

**A minerals research contract report
July 1982**

**PROPOSE AND EVALUATE
METHODS OF CONTROLLING
MERCURY VAPOR
EMISSIONS IN A PROCESSING
MILL FURNACE ROOM**

Contract JO318024
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16. Abstract This report summarizes the work performed under USBM Contract No. JO318024, "Propose and Evaluate Methods of Controlling Mercury Vapor Emissions in a Processing Mill Furnace Room." The objective of the program was to develop cost-effective methods of controlling mercury vapor in a processing mill furnace room with particular emphasis on the McDermitt mercury mill in Nevada. Process, environmental, and operating data were collected at McDermitt and a preliminary evaluation of control systems was performed. Efforts were focused on the furnace, which is the primary mercury emission source, and furnace positive pressure or "blow-back," which is the cause of the greatest furnace emissions. Cost-effective conceptual design alternatives were prepared that addressed the identified emissions problems, particularly furnace blow-back. Two design alternatives were selected and detailed design drawings and cost estimates were prepared. The first alternative agglomerates the filter cake upstream of a belt conveyor, which replaces the existing screw conveyor. Capital costs for the first alternative are estimated to be \$101,000. The second alternative dries the filter cake to 5 percent moisture before conveyance on the belt conveyor. Capital costs for the second alternative are estimated to be \$180,000. Both designs are expected to reduce mercury vapor concentrations by more than 500 $\mu\text{g}/\text{m}^3$ in the Furnace Building and approximately 160 $\mu\text{g}/\text{m}^3$ in the Concentrator Building during furnace operations. Design Alternative No. 2 appears especially attractive because the mercury vapor concentration <i>reductions</i> are accomplished at an annual net revenue <i>increase</i> of approximately \$561,000 because of increased productivity due to feeding a 5 percent moisture cake to the furnace			
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FOREWORD

This report was prepared by Foster-Miller Associates, Inc. (FMA) under U.S. Bureau of Mines (USBM) Contract No. JO318024. It was administered under the technical direction of the Pittsburgh Research Center (PRC). The Technical Project Officer (TPO) was Mr. Edward D. Thimons. Mr. Alan G. Bolton, Jr. was the Contracting Officer for the USBM. This report is the result of work performed during the period May 1981 to March 1982.

The technical effort was performed by the Mining Division of the Engineering Systems Group under the supervision of Mr. David A. Monaghan. The Program Manager was Terry L. Muldoon. Mr. Paul Bartlett, Mr. Robert Pokora, and Mr. Ernest Battista were directly responsible for the control system evaluation, design, and cost-benefit study of alternative control methods.

The cooperation of the *McDermitt Mine* staff during this program is gratefully acknowledged. Special thanks are given to Mr. Vic Botts, Mr. Fran Schultz, Mr. Randy Powell, and Mr. Jerald Hepworth for their cooperation, assistance, and direct support in providing needed data, tests, and process descriptions which form the bases for this report.

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EXECUTIVE SUMMARY

Occupational health hazards associated with mercury have been the subject of study for a number of years and are well documented. Continued exposure to high mercury vapor concentrations in the atmosphere can lead to a variety of chronic mercurial poisoning effects. An 8-hr time-weighted average exposure limit of $50 \mu\text{g}/\text{m}^3$ has been adopted as the exposure limit for mining operations by the Mine Safety and Health Administration (MSHA).

Mercury vapor exposure is encountered in all mercury and other mining operations, such as gold, where mercury is a by-product. In these operations, a major source of mercury vapor is the multiple hearth roaster or furnace.

The purpose of this program was to develop cost-effective methods of controlling mercury vapor emissions in a processing mill furnace room.

The only operating mercury mill in the United States is at McDermitt Mine, in McDermitt, NV. Mine facilities include elaborate emission and effluent control systems. Rigorous environmental monitoring, health and safety, maintenance and housekeeping programs have been instituted. For some operating conditions and mill locations, compliance with the $50 \mu\text{g}/\text{m}^3$ exposure standard has not been achieved. This program therefore focused on evaluating present control systems and recommending cost-effective methods to further reduce mercury vapor concentrations in an effort to achieve compliance with the exposure standard. The Furnace and Concentrator Buildings at McDermitt Mine were the subject of study to accomplish the program's goals.

ES.1 McDermitt Mine Operations

Figure ES-1 presents a simplified flow sheet of the McDermitt operations. Mercury ore is mined by open pit using scrapers in an existing excavation that is approximately 140 acres in size. Ore of different grades is stockpiled and then processed through a grizzly. The ore is ground in a semiautogenous mill, classified, and piped to a flotation area. The ore is concentrated in rougher, cleaner, and recleaner flotation stages. Final concentrate is pumped to a thickener, dewatered to 60 percent solids, and then pumped to a stock tank for storage. Thickened concentrate is slurried and pumped to a vacuum filter which dewateres the concentrate to a cake of about 15 percent moisture. The

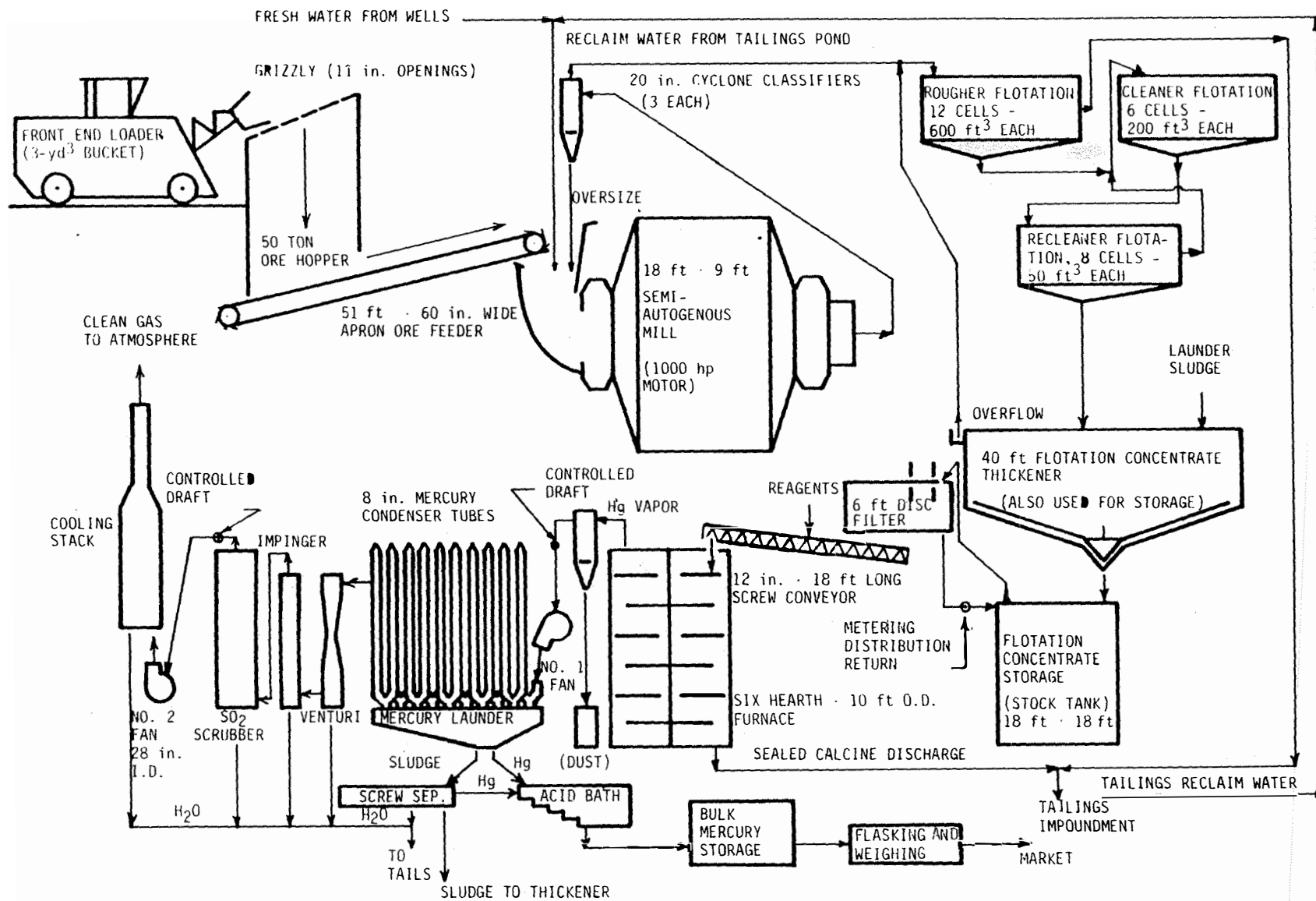


FIGURE ES-1. - Process flow sheet, McDermitt Mine.

cake is transported by screw conveyor to a multiple hearth furnace where the cake is heated and the mercury vaporizes. Mercury vapor exhausted from the furnace is cooled, condensed in condenser towers and collected under water in launders. The recovered mercury is cleaned and bottled in flasks. The gas stream exhausting from the condenser towers passes through a venturi and an impinger tower to remove remaining particulates. The gas then passes through an SO₂ scrubber and cooling tower and is exhausted to the atmosphere with negligible SO₂ content and within the EPA mercury emission limitation of 2300 g/day.

ES.2 Data Collection and Evaluation

The furnace is the major source of emissions and the major contributor to mercury vapor concentrations in both the Furnace and Concentrator Buildings. The highest furnace emissions occur during periods of positive furnace pressure or "blow-back." The furnace normally operates at negative pressure, but when the pressure is positive and blow-back occurs, mercury vapor emissions escape via numerous pathways including:

- a. Feed screw conveyor and back through the open vacuum filter to the Concentrator Building atmosphere
- b. Leaking and open furnace hearth doors
- c. Exhaust circuit, overloading the cyclone because of increased particulate emissions and eventually plugging the condenser tubes.

Program efforts were therefore focused on eliminating blow-back which was determined to be caused by:

- a. Excess feed rate to the furnace
- b. Excess filter cake moisture content
- c. Leaking and open furnace hearth doors, particularly during rabble arm and hub cleaning operations
- d. Exhaust circuit pluggage, such as the condenser tubes, due to steps a through c
- e. No. 1 I.D. Fan operation problems.

Table ES-1 presents the averages of measured concentrations in both buildings for two furnace operating conditions:

- a. When blow-back occurred
- b. When blow-back did not occur.

Mercury vapor concentrations can be reduced by more than 500 $\mu\text{g}/\text{m}^3$ in the Furnace Building and as much as 160 $\mu\text{g}/\text{m}^3$ in the Concentrator Building if blow-back is eliminated. When blow-back did *not* occur during a furnace run, the Concentrator Building mercury concentrations were approximately the same before the run and during the run.

Program efforts at this stage were directed to developing conceptual design alternatives to control the furnace as an emission source and to eliminate furnace blow-back.

TABLE ES-1. - Potential Hg vapor concentration reduction by eliminating furnace blow-back

Furnace condition	Number of furnace runs	Maximum concentration of Hg vapor measured ($\mu\text{g}/\text{m}^3$)	
		Furnace Building, average of three measurement locations	Concentrator Building, average of four measurement locations
Blow-back	6 (1980 to 1981)	>760	320
No blow-back	5 (1980 to 1981)	260	160
Potential Hg vapor concentration reduction by eliminating furnace blow-back		>500	160

ES.3 Conceptual Design Alternatives

Two cost-effective furnace feed conceptual design alternatives were prepared by FMA and reviewed with USBM and McDermitt Mine personnel. The first furnace feed alternative assumed that filter cake at 15 percent moisture can be successfully:

- a. Conveyed by a belt conveyor
- b. Transferred to a surge bin for a brief period
- c. Transferred to and uniformly transported through a gravimetric weighfeeder
- d. Blended with reagents and passed through a rotary airlock.

Figure ES-2 shows the conceptual layout for the furnace feed circuit. The first alternative includes the following design features:

- a. Troughed belt conveyor to transport cake from the present vacuum filter. The belt will be made of a noncorrosive material, such as rubber. The present rapid replacement of the steel screw conveyor due to corrosion will be eliminated.
- b. Moisture sensor at the conveyor to determine feed cake moisture content, which, when excessive, causes furnace blow-back.
- c. Live-bottom surge bin to provide 3 to 4 hr of storage and reaction time before furnace shutdown is required for problems upstream of the bin.
- d. Gravimetric weighfeeder to measure the mass feed rate and provide a signal to meter the proportions of CaO and Na_2S reagents that are added to the cake. Excessive mass feed rate is a known cause of furnace blow-back.
- e. Rotary airlock feeder to isolate the furnace as an emission source from the feed circuit and to feed cake to the furnace.

The second design alternative layout is shown by Figure ES-3 and it includes the following features:

- a. Same configuration as the first concept, except
- b. A dryer is added after the vacuum filter to eliminate cake pluggage, which FMA concludes is inherent to the first concept.

ES.4 Detailed Designs and Cost Estimates

Based on the conceptual design review, detailed design drawings for two furnace feed alternatives were prepared. Other control system components, common to both alternatives, were also designed. General design specifications were prepared for major system components and detailed cost estimates were prepared for each alternative, including the components that are common to both alternatives. Both furnace feed designs include the following features:

- a. Increase in condenser tube diameter from 8 to 10 in. to increase system capacity and reduce the potential for pluggage
- b. Removal of the No. 1 I.D. Fan to eliminate
 1. A potential source of pressure fluctuations due to possible stall conditions, which may cause blow-back
 2. A circuit component which causes a system pressure loss without contributing to system performance
- c. Installation of a back-up No. 2 I.D. Fan
- d. Increased dust collection efficiency to reduce pluggage in the furnace exhaust circuit
- e. Dust removal equipment for collected dust and a means to determine cyclone operation, both for pluggage prevention
- f. Automatic rake cleaning to reduce the potential for blow-back

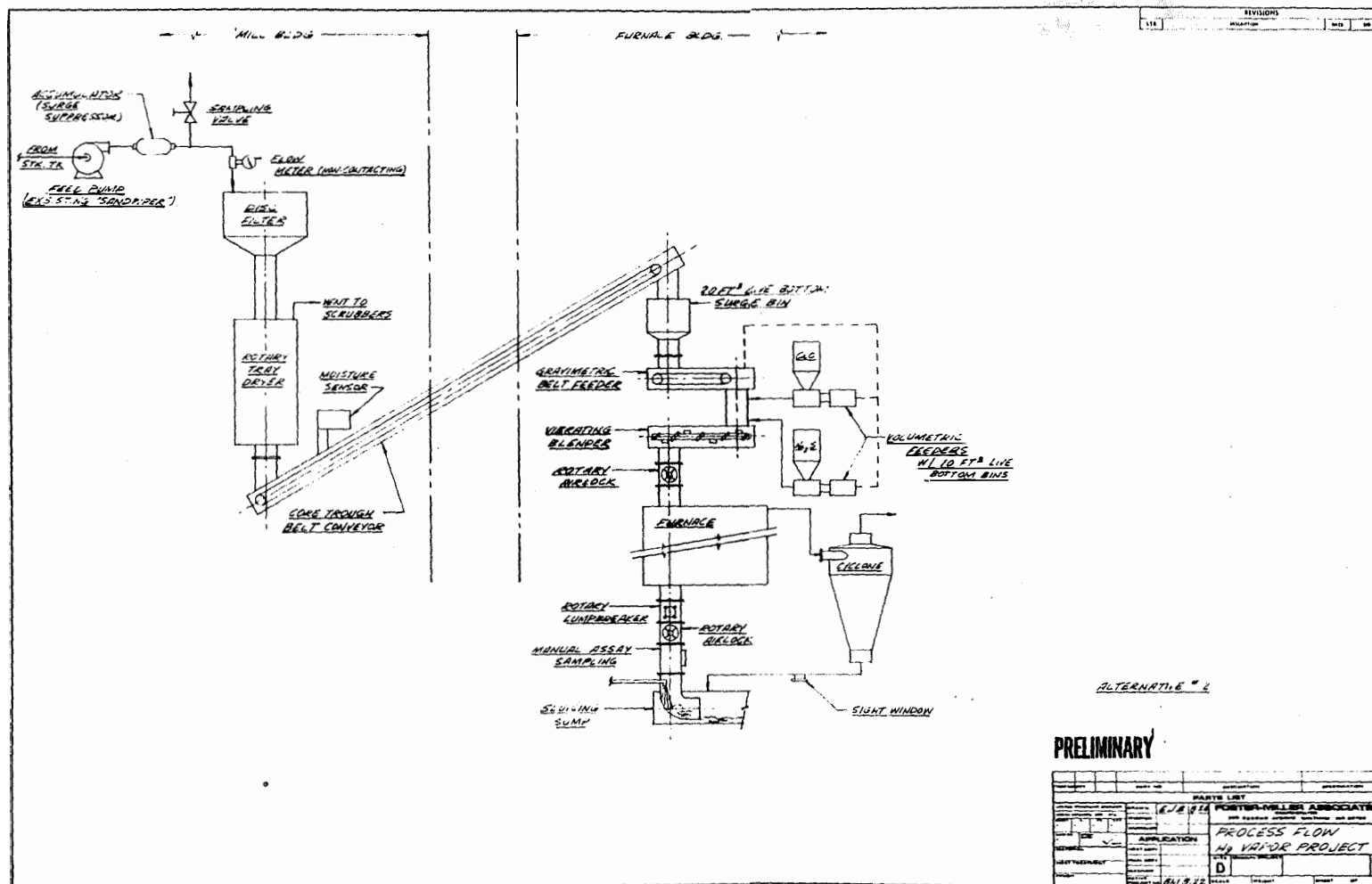


FIGURE ES-3. - Conceptual Design Alternative No. 2.

- g. Conversion to propane on furnace burners because of available supplies and convenience
- h. Improved calcine discharge system to:
 - 1. Isolate furnace with rotary airlock
 - 2. Handle clinkers with a lumpbreaker
 - 3. Sample/assay without exposing operator to continuous operations.

Figure ES-4 presents a flow sheet for the first alternative which assumes successful agglomeration of the filter cake with lime upstream of the belt conveyor. A load cell is installed on the conveyor to determine mass rate instead of using a gravimetric weighfeeder, which is prone to pluggage. Agglomerated cake is conveyed to a surge bin. Na_2S is added after the surge bin and blended with the cake. (Na_2S is presently added at the screw conveyor where it is a recognized cause of corrosion.) The blended cake then discharges to a rotary airlock feeder which isolates the feed circuit from the furnace and feeds the cake to the furnace.

Figure ES-5 presents a flow sheet for the second alternative which includes a rotary tray dryer between the filter and conveyor. A gravimetric weighfeeder is installed after the surge bin and both reagents are fed and blended after the weighfeeder.

Design Alternative No. 1 has the following advantages:

- a. Simple in design
- b. Can be readily installed by mine personnel
- c. Less corrosion than the present system
- d. Relatively inexpensive - capital costs are estimated to be \$101,100 for feed, calcine discharge, and exhaust circuit components and furnace modifications
- e. Improved moisture sensing compared to present methods
- f. Improved mass feed rate measuring compared to present methods.

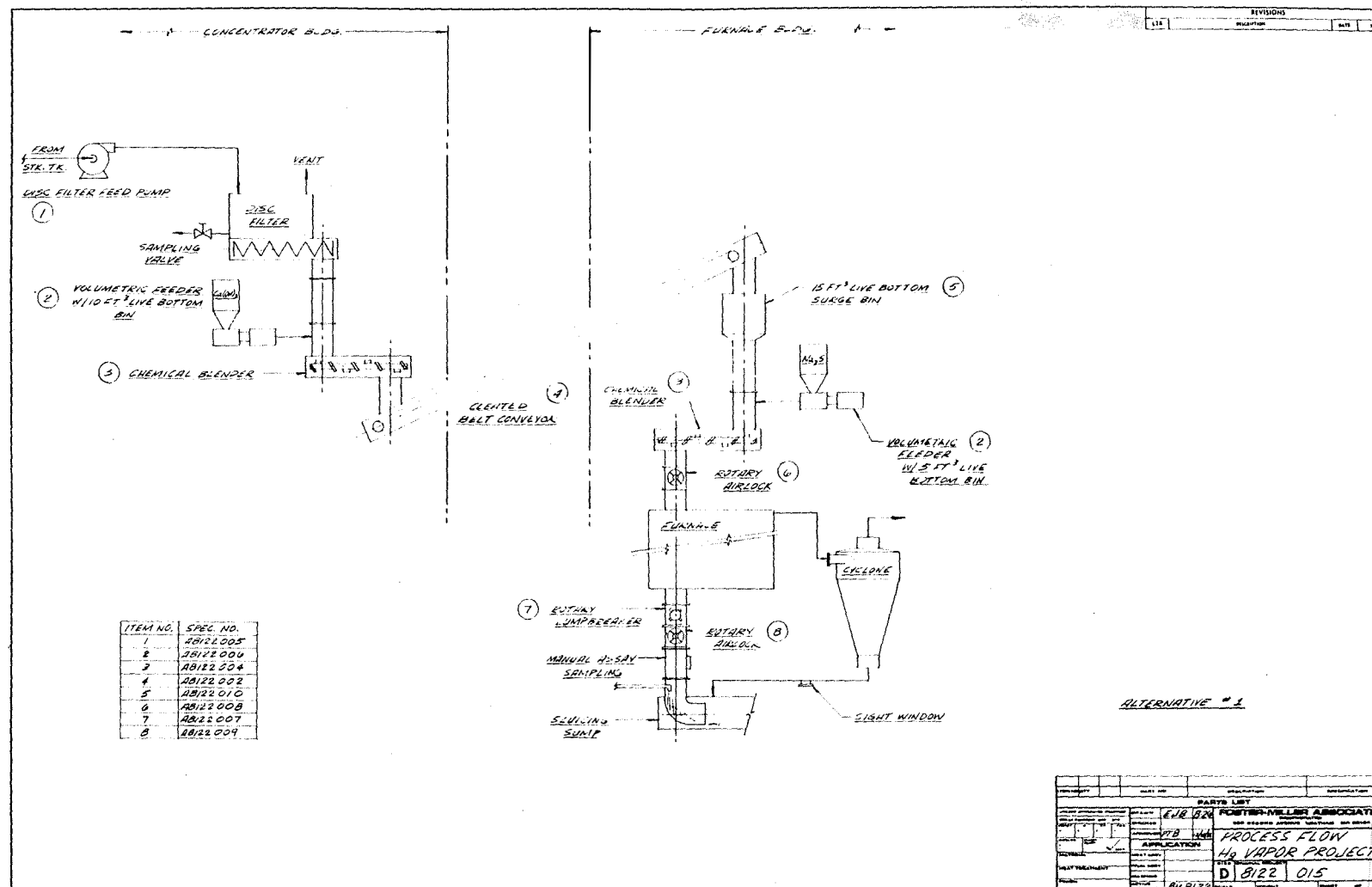


FIGURE ES-4. - Design Alternative No. 1 - process flow.

