FINAL REPORT

MERCURY CONTROL TECHNOLOGY ASSESSMENT STUDY

Duracell, U S.A
Lexington, North Carolina

Survey Report for the
Site Visits of
February 10-11, 1981 and
June 22-23, 1982

Contract No 210-81-7107

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Submitted to

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DISCLAIMER

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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 Cotrol Division met with Mr. James Wallace of Duracell, U.S.A., Lexington, North Carolina on February 10-11, 1981 to gather preliminary information and again on June 22-23, 1982, to conduct an indepth survey on the techniques used to control worker exposure to mercury. Participants in the survey were:

<u>NIOSH</u>

Mr. Alfred A. Amendola, Project Officer
Mr. Dennis O'Brien, Industrial Hygiene Engineer

<u>Dynamac Corporation</u>

Mr. Donato R. Telesca, Program Manager
Mr. David D'Orlando, Engineer
Mr. Robert Reisdorf, Industrial Hygienist
Mr. Andrew Reyburn, Industrial Hygienist
Mr. Jan Scopel, Engineer

<u>Duracell, U.S.A</u>

Dr. George Wallis, Manager of Environmental Affairs (Corporate)
Mr. James Wallace, Plant Industrial Hygienist
Tracey Barber, M.D., Occupational Medicine Consultant

The preliminary survey was completed in two days. The study included a tour of the production process, a review of mercury controls, and interviews with administrative personnel. The indepth CTA was completed in two 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 recirculating air system used at the facility was completed.

This report contains both general information obtained in the preliminary survey at the facility on February 10-11, 1981 and specific information obtained in the in-depth survey. Emphasis is placed on the recirculating ventilation systems used as a mercury control.

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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

Duracell, U.S.A. (Duracell) was selected for an in-depth survey in order to study the overall effectiveness of the recirculating ventilation system used to control mercury vapor concentrations in the cell assembly room.

SUMMARY OF INFORMATION OBTAINED

An opening meeting was held during which the objectives of the survey were discussed. Information on the work place 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

The Duracell Plant produces primarily mercury "Ruben" cells and batteries. It is a large size facility consisting of three major buildings: Oxide Plant, Cell and Battery Assembly Plant, and Job Order/Stores (Plant #3) (Figure 1.). The Oxide Plant houses the mercuric oxide process equipment. Mercury reclamation ovens and wastewater treatment facilities are situated adjacent to this building. The Cell and Battery Assembly Plant houses the Slugger Room, Depolarizer Room, Anode Room, Cell Assembly Area, Battery Assembly Area, Lab, Dispensary and General Offices. In the Job Order building, mercury cells are fabricated into special batteries. The buildings are constructed of blockwall, and the two production plants have a brick facing.

There are 678 production workers employed at Duracell. The Plant operates two shifts per day, 5-6 days per week. Approximately 230 workers (including maintenance personnel) are involved in processes or areas where mercury is used or present. The following list shows the number of employees working in process areas involving mercury.

1.	Oxide Plant	- 18
2.	Slugger Room	- 56 (rooms 2 and 3 combined)
3.	Depolarizer Room	
4.	Anode Room	- 9
5.	Cell Assembly Area	-148

Workers in the Battery Assembly Area and Job Order handle sealed mercury cells therefore the potential for exposure to mercury there is less than in other areas of the plant.

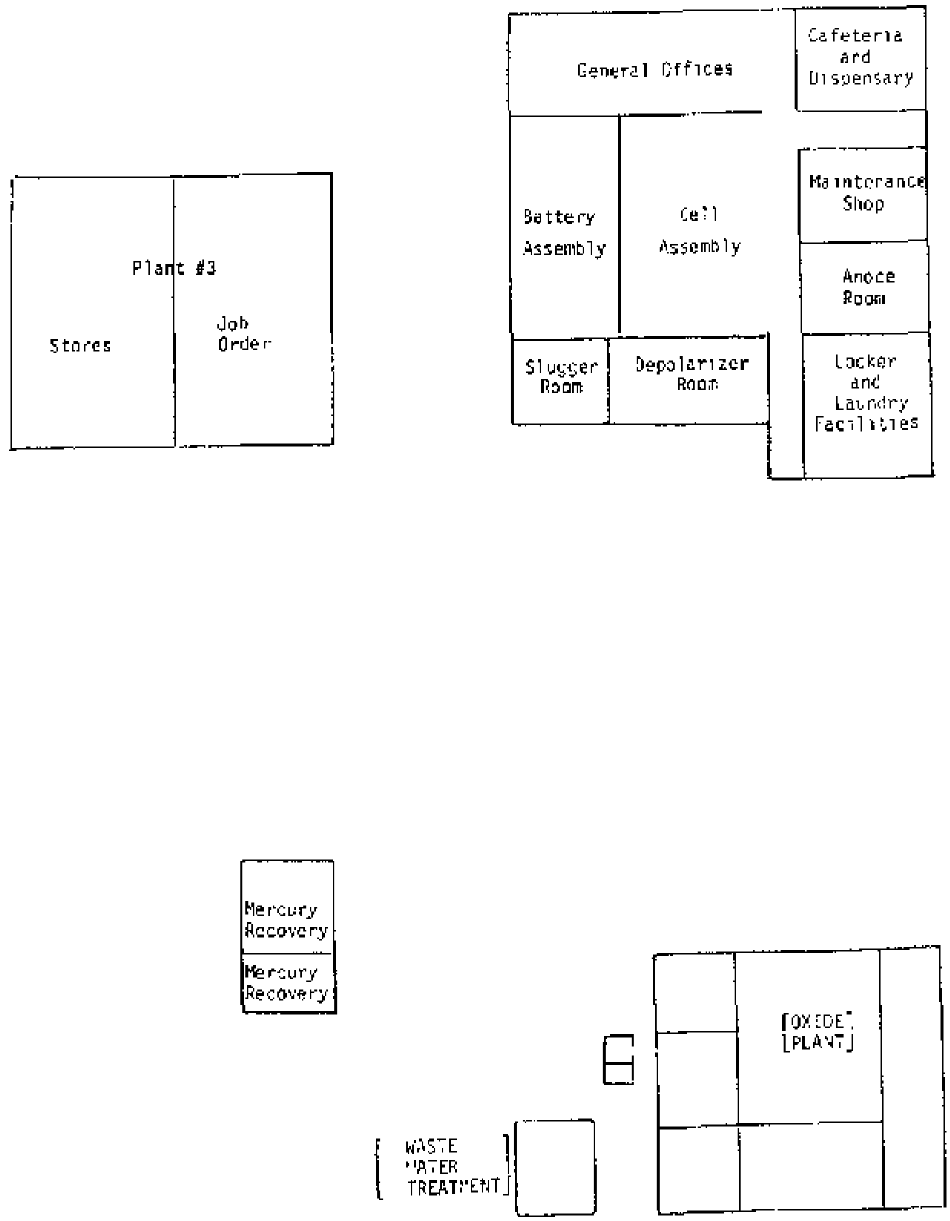


Figure 1 Layout Of The Battery Manufacturing Facility

PROCESS DESCRIPTION

(for mercury cell manufacturing and mercury reclamation)

OXIDE PLANT (Figure 2)

Mercury Handling

The elemental mercury, used as a primary material for both anode and cathode production, arrives at the Oxide Plant in one of the following forms:

- o 2205 lb heavy duty virgin mercury containers,
- o 76 lb virgin mercury flasks,
- o reclaimed mercury cylinders from outside contractors,
- o reclaimed mercury from plant's reclamation facility,
- o bottles containing reject acid rinsed mercury.

All of the above containers are stored closed in security storage. The last three types of mercury must be purified before use in the process. Purified mercury is transferred by vacuum to the appropriate storage tanks. When mercury is to be added to the process, it is transferred by compressed air to the Pfaudler reactor.

Reaction

The production of a mercuric oxide precipitate is a two stage process. First, the mercury is reacted with chlorine and a brine solution to form mercuric bichloride. This is then reacted with a caustic solution to form the mercuric oxide precipitate.

When the reaction is completed the solution is allowed to settle and the precipitate is then pumped to a wash tank.

