FINAL REPORT

MERCURY CONTROL TECHNOLOGY ASSESSMENT STUDY

Sybron/Taylor Medical Products Division
Arden, North Carolina

In-depth Survey Report
for the Site Visits of
March 23-24, 1981 and
October 20-22, 1981

Contract No 210-81-7107

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Submitted to

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FOREWORD

A Control Technology Assessment (CTA) team consisting of members of the National Institute for Occupational Safety and Health (NIOSH) and Dynamac Corporation, Enviro Control Division, met with representatives of the Sybron/Taylor Medical Products Division at the Arden, North Carolina, plant on March 23-24, 1981, to conduct a preliminary survey on the techniques used to control worker exposure to mercury. An indepth survey was conducted at the same facility on October 20-22, 1981, to conduct a detailed study of the Mercury Fill Room. Participants in the surveys were:

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A. Ingle, Group Leader
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The preliminary CTA survey was completed in 2 days. The study included air sampling, detailed inspections of plant equipment, review of equipment drawings, and interviews with personnel in operations, safety, and engineering.

The indepth CTA survey was completed in 3 days. The survey included personal and area monitoring, a ventilation study of the Mercury Fill Room, and a detailed study of the operation of the Taylor Mercury Fillers.

This report contains both general information obtained in the preliminary survey and specific information obtained in the indepth survey. Emphasis is placed on controls in the Mercury Fill Room. The preliminary survey report, available on request from Mr. A. Amendola, NIOSH, contains detailed information on the controls in the Glass Department.

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INTRODUCTION

CONTRACT BACKGROUND

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

JUSTIFICATION FOR SURVEY

The Sybron/Taylor Medical Products Division (Taylor Instruments) plant was selected for a survey because it is a large-scale producer of mercury-filled thermometers. Over 55 employees are involved in the manufacture of thermometers. Control strategies at the Taylor Instruments plant include an extensive ventilation system and a unique mercury fill system.

SUMMARY OF INFORMATION OBTAINED

An opening conference was held during which the objectives of the program were discussed with Taylor representatives. Information on mercury controls was obtained from meetings with the production foreman, health and safety officer, and facilities engineer. Detailed drawings of the ventilation system for the thermometer manufacturing area (Glass Department) were obtained from the engineer. Area and personal monitoring of workers in the Mercury Fill Room was conducted. Airflows in the air exhaust and air supply systems were measured.

PLANT DESCRIPTION

The Taylor Instruments plant is located in Arden, North Carolina. The area around the plant is forestland. Products produced at the plant are: mercury-filled thermometers, spirit thermometers (isopropyl alcohol and dye filled), mercury sphygmomanometers, stethoscopes, and other medical products.

Mercury thermometers are manufactured in the Glass Department of the Taylor Instruments plant. The Glass Department is isolated from the rest of the plant because it is the only area of the building in which mercury is handled. This part of the building is 17 years old. It is constructed of steel beams and masonry. The ventilation system is separate from that of the rest of the plant. There are no windows in the Glass Department.

The Glass Department consists of three offices and eleven rooms used for production. Most of the rooms have either sliding or swing-shut doors that are kept closed to reduce the dispersion of mercury vapor throughout the Glass Department. Figure 1 illustrates the layout of the department, and each work station involved in the production of mercury thermometers is identified. Some of the production steps are performed in other areas of the Glass Department than those labeled. The work stations identified on the diagram are where each production step is most normally performed.

Spirit thermometers are also manufactured in the Glass Department. These work stations are not described in this report.

The plant operates one production shift per day, 5 days per week, with a skeleton second shift. There are approximately 44 production workers in the Glass Department, including 5 workers on the second shift. Approximately 10 of these workers are involved in processes that are considered by plant management to have high potential for exposure to mercury. These processes are:

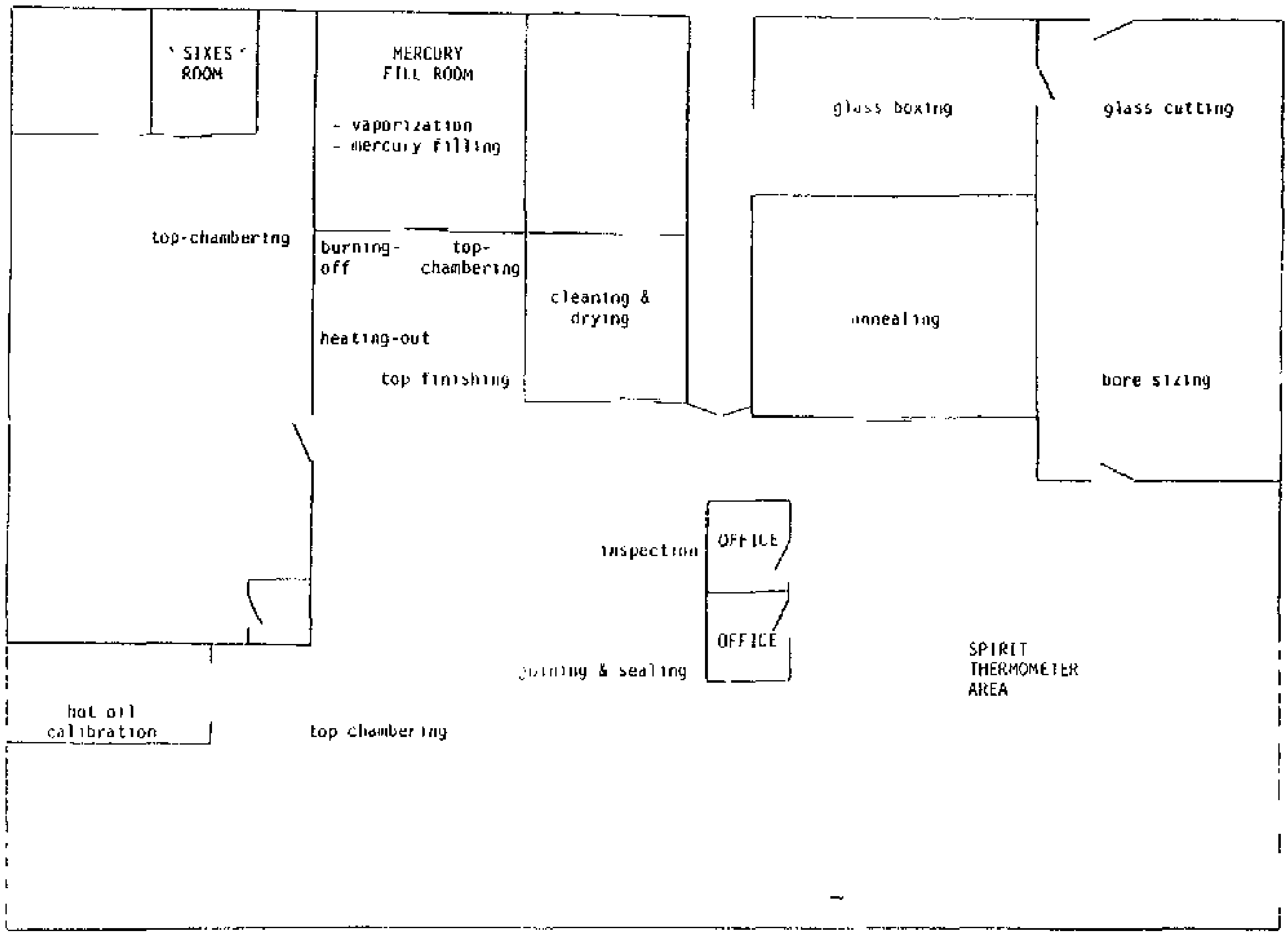

Figure 1 Glass Department Layout

- Industrial thermometer manufacturing
- "Sixes" thermometer manufacturing (maximum-minimum thermometers)
- Industrial odds and ends manufacturing (specialty instruments)
- Industrial thermometer repairing
- Sphygmomanometer manufacturing.

In addition to production workers, there are two maintenance workers who may be exposed to mercury.

PROCESS DESCRIPTION

THERMOMETER MANUFACTURING PROCESS

The thermometer manufacturing process described below has been in effect at Taylor Instruments since production began in 1965.

Tube and Bulb Preparation

Long glass tubes are cut to specified lengths, and the exact bore hole size of each tube is determined in order to select the correct sized bulb for the tube. Volumetric measurement of bore size is conducted by measuring the length of a specified volume of mercury within the tube bore. Approximately 25 percent of the tubes are measured volumetrically with mercury. Tubes are grouped into batches of specific bore hole sizes. One end of the tube is heated over a burner and a short glass tube is joined to it. This short tube is formed into a bulb by heating the open end, crimping it closed, breaking off the crimped piece of glass, and rounding off the tip of the resulting bulb.

Residual mercury in each glass tube must be vaporized and removed before the annealing process so that the mercury will not oxidize and produce a solid when heated. This is accomplished by using the Taylor Mercury Filler in the Mercury Fill Room. The mercury filler consists of a bell jar and a mercury fill system. Each batch of tubes is sealed in the bell jar and the bell jar is evacuated. The oven is lowered over the bell jar and is heated to 370 C (700 F) for approximately 6 hours. Mercury in the tubes is vaporized and is pulled out of the tubes by a vacuum. The tubes are then annealed and cleaned in preparation for mercury filling.

Mercury Filling

Prepared tubes are brought to the Mercury Fill Room. Each batch is set with open ends down into a pan. The pan is set under the bell jar and the bell

