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FINAL REPORT

MERCURY CONTROL TECHNOLOGY ASSESSMENT STUDY

Louisiana State University
School of Dentistry
New Orleans, Louisiana

In-depth Survey Report
for the Site Visit of
April 27-28, 1981

Contract No. 210-81-7107

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Submitted to:

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REPORT NO.:
ECTB 109-17b

FOREWORD

A Control Technology Assessment (CTA) team consisting of members of the National Institute for Occupational Safety and Health (NIOSH) and the Dynamac Corporation Enviro Control Division met with representatives of the Louisiana State University (LSU) School of Dentistry in New Orleans, Louisiana on April 27 and 28, 1981 to conduct an in-depth survey on the techniques used to control worker exposure to mercury. Participants in the survey were:

Dynamac Corporation

Mr. Donato Telesca, Program Manager
Mr. David D'Orlando, Environmental Engineer
Mr. Robert Reisdorf, Industrial Hygienist

National Institute for Occupational Safety and Health (NIOSH)

Mr. Paul Caplan, Assistant Project Officer

LSU School of Dentistry

Dr. Robert Coker, Assistant Dean for Clinical Administration
Dr. Robert Sundin, Director of Extramural Programs
Dr. Barry Haindel, Director of Environmental Affairs
Dr. William von der Lehr, Director of Operative Dentistry
Mr. John McMahon, Administrative Supervisor
Mrs. Marjory Fallo, Dental Assistant Program Supervisor
Mr. Lionel Augustin, Dental Maintenance
Mr. Carl Froeba, Maintenance Engineer

The in-depth CTA was completed in two days. The study included air sampling, review of mercury controls, and interviews with administrative personnel.

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INTRODUCTION

CONTRACT BACKGROUND

The Mercury Control Technology Assessment Study has been initiated to assess the current technology used to protect the worker from exposure to hazardous levels of mercury. The objective is to identify and evaluate the exemplary methods employed by industries to control worker exposure to elemental mercury and mercury compounds. A result of the study will be the publishing of a comprehensive document describing the most effective means of controlling emissions and exposures. This report will be available to companies which handle mercury to transfer technology within the eight major mercury using industries. The study will also identify directions where additional research is necessary.

JUSTIFICATION FOR MERCURY CTA SURVEY

Louisiana State University (LSU) School of Dentistry was selected for an in-depth survey because of its large operative dentistry department and its previous efforts to conform to the Occupational Safety and Health Administration (OSHA) mercury exposure standard through a self-initiated Health Hazard Evaluation (HHE) by the National Institute for Occupational Safety and Health (NIOSH). Exposure levels reported in the HHE were generally well below the permissible exposure limit set by OSHA, making this facility desirable for study. Of particular interest is a proposed control: self activating mercury/alloy containing capsules.

SUMMARY OF INFORMATION OBTAINED

An opening conference was held with LSU representatives during which objectives of the program were discussed. The methods of handling mercury at this facility were explained and several controls used at the dental school's clinic were described. Additional meetings were arranged for discussion of 1) the amalgamation process; 2) the ventilation system, 3) local and remote vacuum cleaning procedures; 4) mercury vapor suppressants; and 5) dental supply sources.

DESCRIPTION OF FACILITY

LSU School of Dentistry Clinic is located in the eight story building of the Dental Center at 1100 Florida Avenue, New Orleans. The clinic building is 9 years old and is constructed of steel beams and concrete.

The following is a list of the employees and students at the clinic:

21 staff dental assistants
13 dental assistant students
57 dental hygienist students
26 dental technician students
101 freshmen dental students
91 sophomore dental students
88 junior dental students
78 senior dental students
20 faculty
20 maintenance and janitorial personnel

All of these people, with the exception of dental technician students, have a potential for mercury exposure.

Mercury is handled on three of the eight floors of the building (Figures 1,2, and 3). Four departments of the school require the use of mercury. These are listed according to floor in Table 1.

Table 1.