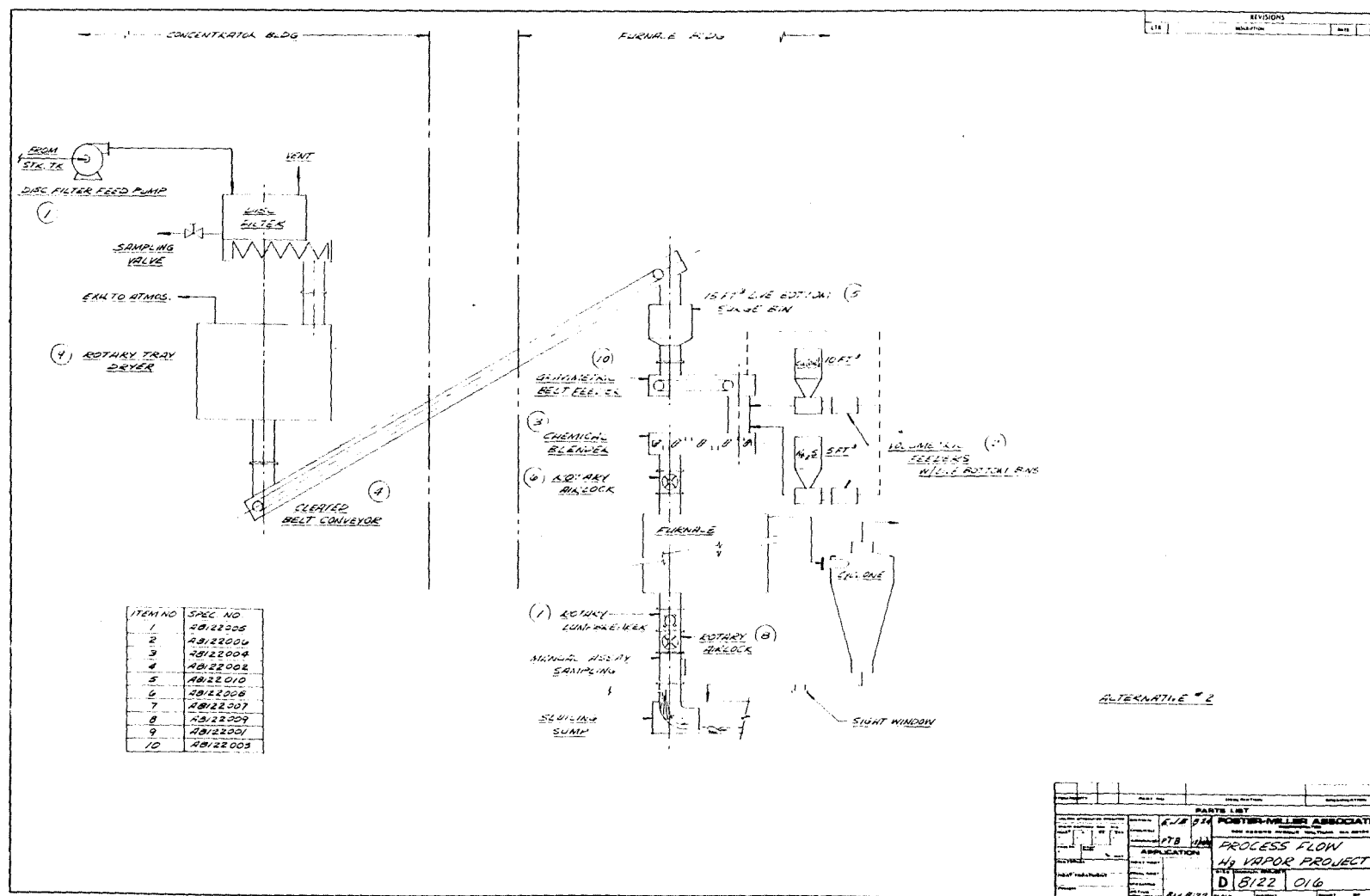


FIGURE ES-5. - Design Alternative No. 2 - process flow.

The first alternative has the major disadvantage of handling a moist, dense cake that may cause pluggage by adhering to surfaces at transfer points and within confined spaces.

Design Alternative No. 2 has the following advantages:

- a. Handling a filter cake which is dried to 5 percent moisture thus eliminating the pluggage problems inherent with the first alternative and eliminating cake moisture content as a cause of blow-back.
- b. A greater mercury throughput is possible compared to the first alternative and the present configuration because less moisture is conveyed to the furnace.
- c. Precise mass feed rate measuring and reagent metering.
- d. Less corrosion than the present system.

The second alternative has the following disadvantages:

- a. The configuration is more complex than the first alternative.
- b. An emission source is added (the dryer).
- c. Capital costs are relatively high - \$180,000 estimated for the feed, calcine discharge, and exhaust circuit components and furnace modifications.
- d. A field trial is necessary to establish dryer operating conditions.
- e. There is limited available space for a dryer.

ES.5 Cost-Benefit Study

The final task of the program was the preparation of a cost-benefit study for proposed control systems. The Sinking Fund Method was used for depreciation of capital items over an estimated 5-year life. Estimates for fixed and variable costs were discussed with plant personnel, and actual values for such items as operating hours and repair costs were obtained from plant personnel.

Fixed and variable costs were annualized and subtracted from the annual gross revenue increase for each design alternative. The resulting net revenue *increases* for each alternative are presented in Table ES-2 with the estimated mercury vapor concentration reductions previously reported in Table ES-1.

Design Alternative No. 2 appears especially attractive with an estimated annual net revenue *increase* of almost \$561,000 and mercury vapor concentration *reductions* of more than 500 $\mu\text{g}/\text{m}^3$ in the Furnace Building and approximately 160 $\mu\text{g}/\text{m}^3$ in the Concentrator Building.

ES.6 Application of Program Results to Other Mineral Processes

Program results can be applied to other mineral processing plants in the following areas:

- a. Isolation of a furnace or roaster as a major emission source
- b. Conveyance, storage, and metering of concentrate/vacuum filter cake with very unfavorable physical characteristics, such as high density, moisture, abrasion, viscosity, and corrosion
- c. Improving furnace or roaster draft pressure by
 1. Reducing furnace leakage through automatic cleaning operations
 2. Reducing exhaust system pressure losses through optimum exhaust fan design and eliminating constrictions to exhaust flow.

TABLE ES-2. - Summary of cost-benefit

Design Alternative	Health and safety benefit		Cost estimate		
	Hg vapor concentration (μg/m ³)				
	Estimated average reduction by eliminating blow-back	Estimated average background achievable with no blow-back	Gross revenue increase (\$/year)	Total annualized costs ³ (\$/year)	Net revenue increase (\$/year)
<u>No. 1</u>					
Furnace Building	>500	300	\$101,150 ¹	42,770	58,380
Concentrator Building	≈160	160			
<u>No. 2</u>					
Furnace Building	>500	300	644,900 ²	84,170	560,730
Concentrator Building	≈160	160			
¹ 1 percent increase in production.					
² 6.8 percent increase in production.					
³ Sinking Fund Method used for depreciation.					

1. INTRODUCTION

This document is the Final Technical Report for USBM Contract No. JO318024, "Propose and Evaluate Methods of Controlling Mercury Vapor Emissions in a Processing Mill Furnace Room." The report presents the details of a preliminary evaluation of emission sources contributing to excessive mercury vapor concentrations; conceptual designs to reduce those concentrations; and two detailed design alternatives which include specifications, drawings, and a cost-benefit analysis.

1.1 Background

Exposure of employees in mining and milling operations to mercury vapor is regulated by the MSHA. Under MSHA regulations full shift time-weighted average exposures must be maintained to less than 50 $\mu\text{g}/\text{m}^3$.

The primary source of mercury production in the United States is the McDermitt Mine at McDermitt, NV. The mine has been in production since April 1975. During this period, mine personnel have maintained a rigorous program aimed at keeping mercury vapor concentrations in the mill to a minimum. Mercury vapor concentrations in the mill, particularly in the multiple hearth furnace building, however, typically exceed the 50 $\mu\text{g}/\text{m}^3$ standard.

Although personnel are always well protected with respirators, the USBM felt that lower mercury levels were possible through process improvements. The USBM also felt that the technology developed to accomplish the process improvements will be applicable to furnace operations in other mineral processing plants.

1.2 Objectives

The objective of the program was to develop a cost-effective method, or methods, of controlling toxic vapor in a processing mill furnace room with particular emphasis on the McDermitt mercury mill in Nevada.

1.3 Scope of Effect

The program was to be completed in two phases:

- a. Phase I - Propose and do a preliminary evaluation of control systems

- b. Phase II - Make detailed designs and cost estimates of the most promising systems.

Phase I efforts included:

- a. Data collection of process, environmental, and operating information
- b. Identification and determination of the relative contribution of emission sources to mercury vapor concentrations
- c. Preparation of conceptual design alternatives to reduce mercury vapor concentrations cost-effectively.

Design approaches that were considered include:

- a. Process equipment selection
- b. Process component redesign or modification
- c. Improved ventilation.

Phase II efforts included the preparation and submittal of:

- a. Detailed drawings for two design alternatives
- b. General design specifications for 10 major components in each design alternative
- c. A cost-benefit study to determine the costs associated with each design alternative for reducing mercury vapor concentrations.

2. PROCESS DESCRIPTION - McDERMITT MINE OPERATIONS

The McDermitt mine and mill is located in McDermitt, NV. Mercury ore is mined by open pit and transported to the mill. A generalized plan view of the mine and mill is shown in Figure 1. Figure 2 shows the plant site plan. Open pit operations are briefly discussed in this section with little elaboration since the focus of the program was the plant site. The plant site is discussed in detail for processing stages within and adjacent to the Concentrator and Furnace Buildings.

2.1 Open Pit Operations

Mercury minerals within the McDermitt orebody include:

- a. Cinnabar, HgS (70 percent)
- b. Corderoite, $\text{Hg}_3\text{S}_2\text{Cl}_2$ (30 percent)
- c. Metacinnabar, Mercury Oxychlorides, and rare native mercury traces.

The existing pit excavation is approximately 140 acres in size and it will extend to a depth of 165 ft below the original surface elevation. Current plans include milling approximately 300,000 tons/year and waste stripping 2,640,000 tons/year. The overall waste-to-ore ratio for the orebody is 4.7:1.

Ore mineralization is erratic making selectivity in mining very important. After a scraper makes a cut in the ore zone, the cut is grab sampled and panned. A discrimination is quickly made between waste, low grade, and high grade ore, and the scraper operator stockpiles the cut accordingly.

2.2 Mineral Processing

The four basic stages of the processing plant include:

- a. Mineral grinding and concentration
- b. Furnace operation
- c. Mercury recovery
- d. Emission and effluent controls.

A plant flow sheet is presented in Figure 3.

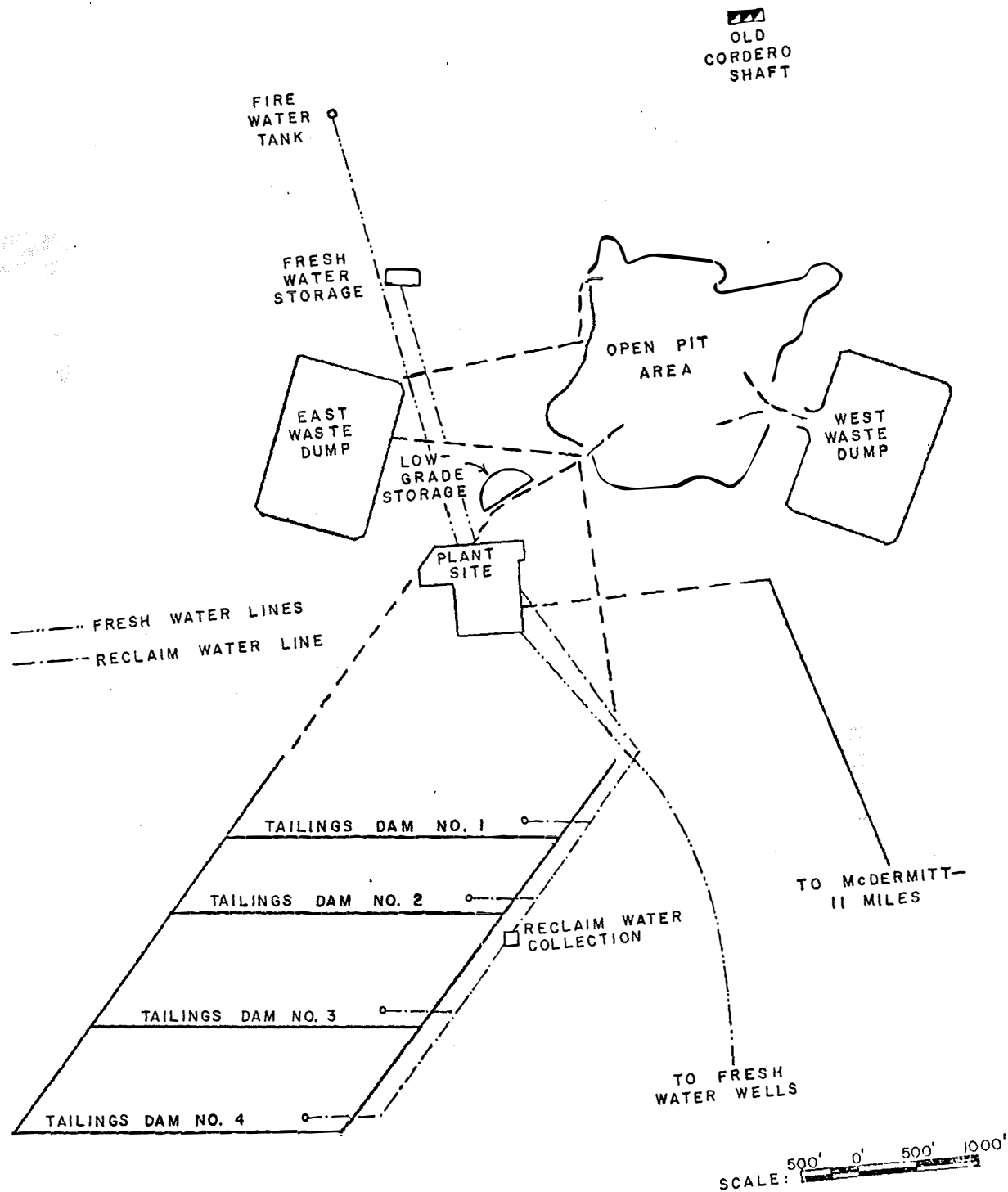


FIGURE 1. - Generalized plan of McDermitt Mine area.

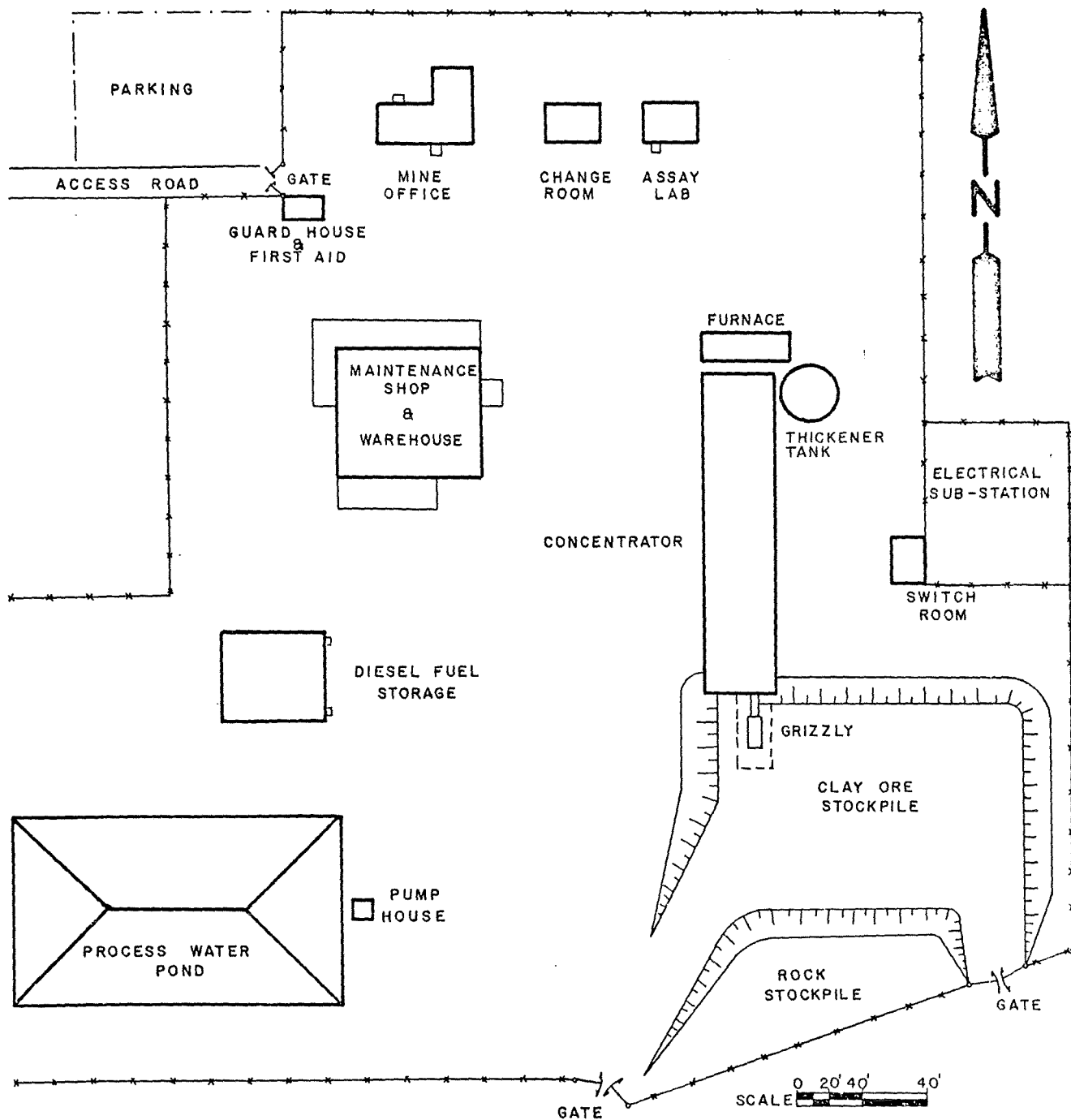


FIGURE 2. - McDermitt Plant site plan.

2.2.1 Mineral Grinding and Concentration

A Caterpillar 966C front-end loader transports the stock-piled clay ore to a grizzly with 11-in. openings, where the ore passes through into a 50-ton hopper. Rock for grinding media is similarly added, and the ore and grinding media fall onto a 51-ft long $\times$ 60-in. wide Telsmith apron feeder with a variable speed drive.

The feeder discharges into a Koppers "Hardinge" 18-ft $\times$ 9-ft long semiautogenous mill driven by a 2300V/1000 hp synchronous motor turning at 200 rpm. The following charges are added to the mill feed:

- a. 1/2-lb/ton of 3-1/2 in. diam balls, on a daily basis
- b. 150 cm³/ton of aqueous (contained) Na₂S, which acts as a mercury vapor depressant
- c. 0.25 lb/ton of Ca(OH)₂ to prevent the formation of H₂S.

The mill discharge is classified by three Krebs 20-in. cyclones in parallel (one extra cyclone acts as a spare). Inlet pressure is held to 8 psi. The cyclone underflow returns to the mill by gravity with the addition of American Cyanamid A-242 at 330 cm³/ton, which acts as the flotation collector. Cyclone overflow is piped to the flotation section at 65 to 70 percent minus 200 mesh. Figure 4 shows the mill and the cyclone classifiers.

Figure 5 shows the flotation area. The rougher flotation of the cyclone overflow is performed by six 600-ft³ Denver cells in series with six scavenger cells of the same capacity. Methyl Isobutyl Carbinol (MIBC) is added to the rougher feed at 300 cm³/ton to act as a frother. MIBC is added to the scavenger cells at 8 cm³/ton. Concentrate from the 12 rougher cells enters a cleaner circuit of six 50-ft³ Denver cells, and then a recleaner circuit of four 50-ft³ Denver cells. Tails from the cleaners are recycled to the roughers, and tails from the recleaners are recirculated through the cleaners. All tails eventually return to the scavenger cells where they are then transported to one of four tailings ponds. The flotation circuit operates at a density of 30 percent solids and a retention time of 48 min for a 100 ton/hr throughput. Final concentrate sizing is 83 percent minus 200 mesh, and it contains approximately 1500 lb mercury per ton.

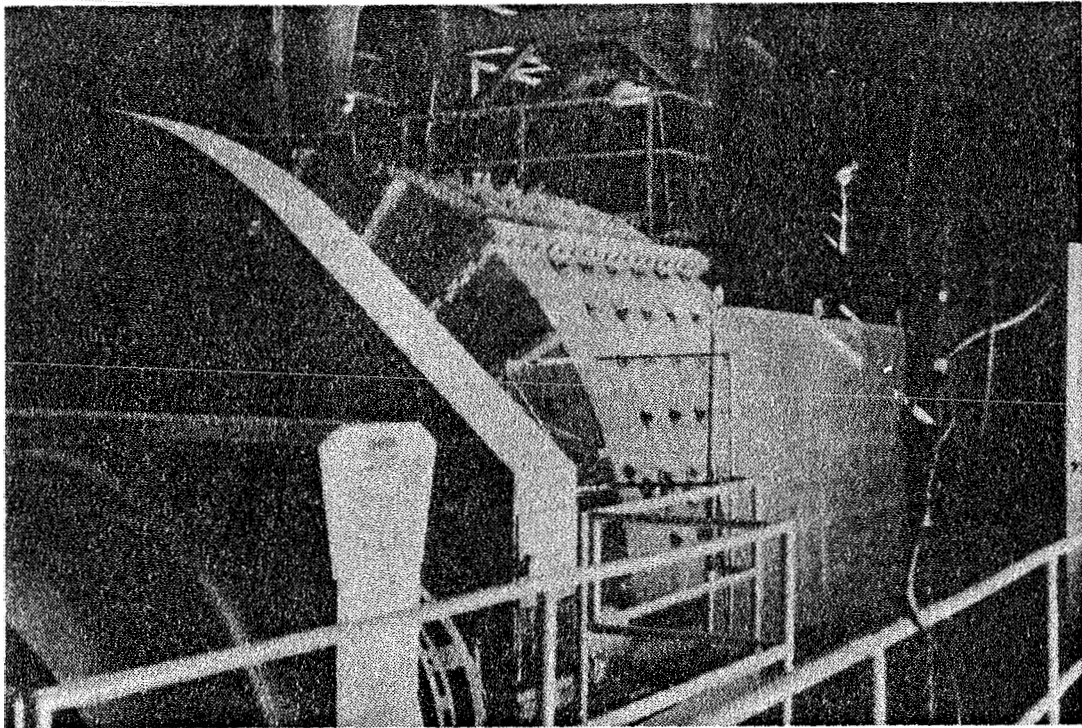


FIGURE 4. - Semiautogenous mill and classifiers.