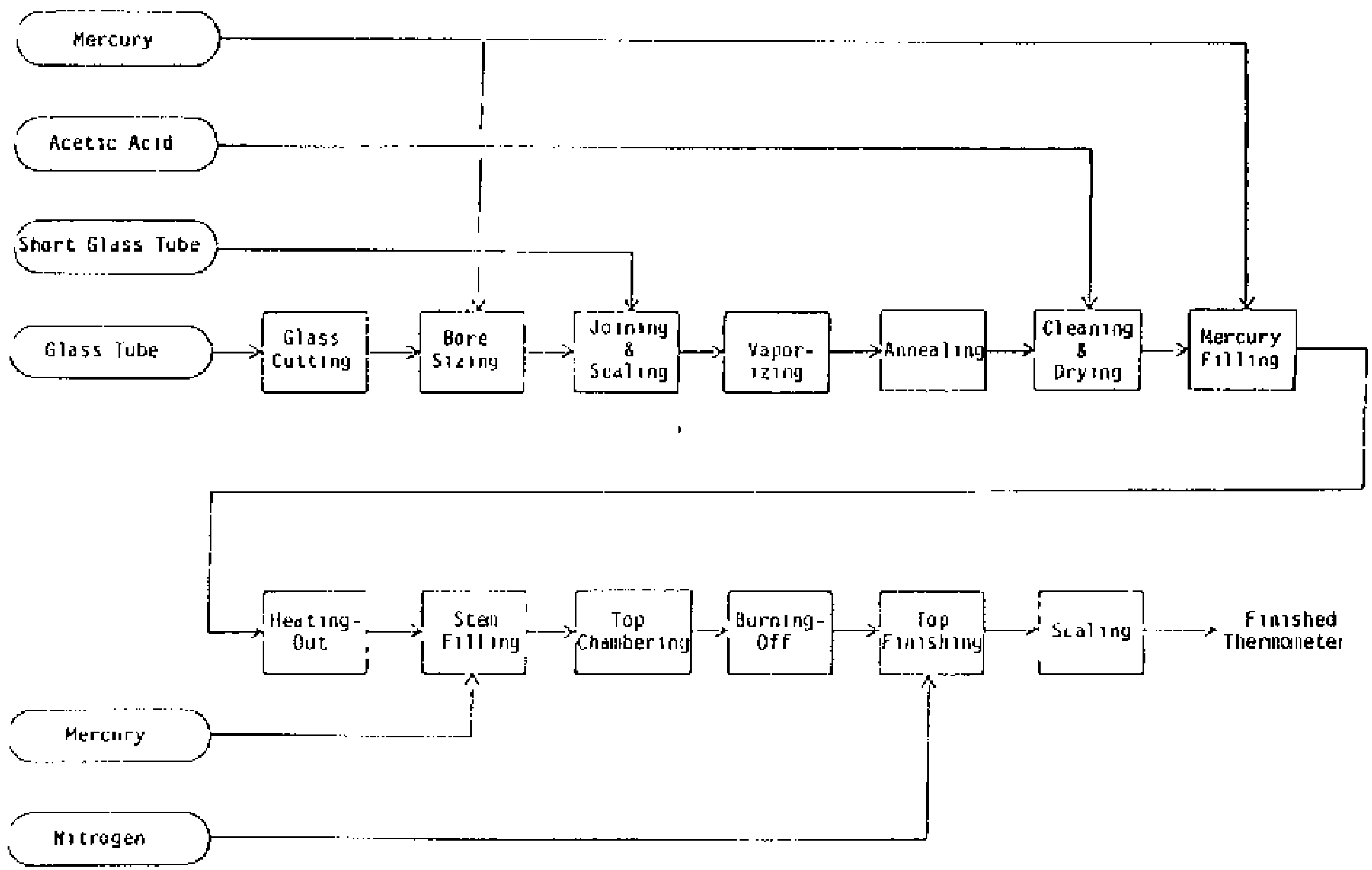

Figure 2 Thermometer Manufacturing Process

jar is lowered and sealed. The oven is lowered over it. A vacuum is drawn and, at the same time, the tubes are heated. Mercury is allowed to flow into the pan by opening a valve at the side of the unit. When the vacuum is released, the mercury flows from the pan up into the tubes. The oven is lifted, thermometers are allowed to cool, and the pan containing filled tubes and excess mercury is removed from the bell jar. A plastic bag is put over the pan and it is set aside.

Thermometer Finishing

Excess mercury in the tube stems is driven out the open ends by immersing the bulb ends of the tubes in a hot water bath (heating-out). The stems of the tubes are then filled with mercury to a specified point. Open ends of the tubes are melted closed and a bubble chamber (top chamber) is formed at the tops of the tubes. The mercury column is shortened to a specific height by the burn-off process. Tubes are cut to finish length and the ends of some of the tubes are formed into a ring. The completed tubes are graduated according to the appropriate temperature range.

MERCURY CONTROL TECHNIQUES

PROCESS DESIGN AND MODIFICATIONS

Taylor Mercury Filler

The Taylor Mercury Filler (Figure 3), which is used for introducing elemental mercury to the glass thermometer tubes, is operated in a manner that helps to control the emission of mercury vapor. The vacuum maintained in the sealed bell jar reduces the escape of mercury vapor during the fill process. Liquid mercury is contained either inside the thermometer tubes or in a pan under the tubes. The Taylor Mercury Filler consists of a bell jar, a vacuum system, an oven, and a closed mercury addition system (Figure 4).

Bell Jar--
The bell jar rests on an annular-shaped ceramic base set on a bench. By lifting the bell jar, pans of thermometers can be set inside the annular base. The bottom of the pan rests on a set of deflection plates that cover a hole leading to the vacuum system. These plates prevent liquid mercury from falling into the vacuum hole. There is also a 1-inch circular metal lip around the plates to prevent mercury droplets from flowing from the bell jar base into the hole. When the bell jar is lowered, it sets into a seal at its base, which prevents leaks when the vacuum is drawn.

Vacuum System--
The vacuum is drawn through a series of two pumps consisting of a Cenco HYVAC 7 fore pump (run by a 0.5-horsepower Dayton motor) and a mercury diffusion pump built by Taylor. The fore pump is a standard vacuum pump that is capable of drawing a vacuum down to 100 micrometers (um). The pump has a mercury trap at the intake. The mercury diffusion pump takes over at 100 um and is capable of drawing a vacuum in the bell jar down to 1 um.

