

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. HE 78-85-513

TRI-DISTRICT HEALTH CLINIC
ALGOMA, WEST VIRGINIA 24807

August 1978

I. TOXICITY DETERMINATION

A Health Hazard Evaluation was conducted by the National Institute for Occupational Safety and Health (NIOSH) on May 24, 1978, at the Tri-District Health Clinic in Algoma, West Virginia, to determine the levels of exposure to inorganic mercury. Breathing zone and general area air samples were collected through the use of 3M* Mercury Monitor Badges and MSA* iodine impregnated activated charcoal tubes. A Bacharach* Mercury Sniffer was used to search for specific areas of mercury vapor contamination. In addition, 24-hour and spot urine samples were collected as indicators of inorganic mercury absorption. The urine mercury levels, direct reading instrument levels, and breathing zone and general area air samples indicate that inorganic mercury levels were below the NIOSH recommended standard and a health hazard did not exist at the time of this evaluation.

II. DISTRIBUTION AND AVAILABILITY

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 22151. Information regarding this report's availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati address.

*Use of brand names does not imply endorsement by NIOSH.

Copies of this report have been sent to:

- a) Clinic Administrator, Tri-District Health Clinic, Algoma, West Virginia.
- b) Director, Tri-District Dental Clinic.
- c) U.S. Department of Labor, Region III.
- d) NIOSH, Region III.

III. INTRODUCTION

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

NIOSH received such a request from personnel at the Tri-District Health Clinic in Algoma, West Virginia, concerning exposures to inorganic mercury vapor.

IV. HEALTH HAZARD EVALUATION

A. Process Description

The dental offices of the Tri-District Health Clinic consist of a reception area, a laboratory, two operatories, the dentist's office, and a restroom. All of the rooms have room size heating and air conditioning units and windows, with the exception of the restroom which has only a window and the dentist's office which has neither. The rooms consist of tiled floors, painted concrete walls, and ceilings of acoustical tiles over concrete. Drugs, which include sealed bottles of mercury are stored in the dentist's office. The dental offices are staffed by the dentist and a dental assistant. A second dentist may be added to the dental clinic staff in the coming year.

Mercury is handled primarily in the two operatories---adjacent rooms of approximately 180 square feet each. The mercury handling procedure had undergone several modifications since the clinic opened in June 1975. Originally, two drops of mercury from a one pound bottle were added to two alloy pellets in a plastic capsule. The capsule was then agitated on an amalgamator. The resulting amalgam was wrapped in a circular piece of cloth and "squeezed" to eliminate excess mercury, creating a stronger amalgam. To reduce mercury exposure the dentist subsequently altered this process through the use of precapsulated amalgams. These amalgams consist of pre-weighed amounts of mercury and alloy in a plastic capsule. The capsule is agitated on the amalgamator and the resulting amalgam is "squeezed" to eliminate any excess mercury that may be present.

Finally, to reduce mercury vapor exposure even further, the process was altered by eliminating the step which involved "squeezing" the amalgam to remove any excess mercury. This step may actually be unnecessary since the precapsulated amalgams are reported to contain the optimum ratio of mercury to alloy. After the amalgam is formed, it is used in tooth filling procedures. Approximately 40 amalgams are mixed per month. Exposure to inorganic mercury vapor in the clinic results from the formation and use of these amalgams.

B. Evaluation Methods

1. Environmental

Instantaneous measurements of mercury contamination, as well as long term sampling designed to determine time-weighted average exposures, were performed to monitor the dental clinic environment for mercury vapor. Instantaneous measurements were obtained with the aid of a Bacharach Mercury Sniffer. This direct reading instrument was used to search for sources of mercury vapor contamination.

Time-weighted average concentrations were obtained through the use of 3M Mercury Vapor Monitor Badges and MSA iodine impregnated charcoal tubes. The monitor badges use a binary diffusion system to integrate exposure levels. Mercury vapor is absorbed on a gold collection surface. As mercury vapor comes in contact with the gold film, an amalgam is formed. The quantity of mercury absorbed is related to reductions in the conductivity of the resulting amalgam. The badges were analyzed by the manufacturer. Iodine impregnated activated charcoal tubes were also used as indicators of time weighted average exposure levels. Air was drawn through the charcoal tubes with Sipin* pumps at flow rates of about 100 cubic centimeters per minute. Inorganic mercury vapor is adsorbed on the charcoal tubes; the quantities were subsequently determined by atomic absorption.

2. Medical

Inorganic mercury absorption was monitored by analysis of urine samples. Twenty-four hour urine samples were collected from the dentist and dental assistant, while a spot urine sample was collected from the postmistress (works in adjacent office). A spot urine sample was collected as a control. All urine samples were analyzed by a method incorporating flameless atomic absorption spectroscopy.