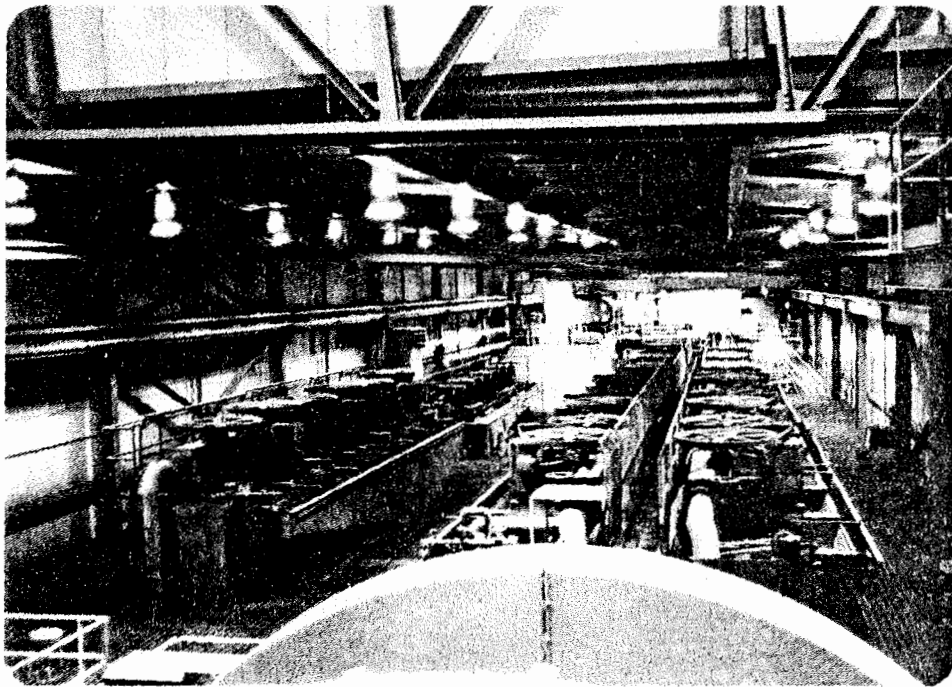


FIGURE 5. - View of flotation area taken from Koppers Mill.

Figure 6 shows the 40-ft diam $\times$ 12-ft high Denver thickener where the final concentrate is pumped and dewatered to 60 percent solids. Superfloc 127 is added to the thickener at 100 cm³/min to act as a flocculant. The thickener overflow is pumped back to the rougher cells. The underflow is pumped to an 18-ft diam $\times$ 18-ft high stock tank for storage (Figure 7).

Thickened concentrate is slurried and pumped to a Denver 6-ft diam, two-disc multileaf vacuum filter (Figure 8). The filter dewateres the concentrate to about 12 to 15 percent moisture (weight basis) and feeds it to a 1-ft diam $\times$ 18-ft long enclosed screw conveyor which transports the concentrate to the top of the furnace. Two reagents are added at the screw conveyor:

- a. 50 lb/hr of CaO, which acts as flux
- b. 300 cm³/min of Na₂S (dry), which aids in the reduction of corderoite and other mercury oxychlorides found in the ore.

Figures 9 and 10 show the CaO and Na₂S feeders, respectively. Figure 11 shows the screw conveyor discharge into the furnace.

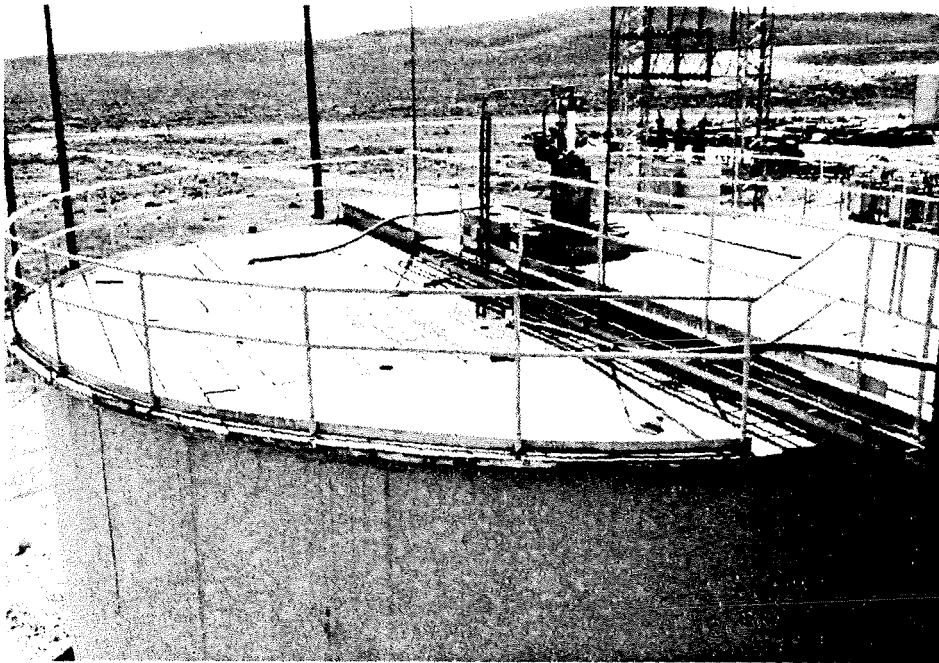


FIGURE 6. - Thickener.

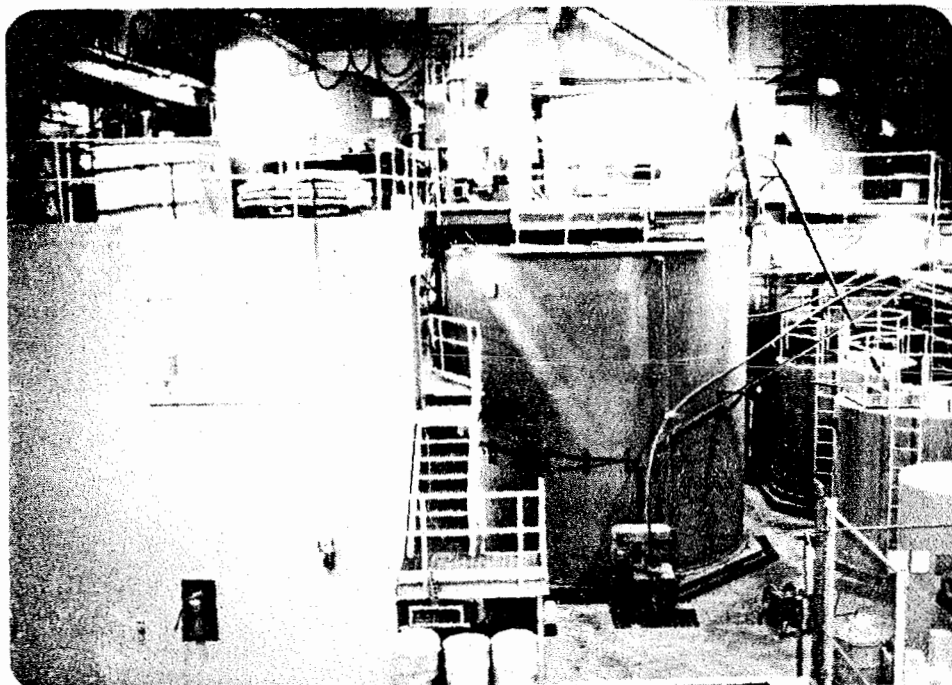


FIGURE 7. - Stock tank.

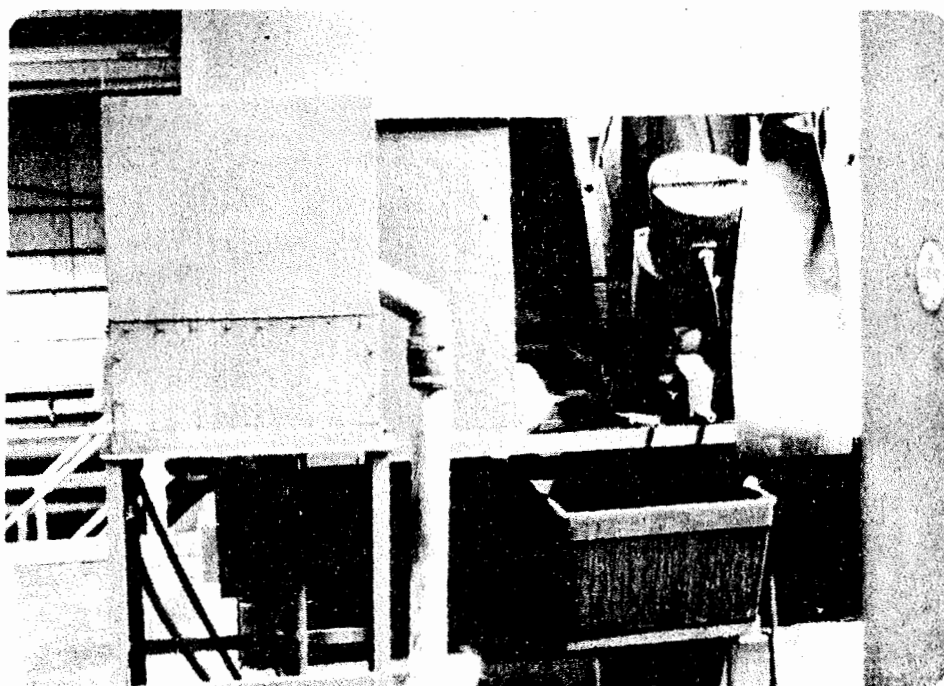


FIGURE 8. - Two-disc vacuum filter.

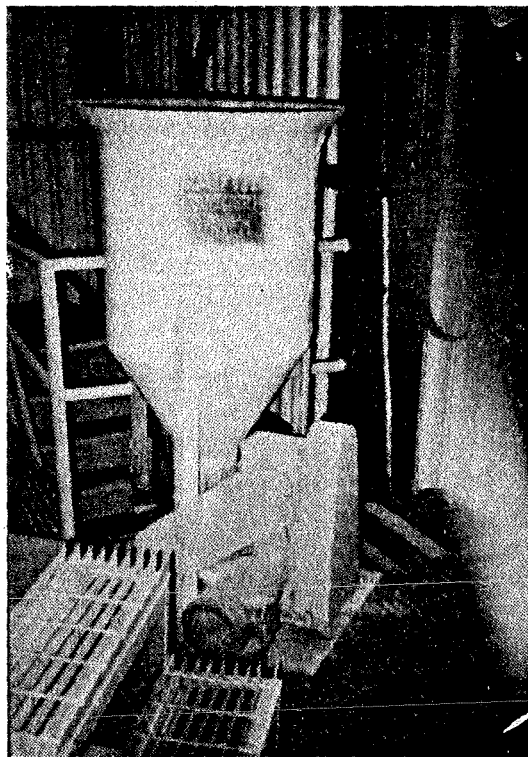


FIGURE 9. - CaO feeder.

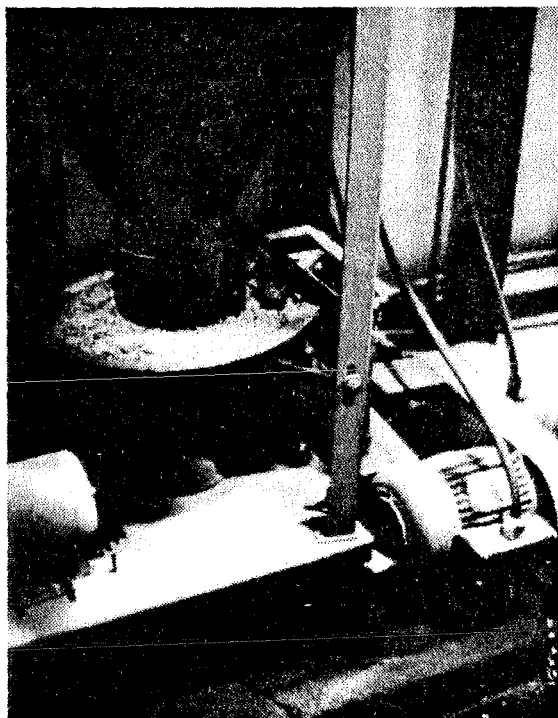


FIGURE 10. - Na₂S feeder.

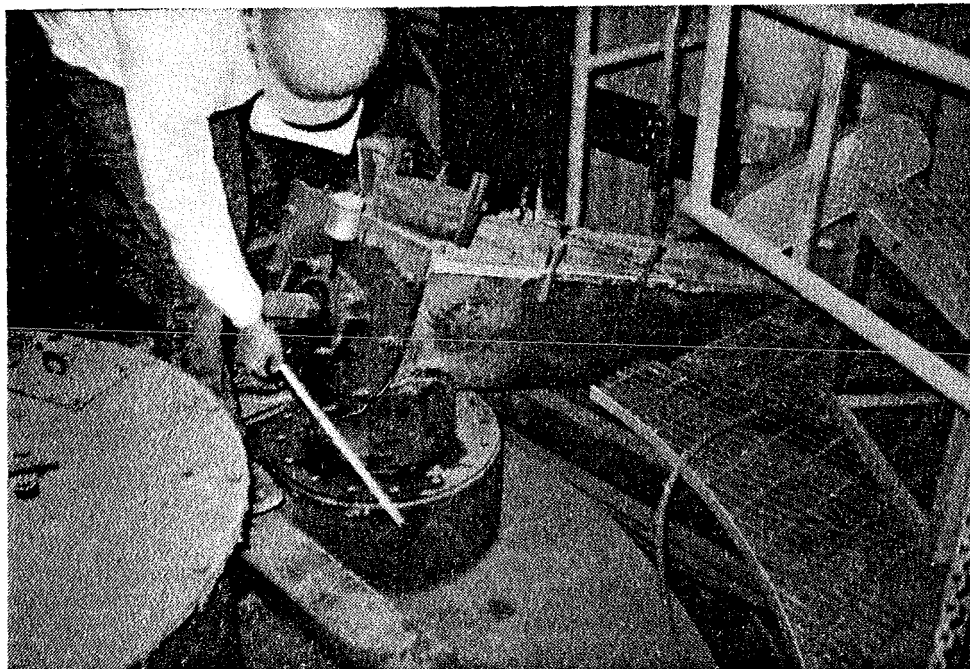


FIGURE 11. - Screw feeder discharge into furnace.

2.2.2 Furnace Operation

The Envirotech 10-ft diam, 6-hearth furnace (Figure 12) is housed in a separate building. The furnace is designed for a concentrate feed rate of 1100 lb/hr, and it is capable of operating at 1500 lb/hr. The furnace is fired with No. 2 fuel oil and propane pilots. A fuel conversion to propane is possible in the near future.

Burners are mounted on hearths 2 (top) through 5 (bottom), and all are used during startup. Only burners on hearths 2 and 4 are used during steady-state operations. Secondary air is introduced on hearth 5. Hearth temperatures vary from 1200° to 1600°F with the exception of hearth 1 which is approximately 800°F.

Rabble arms on each hearth are driven by a common vertical, central shaft. The feed is continuously moved inward by the arm on one hearth and then dropped to the next lower hearth, where the feed is moved to the periphery and the cycle continues. The moving bed thus has a long residence time allowing virtually all the mercury in the feed to be volatilized.

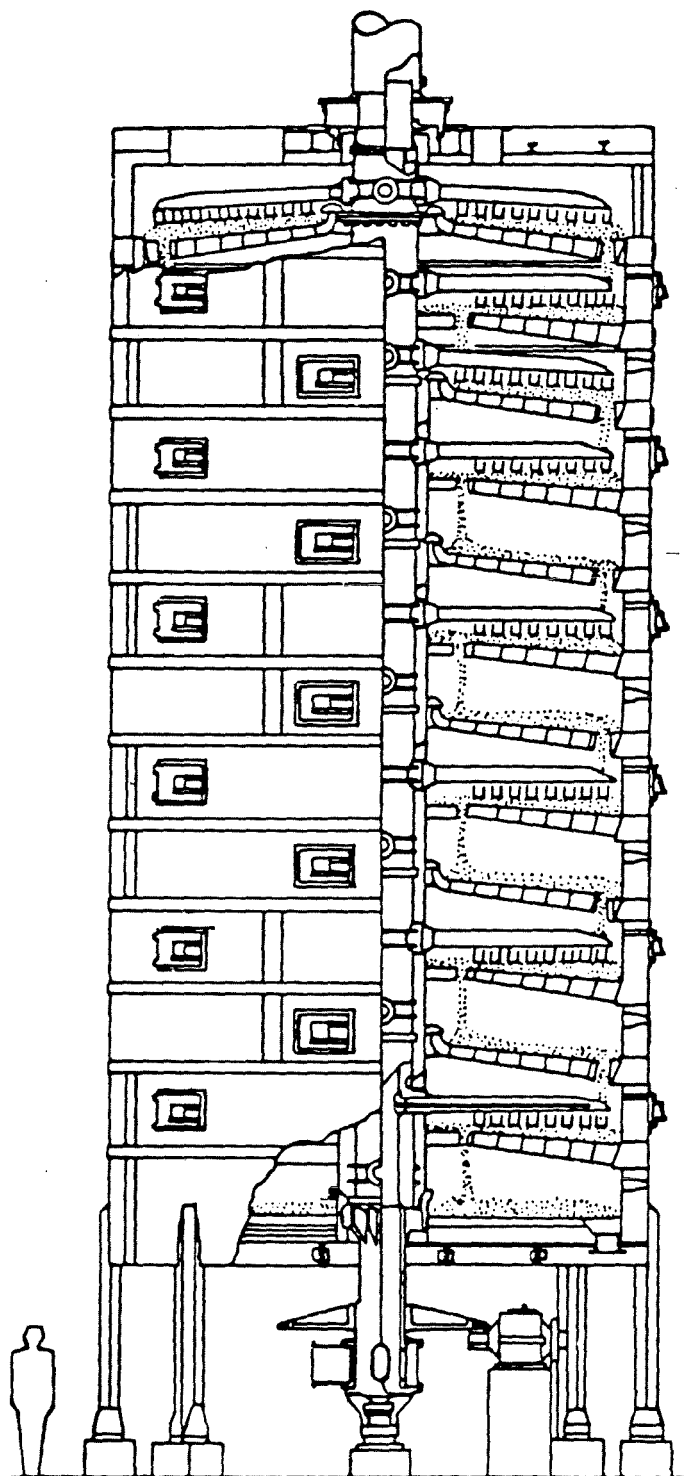


FIGURE 12. - Multiple-hearth furnace.

2.2.3 Mercury Recovery

Two induced draft (I.D.) fans originally maintained a negative pressure in the furnace and the exhaust gas system. The No. 1 I.D. Fan is located above the furnace and upstream of the condenser tubes. The No. 2 I.D. Fan is located downstream of the SO₂ scrubber and at the base of the cooling stack. The No. 1 I.D. Fan was determined to be ineffective and it is no longer used, although it temporarily remains in place. The negative pressure is maintained by only No. 2 Fan to prevent the release of mercury vapor from the system.

The furnace exhausts dust, mercury vapor, water vapor, SO₂, some chlorine compounds, plus the products of combustion and excess air at a rate of 1800 acfm at 750°F. Dust is removed by a cyclone immediately upstream of the No. 1 I.D. Fan. Exhaust gases from the cyclone then enter two parallel air condenser tube towers. Each tower consists of 12 8-in. diam tubes in series (Figure 13). The mercury condenses in the towers and is collected under water in launders (Figure 14).

The launder sludge is processed (squeezed) through a spiral classifier (Figure 15) to separate the liquid mercury. The remaining residue is then pumped to the thickener. The separated mercury is routed back to the mercury leaving the launders.

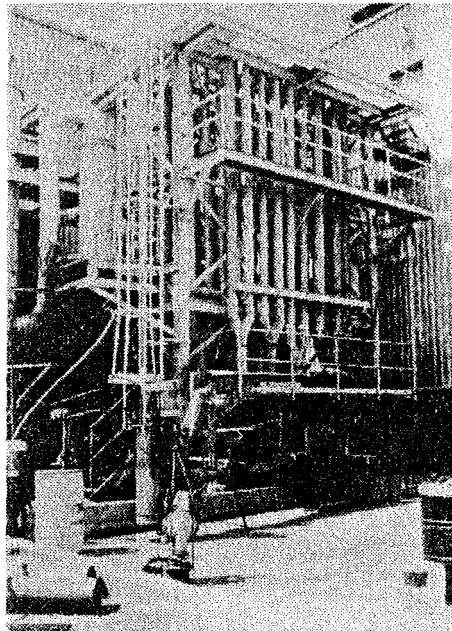


FIGURE 13. - Condenser towers.

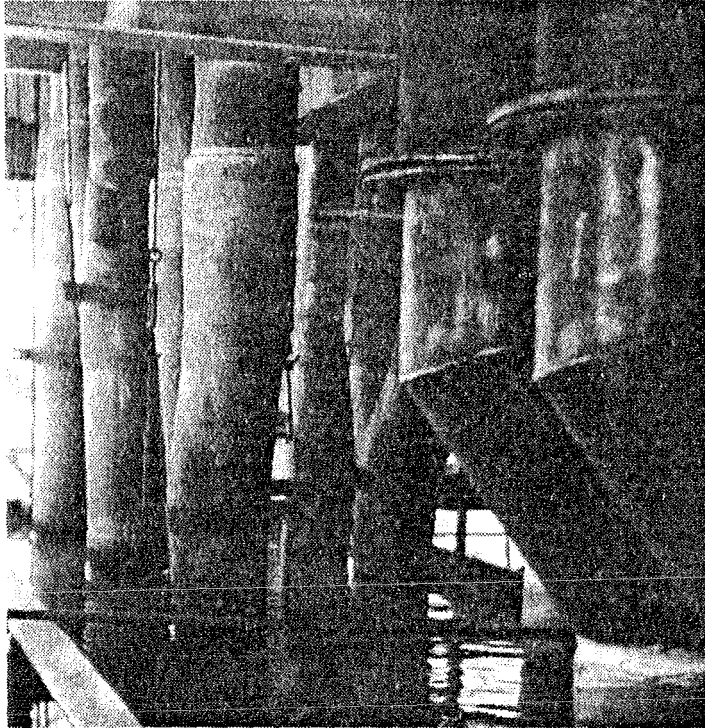


FIGURE 14. - Mercury launder.

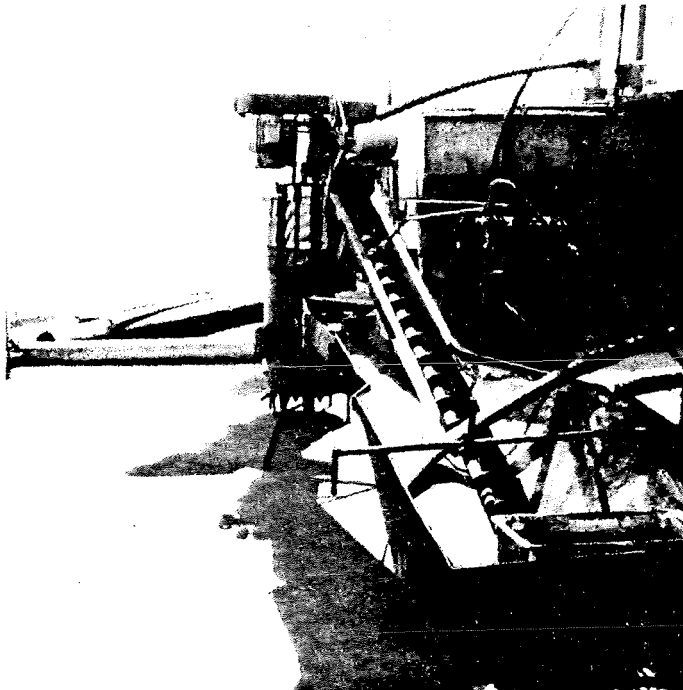


FIGURE 15. - Sludge squeezer.

