FINAL REPORT

MERCURY CONTROL TECHNOLOGY ASSESSMENT STUDY

H-B Instrument Company
Philadelphia, Pennsylvania

Preliminary Survey Report
for the Site Visit of
September 1, 1981

Contract No. 210-81-7107

November 24, 1981

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 Enviro Control, Inc. (ECI) met with the representatives of the H-B Instrument Company in Philadelphia, Pennsylvania on September 1, 1981 to conduct a preliminary survey on the techniques used to control worker exposure to mercury. Participants in the survey were:

Enviro Control, Inc. CTA Team

Robert Reisdorf, Industrial Hygienist
David D'Orlando, Engineer

National Institute for Occupational Safety and Health

Alfred Amendola, Project Officer
Stephanie Spottswood, Assistant Project Officer

H-B Instruments Company

John Stewart, Chairman of the Board
Edward Hiergesell, President
James Robinson, Vice President of Manufacturing

The preliminary CTA survey was completed in one day. The study included air sampling, detailed inspections of control equipment, and review of monitoring programs.

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I. INTRODUCTION

A. 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 publication of a comprehensive document describing the most effective means of controlling 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 directions where additional research is necessary.

B. Justification for Preliminary Survey

Preliminary surveys are intended to generate information about the control strategies used at various facilities and they will be used to determine where in-depth surveys will be conducted. The H-B Instrument Company was selected for a preliminary survey because of the extensive measures which the company has taken to protect its employees from exposure to mercury since its control program evaluation in 1980. Work practices and engineering controls have been implemented to address the potential exposure problems previously observed at the plant.

C. Summary of information Obtained

An opening meeting was held during which the H-B Instrument Company representatives explained the progression of the company's concern for mercury control. Controls implemented since 1980 were discussed and a package of control prices and information was presented to the survey team. The production process was discussed and a tour of the manufacturing facility was given. Information on mercury control technology was exchanged between the parties present.

II. PLANT DESCRIPTION

H-B Instrument Company is located in Philadelphia, Pennsylvania. The major products produced and distributed are mercury and spirit filled thermometers, hydrometers, digital thermometers, relays, and thermostats.

The business is conducted in a two-story building with a basement. The exterior walls are constructed of brick and concrete block. The ground level floor is concrete and the upper level floor is wood. The first floor consists of a storage area, shipping department, assembly area, and an employee lunch area. Administrative offices and thermometer and hydrometer production areas are located on the second floor (Figure 1). The thermometer/hydrometer production area includes an open production floor and separate rooms for bulbing, blistering, mercury filling, and hydrometer assembly.

The building was originally built in the 1920s as a textile manufacturing plant. H-B Instruments occupied the building in late 1951. Since that time, major renovations have included the isolation and ventilation of the Mercury Fill Room in 1967 and the installation of several mercury controls in 1980.

Employees work five days per week from 7:30 am to 4:00 pm. The work force consists of 57 employees of which approximately 40 are production workers. Thirty-three production workers work in the thermometer/ hydrometer production area on the second floor.

