FINAL REPORT

MERCURY CONTROL TECHNOLOGY ASSESSMENT STUDY

MICRO SWITCH
a Honeywell Division
Freeport, Illinois

Preliminary Survey Report
for the Site Visit of
May 5, 1981

Contract No. 210-81-7107

November 10, 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 representatives of Micro Switch, a Honeywell Division in Freeport, Illinois on May 5, 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

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

National Institute for Occupational Safety and Health (NIOSH)

Mr. Alfred Amendola, Project Officer

Micro Switch

Mr. Curtis Stoops, Superintendent of Assembly
Ms. Kathy Voss - Hazardous Material Administrator
Mr. William Wienand - Factory Supervisor
Mr. Edward Resnick - Plant Engineer
Mr. Carl Blair - Engineer
Mr. Robert Bangasser - Engineer
Mr. James Wignall - HVAC Engineer

The preliminary CTA was completed in one day. The study included a process tour, review of mercury controls, and interviews with administrative personnel.

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 in controlling worker exposure to elemental mercury and mercury compounds. A result of the study will be the publication of a comprehensive document which describes the most effective means to control emission and exposures. This report will be made available to companies which handle mercury to transfer technology within the major mercury industries. Another intent of the study is to determine 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. Micro Switch, a Honeywell Division, was selected for a preliminary survey because of its large mercury switch manufacturing facility. It has well documented health and air monitoring programs to complement its engineering control efforts.

C. Summary of Information Obtained

An opening meeting was held during which the objectives of the program were discussed with Honeywell representatives. Information on the Micro Switch Air Monitoring Program, Urinalysis Monitoring Program, and the Employee Education and Awareness Program was obtained. Additional meetings were arranged for discussion of monitoring program details, existing engineering controls and work practices and proposed ventilation system changes.

II. PLANT DESCRIPTION

Micro Switch, located in Freeport, Illinois, has been engaged in the manufacture of electrical switches for 25 years. Originally, mercury switches were manufactured in their Plant #1 facility. Mercury Switch moved into the expanded Plant #4 facility 12 years ago. In 1979 another plant expansion was undertaken bringing the Plant #4 facility to a total of 280,000 square feet. Mercury Switch production occupies 25,000 square feet in the northeast section of the plant, the same location for the past 12 years. All of Plant #4 is constructed of steel beams with corrugated roofing.

One hundred and fifty people currently work in the Mercury Switch department. The switches are hermetically sealed glass tubes containing solid metal contacts and liquid mercury. They are important components in the manufacturing of thermostats. Micro Switch is the largest manufacturer of glass enclosed mercury switches.