Floor	Department	Description of Work	Clinic Name	Number of Chairs*	Reference Figure
2	General Dentistry	all dentistry	Senior Clinic	100	1
3	Operative Dentistry Fixed Prosthodontics	tooth filling bridge work and crowns	Junior/Sophmore Clinic	50	2
4	Pedodonics	children's dentistry	Pedodonics Clinic	30	3

*Each chair is situated in its own cubicle which contains individual lighting, storage, and a movable console of dental utilities.

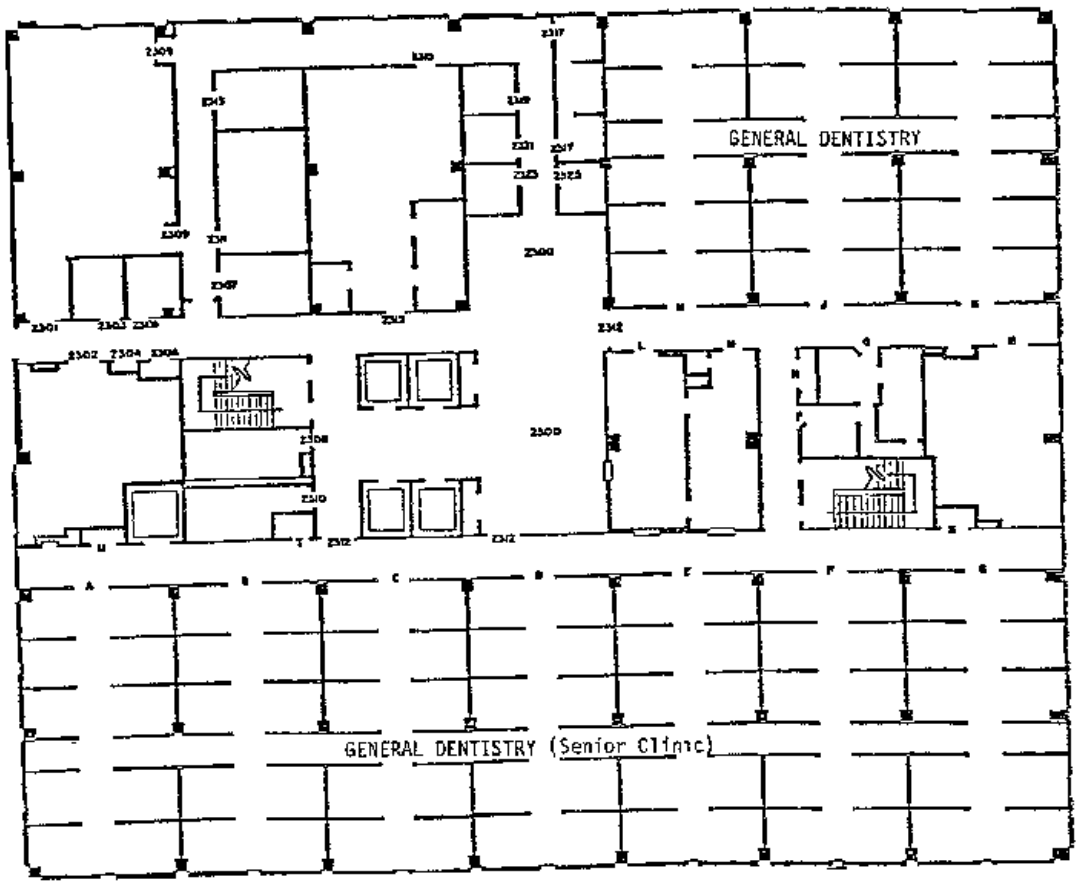

Figure 1. Clinic Building (Second Floor)