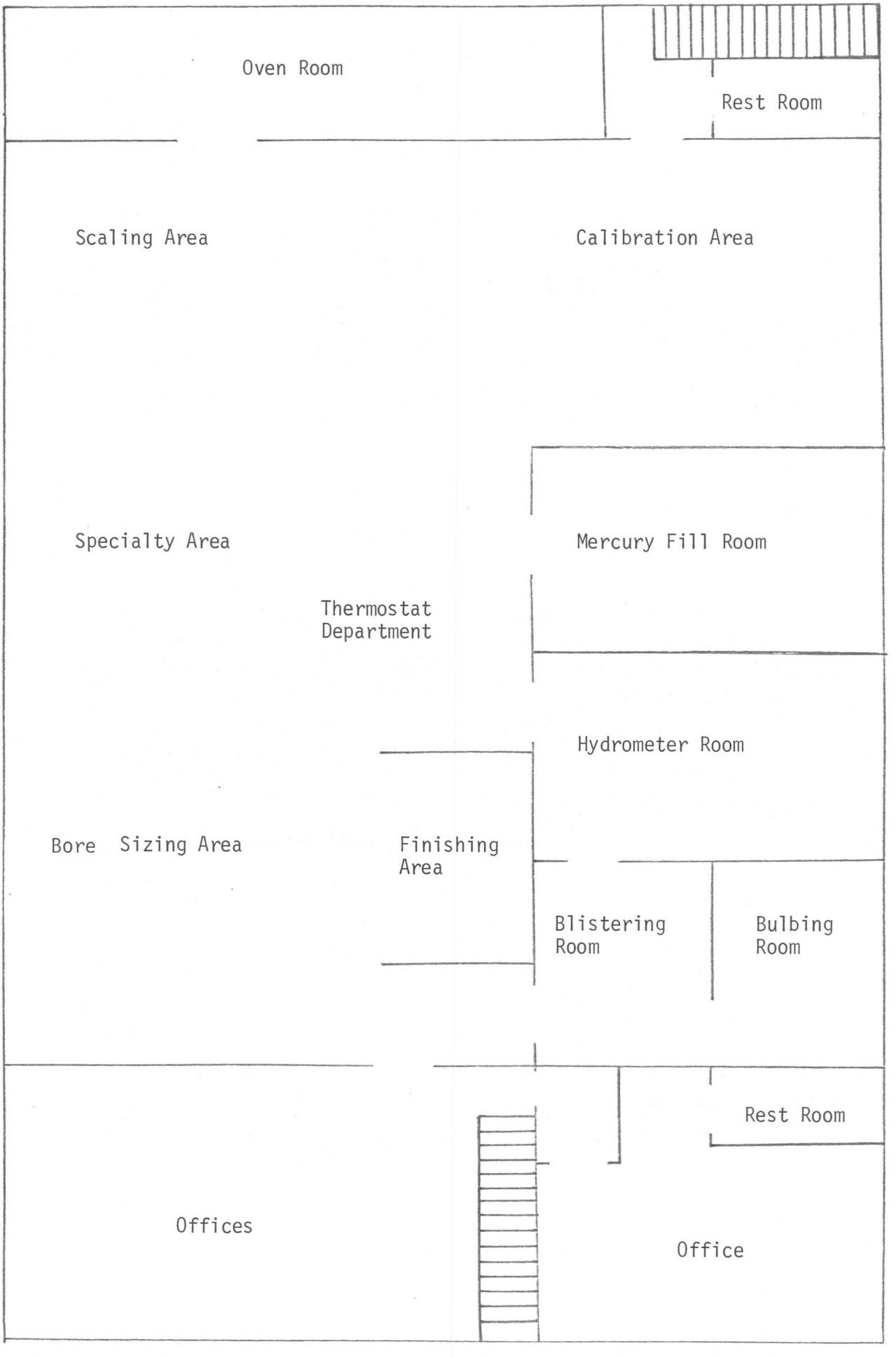


Figure 1. Thermometer/Hydrometer Manufacturing Area (2nd Floor)
(Not drawn to scale.)

III. PROCESS DESCRIPTION (mercury filled thermometers)

1. Bore Sizing

Glass tubes for the thermometers arrive at the plant in 25 pound bundles. Each tube is 52 inches long. The bore sizes of the tubes are determined volumetrically by measuring the length of a specified volume of mercury which is injected by air into a random sample of tubes. Tubes are grouped into bundles of equal bore size and are cut to specified lengths in a foot operated glass shear. Glass which has contained mercury for bore sizing is stored in plastic containers.

2. Blistering

A funnel must be formed on the end of the glass cane that will be connected to the thermometer bulb. This is to facilitate the rise of mercury back into the capillary in the event that the mercury drops below this level. To produce this funnel, a bubble is blown in the center of each glass cane. The formation of the bubble is accomplished on a 9-station rotating blistering machine. As each tube rotates, the center is heated, air is injected into it, and a bubble is formed at the soft point in the center of the cane. The canes are removed from the machine and are cut exactly in the middle of the bubble, forming 2 thermometer tubes with funnel shaped ends.