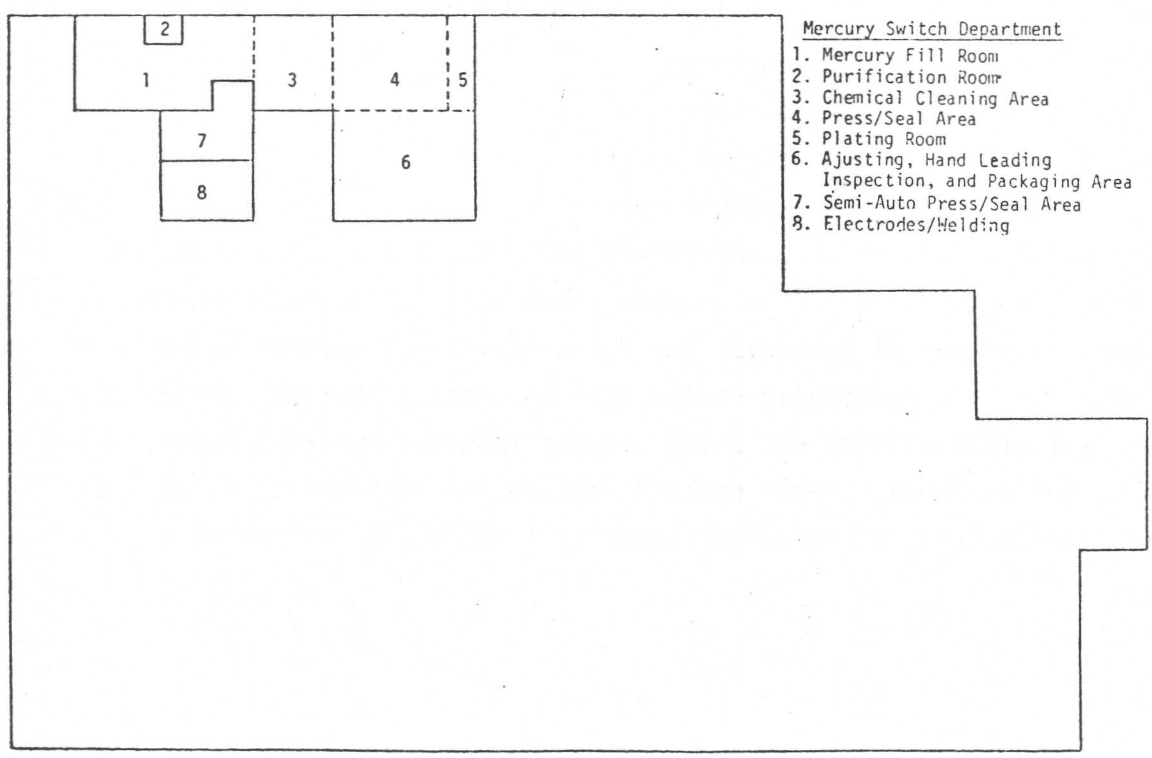

Figure 1. Plant #4

There are eight rooms in the Mercury Switch Department. These are the Fill Room, Purification Room, Chemical Cleaning Area, Press Seal Area, Plating Room, the Adjusting, Hand/Leading, Inspection, and Packaging Area, the Semi-Automatic Press/Seal Area, and the Electrodes/Welding Area. The personnel distribution in the three most heavily used rooms are:

	1st Shift	2nd Shift	3rd Shift	Total
Press Seal Room	25	12-15	0	37-40
Fill Room	6-10	6	1	12-18
Adjusting, Leading, etc.	70	15	0	85

These figures include supervisors, operators, and maintenance personnel.

III. PROCESS DESCRIPTION

Press and Seal

In the pressing and sealing operation, electrodes are inserted into glass tubes and sealed in place prior to mercury filling. Electrodes and pre-cut glazed glass tubes are purchased from outside vendors. A rotary press seal machine performs all of the press and seal functions on the glass tubes. Tubes drop into individual carriers on the machine. As the tubes are rotated, they are sealed by gas burners. The electrodes are placed and positioned inside the tubes. One end of the tube is then heated, constricted, crimped closed around the electrodes and sealed. The tubes are annealed to release the strain which has developed in the glass stem. The rotary press sealer is used for high volume production of the standard 0.35-inch and 0.609-inch diameter tubes. There are approximately six odd-sized tubes in addition to the two standard sizes. Pressing and sealing for these low volume items is done semi-automatically in another area.

Electrode Adjusting

The positions of the electrodes inside the tube are checked and adjusted to insure that the mercury makes a clean contact. Adjustment of the electrodes is accomplished with the aid of a shadow graph, which projects an image on a screen in front of the worker. Tubes are held in place by a mandrel which prevents rotational variance. Electrodes are adjusted by the worker using a small tool which fits inside the glass tube. Reference lines on the screen guide the worker in making the adjustments.

Constricting

After adjusting, the switches are turned to the Press/Seal Area for constricting. Constricting is the process of necking down the glass tube in a precise place and manner to facilitate tipping off at a later time. Constricting is also done with gas burners. This glass working produces strain in the glass which requires a second annealing cycle in the work flow.

Cleaning

Following the second anneal, the tubes are packed in baskets and taken to the Chemical Cleaning Area. Here the tubes go through several different chemical solutions, hot water bath soaks, and clean water rinses. These chemical processes clean and treat the internal electrodes and glass before the mercury filling process.

