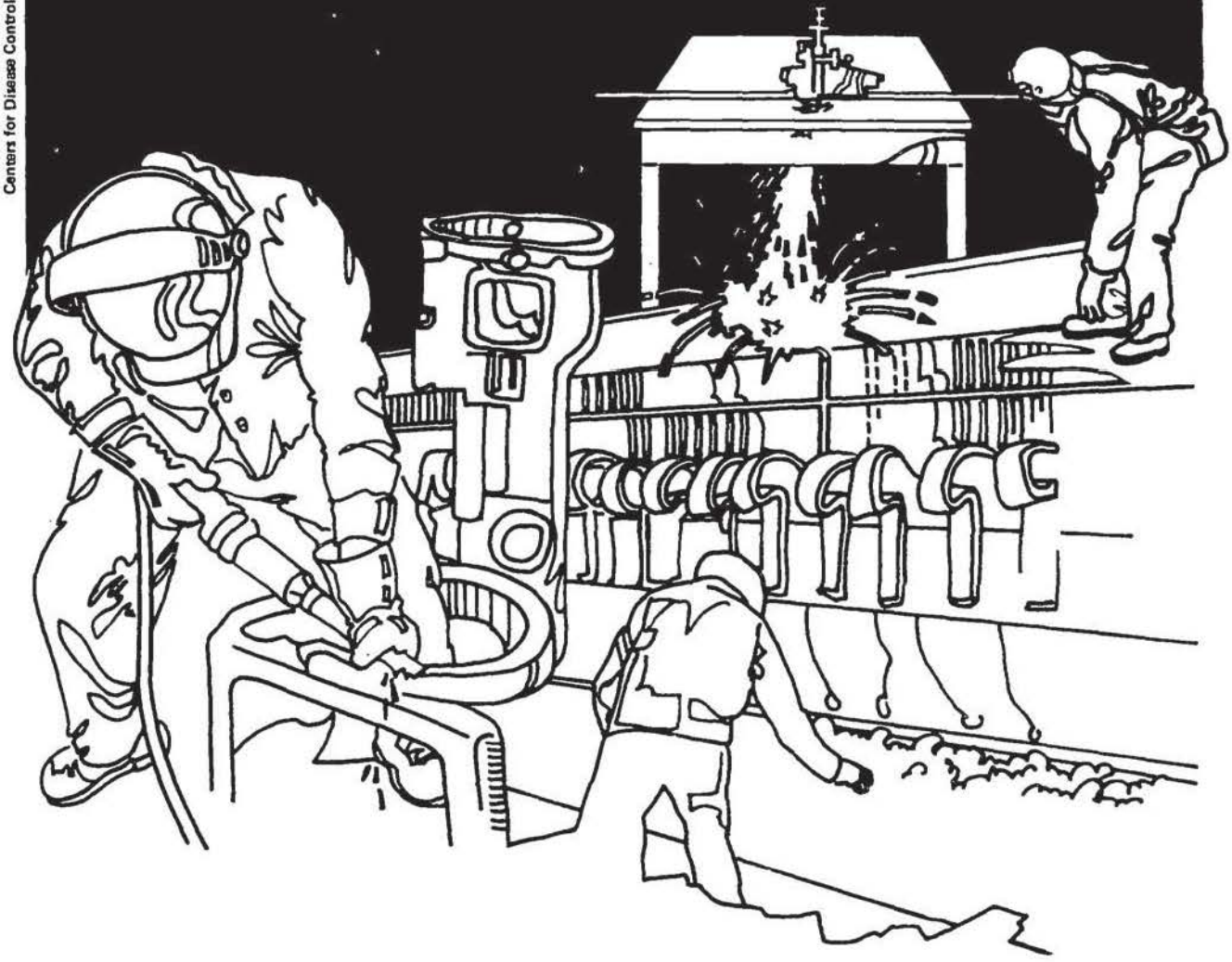
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health

NIOSH



Health Hazard Evaluation Report

HETA 83-338-1399
PALMER INSTRUMENTS, INCORPORATED
CINCINNATI, OHIO

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from 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 Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial nygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 83-338-1399
JANUARY 1984
PALMER INSTRUMENTS, INCORPORATED
CINCINNATI, OHIO

NIOSH INVESTIGATOR:
Steven A. Lee, M.S., C.I.H.

I. SUMMARY

In July 1983, the National Institute for Occupational Safety and Health (NIOSH), received a request to evaluate mercury vapor exposure among thermometer manufacturing workers at Palmer Instruments, Incorporated, Cincinnati, Ohio. At the time of the study, up to eight workers were potentially exposed to mercury vapor at this facility.