3. Bulbing

Bulbs are formed and attached to the thermometer tubes on a 10-station bulbing machine. Small glass tubes (approximately one inch long) are loaded onto each station and are held in place by a chuck. Thermometer tubes are mounted above the small tubes, funnel end down. As each tube rotates in the machine, the ends of both tubes are heated and are joined together. The bottom end of the small tubes are then heated until a bulb end is formed. Excess glass remaining in the chuck is discarded as the bulbed tubes are removed from the machine.

4. Mercury Filling

Thermometer tubes are filled with mercury by a vacuum operation located in the Mercury Fill Room. Groups of tubes are put in a pan (bulbed end up) and are set under a bell jar. A vacuum of one micron is drawn in the bell jar. Two 10-pound glass bottles of mercury are passed through a gold filter to remove impurities, heated in an oven to 200 F, and emptied into the top of a flask which is mounted on top of the bell jar. A valve which connects the flask to the bell jar is opened, allowing the mercury to flow into the pan. When all the mercury has passed through the valve, the vacuum in the jar is released. Because a vacuum remains in the glass tubes, the air pressure forces the mercury into the bulbs and capillaries. The pan of filled tubes is then removed from the bell jar. Excess mercury in the bottom of the pan is refiltered and used again in the fill process.

The mercury filling process area is usually associated with high ambient mercury vapor levels.

5. Letting-Out

Excess mercury in the filled tubes is removed in the "letting-out" process. Bulbs are immersed in baths of specified temperatures ranging from 50 C to 295 C. The excess mercury rises and flows out of the capillaries and is hand-brushed into a box at the work station.

6. Finishing

The air which remains in the upper portion of each capillary is evacuated and nitrogen is injected to take its place. The tubes are mounted on a finishing machine to seal and finish the open ends. End pieces (buttons, rings, or rounded tips) are inserted into chucks on the machine. The thermometers are inverted and mounted over these end pieces. The ends of the tubes and the end pieces are heated and joined as each station rotates on the machine. The bulb ends of the thermometers are also heated in the

machine, forcing the nitrogen to expand and form an expansion chamber at the end of the glass tube.

The finishing process is also associated with high ambient mercury vapor levels.

7. Calibration

Completed mercury filled thermometer tubes are calibrated by immersion in water and oil baths of specified temperatures. The tubes are etched by knife at the high and low mercury levels according to the temperature range.

8. Scaling

The distance between the etched high and low points on the thermometer tubes is measured. Thermometers are then grouped in batches of equal scale length, and scales are matched to them. The scales are fired onto the tubes by heating in ovens.

9. Testing and Packaging

Completed thermometers are tested in various temperature baths and are packaged for distribution.

IV. MERCURY CONTROL STRATEGY

A. Engineering Controls

1. Exhaust Fans - The Thermometer/Hydrometer Manufacturing Area (second floor) has 9 roof exhaust fans and 3 wall exhaust fans, the locations of which are indicated in Figure 2. Six of the roof fans, both of the wall fans, and an additional wall fan on the first floor were installed in 1980 at a total cost of $3,750. The new roof