Recovered mercury flows to a cleaning bath in the Concentrator Building (Figure 16). The cleaned mercury is then placed in bulk storage tanks (Figure 17). From bulk storage the mercury is double-filtered and bottled. The conventional container is a 76-lb capacity metal flask.

2.2.4 Emission and Effluent Controls

Emission Control

The gas stream exhausting from the condensers passes through a venturi and an impinger tower to remove remaining particulates. The gas stream then passes through an SO₂ scrubber and cooling tower and is exhausted to the atmosphere at ambient temperature with negligible SO₂ or mercury vapor content. Stack emissions comply with the EPA mercury limitation of 2300 g/day (0.2 lb/hr). Figure 18 shows the emission control system.

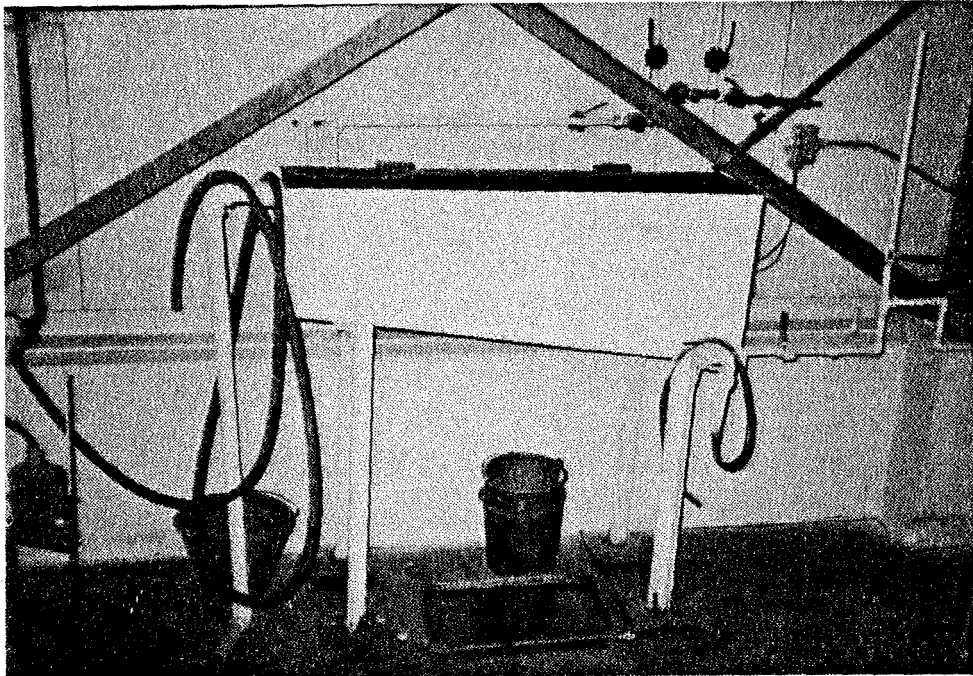


FIGURE 16. - Acid wash tank.

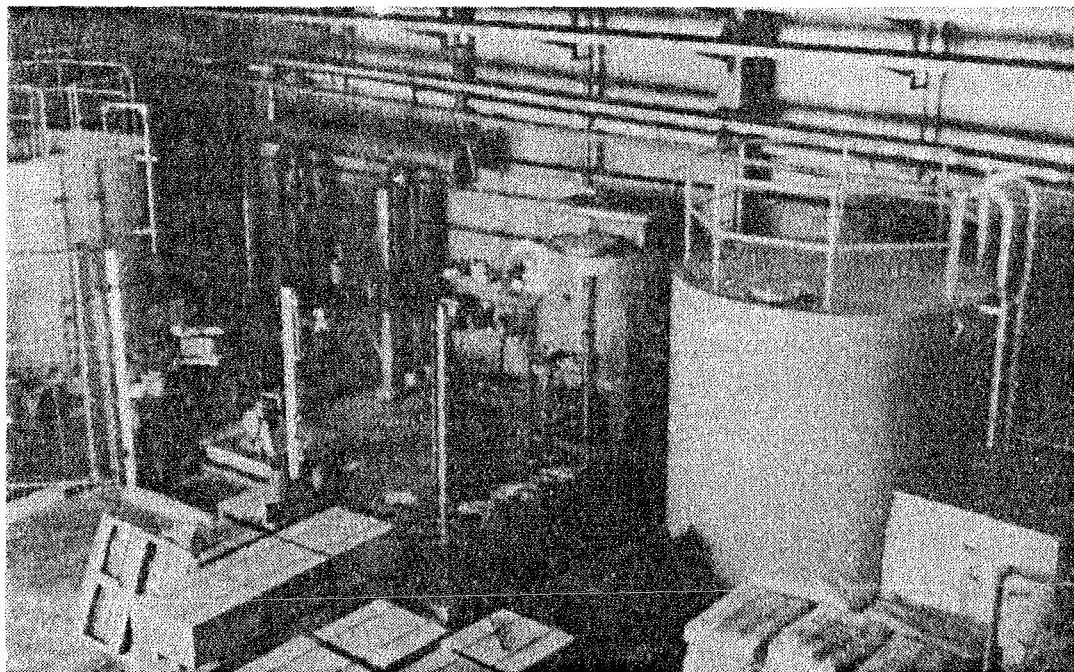


FIGURE 17. - Mercury storage tanks.

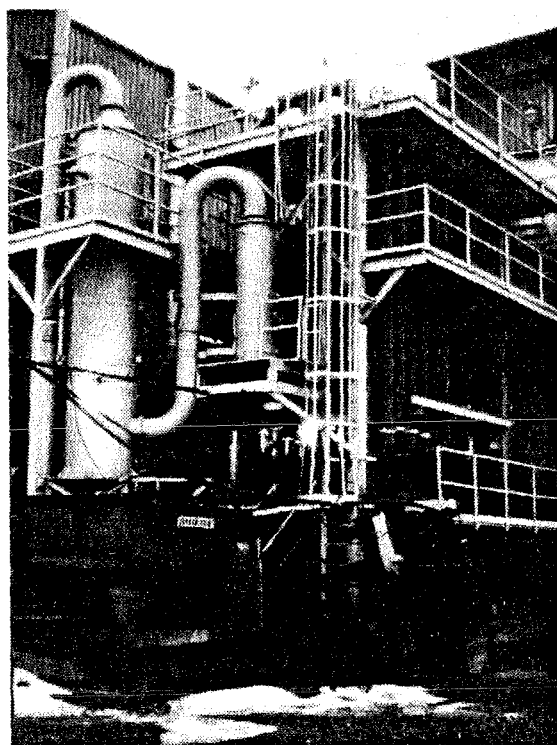


FIGURE 18. - Emission control system.

Effluent Control

One of four tailings ponds receives tailings and effluent from:

- a. Scavenger cells in the Concentrator Building
- b. Flushed calcines from the furnace discharge
- c. Emission control system discharges from:
 1. Cooling stack
 2. SO₂ scrubber
 3. Impinger tower
 4. Venturi
- d. Separator or "squeezer" of launder sludge.

The emission control system effluents tend to depress the pH in the tailings ponds. However, the Concentrator Building tailings are slightly basic due to the addition of hydrated lime and pond water is thus neutralized making future reclamation possible.

In addition to emission and effluent controls, a well-staffed and equipped maintenance department maintains plant equipment in good running order and performs a variety of housekeeping tasks to keep mercury vapor concentrations to a minimum. Most plant equipment can be repaired on-site, and both preventive and repair maintenance are performed between furnace runs. Housekeeping is aggressively pursued between furnace runs and when the flotation area is down since these periods present the opportunity of full access to equipment.

3. DATA COLLECTION AND ANALYSIS

Processing mercury as a primary product is limited to one operating mine in the United States at McDermitt, NV. The program's objective of evaluating and controlling mercury emissions from a processing mill furnace room thus required a site-specific investigation of emission sources at McDermitt. The investigation determined, however, that the results are applicable to a variety of other mineral processes since many of the emission sources are components that are commonly used throughout industry.

A summary of data collection and analysis results for Phase I, "Preliminary Evaluation of Control Systems," is presented in this section. Later sections present conceptual and detailed designs of alternatives for reducing mercury vapor emissions from identified emission sources.

The Phase I preliminary evaluation consisted of the following tasks:

- a. Data collection
- b. Identification of emission sources
- c. Determining the relative contribution of those sources to mercury vapor concentrations
- d. Conceptual design alternatives to reduce mercury concentrations on a cost-effective basis.

The phase was initiated with a series of data collection visits to McDermitt Mine to:

- a. Discuss and observe operations
- b. Collect process, environmental, and operating data
- c. Conduct process and environmental measurements and collect samples for analysis to supplement available data
- d. Perform special tests with mine personnel to more fully explain the physical phenomena associated with specific plant operations.

The intent of the data collection and evaluation was to provide information that can be used to determine the relative significance of mercury vapor emission sources and to cost-effectively select approaches for alleviating mercury concentrations. Approaches that were to be considered included:

- a. Process equipment selection
- b. Process component redesign or modification
- c. Improved ventilation.

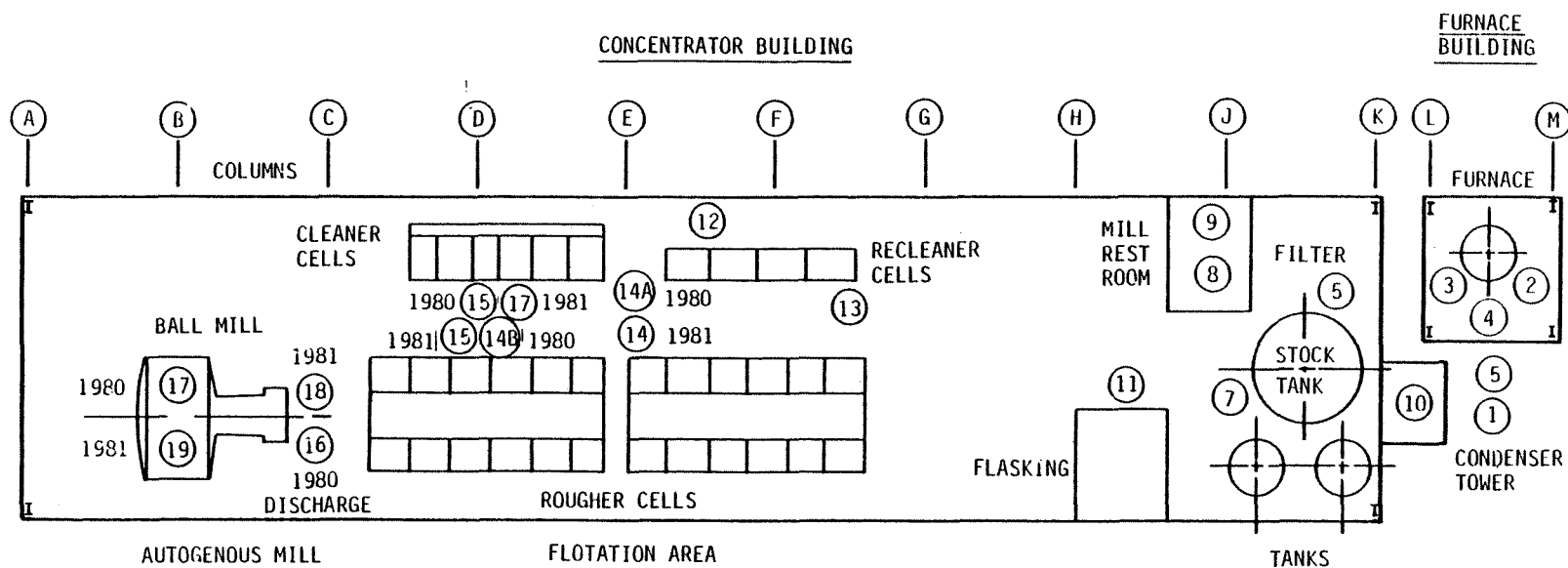
Phase I activities thus concluded with the presentation of conceptual designs for reducing mercury vapor emissions from identified sources within and adjacent to the Concentrator and Furnace Buildings.

The McDermitt Mine's environmental staff routinely collects mercury vapor concentration data at 27 stations with a Mercometer. Monitoring frequency is normally once per 7 days, but during a furnace run the frequency is typically increased to once every 2 to 4 days. There are approximately eight furnace runs per year lasting as long as 15 days each. The furnace is operated 24 hr/day during a run. Concentrator Building processes are often operated when the furnace is not operated. Figure 19 illustrates the monitoring station locations of interest in the following plant site areas:

- a. Concentrator Building
- b. Furnace Building
- c. Condenser area.

Monitoring stations that are not shown in Figure 19 include the Assay Laboratory, Service Building, Warehouse, and Office Building.

An initial data collection visit to the mine was made in May 1981. Process operations and monitoring activities were observed, and operating and environmental data were collected. Table 1 presents a quarterly summary of mercury vapor concentration day-weighted averages at the 18 stations illustrated in Figure 19. Note that five of the stations were renumbered beginning 1 January 1981 as shown by Figure 19 and Table 1.



NOTES:

1. SCALE: 1 in. = 25 ft - 0 in.
2. (2) - FIRST FLOOR FURNACE, (3) - SECOND FLOOR FURNACE, (4) - THIRD FLOOR FURNACE
3. (1) - CONDENSER LAUNDERS BENEATH (5) - CONDENSER PLATFORM
4. (12) - FLOTATION AREA BASEMENT; ALL OTHER STATIONS ON OPERATING LEVELS.

FIGURE 19. - Monitoring station locations.

TABLE 1. - McDermitt Mine - mercury vapor concentrations (day-weighted averages by monitoring station, $\mu\text{g}/\text{m}^3$)

Year and quarter	Monitoring station																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14A (14)	14B (15)	15 (17)	16 (18)	17 (19)	Avg
<u>1979</u>																			
1	97	160	194	178	66	227	164	130	54	140	91	60	93	71	94	88	63	55	113
2	351	335	364	422	169	254	150	69	124	193	84	90	140	80	162	149	83	65	182
3	414	344	387	425	163	198	160	93	70	80	90	52	212	66	161	215	82	71	182
4	162	205	249	290	111	226	112	76	51	106	65	49	129	76	167	104	86	65	129
Yearly average	256	261	299	329	127	226	147	92	75	130	83	63	144	73	146	139	79	64	152
<u>1980</u>																			
1	71	221	219	273	56	219	181	86	54	138	98	68	188	112	133	147	140	71	138
2	373	342	352	482	183	252	145	79	83	151	95	91	244	119	252	263	135	97	208
3	305	207	290	530	151	256	164	72	88	161	130	57	166	94	165	197	118	75	179
4	120	89	152	252	63	302	215	86	51	177	127	78	200	156	245	256	231	182	166
Yearly average	217	215	253	384	113	257	176	81	69	157	113	74	200	120	199	216	156	106	173
<u>(1981)</u>																			
1	53	68	103	144	42	242	173	89	76	117	112	70	116	99	107	137	122	139	112
2	258	132	358	206	123	378	229	96	87	247	114	73	186	155	215	169	144	136	184
<u>Notes</u> 1. Monitoring stations marked "()" were renumbered beginning 1 January 1981. 2. Only two quarters are reported for 1981.																			

Mercury vapor concentrations reported in Table 1 exceeded a quarterly average of $200 \mu\text{g}/\text{m}^3$ at the following monitoring stations:

- a. No. 1 - Condenser launders
- b. Nos. 2, 3, 4 - First, second, and third furnace floors, respectively
- c. No. 6 - Furnace concentrate filter
- d. No. 7 - Above stock tank
- e. No. 10 - Mercury cleaning tank
- f. No. 13 - Recleaner cells
- g. No. 14B (15) - Scavenger cells
- h. No. 15 (17) - Cleaner cells
- i. No. 16 (18) - Mill discharge.

The relative contributions of the above sources, and others, to mercury concentrations cannot be defined until the significance of the furnace as a source is described.

The highest mercury concentrations were recorded at monitoring stations Nos. 2, 3, and 4, which correspond to the first, second, and third floors of the Furnace Building, respectively. Figure 20 presents a plot of Furnace Building mercury concentrations that are reported as the percent of readings equal to and greater than $200 \mu\text{g}/\text{m}^3$ for 1979, 1980, and the first two quarters of 1981. The final 1981 data will probably contain significantly more readings above $200 \mu\text{g}/\text{m}^3$ due to the very low vapor pressure of mercury causing increased emissions during the warmer months of the year. Thus little or no improvement in reducing mercury emissions from the furnace has been accomplished. A discussion of conditions at Station No. 6, the Furnace Concentrate Filter, will provide an explanation of why the furnace is the predominate source of emissions and why the furnace emissions have not been reduced.

Station No. 6 is one of the closest monitoring locations in the Concentrator Building to the furnace. Figure 21 presents a plot of mercury concentrations versus distance from the furnace

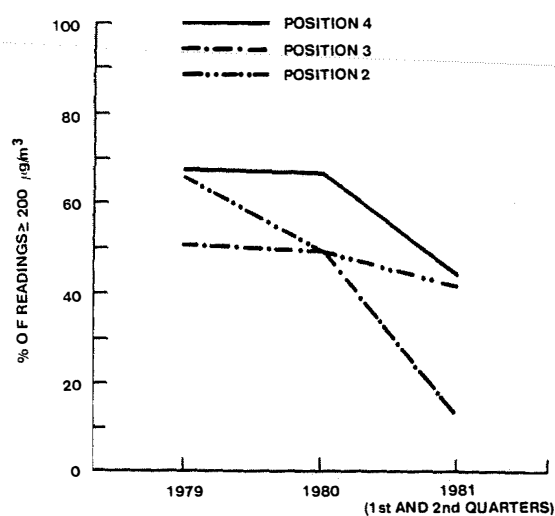


FIGURE 20. - Mercury vapor concentrations ($\mu\text{g}/\text{m}^3$) in Furnace Building - McDermitt Mine.

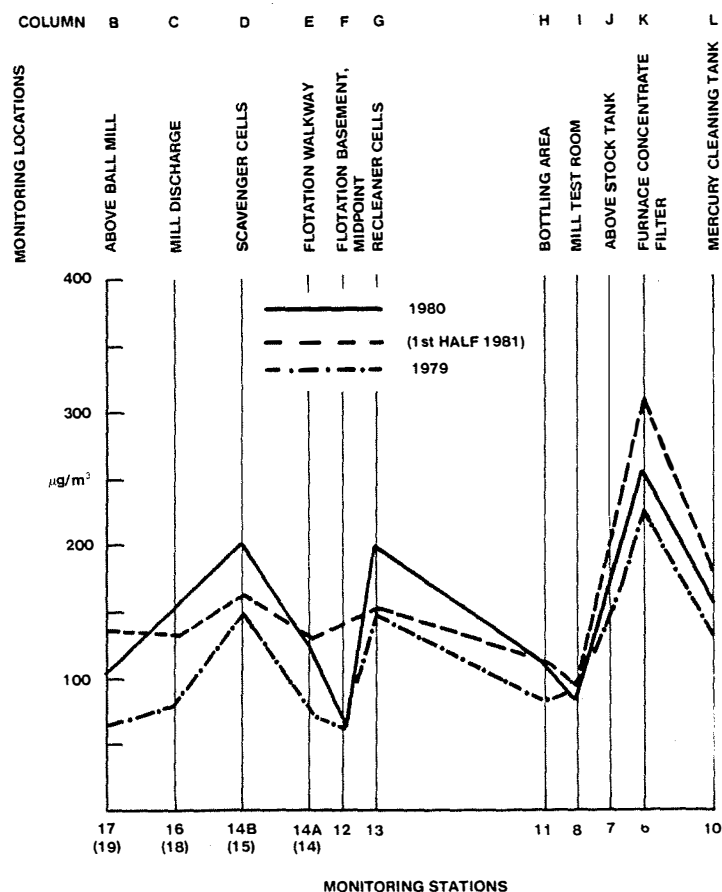


FIGURE 21. - Yearly weighted average mercury vapor concentration ($\mu\text{g}/\text{m}^3$) - McDermitt Mine.

for the stations that are generally listed in items a through i above. The highest concentrations in the Concentrator Building were recorded at Station No. 6 and concentrations are increasing with progressive years. The Furnace Concentrate Filter or vacuum filter is open to the building atmosphere and the filter operates during a furnace run. When the furnace is operating, mercury vapor concentrations rise dramatically, as illustrated by Figure 22. Monitoring data for Station No. 6 was plotted as shown by Figure 22, and two data points from the plots were tabulated:

- a. The last measured concentration *before* a furnace run
- b. The maximum concentration measured *during* a furnace run.

Table 2 is the result of tabulation. The measurement averages for 1979, 1980, and 1981 that are listed in Table 2 are plotted for convenience in Figure 23. Concentrations are thus nearly *doubled* at Station No. 6 when the furnace is operated, and Figure 23 also clearly illustrates the dramatic rise in concentrations over progressive years. Enclosing the vacuum filter and safely exhausting its emissions is an obvious conclusion, but that does not reduce emissions from the source which is the furnace.

The furnace normally operates at a slightly negative pressure to prevent mercury vapor emissions from escaping into the Furnace Building. A condition of positive pressure in the furnace when emissions escape from the furnace is referred to as blow-back. Mine personnel have observed numerous conditions when blow-back has occurred:

- a. Excess feed rate to the furnace (hearth temperatures cool and the burners fire more than usual causing positive furnace pressure)
- b. Excess filter cake moisture (same effect as item a above)
- c. Condenser tube pluggage (furnace then exhausts via any convenient pathway, such as back through the feed circuit and the open vacuum filter).

