FINAL REPORT

MERCURY CONTROL TECHNOLOGY ASSESSMENT STUDY

D. F. Goldsmith Chemical and Metal Corporation
Evanston, Illinois

Indepth Survey Report
for the Site Visit of

May 4-6, 1982

Contract No. 210-71-7107

September 1982

Submitted to:

Alfred A. Amendola, Project Officer
National Institute for Occupational
Safety and Health
Division of Physical Sciences and Engineering
4676 Columbia Parkway
Cincinnati, Ohio 45226

Submitted by:

Donato R. Telesca, Manager
Engineering Department
Dynamac Corporation
Enviro Control Division
11140 Rockville Pike
Rockville, Maryland 20852

DISCLAIMER

FOREWORD

A Control Technology Assessment (CTA) team consisting of members of the Dynamac Corporation Enviro Control Division met with Mr. Donald Goldsmith of D.F. Goldsmith Chemical and Metal Corporation in Evanston, Illinois on May 4-6, 1982, to conduct an indepth survey on the techniques used to control worker exposure to mercury. Participants in the survey were:

Dynamac Corporation

Mr. David D'Orlando, Engineer
Mr. Robert Reisdorf, Industrial Hygienist
Mr. Andrew Reyburn, Industrial Hygienist

D.F. Goldsmith Chemical and Metal Corporation

Mr. Donald Goldsmith, President
Mr. James Moran, Production Supervisor

The indepth CTA was completed in three days. The study included a process tour, review of mercury controls, and discussion of work practices. Area sampling for mercury vapor and particulate was conducted and a ventilation study of the air recirculation unit used at the facility was completed.

This report contains both general information obtained in the preliminary survey at the facility on August 27, 1981 and specific information obtained in the indepth survey. Emphasis is placed on the ventilation systems use as a mercury control. For detailed information on the other controls used at D.F. Goldsmith Chemical and Metal Company, refer to the preliminary survey report. This report is available upon request from Mr. A. Amendola, NIOSH.

TABLE OF CONTENTS

INTRODUCTION

CONTRACT BACKGROUND

The Mercury Control Technology Assessment Study has been initiated to assess the current technology used to protect the worker from exposure to mercury. The objective is to identify and evaluate 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 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 determine where additional research is necessary.

JUSTIFICATION FOR SURVEY

D.F. Goldsmith Chemical and Metal Company was selected for an indepth survey in order to study the overall effectiveness of the plant's ventilation system in controlling mercury vapor concentrations in the work areas. Particular emphasis is to be placed on evaluating the plant's recirculating air unit.

SUMMARY OF INFORMATION OBTAINED

An opening meeting was held during which the objectives of the survey were discussed. Information on the workplace air monitoring, biological monitoring, work practices, engineering controls, and personal protective equipment used at the facility was obtained. Area sampling for mercury vapor and particulate was conducted. The efficiency of the air recirculation unit was calculated.

PLANT DESCRIPTION

D.F. Goldsmith Chemical and Metal Company is located in Evanston, Illinois. Its major products are prime virgin mercury, precious metals and rare inorganic chemicals.

The processing and packaging facility occupies a one story converted office building (approximately 4200 sq.ft.) which was built in 1964 and a small garage (570 sq.ft.) located adjacent to the building. The main building is contructed of block wall with cement floors. It houses company offices, rented office space, a small kitchen, and the processing/packaging rooms (bottle filling, mixing and weighing, shipping and receiving, and storage) (Figure 1). The garage, also called the still building, is constructed of corrugated metal with a cement floor and roll-up garage door.

Renovations to the facility in 1975 and 1976 included the installation of a Torit particulate filter, new floors, and an exhaust hood and filling table in the bottle filling room.

There are seven employees at D.F. Goldsmith. They are the company president, a secretary, a salesman, a production supervisor, and two production workers.

PLANT DESCRIPTION

D.F. Goldsmith Chemical and Metal Company is located in Evanston, Illinois. Its major products are prime virgin mercury, precious metals and rare inorganic chemicals.

The processing and packaging facility occupies a one story converted office building (approximately 4200 sq.ft.) which was built in 1964 and a small garage (570 sq.ft.) located adjacent to the building. The main building is contructed of block wall with cement floors. It houses company offices, rented office space, a small kitchen, and the processing/packaging rooms (bottle filling, mixing and weighing, shipping and receiving, and storage) (Figure 1). The garage, also called the still building, is constructed of corrugated metal with a cement floor and roll-up garage door.

Renovations to the facility in 1975 and 1976 included the installation of a Torit particulate filter, new floors, and an exhaust hood and filling table in the bottle filling room.

There are seven employees at D.F. Goldsmith. They are the company president, a secretary, a salesman, a production supervisor, and two production workers.

