U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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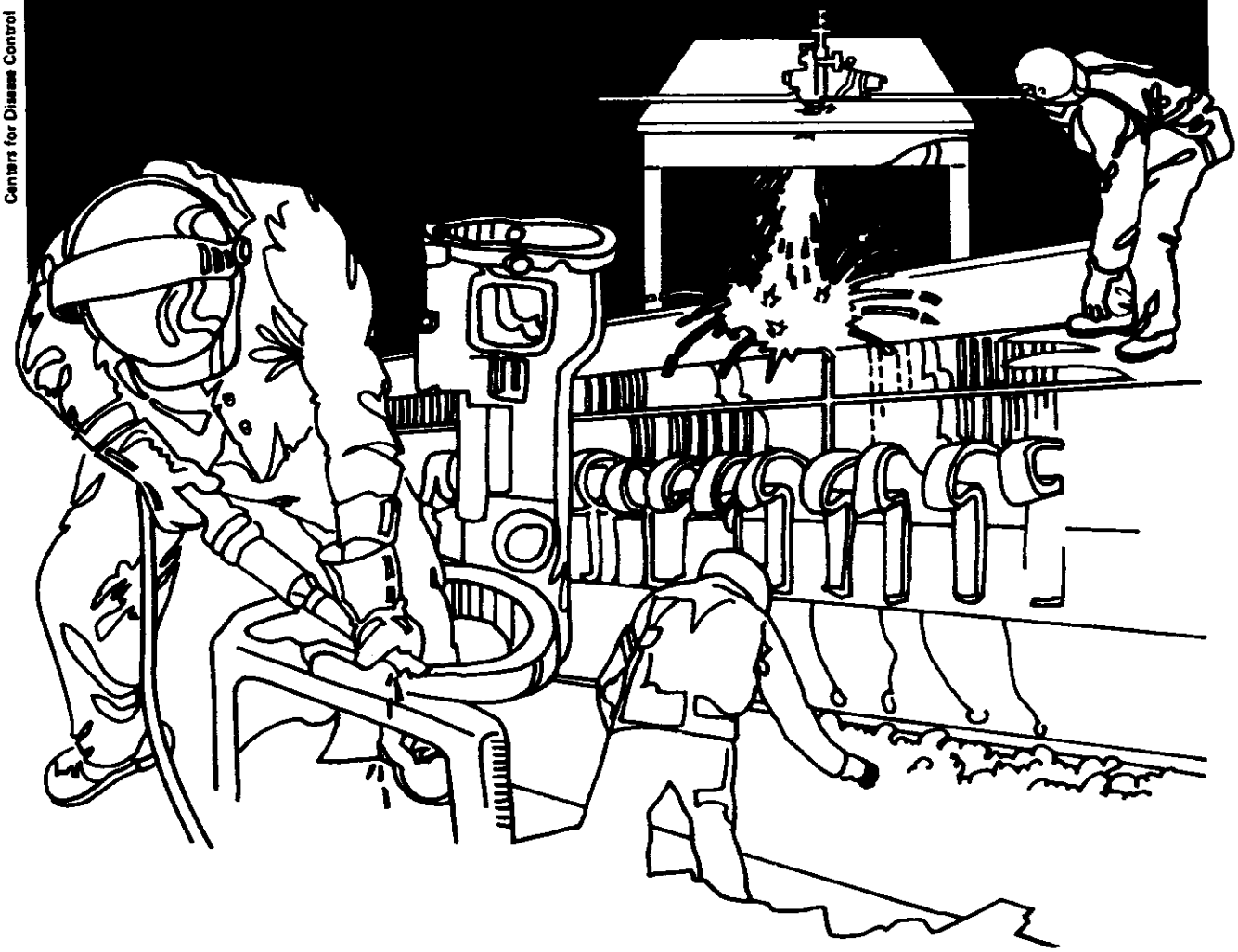

Health Hazard Evaluation Report

HETA 87-147-1873
ROTHAN & ROTHAN, DDS
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.