Oven--
An oven is used to remove moisture from the glass tubes and to assist in drawing a vacuum. The oven consists of a hollow ceramic cylinder with a

Figure 3. Taylor Mercury Fillers.

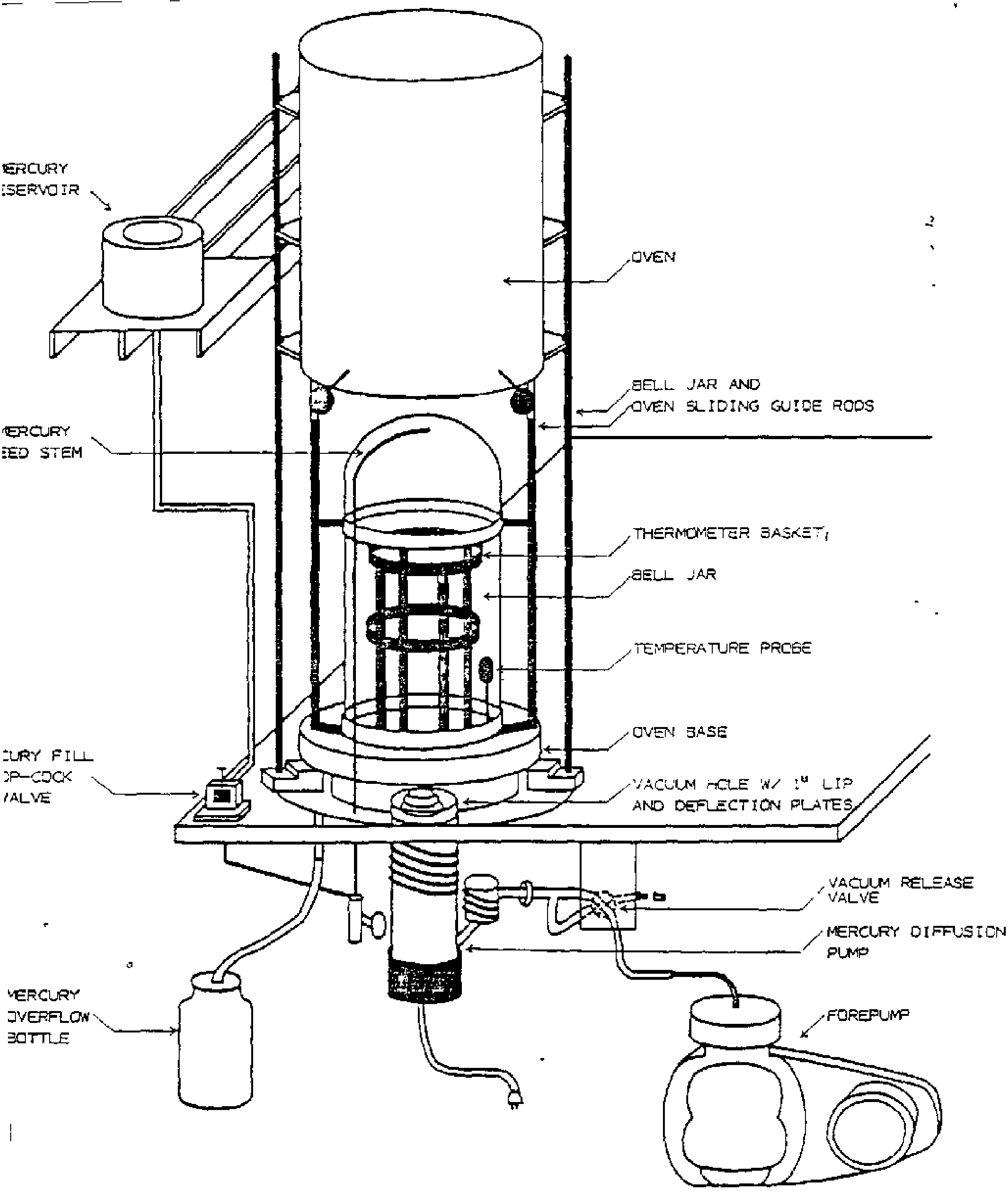

Figure 4. Schematic Diagram of Taylor Mercury Filler.

stainless steel shell and a heating element. It is lowered over the bell jar and seals against the ceramic base.

Mercury Addition System--

The mercury addition system is the major control in the Mercury Filler. It is a completely enclosed system that, when coupled with the sealed bell jar, mercury deflection plates, and dual vacuum system, helps to prevent the escape of mercury liquid and vapor. Mercury is contained in a covered stainless steel reservoir mounted above the bell jar. One reservoir is used to supply three Mercury Fillers. Stainless tubing connects the reservoir to a stopcock valve mounted below it on the bench. From the stopcock, additional tubing leads down under the bench and up through a mercury feed stem inside the bell jar. By opening the valve, mercury flows through the tubing to the feed stem and into the top of the bell jar where it falls over the tubes into the pan below.