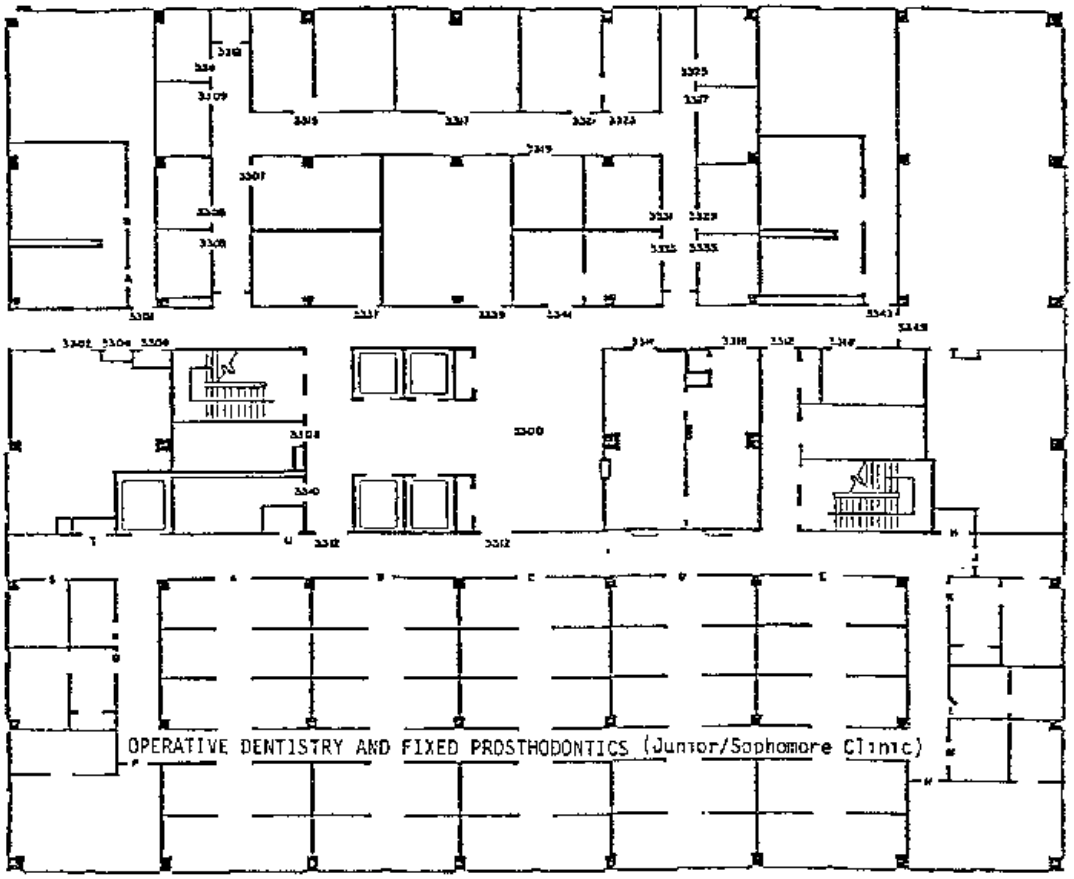

Figure 2. Clinic Building (Third Floor)