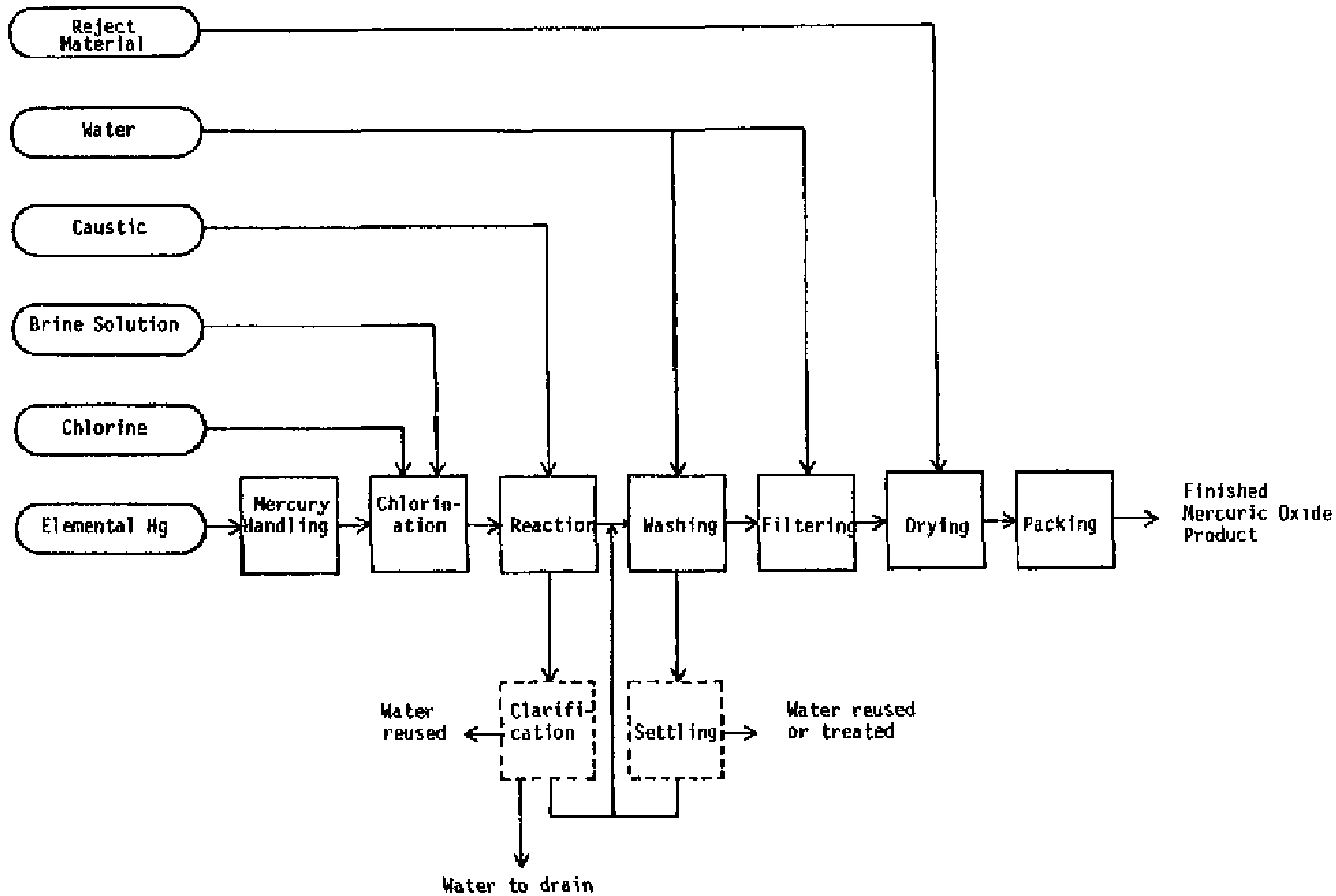


Figure 2 OXIDE PLANT - Process Flow Diagram

Washing and Filtering

The wet mercuric oxide precipitate is subjected to several washings to remove residual chloride ions. After washing, the slurry is laid down on a belt filter where it is washed again by a series of spray headers. The wash water is returned to process. The moist mercuric oxide cake falls off the belt filter into a hopper, and is fed to a screw conveyor which delivers the cake to a series of drop chutes. These drop chutes feed to a series of vacuum dryers.

Drying and Packaging

Abbe rotary core vacuum dryers are used to remove the remaining moisture from the product. When the drying cycle has been completed the dried powder is gravity fed into a hopper through a sleeve that fits around the outlet of the dryer and the inlet of the hopper. At this stage the mercuric oxide is a fine, dry, easily suspended powder. A series of short flexi-feed conveyors lift the powder to a surge hopper.

Another flexi-feeder conveyor is used to feed the powder to a Sweco (screening device) where foreign matter, scale, and oversized particulates are removed. The rejects from the Sweco flow into a 55 gallon drum, and are later heated in a reclamation oven to recover the mercury. The on-size powder from the Sweco screen is flexicon (screw) conveyed to a packing station where batches are prepared at predesignated weights. The packing station is enclosed in a hood to minimize dispersion of fine mercuric oxide particulate in the packing room.

SLUGGER ROOM (Figure 3)

Blending

The slugging process is intended to produce a uniform granulated mixture of mercuric oxide and other materials for use in fabricating the cathode of the mercury cell. The process begins with the blending of various combinations of the following raw materials: cadmium oxide, graphite, and manganese dioxide with the mercuric oxide produced in the Oxide Plant.

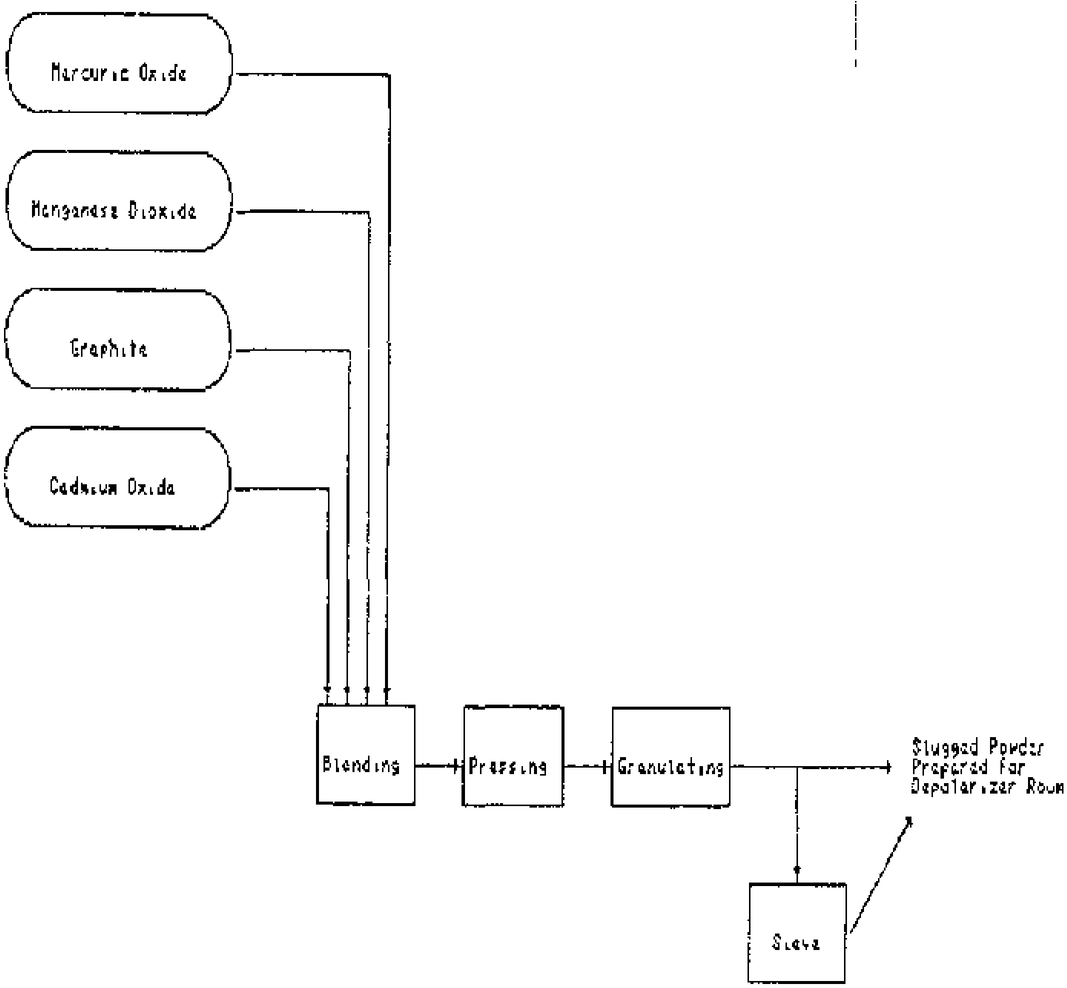


Figure 3. Slugger Room - Process Flow Diagram

These metal components are manually poured into the V-blender (Figure 4). When the blending cycle is completed, the mixture is gravity fed through an enclosed boot to either the presses or roller compactors below.

Slugging

Presses. Stokes' presses pelletize the blended mixture into pellets (slugging). The force of compaction causes displacement of air containing particulates. For this reason, the presses are enclosed in a plexi-glass structure, with individual local exhaust ventilation systems. The pellets are then granulated and gravity fed to a metal container.

Roller Compactors. Blended powder flows between two rollers to form a compacted cake. The cake is granulated and gravity fed to a Sweco where two different screens are used to separate oversized and undersized particles coming off of the granulator. These reject particles are gravity fed to an enclosed bucket conveying system which transports the material back to the roller compactors. The selected material goes to metal containers like those previously mentioned.

DEPOLARIZER (DP) ROOM (Figure 5)

Pelletizing

The granulated mixtures produced in the Slugger Room are transferred to the DP Room in preparation for the manufacturing cathodes. The mixture is fed to Stokes' presses to produce cathode pellets according to the specifications of the different cells being manufactured. As in the Slugger Room, all of the presses are enclosed in plexi-glass structures with local exhaust ventilation systems.

Consolidation

The cathode pellets are set into cans of various sizes and are compacted by a Stokes' press to a specified height. This machinery is enclosed along with the pelleting press. The finished cathodes are stored in bins in preparation for assembly into mercury cells.