The present mercury addition system is being replaced by an aspirator system that will provide a purer quality mercury to the Filler. This new system consists of an aspirator jar (with a double-holed stopper at the top and a mercury feed tube at the bottom) and an oxygen and argon injection system. The system will work in the following manner:

- Mercury is poured into the aspirator jar and the jar is capped with the double-holed stopper.
- The jar is evacuated through one stopper hole.
- Oxygen is pumped into the second stopper hole and bubbled through the mercury in order to oxify (purify) it.
- The oxygen is shut off and the vacuum is released.
- Argon is injected through the first stopper hole. Argon, which is heavier than air, keeps air from coming in contact with the mercury.
- The mercury stopcock valve is opened, allowing mercury to flow out of the aspirator and into the Filler.

The scum that will develop on the mercury surface due to oxidation will have to be skimmed off approximately once per month.

CONTAINMENT

Worktables in the Fill Room have been designed to minimize mercury absorption and spillage. All work surfaces are made of stainless steel to prevent mercury permeation. Tables where workers store thermometers have either half-inch lips around the edges or gutters along the sides to contain the mercury droplets and prevent them from falling off the table. The gutters have a drain hole through which mercury may be removed.

The transfer station where mercury is poured into containers has a screened work surface over a sloped stainless steel sink that drains into a mercury collection bottle. This station effectively collects small mercury spills that occur as a result of the pouring.

All table legs are caulked at the floor to prevent mercury from collecting under them.

GENERAL VENTILATION

The general ventilation in the Mercury Fill Room is particularly important due to the large amount of heated mercury handled there. Mercury control is accomplished by an exhaust air and a supply air system designed to move approximately 5,200 cubic feet per minute (cfm) of air through the room.

Air is supplied to the room by a 5,200 cfm (design) Trane Air Handler and is delivered through two ceiling, circular diffusers. The air handler fan is powered by a 5-horsepower motor and has an outlet velocity of 1,550 feet per minute (fpm). The total cooling load is 300,000 British thermal units per hour (Btu's/hr), and the heating load is 253,000 Btu's/hr.

Air is exhausted from the room by a 5,200 cfm (design) exhaust fan operating at a suction pressure of 0.75 inches of water. The exhaust air system consists of five rectangular floor exhaust ducts. There are four 8-inch by 16-inch ducts and one 12-inch by 18-inch duct. The locations of these exhausts within the Fill Room are illustrated in Figure 5. Locating the face of the exhaust

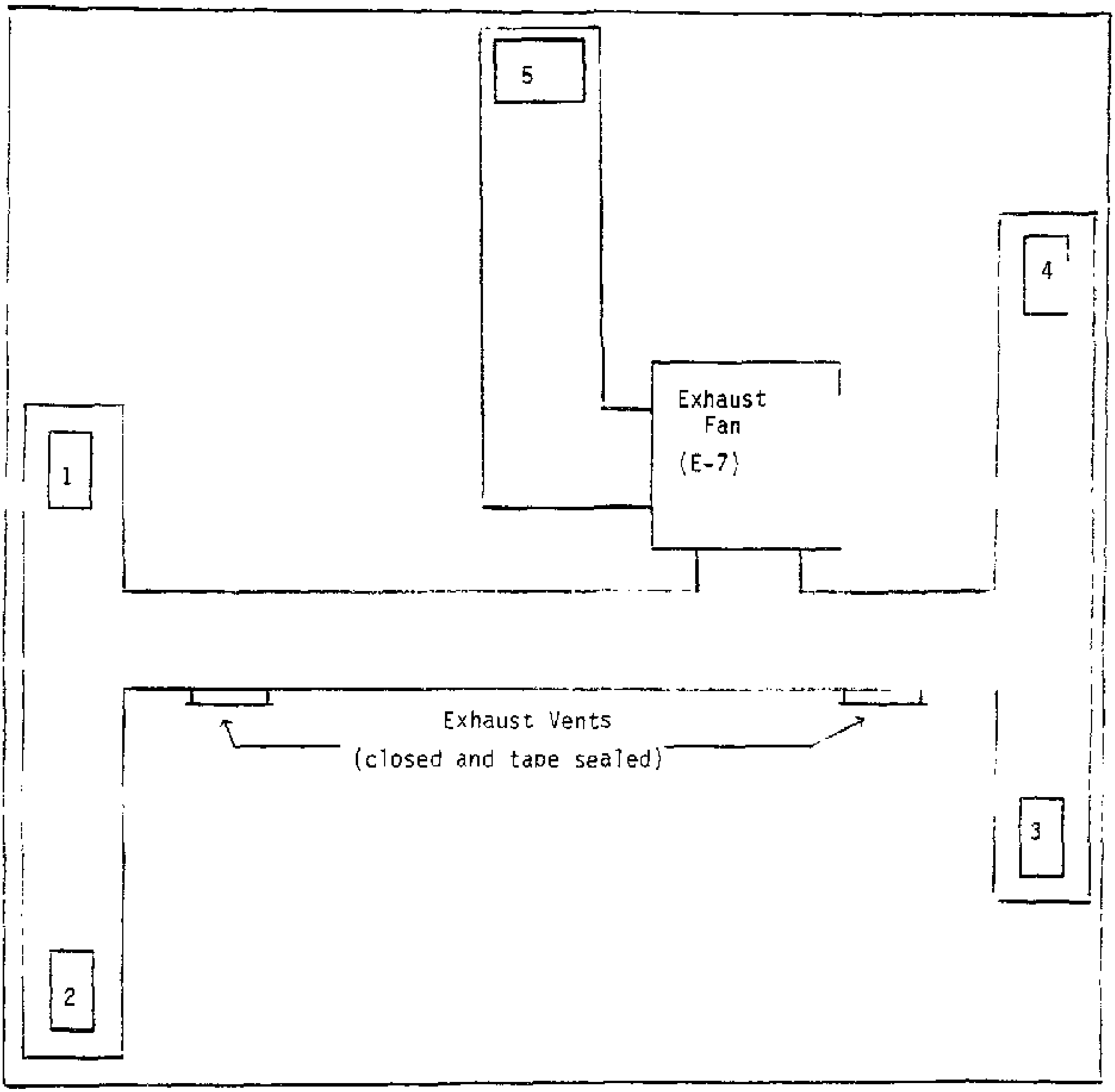

Figure 5. Mercury Fill Room Exhaust Air System.