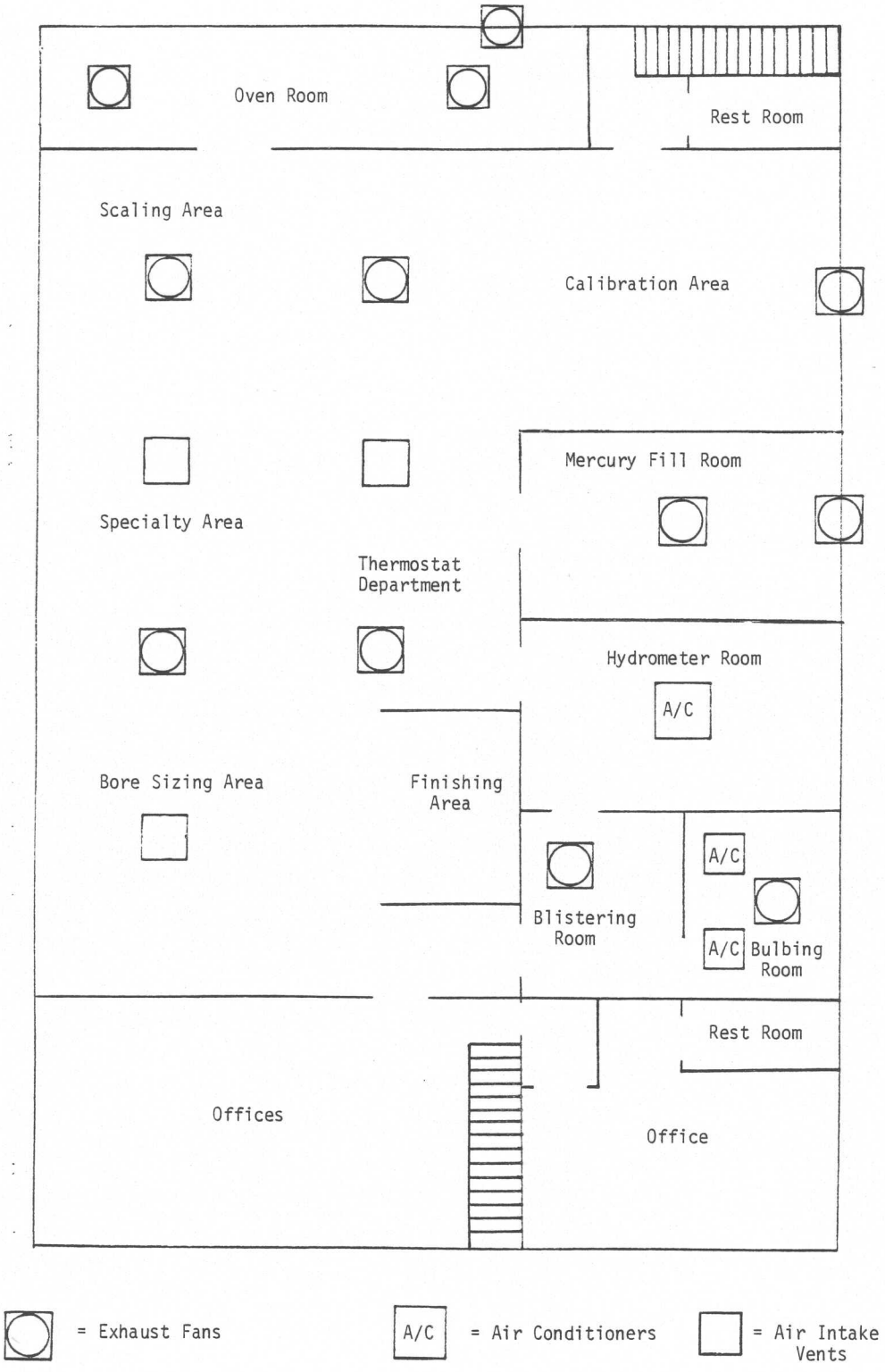


Figure 2. Manufacturing Area Exhaust Fans and Air Conditioners.

fans were installed in existing roof vents. Each roof fan can operate in an exhaust or intake mode. Fans are operated in the "intake" mode when bad weather prohibits the opening of windows to supply air to the production area. The exhaust fans are 28-inches in diameter and are rated at approximately 3600 cubic feet per minute (CFM) each.

The exhaust fans draw air through 16 scuppers located in the manufacturing plant and through the windows which are opened at the beginning and end of each work day and during breaks. Scuppers are small vents (approximately 16" x 6") located in the walls at floor level. Air is also drawn through the 3 air intake vents in the manufacturing area.