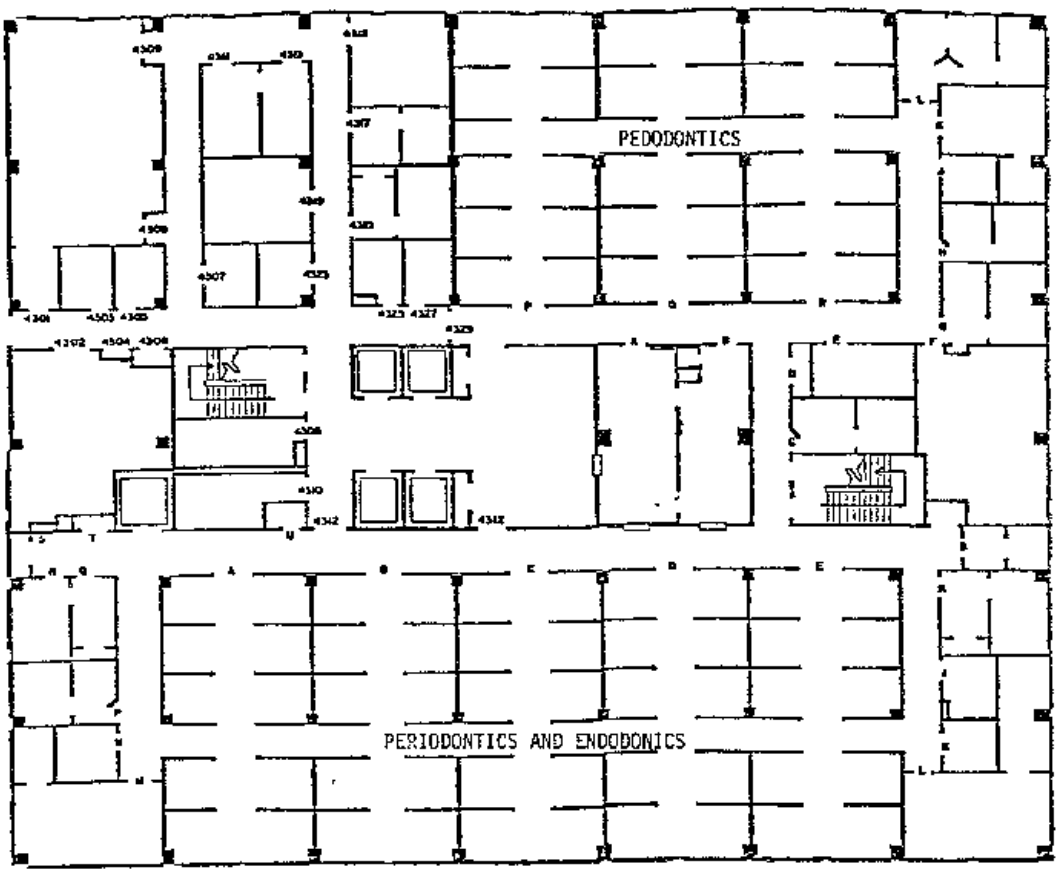

Figure 3. Clinic Building (Fourth Floor)

PROCESS DESCRIPTION

The handling of mercury in the clinic is described from the supply stage to the completion of a filling and the disposal of the excess mercury and amalgam. There are two methods by which mercury is supplied to the clinic, and there are several methods by which the excess amalgam is disposed. There is a proposed mercury control technique which has been evaluated, accepted, and will be implemented as standard procedure during the fall of 1981. This control, the use of Dispersalloy® Self-Activating Capsules, will eliminate several of the steps outlined in the following description. Dispersalloy® capsules are described in detail in the engineering controls section.

The procedures used in preparing dental amalgam are conducted by both dental students and dental assistants except where specified in the process description.

Elemental Mercury Supply

General clinic supplies for dental assistant--
A closely monitored mercury inventory is maintained in the supply room in the basement of the building. Mercury is reordered when the supply reaches six one-pound bottles. The manufacturers of the mercury used during the site visit were Eastern Smelting and Refining Corporation and B. F. Goldsmith Chemical and Metal Corporation. The mercury arrives in sealed one pound (.45 kilogram) plastic bottles. When mercury is needed in the clinic, a one pound bottle is delivered using a dumb waiter. It is stored in a locked safe.

Supply for dental students--
There is an insufficient number of dental assistants to work with each dental student. For this reason, dental students must often make their own amalgam for tooth filling. Individual dental students are responsi-

ble for obtaining all of their dental supplies, including mercury. They purchase mercury from J. T. Baker, Healthco Dental, and Patterson Dental. The students purchase mercury in the same type of containers as the clinic; one pound sealed plastic bottles. They store the containers in their personal instrument kits.

Transfer

Mercury is transferred from the one pound bottles to special mercury dispensers. The caps on each container are removed and mercury is poured from the bottle through a funnel into the dispenser. This is either done by the Dental Assistant Program Supervisor or the dental students. Each dispenser is refilled approximately monthly. One mercury dispenser is stored in each of the 21 mobile cabinets used by the dental assistants. In addition to this, the 257 upper classmen dental students each have a mercury dispenser as a part of their instrument kits.