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ROTHAN & ROTHAN, DDS
CINCINNATI, OHIO

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I. SUMMARY

In February 1987 the National Institute for Occupational Safety and Health (NIOSH) was requested by employees at Rothan and Rothan, DDS, Dental offices, Cincinnati, Ohio, to assess the potential hazard to employees from mercury exposure.

NIOSH investigators visited the dental office on March 13, April 21, and May 5, 1987, to conduct an environmental evaluation. During the visits NIOSH investigators collected personal and area mercury air samples, assessed surface mercury contamination, collected air samples for methyl methacrylate and a bulk material sample for asbestos analysis. In addition, mercury hygienic techniques were evaluated and office personnel were administered non-directed questionnaires.

Airborne mercury concentrations ranged from 4.1 to 13 micrograms per cubic meter (ug/m^3) in 22 personal samples and from 5.3 to 11 ug/m^3 in 8 area samples. These concentrations were all well below the current full-shift exposure limit of 50 ug/m^3 for NIOSH and ACGIH. Short-term air samples collected while an employee was using a powered vacuum cleaner ranged from 19 to 32 ug/m^3 in three samples. The highest value was obtained in a personal sample worn by the employee conducting vacuuming. Concentrations of mercury in 44 instantaneous area air samples were all below 20 ug/m^3 (arithmetic mean = 8.5 ug/m^3). Nine instantaneous air samples collected while the employee ran the vacuum cleaner, ranged from 33 to 97 ug/m^3 (arithmetic mean = 67 ug/m^3). All values were below the OSHA standard of 100 ug/m^3 (as a ceiling value not to be exceeded). Surface readings for mercury contamination were higher in the immediate vicinity of mercury use areas. The highest contamination readings were obtained on the powered vacuum cleaner used to clean the office carpeting. A bulk sample of "separation" material previously used for dental models contained 40 - 45% chrysotile asbestos. Methyl methacrylate concentrations were low.

Two of the 11 office personnel interviewed reported symptoms (tiredness, fatigue, and memory loss) which they believed might be due to working in the office. It was not possible to correlate the symptoms with any chemical exposure.

Based on these results it has been determined that a health hazard did not exist for the dental office personnel from mercury exposure except when the powered vacuum cleaner was used. Instantaneous air concentrations averaged almost 8-times higher during vacuuming than at other times. Most work practices were consistent with recommended procedures. Recommendations made in Section VIII of this report include replacement of the old carpeting and the vacuum cleaner.

KEYWORDS: SIC 8021 (Offices of Dentists), mercury, mercury hygienic techniques, vacuum cleaner, asbestos

II. INTRODUCTION

On February 11, 1987, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation at a dental office located in Cincinnati, Ohio. The request was submitted by several dental office employees concerned with the potential hazard from mercury exposure.

NIOSH visited the dental office on March 13, April 21 and May 5, 1987 to conduct an environmental evaluation. Results and recommendations were presented in a letter distributed on June 30, 1987.

III. BACKGROUND

The dental office constitutes one fourth of a small medical facility built in the 1950s. The dental office consists of six dental operatories, a laboratory, a waiting room, a reception area, an equipment room and a bathroom. The staff includes two full-time dentists, two part-time dentists, and nine support personnel including dental hygienists, dental technicians, and receptionists. The entire floor area is carpeted except for the equipment room. The carpeting was estimated to be about 10 years old.

Typical work hours are from 8:30 a.m. to 5:00 p.m. The office staff was not certain of how much mercury they used per year. Mercury is used for making amalgams. The number of amalgams made per day varies but is usually less than 10. The office does not use any anesthetic gases but is considering using a nitrous oxide system. When an amalgam is needed, a dental assistant places an amalgam tablet into a small capsule and adds a measured amount of mercury. The capsule is then capped and vibrated in a small machine called an amalgamator for 15 seconds. The amalgam is then given to the dentist, who uses it to fill a recently drilled cavity. The process appears similar to that described in other publications.[1,2] The office had four amalgamators, two of which had covers for the vibration chamber.