*Use of brand names does not imply endorsement by NIOSH.

C. Evaluation Criteria

1. Toxic Effects¹⁻⁴

Elemental mercury has significant vapor pressure, is electroneutral, and lipid soluble. These properties permit rapid passage across the alveolar membranes of the lung, absorption into the bloodstream, and diffusion into tissues. Elemental mercury is quickly oxidized to Hg^{++} once it reaches the blood stream. Inorganic mercury can be considered a general protoplasmic poison with inhalation as the prime mode of entry. The toxic action is due to the ability of the mercury ion to form highly undissociated linkages to sulfhydryl (-SH) groups present in proteins. The mercury ion can also form strong bonds with other ligands such as amine, phosphoryl, or carboxyl groups present in living cells. The ability to form bonds such as these with physiologically important groups indicates that mercury is a potent and nonspecific inhibitor of a wide variety of enzymes.

There are three general physiological effects considered to be classical signs of inorganic mercury poisoning: (a) oral cavity disorders such as an inflammation of the gums (gingivitis), an inflammation of the oral mucous membranes (stomatitis), or excessive salivation; (b) involuntary movement disorders; and (c) psychological disturbances (erethism). Involuntary movement disorders (tremors) first appear as a fine "intention" tremor of the hands, producing a change in the handwriting, making it either illegible or inconsistent, with letters omitted. The tremor may be characterized by fine, rhythmical, static trembling, interrupted by sudden, coarse, jerking movements and aggravated by involuntary movements. Erethism is characterized by frequent anger, irritability, inability to concentrate, indecision, fearfulness, depression, headache, fatigue, loss of memory and drowsiness. Characteristics such as these make erethism due to exposure to inorganic mercury difficult to diagnose since they may be attributed to other disturbances, such as anxiety.

Inorganic mercury poisoning may also exhibit several nonspecific symptoms such as weakness, unusual fatigue, loss of appetite, insomnia, and gastrointestinal disturbances. These nonspecific symptoms could be due to many different disorders, but may be considered to be predecessors of more specific symptoms of mercury poisoning if they are exhibited in individuals known to be exposed to inorganic mercury. The kidney is involved as a storage and elimination site which results in an accumulation of mercury in this organ and possibly renal damage.

2. Environmental

Inorganic mercury exposure limits have been established by several agencies. The National Institute for Occupational Safety and Health and the American Conference of Governmental Industrial Hygienists (ACGIH) have recommended exposure limits. The U.S. Department of Labor (OSHA) has established a legally enforceable exposure limit. These limits are of two types: (a) Time-weighted average values which are levels to which a worker may be exposed repeatedly for a normal 8-hour workday or 40-hour workweek, day after day, without adverse effects^{3,5} and (b) Ceiling values which are exposure levels which should not be exceeded at any time during an 8-hour work period.⁶

<u>Source</u>	<u>Exposure Limits (mg/M³)*</u>	
	<u>TWA</u>	<u>Ceiling</u>
ACGIH ⁵	0.05	-
OSHA ⁶	-	0.10**
NIOSH ³	0.05	-

*Milligrams of contaminant per cubic meter of air

**Enforced as a TWA.

3. Medical

Mercury may be eliminated through urination, defecation, perspiration, and exhalation. The principal modes of excretion are by defecation and urination with the majority of mercury eliminated in the urine.³

Abnormally high levels of mercury in the urine confirm exposure to mercury, but there is poor correlation between urine mercury levels and the onset of symptoms. In addition, there is poor correlation between urine mercury levels and environmental exposure levels.¹ However, urine mercury levels are still the best available indicator of mercury absorption. The following information may be used a guide for the interpretation of urine mercury levels:

<u>Mercury Levels in Urine (Micrograms/Liter)</u>	
Normal	Less than 30
Increased absorption	above 50
Warning	above 100
Hazardous level-remove from exposure	above 200
Symptoms of mercury poisoning probable	above 300

A normal person, not working with mercury, should have a urine mercury level below 15 micrograms/liter (ug/l). A person overexposed to mercury should not return to the mercury contaminated environment until the urine mercury level falls below 50 ug/l in order to allow a margin of safety.⁷

D. Evaluation Results and Discussion

Environmental and biological monitoring for exposure to inorganic mercury vapor consisted of instantaneous direct readings, long term air sampling, and urine collection and analysis.