ducts at floor level does not necessarily improve mercury vapor removal from the Fill Room because mercury vapor is assumed to be uniformly mixed with the room air.

Airflow measurements conducted during the survey show that Taylor is presently supplying and exhausting approximately 3,500 cfm of air in this room (see Survey Data section). The total room volume has been calculated to be 16,320 cubic feet (cu ft). The general airflow in the Fill Room is from the supply registers at ceiling level to the exhausts at the floor level.

TEMPERATURE CONTROL

The temperature of the Glass Department at Taylor Instruments is maintained below 21 C (70 F) in order to reduce mercury vaporization. This control is important because a deviation of a few degrees above the 21 C (70 F) limit can result in a significant increase in the vapor pressure of mercury, causing the vaporization rate to increase. Table 1 illustrates the effect of temperature on mercury vaporization.

TABLE 1

Temperature Effect on Mercury Vapor Pressure

Temperature (C)	Temperature (F)	Vapor Pressure of Mercury (in 10^{-6} mmHg)
16	60.8	846
18	64.4	1,009
20	68.0	1,201
22	71.6	1,426
24	75.2	1,691
26	78.8	2,000
28	82.4	2,359
30	86.0	2,777

The table shows that by raising the ambient air temperature from 18 C (64.4 F) to 26 C (78.8 F), the vapor pressure of mercury is doubled. It can also be seen that a temperature increase from 24 to 26 C results in almost twice the vapor pressure increase as a temperature increase from 16 to 18 C. Lowering the temperature a few degrees in an environment where a large amount of mercury is used may make the difference between achieving or exceeding the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL).

PERSONAL PROTECTIVE EQUIPMENT

When a worker is required to remain inside the Mercury Fill Room for more than 15 minutes on a single occasion, he/she must wear a respirator (3M #8707, air-purifying, half-face disposable respirator, containing iodine impregnated charcoal as the primary adsorption medium). In the case of a large mercury spill (greater than 1 quart), the worker responsible for vacuuming up the spill must wear a respirator, latex gloves, and a disposable cloth suit.

WORK PRACTICES

Work practices in effect at Taylor to reduce worker exposure to mercury are:

- A syringe is used to transfer mercury during bore sizing of tubes.
- Tube stems are filled using syringes to reduce dermal contact.
- Doors of each mercury handling room are kept closed.
- Employees are required to wash their hands before eating, smoking, and leaving the plant.
- The area is evacuated in the event of large mercury spills (greater than 1 quart).
- The time workers can spend inside the Mercury Fill Room is limited to 1-2 hours per day. Also, workers without a respirator should not remain inside this room for more than 15 minutes on any single occasion.
- Smoking is permitted only at several designated areas within the production area. These areas include some work stations.
- All production steps involving the heating of mercury-filled tubes are conducted at work stations where local exhaust ventilation is present.
- Job rotation is conducted in areas where a high potential for exposure to mercury exists.

HOUSEKEEPING

Housekeeping practices in effect at Taylor include:

- Mercury-containing wastes are kept in a sealed 55-gallon drum in the Mercury Fill Room.
- Trashcans have closed lids.
- Mercury-filled tubes are kept in covered plastic storage bins.
- The epoxy painted walls are washed with soap and water every 6-8 weeks.
- Floors are washed with HgX[R], a mercury vapor suppressant, every 6-8 weeks.
- Production areas are vacuumed daily using Mer Vac[R] vacuum cleaners.
- Mercury spills are vacuumed immediately and checked either visually or with a mercury vapor detector (Bacharach MV-2) to determine the completeness of the cleanup.
- Mercury is stored in closed containers and kept in a closed storage cabinet.
- Plastic bags are kept over each pan that contains thermometers and excess mercury so as to reduce the amount of mercury vapor emitted.
- Work surfaces and floors are inspected routinely for mercury droplets. This is done by shining the beam of a flashlight in the plane of the surface to highlight the droplets.

MONITORING PROGRAMS

Biological Monitoring

Biological monitoring is an important part of the plant medical program. This involves routine (every 6 weeks) monitoring of selected workers' urine to determine the concentration of mercury. Grab samples rather than 24-hour urine composite samples are used. Usually only those workers in areas where potential exposure to mercury is considered to be high are monitored on a routine basis. If the concentration of mercury in urine exceeds 0.30 milligrams per liter (mg/L), the employee is transferred to an area where the potential for exposure to mercury is low. The employee is reinstated when the urine-mercury level drops below 0.30 mg/L. The biological monitoring program has been in effect at this facility since 1965. Analysis of urine for mercury is performed at the facility. Duplicate analysis is performed by an outside lab as a cross-check. Records are maintained by the safety director.