Mercury Filling

Mercury is injected into the open end of the glass tubes at the rotary fill machine located in the Mercury Fill Room. The machine, which has thirty-two stations, is used only for high volume production. Each station has a device for holding a glass tube and a mercury reservoir. Reservoirs are filled with purified mercury approximately every twelve hours of operation. The sequence of the rotary fill operation is as follows:

1. Glass tubes are loaded manually on the stations.
2. Each tube is evacuated in preparation for filling.
3. Mercury is dispensed into the tube when a station reaches the fill point (by piston which rises and receives a specified amount of mercury from the reservoir. The piston falls and releases the mercury into the tube.)
4. Vacuum is released and residual mercury in the piston shaft is drawn into the tube.
5. The tube is exhausted and then backfilled with hydrogen gas. This step is repeated three times to insure that the oxygen is removed.
6. The open end of the tube is heated, constricted, and sealed.
7. Excess glass is pulled away from the seal and discarded through a discharge chute into a bucket of water.
8. The completed filled tube is released into a transport container.

Low volume products are filled with mercury at a manual fill station located in the Mercury Fill Room. This station operates on an as-needed basis, and includes the controlled use of mercury drawn out of a bottle by vacuum.

Flashing

The mercury filled tubes must go through a flash process to decontaminate the electrodes to achieve proper conductance. An electrical current is applied to the electrodes while the glass tubes are being agitated. The agitation causes intermittant switch closure which burns the contaminants off the metal electrodes.

Leader Attachments

Wire leads are attached to the contacts of the electrodes. High volume lead attaching is conducted on a machine in the Mercury Fill Room. The machine, which is operated by a "leader welder", cuts lead wires to specified length, attaches contact clips, and welds the leads to the end of the electrodes. The operation is performed in the Fill Room because mercury filled tubes are subject to more frequent breakage in this process. Lead attachment for low volume tubes is done manually. The leads are wrapped around the electrode contacts with a special tool and are soldered at the connection.

Branding

Many of the switches produced must be branded with a listing and date code. This is conducted in the Mercury Fill Room because of the breakage problems.

Inspection and Packaging

The completed switches are inspected for lead integrity and proper resistance. They are packaged and stored in preparation for transportation to Honeywell assembly plants and other customers.

Mercury Purification

Mercury used for the switches is purified in a separate room. Micro Switch receives mercury in seventy-six pound flasks which are stored in wooden cases. When needed, the flasks are emptied into a covered settling tank and the mercury is allowed to stand for 48 hours. It is then gravity fed to an oxifier where it is agitated and air is blown through it for approximately four hours. Impurities in the mercury are oxified and float to the top. The mercury is then allowed to flow into one of four settling tanks. After seventy-two hours of settling, it is then gravity fed from the bottom by rubber hose into one pint bottles which are used to fill the mercury reservoirs.

IV. MERCURY CONTROL

A. Engineering Controls - Mercury Fill Room

The Mercury Fill Room is separate from the rest of the mercury switch area. It has its own ventilation system consisting of an air supply system and an air exhaust system. The pressure in the room is maintained negative with respect to the rest of the plant by exhausting more air than is supplied to the room. The design operating room temperature is 19 C (67 F) to reduce mercury vaporization.

1. Air Supply System

The existing air supply system in the Mercury Fill Room delivers approximately 16,000 cubic feet per minute (CFM), utilizing two 8000 CFM Lennox Air Handlers (north and south) (Figure 2.). Each unit has a 25 ton Carrier cooling coil. It is a constant volume, variable temperature system which supplies about 80% make-up to the room. An "Economizer" control system regulates the air by automatically controlling dampers. This allows for intake from either outside air or from pre-conditioned air inside another part of the plant. Intake from these two sources should be balanced to minimize the temperature adjustment needed. However, Micro Switch does not feel that this system is working optimally. A new air supply system is being designed to replace the north Air Handler.