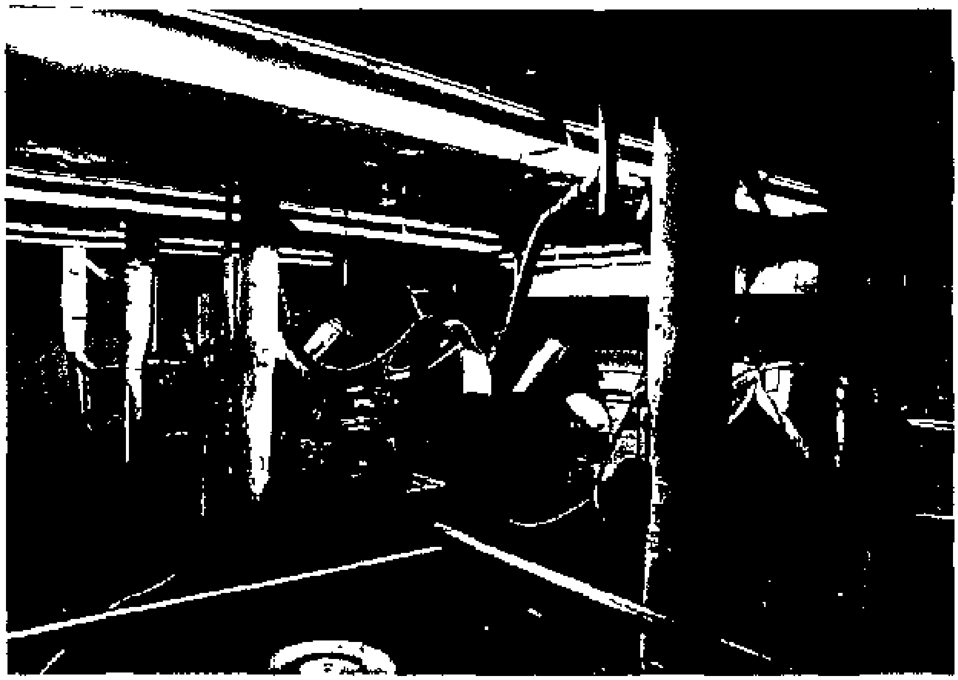


Figure 4   Slugger Room V-Blenders

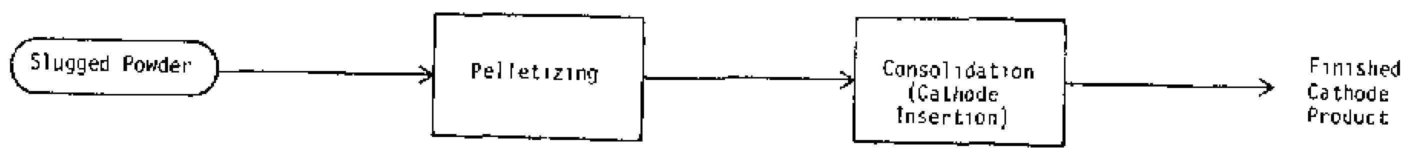


Figure 5 DEPOLARIZER ROOM - Process Flow Diagram

ANODE ROOM (Figure 6)

Mixing

The production of the anode begins with the mixing of acid rinsed mercury with zinc powder. The mixing is done in a container (with lid closed) under a hood.

Vacuuming and Filtering

The amalgam mixure is prepared for oven drying by performing the following operations over a vacuum filter:

- o transferring the amalgam mixture from mixer to the filter vessel.
- o removing water by vacuum.
- o adding alcohol to remove water.
- o removing alcohol by vacuum.

The moist amalgam is then set into trays (under a hood) in preparation for drying.

Oven Drying

The trays of amalgam are placed into a vacuum oven where the remaining moisture is removed. When drying is complete, the oven is cracked open and the vapor from inside is vented into an exhaust hood at the front of the oven. The trays are then removed.

Screening

The dried amalgam is passed through a vibrating screen to remove unwanted large particles, and agglomerated material is collected in a bucket. This operation is conducted in an enclosure with local exhaust ventilation.

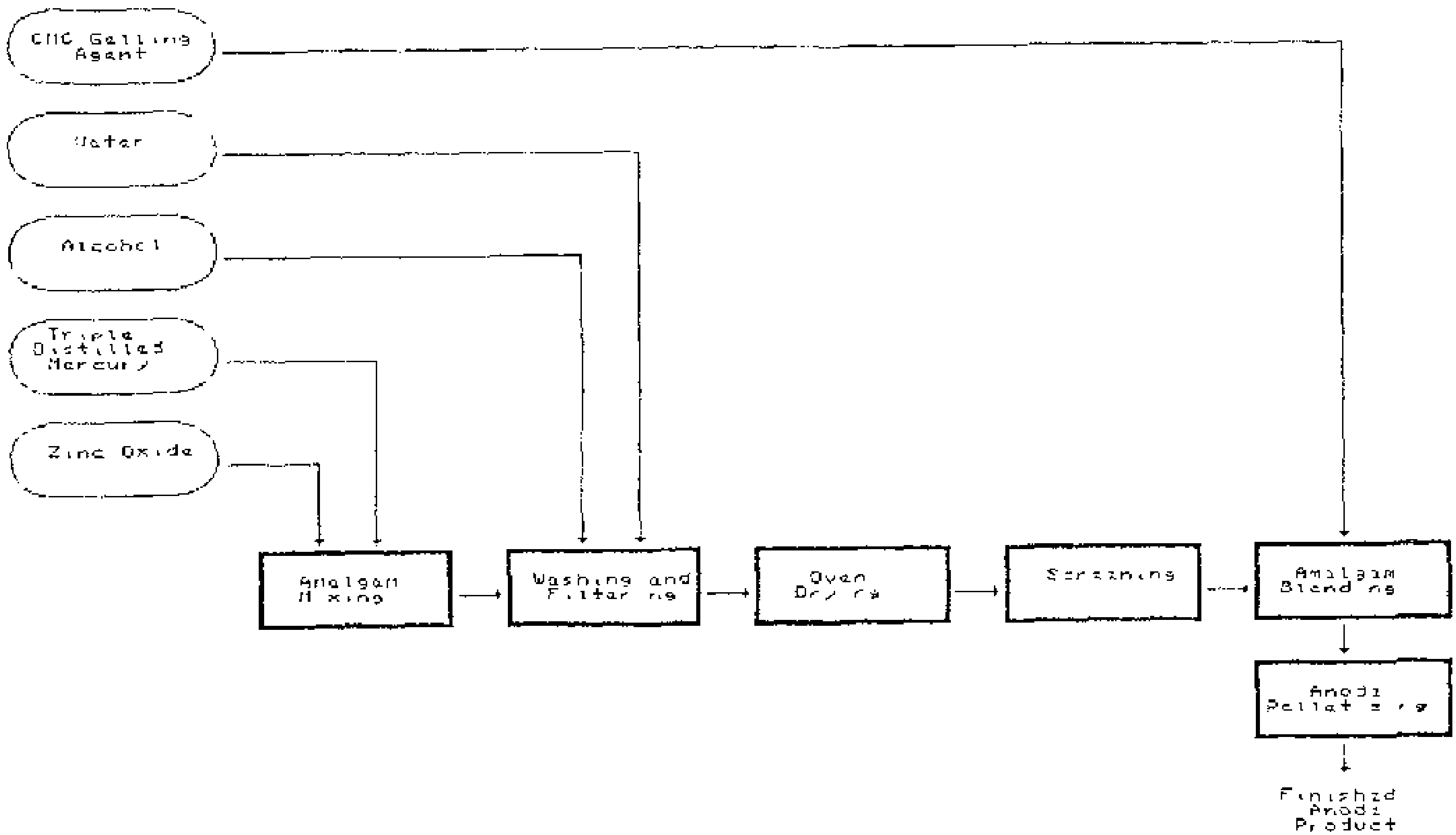


Figure 6 ANODE ROOM - Process Flow Diagram

Blending

The screened amalgam is then blended with a small amount of gelling agent in preparation for pelletizing. The two substances are manually fed into the V-blender. The blender is situated inside a hood. The mixture is collected below the blender.

Anode Pelletizing

The amalgam is emptied into a feed hopper located above a press. The press is enclosed in a plexi-glass structure which is equipped with an LEV system. Here, the amalgam is pelletized into anodes of various shapes and sizes according to the specifications of the particular cell to be manufactured.

CELL ASSEMBLY (Figure 7)

The assembly of the mercury cells is done both automatically and semi-automatically on the production floor. The cathode (can and pellet), anode, electrolyte, and a top cover are assembled and are sealed with a crimper. Other components, such as an insulator, an absorber, and a barrier may be added to the cell according to design specifications.

Assembly is designed so that the anode and cathode trays are enclosed and ventilated.

The cells are now prepared for sale or for assembly into multi-celled batteries.

MERCURY RECLAMATION

Throughout the various processes in the mercury cell manufacturing facility, different forms of wastes are generated. Because of the high cost of the raw materials used and the cost of the disposal of the waste to hazardous waste landfills, it is economically feasible to reclaim the elemental mercury if the waste material has greater than approximately 10% (by weight) mercury