In addition to daily staff clean-up, one employee cleaned the office once a week over a two-hour lunch break (for the other employees). During this time a powered vacuum cleaner was used for about 45 minutes.

IV. MATERIALS AND METHODS

On March 13, 1987, a NIOSH investigator conducted an initial visit at the dental office. Subsequently visits were conducted on April 21 and May 5, 1987. The investigation consisted of airborne monitoring for mercury, evaluation of general mercury contamination, and evaluating employee work practices. In addition, air samples for methyl methacrylate and carbon dioxide, and a bulk sample (for asbestos analysis) of a separation material (no longer used) were collected.

Airborne mercury samples were collected using sorbent tubes, and a Jerome Instruments Company mercury vapor analyzer - Model 411. Sorbent tubes were used to collect full-shift time-weighted-average (TWA) and short-term air samples to estimate personal exposures to airborne mercury. The mercury vapor analyzer was used to evaluate instantaneous airborne mercury concentrations and to obtain surface level readings to evaluate mercury surface contamination.

The sorbent tubes were attached via flexible tubing to battery-operated pumps calibrated at approximately 0.1 liters of air per minute (LPM). The tubes were analyzed using flameless absorption spectroscopy. Carbon dioxide samples were collected using Draeger gas detector tubes.

All full-time office personnel were administered questionnaires to determine if they were experiencing health effects that might be due to working in the office.

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 (TLVs), and 3) the U.S. Department of Labor (OSHA) occupational health standards.[3-5] Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLVs 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 those levels specified by an OSHA standard.

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.

B. Inorganic Mercury

Mercury can enter the body through the lungs by inhalation, through the skin by direct contact, or through the digestive system.[6]

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.[6,7] 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.[6,7]

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).[7] 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]

VI. RESULTS

A. Environmental Sampling

1. Mercury

Table I presents the results of full-shift TWA concentrations for mercury collected on sorbent tubes. Airborne concentrations ranged from 4.1 to 13 ug/m^3 for 22 personal samples and from 5.3 to 11 ug/m^3 on eight area samples. Table 2 presents mercury air concentrations for short-term air samples collected on sorbent tubes. Mercury concentrations in one personal and two area samples ranged from 19 to 32 ug/m^3. These three samples were collected while an employee ran a powered vacuum cleaner, during the lunch break.

All values were below the current full-shift criterion of 50 ug/m^3 for NIOSH and ACGIH. All samples were less than 40% and 13 of the samples were less than 20% of the criterion.

Table 3 presents the results of instantaneous area sampling for mercury vapor concentrations, collected using the mercury vapor analyzer. Concentrations ranged from 1 to 17 ug/m^3 for 44 readings (arithmetic mean = 8.5 ug/m^3). As a comparison Table 4 presents the results of instantaneous samples for mercury collected while an employee ran the powered vacuum cleaner. Air concentrations ranged from 33 to 97 ug/m^3 on 9 samples (arithmetic mean = 67 ug/m^3). Four of the nine readings were at or above 88 ug/m^3. While all samples were below the OSHA PEL of 100 ug/m^3 (ceiling value not to be exceeded) the arithmetic mean value was almost 8-times higher during vacuuming than at other times.

Figures 1-2 present the results of mercury concentrations measurements taken near surfaces. Highest values were found in the immediate vicinity of mercury use areas (amalgamators). Most readings were relatively low (0-10 ug/m^3) except at the mercury use areas where readings ranged up to 312 ug/m^3. The NIOSH investigators noted mercury concentrations near the rug surface increased after the powered vacuum cleaner was used (Figure 2). Values often increased by 2-4 times.

The highest readings were obtained on or inside the powered vacuum cleaner. Readings of 1300 and 1700 ug/m^3 were measured inside the vacuum cleaner beater bar and hose respectively.