On August 16, 1983, NIOSH conducted industrial hygiene sampling at the plant. Personal breathing-zone air samples for mercury vapor were collected on 3M Mercury Vapor Monitors®. Also, results of the company's urine mercury monitoring program were evaluated by NIOSH.

Exposure to mercury vapor among the eight workers sampled by NIOSH ranged from 24 to 210 ug/m^3 with a mean of 60 ug/m^3. Three workers, all located in the Tube Room/Pump Room Area, were exposed to mercury vapor exceeding the NIOSH recommended limit of 50 ug/m^3, as an 8-hour average exposure. The OSHA permissable exposure limit for mercury vapor is 100 ug/m^3, as a ceiling concentration. Three weeks before the NIOSH visit, six of the eight mercury workers had urine samples analyzed for mercury. Urine mercury levels ranged from 10 to 250 ug/liter with a mean of 100 ug/liter. NIOSH recommends that any person with a urine mercury level greater than 200 ug/liter should be removed from exposure until the urine mercury level is below 50 ug/liter.

Based on the results of this evaluation, NIOSH concludes that a hazard due to overexposure to mercury vapor existed at the time of the NIOSH investigation. Recommendations for controlling this hazard by improved housekeeping, engineering controls, and personal protective equipment are presented in Section VII of this report.

KEYWORDS: SIC 3829 (Measuring Devices Manufacturing) inorganic mercury, mercury vapor, thermometer manufacturing.

II. INTRODUCTION

In July 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request from the management of Palmer Instruments, Incorporated, Cincinnati, Ohio, to evaluate worker exposure to mercury vapor during the manufacturing of thermometers.

On August 16, 1983, NIOSH conducted an industrial hygiene survey and submitted recommendations stressing the need for improved housekeeping and engineering controls to reduce mercury exposure.

III. BACKGROUND

Palmer Instruments employs about 20 workers to manufacture thermometers for industrial and household use. Most of the mercury is handled in the Pump Room/Tube Room Area. In the Pump Room, mercury is mechanically added to dial thermometers, which are then pressurized and crimped. The mercury above the crimp is "burned off" (vaporized by heating) inside an exhaust hood and the thermometer is welded shut before being calibrated.

In the Tube Room, the glass rods are cut and fire-polished. Then the bubble chamber is formed and filled with mercury. These thermometers are left open while being calibrated in water or oil temperature baths. Excess mercury is spilled over into the bath or "burned off" in an exhaust hood.

Up to eight workers are potentially exposed to mercury vapor.

IV. METHODS

NIOSH collected eight personal breathing-zone samples for mercury vapor on August 16, 1983. The samples were collected on 3M No. 3600 Mercury Vapor Monitors®. This method uses the principle of diffusion to collect mercury vapor on a gold collection surface. Analysis consists of measuring the conductivity changes caused by the presence of mercury on the gold collector.

Direct-reading measurements were taken with a Bacharach Mercury Vapor Sniffer®. This instrument was used to identify mercury vapor sources and to instantaneously measure mercury vapor in general work areas.

The local exhaust ventilation systems were evaluated by using a Sierra Thermoanemometer Model 440 for measuring face and capture velocities, and by using smoke-generating tubes for delineating air flow patterns.

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

INORGANIC MERCURY

A. Toxicological

Mercury can enter the body through the lungs by inhalation, through the skin by direct contact, or through the digestive system.[1]

Acute or short-term exposure to high concentrations of mercury causes tightness and pain in the chest, difficulty in breathing, coughing, inflammation of the mouth and gums, headaches, and fever.[1,2] Acute mercury poisoning is, however, relatively rare in industry today.

Chronic or long-term exposure to lower concentrations of mercury is more common. Chronic mercury poisoning is known to cause kidney damage (nephrosis), tremors and shaking (usually of the hands), inflammation of the mouth and gums, metallic taste, increase in saliva, weakness, fatigue, insomnia, allergic skin rash, loss of appetite and weight, and impaired memory. These symptoms generally occur gradually and may be associated with personality changes such as irritability, temper outbursts, excitability, shyness, and indecision.[1,2]

NIOSH currently recommends that exposure to inorganic mercury be limited to 50 micrograms per cubic meter (ug/m^3) as an 8-hour time-weighted average (TWA).[3] The American Conference of Governmental Industrial Hygienists (ACGIH) also recommends that inorganic mercury exposure be limited to 50 ug/m^3 as an 8-hour TWA.[4] The current Occupational Safety and Health Administration (OSHA) standard for inorganic mercury is a ceiling level of 100 ug/m^3.[5]

Mercury does not remain in the body indefinitely; it is gradually excreted over a period of time. Most of the mercury is excreted in the urine, with smaller amounts eliminated in feces, sweat, and saliva. Biological monitoring for mercury exposure is generally done by urinalysis. The amount of mercury that is excreted in the urine can vary unpredictably from day to day, and even from hour to hour. While this variability makes interpretation of urine levels difficult, it is still the best available measure of mercury absorption.