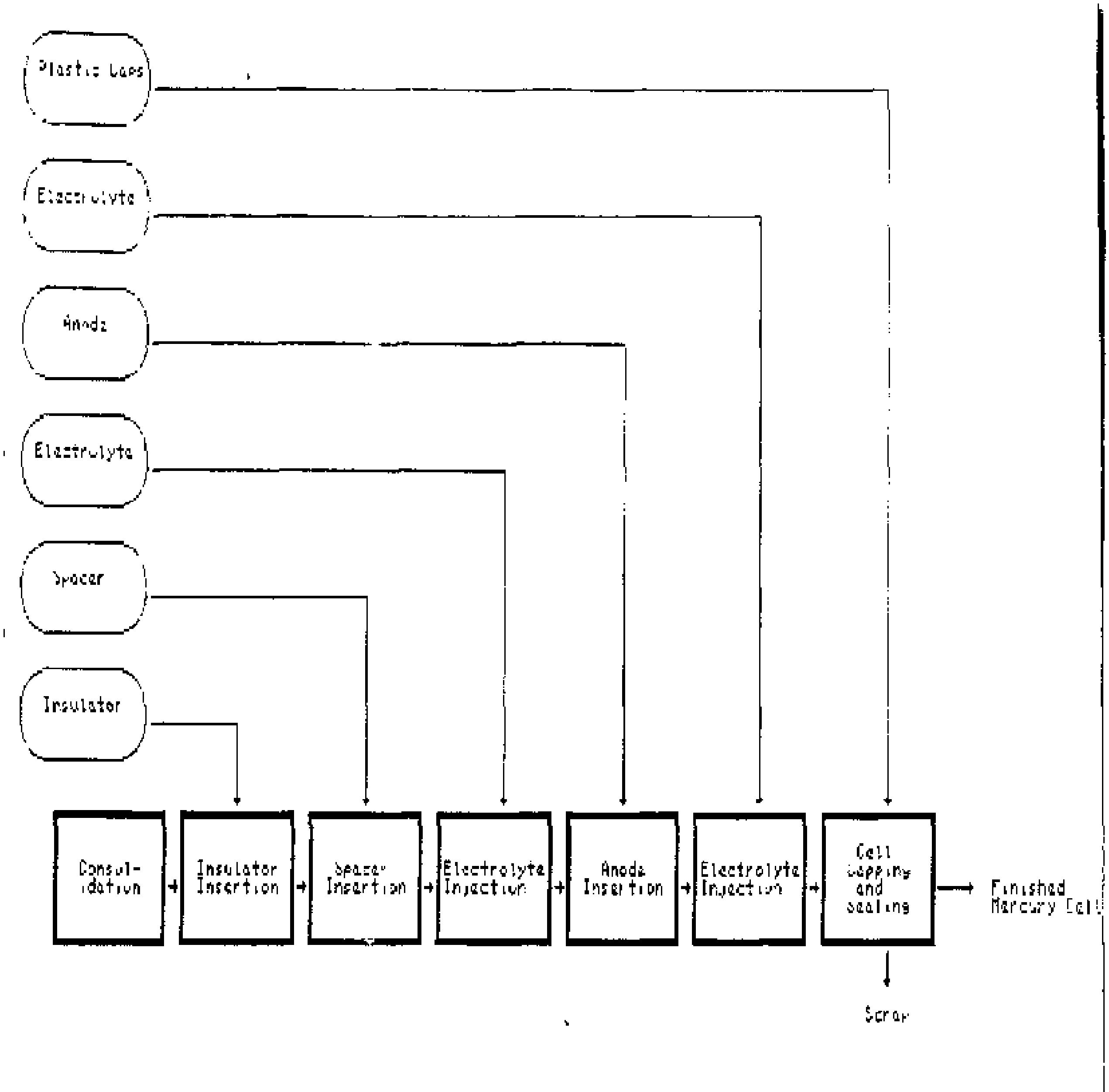


Figure 7. Cell Assembly - Process Flow Diagram.

content (dependent on the current cost of recovery and cost of mercury). This is done in the plant's Mercury Reclamation facility. Here, reject cathode materials, cells and batteries, are layered onto loading trays with reject mercuric oxide waste treatment sludge and unusable materials from the baghouse and are heated to vaporize mercury. This vapor is then condensed to form liquid mercury. It is purified at the mercury handling facility in the Oxide Plant. The charred residue is then sent to hazardous waste landfill. Mercury vapor and particulate control is provided for this operation.

MERCURY CONTROL STRATEGY

ENGINEERING CONTROLS

Mercury is a major component of both the anodes and the cathodes used to make the Ruben cell. Consequently, mercury may be present in some of the major manufacturing areas of the plant. The engineering controls used in each area to reduce mercury vapor levels and mercuric oxide particulate concentrations are listed below according to process areas.

Oxide Plant

- an exhaust hood is located over the mercury transfer area.
- a portable vacuum cleaner is used to clean up mercury droplets. The vacuum cleaner is equipped with particulate and vapor control.
- a duct leading to roof exhaust fans draws mercury from the second stage reaction vessels.
- double mechanical seals are used on pump shafts. They are replaced approximately every six months.
- teflon and rubber gasketing is used at flanges.
- a clarifier has been installed to reduce the amount of mercuric oxide going to wastewater treatment system.
- a pipeline leading from the clarifier to the waste water treatment facility has recently been installed at a cost of approximatly $3,000. This is expected to reduce the amount of mercuric oxide in the floor drains.
- the spent wash water is sent to a settling tank in the packaging room to remove mercuric oxide before sending water to the drains.
- the filter cake coming off the belt filter is kept moist to avoid the suspension of dry mercuric oxide powder in the air.
- a rubber boot connects the conveyor with the dryer cover to reduce particulate emission during dryer filling.
- the dryer cover has a ventilation duct to draw off particles dispersed during filling. The exhaust air from this duct enters a baghouse outside of the building. The baghouse flow is continuously pulse-reversed into a 55 gallon drum.

- a house vacuuming system is planned for installation (est. cost $5,000).

- a pneumatic conveying system has been installed in order to reduce particulate emission which results from emptying reject material into dryers (est. cost $10,200). This system has access to loading stations at each dryer.

- a three sided back draft slot hood has been installed at the packing station (Figure 8). Duracell has determined that this control has reduced particulate dispersion by a factor of 5.

- the Oxide Plant heating system is 100% outside make-up air.

- roof exhaust fans are located in all areas.

- doors, (both plastic strip and solid) are used to isolate the separate rooms (processes) in the Oxide Plant.

Slugger Room

- a blending system is planned for installation (estimated cost $223,000). The automatic system will contain manual bag and can unloading stations going to pneumatic feeders. This control is expected to reduce particulate emission which results during hand feeding of mercuric oxide powder into the blender.

- the Stokes' press, slant screen and granulator are all enclosed in a plexi-glass structure with 3 or 4 exhaust ports (Figure 9). A 50 ft/min minimum air velocity is maintained across the enclosure. Two baghouses are used to filter the mercuric oxide from the exhaust air stream.

- The feeder will introduce measured amounts of various components to bulk hoppers which are attached to a blender. The components are blended together and the mix is transferred to the sluggers or roller compactors.

- two roller compactor systems have closed bucket conveying systems for feeding of the blender powder.

- the air supply system is 100% outside make-up air.

- a house vacuum system is used to remove mercuric oxide powder for the equipment, and to clean up accidental releases.

Depolarizer Room

- equipment is enclosed in plexi-glass structures similar to those in the Slugger Room.

Figure 8 Mercuric Oxide Packaging Station
- three sided back draft slot hood
- air supplied respirator

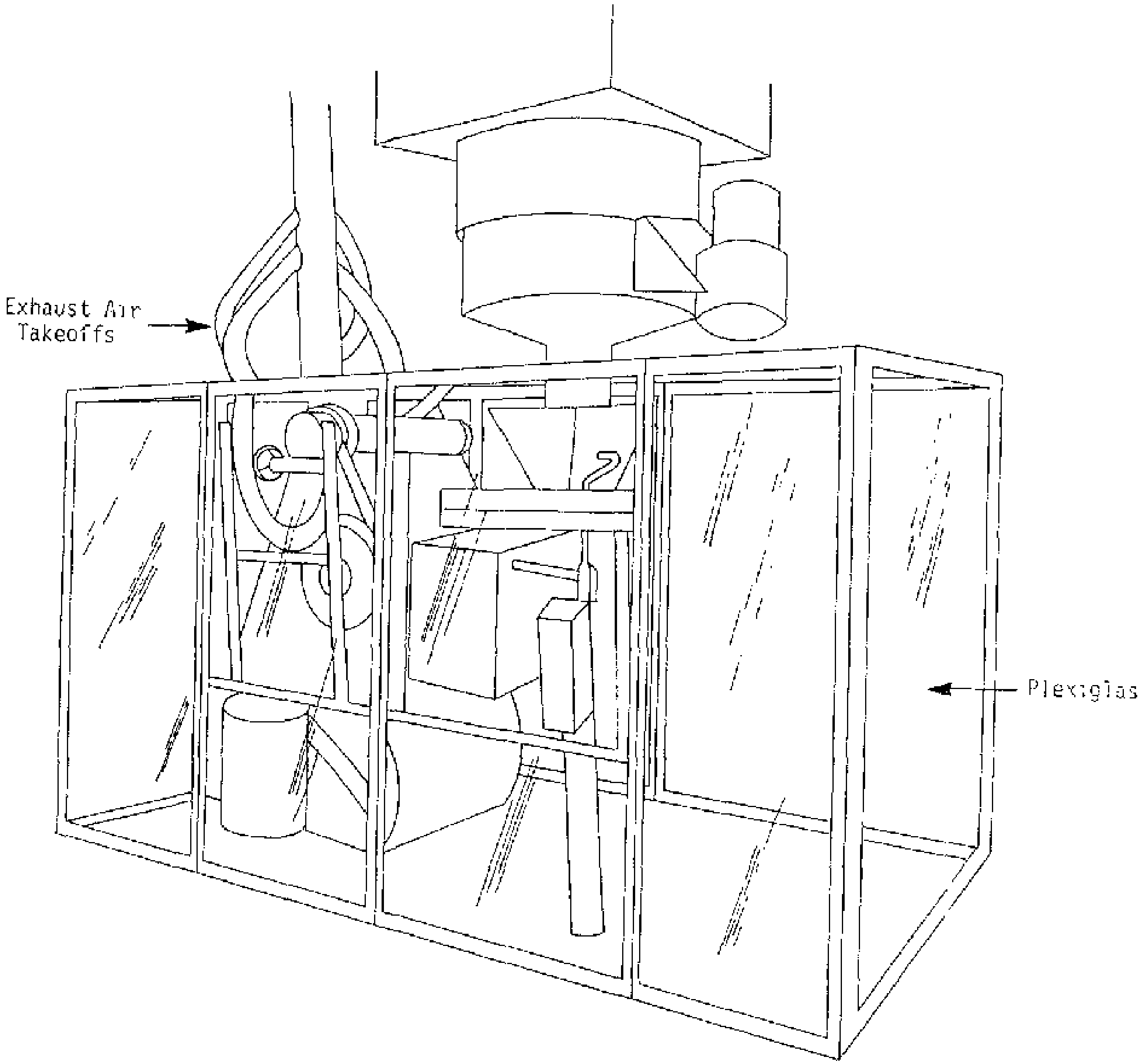


Figure 9 Plexi-glass Machine Enclosure

- new enclosures are being designed so that most maintenance work can be done from outside the enclosures. Cost per enclosure is estimated to be $5,000.

- the air supply system is 100% outside make-up air.

- a house vacuum system is used for cleaning.

Anode Room

- an exhaust hood is located over the mix station to remove mercury vapor.

- a three sided back draft slot hood encloses the loading tray work station (Figure 10)

- an exhaust hood is located over the oven door to remove mercury vapor which may escape from the oven when the door is opened (Figure 11).

- an exhaust hood engulfs the entire blending station (Figure 12) to control particulate dispersed during the blender loading and unloading.

- the sieve is enclosed in a plexi-glass container (Figure 13).

- the anode presses are enclosed in plexi-glass structures similar to those in the Slugger Room.

- the air supply is 100% recycling system with particulate and charcoal filters. There is a 15% air make-up due to natural infiltration.