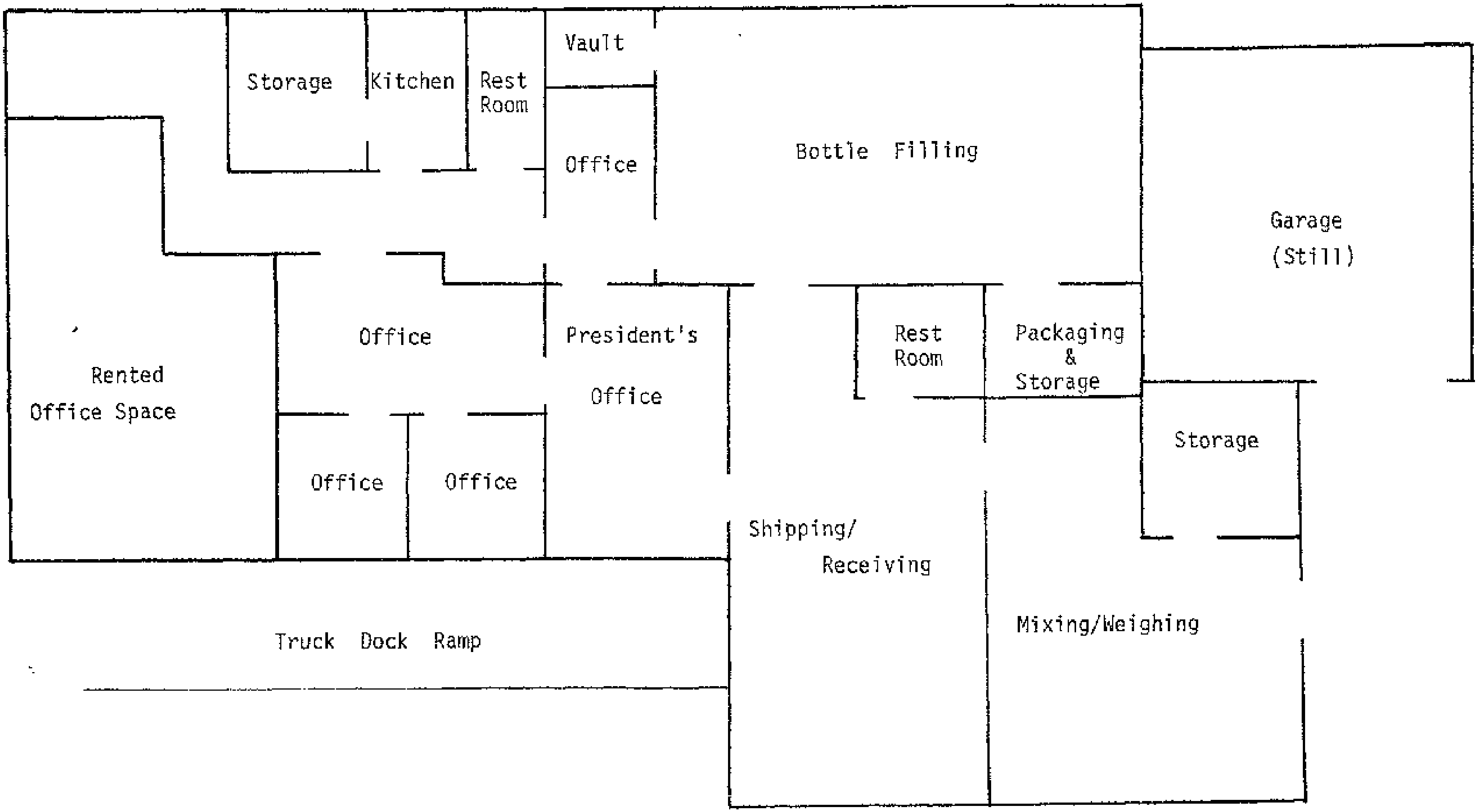

Figure 1. D.F. Goldsmith Chemical and Metal Corporation Lay-out

PROCESS DESCRIPTION

PREPARATION

The mercury to be purified arrives at the facility in plastic or steel flasks (Figure 2). The flasks are weighed to determine the precise weight of mercury received. Flasks are transferred to the still building.

PRE-TREATMENT

The flasks of mercury are poured into an open vessel (acid tank) in the still building. The vessel is covered and the mercury is treated by agitating in the presence of an acidic or caustic solution. The mixture is agitated for a designated period of time. The more contaminated the mercury is, the longer it is agitated.

Treated mercury is removed from the vessel by allowing it to flow through a tap into one quart plastic containers. The mercury is visually inspected and if acceptable, it is brought to the still.

DISTILLATION

Mercury is batch distilled at this facility. Bottles of treated mercury are emptied into a stainless steel funnel (Figure 3) mounted above the fiber-glass insulated distillation vessel (still). The mercury is allowed to flow into the vessel by opening a valve at the bottom of the funnel. The still temperature is maintained by a hot oil bath, and a vacuum is applied. The mercury vaporizes and rises into a water-cooled condenser mounted above the still. As the mercury liquifies, it falls into a receiver vessel. When the vessel is full, the mercury is withdrawn through a tap at the bottom into one-quart plastic bottles (Figure 4). The bottles are capped, placed in a covered steel cart, and transported to the bottle filling area.