2. Other Chemicals

The bulk sample of the "separation" material, once used for dental models, contained 40 - 45% chrysotile asbestos. This material was no longer used but had been stored in a drawer, located in the laboratory.

Indoor carbon dioxide (CO_2) concentrations ranged from 1800 to 2200 ppm on April 21 (outdoor values were 400 - 500 ppm) and from 1350 to 2150 ppm on May 5, 1987 (outdoor values were 300 ppm). As a comparison, CO_2 concentrations of above 1000 ppm are indicative of poor indoor air quality and usually associated with widespread occupant complaints. Unless there is a source of CO_2, other than the normal expired breath of occupants, this data suggest that more outside air should be introduced into the dental suite.[8-10]

Methyl methacrylate concentrations were 2.4 milligrams per cubic meter of air in one 29 minute personal sample, collected while an employee used orthodontic resin and a caulk repair material. One 1-1/2 hour area sample measured 0.4 mg/m^3. Methyl methacrylate was detected in the backup section of the sorbent tube, indicating there may have been some breakthrough. The only corresponding short-term criteria was the ACGIH STEL of 510 mg/m^3.[11] ACGIH deleted the STEL in their 1987-1988 TLV Booklet.[4] For chemicals with no assigned STEL, the concept of an Excursion Limit is used. The Excursion Limit is, that the short-term exposure should not exceed, the TLV-TWA by more than 3 to 5 times, depending on length of the excursion.[4] The current TLV-TWA for methyl methacrylate is 410 mg/m^3.[4]

B. Questionnaires

Results of the questionnaires administered to all 11 full-time office personnel revealed that most employees were not experiencing adverse health effects. Only two of those questioned reported symptoms that might be due to working in the dental office. One reported symptoms of fatigue while in the office and one reported some memory loss. This symptom, which has been associated with chronic or long-term mercury exposure, would not be expected from exposures in the range measured in this dental office. Past exposure to mercury, if levels were higher, (this person had worked in a dental office for over 25 years) could be responsible.

C. General Observations

At the time of the NIOSH survey the dental office was using some good techniques for working with mercury. Two of the amalgators were equipped with covers for the vibration compartments. Additionally, amalgam scrap was stored under a solution and the office was clear of visible mercury contamination. Employees were aware of mercury being a hazardous material and appeared to be conscientious about housekeeping.

VII. DISCUSSION AND CONCLUSIONS

The results of this investigation indicate that while TWA personal exposures to airborne mercury concentrations were well below the current occupational exposure limits, the powered vacuum cleaner was a primary source of mercury exposure. Mercury air concentrations were much higher during vacuuming. Mercury/amalgam surface contamination was highest in the immediate vicinity of mercury use areas (i.e. mixing area). Methyl methacrylate air concentrations were low.

The results of mercury vapor surface measurements taken on the vacuum cleaner suggest that its use may have reduced the overall carpet contamination. Some publications have discussed the effectiveness of vacuum cleaners in mercury clean-up.[7,12] The problem of using a standard vacuum cleaner is discussed in another article. The article reported that after vandals spilled twenty pounds of mercury in a dental office, airborne mercury levels increased, when a vacuum cleaner was used to clean the spill.[13] The authors note that the old vacuum cleaner continued to generate hazardous levels of mercury even after new carpeting was installed in the office. While that situation was unusual and differs from the one encountered at the Rothan Dental office, the NIOSH investigators observed the same type of problem with the use of a standard vacuum cleaner.

Dental offices often have carpeting due to consideration of safety, aesthetics, and comfort.[14,15] Another reported advantage is that carpeting limits the area of contamination from a mercury spill.[13] The principal problem with carpeting is that once it is contaminated with mercury, decontamination is virtually impossible. For carpeted offices, two of the best recommendations are to replace the carpeting (especially in high use areas) often and use vacuum cleaners specifically designed for mercury clean up. Regardless of the type of flooring present, the most important recommendation for working with mercury is to use good mercury-hygiene-techniques. Good work practices will limit mercury contamination of the floor and other surface areas.

