - Spot sample collected 4-11-76 by NIOSH
b - 24 hour sample collected 4-19-76 by NIOSH

*Normal Ranges

Men - 107 to 139 cc/min
Women - 87 to 107 cc/min

TABLE III

SUMMARY OF URINE MERCURY DETERMINATIONS DONE BY NIOSH

JAY INSTRUMENTS AND SPECIALTY COMPANY
CINCINNATI, OHIO

APRIL 1976

Group	N	Mean	SD	Range
Thermometer - Spot	9	107	90.4	44 - 283
- 24-Hour	9	134	144.7	12 - 394
Family Members	11	6.5	1.3	6 - 10
Control	12	6.8	2.6	6 - 15
Symptomatic Workers - Spot	5	151	104	38 - 283
- 24-Hour	5	202	169	12 - 397
Assymptomatic Workers - Spot	4	52	9	44 - 62
- 24-Hour	4	48	11	34 - 62