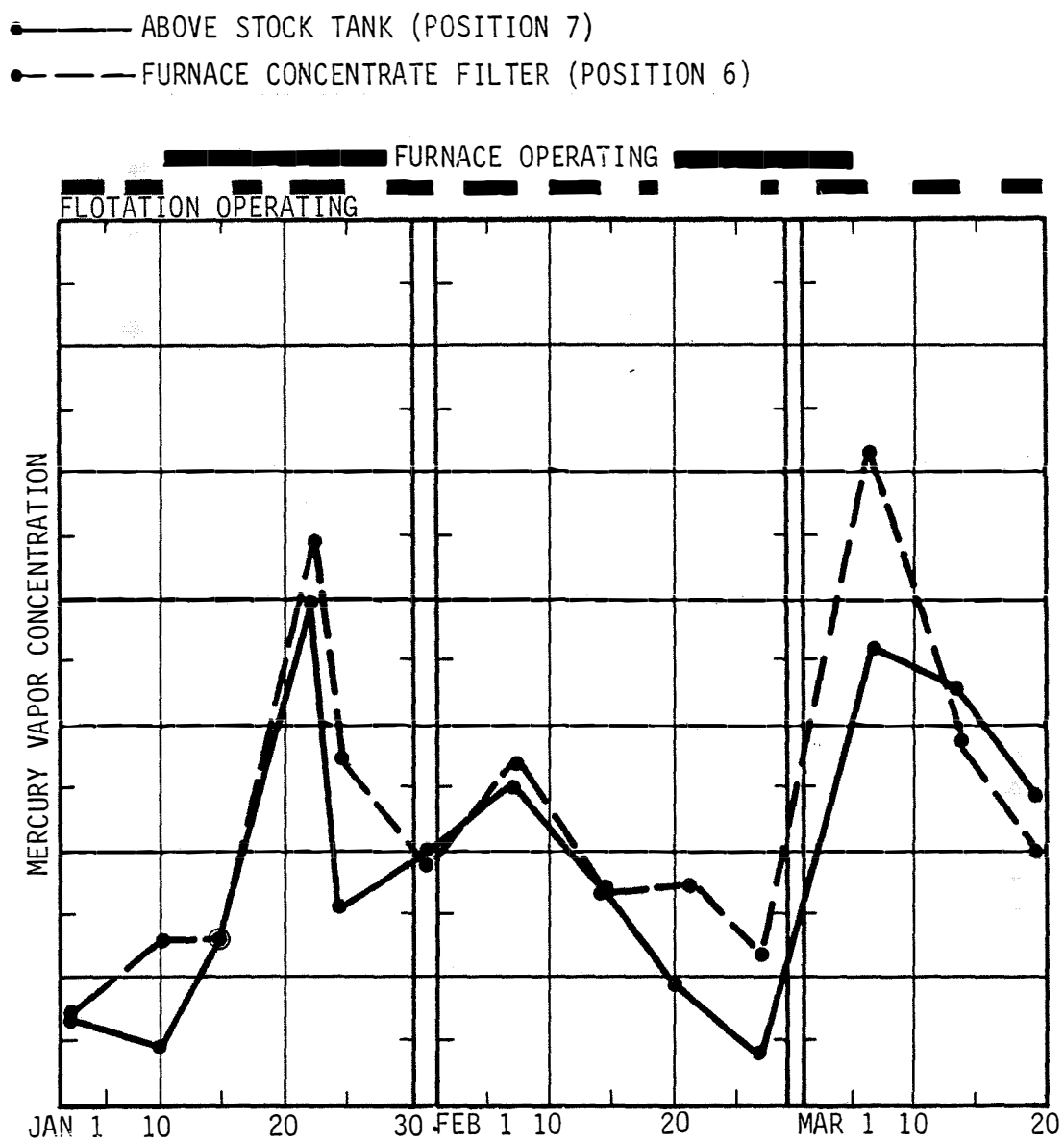


FIGURE 22. - Mercury vapor concentration versus time.

TABLE 2. - Effect of furnace operation on Hg vapor concentrations at position 6 (furnace concentrate filter)

Year	Last measurement before furnace run		Maximum concentration measured during run		Hg concentration increase due to furnace ($\mu\text{g}/\text{m}^3$)
	Date	Hg concentration ($\mu\text{g}/\text{m}^3$)	Date	Hg concentration ($\mu\text{g}/\text{m}^3$)	
1979	3/29	319	4/11	319	0
	5/3	180	5/15	473	293
	6/11	220	6/20	170	-50
	7/12	175	7/19	275	100
	8/7	101	8/16	248	147
	9/6	130	9/13	248	118
	10/25	137	11/6	405	268
	11/28	125	12/6	220	95
	Averages	173		295	122
1980	1/10	130	1/22	450	320
	2/14	164	3/6	517	353
	4/10	215	4/16	440	225
	5/15	325	6/4	242	-83
	8/26	164	9/11	400	236
	10/27	215	11/6	187	-28
	12/4	187	12/11	370	183
	Averages	200		372	172
1981 (two quarters only)	1/15	460	1/29	370	-90
	3/5	240	3/24	350	110
	5/15	184	6/1	600	416
	Averages	295		440	145
1980 and 1981 averages		229		392	163

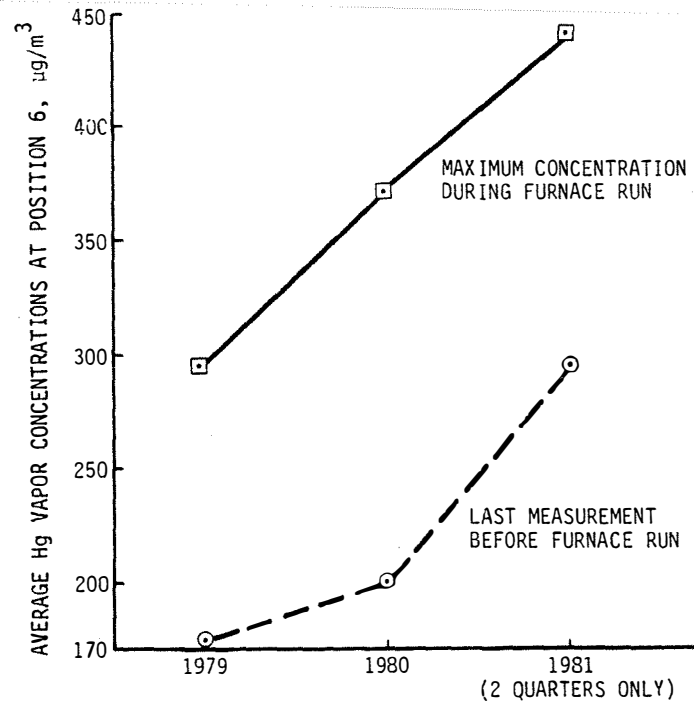


FIGURE 23. - Effect of furnace operation on Hg vapor concentrations at position 6 (furnace concentrate filter).

In addition to the above conditions, the data analysis at this stage revealed that the No. 1 I.D. Fan might also be a contributor to blow-back. Confirmation of some operating data and specific process measurements were necessary to determine possible I.D. fan problems and to relate mercury vapor emissions and concentrations to operating conditions. Data of particular interest included:

- a. Furnace operating conditions
 1. Draft pressure
 2. Hearth temperatures
 3. Exhaust gas flow volume
 4. Appearance of doors and seals
- b. Furnace exhaust circuit conditions
 1. Pressure drop across circuit components
 2. Pressure rise across induced draft fans

3. Revolutions per minute of induced draft fans
4. Temperatures at various circuit locations
5. Exhaust duct sizes.

FMA observed operations and conducted process measurements to obtain the above data on 27 July 1981. Figure 24 summarizes the results of the observations and measurements.

Identifying emission sources and their relative contribution to mercury vapor concentrations was possible by combining the available data and the data collected during the 27 July tests.

The No. 1 I.D. Fan was observed on 27 July to be free-wheeling and the furnace pressure slightly negative. When the operator opened the door to Hearth 1 to clean the rabble arm and hub, the furnace pressure went slightly positive, and a surge of emissions was observed through the open door. Two empirical conclusions were drawn:

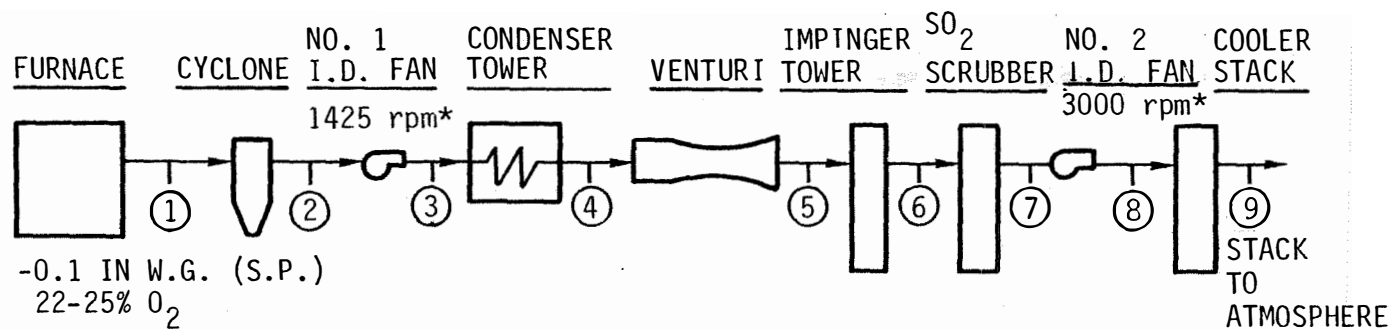
- a. A mechanism needs to be provided to clean the rabble arm and hub so the door can remain closed on Hearth 1
- b. Additional draft and thus a greater margin of negative pressure within the furnace is needed...the most effective means being the removal of the No. 1 I.D. Fan.

From discussions with mine personnel, we determined that there is a synergism between the two above items. Whenever a door is opened, the hearth cools, and clinkers are more likely to form causing the operator to open the door and clean the rabble arm and hub.

The filter cake was found to be of a physical nature that did not lend itself to easy conveyance, handling, or a predictable feed rate. A chemical analysis of the filter cake revealed:

- a. A density of 256 lb/ft³
- b. A pH of 10.4
- c. A moisture content of 11.3 percent by weight
- d. A dynamic viscosity of 200,000 CPS and a static viscosity of 350,000 CPS.

Temp. Profile	
Hearth	°F
2	1440
3	1400
4	1640
5	1420
6	1500



Location	Velocity Pressure, in. W.G.	Static Pressure, in. W.G.	Inside Diameter, in.	Temperature, °F
1		-0.3		900
2		-4.0		
3	1.5*	-2.5*		760*
4		-8.5 ±0.5		110
5		-22.5		115
6		-25.5		75
7		-24		
8	2.5*	+0.5*	8*	120
9	0.15*	0*	11*	< 200*

TEST DATE: 27 JULY 1981

*MEASURED BY FMA; ALL OTHERS
FROM PROCESS INSTRUMENTATION.

FIGURE 24. - Furnace exhaust circuit tests.

A slight variation in volume feed rate of the very dense cake therefore significantly affects the mass feed rate to the furnace. Vacuum filters, such as the type used at McDermitt, typically provide a cake at approximately 20 percent moisture by weight. A 15 percent moisture cake is common in practice at McDermitt, and our measurements determined the cake moisture to be 11.3 percent on 27 July 1981. A cake moisture content variation between 11 and 20 percent is therefore possible.

Two of the three observed reasons for furnace blow-back were thus confirmed as highly probable by observations on 27 July and the filter cake analysis:

- a. Excess feed rate to the furnace
- b. Excess filter cake moisture.

The third observed reason, condenser tube pluggage, is certainly possible if either item a or b occurs. Hearth temperatures will drop, furnace emissions will increase, and particulate carry-over from an overloaded cyclone then results causing tube pluggage.

In addition, it is possible that the No. 1 I.D. Fan has operated in stall. Mine personnel found it difficult to balance the two I.D. fans, which are in series, and they therefore allow the No. 1 fan to "free-wheel," as observed on 27 July 1981. It thus presents a resistance to the circuit and does not contribute to system performance. If it is in stall when operated, the static pressure will fluctuate substantially within a relatively narrow flow regime, and the result may be furnace draft fluctuations and thus blow-back.

Mercury vapor concentrations in the Concentrator Building have historically increased during a furnace run because of frequent blow-back occurrences. Concentrator Building concentrations remained approximately the same before and during a furnace run when blow-back did not occur.

The dramatic effect of furnace blow-back on Concentrator Building concentrations can be demonstrated by presenting the blow-back data of Table 3 and comparing it to the operating data of Table 2.

**TABLE 3. - Potential Hg vapor concentration reduction
by eliminating furnace blow-back**

Furnace condition	Maximum concentration of Hg vapor measured by location ($\mu\text{g}/\text{m}^3$)										Comments
	Furnace Building					Concentrator Building					
	Date	2	3	4	Average	6	13	14A 14 (1981)	14B 15 (1981)	Average	
Blow-back	<u>1980</u>										"-": not measured
	1/22	400	-	-	400+	450	-	100	-	275	
	4/16 to 2/24	627	545	792	655	440	440	265	814	490	
	5/28 to 6/5	539	572	858	656	242	275	180	352	262	
	7/28	209	-	792	500+	-	220	120	183	174	
	9/11 to 9/25	475	515	1000+	663+	400	363	133	663	390	
	<u>1981</u>										
	5/27	>1800	>1600	-	>1700	-	-	-	-	-	
Average: >762					383		Average: 318			Concentration averages per building	
No blow-back	<u>1980</u>										Mill down for repairs
	2/21	231	253	495	326	176	133	85	84	120	
	11/6	245	405	615	422	187	146	117	235	171	
	12/11	121	77	360	186	370	188	185	205	237	
	<u>1981</u>										
	2/19	120	95	290	168	121	-	-	-	121	
	3/24	198	185	210	198	350	89	80	79	150	
Average: 260					241		Average: 160			Concentration averages per building	
Concentration reduction possible by eliminating blow-back (Δ)	$\Delta = >500$					$\Delta = \sim 160$					Δ = blow-back "average" minus no blow-back "average"

Notes:

1. The average "no blow-back" concentrations of 260 and 160 $\mu\text{g}/\text{m}^3$ of Hg vapor for the Furnace and Concentrator Buildings, respectively, may include a cumulative amount due to blow-back. By eliminating blow-back, the "no blow-back" background concentrations may therefore be reduced somewhat. The " Δ " reported here will thus be higher.
2. Due to infrequent measurements, it is possible that the actual furnace running backgrounds are approximately 300 to 350 $\mu\text{g}/\text{m}^3$ (Furnace Building) and 200 to 250 $\mu\text{g}/\text{m}^3$ (Concentrator Building) for the "no blow-back" furnace condition, as opposed to the average concentrations reported above in the table.

Furnace blow-back data are most complete for 1980 and 1981. Concentrator Building concentrations are presented in Table 3 at several locations, including Station No. 6, for periods when furnace blow-back occurred and when no blow-back occurred. Notice from Table 3 that the average of maximum concentrations recorded at Station No. 6 was:

- a. 383 $\mu\text{g}/\text{m}^3$ during blow-back
- b. 241 $\mu\text{g}/\text{m}^3$ when blow-back did not occur.

From Table 2, the average of the last measurements taken *before* a furnace run at Station No. 6 and during the same reporting period was 229 $\mu\text{g}/\text{m}^3$.

We can thus conclude that:

- a. The mercury vapor concentration at Station No. 6 was approximately the same *before* a furnace run and during a furnace run with no blow-back.
- b. Mercury vapor concentrations at Station No. 6 and other monitoring locations in the Concentrator Building increased substantially whenever blow-back occurred.

We can also conclude from observations and the evaluation of mercury concentration and operating data that:

- a. Furnace blow-back is a major contributor to mercury vapor concentrations in both the Furnace and Concentrator Buildings.
- b. Furnace blow-back causes include:
 - 1. Excess feed rate to the furnace.
 - 2. Excess filter cake moisture content.
 - 3. Condenser tube pluggage.
 - 4. Furnace door leaks, particularly when a hearth door is opened.
 - 5. A possible No. 1 I.D. Fan stall condition when it is operated and reduced furnace draft margin when the fan is free-wheeling.

- c. The furnace feed circuit is not isolated from the furnace and blow-back emissions can enter the Concentrator Building via the screw conveyor and the open vacuum filter. Successful isolation of the feed circuit and enclosing/venting the vacuum filter will result in substantial mercury vapor concentration reductions in the Concentrator Building, as shown by Table 3.

Program efforts were therefore focused on first solving furnace emission problems and blow-back in particular. The program then proceeded to conceptual designs for Furnace and Concentrator Buildings and condenser area modifications to reduce mercury vapor concentrations. Design responsibilities for FMA and McDermitt Mine personnel were assigned. The following section discusses the conceptual design effort and the agreed upon assignments.

4. CONCEPTUAL DESIGN ALTERNATIVES

Three conceptual design alternatives were developed and presented to the USBM and McDermitt Mine personnel. Each alternative responded to the identified emissions problems, particularly furnace blow-back. Collectively the alternatives provided a progressive degree of sophistication and thereby a range of system capabilities (and costs) from which to select. All three alternatives included the following features:

- a. Increase in condenser tube diameter from 8 to 10 in. to increase system capacity and reduce the potential for pluggage
- b. Improved furnace feed system with the following provisions:
 1. A rotary airlock to isolate the feed circuit from the furnace and thus prevent blow-back
 2. Surge capacity to allow uniform feeding and to provide 3 to 4 hr of reaction time to problems upstream of the surge bin
 3. Metering after the vacuum filter for more precise feed rate control
 4. Reagent mixing with rate control and larger capacity to reduce labor
- c. Removal of the No. 1 I.D. Fan to eliminate
 1. A potential source of pressure fluctuations which may cause blow-back
 2. A circuit component which causes a system pressure loss without contributing to system performance
- d. Installation of a back-up No. 2 I.D. Fan (in parallel to present No. 2 fan)
- e. Increased dust collection efficiency to reduce pluggage in the furnace exhaust circuit
- f. Dust removal equipment for the cyclone to facilitate disposal of collected dust, and a means to determine that the cyclone is operating without pluggage

- g. Automatic rake cleaning for Hearth 1 to reduce
 - 1. Clinker formation
 - 2. The need to open the hearth door for cleaning
 - 3. Potential for blow-back
- h. Conversion to propane on furnace burners because of available supplies and convenience
- i. Improved calcine discharge system with the following provisions:
 - 1. Isolation from the furnace to prevent steam from calcine discharge line flushing from entering the furnace and causing clinker formation
 - 2. Sampling/assay capability that does not expose an operator to continuous operations
 - 3. Ability to handle clinkers which have previously caused discharge line pluggage.

Each alternative is briefly discussed in the following subsections.

4.1 Conceptual Design Alternative No. 1

The first concept is based on the assumption that the filter cake discharged from the vacuum filter at approximately 15 percent moisture can be successfully:

- a. Conveyed by a belt conveyor
- b. Transferred to a surge bin for a brief period
- c. Transferred to and uniformly transported through a gravimetric weighfeeder
- d. Blended with reagents and passed through a rotary airlock.

Figure 25 shows the conceptual design layout for the furnace feed circuit.

FIGURE 25. - Conceptual Design Alternative No. 1.

Filter cake is discharged from the present twin screws of the vacuum filter and transported by a troughed belt conveyor to a live-bottom surge bin. A moisture sensor is mounted on the conveyor housing. The cake is discharged from the bin to a gravimetric weighfeeder which provides a signal to the reagent feeders. CaO and Na_2S are added proportionally at the weighfeeder discharge and blended. The blended cake is discharged to a rotary airlock feeder which isolates the feed circuit from the furnace and feeds the blended cake to the furnace.

The first alternative has the following advantages:

- a. Simple in design
- b. Less corrosion than the present system since Na_2S is added after the conveyor and just prior to the furnace
- c. Relatively inexpensive.

Capital equipment costs were estimated, at the program's conceptual design phase, to be approximately \$80,000 (1981 prices). All components were found to be readily available and provided as units that lended themselves to installation within a reasonable period by mine personnel.

FMA concluded, however, that the first alternative has the major disadvantage of handling a moist, dense cake that may cause pluggage by adhering to surfaces at transfer points and within confined spaces. Potential pluggage points include:

- a. Conveyor discharge
- b. Surge bin
- c. Gravimetric weighfeeder
- d. Rotary airlock.

4.2 Conceptual Design Alternative No. 2

The second concept is the same as the first alternative except that a dryer is added after the vacuum filter. The major disadvantage of pluggage which is inherent to the first concept is eliminated since the dryer provides a cake at only 5 percent moisture. In addition, less moisture is conveyed to the furnace which allows a greater mercury throughput. Figure 26 shows the conceptual design layout for the second alternative. Capital

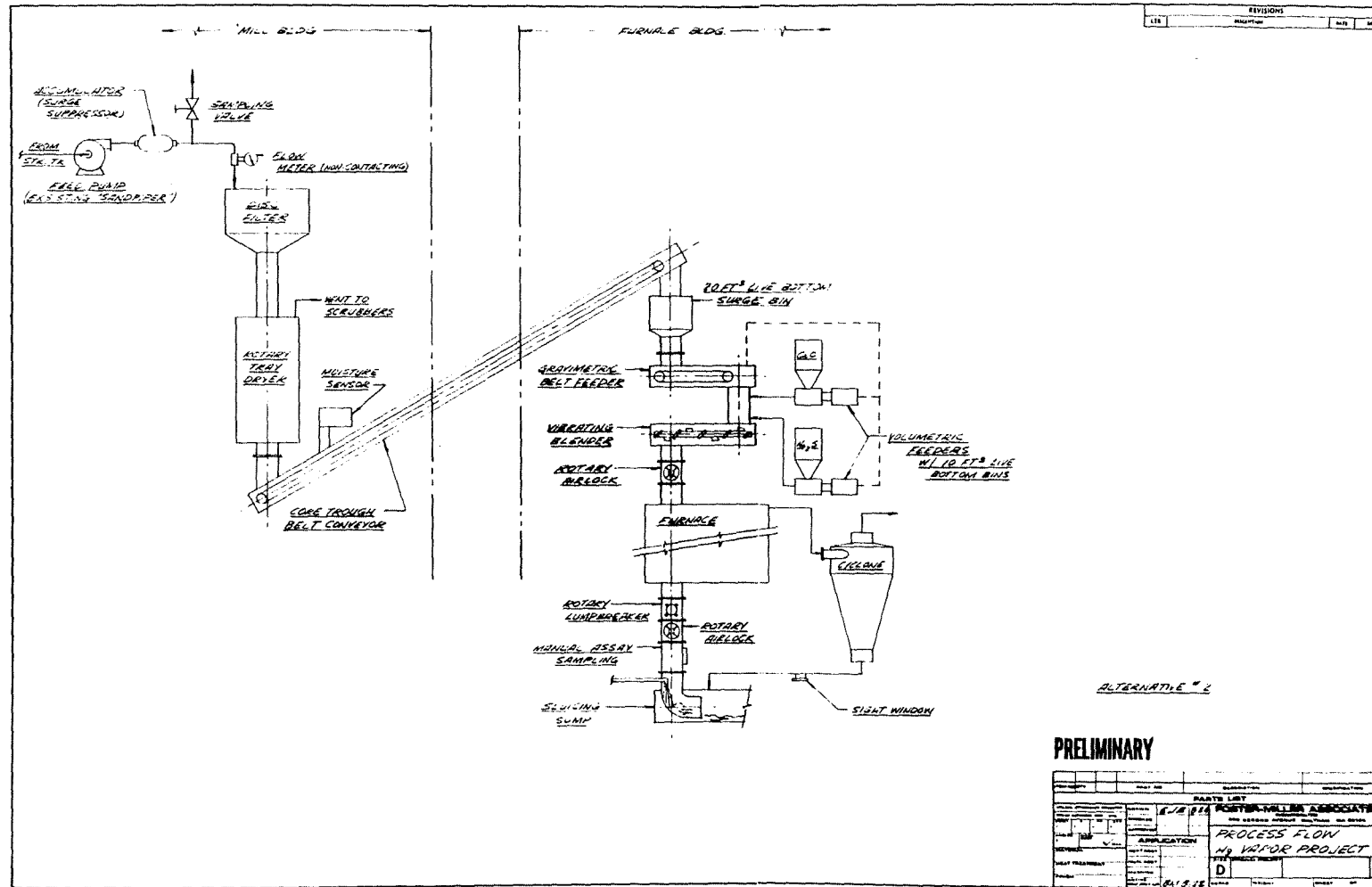


FIGURE 26. - Conceptual Design Alternative No. 2.

costs were estimated to be approximately \$160,000, and the improved productivity was estimated to more than offset the cost of the concept.