In addition to the previously referenced articles, the American Dental Association provides literature on safety and hygiene for dental facilities. This literature includes specific guidelines for working with various materials, including mercury and X-ray equipment.[16]

VIII. RECOMMENDATIONS

The following recommendations are made per conditions encountered during the NIOSH survey.

1. The old carpet which is contaminated with mercury should be replaced.

2. If new carpeting is installed, vacuum cleaners designed for mercury clean up - such that mercury vapor is not discharged into the workroom air - should be obtained and used.

3. Spilled mercury droplets should be cleaned up using a vacuum system with a water trap.

4. Pre-enclosed amalgam capsules should be considered for future use, as this would eliminate one mercury-handling step.

5. The amalgamators not equipped with vibration chamber covers should be so equipped.

6. The old separation material should be disposed of and the drawer it was stored in and all the contents of the drawer, cleaned with a wet cloth.

7. If a nitrous oxide system is installed, it should be equipped with a scavenging system.

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Table 1

Airborne Mercury Concentrations
Personal and Area Samples

Rothan & Rothan, DDS
Cincinnati, Ohio
HETA 87-147

Job/Location	Sample Number	Date	Sampling Time	Sample Volume (Liters)	Air Concentration (ug/m^3)
Dentist A	010	4/21	833-1210 1412-1715	39	4.9
	036	5/5	832-1218 1412-1738	41	8
Dentist B	011	4/21	832-1204 1413-1717	38	7.6
	037	5/5	840-1211 1413-1711	40	6.7
Dental Asst. A	013	4/21	838-1207 1405-1653	36	5.5
	039	5/5	830-1225	39	8.2
Dental Asst. B	004	4/21	825-1204 1406-1621	36	6.5
	030	5/5	822-1222 1408-1736	41	7.3
Dental Asst. C	007	4/21	831-1208 1358-1650	39	13
	033	5/5	829-1159 1400-1704	40	7.5
Dental Asst. Office Manager A	005	4/21	827-1205 1402-1707	40	11
	031	5/5	823-1157 1358-1713	39	4.1
Dental Asst. Office Manager B	006	4/21	823-1201 1356-1714	42	7.4
	032	5/5	822-1209 1404-1735	43	6.9

(continued)

Table 1 (continued)

Job/Location	Sample Number	Date	Sampling Time	Sample Volume (Liters)	Air Concentration (ug/m^3)
Dental Hygienist A	009	4/21	826-1211 1408-1646	39	6.4
	035	5/5	825-1221 1331-1707	45	6.9
Dental Hygienist B	008	4/21	831-1202 1355-1710	40	8.7
	034	5/5	835-1220 1330-1714	45	8.2
Receptionist A	012	4/21	837-1203 1355-1703	38	8.2
	038	5/5	824-1206 1404-1742	42	7
Receptionist B	014	4/21	844-1206 1411-1647	35	7.8
	040	5/5	0835-1209 1414-1714	38	6.9
On light in dental operatory room no.	015	4/21	944-1215 1418-1657	29	11
X-ray room on wall near x-ray machine	017	4/21	935-1215 1417-1655	31	7.8
	043	5/5	857-1211 1420-1651	34	5.3
Reception Area on column	018	4/21	940-1216 1419-1659	30	7.2
	044	5/5	852-1212 1422-1658	37	6.7
	046	5/5	852-1212 1422-1658	37	7
Dental operatory no. 5 on cabinet	041	5/5	906-1211 1421-1741	37	6.4
Dental operatory no. 2 under shelf	042	5/5	902-1212 1423-1703	35	7.5
Outside in parking lot	016	4/01	952-1213 1420-1646	26	ND