- a house vacuum system is used to remove amalgam powder

Cell Assembly Area

- mercury containing cathodes are held in plexi-glass enclosures with exhaust air ports The exhaust air is filtered through the baghouse.

- anode assembly trays have screened bottoms with an exhaust air take-off situated under the screen The exhaust air is filtered through a baghouse.

- scrap or reject anodes and cathodes are kept under water to reduce mercury vapor levels

- Assembly Area has a dual air supply system.

1) a 50,000 cubic feet per minute 100% recirculation system with charcoal filters Filters are replaced approximately every two years. Filter efficiency is checked on a quarterly basis

2) a 15% make-up HVAC system.

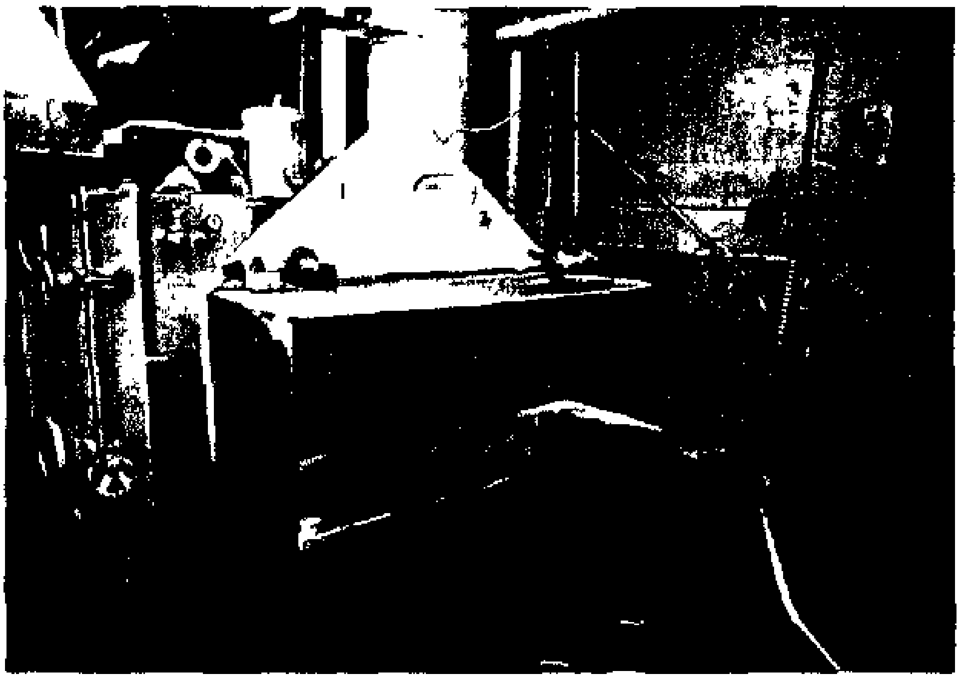


Figure 10 Three Sided Back Draft Slot Hood Over Loading Tray Station

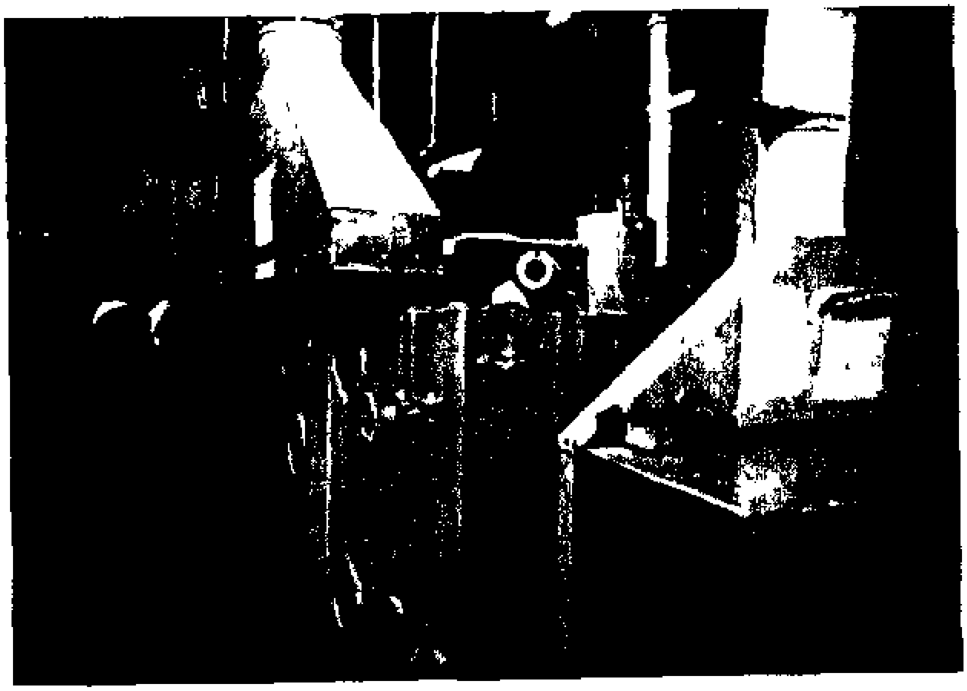
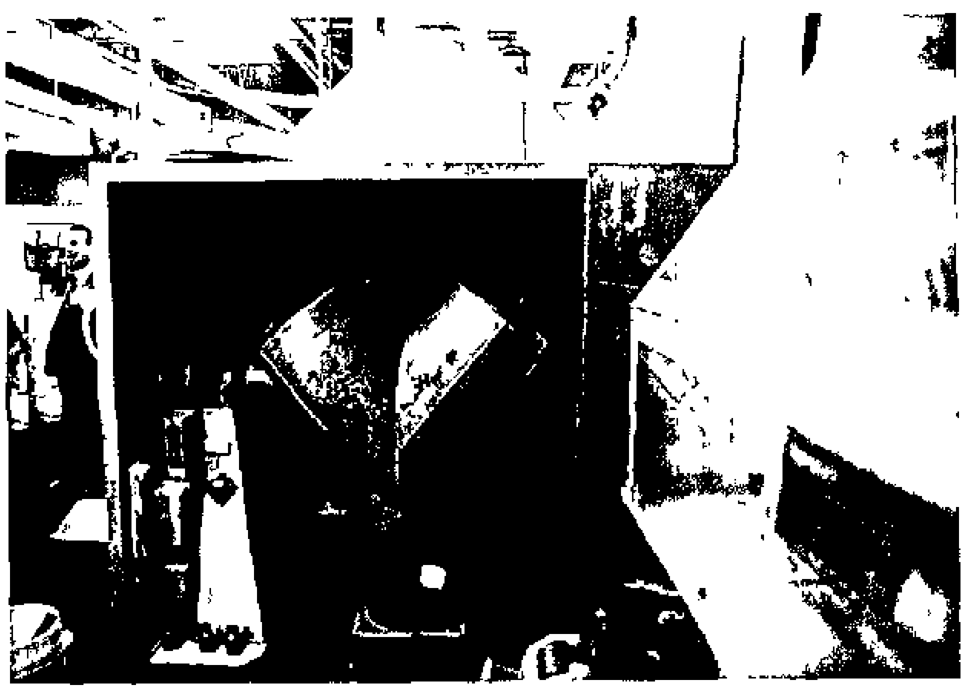


Figure 11 Exhaust Hood Over Oven Door

Figure 12 Exhaust Hood Over Amalgam V-Blender



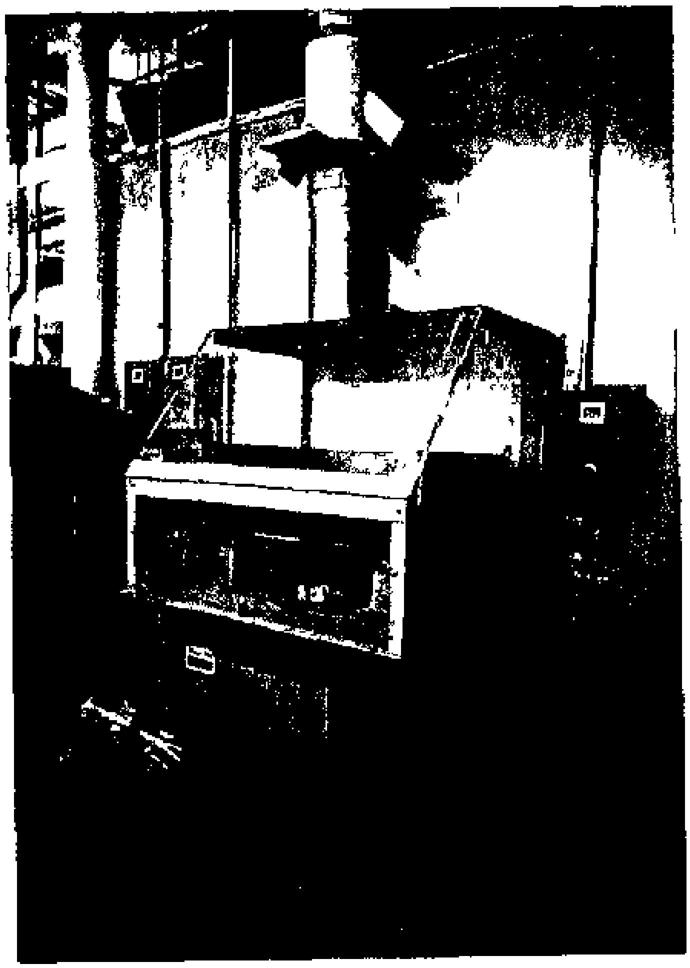


Figure 13   Plexi-glass Enclosed Sieve

Mercury Recovery

- an exhaust system provides 250 ft/min (plant measurement) air velocity across the oven doors to remove mercury vapor from the reclamation ovens (Figure 14) (approximate cost - $40,000). Vapor is passed though a wet scrubber.

- Duracell is designing enclosed bulk scrap bins at an estimated cost of $5,000 each. Scrap is emptied from the oven trays to these bins which are exhausted to the scrubber.