Air Contaminant Monitoring

The air sampling program is under the supervision of the plant Health and Safety Officer. The sampling program began in 1965 using a Beckman Mercury Vapor Detector. In 1971 this instrument was replaced with a Bacharach MV-2 Mercury Vapor Detector. Personal sampling to determine time-weighted average (TWA) exposure to mercury vapor is not conducted. Air sampling data collected at this facility has been maintained since 1965.

OTHER PROGRAMS

Medical Programs

Currently, preemployment physical examinations are given to all plant personnel. The examinations are given every 6 months to the workers in job categories considered to have high potential for exposure to mercury. Physical examinations may also be given based on the nurse's recommendation.

Education and Training

Each new employee at Taylor Instruments is given a training session in which plant mercury handling and cleanup procedures are taught. The employee also receives information on the potential health effects of mercury exposure.

SURVEY DATA

AIR SAMPLING DATA

Monitoring of the workplace air was conducted using two methods: a direct reading instrument that provides an instantaneous measurement of mercury vapor, and a long-term sampler to determine the integrated TWA exposure over the workshift. The former method employed the dual-range Jerome Model 401 Mercury Vapor Detector. This instrument has a sensitivity of 0.001 milligrams per cubic meter (mg/m^3) and a range of 0.001-0.5 mg/m^3.

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 using a buret (soapbubble meter). Analyses of samples were done by flameless atomic absorption. A summary of grab samples collected with the mercury vapor detector is presented in Table 2.

Workplace concentrations of mercury vapor were generally less than the PEL of 0.1 mg/m^3 (as a TWA) throughout the plant. Within the Fill Room, average concentrations increased from 0.049 mg/m^3 to 0.226 mg/m^3 when a fill unit was opened for thermometer removal. Average concentrations decreased to 0.030 mg/m^3 approximately 1 minute after the thermometers were removed and covered. The rapid dissipation of mercury vapor indicates an effective general dilution ventilation system. The concentration of mercury vapor ranged from 0.008 to 0.022 mg/m^3 in production areas other than the Fill Room.

Results of area samples to determine the full-shift TWA concentration of mercury vapor in the Fill Room are presented in Table 3.

TABLE 2

Results of Area (Grab) Samples Taken with a Mercury Vapor Detector*

Location	Average Concentration of Mercury Vapor (mg/m^3)	Comments
Glass Department	0.008 (3)**	--
Production Area (center of room)	0.014 (2)	--
High point etch	0.034 (2)	--
Fill Room	0.042 (2)	Fill units operating
Fill Room	0.292 (4)	Removing thermometers units
Outside Fill Room	0.022 (2)	--
Fill Room	0.032 (7)	Center of room-- fill unit operating
Fill Room	0.035 (8)	Center of room-- fill unit operating
Fill Room	0.049 (6)	3 feet from fill unit
Fill Room	0.226	Removing thermometers from unit
Fill Room	0.030 (2)	One minute after filled thermometers were removed and covered

*All readings taken at breathing zone height (approximately 5 feet).

**Number in parentheses indicates number of samples.

TABLE 3

Results of Area Samples Taken in Fill Room on October 20-22, 1981*

Location	Range of Mercury Vapor Concentrations (mg/m^3)	Average Concentration of Mercury Vapor (mg/m^3)
Center of Room	0.018-0.054 (3)**	0.040
3 feet from Fill Units	0.037-0.107 (3)	0.095

*All readings taken at breathing zone height.

**Number in parentheses indicates number of samples.

Both grab sample and TWA sample results indicate generally higher concentrations of mercury vapor near the fill units. Concentrations were lower elsewhere in the Fill Room, demonstrating that mercury vapor emitted from the units was being effectively exhausted or dissipated.

Personal monitoring was conducted to determine both full-shift TWA exposure and exposure during Fill Room activities. The results of personal monitoring (Table 4) demonstrate that the PEL was not exceeded during the survey. The samples are representative of daily mercury vapor exposure in that they encompass all of the routinely performed activities associated with thermometer filling and activities associated with other thermometer manufacturing operations.

TABLE 4

Personal Sampling Data
(Full Shift)

Employee	Job Classification/Date	TWA Concentration of Mercury Vapor (mg/m^3)
A	Fill Room Worker 10/20/81	0.036
A	Fill Room Worker 10/21/81	0.061
B	Fill Room Worker 10/22/81	0.052

The sampling period of the partial shift monitoring encompassed only the time spent inside the Fill Room each day. The sampling period TWA exposures are presented in Table 5.

TABLE 5

Personal Monitoring of Fill Room Activities
(Partial Period)

Employee	Job Classification/Date		Sample Time (min)	Sample Period TWA (mg/m^3)
A	Fill Room Worker	10/20/81	132	0.200
A	Fill Room Worker	10/21/81	175	0.050
B	Fill Room Worker	10/22/81	75	0.093
C	Fill Assistant	10/20/81	33	0.024
C	Fill Assistant	10/21/81	30	0.054

The results of both full-shift and partial-period sampling show that the controls in the Fill Room are effective in maintaining worker exposure levels below the OSHA PEL of 0.1 mg/m^3 (as an 8-hour TWA) for the periods of time that are normally spent in the Fill Room.