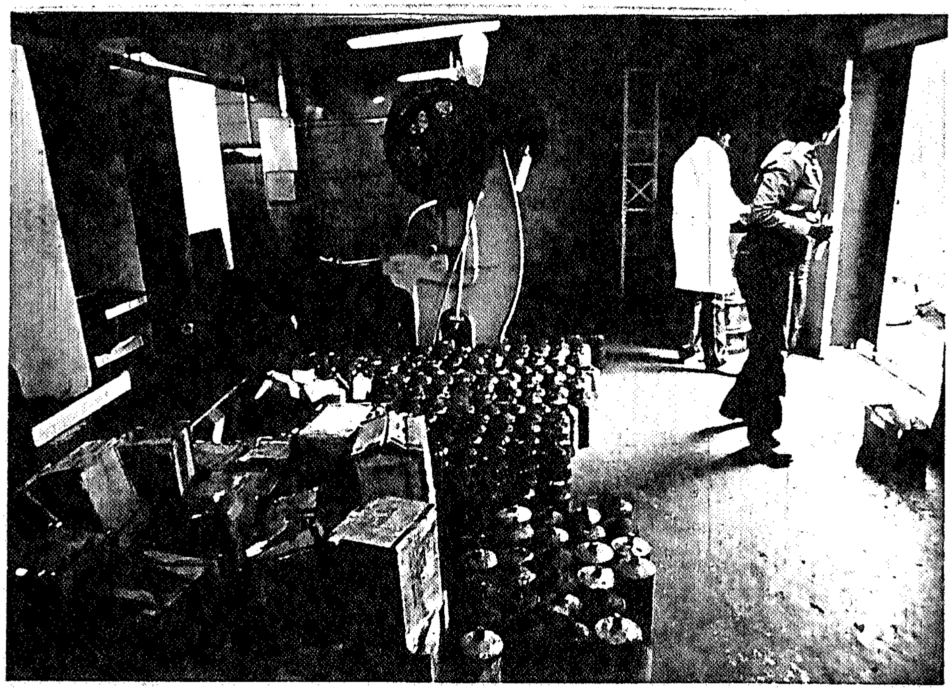

Figure 2. Mercury Flasks in Receiving Room

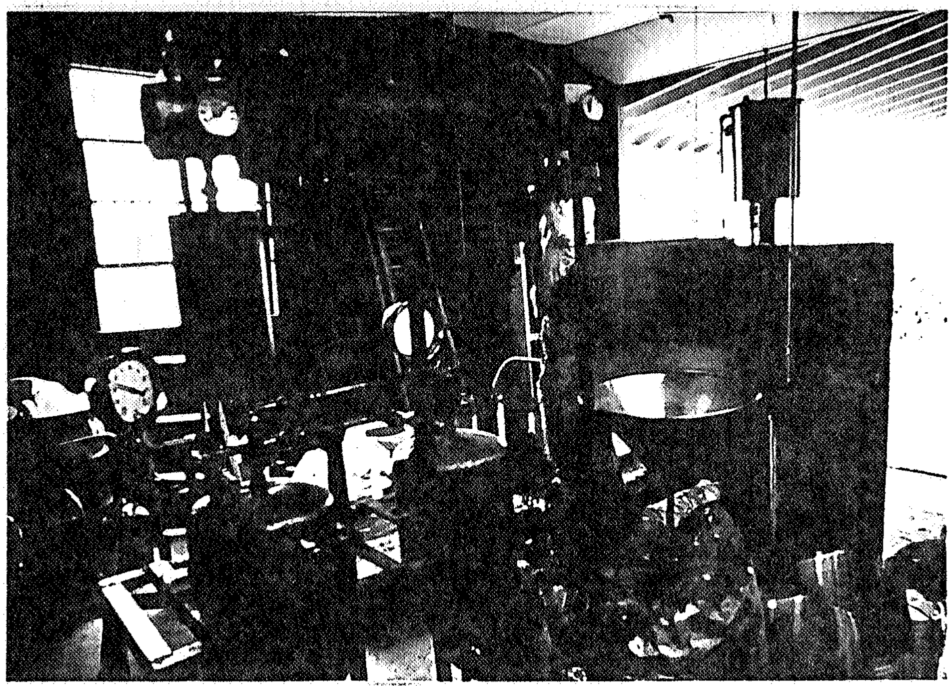

Figure 3. Funnel on Distillation Vessel

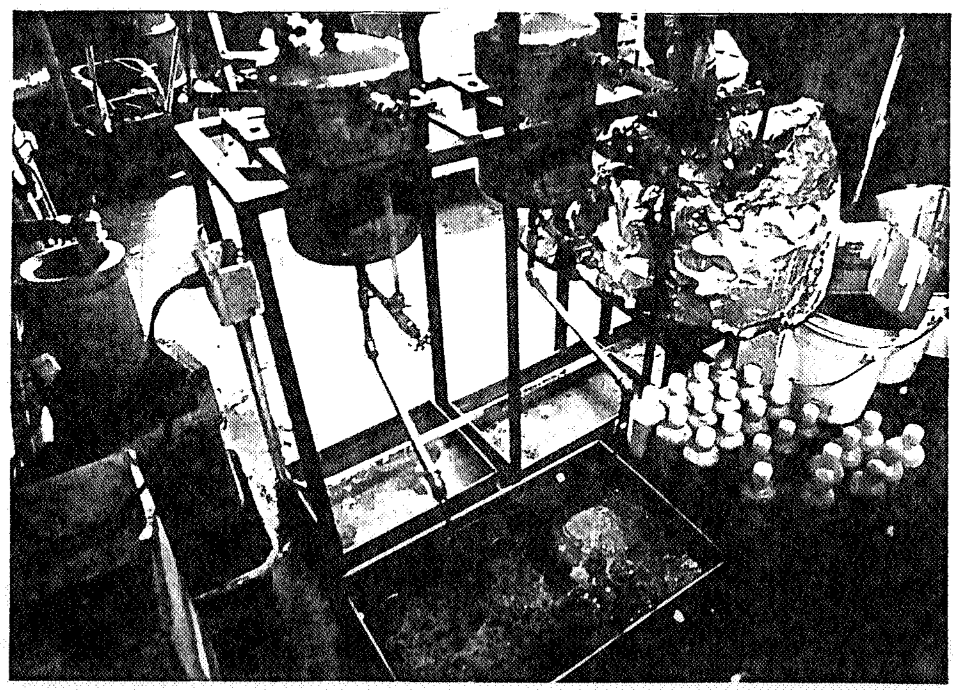

Figure 4. Receiver Vessels and Quart Bottles of Mercury

BOTTLE FILLING

The plastic bottles are removed from the cart and are placed into stainless steel trays containing approximately one inch of water. Approximately eight quarts of mercury are poured into a hold tank on a filling device (Figure 5). A volumetric glass flask is attached to the holding tank by tubing. The size of the small bottles to be filled determines the volume of the flask used. Mercury is allowed to flow from the holding tank into the flask until the flask overflows through a tube into an overflow bottle. Mercury is dispensed from the flask to a bottle by opening a valve at the bottom of the flask (Figure 6). Each bottle is capped immediately after filling. The mercury is usually bottled in one or five pound quantities. Mercury in the overflow bottle is poured back into the top of the holding tank. The filled bottles are placed in a pan containing an inch of water and are transferred across the room to a work bench where adhesive lables are attached. The bottles are packed and shipped according to order.