- the feasibility of slurrying reject mercuric oxide when loading the oven trays is being investigated. This will supress te emission of mercuric oxide dust into the air during tray loading.

- reject cells and batteries will be loaded wet onto the oven trays.

INDEPTH STUDY OF AIR RECIRCULATION SYSTEM

The recirculating air system for the cell assembly room at this battery manufacturing plant is designed to remove both mercury vapor and particulate. The system consists of two separate air handling/filtering units, each with one 27-square-foot intake and a network of distributors (Figure 15). The air handling units are mounted parallel on the roof of the building. They are large "walk-in" units that have been modified to improve mercury vapor removal and reduce filter replacement costs. Each air handler in the original system, installed by Industrial Air, Inc., Greensboro, North Carolina, consisted of the following components.

One centrifugal blower

- manufactured by Eldons Manufacturing Corp., Elgin, Illinois

- 36.5-inch-diameter wheel

- operates at 26,000-cfm, 3 inches static pressure, using a 15-hp motor.

One set of 35 percent efficient modular fiber filters

- manufactured by Cambridge Filter Corp., Syracuse, New York

- 12 filters set into a filter bank measuring 6'2-1/2" x 8'3/8".

One set of 95 percent efficient modular fiber filters

- set into filter bank measuring 6'2-1/2" x 8'3/8"

- each filter containing 120 square feet of filter media area.

Figure 14   Reclamation Oven Exhaust System

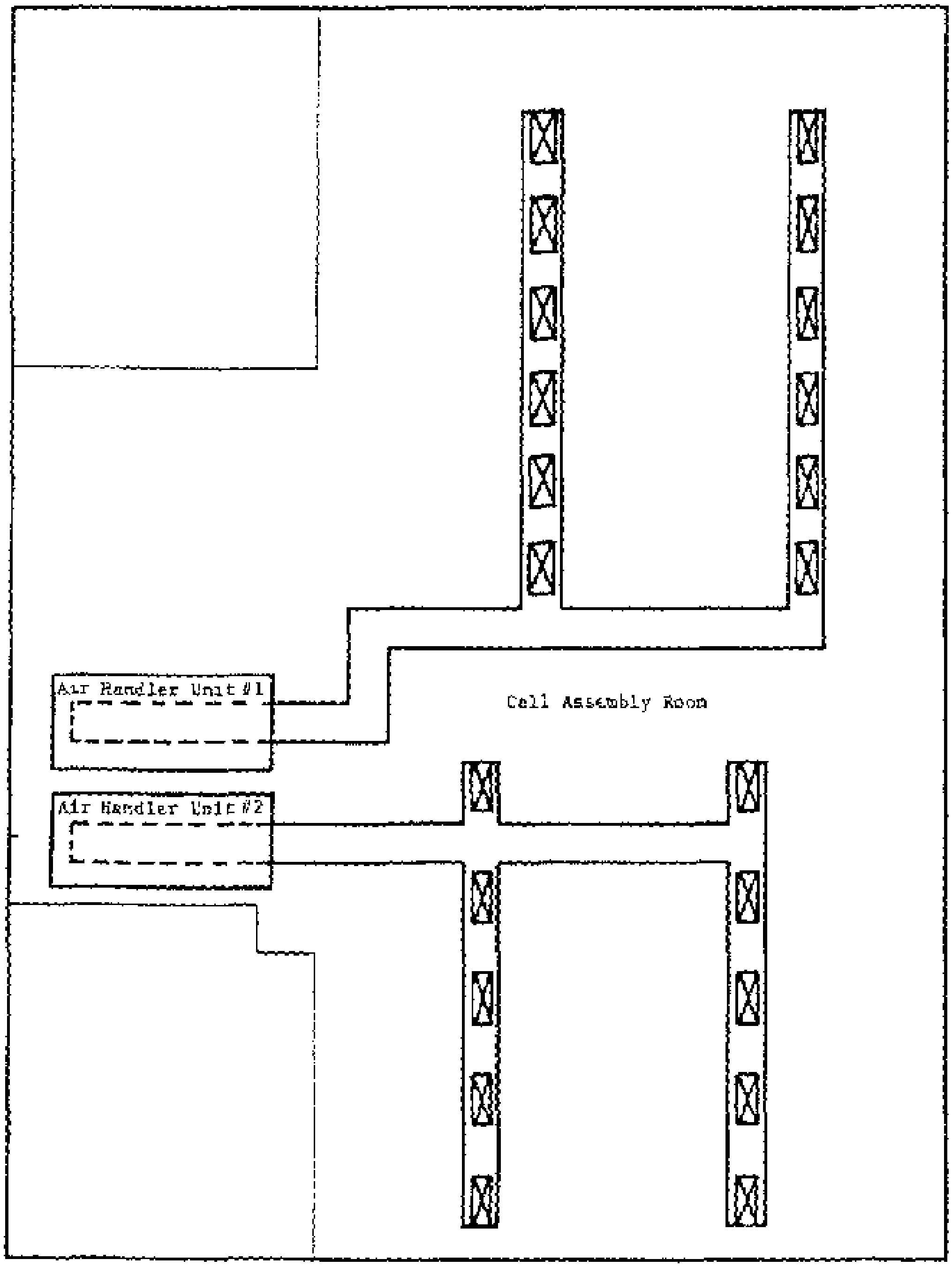


Figure 15. Schematic of Recirculating Air System.

One set of 95 percent efficient charcoal filters

- manufactured by Barneby-Cheney
- 144 filter trays set at an incline into an 8- by 6-foot filter rack
- a total of 33.7 cu ft of filter media in the filter rack
- approximately $64 per tray
- each tray consists of iodine-impregnated charcoal pressed between metal screens.

One set of cooling coils

One set of steam coils

The 35 percent efficient particulate filters (Figure 16) were replaced monthly, and the 95 percent efficient particulate filters were replaced yearly. Plant representatives found that the charcoal filters achieved 86 percent efficient mercury vapor removal when initially installed. When the efficiency fell to 60 percent, new filters were ordered. The filter trays were replaced when the efficiency fell to 50 percent (replaced approximately once per year).

In 1982, plant representatives began efforts to reduce filter costs while maintaining reduced mercury vapor concentrations. They installed a second charcoal filter bank to utilize the 50 percent efficient filters rather than discarding them. A new filter bank was installed behind the original one. The 50 percent efficient filters were moved to the front rack and new filters were installed in the back rack. The filter replacement procedure was changed to the following·

- when total efficiency reach 60%, order new filter
- when total efficiency reached 50%, discard front rack filters and move back rack filters to front. Install new filters on back rack.

The pressure drop resulting from the addition of another filter bank necessitated an increase in air handler capacity. The layout of the air handler housing prohibited the installation of a larger fan, therefore, the plant

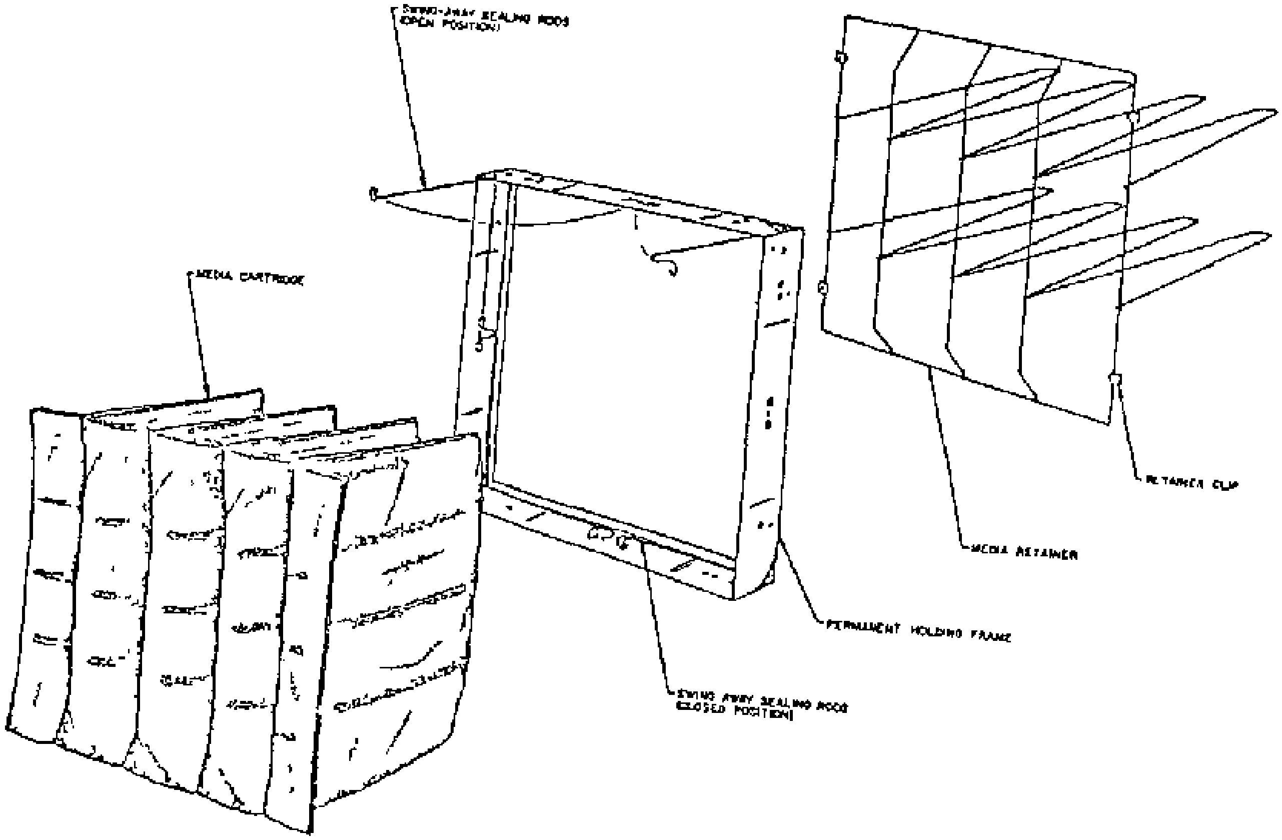


Figure 16. Fiber Filters for Particulate Removal.

installed an additional 26,500-cfm blower in each air handling system. The resulting configuration was two blowers operating in series with the filter banks and conditioning coils situated between them. The original and modified configurations are illustrated in Figure 17.