Occupational exposure criteria: NIOSH and ACGIH = 50(ug/m^3)(8-10 hour TWA)
Arithmetic mean of 22 personal samples = 7.5 ug/m^3
Arithmetic mean of 8 area samples = 7.4 ug/m^3
Arithmetic mean of all 30 indoor personal and area samples = 7.5 ug/m^3

Table 2

Short Term Mercury Air Concentrations Collected During Vacuuming

Rothan & Rothan, DDS
Cincinnati, Ohio
HETA 87-147

Name/Location	Sample No.	Sample Time	Sample Volume (Liters)	Concentration (ug/m^3)
Employee doing vacuuming cleaning personal sample	055	1314-1340	13	32
Operatory Room No. 5, on sink area sample	056	1314-1340	13	27
Reception Area-on column On Counter, area sample	057	1314-1340	13	19

Occupational exposure criteria: OSHA = 100 ug/m^3(ceiling)

These samples were collected while employee cleaned the office during a 2-hour lunch break. Other employees left the office during the lunch break.

Table 3

Instantaneous Mercury Air Concentrations
Samples Collected with Direct Reading Instrument

Rothan & Rothan, DDS
Cincinnati Ohio
HETA 87-147

Location	Date	Time	Air Concentration (ug/m^3)
Equipment/supply	4/21	1042	8
	4/21	1138	6
	4/21	1551	14
	5/5	955	3
	5/5	1127	8
	5/5	1419	15
	5/5	1600	8
X-ray room by area sample	4/21	1043	7
	4/21	1134	6
	4/21	1553	16
	5/5	956	4
	5/5	1129	7
	5/5	1420	15
	5/5	1602	7
Laboratory by sink	4/21	1045	8
	4/21	1137	8
	4/21	1554	17
	5/5	958	5
	5/5	1130	10
	5/5	1421	15
	5/5	1607	8
In hall between room 3 & 4	4/21	1046	6
	4/21	1135	5
	4/21	1555	16
	5/5	1000	5
	5/5	1130	10
	5/5	1422	15
	5/5	1608	7
Reception area on column	4/21	1046	5
	4/21	1135	4
	4/21	1555	13

Table 3 (continued)

Location	Date	Time	Air Concentration (ug/m^3)
Room 2 on table	4/21	1047	1
	4/21	1136	1
	4/21	1556	5
Waiting Area	4/21	1048	5
	4/21	1130	9
	4/21	1545	15
	5/5	1001	4
	5/5	1132	7
	5/5	1424	13
	5/5	1613	6
At front door, inside	4/21	1049	6
	4/21	1131	10
	4/21	1559	10
Outside	4/21	1051	0
	4/21	1132	2
	4/21	1536	0
	5/5	1008	6
	5/5	1134	1
	5/5	1425	ND
	5/5	1618	ND

Occupational exposure criteria: OSHA = 100 ug/m^3(ceiling)

Arithmetic mean of 44 office samples (does not include samples collected inside front doo or outside) = 8.5 ug/m^3

Table 4

Instantaneous Mercury Air Concentrations
Collected While Employee Ran Powered Vacuum Cleaner