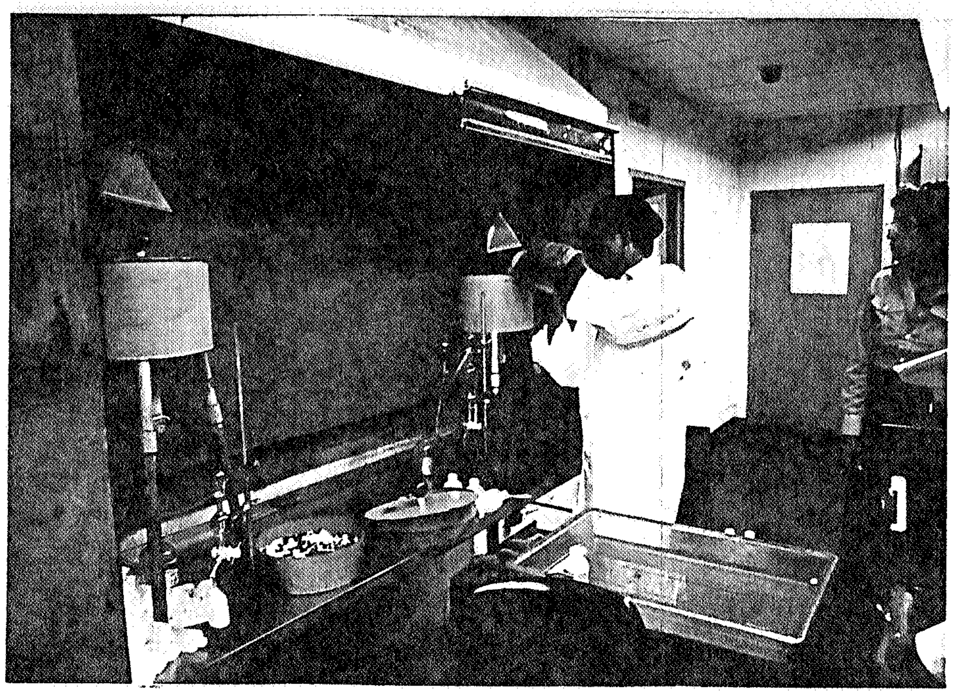

Figure 5. Worker Pouring Mercury into Holding Tank

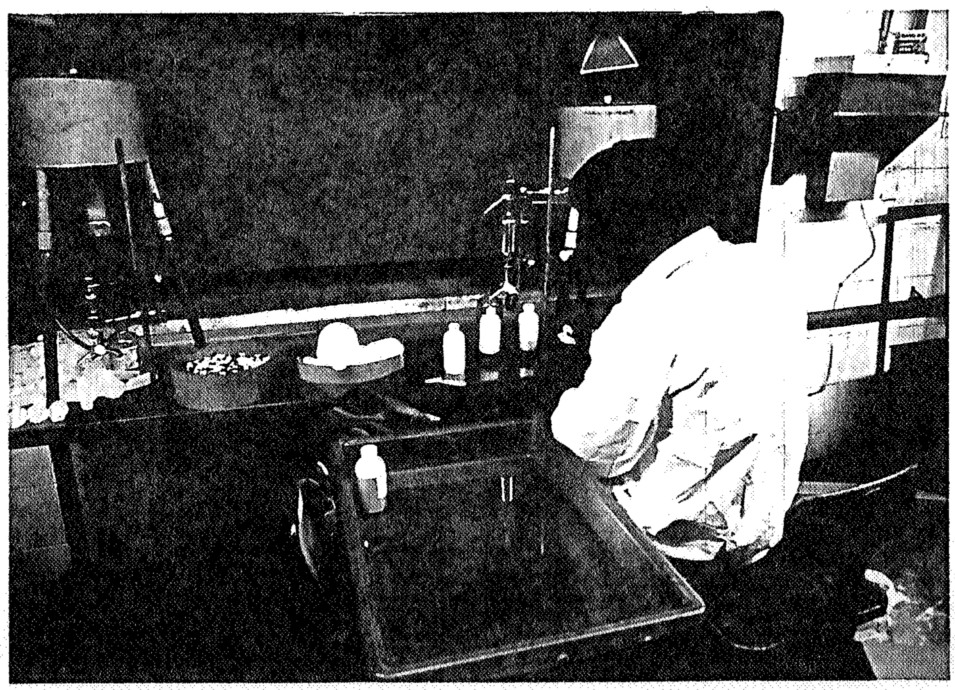

Figure 6. Worker Filling Bottles with Mercury

MERCURY CONTROL STRATEGY

Ventilation is the principal control used at this facility to reduce worker exposure to mercury. The methods of ventilation used are three-fold: (1) local exhaust, (2) dilution, (3) recirculation. The locations of all exhausters, supply air diffusers, supply air intakes, vents, and recirculation take-offs are illustrated in Figure 7.

LOCAL EXHAUST VENTILATION

The operation involving the greatest amount of mercury handling indoors at this facility is the filling of bottles with mercury. This operation is performed at a special work station. The station, consisting of two bottle fillers, is enclosed by a three-sided exhaust hood. The roof exhaust fan for the work station is a 1,400 CFM (design) Greenbeck Model CBE1884 situated on the north side of the building. The fan draws air through a 3" by 70" slot at the back of the hood at bench level, and through two small local exhaust hoods (6" x 6" openings) located immediately above each bottle filler. There are two mylar shades on the front of the hood which, when drawn down across the face of the hood, increase exhaust air velocity through the the remaining open hood space.

DILUTION VENTILATION

Air Exhaust

The D.F. Goldsmith facility has seven operating Jenn-Air roof exhaust fans. One of the fans is a 1000 cubic feet per minute Model 101 CRAEJ, six are 175 cubic feet per minute (design) Model 71 CRAFJ fans. These units exhaust from the kitchen, ladies room, men's room, receiving area, storage room, and the mixing/weighing area. The garage, which houses the still, has an 18-inch diameter wall fan which is rated at 2,200 to 4,000 cfm.