The charcoal filter trays are front or side loaded horizontally at a slight angle in the filter rack. The edges of the trays are connected in a continuous zig-zag configuration through the use of compression fittings (Figure 18). An effective seal is made when the airflow through the unit forces the surface of connecting tray edges against the fitting. Plant representatives stated that clamped connections would provide a more effective seal, but they are considerably more costly.

PERSONAL PROTECTIVE EQUIPMENT

In certain sections of the Oxide Plant, Depolarizer, and Slugger Rooms, workers are required to wear respirators (3M Disposable Mercury Vapor Respirator #8707) at all times. These respirators are changed at breaks. Certain tasks in the Oxide Plant have a higher potential for exposure to mercury. These include the acid rinsing operation, and oxide bagging and transfer. For these tasks, a supplied-air, pressure-demand respirator (Scott Demand - Scotoramic Facepiece #801548) is required.

Other personal protective equipment is used at this facility to reduce exposure to mercury·

- o latex gloves (Derma Thin -- Best Co.) are worn by all employees who routinely handle mercury or mercury-containing materials.
- o in the Oxide Plant, Slugger Room, and Depolarizer Room, all employees are required to wear a complete set of company-supplied clothing. This includes overalls, shoes (or boots), underwear, socks, caps, and gloves. Clean clothing is supplied each workday. Work clothes are laundered at the laundry facility located adjacent to the locker room.
- o in the cell assembly area, latex finger cots are used by workers who handle anodes and cathodes.

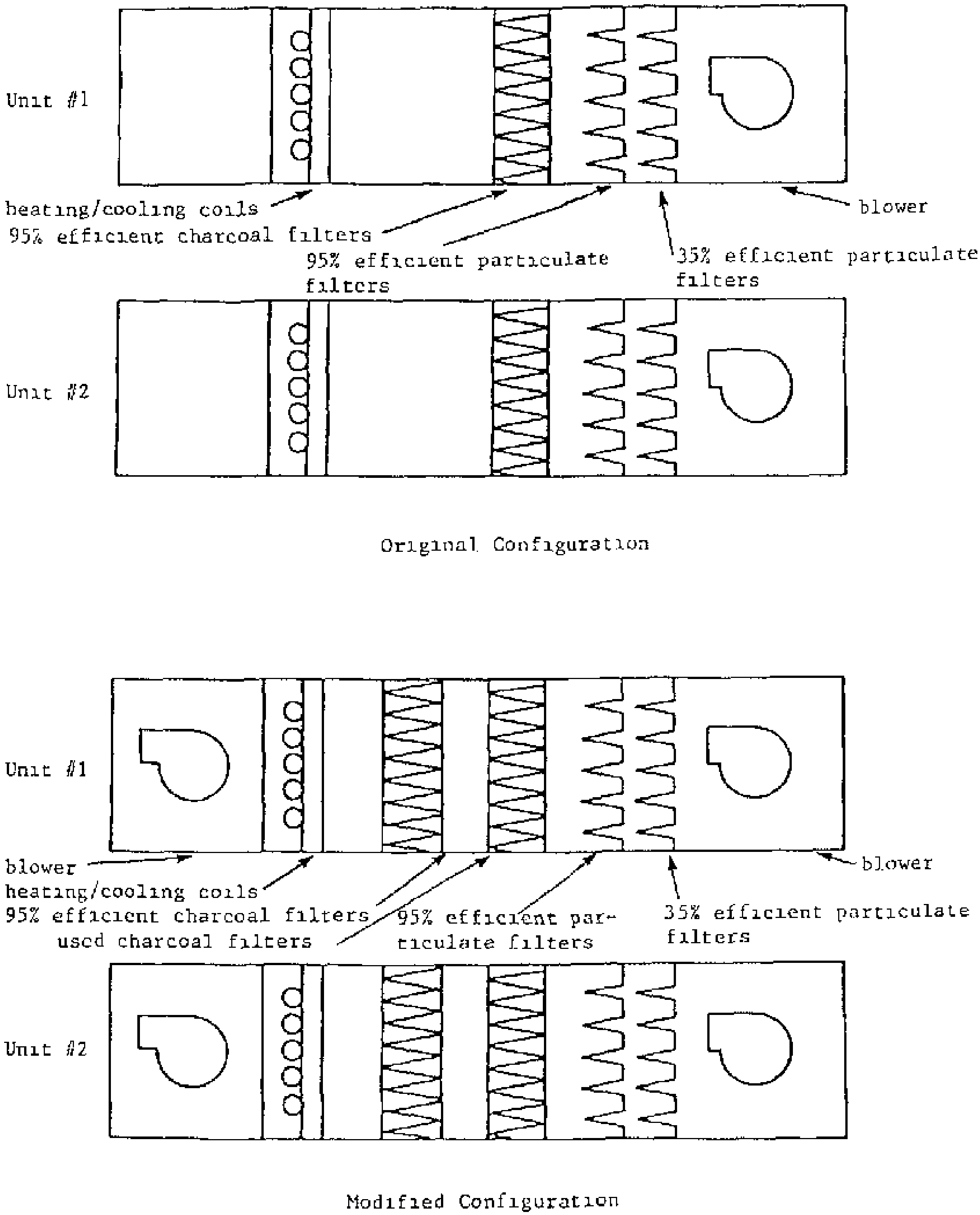


Figure 17. Original and Modified Air Handler Configurations.

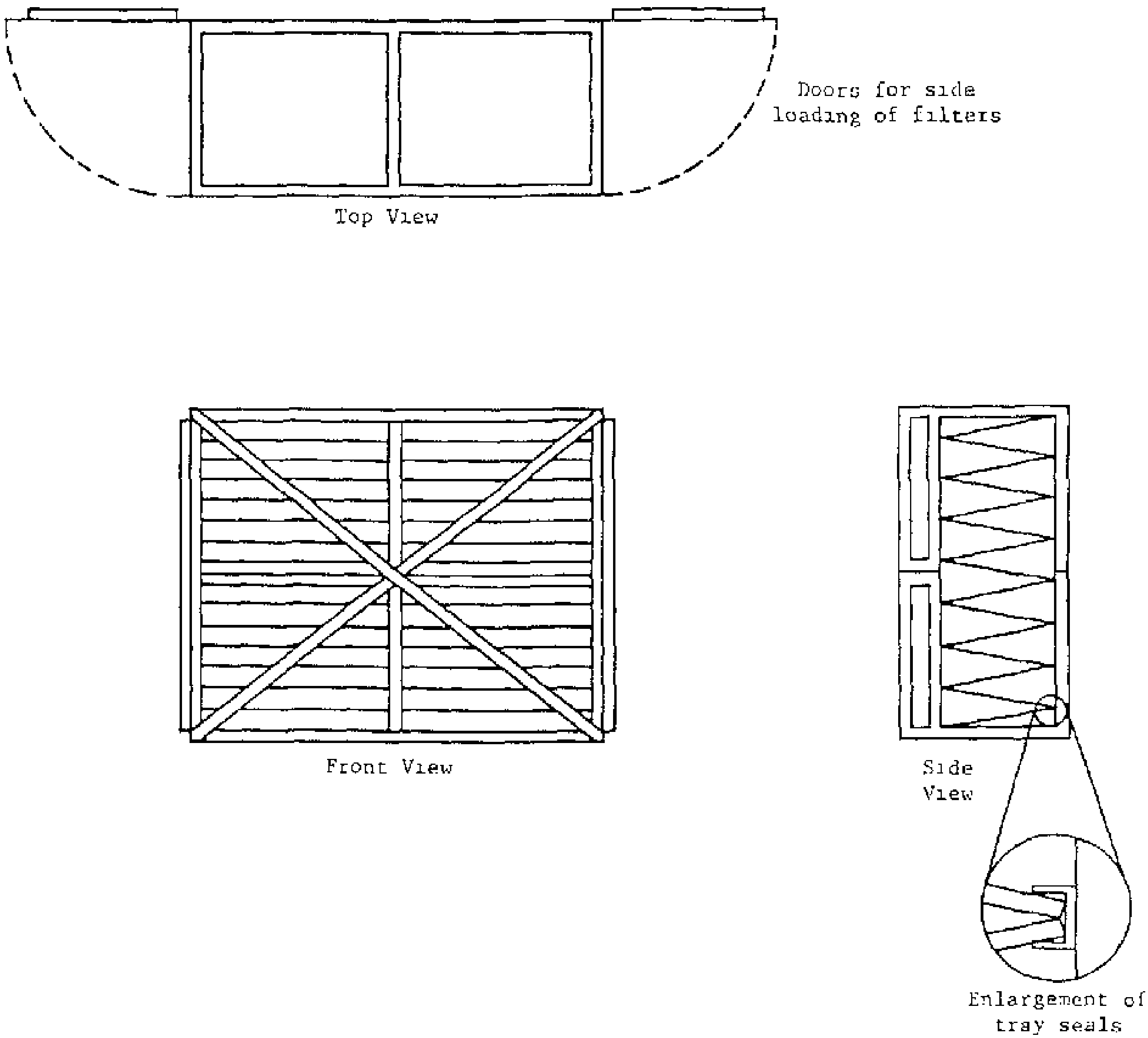


Figure 18. Charcoal Filter Rack Configuration.

WORK PRACTICES

Procedures and practices have been implemented to control exposure to mercury The following list summarizes the work pactices (including personal hygiene practices) in effect.