Encapsulation

Amalgam to be made for tooth filling is formed by mixing mercury with an alloy. The alloy used at the clinic is in pellet form and is stored in 3 inch long plastic tubes or in small bottles. Pellets are composed of approximately 60 percent silver, 25 percent tin, and 15 percent zinc and copper. A pellet, or pellets, and an equal amount (by weight) of mercury are put inside a two-piece plastic capsule along with a pestle. By maintaining a 1 to 1 ratio of alloy to mercury, an optimal amalgam is formed and there is little residual mercury. Dentists differ in their opinion of optimal ratios.

The mercury dispensers are used to deliver a specified amount of mercury for the amalgam into the plastic capsule. A drop of mercury is termed a "spill". One or two spills of mercury are used for each amalgam mixing depending on the size of the filling to be made. There are two types of dispensers used at the clinic. The first type, a Caulk Saf-T-Cote^{R} is used by inverting the bottle over the open capsule and pressing the delivery button. A specified amount of mercury is released into the

capsule. The second type of dispenser delivers both an alloy pellet and a drop of mercury into the capsule at the same time. A small cotton roll is kept inside each dispenser. This cleans the mercury by collecting surface dirt and dust. A minimum level of mercury must be kept in the bottles to insure that spills are of the correct amount.

Amalgamation

When the alloy pellet, mercury, and pestle have been put inside the open plastic capsule, the capsule is capped and placed between the agitation arms of the amalgamator. LSU Dental Clinic uses Caulk Varimax-II amalgamators (wiggle bugs). The agitator arms are enclosed by a box measuring 3 inches long, 2 inches deep, and 2 inches high. This enclosure is used to contain the amalgam if the capsule should shake loose, and it also confines small mercury beads which may be on the capsule surface. The capsule is agitated by the amalgamator for approximately fifteen seconds. It is removed from the machine, uncapped, and emptied into a glass Dappen dish. The pestle is separated from the amalgam and removed from the dish with a pair of cotton-tipped pliers.

Tooth Filling

Amalgam is removed from the Dappen dish with an amalgam carrier. The carrier is pressed into the amalgam until the cavity of the instrument is filled. The dental student depresses the plunger forcing the amalgam out of the carrier and into the cavity of the tooth to be filled. Amalgam is condensed (pressed) into the tooth and is carved (formed) by the dental student until a smooth shape consistent with the rest of the tooth has been achieved.

Waste Disposal

Amalgam which remains in the Dappen dishes is emptied into small plastic bottles at each cubicle. These bottles have one to two inches of water in them and they are kept closed. They are emptied by maintenance personnel approximately every six months into a large mercury waste container

in which all of the clinic's waste amalgam is kept. A disposal plan for this waste is currently being developed.

Excess amalgam which is carved from the filling is removed from the patient's mouth with an aspirator. This instrument draws saliva and amalgam through a fitting and into a mobile console which is located inside the cubicle. A central vacuum system supplies the suction necessary for this function. A closed trap inside the console removes the solids from the waste stream. The trap is emptied periodically by maintenance personnel and the waste material is stored with the other mercury waste. Amalgam remaining in the patient's mouth is expectorated into the cuspidor which drains through the clinic drainage system. A trap is set inside this drain to catch the amalgam. It is emptied daily by maintenance personnel, and collected material is disposed of with the other amalgam waste.

MERCURY CONTROL TECHNIQUES

Some operatory procedures implemented for better dental practice also control worker exposure to mercury. Certain engineering controls and work practices have also been implemented to address emission and exposure problems. These controls and practices are described below.

