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MINPECO

ORE HANDLING IMPROVEMENTS

Salaverry, Chimbote, Callao, Matarani

OTR-003-T-01-0210-00

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By

CE MAGUIRE, INC.

Architects • Engineers • Planners

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CHAPTER ONE

Introduction

A. AUTHORIZATION

Minero Peru Commercial (MINPECO) is the marketing agency for the mining industry in Peru and is responsible for the worldwide sale of Peru's mineral products. To effectively plan a sound capital investment program, the Board of Directors of MINPECO decided to undertake a study of the major mineral exportation ports in the country in order to optimize and modernize handling and loading operations. This program is even more important now due to recent substantial increases in both production and market value of minerals.

To this end, the government of Peru, acting through its Ministry of Energy and Mines, requested technical assistance of the government of the United States through the U.S. Embassy in Lima. The United States Government, through the Agency for International Development (AID), contracted with the engineering consulting firm of CE Maguire, Inc., to undertake a study of MINPECO exporting operations through the ports of Salaverry, Chimbote, Callao and Matarani. Authorization and notice to proceed was issued to CE Maguire, Inc. on May 2, 1980 by Contract No. AID/OTR-C-1799.

B. PURPOSE

In general, the study consists of site investigations at MINPECO facilities in three ports at which they now operate (Salaverry, Callao and Matarani), and at the port of Chimbote where they plan to establish operations. These four major depot-port areas have a series of problems that vary in kind and intensity. They all have receiving stations or deposit yards equipped with weighing facilities at the points of entry. These yards are able to store a supply of materials equal to the export demand for at least two months, although inventories sometimes exceed this level. This provides an uninterrupted flow of materials for export. The objectives of the study are to identify the nature of the problems that are now creating materials handling bottlenecks and to make recommendations for solutions to these problems, including recommendations regarding appropriate "state of the industry" equipment that MINPECO should acquire. The principal issues are the materials handling methods of operation and potential improvements to the presently used modes.

In order to observe and understand MINPECO operations firsthand, a study team from CE Maguire, Inc. visited Peru in May and June, 1980 to examine the present methods of materials handling and operations employed by MINPECO at the four port areas under study.

The operations of MINPECO can be itemized as follows:

1. Receiving and storing the concentrates and minerals in the deposit yards. These materials may come directly from mines or from satellite receiving stations.

2. Assaying the concentrates or minerals to determine the degree of purity of the principal material, plus the presence of other minerals.

3. Loading and transporting the materials to shipside.

4. Loading materials on-board the vessels.

The project team observed "preloading" materials handling in the MINPECO deposit yards prior to the arrival of chartered export vessels and also observed actual ship loading at the ports of Salaverry, Callao and Matarani. Additional information regarding MINPECO operations was obtained through interviews with various departmental staffs at MINPECO headquarters at Lima. Augmenting this data were conversations with the Commercial Attache at the U.S. Embassy, personnel at the U.S. AID Mission in Lima, and various staff of ENAPU Peru[1], both at its headquarters in Callao and at the individual ports visited.

C. BACKGROUND

Minero Peru Commercial (MINPECO) is the public agency responsible for the sale of the majority of Peru's exportable mineral concentrates and ores; MINPECO negotiates mineral sales to foreign refineries or processors based on two modes of operation. In the case of the large mining companies, MINPECO principally negotiates back-to-back sales[2] of concentrates to foreign refineries, paying the mining company when payment has been received

[1]ENAPU Peru (Empresa Nacional de Puertos) is the National Port Authority which administers all maritime terminals in Peru.