2. Air Conditioning - There are currently three air conditioners on the second floor (Figure 2), two of which are roof units located above the bulbing room. These units have fresh air intakes. The third unit is a York combination heating and air conditioning roof unit. It was installed in the Hydrometer Room in 1980 at a cost of $4,325. The first floor of the building has a modified air conditioning system with two air conditioning units. The system was modified in 1980 to convert it from a recycle to a fresh air make-up system. Fresh air ducts, outside intake louvers, mixing boxes, and dampers were installed at a cost of $3,500.

3. Mercury Fillers - The mercury fillers are large bell jars with flasks for mercury filling situated on top. They are mounted on a stainless steel work bench which has: 1) welded seams to prevent mercury from getting in cracks; 2) one inch guards along the sides to prevent mercury from dropping onto the floor; and 3) two small drain holes with bottles under them to collect and dispose of mercury brushed off at the bench.

The vacuum for the filler is drawn by a vacuum pump which has a positive seal in the port to prevent mercury from getting into it. The jar is evacuated through an opening in the baseplate of the unit. This opening has a one inch lip around it so that stray mercury droplets on the baseplate are not drawn into the pump. A plug is put into the opening after filled thermometers are removed as an added precaution to prevent mercury from reaching the pump.

The Mercury Fill Room is isolated from the rest of the manufacturing area. A remote vacuum indicator is located outside of the room so that the operator does not need to periodically enter the Fill Room to check the vacuum being drawn on the filler.

During fill and clean-up, the ceiling fan is in the intake air position and the wall fan is in the exhaust position in order to create an air flow away from the worker.

4. Local Exhaust Hoods - Two local exhaust hoods are located over the calibration stations in the manufacturing area. The hoods, made of 18 gauge galvanized metal, are tied into a common 10,800 CFM roof exhaust fan. A mercury trap with a drain tap is located under the fan where the ducts from the two hoods combine. To date, no mercury has been found in this trap. The hoods were installed in 1980 at a cost of $3,638.

5. Vacuum Cleaners - H-B Instruments uses 6 portable stainless steel can style vacuum cleaners (manufactured by National Super Service) purchased in 1980 for a total of $6,461. The vacuum cleaners have charcoal filters which are replenished with 7000 grams of fresh iodine impregnated charcoal every 2 to 3 months.

6. Floors - The entire floor of the manufacturing area was recovered in 1980 in order to reduce the absorption of mercury into the wood floors. The base wood of the main floor (11,000 sq. ft.) was

cleansed with several applications of HgX® (a mercury vapor suppressant), covered with 1/4 inch plywood, sealed with vinyl epoxy and covered with vinyl tiles at a cost of $12,190. The floor of the Mercury Fill Room (400 sq. ft.) was covered with several sheets of vinyl which were sealed together to form a single sheet. This was done at a cost of $1,762.

B. Personal Protective Equipment

The following personal protective equipment is used to control worker exposure to mercury at this facility:

- respirators - 3M #8707 Disposable Mercury Vapor Respirators are worn whenever workers enter the Fill Room and for the following operations in the production area: high temperature calibration, letting-out, and measuring bore size. The respirators are used for 8 hours or a maximum of 1 work day.
- gloves - Surgical grade latex gloves (Searl Corporation) are worn at the Finishing Station, Threading Station, Calibration Station and during filling and cleaning operations in the Fill Room. Gloves are disposed of daily except in the Fill Room where gloves are changed after each fill operation.
- disposable smocks - Disposable smocks (Dupont Tyvek®) are worn whenever a worker enters the Fill Room. The smock is reused during subsequent visits to the Fill Room and is disposed of when the fill operation is completed.
- cloth laboratory coats - All production workers wear cotton laboratory coats. These are changed every 2 weeks or sooner if visibly contaminated. Laundry service is provided by an outside company knowledgeable in handling clothing possibly contaminated with mercury.
- foot coverings - All workers must either keep a pair of working shoes at the facility or wear Tyvek® disposable foot coverings. Foot coverings are changed daily.