ISOLATION AND CONTAINMENT

Ritter Dental Unit--

The Ritter Dental Unit is a mobile console located inside each dental cubicle. The unit contains supply air for air-driven tools, water for water syringe, a cuspidor, and two aspirator lines connected to a house vacuum system. The cuspidor is used for disposal of patients' expectorant. Both high and low volume aspirator lines are used for operatory work and surgery. The low volume line is used for removing saliva from the patient's mouth. It has a screen in it to prevent plugging with amalgam. The high volume line is used to vacuum mercury spills which occur within the cubicle. There is a trap in the aspirator lines which removes elemental mercury, amalgam, and other particulates from the waste stream. The suction in the unit is drawn by a house vacuum system located in the basement of the building. A vacuum of seven inches of water is maintained by two compressors powered by 30-horsepower motors. After liquid/gas separation, the air is vented to the roof.

Mercury Spill Portable Vacuum Cleaner--

A portable vacuum pump (Gomco Surgical Mfg.) mounted on a small push cart is used to remove spills which can not be reached by the vacuum system in the Ritter unit. Spilled mercury is drawn through plastic tubing to an in-line plastic bottle which acts as a liquid mercury trap. The vacuum pump exhausts through a replaceable fiber filter (not intended to remove mercury vapor). After vacuuming a spill, mercury which has collected in the bottle is transferred to a closed container for disposal with other clinic mercury waste. This vacuum unit is designed to provide suction during surgery.

DILUTION VENTILATION

Clinic ventilation is achieved by a series of air handlers. There are two air handlers on every floor. Each has two sets of filters. First, there are continuously advancing fiber pre-filters for particulate removal. The next filtration stage consists of a set of sock filters. Air changes in the clinics average four per hour. Fifteen to seventeen percent of the total air flow is fresh air make-up.

PROCESS SUBSTITUTION

Self-Activating Dental Capsules--
Effective Fall 1981, the LSU School of Dentistry Clinic will implement the use of Johnson and Johnson Dispersalloy® Self-Activating Capsules. These capsules, available in one, two, and three spill sizes, contain a pre-capsulated charge of mercury and Dispersalloy® powder (Figure 4). Mercury is isolated from the alloy by a diaphram which is punctured by a pestle (also pre-enclosed in the capsule) upon agitation in the amalgamator. The capsule is easily pulled apart to release the amalgam by twisting and pulling both ends.

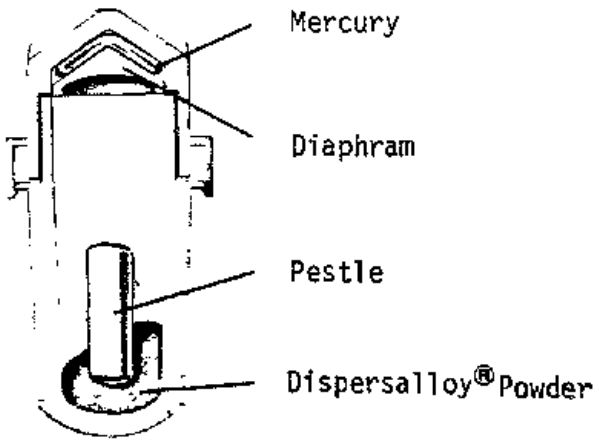

Figure 4. Dispersalloy® Capsule

Pre-capsulation of the mercury and alloy eliminates the need for:

1) separate elemental mercury supply
2) transfer of mercury to dispensers
3) manual mercury encapsulation by the dental team

This will result in a decrease of potential mercury exposure points in the clinic.

PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment designed for protection against mercury or mercury vapor is not used at this facility.

WORK PRACTICES

The staff at the facility are aware of the potential hazards associated with use and handling of mercury. Health and safety measures with respect to control of exposure to mercury are centered on:

- limiting access to mercury
- using small quantities
- quick cleanup of spills (27 mercury spills have been reported since 1979)

In the event of a mercury spill in the dental clinic area, students or employees must contact the engineering department for clean-up. Students and employees do not clean up spills of mercury.