The proposed $150,000 air supply unit (Figure 3) is a single 120 ton (1.44×10^6 Btu/hr) air handler designed to supply 16,000 CFM of 100% outside make-up air at a temperature of 19 C (67 F). Heating capacity for the new unit will be 1,250,000 Btu/hr. It is expected to supply a minimum of fifteen air exchanges per hour in the Mercury Fill Room. The air handler will reduce temperature cycling which results from the "Economizer" control on the existing unit's air conditioner. Four stage cooling will be accomplished by four 30-ton compressors. Higher

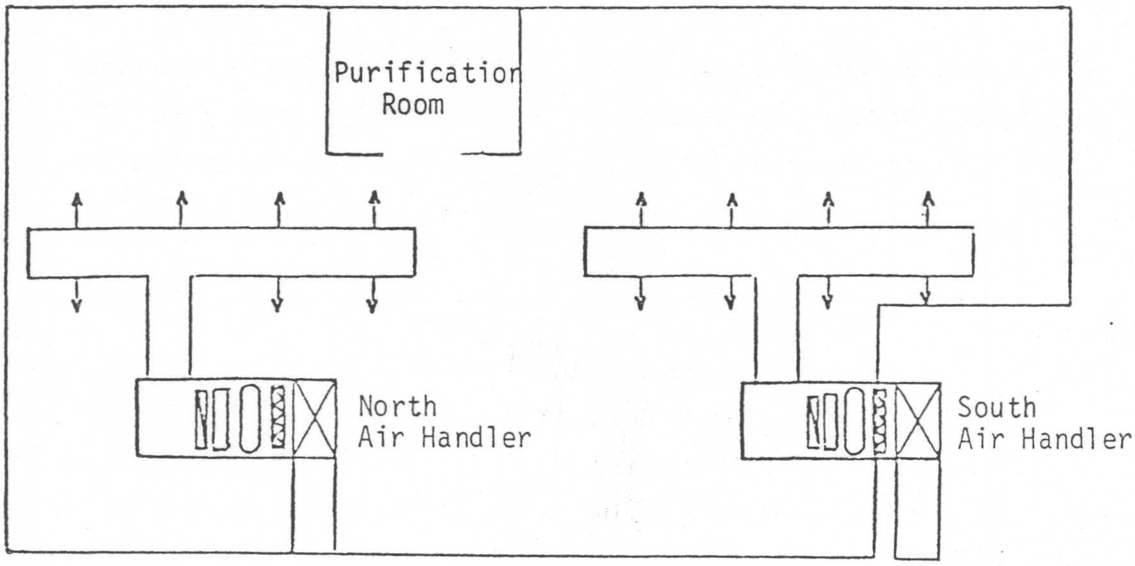

Figure 2. Mercury Fill Room Present Air Supply System

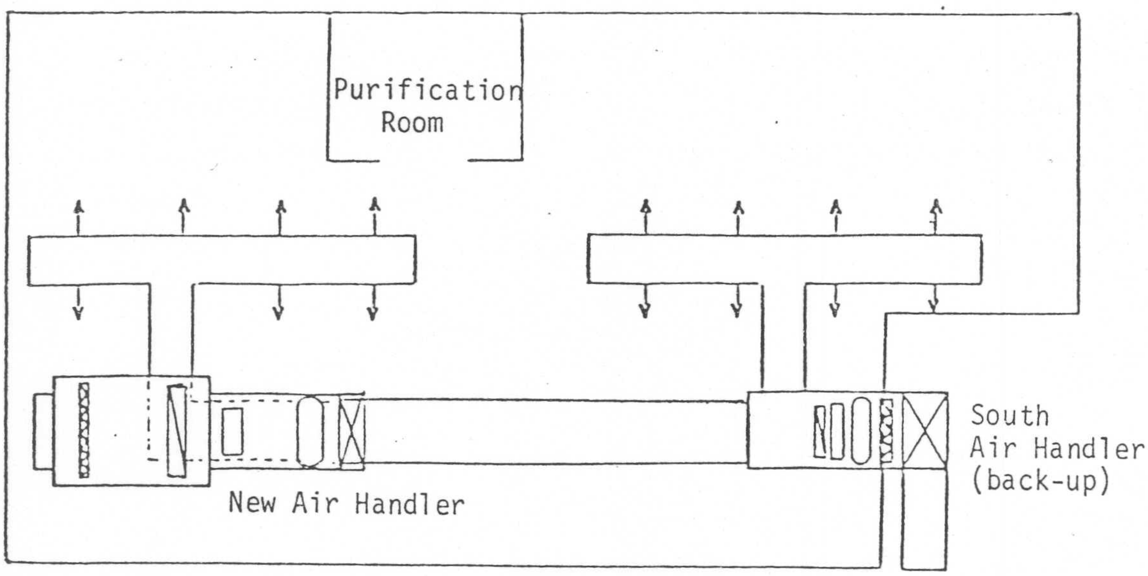

Figure 3. Mercury Fill Room Proposed Air Supply System

energy costs are expected with the new system because only outside air will be used. The existing South air handler will remain operational for use as a back-up system whenever the outside air temperature exceeds 100 F (37.8 C).

2. Air Exhaust System

The Mercury Fill Room has an extensive local exhaust ventilation system which utilizes three separate exhaust fans. There are two 8300 CFM centrifugal New York Blowers with upgraded belts and pulleys and one 3000 CFM axial Jenn-Aire Blower. More air is exhausted (19,600 CFM) than supplied (16,000 CFM) to maintain a negative pressure in the Fill Room.

The local exhaust features in use in the Merucry Fill Room and the Purification Room are described below. Each item is indexed to a reference location in Figure 4.

Local Exhaust Ventilation (LEV) Key (For Figure 4)

Key		Duct Size (diameter)
o	Floor exhaust	6 inches
O	Floor exhaust	12 inches
1.	Flat circular exhaust hood (for mercury filling) features: - LEV in front of fill station - peripheral water pan to inhibit vaporization of mercury droplets - load station water pan	10 inches