Disadvantages to the second concept include:

- a. A field trial is necessary to establish dryer operating conditions and requirements to produce a 5 percent moisture cake.
- b. The configuration is more complex than the first alternative.
- c. An emission source is added (the dryer).
- d. There is limited available space for a dryer.
- e. The belt conveyor is at a greater inclined angle than the first alternative thus making the system installation more difficult.

FMA proposed the second alternative since material handling properties were vastly improved and increased productivity made the design economically attractive.

4.3 Conceptual Design Alternative No. 3

The third concept is shown by Figure 27, and it is a response to McDermitt Mine for a configuration that can store enough filter cake for an entire furnace run. The configuration presents the advantage of not having to operate the flotation area during a furnace run. The design is the same as the second alternative except that a 14-day capacity, reinforced concrete bin is installed after the belt conveyor. An additional conveyor section is also required from the bin discharge at ground level to the feed of the small surge bin atop the gravimetric weighfeeder.

The capital costs for the third alternative were estimated to be approximately \$253,000. In addition to the high capital costs, the system is complex, expensive to install, and not readily installed by mine personnel. Alternative No. 3 was therefore dropped from further consideration.

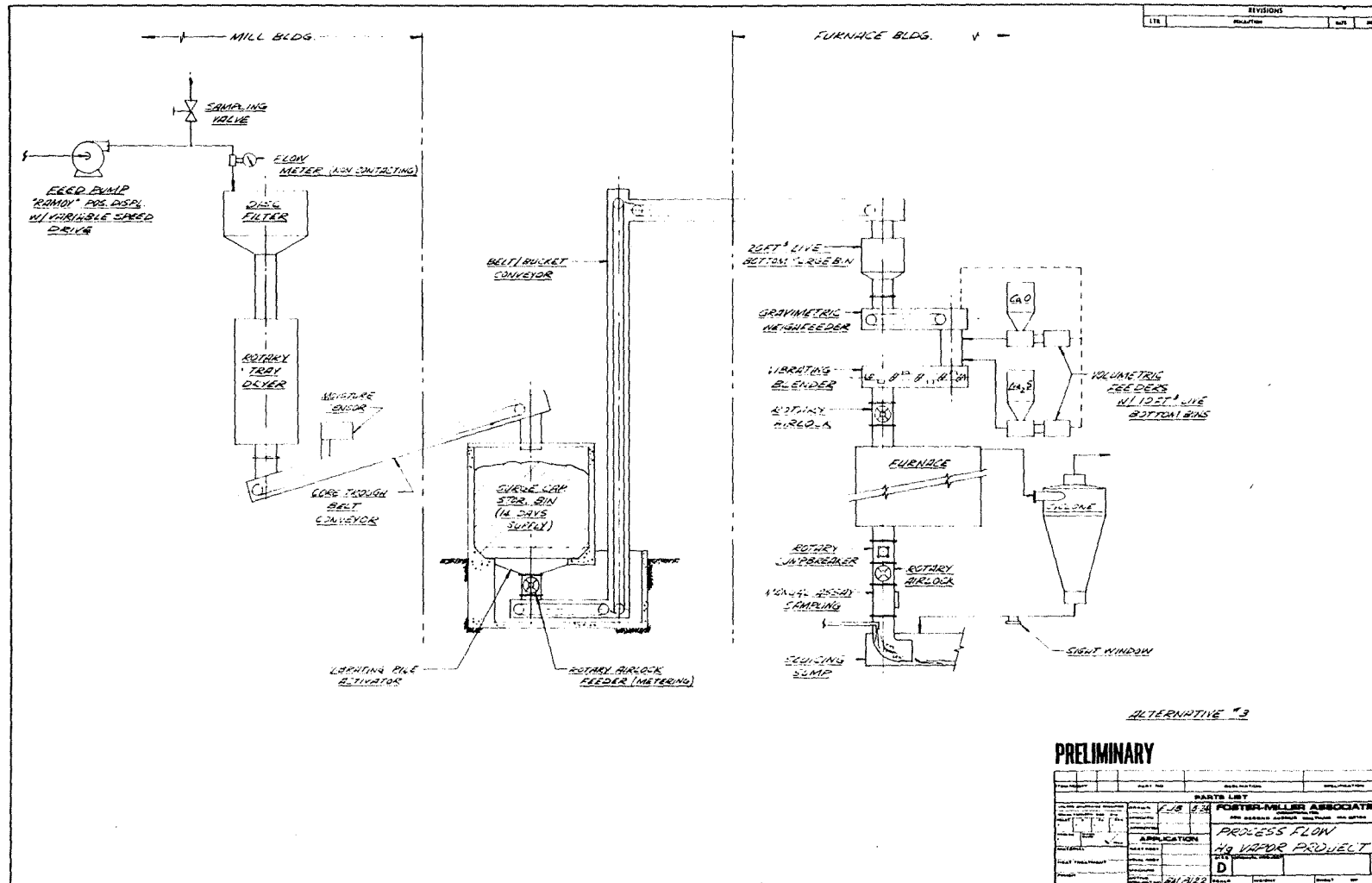


FIGURE 27. - Conceptual Design Alternative No. 3.

4.4 Conceptual Design Conclusions

Design Alternatives No. 1 and No. 2 were discussed in greater detail with the USBM and mine personnel. The problem of cake pluggage was recognized if drying is not provided, but mine personnel were reluctant to add a dryer and thus a new emission source. The mine decided to explore the feasibility of filter cake agglomeration by blending lime with cake upstream of the conveyor. If agglomeration is possible, the chances for cake plugging at transfer points and within confined spaces is greatly reduced, and a minor modification to the configuration for Alternative No. 1 is all that is required.

FMA decided and the USBM concurred that detailed designs would be prepared for:

- a. A modified Alternative No. 1 with lime being blended upstream of the conveyor
- b. Alternative No. 2 with a dryer.

Detailed designs would thus be available for two fundamental material transport conditions in the mineral processing industries:

- a. Wet filter cake (11 to 15 percent moisture)
- b. Dry filter cake (<5 percent moisture).

The detailed design efforts were performed as the second phase of the program. The results of that phase are discussed in the next section.

5. DETAILED DESIGNS AND COST ESTIMATES

Based on the conceptual design review, detailed design drawings for two furnace feed alternatives were prepared. Other control system components were also designed. General design specifications were prepared for major system components and a cost-benefit study was performed. The detailed designs, general specifications, and the cost-benefit study results are summarized in the following subsections.

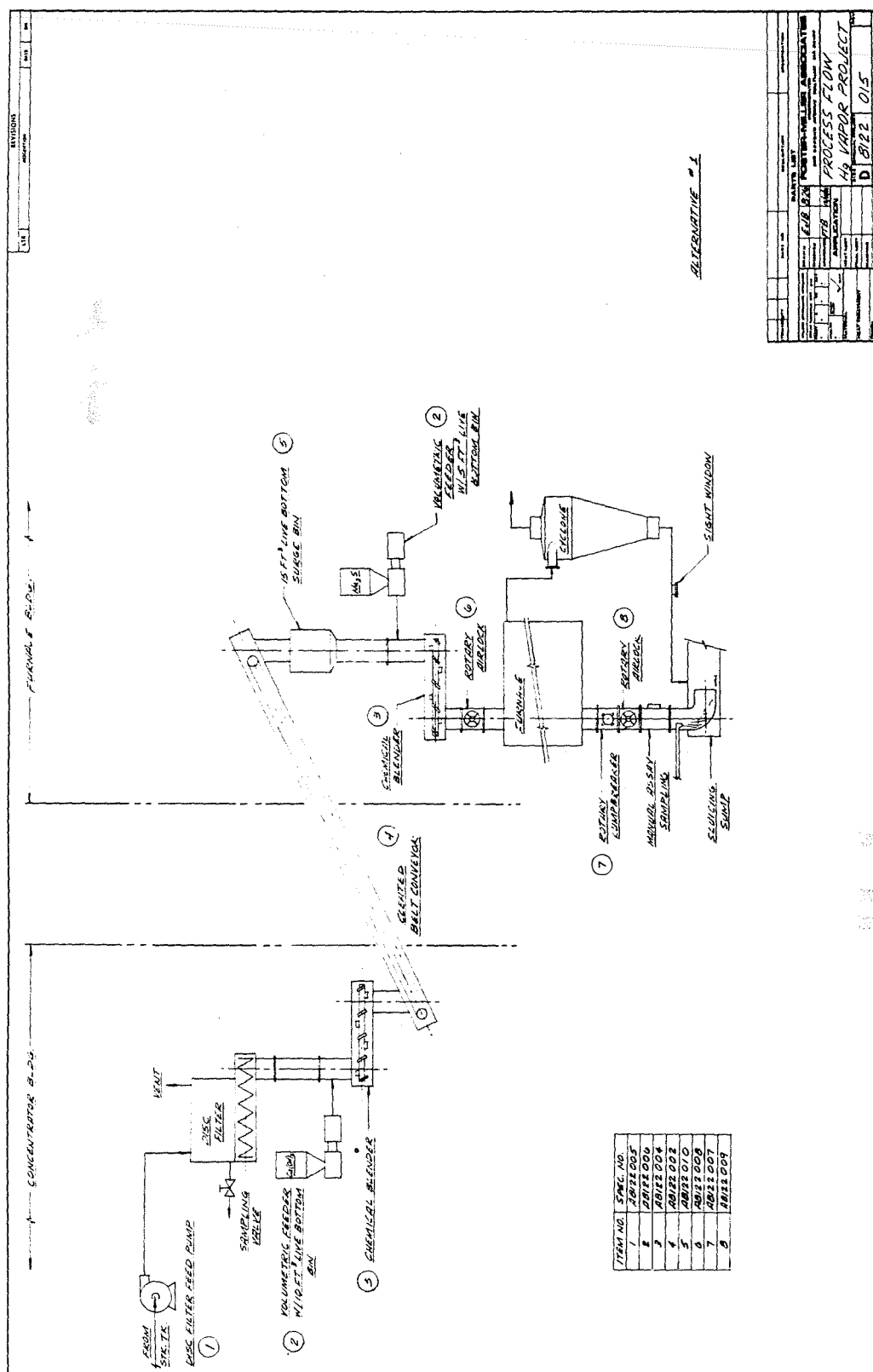
5.1 Furnace Feed System Alternative No. 1

Figure 28 presents the flow sheet for the alternative which assumes successful agglomeration of filter cake with lime. Lime is added and blended upstream of a cleated belt conveyor. The conveyor includes a load cell for determining mass feed rate. Since the filter cake is assumed to be agglomerated, and it is still wet, FMA recommended a load cell instead of the gravimetric weighfeeder which was envisioned during the conceptual design stage. The potential for pluggage and erratic feed (size and rate) was judged to be too great to employ a weighfeeder.

The agglomerated feed is conveyed to a 15 ft³ live-bottom surge bin. Na₂S is added after surge storage and blended with the cake. The blended cake then discharges to a rotary airlock feeder which isolates the feed circuit from the furnace (to prevent blow-back) and feeds blended cake to the furnace. Furnace calcines discharge to a lumpbreaker and then to a rotary airlock which isolates the furnace from calcine sluicing.

Design specifications for the components that are itemized in Figure 28 are contained in Appendix A and they include:

- a. Disc filter feed pump
- b. Volumetric feeder
- c. Chemical blender
- d. Belt conveyor
- e. Live-bottom surge bin
- f. Rotary airlocks (high and medium temperatures)
- g. Lumpbreaker.



A capital cost of \$101,000 was predicted for Alternative No. 1, based on a detailed cost estimate of equipment items.

5.2 Furnace Feed System Alternative No. 2

Figure 29 presents the flow sheet for the second feed system alternative. Alternative No. 2 is different from the first alternative in two important respects:

- a. A dryer is added after the twin screws for the vacuum filter and before the conveyor. The cake is dried to 5 percent moisture, consequently...
- b. A gravimetric weighfeeder is added after the surge bin.

The second alternative therefore has a feed system which:

- a. Conveys and handles a drier cake than the first alternative and therefore is less prone to pluggage
- b. More accurately controls the feed rate to the furnace.

Both reagents are added after the weighfeeder and they are proportioned by a signal from the weighfeeder.

Design specifications for the components that are itemized in Figure 29 are contained in Appendix A. Items that were not previously discussed for Figure 28 include:

- a. Rotary tray dryer
- b. Gravimetric weighfeeder.

A capital cost of \$180,000 was predicted for Alternative No. 2, based on a detailed cost estimate of equipment items.

5.3 Other Control System Components

Detailed designs were prepared for the following components which are common to both furnace feed system alternatives:

a. Automatic rake arm for Hearth 1

The rake arm incorporates a cantilevered design which is conveniently attached to the exterior of the furnace. The fixed rake arm cleans the rabble arm and hub of the furnace as they revolve. The need for operator intervention or opening the hearth door is minimized, and blow-back occurrences are thus further reduced.

b. Furnace Discharge Modifications

A lumpbreaker for clinkers and a rotary airlock are proposed for the furnace calcine discharge. The hot calcine is flushed by a water spray downstream of the airlock which prevents any steam from entering the furnace, cooling the bottom hearth, and thus forming clinkers. A sampling port is also detailed.

c. No. 2 I.D. Back-Up Fan and Modifications

The mechanical configuration and electrical schematic for the back-up fan and sequencing of air valves are detailed. The No. 1 fan is normally energized and its inlet and discharge butterfly valves are normally open. The No. 1 fan is shut down by throwing a three-pole, double-throw switch. The entire No. 1 circuit is deenergized, including the three-phase motor and the single phase actuators for the butterfly valves, which then close.

The No. 2 fan circuit is energized when the switch is thrown. The three-phase motor for the No. 2 fan is started, and the fan's inlet and discharge valve actuators are energized and the valves open.

d. Layout - Feed Pump

The configuration for the disc filter feed pump is shown. Concentrate from the stock tank is pumped to the vacuum filter. The configuration assumes a progressive cavity (PC) type pump.

- e. Three control systems will be detailed by McDermitt Mine and are not included in this report:
 - 1. Condenser tube diameter change to 10 in.
 - 2. Vacuum filter enclosure and exhaust system
 - 3. Improved dust collection system.

5.4 Cost-Benefit Study

The following data were obtained from McDermitt Mine for the cost-benefit study:

- a. Utilities, fuel:
 - 1. 2.245¢/kW-hr (1982)
 - 2. \$0.841/gal propane
 - 3. \$1/gal No. 2 fuel oil at 150,000 Btu/gal; burn 6 gal/hr (furnace)
- b. Furnace operating hours - 2500 hr/year (projected for 1982 by McDermitt)
- c. \$7400 in 1981 for repair/replacement of furnace feed screw conveyor.

The following assumptions were made by FMA for both design alternatives:

- a. Cost of installation - 20 percent of capital costs
- b. Salvage value - 15 percent of capital costs
- c. Useful life - 5 years
- d. Taxes, insurance - 2 percent of installed value per year
- e. Interest - 15 percent of installed value per year
- f. Maintenance - 5 percent of installed value per year.

The price of mercury for the reported results is \$380 per 76 lb flask (1 and 2 March 1982, Wall Street Journal).

The estimate for annualized costs included fixed costs:

- a. Depreciation by the Sinking Fund Method
- b. Taxes, insurance
- c. Interest

and variable costs:

- a. Operating costs
 - 1. Labor
 - 2. Fuel
 - 3. Utilities
- b. Maintenance costs.

Table 4 presents the estimated annualized costs for both furnace feed system design alternatives. The annualized costs for each alternative include the "other control system components" that are itemized in subsection 5.3.

TABLE 4. - Summary of costs for design alternatives

Estimate method	Design alternative	Estimated annualized costs (\$/year)		
		Fixed costs	Variable costs	Total costs
Sinking Fund	1	36,370	6,400	42,770
	2	64,760	19,410	84,170

The gross revenue increase for Alternative No. 1, based on an assumed .1 percent productivity increase due to a metered feed rate is:

$$\text{Gross revenue increase} = (0.01) (750 \text{ lb-Hg/hr}) (\$5/\text{lb-Hg}) \\ (2500 \text{ hr/year}) + \$7400/\text{year} \\ \text{screw replacement}$$

$$\text{Gross revenue increase} = \$101,150/\text{year}$$

The net revenue increase for Alternative No. 1 is therefore:

$$\text{Net revenue increase} = \text{gross revenue increase} - \text{annualized costs}$$

$$= 101,150 - 42,770$$

$$\text{Net revenue increase} = \underline{\$58,380/\text{year}}.$$

Reducing the cake moisture content to 5 percent with Alternative No. 2 allows an increase in mercury production to 801 lb/hr or a 6.8 percent increase. Therefore,

$$\text{Gross revenue increase} = (0.068) (750 \text{ lb/hr}) (\$5/\text{lb-Hg}) \\ (2500 \text{ hr/year}) + \$7400$$

$$\text{Gross revenue increase} = \$644,900/\text{year}$$

The net revenue increase for Alternative No. 2 is therefore:

$$\text{Net revenue increase} = 644,900 - 84,170$$

$$\text{Net revenue increase} = \underline{\$560,730/\text{year}}.$$

Stated in other terms, the annualized costs of the Alternative No. 1 redesign are offset by resulting revenues after 5 months of production ($\$42,770 \div \$101,150 = 0.42$ years).

Similarly, the annualized costs of the Alternative No. 2 redesign are offset by resulting revenues in less than 2 months of production.

Table 5 presents an estimate of mercury vapor concentration reductions if furnace blow-back is eliminated. Concentrations in the Furnace and Concentrator Buildings are listed in Table 5 for occurrences of blow-back and compared to periods of no

TABLE 5. - Potential Hg vapor concentration reduction
by eliminating furnace blow-back

Furnace Condition	Maximum concentration of Hg vapor measured by location (ug/m ³)										Comments	
	Furnace Building					Concentrator Building						
	Date	2	3	4	Average	6	13	14A (1981)	14B (1981)	Average		
Blow-back	<u>1980</u>											
	1/22	400	-	-	400+	450	-	100	-	275	"-": not measured	
	4/16 to 2/24	627	545	792	655	440	440	265	814	490		
	5/28 to 6/5	539	572	858	656	242	275	180	352	262		
	7/28	209	-	792	500+	-	220	120	183	174		
	9/11 to 9/25	475	515	1000+	663+	400	363	133	663	390		
	<u>1981</u>											
5/27	>1800	>1600	-	>1700	-	-	-	-	-			
Average: >762						383		Average: 318			Concentration averages per building	
No blow-back	<u>1980</u>											
	2/21	231	253	495	326	176	133	85	84	120	Mill down for repairs	
	11/6	245	405	615	422	187	146	117	235	171		
	12/11	121	77	360	186	370	188	185	205	237		
	<u>1981</u>											
	2/19	120	95	290	168	121	-	-	-	121		
	3/24	198	185	210	198	350	89	80	79	150		
Average: 260						241		Average: 160			Concentration averages per building	
Concentration reduction possible by eliminating blow-back (Δ)	Δ = <u>>500</u>					Δ = <u>≈160</u>					Δ = blow-back "average" minus no blow-back "average"	
Notes:												
1. The average "no blow-back" concentrations of 260 and 160 ug/m ³ of Hg vapor for the Furnace and Concentrator Buildings, respectively, may include a cumulative amount due to blow-back. By eliminating blow-back, the "no blow-back" background concentrations may therefore be reduced somewhat. The "Δ" reported here will thus be higher.												
2. Due to infrequent measurements, it is possible that the actual furnace running backgrounds are approximately 300 to 350 ug/m ³ (Furnace Building) and 200 to 250 ug/m ³ (Concentrator Building) for the "no blow-back" furnace condition, as opposed to the average concentrations reported above in the table.												

blow back. During blow back, the average concentration was greater than $760 \mu\text{g}/\text{m}^3$ in the Furnace Building and approximately $320 \mu\text{g}/\text{m}^3$ in the Concentrator Building for all of 1980 and the first half of 1981. With no blow-back the concentrations dropped to $260 \mu\text{g}/\text{m}^3$ in the Furnace Building and $160 \mu\text{g}/\text{m}^3$ in the Concentrator Building during the same period. Reductions of $500 \mu\text{g}/\text{m}^3$ and approximately $160 \mu\text{g}/\text{m}^3$ are therefore possible in the Furnace and Concentrator Buildings, respectively, by eliminating blow-back.

Table 6 summarizes the cost of achieving reduced mercury vapor concentrations for each design alternative.

5.5 Detailed Design Conclusions.

The detailed designs for both furnace feed systems were reviewed with McDermitt personnel, and they selected Design Alternative No. 1 for the following reasons:

- a. Low capital costs
- b. Simple design with readily available equipment
- c. Can be readily installed by mine personnel
- d. Does not add an emission source, which Alternative No. 2 does because of the dryer.

The first alternative does assume that filter cake is sufficiently agglomerated with lime to mitigate pluggage. Agglomeration feasibility tests are therefore required to demonstrate the concept before installation drawings are finalized.

TABLE 6. - Summary of cost-benefit

Design Alternative	Health and safety benefit		Cost estimate		
	Hg vapor concentration (µg/m ³)				
	Estimated average reduction by eliminating blow-back	Estimated average background achievable with no blow-back	Gross revenue increase (\$/year)	Total annualized costs ³ (\$/year)	Net revenue increase (\$/year)
<u>No. 1</u>					
Furnace Building	>500	300	101,150 ¹	42,770	58,380
Concentrator Building	≈160	160			
<u>No. 2</u>					
Furnace Building	>500	300	644,900 ²	84,170	560,730
Concentrator Building	≈160	160			

¹ 1 percent increase in production.

² 6.8 percent increase in production.

³ Sinking Fund Method used for depreciation.

6. CONCLUSIONS

The following conclusions can be drawn from the program's results.