Several special collection procedures should be used in order to make urine mercury levels as meaningful as possible. First, a full 24-hour collection of urine is desirable; this helps to avoid some of the variability that may be seen in "spot" samples that are collected at only one time in the day. Second, repeated measurements of urine mercury levels over a period of time will more accurately depict trends in an employee's mercury excretion. Third, averaging the urine mercury levels from several employees working in the same area doing similiar

jobs will achieve a more accurate assessment of mercury absorption. The best available procedure is to collect 24-hour urines from all workers in the area, and then to average the results for the entire group.

A guide to interpreting urine mercury levels is as follows.[6]

	Mercury Levels in Urine micrograms/liter
Normal	less than 30
Increased absorption	above 50
Warning	above 100
Hazardous level	above 200
Symptoms likely of mercury poisoning	above 300

A normal person who does not work with mercury should have a urine mercury level below 15 ug/l (or 0.015 milligrams/liter). Workers should be removed from exposure at the "Hazardous Level" (above 0.200 milligrams/liter). Because of the variability in urine mercury excretion, it is wise to verify the high level with a repeated 24-hour urine collection before transferring a worker for a prolonged period of time. Ideally, a worker who is transferred to a low-exposure area should not return to the mercury-exposed workplace until his urine mercury level is below 0.050 milligrams/liter to allow an adequate margin of safety when he returns to a mercury exposure area.

VI. RESULTS

Exposure to mercury vapor among the eight workers sampled by NIOSH ranged from 24 to 210 ug/m^3 with a mean of 60 ug/m^3 (Table). The mean mercury vapor exposure among the four employees in the Pump Room/Tube Room Area was 92 ug/m^3. Exposure to mercury among workers in other areas averaged 29 ug/m^3.

Direct-reading mercury vapor measurements in the Pump Room/Tube Room Area ranged from 20 to 40 ug/m^3 throughout the day except for short periods (< one minute) during "burn-off", at which time mercury levels reached 150 ug/m^3 in the Tube Room and 100 ug/m^3 in the Pump Room.

Palmer Institute conducted mercury monitoring, also using 3M passive monitors, from September 1980 through December 1982. Eleven workers were exposed to mercury vapor at concentrations ranging from 20 to 400 ug/m^3 with a mean of 120 ug/m^3. The company has monitored mercury levels in the urine of employees every six months for the last 10 years. These samples are analysed by Kettering Laboratory, Cincinnati, Ohio, in accordance with NIOSH Method P&CAM 165. The last set of urine samples was collected on July 25, 1983 (Table). Urine mercury levels ranged from 10 to 250 ug/liter with a mean of 100 ug/liter.

There are three exhaust hoods in the Pump Room with face velocities of 1100, 600, and 500 feet per minute (fpm). During the NIOSH visit, mercury was "burned off" in the hood exhausting 600 fpm.

In the Tube Room each of the oil and water baths were exhausted by semi-circular hoods with three or four slots each located at the top of the bath. The face velocities of the hoods were fairly high, ranging from 1000 to 1800 fpm. However, the tops of the thermometers usually extend well above the exhaust hoods when the thermometers are placed in the baths, thus, the ventilation systems can not effectively control mercury vapor. It was noted that potential capture velocities ranging from 100 to 200 fpm could be achieved if the exhaust hoods were moved to the same height as the top of the thermometers. A capture velocity of 200 fpm would be sufficient to control mercury vapors.

The "burn-off" exhaust hood had a capture velocity of 100 fpm, however, there was a slot on each side of the hood to make it easier to insert the thermometer into the hood. Interfering air movements could easily disrupt this system. There were portable fans being used in this area during the NIOSH survey.

Small droplets of mercury metal contamination were visible throughout the Pump Room/Tube Room Area.

VII. CONCLUSION/RECOMMENDATIONS

Potentially hazardous exposure to mercury vapor existed during the NIOSH survey, particularly among workers located in the Tube Room/Pump Room Area. The following recommendations are directed at reducing mercury vapor exposures as low as possible.

Housekeeping

Spills or droplets of mercury must be immediately cleaned up with a vacuum system equipped with a mercury-absorbent exhaust filter. All operations involving mercury should be performed over impervious surfaces free of crevices. The floor, some walls, exhaust hoods, and other surfaces in mercury work areas should be painted or coated with hard, low-porosity materials. Trash containers which may contain any waste contaminated with mercury should be constructed of non-porous materials and should have lids. These containers should be emptied and washed daily.