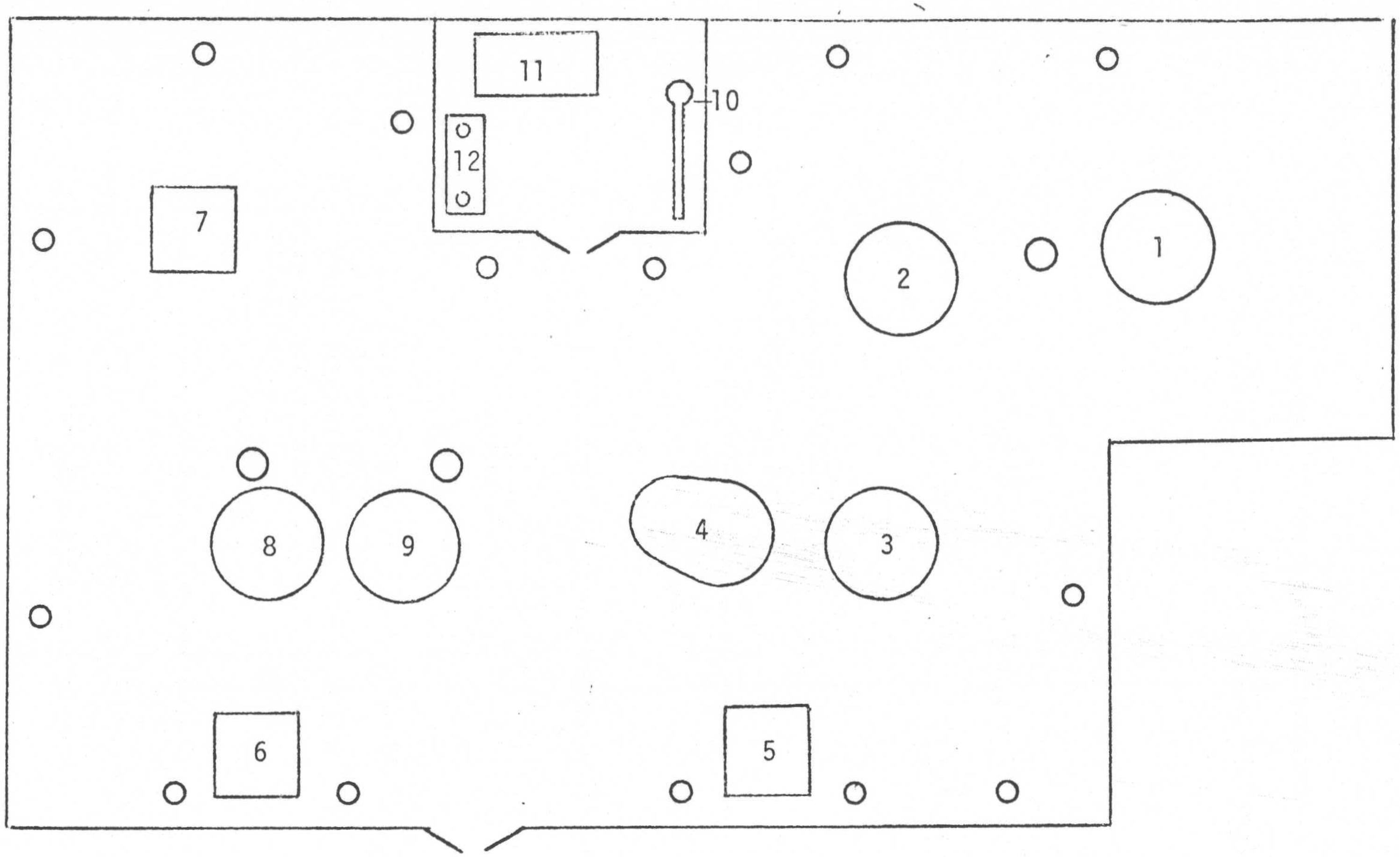

Figure 4. Mercury Fill Room Local Exhaust Ventilation

	Duct Size (diameter)
2. conical circular exhaust hood (for mercury filling) features: - peripheral and load station water pans	12 inches
3. flat circular exhaust hood (for mercury filling) features: - LEV in front of fill station - peripheral water pan (to inhibit vaporization of mercury droplets) - load station water pan	10 inches
4. conical cam-shaped exhaust hood (for high volume mercury filling) features: - plastic curtained sides - LEV in front of fill station - peripheral and load station water pans	12 inches
5. local exhaust hood (for thalium/mercury amalgam fill and tip process)	4 inches
6. local exhaust hood (for low volume mercury filling) features: - load station water pan	6 inches
7. leader welder station exhaust system	
a. conical circular hood (over mercury filled tube feed)	8 inches
b. floor exhaust (in case tubes are dropped at worker's feet)	4 inches
c. slotted hood (at potential tube breakage point on machine)	2 inches
8. flat circular exhaust hood (for low volume exhaust and tipping) features: - peripheral LEV with diffuser holes - load station water pan	10 inches

		Duct Size (diameter)
9.	flat circular exhaust hood (for low volume exhaust and tipping) features: - peripheral LEV with diffuser holes - load station water pan	10 inches
10.	slot hood (in front of mercury settling tanks	12 inches
11.	treated mercury station exhaust system features:	
	- three sided exhaust hood with plexi-glass door	10 inches
	- LEV for cabinet storage under hood	3 inches
12.	LEV for mercury bottle storage cabinet	3 inches

B. Personal Protective Equipment

In the Fill Room, all workers wear disposable Tyvek® smocks which are changed weekly. In addition, workers who may contact liquid mercury wear latex disposable gloves which are changed daily. The Group Leader who is responsible for much of the mercury handling operations in the Fill Room wears a disposable respirator (3M #8707 Mercury Vapor Respirator) and disposable gloves. In addition, Group Leaders and janitors use one pair of shoes exclusively for work.