Plantwide

- employees are required to wash hands (including fingernails) prior to smoking or eating.
- hair must be kept short and facial hair is not permitted (so as not to serve as a reservoir for mercury and to insure proper respirator fit when required)
- it is recommended that fingernails be kept short.
- mercury containing materials are to be covered or kept under water.
- possession of food or cigarettes in production area is prohibited.
- showers and clothing change are required after work in high-exposure areas.
- use of compressed air to clean off surfaces or clothing is probhibited.

Depolarizer and Slugger Rooms

- pellet clutter must be kept to a minimum.
- machine enclosures must be kept closed.
- compressed air must be shut off when unit is not in use.
- materials' transport and storage bins must be kept covered.
- compressed air must not be used for cleaning.

HOUSEKEEPING

The following housekeeping procedures have been initiated to control exposure to mercury

- spills are cleaned using vacuums (most areas are served by a central vacuum system).

- floors are washed with HgX mercury decontaminant at least once each day in the Oxide Plant, Depolarizer Room, Anode Room, and Slugger Room.
- dry sweeping is used as a last resort for clean-up.
- compressed-air sweeping is not permitted.
- scrap mercury-containing materials are placed in a container under water.
- presses and surrounding work areas are cleaned (vacuumed) periodically.
- bins used to transport consolidation materials are wiped to control dust accumulation.

MONITORING PROGRAMS

Biological Monitoring

Biological monitoring is an important aspect of the medical program. This involves routine (usually monthly) urinalysis on workers in high exposure areas. Durcell's occupational physician considers biological monitoring to be the best available indicator of a worker's overall exposure to mercury (both mercury vapor and particulate). If levels of mercury in urine exceed .35 mg/l, the employee is immediatley moved to a no-exposure area of the plant. If the level is in the range of 0.25 to 0.35 mg/l, a second test is conducted and if the level remains above 0.25 mg/l, the employee is relocated. The employee is reinstated to his original position when the urine-mercury level drops to 0.1 mg/l.

Continuous monitors for the detection or control of mercury vapor are not used at this facility due to the exposure regime which consists of both particulate and vapor forms of mercury.

An examination of the biological monitoring data provided an indication of recent improvements in mercury exposure control. The company has lowered the urine mercury criteria for relocation of employees to increase the margin of safety. As a result of decreasing biological levels of mercury, recent monitoring results show fewer cases of urine mercury concentrations in excess of the "relocation threshold".

Air Contaminant Monitoring

Personal and area sampling is conducted on a routine basis to determine airborne concentrations of mercury vapor and mercuric oxide. This monitoring program involves the use of a direct reading instrument for the detection of mercury vapor, and integrated time-weighed average (TWA) sampling for both mercury vapor and particulate. Either 3M Badges or an adaption of NIOSH P&CAM 176, (in which hopcalite solid adsorbent is used as the adsorption medium for mercury vapor) are used for TWA sampling. A cellulose-ester filter is used as the sampling medium for both mercuric oxide and amalgamated zinc.

OTHER PROGRAMS

Health and Safety

The Plant Manager is responsible for health and safety at this facility. The program requirements are carried out by the plant's industrial hygienist. The industrial hygienist is responsible for plant health hazard evaluations, abatement of hazardous condition and administration of the respiratory protection program. He shares the responsibility with both employees and supervisors of adhering to proper personal hygiene procedures throughout the plant. Enforcement of health and safety practices is the responsibility of the Unit Supervisors.

Education Program

All new employees must take part in the education and training program which is directed at teaching employees about the hazards of working with mercury, the need for personal hygiene on the job, and the proper use of personal protective equipment. Included in this program is a training film on the hazards of working with mercury which was developed by plant representatives.

SURVEY DATA

INITIAL SURVEY SAMPLING METHODS

Spot sampling using a mercury vapor detector (Jerome #401) was conducted during the survey. These results reflect the concentration of mercury vapor present at the instant that the samples were taken. In certain areas airborn mecuric oxide particulates were present.

SAMPLING RESULTS

The results of sampling are shown in Table 3. Mercury vapor was detected in all environments sampled. The highest sample concentration detected was 0.1 mg/m^3. This level is equal to the Occupational Safety and Health Administration (OSHA) Standard for a time weighed average exposure to mercury vapor. Airborne mercuric oxide particulate, if present, would not be reflected in these results.

TABLE 3

Mercury Vapor Concentrations Determined with Jerome Model 401 on 2/11/81

Location/Operation	Concentration Range mg/m^3
Depolarizer Room (center of room)	0.040-0.050
Slugger Room (center of room)	0.090-0.100
Slugger Room (Near "V" Blender)	0.020-0.045
Slugger Room (Near Slugging Machine)	0.040-0.090
Oxide Plant (Triple Distrill Room)	0.040-0.068
Oxide Plant (HgO Fill Area)	0.055-0.060

INDEPTH SURVEY AIR SAMPLING DATA (Cell Assembly Area)

Two methods were used for mercury vapor sampling at the facility. Direct reading samples were taken using a Jerome Model 401 mercury vapor detector. Time-weighted average (TWA) samples were also taken using solid sorbent media (Hopcalite) and air sampling pumps. Analysis of the sorbent was conducted using flameless atomic absorption spectrophotometry.

Sampling was also conducted for mercuric oxide particulate. This was done with glass fiber filters mounted in cassettes, and used with high-flow sampling pumps operating at 20 liters of air per minute.

Sampling was undertaken to assist in the evaluation of the recycle air filtration system. Direct reading and time-weighted samples were taken at locations in the Cell Room serviced by the system, and inside the air handler. The air handler was sealed and operating normally during sampling. Within the air handler, samples were located both before and after the filter banks. Fresh make-up air entering the system was also sampled.

The results of time-weighted sampling are presented in Table 4. Mercury vapor concentrations in the cell room at two production lines were well below the 0.1 mg/m^3 OSHA 8-hour permissible exposure limit (PEL). Direct reading sampling conducted at various locations around the Cell Room showed similar concentrations in this area. These results are presented in Table 5.

Mercury vapor concentrations throughout the cell room ranged from 0.015 to 0.040 mg/m^3. This range was consistent with concentrations found in the air handler prior to the filtration. As previously discussed, the air handlers draw air from one end of the room and return filtered air to various points throughout the room. According to plant representatives mercury vapor concentrations increase across the room with the highest concentrations occurring near the intakes. This is because the assembly lines located nearest the intake produce the greatest amount of vapor. Direct reading sampling results generally confirm this, with mercury vapor concentrations at Line #16 higher than those of the central room and the packaging area opposite the assembly lines.

TABLE 4

TWA Mercury Vapor Sampling Results
(6/22/82-6/23/82)

Sample Location	Concentration (mg/m^3)	
	Range	Average
Cell Room (line #1)	0.011-0.020 (2)*	0.015
Cell Room (line #16)	0.028-0.041 (2)	0.035
Air Handler (before filters)	0.011-0.027 (4)	0.020
Air Handler (after filters)	0.001-0.007 (4)	0.003
Air Handler (fresh air intake)	0.001-0.003 (2)	0.001

*Numbers in parentheses indicate number of samples taken.

TABLE 5

Direct Reading Mercury Vapor Sampling Results
(6/22/82-6/23/82)

Sample Location	Concentration (mg/m^3)	
	Range	Average
Cell Room (line #1)	0.018-0.022 (4)*	0.020
Cell Room (line #16)	0.027-0.030 (4)	0.028
Cell Room (central area)	0.022-0.024 (2)	0.023
Cell Room (packaging)	0.023-0.025 (2)	0.024
Air Handler (before filters)	0.023-0.032 (10)	0.030
Air Handler (after filters)	0.006-0.010 (10)	0.008
Air Handler (fresh air intake)	0.003-0.015 (4)	0.007

*Numbers in parentheses indicate number of samples taken.

Sampling inside the air handler demonstrated the effectiveness of the filtration system. Mercury vapor concentrations prior to the filter banks were similar to Cell Room levels, but following the filter banks the concentration was reduced by 70 to 80 percent. A detailed mercury removal efficiency study is described below.

EFFICIENCY STUDY OF THE AIR RECIRCULATION SYSTEM

Ventilation measurements, taken in Air Handler Unit #1, during the survey, showed that the actual airflow achieved using the two fans in series was 38,600 cfm (average of four measurements taken in plenum between fans). The airflow measured at the in-plant air intake for the air handler was 27,200 cfm. The discrepancy between these two airflows is accounted for by the fact that an estimated 6,000 to 10,000 cfm was leaking through the closed fresh air intake louvers. Therefore, it can be concluded that the air handler is actually operating in approximately a 75% recirculating mode.

Mercury removal efficiency of the air system was determined using mercury vapor measurements taken at the upstream and downstream sides of the charcoal filter banks.

Both direct reading samples and time weighted average (TWA) samples were taken. Separate efficiency calculations for each method are presented in Table 6.

TABLE 6

	Average Mercury Vapor Concentrations (mg/m^3)		Mercury Removal Efficiency
	upstream of filters	downstream of filters	
Direct reading sample	.030	.008	73%
TWA sample	.020	.003	85%

CONCLUSIONS AND RECOMMENDATIONS (Cell Assembly Area)

The limited sample data show that mercury vapor levels were generally below the OSHA Standard of 0.1 mg/m^3 (as a time weighted average) during the surveys. The following control strategies are thought to be significant in reducing employee exposure to mercury in the cell assembly area·

- o The ventilation system including the temperature control and mercury vapor and oxide filtration/recirculation sytem.
- o The work practices program, in particular the strict personal hygiene requirements.

The recirculation of industrial exhaust air is one of a number of available engineering approaches in use to control exposure of mercury vapor. Recirculation systems can provide for substantial reductions in consumption of energy for tempering make up air. However, since mercury vapor is toxic at high concentrations, there is a potential for the development of adverse health conditions whenever the performance of such systems is less than optimum. The system in use at Duracell is efficient in reducing general room concentrations of mercury vapor while reducing energy consumption. This system could be applied to most other large scale mercury operations.

A periodic monitoring program of the air recirculation system should be instituted to determine if the system is performing optimally. This program should include monitoring filter efficiency, determining air flow characteristics, and determining the quality of the reintroduced air.