C. Work Practices (including housekeeping)

Procedures and practices have been implemented to control exposure to mercury. The following is a summary of the work practices in effect:

- smoking is not permitted in the production areas.
- food or beverages are not permitted in the production areas.
- employees are required to wash their hands before breaks and at the end of the day.
- all windows in the production area are opened before start-up and during breaks and lunch to allow for maximum air changes. This practice was initiated in mid-1980.
- all mercury containers must be covered.
- mercury spills must be reported to the supervisor immediately.
- unsealed mercury thermometers must be kept in the Fill Room when not in production. Unfinished thermometers must be returned to the Fill Room at the end of the work day.
- the mercury fill system must be cleaned after each fill.
- mercury to be reprocessed must be stored in containers and sealed.
- access to the Mercury Fill Room is limited to Fill Room and maintenance employees.
- persons entering the Fill Room must wear a respirator.
- an individual employee is limited to conducting only one mercury fill operation per day.
- during fill operations and clean-up, the ceiling fan must be on intake air position and wall fan on exhaust position to allow for air movement away from employee.
- floors are washed weekly with HgX®, a mercury vapor suppressant. Prior to mid 1980, HgX® was not used. In addition, floors were not washed on a regular basis.

- spills are vacuumed immediately using a vacuum cleaner equipped with a charcoal filter.

D. Monitoring Program

1. Biological Monitoring

The biological monitoring program was initiated in mid-1980 and consists of yearly urinalysis for mercury. All employees are included in the program. Twenty-four hour urine samples are collected. If the concentration of mercury exceeds 200 micrograms per liter (µg/L) of urine, an employee will be transferred to a location where the potential for exposure is lower.

2. Air Contaminant Monitoring

Air sampling to determine the concentration of mercury vapor has been conducted for approximately 10 years. Prior to 1980, yearly monitoring using a Beckman Mercury Vapor Detector was conducted. Since 1980, a Bacharach MV-2 Mercury Vapor Detector has been used and monitoring is now conducted on a weekly basis. Also, since 1980, personal monitoring to determine the time-weighted average exposures to mercury has been conducted.

V. SURVEY DATA

Spot sampling using a mercury vapor detector (Jerome #401) was conducted. The area sampled and the results are presented in Table 1. These results reflect the concentrations at the time that monitoring was conducted. Periodic fluctuations in the mercury vapor concentration may not be reflected in these data.

The results ranged from 0.010 to 0.042 milligrams of mercury per cubic meter of air (mg/M^3), compared with a background concentration (measured outside of the plant) of 0.001 mg/M^3. The highest concentration was detected in the employee lunch area, indicating mercury contamination remote from the production areas.

VI. CONCLUSIONS AND RECOMMENDATIONS

Existing control strategies at the facility appear to be adequate in maintaining mercury vapor levels below the Occupational Safety and Health Administration (OSHA) standard of 0.1 mg/M^3 (as a time-weighted average).

Plant representatives believe that adequate control of mercury exposure was achieved with the implementation (mid-1980) of the following control strategies:

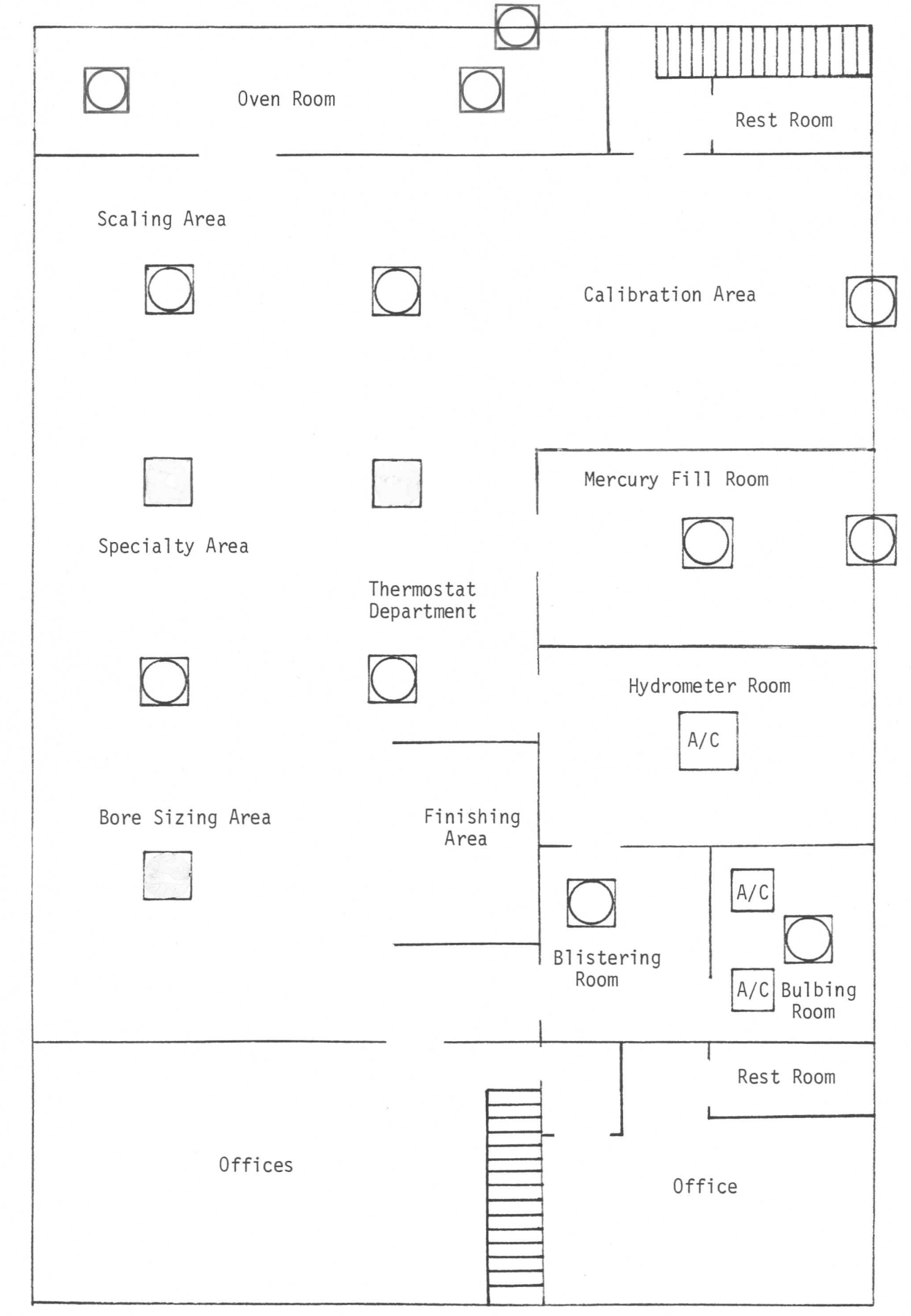
- periodic fresh air dilution ventilation which is conducted 5 times per day by opening all the windows in the production area and turning all ventilation fans to the exhaust mode.
- weekly mopping of floors with HgX®.
- sealing the floors in the production area with an epoxy paint and sealing the floor in the Fill Room with a vinyl coating.