The direct reading instrument showed generally non-detectable levels of contamination in all tested areas when instrument flutter was averaged out. The rooms tested included both operatories, the laboratory, the dentist's office and the mercury storage cabinet. The areas tested in the operatories included the counter tops, the amalgamator, the seam between the cabinets and floor, the drain, the waste can, the dental chair and surrounding floor space, and the cabinet floor surrounding the waste can. The areas tested in the laboratory included the counter tops near the grinder/polisher and the floor near the cabinets. The areas tested in the office included the chair, the desk top, the floor surrounding the desk and the storage cabinet.

Long term air sampling consisted of seven mercury badge samples and seven iodine impregnated charcoal tube samples. The mercury concentrations detected with these samples ranged from non-detectable to 0.022 mg/M³ or 0.0 to 44% of the NIOSH criteria for a recommended standard. However, of these samples, only one was over 40% of the criteria and only two were above 20% of the criteria. Both of the samples which exhibited concentrations over 20% of the NIOSH criteria are area samples in Operatory #2. More detailed information can be obtained from Table II.

Four urine samples were collected. The mercury levels in all four samples were less than the limit of detection (10.0 ug/l).

Since all urine mercury samples were low, as were the Mercury Sniffer readings, and only 2 of 14 long-term samples were above 20% of the NIOSH recommended standard, a health hazard was judged not to exist at the Tri-District Health Clinic at the time of the survey. However, contamination levels may be artificially low because the clinic was temporarily closed for thirty days prior to the evaluation. The following recommendations should help in maintaining low levels of contamination and reducing those in Operatory #2.

V. RECOMMENDATIONS

Mercury is a silver-colored, heavy metal which is liquid and evaporates readily at room temperature. Since mercury has a low surface tension, spilled mercury tends to break up into small droplets, thereby increasing the surface area and the rate of vaporization.⁴ These properties require careful mercury handling and strict housekeeping procedures.

General Recommendations in Mercury Hygiene have been suggested by the American Dental Association⁵ (Attachments 1 & 2). In addition, recommendations specific to operations at the Tri-District Health Clinic are made in order to maintain low mercury exposure levels.

- 1) The floors should be stripped of old wax, cleaned, re-waxed and buffed. This floor maintenance will help prevent mercury from becoming trapped in the cracks between tiles and in accumulated wax. The entire procedure should be repeated periodically.
- 2) Trash should be emptied on a daily basis.
- 3) When possible, air should be exhausted and not recirculated, particularly in the operatories.
- 4) Office furniture should be non-porous. For example, vinyl rather than cloth covered chairs should be used.
- 5) The "squeezing" procedure may be continued if so desired, but the exuded mercury should be collected and not allowed to contaminate the clinic. This will prevent contamination of equipment not used in tooth filling procedures. In addition, the pieces of cloth or gauze used to eliminate excess mercury should be discarded in sealed containers.
- 6) Local exhaust ventilation for the grinder/polisher in the laboratory is recommended. While not related to mercury contamination, a local exhaust system will help in reducing exposure to airborne particulates. In addition, particulates generated during grinding and polishing procedures should be cleaned from the grinder/polishers area on a regular, frequent basis.

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Table I
 Urine Mercury Levels
 Tri-District Health Clinic
 Algoma, West Virginia

May 24, 1978

<u>Sample Type</u>	<u>Person Sampled</u>	<u>Urine Mercury (micrograms/liter)</u>
24 hour	Dentist	N.D. ¹
24 hour	Dental Assistant	N.D.
spot	Postmistress	N.D.
spot	Control (NIOSH Investigator)	N.D.

1. N.D.=non-detectable. The lower limit of detection was 10 micrograms/liter.

Table II
Results of Air Sampling for Mercury Vapor

Tri-District Health Clinic
Algoma, West Virginia

May 24, 1978

Sample Type	Location	Mercury Vapor Concentration (mg/M ³) ¹			
		Monitor Badge		Charcoal Tube	
		Sample Time	Sample	Sample Time	Sample
Personal	Dentist	0840 - 1456	0.004	0936 - 1416	N.D. ²
Area	Operatory No. 2	0842 - 1459	0.022	--	--
Area	Operatory No. 1	0845 - 1500	0.003	--	--
Area	Office - Near Desk	0848 - 1502	0.003	0950 - 1407	N.D.
Area	Laboratory - Center of Room	0852 - 1505	0.004	--	--
Personal	NIOSH Investigator	0905 - 1507	0.008	--	--
Personal	Receptionist	0905 - 1508	0.002	--	--
Area	Mercury Storage Cabinet	---	--	0959 - 1408	N.D.
Area	Laboratory - Between Grinder/ Polishers	---	--	0941 - 1415	0.008
Area	Receptionist Desk	---	--	0953 - 1412	N.D.
Area	Operatory No. 2 - Near Sink	---	--	0954 - 1407	0.012
Area	Operatory No. 1 - Near Sink	---	--	0943 - 1409	0.006
NIOSH Recommended criteria			0.050		0.050