A substantial portion of the Fill Room Worker's exposure to mercury vapor is derived from Fill Room activities. The Fill Room worker's exposure during Fill Room activities was 0.20 (132 minutes' duration) on 10/20/81 and 0.093 (75 minutes' duration) on 10/22/81, indicating potential exposure above or near the OSHA standard if longer periods of time were spent in the Fill Room.

Consequently, the current practice of minimizing the amount of time a worker may spend inside the Fill Room is necessary to maintain worker exposure below the OSHA PEL.

VENTILATION STUDY OF MERCURY FILL ROOM

A ventilation airflow study was made on both the air exhaust and air supply systems in the Mercury Fill Room. This was conducted in order to compare actual with the design airflows.

Exhaust Airflow Measurements (Exhaust Fan E-7)

Airflow in the exhaust air system in the Mercury Fill Room was measured by a 16-point traverse using a standard Pitot tube with an inclined manometer. Flow was measured in each of the five rectangular floor ducts at approximately 5-1/2 feet up from the floor.

One of the ducts measured has an exhaust air takeoff leading to an exhaust hood. The door on this hood was closed, and the cracks were sealed with duct tape to cause the total exhaust flow to be through the floor duct. There are two exhaust air vents in the system at the ceiling level. These vents are normally closed. This resulted in the isolation of the exhaust airflow to the five floor ducts.

The results of the airflow measurements are shown in Table 6. The total measured airflow through exhaust system E-7 was 3,402 cfm. This compares to a design rating of 5,200 cfm.

TABLE 6

Exhaust Air System (E-7) Airflow Measurements
October 20 and 21, 1981

Duct Number	Duct Dimensions (in)	No. of Rectangles Measured	Rectangle Area (sq in)	Total Duct Area (sq in)	Average Velocity* (fpm)	Airflow** (cfm)
1	8 x 16	16	8	128	974	866
2	8 x 16	16	8	128	915	813
3	8 x 16	16	8	128	587	522
4	8 x 16	16	8	128	990	880
5	12 x 16	16	8	216	362	321

*Average of two separate readings taken on each duct: one on October 20 and one on October 21.

**Total measured exhaust airflow of system = 3,402 cfm.

Supply Airflow Measurement (Air Handler 4)

Airflow in the supply air system in the Mercury Fill Room was measured by a standard Pitot tube with an inclined manometer. Measurement was made in the rectangular duct at ceiling level approximately 14 feet downstream from the air handler. This point is 4 feet upstream from the first diffuser, and 1 foot downstream from a supply air takeoff leading to another room. Measurement was made at this point to minimize the turbulent effects of the air handler and diffuser and to obtain a reading that would not include the airflow through the supply air takeoff. Taking measurements so close to this takeoff may have influenced velocity pressure readings; however, the consistency of the readings indicated that this effect was probably minimal.

The results of the supply airflow measurements are shown in Table 7. The total measured airflow through the supply system was 3,817 cfm. This compares to a design rating of 5,200 cfm. Airflow through the supply air takeoff located upstream of the measuring point accounts for part of the discrepancy.

TABLE 7

Supply Air System (AH-4) Airflow Measurements
October 21, 1981

Duct Dimensions (in)	No. of Rectangles Measured	Rectangle Area (sq in)	Total Duct Area (sq in)	Average Velocity (ft/sec)	Total Airflow (cfm)
14 x 48	32	21	672	818	3,817

CONCLUSIONS AND RECOMMENDATIONS

Existing control strategies at this facility appear to be adequate to maintain mercury vapor levels associated with the manufacture of mercury-filled instruments within the OSHA PEL of 0.1 mg/m^3 (as an 8-hour TWA).

Based on general observations, information supplied by the plant representatives, and sampling data, the following statements are made with regard to engineering controls.

Control of mercury vapor is achieved using:

- The Taylor Mercury Filler; the mercury filling equipment is enclosed and is operated under vacuum.
- Isolation of the mercury filling area; mercury filling is conducted in a separate room.
- Dilution ventilation; approximately 3,500 cfm of air (measured airflow) is supplied to 16,320 cu ft of production area.
- Temperature control; the temperature within the production areas is maintained below 21 C (70 F) at all times.

The results obtained by Taylor in employing these controls shows that operations involving a significant usage of elemental mercury at elevated temperatures should be enclosed. Also, the current practice of minimizing the time spent by any worker in the Fill Room to 1-2 hours per day must be continued to ensure that workers' daily 8-hour TWA exposure to mercury vapor does not exceed the current OSHA PEL.

Based on observations made at the Taylor Instruments plant, dilution ventilation should be employed to protect workers from exposure to mercury in the filling operation of the thermometer manufacturing process. Ventilation systems should be designed to compensate for the shortcomings of other mercury controls in effect. If sound work practices, local exhaust ventilation systems, and effective process controls are employed, mercury vapor levels will be minimized and less extensive dilution ventilation systems will be needed. The most inexpensive solution (from an energy standpoint) is to reduce the amount of mercury vapor escaping into the ambient air, thereby reducing ventilation requirements. When dilution ventilation is necessary, proper temperature control can reduce the air volume needed to maintain acceptable mercury vapor concentrations.

It should be noted that the distance of exhaust air takeoffs from the floor in a ventilated room is not necessarily related to mercury removal. Takeoffs should be located in the best positions to draw air across the room and away from the workers' breathing zones.