C. Work Practices (Other Than Housekeeping)

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

- Eating, drinking, and smoking are not allowed in the Mercury Fill Room. Transportation or storage of drinking, eating or smoking materials and purses are also prohibited.

  Other mercury areas carry slight variations of these restrictions depending on the amount of mercury exposure an employee may be subjected to. (Some mercury areas are free of exposed mercury and carry no restrictions.)

- Employees are required to wash hands before breaks and lunch.
- Waste glass is kept in containers under water to reduce mercury vapor generation.

D. Housekeeping

The following housekeeping procedures have been implemented to control exposure to mercury:

- Floors in the Fill Room are mopped two times a day with HgX® slurry, a mercury vapor suppressant.
- Spills are cleaned using a house vacuum system. This system is exhausted to the ambient air. No filter is used, however, there is a trap in the system to contain the mercury. In the case of remote spills, a portable vacuum cleaner (ARCO MRS-3 American Vacuum Company) equipped with a charcoal filter is used. Only experienced personnel may clean spills. In the Fill Room, only the janitor or the Group Leader may perform this job.
- A janitor is assigned to work in the Fill Room during production hours. This person is responsible for general housekeeping, HgX® mopping and spill clean-up. He/she wears a disposable smock and a pair of shoes used exclusively for work.
- Dry sweeping is not permitted.

E. Monitoring Programs

1. Biological Monitoring

A biological monitoring program consisting of pre-employment and routine urinalysis for mercury is in effect at this facility. The elements of this program are:

- Pre-employment monitoring

An initial urinalysis for mercury is required of all new employees transferring into the mercury use areas. Spot samples rather than 24-hour urine collections are used. If urine mercury levels exceed 0.05 mg/l, the individual is considered unacceptable for employment in this area.

- Routine monitoring

Yearly monitoring is required for all employees stationed in the mercury use area.

Quarterly monitoring is required for employees stationed in the Mercury Fill Room and Mercury Purification Room and includes the janitors who maintain the Fill Room.

Quarterly monitoring is conducted in January, April, July and October to determine fluctuation due to seasonal climatic variations and/or personal seasonal habits.

Monitoring at job termination is conducted to establish a complete health record for each employee.

- Sample collection and analysis

A minimum of 25 ml of urine per sample is required.

Samples are collected in the latter half of the work week.

If either sample volume is insufficient or the specific gravity is less than 1.010, the employee must submit another sample.

Samples are preserved with potassium persulfate and analyzed within two weeks.

The analytical method is based on NIOSH method P+CAM 165.

- Action summary

When a urine mercury level is at or above 0.2 mg/l, the individual is monitored weekly and the following action will be taken:

The nurse will advise the employee and his supervisor of the reading.

The supervisor will review with the employee the safety rules posted in his/her department, and other employee education material.

The employee must give weekly specimens until he/she remains below 0.2 mg/l for three consecutive weeks.

If during the weekly monitoring the employee has four consecutive levels at or above 0.2 mg/l, the employee will be removed from the mercury area. If an employee is transferred to another area but remains employed at this company, the employee must submit weekly specimens until the level remains below 0.2 mg/l for three consecutive weeks. The above requirements also apply to an employee who has three non-consecutive specimen levels in excess of 0.3 mg/l of mercury in a three year period. Once removed from a job because of an elevated urine mercury level, a worker will not be reinstated.

2. Air Contaminant Monitoring

Periodic monitoring is conducted to determine the level of mercury vapor. This involves weekly surveys with a direct reading instrument and periodic personal monitoring to determine the time weighted average (TWA) exposure.

Weekly monitoring involves the use of a Bacharach MV-2 Mercury Vapor Detector. The vapor readings are taken on various days of the week and at random time periods. Concurrent temperature readings are usually taken to indicate vapor fluctuations due to temperature. Room air measurements are made in various locations within the following rooms and areas:

a. Mercury Purification Room
b. Mercury Fill Room
c. Mercury Plating Room
d. Oven Room
e. Inspection and Adjusting Areas
f. Leading Area
g. Packing and Pressing Areas
h. Waste Crushing Area

Readings are also taken in the breathing zones of the individual employees for whom a greater potential for exposure exists. This includes:

a. Most employees working in the Mercury Purification and Fill Rooms.

b. Leader welder.

c. Branding machine operator.