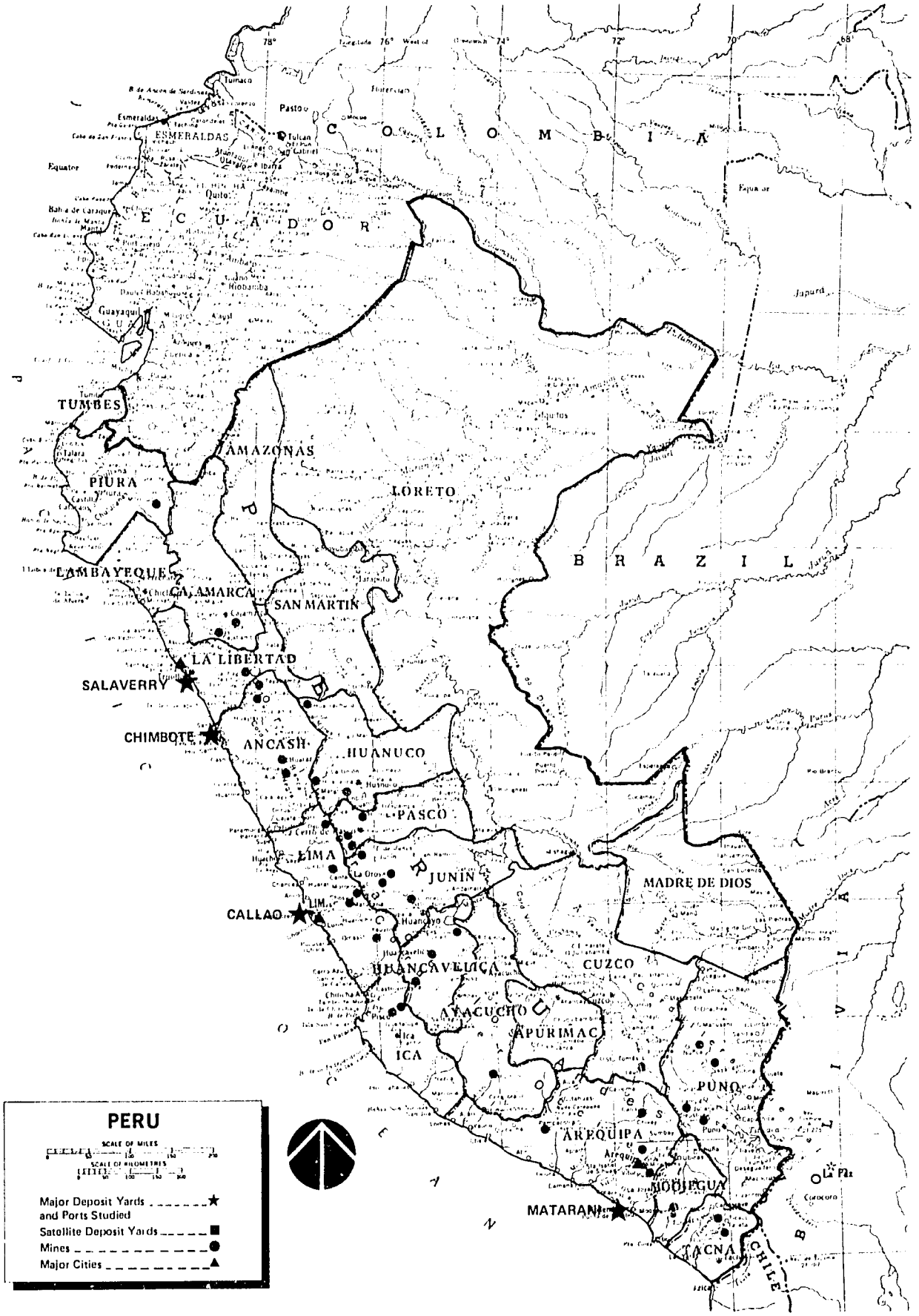
[2]Back-to-back sales means that MINPECO acts as the sales agent only for the sale and does not purchase the material but receives a percentage commission on the sale.

from the buyer. Products of small mines are purchased outright by MINPECO, however, based on the results of an assay and are then sold by MINPECO in individually contracted sales. Small mines are initially paid an approximate value for their products based on past assay results from their mines; final payment is based on the documented assay results from Lima. Mid-sized mining companies use either of the above two arrangements, depending upon the situation and the volume of the sale.

In most cases MINPECO is also responsible for the bulk handling of materials for export. Although several of the very large mining companies physically handle the transportation and exportation of their own concentrates, the majority of mining companies ship their products through MINPECO's storage yards. Mining companies transport their products by truck or rail to MINPECO's closest deposit (storage yard) on the coast or to satellite deposits in the interior; mines with large amounts of production generally transport their higher volume shipments to the coastal deposits, as the interior stations are intended principally for the benefit of smaller mining companies. MINPECO arranges for the transport of products from the interior satellites to the MINPECO deposits at the ports of export. Materials arriving at the MINPECO deposits are stockpiled until a chartered vessel arrives for their export.