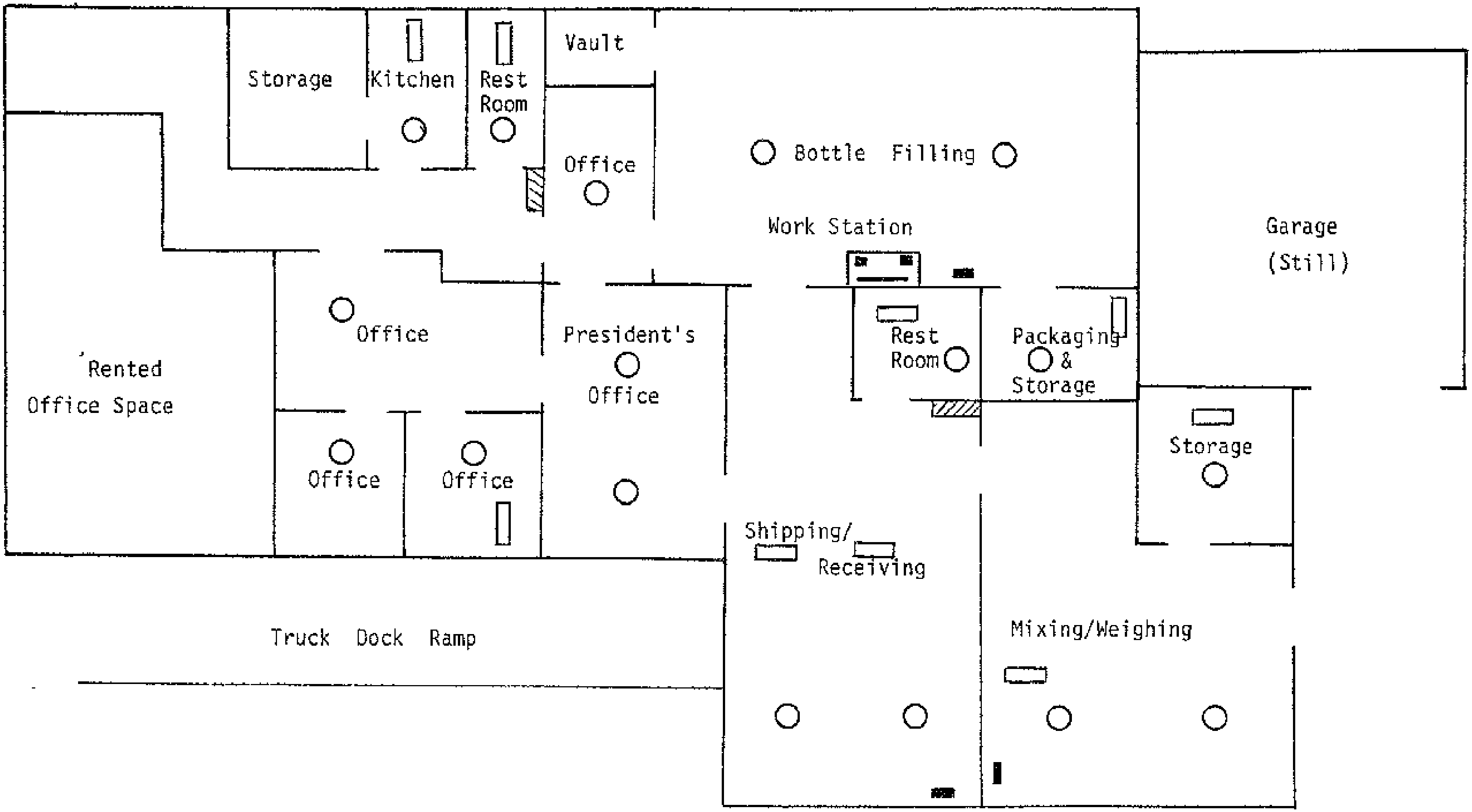

Figure 7. Plant Lay-out Showing Approximate Locations of Ventilation Openings

○ = circular supply-air diffusers

▭ = ceiling exhaust vent

▬ = Torit exhaust air vent

▨ = intake for air handler

Air Supply

Air is supplied to the facility using two air handlers located on the roof. One is a Westinghouse Model 1K090B25C0, which services the offices in the building. This unit has an air conditioning capacity of 7.5 tons and a heating capacity of approximately 187,000 Btu. The unit is capable of operating with approximately 100% recirculation of air. It also has a fresh air intake for blending outside air with recirculation air. The recirculation air intake is located in the front hallway. The design airflow of the air handler is 3,000 cfm. Supply air is distributed to the work areas through 8-inch ceiling diffusers.

This unit was not operating during the second day of the survey due to a blown fuse. As can be seen in the results in the Survey Section, this corresponded with higher mercury vapor concentrations in the office area. When the unit was started up on the third day of the survey, mercury vapor concentrations in the office area were lower. The reduction could be due to either the fresh air make-up or the reduction in temperature which resulted (ambient temperatures were in the 80's and air conditioning reduced the office temperatures to low 70's).

The other air handler is a Westinghouse Model 1D06W1H1N which services the manufacturing and packaging area. It is rated at 2,000 cfm with an air conditioning capacity of 5 tons and a heating capacity of 112,500 Btu. The unit has a dampered intake louver which provides the capability of drawing fresh (outside) air as well as recirculated air. Opening the damper 100% provides a fresh airflow of approximately 900 cfm (measured) to the air supply system. This results in a 50% fresh air/50% recirculation air mixture of air supplied to the manufacturing area.

During the survey, the fresh air intake was completely closed and the air supply system was operating at approximately 100% recirculation. This is further evidenced by the fact that MnO_2 particulate (associated with Torit unit discharge) was visable at and around all of the supply air diffusers in the manufacturing area, indicating a return of a high percentage of plant air. On the third day of the survey the fresh air intake louver was opened completely. The results in the Survey Section show that the corresponding mercury vapor concentrations were reduced considerably that day. The addition of 900 cfm of fresh dilution air could account for this reduction.

TORIT RECIRCULATION UNIT

D.F. Goldsmith uses a pre-coat bag filter system to remove mercury vapor from plant air. The system consists of a Torit Model #125-50LB "dust collection" unit manufactured by the Torit Division of the Donaldson Company, St. Paul, Minnesota (Figure 8). The cost of the Torit was $6,735 in 1976. The unit draws plant air from three sources; the southeast corner of the receiving area (next to the Torit); the southeast side of the bottle filling room (next to the fill station); and from the southwest corner of the mixing room. In each room, the air is drawn through a 4 inch by 10 inch intake duct. The ducts from the three sources connect at a junction box adjacent to the Torit and the flows combine to pass through the filter unit. The pre-coat media on the filter bag cartridges is a manganese dioxide (MnO_2) material. The manganese dioxide adsorbes the mercury vapor and removes it from the air stream. Presently, the manganese dioxide is shaken down and replenished on a weekly basis.