Engineering Controls

The Pump Room/Tube Room Area should be enclosed and isolated as much as possible from the rest of the plant to help reduce the number of workers exposed to mercury. The room air should be kept at a negative pressure relative to the rest of the plant. Doors should be kept closed and traffic to and from areas should be minimized.

Most of the local exhaust ventilation that was operating during the NIOSH visit was inadequate for controlling mercury vapors. In most cases the point of mercury vapor liberation was simply outside the effective capture range of the exhaust hood. These systems should be repositioned, better enclosed, or otherwise modified until a minimum capture velocity of 200 feet per minute is achieved and maintained.

The Pump Room/Tube Room Area should be air-conditioned for the following three reasons: (1) The volatility of mercury metal can be greatly reduced by reducing its temperature. For instance, mercury work areas reached a temperature of about 97°F during the NIOSH visit. If this were lowered to 80°F, the vapor pressure of mercury and its consequent potential for vapor generation would be cut in half. (2) Conditioned air would eliminate the use of portable fans currently used for employee comfort. These fans cause cross drafts and turbulence which interfere with the efficiency of local exhaust ventilation. (3) The more comfortable work environment will improve the acceptance and use of personal protective equipment.

Personal Protective Equipment

Pump Room/Tube Room workers should be provided daily with clean protective clothing. Disposable gloves, aprons, and shoe covers should be used and should not be worn outside the area.

Respirators should not be used in place of engineering controls. When respirators are used, a formal respiratory protection program comprised of written standard operating procedures must be established in accordance with Occupational Safety and Health Standards, 29 CFR 1910.134. The procedures should include specific requirements for respirator use, selection, cleaning, inspection, maintenance, training, and supervision.

Monitoring/Education

Full-shift personal breathing-zone mercury vapor levels should be periodically monitored. Mercury vapor exposures should also be measured after any changes in the work environment which may affect airborne mercury concentrations.

Periodic monitoring of workers for urine mercury levels should be continued. When the Tube Room/Pump Room Area is properly enclosed, exposure to mercury among workers located outside the area should decrease. Nevertheless, urinalysis should be continued until at least two consecutive monitoring periods show no evidence of excessive mercury absorption.

Any person with a urine mercury level greater than 200 ug/liter (repeated once to confirm the high level) should be removed from exposure until the urine mercury level is below 50 ug/liter.

New employees should receive a pre-employment history, physical examination, and urine mercury analysis. Workers should receive thorough training on the health hazards of mercury, as well as the work practices and personal hygiene measures necessary to avoid these hazards. This training is extremely important for new employees in order to prevent the development of sloppy habits in handling mercury.

VIII. REFERENCES

1. Occupational Safety and Health Administration. Mercury. Occupational Safety and Health Administration, 1975. (DOL (OSHA) publication no. 2234).

2. National Institute for Occupational Safety and Health. NIOSH/OSHA occupational health guidelines for chemical hazards. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1981. (DHHS (NIOSH) publication no. 81-123).

3. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to inorganic mercury. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1973. (DHEW (NIOSH) publication no. 73-11024).

4. American Conference of Governmental Industrial Hygienists. Threshold limit values for chemical substances and physical agents in the workroom environment with intended changes for 1982. Cincinnati, Ohio: ACGIH, 1982.

5. Occupational Safety and Health Administration. OSHA safety and health standards. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised 1980.

6. 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, Berkeley, California 94704.

7. Price JH, Wisseman CL. Health Hazard Evaluation - Cincinnati, Ohio: Report No. TA 77-52. National Institute for Occupational Safety and Health, 1977.

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by: Steven A. Lee, M.S., C.I.H.
Industrial Hygienist
Industrial Hygiene Section

Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations, and Field Studies
Report Typed By:	Jacqueline Grass Clerk/Typist Industrial Hygiene Section

X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Palmer Instruments, Incorporated
2. NIOSH, Region V
3. OSHA, Region V

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE

Air and Urine Mercury Exposure

Palmer Instruments, Incorporated
Cincinnati, Ohio

HETA 83-338

Job/Location	Air Sampling/NIOSH August 16, 1983 Sample Time	Air Mercury Concen. (ug/m^3)	Urine Sampling/Kettering Labs July 25, 1983 Urine Volume (milliliters)	Specific Gravity	Urine Mercury Concen. (ug/liter)
Welder, Pump Room	735-1525	210	128	1.025	60
Run Out/Burn Out, Tube Room	718-1520	59	80	1.024	250
Tube Maker, Tube Room	720-1520	39	128	1.022	170
Pole Maker, Pump Room/Tube Room	724-1520	60	105	1.030	100
Lead Person	726-1520	28	25	1.020	70
Assembler	730-1520	37	-	-	-
Assembler	732-1520	24	-	-	-
Calibrater	734-1520	26	85	1.009	10
Evaluation Criteria:		50			200