Later chapters of this report contain detailed descriptions of existing MINPECO materials handling procedures at the ports of Salaverry, Chimbote, Callao, and Matarani. These four port areas were selected for in-depth study due to the existence of actual or potential problems in MINPECO's operations. At the present time MINPECO does not operate a deposit in Chimbote; however, two shipments in 1980 have already been exported from that port under MINPECO's supervision, and MINPECO is interested in establishing a permanent base of operations there. The other three deposits are on-going operations.

Figure 1 shows the regional location of the four ports. Salaverry is the northernmost, located 24 km from Trujillo, Peru's second largest city. Salaverry's principal exports are sugar and minerals. Chimbote (the second port studied) is located south of Salaverry, 130 km southwest of Trujillo. Principal products passing through the port of Chimbote are fish meal, steel and materials used in the production of steel. Callao, located 15 km from Lima, has been Peru's largest and most important port since its founding shortly after the Spanish conquest. The fourth port, Matarani, is located in



GENERAL LOCATION MAP

FIGURE 1

the southern region of Peru and serves as a major importing and exporting port for landlocked Bolivia in addition to its importance to Peru's mining sector. Matarani is the closest port to Peru's third largest city of Arequipa. A comparison of total tonnages of cargo shipped through these ports is shown in Table 1, giving a general indication of the relative volumes handled in these four ports during 1977, 1978, and 1979.

TABLE 1

PORT SHIPPING STATISTICS, 1977 - 1979

	SALAVERRY		CHIMBOTE		CALLAO		MATARANI	
	No. of Ships	Cargo Tonnage (metric tons)	No. of Ships	Cargo Tonnage (metric tons)	No. of Ships	Cargo Tonnage (metric tons)	No. of Ships	Cargo Tonnage (metric tons)
1977	326	913,830	212	1,112,454	1,397	5,697,711	274	365,573
1978	280	837,913	205	997,293	1,481	4,804,717	353	442,969
1979	--	616,962	-	1,336,327	--	3,010,546	-	603,141

SOURCE: ENAPU Peru Annual Reports, 1977 and 1978; 1979 figures provided by ENAPU Peru personnel.

The four ports studied in this report are operated by the Empresa Nacional de Puertos Peru (ENAPU Peru), which charges tariffs to any ship using their port facilities. A list of these tariffs appears in Table 2.

TABLE 2

ENAPU PERU SHIP BERTHING TARIFFS

Use of port (Per registered ton of vessel)	$0.065
Use of pier - Callao (Per registered ton of vessel per day)	$0.039
Use of pier - Salaverry, Chimbote, Matarani (Per registered ton of vessel per day)	$0.026
Berthing/Departing (Per registered ton of vessel per operation)	$0.091

SOURCE: ENAPU Peru, Reglamento de Tarifas.

ENAPU Peru also charges a storge fee for materials stockpiled in the general port area or on the pier. These tariffs appear in Table 3.

TABLE 3

ENAPU PERU MATERIAL STORAGE TARIFFS

STORAGE IN GENERAL PORT AREA

First 15 days	No Tariff
Next 30 days	$0.01/ton/day
Next 30 days	$0.02/ton/day
Each additional 30-day period	Double the rate of the previous 30-day period

STORAGE ON PIER

First 3 days	No Tariff
Next 4 days	$0.03/ton/day
Next 4 days	$0.06/ton/day
Each additional 4 days	Double the rate of the previous 4-day period.

SOURCE: ENAPU Peru, Reglamento de Tarifas.

In addition to these berthing and storage charges, MINPECO in many cases incurs additional charges for the rent or lease of equipment and the contracting of Agencias Maritimas[1] employees (stevedores) for loading or handling operations. Since shipping arrangements vary considerably from port to port, these charges will be discussed later in this report under the individual ports.

Figure 1 also shows the satellite deposits operated by MINPECO for the benefit of the small mine operators. Neither Salaverry nor Chimbote are serviced by satellite storage areas; however, Callao receives material from the satellite station of Huancayo, and Matarani handles products from satellites in Tacna, Arequipa, and Juliaca. Most of the large and mid-sized mines have also been represented in Figure 1 to indicate the location of the sources of mineral products.

[1]Agencias Maritimas - companies which provide labor and materials services for shipping.