The Torit consists of a chemical charging hopper, a series of filter bags, a blower, a discharge plenum, a shakedown valve, and a shakedown tray (Figure 9). The charging hopper is the junction box where the flows combine from the three exhaust take-offs. It is a rectangular section of duct with a sheet metal door. To charge the unit with MnO_2, the door is opened while the blower is operating and the MnO_2 is added until a pressure drop of 3 inches of water is achieved across the unit. This will provide for an airflow of approximately 3000 cfm through the Torit. The pressure drop is determined by reading a magnahelic gauge on the side of the unit.

The filter section of the Torit consists of 36 cloth filter bags with wire mesh frames. Approximately twice a week, the Torit is shut off and the MnO_2 is shaken down from the bags to a shakedown tray using a crank on the

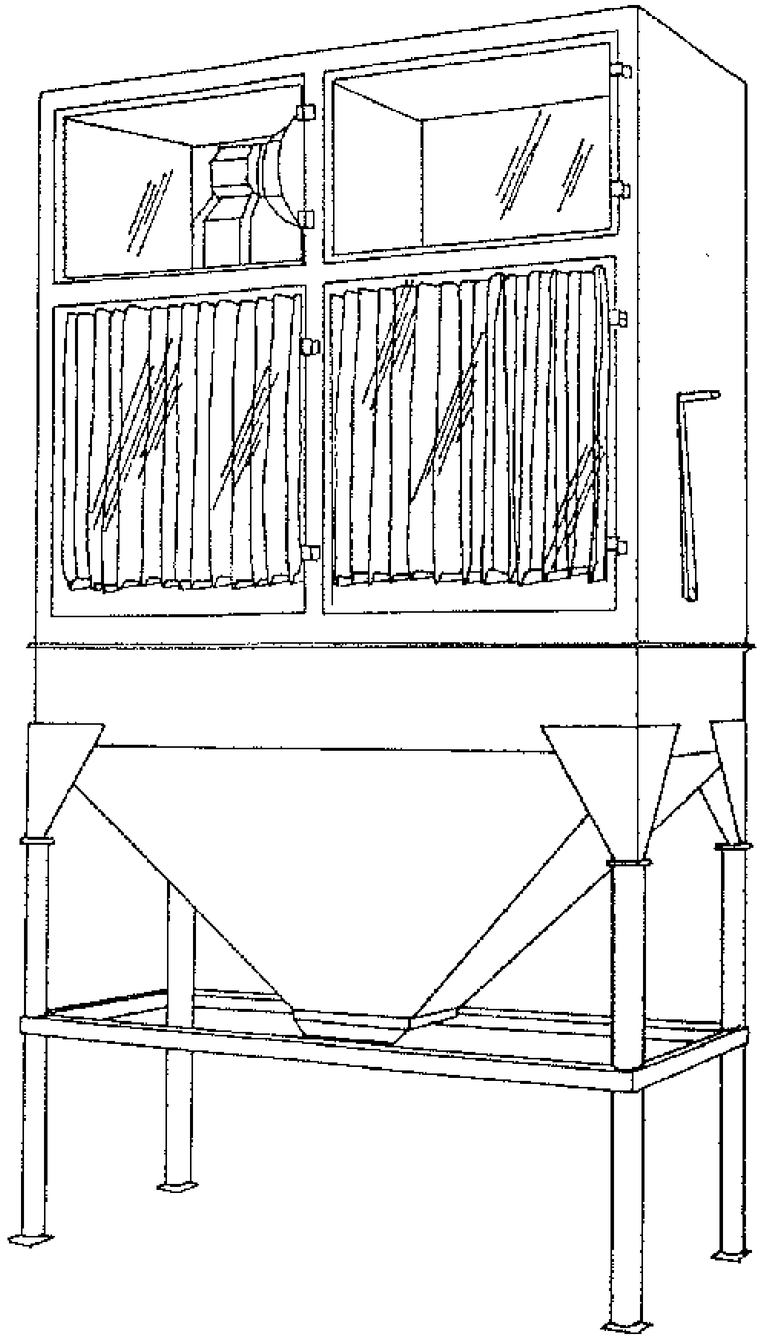

Figure 9. Torit Unit Opened Showing:
- Chemical Charging Hopper
- Blower
- Filter Bags.

side of the Torit. The Torit is then started up again and the MnO_2 is drawn back onto the bags. This practice helps to insure that an even precoat remains on the filter bags. When the MnO_2 is being replaced, the used powder is removed from the shakedown tray. Used powder is sent to an outside firm for mercury reclamation and disposal.

The blower draws air through the filter bags and into a suction plenum. The blower has a 5 horsepower motor. It exhausts into a discharge plenum mounted above it. The discharge plenum has a 14 inch by 10 inch opening through which the exhaust air is released to the receiving area at ceiling level. MnO_2 can be found at the discharge of the unit, and to some extent throughout the building. A hole found in one of the filter bags could be contributing to this filter media break-through.

The information presented in the Survey Section shows that the airflows from the fill room, receiving area, and mixing area are 776 cfm, 608 cfm, and 1126 cfm respectively. The total airflow through the Torit is therefore approximately 2500 cfm. The mercury removal efficiency of the unit was calculated to be 76%. It may therefore be concluded that the filter unit is effective in removing mercury vapor from the workplace air. Improved control of mercury vapor concentrations in the fill room could possibly be obtained by increasing the exhaust airflow to the Torit. This could be accomplished by installing louvers on the take-offs so that exhaust airflow from the mixing room could be reduced thereby increasing the flow from the fill room.

PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment in use at this facility to control exposure to mercury includes:

- Respirators (3M #8707 Disposable Mercury Vapor Respirator - not approved by NIOSH) are worn in the still room. These are disposed of after 8 hours of use (usually over a several day period).
- Disposable laboratory coats made of Tyvek^R are worn by all workers. The coats are used for about 1 week before disposal.
- Vinyl coated cloth gloves are worn when in the distillation room. These are changed whenever they wear out.