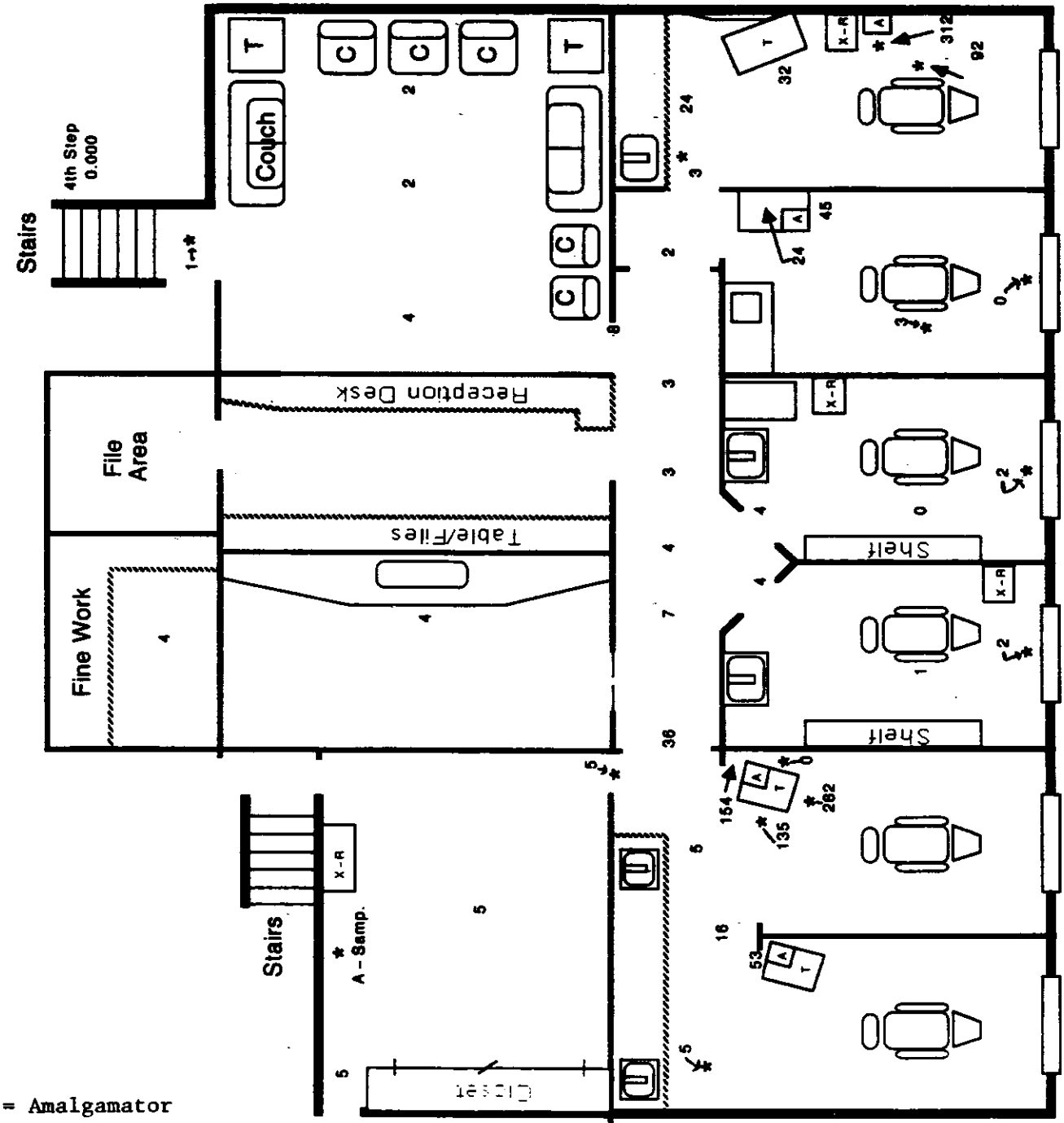
Rothan & Rothan, DDS
Cincinnati, Ohio
HETA 87-147

Location	Time	Mercury Air Concentrations
Breathing zone above vacuum cleaner	1320	35
Breathing zone 5 feet from where employee was vacuuming	1332	54
	1333	97
	1334	48
	1334	95
	1335	88
	1335	94
	1336	73
	1337	33

Occupational exposure criteria: OSHA = 100 ug/m^3(ceiling)

Arithmetic mean of these nine samples = 69 ug/m^3

Figure 1
Surface Mercury Vapor Readings (ug/m^3)
Rothan & Rothan, DDS
HETA 87-147
April 21, 1987



A = Amalgamator
A-Samp = Area Sample
X-R = X-ray Machine
C = Chair
T = Table

Figure 2
Surface Mercury Vapor Readings (ug/m^3)
Before and After Powered Vacuum Cleaner was operated for 45 minutes
Rothan & Rothan, DDS
HETA 87-147
April 21, 1987