Readings may also be taken in the event of spills, equipment breakdown or temperature elevations. In the event of a reading in excess of 0.1 mg/m^3 the responsible supervisor will investigate the situation immediately.

Personal monitoring is conducted with the use of Passive Mercury Vapor Monitors (3M Company). This monitor is designed to measure the TWA mercury vapor concentrations over an 8 hour period. Monitoring is conducted on a twice yearly basis in April and October. Usually five persons per shift are selected for monitoring purposes. These include:

a. Group Leader
b. Janitor
c. Random Operators

If exposure to mercury vapor exceeds the current Occupational Safety and Health Administration's (OSHA) Standard of 0.1 mg/m^3 (as a TWA), the supervisor will investigate the cause. Based on coincident urinalysis of that employee the supervisor may initiate partial or complete removal of the employee from the area.

Continuous monitors for the detection or control of mercury vapor are not used at this plant.

F. Other Programs

1. Employee Education

All new employees must read and sign an employee education and awareness document. This document outlines the potential hazards of mercury, the importance of personal hygiene, the monitoring program, and the proper clean-up procedures for working with mercury.

V. SURVEY DATA

Air monitoring using a mercury vapor detector (Jerome #401) was conducted during the survey. Many of the sample locations were the same as those selected for weekly monitoring by plant personnel. The results of sampling are shown in Table 1. Mercury vapor was detected in all environments sampled. The highest sample concentration detected was 0.052 mg/m^3.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. Engineering Assessment of Control Effectiveness

Mercury vapor levels in the mercury switch production area were below the 0.1 mg/m^3 OSHA standard. Contributing to this achievement were the air supply system, local exhaust ventilation, temperature control, and work practices previously described. The vapor levels should be further reduced upon start-up of the proposed air supply system. This could result from the change to 100% outside make-up air, the reduction in temperature fluctuation, and the use of the old south air handler during hot weather.

Two recommendations can be made based on survey observations:

1. The mercury scrap drums should only be filled to a point where a 5 to 6 inch level of water can be maintained above the scrap.
2. The sides of the flat circular hoods could be enclosed by plastic curtains in the same way as the flat cam-shaped hood. This should result in an increased air flow across the face of a worker through the open end of the enclosure.

B. Recommendations for Further Study

An in-depth survey of the Micro Switch plant is recommended when the new air supply system is installed and operating. Continuous temperature monitoring and air flow determinations in the Fill Room could provide valuable detailed information on ventilation systems' effects on mercury control. Also of interest would be the magnitude of the pressure

TABLE 1

Mercury Vapor Levels Determined With
Jerome Model #401
on 5/5/81

	Concentration mg/m^3
Mercury Purification Room	0.030
Mercury Fill Room	
Leader Welder	0.045
Branding Machine Operator	0.012
3 Head Fill Machine	0.006
Wet Eisler	0.006
Dry Eisler	0.010
Fill Machine No. 1	0.014
Fill Machine No. 2-lg. glass	0.014
Fill Machine No. 3	0.052
Fill Machine No. 4	0.007
Gyro Bench	0.008
Fill Room Desk	0.014
Large Glass Flasher	0.020
Flasher Facing West	0.020
Switch Handling Room	
Leading Area-South End	0.008
Leading Area-North End	0.014
Packing Area	0.008
Sampling Area	0.006
Epoxy Booths	0.008
Office	0.006
Office	0.007
Office	0.006
Office	0.008

differentials between the Purification Room, Mercury Fill Room, and the rest of the plant.

The use of the plastic strip curtained exhaust hood was effective because it provided good visability and easy access to the work stations and allowed an air flow past the workers' faces. It would be of value to confirm this assumption and compare the effectiveness of the plastic curtained hood to that of a completely enclosed hood.