- a. The multiple hearth furnace at McDermitt is the largest single source of mercury vapor emissions and the greatest contributor to mercury concentrations in both the Furnace and Concentrator Buildings.
- b. The highest emissions from the furnace are caused by positive pressure in the furnace or "blow-back".
- c. Positive pressure in the furnace or blow-back is caused by:
 1. Excess feed rate and excess filter cake moisture content.
 2. Exhaust system pluggage, such as in the condenser tubes, from particulate emission carry-over from the cyclone.
 3. Hearth cooling from opening a furnace door for cleaning.
- d. Blow-back can be eliminated by:
 1. Isolating the feed circuit from the furnace.
 2. Controlling feed rate and moisture content of the feed to the furnace.
 3. Maintaining a negative pressure in the furnace:
 - a) Minimizing furnace leakage by keeping hearth doors closed and well-sealed.
 - b) Minimizing furnace exhaust system pressure losses, such as removing the "free-wheeling" No. 1 I.D. Fan which is not contributing to system performance.
- e. Eliminating blow-back will result in mercury vapor concentration reductions of $500 \mu\text{g}/\text{m}^3$ in the Furnace Building and approximately $160 \mu\text{g}/\text{m}^3$ in the Concentrator Building during furnace operations.

- f. Both Design Alternatives No. 1 and No. 2 are cost-effective methods for reducing mercury vapor concentrations that are associated with mercury mill operations. Results of the cost study show that at \$380 per 76 lb mercury flask:
 - 1. Design Alternative No. 1 will result in a net revenue *increase* of approximately \$58,000/year.
 - 2. Design Alternative No. 2 will result in a net revenue *increase* of approximately \$561,000/year.
- g. Program results can be applied to other mineral processing plants in the following areas:
 - 1. Isolation of a furnace or roaster as a major emission source from feed and calcine/solids discharge circuits.
 - 2. Conveyance, storage, and metering of concentrate/vacuum filter cake with very unfavorable physical characteristics, such as high density, moisture, abrasion, viscosity and corrosion.
 - 3. Improving furnace or roaster draft by:
 - a) Reducing furnace leakage through automatic cleaning operations.
 - b) Reducing exhaust system pressure losses through optimum exhaust fan design and eliminating constrictions to exhaust flow.

APPENDIX A
GENERAL DESIGN SPECIFICATIONS

GENERAL SPECIFICATIONS
FOR
MERCURY VAPOR EMISSIONS PROJECT

USBM Contract No. J0318024;
FMA-BM-8122

PROPOSE AND EVALUATE METHODS OF CONTROLLING
MERCURY VAPOR EMISSIONS IN A PROCESSING MILL
FURNACE ROOM

Submitted to:

U.S. Bureau of Mines
Bruceton Mining Research Center
Building 20
P.O. Box 18070
Cochrans Mill Road
Pittsburgh, PA 15236

Submitted by:

Foster-Miller Associates, Inc.
350 Second Avenue
Waltham, MA 02154

December 1981

GENERAL SPECIFICATIONS

BM-8122 - MERCURY VAPOR EMISSIONS PROJECT

SPECIFICATION NO. A8122001

30 November 1981

TYPE OF EQUIPMENT

Filter Cake Dryer

ABSTRACT

A filter cake dryer is to be used to dry mercury ore concentrate which discharges by gravity from a vacuum disc filter. Filter cake is to be fed into the dryer directly from the filter by the filter's integral twin screw feeder. The dryer is to be sized by the OEM and materials/coatings are to be determined by the OEM based on the following information.

QUOTATION

The OEM¹ is requested to submit a quotation which includes:

- Dryer assembly from product inlet flange connections to product discharge flange connections and emission exhaust flange connections
- Dryer burner(s) and air supply assembly
- Dryer drive, if applicable, including electrical and mechanical connections, and remote electrical activation and operation monitoring at a mine-supplied control console (50 ft away)
- Materials/coatings/linings to insure good service life and minimum maintenance
- Installation drawings and calculations or product literature outlining capabilities and capacities
- Shipping charges to McDermitt, Nevada, and any anticipated charges for installation and startup
- One complete set of recommended spare parts (to be mine stocked) for the proposed system including any special lubricants and oils that may be required and shipping charges
- List of emergency service contacts with addresses and telephone numbers

¹Original equipment manufacturer.

- Any costs for laboratory testing of material
- Separate quotations for any alternatives that deviate from the reference drawings or favorably affect cost/performance
- Partial user reference list.

PRODUCT DATA

1. Dryer Inlet

Filter cake state - 11 to 15 percent moisture by weight

Viscosity of cake - 200,000 CPS (dynamic);
350,000 CPS (static)

Specific heat - unknown

pH - 10

Density - 256 lb/ft³ (at 11 percent moisture)

Product feed rate - 1200 lb/hr (solids plus water)

Temperature - 75°F to 85°F

Particle size of cake - 83 percent minus 200 mesh

2. Dryer Discharge

Filter cake state - 5 percent moisture by weight

Temperature - not to exceed 130°F

TYPICAL SOLIDS COMPOSITION OF FILTER CAKE (Major Compounds Only)

Cinnabar (HgS), specific gravity = 8.1: 70 percent by weight

Corderoite (Hg₃S₂Cl₂), specific gravity = 6.85: 30 percent by weight

Approximate elemental composition of solids:

Hg 77 percent by weight

S 11 percent by weight

Cl₂ 12 percent by weight

DRYER SERVICE CONDITIONS

Capacity - 1200 lb/hr (solids plus water) at inlet

Product temperature in dryer - not to exceed 130°F

Retention time - to be determined by OEM and confirmed by lab tests

Elevation - dryer application for 4500 ft above sea level

Filter cake is corrosive and highly abrasive

Operating hours - 24 hr/day for 15-day furnace run only, 8 furnace runs/year

Space restrictions - installation envelope: 8 × 8 × 8 ft

Five-year service life with minimum maintenance

MATERIALS OF CONSTRUCTION

All wetted nonmetallic parts are to be materials that are highly resistant to chemical corrosion and abrasion (refer to "Product Data" and "Typical Solids Composition"). All wetted metallic parts are to be compatible with the corrosive/abrasive environment or protected with suitable coatings or linings. The OEM is requested to recommend materials/coatings/linings to be used on each individual part based on OEM's proprietary knowledge of their equipment. Selection must be cost-effective and selection will be subject to review. The buyer will more favorably consider the use of conventional materials that can be cost-effectively maintained by mine personnel at this remote mine location.

The dryer unit must be totally enclosed and sealed to prevent the release of mercury vapor into the surrounding area. Emitted vapors must be exhausted through a vent. The OEM will specify exhaust vent, product inlet, and product discharge flange sizes, sealed connections to prevent the release of mercury vapor, and expected airflow through the dryer.

DRYER BURNER AND AIR SUPPLY, DRIVE AND ELECTRICAL REQUIREMENTS

Assemblies for the dryer's burner(s) and its air supply, drive, and electrical components, such as wiring and terminals, must be constructed of materials and assembled in a manner that is compatible with the environment described under "Product Data" and "Typical Solids Composition."

Explosion-proofing beyond FIA requirements for combustor systems is not required. Dryer drive and all electronics must be totally protected against the environment described above.

The OEM will submit electrical and power requirements for their proposed dryer system. Available electrical service includes:

- 1 ϕ , 60 Hz, 115/230 Vac
- 3 ϕ , 60 Hz, 230/460 Vac

SPARE PARTS AND SERVICE

The OEM will provide a quotation for one complete set of suggested spare parts (to be mine stocked) for the proposed system, including any special lubricants/oils required and a list of emergency service contacts with addresses and telephone numbers.

The dryer to be supplied will be subject to actual testing of the ore concentrate, either at the OEM's lab facilities or by in-field testing of a small rental unit by mine personnel.

GENERAL SPECIFICATIONS

BM-8122 - MERCURY VAPOR EMISSIONS PROJECT

SPECIFICATION No. A8122002

30 November 1981

TYPE OF EQUIPMENT

Belt Conveyor

ABSTRACT

Quotations are requested for two different belt conveyor design alternatives:

Design Alternative No. 1 - mercury ore filter cake at 11 percent to 15 percent moisture by weight is to be discharged from a volumetric feeder and conveyed by the belt conveyor to a surge bin.

Design Alternative No. 2 - filter cake at 5 percent moisture by weight is to be discharged from a dryer and conveyed by the belt conveyor to a surge bin.

For both design alternatives, the filter cake is to be conveyed from a concentrator building to an adjacent furnace building. The conveyor is to be sized by the OEM and materials/coatings/linings are to be determined by the OEM based on the following information.

QUOTATION

The OEM is requested to submit a quotation which includes:

- Enclosed conveyor assembly with inspection doors similar to the configuration shown on Drawings No. R-8122010 (Design Alternative No. 1) and R-8122011 (Design Alternative No. 2), both drawings attached for reference
- Conveyor drive including electrical and mechanical connections, and remote activation at a mine-supplied console 50 ft away (Design Alternatives No. 1 and 2)
- Load cell section for determining mass feed rate of conveyed material (Design Alternative No. 1 only) with feed rate display at conveyor controls

- Materials/coatings/linings to insure good service life and minimum maintenance
- Installation drawings and recommended support, product literature and sizing calculations or criteria
- Shipping charges to McDermitt, Nevada and any anticipated charges for installation and startup
- One complete set of recommended spare parts including any special lubricants/oils that may be required and shipping charges
- List of emergency service contacts with addresses and telephone numbers
- Recommendations for belt cleaning and belt repair.

PRODUCT DATA

1. Design Alternative No. 1 (Drawing No. R-8122010)

Filter cake state - 11 percent to 15 percent moisture by weight

Viscosity of cake - 200,000 CPS (dynamic); 350,000 CPS (static)

pH - 10 (approximately)

Density - 256 lb/ft³ (at 11 percent moisture)

Product feed rate - 1200 lb/hr (solids plus water) or 4.7 ft³/hr

Temperature - 75°F to 85°F

Ore concentrate (solids) is highly corrosive and abrasive

Particle size of cake - 83 percent minus 200 mesh, agglomerated into 1/8 in. diam to 3/4 in. diam nodules by adding lime at a 1:15 mass ratio with filter cake and blending upstream of the belt conveyor

2. Design Alternative No. 2 (Drawing No. R-8122011)

Filter cake state - 5 percent moisture by weight

Viscosity of cake - 200,000 CPS (dynamic); 350,000 CPS (static)

pH - 10 (approximately)

Density - 320 lb/ft^3 (at 5 percent moisture)

Product feed rate - 1130 lb/hr (solids plus water)
or $3.5 \text{ ft}^3/\text{hr}$

Temperature - not to exceed 130°F

Particle size of cake (at 5 percent moisture) -
83 percent minus 200 mesh, agglomerated into unknown
nodule size (to be determined by dryer tests)

Ore concentrate (solids) is highly corrosive and
abrasive

TYPICAL SOLIDS COMPOSITION (Major Compounds Only)

Cinnabar (HgS), specific gravity = 8.1: 70 percent by weight

Corderoite ($\text{Hg}_3\text{S}_2\text{Cl}_2$), specific gravity = 6.85: 30 percent
by weight

Approximate elemental composition of solids:

Hg 77 percent by weight

S 11 percent by weight

Cl_2 12 percent by weight

CONVEYOR SERVICE CONDITIONS

Capacity - 1200 lbs/hr (solids plus water)

Temperature - 75°F to 85°F at inlet, 150°F at discharge and
middle third section of conveyor in outdoor environment
at -10°F to $+105^\circ\text{F}$

Elevation - conveyor application for 4500 ft above sea
level

Operating hours - 24 hr/day for 15-day furnace run only,
8 furnace runs/year

Material to be conveyed is highly corrosive and abrasive

Space restrictions - conveyor must transport material at a
 60° angle from horizontal

Two-year service life with minimum maintenance

MATERIALS OF CONSTRUCTION

All wetted nonmetallic parts are to be materials that are highly resistant to chemical corrosion and abrasion (refer to "Product Data" and "Typical Solids Composition"). All wetted metallic parts are to be compatible with the corrosive/abrasive environment or protected with suitable coatings or linings. The OEM is requested to recommend materials/coatings/linings to be used on each individual part based on OEM's proprietary knowledge of their equipment. Selection must be cost-effective and selection will be subject to review. The buyer will more favorably consider the use of conventional materials that can be cost-effectively maintained by mine personnel at this remote mine location.

The conveyor unit will be totally enclosed and sealed to prevent the release of mercury vapor into the surrounding area. An exhaust vent is to be provided by the OEM and the OEM will specify exhaust vent, product inlet, and product discharge flange sizes and sealed connections to prevent the release of mercury vapor.

It is anticipated that the conveyor belt will have to be a "ribbed" or "trough" design to convey material at a 60 deg angle incline to the horizontal.

CONVEYOR DRIVE AND ELECTRICAL REQUIREMENTS

The conveyor drive assembly and electrical components, such as wiring and terminals, must be constructed of materials and assembled in a manner that is compatible with the environment described under "Product Data" and "Typical Solids Composition." Explosion proofing is not required.

The OEM will submit electrical and power requirements for their proposed conveyor system. Available electrical service includes:

- 1 ϕ , 60 Hz, 115/230 Vac
- 3 ϕ , 60 Hz, 230/460 Vac

SPARE PARTS AND SERVICE

The OEM will provide a quotation for one complete set of recommended spare parts to be mine stocked for the proposed system, including any special lubricants/oils required and a list of emergency service contacts with addresses and telephone numbers.

GENERAL SPECIFICATIONS

BM-8122 - MERCURY VAPOR EMISSIONS PROJECT

SPECIFICATION NO. A8122003

30 November 1981

TYPE OF EQUIPMENT

Gravimetric Weighfeeder

ABSTRACT

The constant speed weighfeeder is to be used to continuously weigh mercury ore concentrate which is gravity discharged from a surge bin, and use the weight rate signal to control the feed rate of two chemical reagent feeders into a reagent blender. The weighfeeder is to be sized by the OEM and materials/coatings/linings are to be determined by the OEM based on the following information.

QUOTATION

The OEM is requested to submit a quotation which includes:

- Weighfeeder assembly including inlet and discharge arrangement
- Weighfeeder drive including electrical and mechanical assemblies for controlling two chemical reagent feeders and the feed rate of the ore itself into a reagent blender. Typically, the reagent feeders "slaved-in" to the weighfeeder accept a 4 to 20 mA control signal and are equipped with SCR variable speed drives. Their feed rates must vary with the feed rate measured on this weighfeeder.
- Materials/coatings/linings to insure good service life and minimum maintenance
- Installation drawings and product literature
- Shipping charges to McDermitt, Nevada and any anticipated charges for installation and startup
- One complete set of recommended spare parts including any special lubricants/oils that may be required and shipping charges
- List of emergency service contacts with addresses and telephone numbers.

PRODUCT DATA

Filter cake state - 5 percent moisture by weight

Viscosity of cake - 200,000 CPS (dynamic);
350,000 CPS (static)

pH - 10 (approximately)

Density - 320 lb/ft³ (at 5 percent moisture)

Concentrate feed rate - 1130 lb/hr (solids plus water)
or 3.5 ft³/hr

Temperature - 100°F to 150°F

Particle size of cake (at 5 percent moisture) - 83 percent
minus 200 mesh, agglomerated into unknown nodule size
(to be determined by dryer tests)

Ore concentrate (solids) is highly corrosive and abrasive

TYPICAL SOLIDS COMPOSITION (Major Compounds Only)

Cinnabar (HgS), specific gravity = 8.1: 70 percent by weight

Corderoite (Hg₃S₂Cl₂), specific gravity = 6.85: 30 percent
by weight

Approximate elemental composition of solids:

Hg 77 percent by weight

S 11 percent by weight

Cl₂ 12 percent by weight

WEIGHFEEDER SERVICE CONDITIONS

Capacity - 1130 lb/hr (solids plus water); 3.5 ft³/hr

Temperature - 100°F to 150°F

Elevation - weighfeeder application for 4500 ft above sea
level

Operating hours - 24 hr/day for 15-day furnace run only,
8 furnace runs/year

Space restrictions - approximately 1-1/2 ft high × 4 ft wide
× 6 ft long

Ore concentrate is highly corrosive and abrasive

Two-year service life and minimum maintenance

MATERIALS OF CONSTRUCTION

All wetted nonmetallic parts are to be materials that are highly resistant to chemical corrosion and abrasion (refer to "Product Data" and "Typical Solids Composition"). All wetted metallic parts are to be compatible with the corrosive/abrasive environment or protected with suitable coatings or linings. The OEM is requested to recommend materials/coatings/linings to be used on each individual part based on OEM's proprietary knowledge of their equipment. Selection must be cost-effective and selection will be subject to review. The buyer will more favorably consider the use of conventional materials that can be cost-effectively maintained by mine personnel at this remote mine location.

The weighfeeder must be totally enclosed to prevent the release of mercury vapor into the surrounding area.

WEIGHFEEDER DRIVE AND ELECTRICAL REQUIREMENTS

The weighfeeder drive assembly and electrical components, such as wiring and terminals, must be constructed of materials and assembled in a manner that is compatible with the environment described under "Product Data" and "Typical Solids Composition." Explosion proofing is not required.

The OEM will submit electrical and power requirements for their proposed weighfeeder system. Available electrical service includes:

- 1 ϕ , 60 Hz, 115/230 Vac
- 3 ϕ , 60 Hz, 230/460 Vac

SPARE PARTS AND SERVICE

The OEM will provide a quotation for one complete set of recommended spare parts to be mine stocked for the proposed system, including any special lubricants/oils required and a list of emergency service contacts with addresses and telephone numbers.

GENERAL SPECIFICATIONS

BM-8122 - MERCURY VAPOR EMISSIONS PROJECT

SPECIFICATION NO. A8122004

30 November 1981

TYPE OF EQUIPMENT

Chemical Blender

ABSTRACT

Quotations are requested for two different constant speed chemical blender design conditions.

Design Alternative No. 1 - two blenders required

One chemical blender will be used to blend mercury ore concentrate and $\text{Ca}(\text{OH})_2$, and one blender will be used to blend mercury ore concentrate that includes $\text{Ca}(\text{OH})_2$ with Na_2S in a continuous process.

Design Alternative No. 2 - one blender required

One chemical blender will be used to blend mercury ore concentrate and two chemical reagents, $\text{Ca}(\text{OH})_2$ and Na_2S in a continuous process.

For both design alternatives, the blenders are to be sized by the OEM and materials/coatings/linings are to be specified by the OEM based on the following information.

QUOTATION

The OEM is requested to submit a quotation for each of the above design alternatives which includes:

- Blender assembly from product inlet flange to discharge flange including mechanical and electrical assemblies and connections for actuating the blender
- Materials/coatings/linings to insure good service life and minimum maintenance
- Installation drawings and product literature
- Shipping charges to McDermitt, Nevada and any anticipated charges for installation and startup

- One complete set of recommended spare parts to be mine stocked for the proposed system including any special lubricants and oils that may be required and shipping charges
- List of emergency service contacts with addresses and telephone numbers.

PRODUCT DATA

1. Design Alternative No. 1

a. One blender to blend ore and $\text{Ca}(\text{OH})_2$

Filter cake product state - 11 percent to 15 percent moisture by weight

Viscosity of cake - 200,000 CPS (dynamic); 350,000 CPS (static)

pH - 10 (approximately)

Density - 193 lb/ft^3 (ore, lime, water)

Product feed rate - 1275 lb/hr nominal; $6.6 \text{ ft}^3/\text{hr}$ nominal

Temperature - 75°F to 85°F

Product feedstock is highly corrosive and abrasive

Particle size of product - 83 percent minus 200 mesh (ore), 98 percent minus 20 mesh (lime). Blending ore and lime agglomerates the product into 1/8 in. diam to 3/4 in. diam nodules.

b. One blender to blend ore/lime and Na_2S

Filter cake product state - 11 percent to 15 percent moisture by weight

Viscosity of cake - 200,000 CPS (dynamic); 350,000 CPS (static)

pH - 10 (approximately)

Density - 170 lbs/ft^3 (ore, $\text{Ca}(\text{OH})_2$, Na_2S , water)

Product feed rate - 1310 lbs/hr nominal; $7.7 \text{ ft}^3/\text{hr}$ nominal

Temperature - 100°F to 150°F

Product feedstock is highly abrasive and corrosive

Particle size of product - ore and lime are agglomerated as 1/8 in. diam to 3/4 in. diam nodules

Na₂S is in flake form

2. Design Alternative No. 2 - One blender to blend ore, Ca(OH)₂, Na₂S

Same as No. 1(b) above for Design Alternative No. 1 except 83 percent minus 200 mesh ore, 98 percent minus 20 mesh lime, and Na₂S flakes are blended simultaneously. The products will probably agglomerate when blended into 1/8 in. diam to 3/4 in. diam nodules.

TYPICAL SOLIDS COMPOSITION OF FILTER CAKE (Major Compounds Only)

Cinnabar (HgS), specific gravity = 8.1: 64 percent by weight

Corderoite (Hg₃S₂Cl₂), specific gravity = 6.85: 27 percent by weight

Approximate elemental composition of solids:

Hg - 70 percent by weight

S - 11 percent by weight

Cl₂ - 10 percent by weight

Ca(OH)₂ - 6 percent by weight

Na₂S - 3 percent by weight

BLENDER SERVICE CONDITIONS

Operating hours - 24 hr/day for 15-day furnace run only, 8 furnace runs/year

Operating environment - 100°F to 150°F, less than 50 percent relative humidity

Product materials are highly corrosive and abrasive

Elevation - application for 4500 ft above sea level

Capacity - Design Alternative No. 1

One blender at 1275 lb/hr, 6.6 ft³/hr nominal

One blender at 1310 lb/hr, 7.7 ft³/hr nominal

Design Alternative No. 2

One blender at 1310 lb/hr, 7.7 ft³/hr nominal

Two year service life and minimum maintenance

MATERIALS OF CONSTRUCTION

All wetted nonmetallic parts are to be materials that are highly resistant to chemical corrosion and abrasion (refer to "Product Data" and "Typical Solids Composition"). All wetted metallic parts are to be compatible with the corrosive/abrasive environment or protected with suitable coatings or linings. The OEM is requested to recommend materials/coatings/linings to be used on each individual part based on OEM's proprietary knowledge of their equipment. Selection must be cost-effective and selection will be subject to review. The buyer will more favorably consider the use of conventional materials that can be cost-effectively maintained by mine personnel at this remote mine location.

The blender will be totally enclosed to prevent the release of mercury vapor into the surrounding area.

BLENDER DRIVE AND ELECTRICAL REQUIREMENTS

The blender drive assembly and electrical components, such as bearings, lubricants, wiring and terminals must be constructed of materials and assembled in a manner that is compatible with the environment described under "Product Data" and "Typical Solids Composition". Explosion proofing is not required.

The OEM will submit electrical and power requirements for their proposed blender system. Available electrical service includes:

- 1 ϕ , 60 Hz, 115/230 Vac
- 3 ϕ , 60 Hz, 230/460 Vac

SPARE PARTS AND SERVICE

The OEM will provide a quotation for one complete set of recommended spare parts (to be mine stocked) for the proposed system, including any special lubricants/oils required and a list of emergency service contacts with addresses and telephone numbers.

GENERAL SPECIFICATIONS

BM-8122 - MERCURY VAPOR EMISSIONS PROJECT

SPECIFICATION NO. A8122005

30 November 1981

TYPE OF EQUIPMENT

Disc Filter Feed Pump

ABSTRACT

The feed pump is to be a Moineaux-type variable speed, progressing cavity (PC), positive displacement pump. The pump is to be used to pump a slurry consisting of mercury ore concentrate and water from a stock tank to a disc filter. The pump is to be sized by the OEM and materials/coatings are to be determined by the OEM based on the following information.