- Plastic shoe coverings are worn when handling flasks of mercury. The coverings are removed upon exiting this room.
- Workers are not permitted to wear work shoes home from the plant.
- HgX^R barrier cream is available for use by workers.

WORK PRACTICES

Procedures and practices have been implemented to control exposure to mercury. The following list summarizes these practices.

- Smoking, eating or drinking are not permitted at the work stations.
- Employees must wash their hands prior to breaks.
- The mercury packaging table must be rinsed down each night.
- Stainless steel trays used to hold bottles of mercury should be checked daily to make sure that they contain at least 1 inch of water.
- Work areas must be vacuumed daily using the house vacuum system.
- Mercury spills must be vacuumed immediately and mopped with HgX^R.
- Production areas must be mopped once per week using HgX^R.
- Employees must read a training manual covering the problems of working with mercury prior to employment.

MONITORING PROGRAM

Biological Monitoring

A medical program directed by a consulting physician is in operation at the facility. The company requires pre-employment and semi-annual physical examinations for all workers. Emphasis is placed on detecting signs or symptoms of mercury poisoning. Urine and blood samples for mercury analysis are collected during the examinations.

All employees at the facility take part in the biological monitoring program, which includes analysis of blood and urine to determine the levels of mercury. Blood monitoring is conducted twice a year; urine monitoring is conducted once a year. Spot urine samples rather than 24 hour composite samples are collected.

The biological monitoring program is directed by a consulting physician. The physician considers blood mercury levels to be a more reliable indicator of exposure than urine-mercury levels. In the last year, worker's blood levels have ranged from 14 to 35 micrograms of mercury per 100 milliliters of blood (ug/100 ml).

The level at which a worker's biological monitoring results are considered unacceptable has not been determined at this facility. There is currently no relocation procedure in the event of a "high" biological monitoring result.

Air Monitoring

Periodic monitoring is conducted to determine the levels of mercury vapor associated with various jobs and locations within the facility. This involves weekly monitoring with a direct reading instrument (Bacharach MV-2 Mercury Vapor Sniffer) at selected locations.

During the course of the survey, concurrent samples were taken using this instrument and an identical model belonging to the survey team. Readings obtained from the company's instrument were uniformly higher by approximately 25%. A calibration discrepancy between these machines is suspected. The survey also determined that company personnel were not zeroing the instrument properly prior to sampling. In response to this, instructions and a copy of the operation manual were provided by the team.

SURVEY DATA

AIR SAMPLING RESULTS

Sampling was conducted to measure the effectiveness of the Torit unit and the ventilation system. Mercury vapor sampling was conducted with a Bacharach Model MV-2 direct-reading instrument, and with Hydrar^R solid sorbent tubes for time-weighted average (TWA) samples. The Hydrar media was used with low-flow sampling pumps operating at approximately 120 milliliters per minute. Analysis of the sampling tubes was conducted using flameless atomic absorbtion spectrophotometry.

Air samples were also taken for manganese dioxide dust in order to determine if of this material is escaping from the Torit unit. This sampling method utilized mixed cellulose ester filters mounted in cassettes and high-flow sampling pumps operating at 2 liters per minute. Analysis was performed by flame atomization atomic absorbtion spectrophotometry.

Time-weighted average sampling results for mercury vapor (Table 1) show relatively high concentrations in the areas of primary concern, the fill and receiving rooms. Concentrations in the fill room were above the OSHA action limit for most of the survey. No significant difference in concentration was seen between samples taken in the center of the fill room and those taken next to mercury filling station. Mercury vapor concentrations in the receiving room were noticably lower than those found in the fill room. The Torit exhaust air as measured with TWA sampling showed levels well below those in either room, which preliminarly indicates it is effective in removing mercury. The Torit is located at the far end of the receiving room oposite the fill room doorway. There is some indication from this data of an increasing mercury vapor gradient existing from the Torit exhaust across the room to the fill room doorway.

Numerous direct-reading samples were taken with the Bacharach MV-2. The results are presented in Table 2. The floor in the fill room is indicated

TABLE 1

TWA Mercury Vapor Area Sampling Results
(5/4/82-5/6/82)

Sample Location	Full-Shift TWA Concentration (mg/m^3)	
	Range	Average
Fill Room (center of room)	0.120-0.260 (9)*	0.190
Fill Room (fill bench area)	0.083-0.190 (3)	0.131
Receiving Room (fill room door)	0.066-0.150 (3)	0.099
Receiving Room (center of room)	0.004-0.130 (3)	0.081
Torit Unit Discharge	0.060-0.071 (2)	0.066

*Numbers in parentheses indicate number of samples taken.

TABLE 2

Direct Reading Mercury Vapor Sampling Results
(5/4/82-5/6/82)

Sample Location	Concentration (mg/m^3)	
	Range	Average
Fill Room (central area)	0.08-0.20 (15)*	0.16
Fill Room (floor)	0.13-0.75 (5)	0.39
Fill room (filling bench)	0.08-0.25 (6)	0.14
Mixing Room	0.03-0.08 (6)	0.06
Receivng Room (central area)	0.05-0.11 (5)	0.08
Torit Intakes (fill and receiving)	0.13-0.14 (2)	0.14
Torit Exhaust	0.01-0.08 (4)	0.05
Supply Air Diffusers (fill room)	0.00-0.03 (4)	0.02

*Numbers in parentheses indicate number of samples taken.

as the main source of contamination, particularly since the actual filling operation takes place for only a short period of time and it is controlled by a local exhaust ventilation system. Mercury vapor concentrations in the mixing room, which is adjacent to the receiving room ranged from 0.03 to

0.008 mg/m^3. Mixing operations do not involve any liquid mercury, and the presence of vapor is presumed to be caused by cross-contamination from the other rooms. These three rooms, fill, receiving, and mixing, are tied into the Torit system via air intakes in each room. The Torit unit exhausts into the receiving room only, and this exhaust air returns to the other rooms via the doorways. Sampling of the Torit exhaust with the mercury vapor detector showed concentrations significantly lower than those in the fill and receiving rooms. These results are in agreement with TWA sampling results reported in Table I. Torit efficiency data are presented in the Ventilation section of the survey results. The data shows that the Torit is effective in removing mercury vapor from the air, however, whether recirculation to the fill room is occuring at a rate sufficient to provide the desired dilution, is questionable.