The clinic is preparing to implement a new procedure for treating mercury spills in which zinc dust and sawdust are mixed in equal proportions and spread on the spill.* Sawdust acts as a media to facilitate the amalgamation of the zinc and mercury. The mixture amalgamates the mercury

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*Anderson, D.H., P.J. Murphy, W.W. White. "A Cleanup Procedure for Handling Mercury Spills." Journal of Chemical Education, February 1978. Volume 55, No. 2, pp. A-74, 76, 78.

liquid with zinc and reduces the emission of mercury vapor. Zinc and sawdust enable mercury to be removed effectively from cracks and pores in surfaces. Vacuuming does not necessarily achieve this. Mercury spills are handled by 1) removing most of the spill mechanically (vacuum) 2) spreading the zinc-sawdust mixture on the remaining mercury, letting it stand for a while, and 3) sweeping up the zinc-mercury-sawdust mixture.

Other practices which may reduce exposure to mercury are in effect, and apply to students and employees in the clinic areas. Some of these practices have been implemented as part of good dental practice rather than to control mercury exposure.

The following list summarizes these practices:

- workers (students and employees) wash their hands before and after working with a patient and before and after breaks.
- workers do not smoke cigarettes in clinic areas.
- dental instruments are cleaned on a regular basis.
- the pestle is removed from the amalgam using cotton-tipped pliers, as opposed to being removed by hand.
- one qualified person fills all dental assistants' mercury dispensers.
- one qualified person distributes the one-pound bottles of mercury.
- all dispensers are kept in the dental assistants' cabinets or dental students' instrument kits.

HOUSEKEEPING

Good dental practice requires that dental hygienists and technicians, and dentists work with a minimum of clutter and waste. Mercury spills are reported to the engineering department for clean-up. Floors are cleaned and polished several times per week (a mercury decontaminant/suppressant is not used). Waste mercury is put into plastic screw-topped bottles and sealed.

SURVEY DATA

AIR SAMPLING DATA

Sampling Methods

Monitoring of workplace air was conducted using two methods: 1) a direct reading instrument to provide an instantaneous measurement of mercury vapor concentration, and 2) a long term sampler to determine the integrated time-weighted-average exposure over the work shift.

The former method employed the dual range Jerome Model 401 Mercury Vapor Detector. This instrument has a sensitivity of 0.001 mg/M^3 and a range of 0.001 to 0.5 mg/M^3. It is specific for mercury vapor and is less subject to interferences by aromatic hydrocarbon compounds than ultra violet detectors.

For the latter method, both personal and area samples were collected. Samples were obtained by using personal monitoring pumps, MSA Model C-200, to draw air through a hopcalite solid sorbent tube. For personal samples, the tube was attached to the shirt collar or lapel of the employee. The flow rates, set at 75 ml of air per minute, were determined both before and after sampling by use of a burette (soap bubble meter). Analysis of samples was done by flameless atomic absorption.

Survey Results

Personal and area sampling was conducted in the operatory areas to determine airborne concentrations of mercury. Eleven persons were selected for personal sampling. Four area samples were collected near the work station to determine general room concentrations of mercury vapor.

Numerous direct reading measurements were taken with the Mercury Vapor Detector. The results, presented in Tables 2 and 3, show that mercury

vapor was detected throughout the operatory areas. Area concentrations average about 0.002 mg/M^3. Concentrations at known or suspected mercury sources (capsules, amalgams, amalgamators) ranged somewhat higher (0.002 - 0.45 mg/M^3). Samples taken near the floor at several locations were approximately the same as background levels indicating that wide-spread contamination is not occurring. Breathing zone levels ranged from 0.002 to 0.005 mg/M^3. The highest breathing zone concentrations (0.004 - 0.005 mg/M^3) occurred at a dental student during condensation of an amalgam. The breathing zone concentrations during amalgam preparation were 0.002 mg/M^3 for several samples indicating no increased exposure for this activity. Some contamination was noted on a dental assistant's fingers (as measured with Mercury Vapor Detector); this contamination was reduced following washing of hands with soap and water, and inside student's supply cabinet drawers (up to 0.18 mg/M^3).