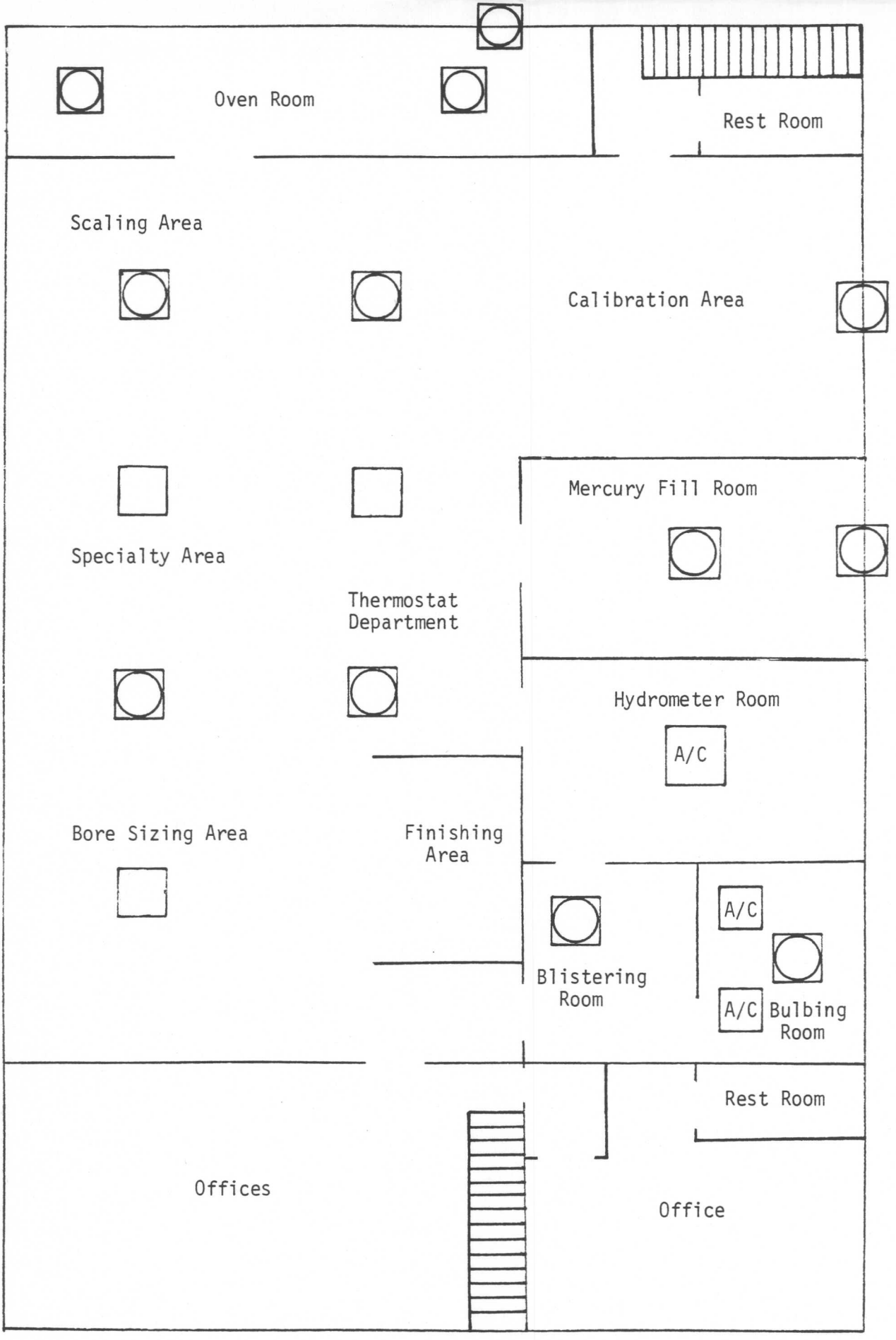
It is recommended that an in-depth survey not be conducted at this facility as sufficient information on mercury controls was obtained during the preliminary site visit.

TABLE 1

Spot Sampling Using Jerome # 401 Mercury Vapor Detector
9/1/81

LOCATION	MERCURY VAPOR CONCENTRATION (mg/M^3)
Bulbing Machine	0.020
Finishing Area:	
Middle Operator	0.022
Middle Operator (second reading)	0.038
Hydrometer Room (mercury is not used)	0.025
Hydrometer Room (same location) (mercury is not used)	0.030
Fill Room (not in operation)	0.020
Outside Fill Room	0.020
Calibration Area	0.030
Oven Room	0.010
Oven Room (same location)	0.010
Relay Area	0.030
Lunch Area	0.042


Oven Room
Rest Room
Scaling Area
Calibration Area
Mercury Fill Room
Specialty Area
Thermostat Department
Hydrometer Room
A/C
Bore Sizing Area
Finishing Area
A/C
Blistering Room
A/C
Bulbing Room
Rest Room
Offices
Office
= Exhaust Fans
A/C
= Air Conditioners
= Air Intake Vents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