QUOTATION

The OEM is requested to submit a quotation which includes:

- PC pump from suction flange fitting to discharge flange fitting
- Pump drive including electrical and mechanical connections and an on/off switch at the pump (remote actuation not required)
- Materials/coatings to insure good service life and minimum maintenance
- Installation drawings, product literature, and performance curves
- Shipping charges to McDermitt, Nevada and any anticipated charges for installation and startup
- One complete set of recommended spare parts to be mine stocked for the proposed system, including any special lubricants and oils that may be required and shipping charges
- List of emergency service contacts with addresses and telephone numbers.

PRODUCT DATA

Product state - slurry

Temperature - 75°F to 85°F

Solids content - 70 percent, weight basis

Ore concentrate (solids) is highly corrosive and abrasive

Slurry density - 146 lb/ft³

Slurry viscosity - 20,000 CPS (approximately)

Pipe size - 2 in. I.D., discharge; 2.5 in. I.D., suction

TYPICAL SOLIDS COMPOSITION (Major Compounds Only)

Cinnabar (HgS), specific gravity = 8.1: 70 percent by weight

Corderoite (Hg₃S₂Cl₂), specific gravity = 6.85: 30 percent by weight

Approximate elemental composition of solids:

Hg 77 percent by weight

S 11 percent by weight

Cl₂ 12 percent by weight

pH = 10 (approximately)

Particle size - 83 percent minus 200 mesh

SERVICE CONDITIONS

Capacity - 3 to 5 gpm (4 gpm nominal)

Suction pressure - flooded

Discharge pressure - 20 to 25 psig

NPSH available - 20 ft water abs. (approximately)

Temperature - 75°F to 85°F

Elevation - pump application for 4500 ft above sea level

Operating hours - 24 hr/day for 15-day furnace run only,
8 furnace runs/year

Slurry to be pumped is highly corrosive and abrasive

Two-year service life with minimum maintenance

MATERIALS OF CONSTRUCTION

All wetted nonmetallic parts are to be materials that are highly resistant to chemical corrosion and abrasion (refer to "Product Data" and "Typical Solids Composition."). All wetted metallic parts are to be compatible with the corrosive/abrasive environment or protected with suitable coatings or linings. The OEM is requested to recommend materials/coatings/linings to be used on each individual part based on OEM's proprietary knowledge of their equipment. Selection must be cost-effective and selection will be subject to review. The buyer will more favorably consider the use of conventional materials that can be cost-effectively maintained by mine personnel at this remote mine location.

PUMP DRIVE AND ELECTRICAL REQUIREMENTS

The pump is to be supplied with a variable speed cost-effective drive to vary the pump output in its capacity range. The pump drive assembly and all electrical components, such as wiring and terminals, must be constructed of materials and assembled in a manner that is compatible with the environment described under "Product Data" and "Typical Solids Composition."

Explosion proofing is not required, but the pump drive and all electronics must be protected against the environment described above.

The OEM will submit electrical and power requirements for their proposed pump system. Available electrical service includes:

- 1 ϕ , 60 Hz, 115/230 Vac
- 3 ϕ , 60 Hz, 230/460 Vac

SPARE PARTS AND SERVICE

The OEM will provide a quotation for one complete set of recommended spare parts to be mine stocked for the proposed unit, including any special lubricants/oils required and a list of emergency service contacts with addresses and telephone numbers.

GENERAL SPECIFICATIONS

BM-8122 - MERCURY VAPOR EMISSIONS PROJECT

SPECIFICATION NO. A8122006

30 November 1981

TYPE OF EQUIPMENT

Volumetric Dry Chemical Feeder(s)

ABSTRACT

Quotations are requested for two different feeder design conditions:

Design Alternative No. 1

Two feeders are required. One feeder is to feed lime, $\text{Ca}(\text{OH})_2$, and one feeder is to feed sodium sulfide, Na_2S . Both feeders are to operate at a fixed feed rate.

Design Alternative No. 2

One lime and one Na_2S feeder are required, as above, except each feeder is to include a variable speed SCR or mechanical drive and accept a 4 to 20 mA control signal from a weighfeeder to meter the feed rate.

The feeders are to be sized by the OEM and materials/coatings/linings are to be determined by the OEM, based on the following information.

QUOTATION

The OEM is requested to submit a quotation for each of the above design alternatives which includes:

- Volumetric feeder assembly including hopper, mechanical and electrical components of the feed mechanism
- Materials/coatings/linings to insure good service life and minimum maintenance
- Installation drawings
- Shipping charges to McDermitt, Nevada and any anticipated charges for installation and startup

- One complete set of recommended spare parts including any special lubricants/oils that may be required and shipping charges
- List of emergency service contacts with addresses and telephone numbers.

PRODUCT DATA

1. Lime, $\text{Ca}(\text{OH})_2$, feeder

Bulk density - 40 lbs/ft³

Feed rate required -

Design Alternative No. 1: 75 ± 10 lb/hr, fixed

Design Alternative No. 2: 75 ± 25 lb/hr, variable

Temperature - 75°F to 85°F (Alternative No. 1);
100°F to 150°F (Alternative No. 2)

Mesh size - 98 percent minus 20

2. Sodium Sulfide, Na_2S , feeder

Bulk density - 33 lb/ft³

Feed rate required -

Design Alternative No. 1: 37 ± 5 lb/hr, fixed

Design Alternative No. 2: 37 ± 13 lb/hr, variable

Temperature - 100°F to 150°F (both design alternatives)

Mesh size - thin flake

FEEDER SERVICE CONDITIONS

Operating hours - 24 hr/day for 15-day furnace run only,
8 furnace runs/year

Operating environment - Alternative No. 1: 75°F to 85°F (lime), 100°F to 150°F (Na_2S); Alternative No. 2: 100°F to 150°F (both feeders); <50 percent relative humidity (both alternatives)

Elevation - feeder application for 4500 ft above sea level

Lime feeder - 10 ft³ storage capacity, Na_2S feeder - 5 ft³ storage capacity

Two-year service life and minimum maintenance.

MATERIALS OF CONSTRUCTION

All exposed internal parts and surfaces (mechanical and electrical) are to be compatible with the particular feedstock, lime or Na_2S . All exposed external parts and surfaces (mechanical and electrical) are to be compatible with an atmosphere containing trace concentrations of mercury vapor and the operating environment described in "Feeder Service Conditions."

The OEM will recommend materials/coatings/linings to be used on each individual part based on OEM's proprietary knowledge of their equipment. The buyer will more favorably consider the use of conventional materials, such as fiberglass which has been successful, that can be cost-effectively maintained by mine personnel at this remote mine location.

FEEDER DRIVE AND ELECTRICAL REQUIREMENTS

The feeder drive assembly and electrical components, such as wiring and terminals, are to be constructed of materials and assembled in a manner that is compatible with the environment described under "Product Data" and "Feeder Service Conditions." Explosion proofing is not required.

The OEM will submit electrical and power requirements for their proposed feeder unit. Available electrical service includes:

- 1 ϕ , 60 Hz, 115/230 Vac
- 3 ϕ , 60 Hz, 230/460 Vac

SPARE PARTS AND SERVICE

The OEM will provide a quotation for one complete set of recommended spare parts to be mine stocked for the proposed system, including any special lubricants/oils required and a list of emergency service contacts with addresses and telephone numbers.

GENERAL SPECIFICATIONS

BM-8122 - MERCURY VAPOR EMISSIONS PROJECT

SPECIFICATION NO. A8122007

30 November 1981

TYPE OF EQUIPMENT

Calcines Lumpbreaker

ABSTRACT

The calcines lumpbreaker is to be used to break up clinkers, which are formed in a rotary hearth furnace, prior to being discharged into a high temperature rotary airlock. The lumpbreaker is to be sized by the OEM and materials/coatings/linings are to be determined by the OEM based on the following information.

QUOTATION

The OEM is requested to submit a quotation which includes:

- Lumpbreaker assembly from inlet flange to discharge flange
- Mechanical and electrical assemblies and connections for actuating the constant speed lumpbreaker
- Materials/coatings/linings to insure good service life and minimum maintenance
- Installation drawings and product literature
- Shipping charges to McDermitt, Nevada and any anticipated charges for installation and startup
- One complete set of recommended spare parts to be mine stocked for the proposed unit including any special lubricants and oils that may be required and shipping charges
- List of emergency service contacts with addresses and telephone numbers.

PRODUCT DATA AND SERVICE CONDITIONS

Calcines temperature - 1500°F

Ambient temperature - 100°F to 150°F

Calcines discharge rate - 150 lb/hr (approximately)

Calcines bulk density - 75 lb/ft³ to 100 lb/ft³

Calcines composition:

Predominantly inert, bone-dry clays, CaSO₄, CaCl₂, NaSO₄, NaCl at unknown amounts

Hg - 0.2 percent by weight (approximately)

Compressive strength unknown but should not exceed 10,000 psi

Operating hours - 24 hr/day for 15-day furnace run only, 8 furnace runs/year

Elevation - application for 4500 ft above sea level

Two-year service life required with minimum maintenance.

MATERIALS OF CONSTRUCTION

All materials and their assembly must be compatible with the "Product Data and Service Conditions" listed above. The OEM will recommend materials/coatings/linings to be used on each individual part based on the OEM's proprietary knowledge of their equipment. Selection must be cost-effective and selection will be subject to review. The buyer will more favorably consider the use of conventional materials that can be cost-effectively maintained by mine personnel at this remote mine location.

The lumpbreaker must be totally enclosed and sealed to prevent the possible release of mercury vapor into the surrounding area.

LUMPBREAKER ACTUATOR AND ELECTRICAL REQUIREMENTS

The lumpbreaker actuator assembly and electrical components, such as bearings, lubricants, wiring and terminals must be constructed of materials and assembled in a manner that is compatible with the environment described under "Product Data and Service Conditions." Explosion proofing is not required.

The OEM will submit electrical and power requirements for their proposed lumpbreaker system. Available electrical service includes:

- 1 ϕ , 60 Hz, 115/230 Vac
- 3 ϕ , 60 Hz, 230/460 Vac.

SPARE PARTS AND SERVICE

The OEM will provide a quotation for one complete set of recommended spare parts to be mine stocked for the proposed unit, including any special lubricants/oils required and a list of emergency service contacts with addresses and telephone numbers.

GENERAL SPECIFICATIONS

BM-8122 - MERCURY VAPOR EMISSIONS PROJECT

SPECIFICATION NO. A8122008

30 November 1981

TYPE OF EQUIPMENT

Medium Temperature Rotary Airlock Feeder

ABSTRACT

A variable speed rotary airlock feeder is to be used for both metering mercury ore concentrate to and sealing the feedstock inlet line from a multiple hearth furnace. The airlock is to be sized by the OEM, and materials/coatings/linings are to be determined by the OEM, based on the following information for two different design alternatives.

QUOTATION

The OEM is requested to submit a quotation for Design Alternatives No. 1 and No. 2 (see "Product Data" below). The OEM may choose to quote one unit only for both alternatives or a different unit for each alternative. The quotation is to include:

- Airlock assembly from inlet flange to discharge flange
- Mechanical and electrical assemblies and connections for actuating the airlock
- Materials/coatings/linings to insure good service life and minimum maintenance
- Installation drawings and product literature
- Shipping charges to McDermitt, Nevada and any anticipated charges for installation and startup
- One complete set of recommended spare parts to be mine stocked for the proposed system including any special lubricants and oils that may be required and shipping charges
- List of emergency service contacts with addresses and telephone numbers.

PRODUCT DATA1. Design Alternative No. 1

Mercury ore feedstock state - 11 percent to 15 percent moisture by weight

Feedstock viscosity - 200,000 CPS (dynamic)
350,000 CPS (static)

pH - 10 (approximately)

Density - 224 lbs/ft³ (15 percent moisture) to
256 lbs/ft³ (11 percent moisture)

Product feed rate - 5.1 to 5.8 ft³/hr, 1300 lbs/hr

Airlock inlet side temperature - 150°F to 200°F

Airlock discharge side temperature - 800°F

Ore concentrate is highly corrosive and abrasive

Particle size of product - 83 percent minus 200 mesh
which may be agglomerated into 1/8 in. diam to 3/4 in.
diam nodules

2. Design Alternative No. 2

Mercury ore feedstock state - 5 percent moisture by weight

Density - 322 lbs/ft³

Product feed rate - 4.0 ft³/hr, 1300 lbs/hr

Remaining parameters same as Alternative No. 1.

TYPICAL SOLIDS COMPOSITION (Major Compounds Only)

Cinnabar (HgS), specific gravity = 8.1: 64 percent by weight

Corderoite (Hg₃S₂Cl₂), specific gravity = 6.85: 27 percent by weight

Approximate elemental composition of solids:

Hg 70 percent by weight

S 11 percent by weight

Cl₂ 10 percent by weight

Ca(OH)_2 6 percent by weight

Na_2S 3 percent by weight

FEEDER SERVICE CONDITIONS

Capacity - Design Alternative No. 1: 5.1 to 5.8 ft³/hr;
1300 lbs/hr

Design Alternative No. 2: 4.0 ft³; 1300 lbs/hr

Operating temperature - inlet side 150°F to 200°F; discharge side 800°F

Operating hours - 24 hr/day for 15-day furnace run only,
8 furnace runs/year

Elevation - application for 4500 ft above sea level

Ore concentrate is highly corrosive and abrasive

Two-year service life with minimum maintenance

MATERIALS OF CONSTRUCTION

All wetted nonmetallic parts are to be materials that are highly resistant to chemical corrosion and abrasion (refer to "Product Data" and "Typical Solids Composition"). All wetted metallic parts are to be compatible with the corrosive/abrasive environment or protected with suitable coatings or linings. The OEM is requested to recommend materials/coatings/linings to be used on each individual part based on OEM's proprietary knowledge of their equipment. Selection must be cost-effective and selection will be subject to review. The buyer will more favorably consider the use of conventional materials that can be cost-effectively maintained by mine personnel at this remote mine location.

AIRLOCK ACTUATOR AND ELECTRICAL REQUIREMENTS

The rotary airlock is to be supplied with a variable speed SCR or a variable speed mechanical drive to vary the airlock output in its capacity range. The airlock actuator assembly and all electrical components, such as bearings, lubricants, wiring, and terminals must be constructed of materials and assembled in a manner that is compatible with the environment described under "Product Data" and "Typical Solids Composition." Explosion proofing is not required.

The OEM will submit electrical and power requirements for their proposed airlock system(s). Available electrical service includes:

- 1φ, 60 Hz, 115/230 Vac
- 1φ, 60 Hz, 230/460 Vac.

SPARE PARTS AND SERVICE

The OEM will provide a quotation for one complete set of recommended spare parts to be mine stocked for the proposed system, including any special lubricants/oils required and a list of emergency service contacts with addresses and telephone numbers.

GENERAL SPECIFICATIONS

BM-8122 - MERCURY VAPOR EMISSIONS PROJECT

SPECIFICATION NO. A8122009

30 November 1981

TYPE OF EQUIPMENT

High Temperature Rotary Airlock

ABSTRACT

A rotary airlock with a 1500°F inlet side and 150°F to 200°F discharge side temperature is to be used to discharge calcines from and seal the discharge port of a multiple hearth furnace. The airlock is to be non-metering and it will operate at a constant speed. The airlock is to be sized by the OEM, and materials/coatings/linings are to be determined by the OEM, based on the following information.

QUOTATION

The OEM is requested to submit a quotation which includes:

- Airlock assembly from inlet flange to discharge flange
- Mechanical and electrical assemblies and connections for actuating the airlock
- Materials/coatings/linings to insure good service life and minimum maintenance
- Installation drawings and product literature
- Shipping charges to McDermitt, Nevada and any anticipated charges for installation and startup
- One complete set of recommended spare parts to be mine stocked for the proposed system including any special lubricants and oils that may be required and shipping charges
- List of emergency service contacts with addresses and telephone numbers.

PRODUCT DATA AND SERVICE CONDITIONS

Calcines temperature - 1500°F

Ambient temperature - 150°F to 200°F

Calcines discharge rate - 150 lbs/hr

Calcines bulk density - 75 lbs/ft³ to 100 lbs/ft³

Calcines have been pre-crushed by a lumpbreaker to an unknown size

Calcines composition:

Predominantly inert, bone-dry clays, CaSO₄,
CaCl₂, NaSO₄, NaCl at unknown amounts

Hg - 0.2 percent by weight (approximately)

Operating hours - 24 hr/day for 15-day furnace run only,
8 furnace runs/year

Elevation - application for 4500 ft above sea level

Two-year service life required with minimum maintenance.

MATERIALS OF CONSTRUCTION

All materials and their assembly must be compatible with the "Product Data and Service Conditions" listed above. The OEM will recommend materials/coatings/linings to be used on each individual part based on the OEM's proprietary knowledge of their equipment. Selection must be cost-effective and selection will be subject to review. The buyer will more favorably consider the use of conventional materials that can be cost-effectively maintained by mine personnel at this remote mine location.

The airlock will be totally enclosed and sealed to prevent the possible release of mercury vapor into the surrounding area.

AIRLOCK ACTUATOR AND ELECTRICAL REQUIREMENTS

The airlock actuator assembly and electrical components, such as bearings, lubricants, wiring and terminals, must be constructed of materials and assembled in a manner that is compatible with the environment described under "Product Data and Service Conditions." Explosion proofing is not required.

The OEM will submit electrical and power requirements for their proposed airlock system. Available electrical service includes:

- 1 ϕ , 60 Hz, 115/230 Vac
- 3 ϕ , 60 Hz, 230/460 Vac.

SPARE PARTS AND SERVICE

The OEM will provide a quotation for one complete set of recommended spare parts to be mine stocked for the proposed system, including any special lubricants/oils required and a list of emergency service contacts with addresses and telephone numbers.

GENERAL SPECIFICATIONS

BM-8122 - MERCURY VAPOR EMISSIONS PROJECT

SPECIFICATION NO. A8122010

30 November 1981

TYPE OF EQUIPMENT

Surge Capacity Storage Bin

ABSTRACT

Quotations are requested for a surge/storage bin which must meet two different design conditions:

Design Alternative No. 1 - mercury ore filter cake at 11 percent to 15 percent moisture by weight is to be discharged from a conveyor to the bin at 1230 lb/hr. The ore will be in an agglomerated state with feedstock nodules ranging from 1/8 in. diam to 3/4 in. diam.

Design Alternative No. 2 - filter cake at 5 percent moisture by weight is to be discharged from a conveyor to the bin at 1160 lbs/hr. The ore will be agglomerated into an unknown nodule size (to be determined by dryer tests).

The surge bin is to store the mercury ore and then discharge the ore into either a gravimetric weighfeeder or a chemical blender. An internal feeder or activator is required to insure that the ore remains free flowing. The bin is to be sized by the OEM and materials/coatings/linings are to be determined by the OEM based on the following information.

QUOTATION

The OEM is requested to submit a quotation which includes:

- 15 ft³ of storage volume
- Vibrating or similarly active bin bottom to feed stored material from the bin for either Design Alternative No. 1 or No. 2
- Activator assembly for the bin bottom
- Materials/coatings/linings to insure good service life and minimum maintenance
- Inlet and discharge flange configuration

- Installation drawings and product literature
- Shipping charges to McDermitt, Nevada and any anticipated charges for installation and startup
- One complete set of recommended spare parts to be mine stocked for the proposed system including any special lubricants and oils that may be required and shipping charges
- List of emergency service contacts with addresses and telephone numbers.

PRODUCT DATA

1. Design Alternative No. 1

Filter cake state - 11 percent to 15 percent moisture by weight

Viscosity of cake - 200,000 CPS (dynamic);
350,000 CPS (static)

pH - 10

Density - 256 lbs/ft³ (at 11 percent moisture)

Product feed rate - 1230 lbs/hr (solids plus water at 11 percent)

Operating environment - 100°F to 150°F, <50 percent relative humidity

Ore concentrate (solids) is highly corrosive and abrasive

Particle size of cake - 83 percent minus 200 mesh, agglomerated into 1/8 in. diam to 3/4 in. diam nodules by adding lime at a 1:15 mass ratio with filter cake upstream of the bin.

2. Design Alternative No. 2

Filter cake state - 5 percent moisture by weight

Viscosity of cake - 200,000 CPS (dynamic);
350,000 CPS (static)

pH - 10 (approximately)

Density - 320 lbs/ft³ (at 5 percent moisture)

Product feed rate - 1160 lbs/hr (solids plus water) or 3.7 ft³/hr

Operating environment - 100°F to 150°F, <50 percent relative humidity

Particle size of cake (at 5 percent moisture) - 83 percent minus 200 mesh, agglomerated into unknown nodule size (to be determined by dryer tests)

Ore concentrate (solids) is highly corrosive and abrasive

TYPICAL SOLIDS COMPOSITION (Major Compounds Only)

Cinnabar (HgS), specific gravity = 8.1: 70 percent by weight

Corderoite ($\text{Hg}_3\text{S}_2\text{Cl}_2$), specific gravity = 6.85: 30 percent by weight

Approximate elemental composition of solids:

Hg 77 percent by weight

S 11 percent by weight

Cl_2 12 percent by weight

SURGE BIN SERVICE CONDITIONS

Capacity - 1200 lbs/hr (solids plus water) at inlet and 15 ft³ of surge storage

Product temperature in bin - 130°F maximum

Maximum weight of stored material (320 lbs/ft³) (15 ft³) = 4800 lbs

Elevation - bin application for 4500 ft above sea level

Operating hours - 24 hr/day for 15-day furnace run only, 8 furnace runs/year

Space restrictions - installation envelope: 4 ft diam × 4 ft long

Five-year service life with minimum maintenance

MATERIALS OF CONSTRUCTION

All wetted nonmetallic parts are to be materials that are highly resistant to chemical corrosion and abrasion (refer to "Product Data" and "Typical Solids Composition"). All wetted metallic parts are to be compatible with the corrosive/abrasive environment or protected with suitable coatings or linings. The OEM is requested to recommend materials/coatings/linings to be used on each individual part based on OEM's proprietary knowledge of their equipment. Selection must be cost-effective and selection will be subject to review. The buyer will more favorably consider the use of conventional materials that can be cost-effectively maintained by mine personnel at this remote mine location.

BIN BOTTOM ACTIVATOR AND ELECTRICAL REQUIREMENTS

Assemblies for the bin activator and electrical components, such as wiring and terminals, must be constructed of materials and assembled in a manner that is compatible with the environment described under "Product Data" and "Typical Solids Composition". Explosion proofing is not required.

The OEM will submit electrical and power requirements for their proposed bin system. Available electrical service includes:

- 1 ϕ , 60 Hz, 115/230 Vac
- 3 ϕ , 60 Hz, 230/460 Vac.

SPARE PARTS AND SERVICE

The OEM will provide a quotation for one complete set of recommended spare parts to be mine stocked for the proposed system, including any special lubricants/oils required and a list of emergency service contacts with addresses and telephone numbers.