1. milligrams of mercury per cubic meter of air

2. N.D. = non-detectable. The limit of detection was 0.2 micrograms of contaminant per sample.

RECOMMENDATIONS IN MERCURY HYGIENE, FEBRUARY 1974

1. Store mercury in unbreakable, tightly sealed containers.
2. Perform all operations involving mercury over areas that have impervious and suitably lipped surfaces so as to confine and facilitate recovery of spilled mercury or amalgam.
3. Clean up any spilled mercury immediately. Droplets may be picked up with narrow bore tubing connected (via a wash-bottle trap) to the low-volume aspirator of the dental unit.
4. Use tightly closed capsules during amalgamation.
5. Use a no-touch technique for handling the amalgam.
6. Salvage all amalgam scrap and store it under water.
7. Work in well-ventilated spaces.
8. Avoid carpeting dental operatories as decontamination is not possible.
9. Eliminate the use of mercury-containing solutions.
10. Avoid heating mercury or amalgam.
11. Use water spray and suction when grinding dental amalgam.
12. Use conventional dental amalgam compacting procedures, manual and mechanical, but do not use ultrasonic amalgam condensers.
13. Perform yearly mercury determinations on all personnel regularly employed in dental offices.
14. Have periodic mercury vapor level determinations made in operatories.
15. Alert all personnel involved in handling of mercury, especially during training or indoctrination periods, of the potential hazard of mercury vapor and the necessity for observing good mercury hygiene practices.

Recommendations in mercury hygiene

Council on Dental Materials and Devices

The Association, through its Council on Dental Materials and Devices, is publishing a series of recommendations concerning safety or proper practices in the dental office. The Council, in cooperation with the Council on Dental Research, sponsored and published an article titled "Significance to Health of Mercury Used in Dental Practice: A Review" in the June 1971 issue of THE JOURNAL (JADA 82:1401 June 1971).

Since mercury as a potential health hazard in dental practice cannot be dismissed or casually treated, the Council has continued to follow reports in this area. Reports of surveys in the US,¹⁻³ Canada,⁴ and England⁵ all show that at least 10% of dental offices have air levels of mercury vapor in excess of the threshold limit value (TLV) of 0.05 mg/m³. A summary of surveys made in the United States will be the subject of a subsequent report. Even though neither a dentist nor a dental assistant has been reported as suffering from chronic mercurialism, many exposures are sufficient to cause concern. This is especially true since the *British Dental Journal*⁶ reported one fatality of a dental assistant that was attributed to acute mercury poisoning. This case was inadequately investigated so nothing is known concerning her medical history or the mercury hygiene of her work spaces. Consequently, the mercury hygiene observed in the office where she worked cannot be identified as the direct source of her mercury poisoning.

Much has been made over the materials and methods used in dental office construction to reduce the potential of mercury contamination. Impervious and seamless work and floor areas with edges lipped to confine spills have been universally recommended. Even so, many decorators continue to install rugs on the floors of dental operatories. Carpeting is not recommended, as decontamination in the event of spills is not possible. The mercury levels in these offices, however, are often lower than the mercury levels in offices decorated as recommended. The determining factor influencing vapor levels is the mercury hygiene observed by the dental personnel in the offices. Consequently, efforts to establish guidelines for proper mercury hygiene must center on the few minutes during proportioning of the mercury and alloy and mixing of the amalgam mechanically. Capsules fitted with

friction grip caps and some preproportioned disposable capsules disperse free mercury during high-speed mechanical trituration.⁷⁻⁸ This loss of mercury during trituration can be detected by wrapping adhesive tape around the capsule prior to the mechanical mixing. If the capsules are tight and no mercury is thrown out, the adhesive side of the tape will be clean after trituration. Drops of mercury, 0.1 mm in diameter and weighing approximately 0.01 mg, can be seen on the tape with the naked eye.⁸ This test should be made on new capsules, as well as occasionally during the use of the capsule.

Von-Nossek and Seidel⁹ and Chandler and co-workers¹⁰ observed a spray of mercury-rich particles during condensation with an ultrasonic instrument. Although no significant mercury vapor was detected, the dispersal of small particles, which can be inhaled by dental personnel and patients, is not considered to be good mercury hygiene.

These foregoing reports, along with Stewart and Stradling's¹¹ code of mercury hygiene for dental operatories, form the basis for the Council's recommendations of criteria for good mercury hygiene.

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