The highest level recorded (0.47 mg/M^3) occurred during a simulated mercury spill clean-up procedure in which a portable surgical vacuum pump was used to clean up a spill consisting of a small quantity (less than 1/4 teaspoon) of mercury. Room levels of mercury remained elevated (compared with background levels) up to 6 minutes after the vacuum was turned off. Use of a vacuum pump may increase worker exposure to mercury. The pump is not equipped with a filter designed to adsorb mercury vapor.

Results of personal and area monitoring to determine time weighted average (TWA) exposure to mercury vapor are presented in Table 2. The results are reported as sampling period TWA concentrations. The sampling period on the second day did not encompass a full work day. During the unsampled period, dental students and employees (dental assistants) were performing non-operatory work (classroom or other activities) where exposure to mercury vapor is unlikely. Consequently, student and employee 8-hour TWA exposure on the second sampling day would be somewhat lower than reported values. Sampling periods are representative of daily

TABLE 2

Average Mercury Vapor Concentrations
Determined with Mercury Vapor Detector
4-27-81/4-28-81

Location/Activity	Concentration (mg/M^3)
3rd Floor operatory-background	0.002(2)*
Cubicle B-3 dental assistants work surface	0.002
B-3-Work surface near opened capsule	0.005(3)
B-4-Background	0.002(2)
B-4-At open capsule	0.005(2)
B-3 Dental Assistant (breathing zone)	0.002(2)
B-3 Dental Student during filling operation	0.002(3)
Storage Room	0.001(5)
Storage Room - at opened box of disposable capsules (Dispersally 2818)	0.005
Outside air	0.001
Engineer's Room - background	0.001
Engineer's Room - near vacuum	
Engineer's Room - near vacuum during spill cleanup	0.45(2)
3 min. after cleanup	0.018
C-4 area - background	0.002
C-4 area with open capsule	0.002

*number in parenthesis indicate number of samples taken

mercury vapor exposure in that they encompass all of the routinely performed activities associated with dental amalgam preparation and tooth filling.

Results indicate that students and employees were not exposed to mercury vapor in excess of the OSHA Standard of 0.1 mg/M^3 (as a TWA) or the ACGIH or NIOSH Recommended Standards of 0.05 mg/M^3 (as a TWA). In many cases, employee exposure concentrations were at or below the limit of detection for this sampling method (0.001 mg/M^3).

CONCLUSIONS AND RECOMMENDATIONS

Sample data presented indicates mercury exposure levels are maintained well below the Occupational Safety and Health Administration's (OSHA) standard of 0.1 mg/M^3 (as a time-weighted-average) and the NIOSH AND ACGIH suggested limits of 0.05 mg/M^3. There are over 300 people who may handle mercury, and the controls and practices in use are adequately protecting all of these individuals. The instruments used for dispensing both mercury and prepared amalgam prevent spillage, overuse, and dermal contact. The Dispersalloy® capsules will probably further reduce the potential for worker exposure to mercury by completely eliminating three mercury handling steps.

The portable vacuum used at the clinic for remote mercury spills is effective in picking up mercury droplets, however, it does not prevent the emission of mercury vapor from the vacuum pump discharge.

Recommendations regarding the potential improvement of mercury control at the LSU School of Dentistry Clinic are listed below:

- the use of a charcoal filter at the discharge of the portable mercury spill vacuum.
- the institution of a biological (urine or blood) monitoring program for staff employees.
- increase workplace air monitoring for mercury contamination.

The proposed spill control which uses zinc dust and sawdust warrants further study.

During the latter part of the survey, members of the survey team and the LSU faculty began a brief experiment to compare the effectiveness of a solution of sodium thiosulfate to water as a mercury vapor suppressant used to cover waste mercury and amalgam. Time and equipment limitations prevented an adequate evaluation from taking place. This endeavor will be pursued on a formal scale in the future.