During the third day of the survey, after finding uniformly high concentrations of mercury vapor on the previous days, the supply air system was altered to provide approximately 50% fresh air. After this modification, the concentrations throughout the facility dropped to an acceptable level.

The results of mercury vapor direct-reading sampling during this period are presented in Table 3.

TABLE 3

Direct Reading Mercury Vapor Sampling Results
(5/6/82 p.m. only)

Sample Location	Concentration (mg/m^3) Range	Average
Fill Room (central area)	0.04-0.08 (3)*	0.06
Fill room (filling bench)		0.08
Receivng Room (central area)	0.01-0.03 (3)	0.02
Supply Air Diffusers (fill room)	0.00 (3)	0.00

*Numbers in parentheses indicate number of samples taken.

For this sampling, the supply air system was permitted to operate for over 2 hours to equilibrate ambient levels prior to actual sampling. This mode of supply air system operation (50% fresh air make-up) is standard procedure, however, the system had accidently been changed without knowledge of the company representative.

The results of sampling for manganese dioxide dust are presented in Table 4. Manganese was detected in all samples, although in relatively low concentrations. The Torit unit discharge showed the highest concentrations indicating that this is the source of the dust. Concentrations in the receiving room, where the Torit is located, were the highest of the three rooms sampled. The fill and mixing rooms had similar concentration, about half that of the receiving room.

TABLE 4

TWA Manganese Dioxide Dust Area Sampling

Sample Location	Full-Shift TWA Concentration (mg/m^3)*	
	Range	Average
Fill Room	0.022-0.044 (9)**	0.036
Mixing Room	0.017-0.044 (3)	0.032
Receiving Room	0.049-0.155 (3)	0.082
Torit Unit Discharge	0.059-0.189(2)	0.123

*TVL for nuisance manganese dioxide dusts = 15 mg/m^3 total dust.
**Numbers in parentheses indicate number of samples taken.

Visual examination of various locations throughout the facility, including supply air diffusers, showed significant amounts of black dust. Presumably the major constituent of this dust is manganese dioxide. This indicates some circulation of the material via the supply air system. The possibility exists that some dust contaminated with mercury is being spread by this means, and that this might be an additional source of mercury exposure.

VENTILATION

Fill Station Exhaust Hood

The exhaust airflow through the Fill Station Exhaust Hood was measured using an Alnor velometer. Table 5 summarizes the results.

TABLE 5

Fill Station Exhaust Hood Air Flow Measurements

Area Measured	Dimensions (inches)	Average Velocity (fpm)	Airflow (cfm)
Full Face of Hood	73 x 43.5	45	990
1/2 Face of Hood (with mylor sheet drawn over other half)	36.5 x 43.5	95	1045
Local Exhaust Hood* (left)	6 x 6	581	145
Local Exhaust Hood* (right)	6 x 6	727	180
Slot* (left)	71 x 3	557	824

*Indicates individual exhaust located inside the Fill Station Hood which partially accounts for the airflow across the face of the hood.

Torit Unit

The exhaust airflow through the 3 Torit exhaust ducts was determined. Air velocities were measured using the Alnor velometer. In addition, the air velocities in two of the Torit ducts were determined using a pitot tube and inclined manometer. The airflows calculated from the pitot tube traverses were approximately 200 cfm lower than the corresponding airflows obtained using the Alnor velometer.

Results of velocity measurements are summarized in Table 6.

TABLE 6

Torit Unit Air Velocity Measurements

Duct Measured	Dimensions (inches)	Average Velocity (fpm)	Airflow (cfm)	Percent of Total Flow
Torit exhaust duct (receiving)	4 x 10	2170	608	24
Torit exhaust duct (fill room)	4 x 10	2770	776	31
Torit exhaust duct (mixing room)	4 x 10	4020	1126	45
TOTAL EXHAUST AIR FLOW			2510	100

The data shows that the total combined airflow through the Torit is approximately 2500 cfm. This value was verified by measuring the air velocity at the 14 inch by 10 inch Torit discharge. The average velocity at the discharge was 2800 fpm, resulting in an airflow of approximately 2700 cfm.

The efficiency of the Torit unit in removing mercury vapor from the exhaust air stream was calculated using the mercury vapor readings at the Torit intakes and Torit discharge to determine a mass balance. The average mercury vapor concentrations measured were:

- Torit exhaust duct (receiving) - .037 mg/M^3
- Torit exhaust duct (fill room) - .080 mg/M^3
- Torit exhaust duct (mixing room) - .047 mg/M^3
- Torit discharge - .013 mg/M^3

Using the above information, the mercury removal efficiency of the Torit unit is calculated to be 76%.

CONCLUSIONS AND RECOMMENDATIONS

Results of area monitoring and grab sampling to determine concentrations of mercury vapor and particulate show that the ventilation systems at this facility must operate per standard operating procedure to maintain levels below the Occupational Safety and Health Administration Standard (0.1 mg/m^3). Failure to operate the air handlers with sufficient fresh air make-up can result in mercury vapor build-up in the work area.

The bottle filling station is effective in drawing air past the worker's breathing zone and it removes much of the mercury containing air from the fill room. The Torit unit removes 76% of the mercury vapor in the air stream drawn through it, however, charcoal filter recirculation systems reportedly have removal efficiencies much greater than 76% and they usually do not have the airborne particulate problems associated with this unit. It is therefore recommended that facilities planning on installing an air recirculation system for mercury removal should investigate charcoal filter in addition to an MnO_2 precoat bag filter with post-filtration.

Additional recommendations are:

- the frequency of floor cleanings in both process and office areas, should be increased.
- all ventilation equipment should be monitored to insure proper operating conditions are achieved.