A vital determinant of MINPECO's growth, and hence the capital and operational improvement plan, is the projection of mining production that will be passing through MINPECO's deposits between 1980 and the year 2000 (the target year for this study). These figures are summarized in Table 4 by port of export. The tonnages listed in Table 4 appear in graph form later in this report for each individual deposit area.

TABLE 4

PROJECTED VOLUME OF MATERIALS TO BE HANDLED BY MINPECO IN METRIC TONS (MT)

	Salaverry	Chimbote	Callao	Matarani	Total
1980	73,600	63,800	477,600	144,700	759,700
1981	99,800	63,800	467,800	149,200	780,600
1982	111,700	63,800	410,900	153,000	739,400
1983	111,700	63,800	544,700	179,100	914,600
1984	142,200	63,800	544,700	439,000	1,189,700
1985 - 2000	142,200	63,800	544,700	660,500	1,411,200

NOTE: Detailed tables of projections by product and by mine are presented in Appendix A with documentation of adjustments made to the raw forecasts.

SOURCE: Office of Planning and Statistics, MINPECO

The steady growth in throughput projected to occur at Salaverry between 1980 and 1984 is relatively evenly distributed among the three main products of lead, zinc and copper, while growth of one mining company, Aguila, accounts for the total growth at Chimbote. Mina Aguila is the only producer that will be served by the proposed MINPECO operation at Chimbote.

In the case of Callao, export of concentrates drops off sharply in 1981 and 1982, due to the opening of a new zinc refinery at Cajamarquilla which will absorb a large amount of zinc concentrate presently exported to foreign refineries. In 1983, however, the opening of five new copper producing mines in central Peru will greatly increase MINPECO's total throughput at Callao, more than offfsetting the volume of material that will go to Cajamarquilla.

Matarani will experience by far the greatest growth of the four operations included in this study, due almost entirely to growth in the copper mining sector and principally to very large anticipated growth of the Cerro Verde and Tintaya mines. Matarani will experience rapid growth, even surpassing the throughput of MINPECO's Callao operation by the year 1985.

The projections contained in this report and utilized in the formulation of recommendations were developed by MINPECO's Office of Planning and Statistics based on projections of mine production developed by the Ministry of Energy and Mines. New mines coming into production that would augment exports and new refinery projects that would diminish the amount of unrefined exports were considered, based on present knowledge of their occurrence. The projections were adjusted by CE Maguire, Inc., based on further suggestions and information from the Planning Office. Appendix A of this report contains explanation and documentation of these adjustments.

It should be noted that the figures in Table 4 show no projected growth after 1985, and at some of the deposits growth stops even earlier. This occurence is due to the fact that proposals for new mine openings or expansions (and hence increased production) are not programmed far into the future. This study considers two growth scenarios in addition to the figures presented in Table 4. These two scenarios consist of two percent and four percent additional compounded annual growth at each MINPECO deposit considered in this study, starting from the point where the basic projections at each port area show a levelling. These alternate growth scenarios are also presented graphically in the discussion of each individual deposit.

The following four chapters of this report deal individually with the MINPECO operations at Salaverry, Chimbote, Callao, and Matarani in terms of: (a) existing operations, (b) actual or potential problems and some alternative solutions, and (c) recommendations of actions to be taken by MINPECO to improve materials handling operations at each of the four deposits. Chapter Six presents some company-wide issues or problems that are not appropriate for discussion in the individual port area chapters, and Chapter Seven presents a summary of recommendations including a priority schedule as well as costs of proposed improvements.

D. SELECTION OF EQUIPMENT MANUFACTURER

The shiploading equipment recommended in this report is designed and manufactured by Barber-Greene Company. This company was selected for three reasons:

- Barber-Greene shiploading equipment is currently used by MINPECO in Callao and Matarani and MINPECO personnel are familiar with its operation;
- Barber-Greene has a local representative in Lima; and
- Barber-Greene is able to supply all parts of the recommended system at Salaverry, Callao and Matarani.

It should be noted, however, that other manufacturers are available and are capable of providing equal equipment to the recommended components.

Similarly, Caterpillar Tractor Company has been used as an example of a supplier of mobile equipment for much the same reasons as those stated above. In this situation also, other equipment manufacturers produce equal equipment that could also be utilized by MINPECO.

CHAPTER TWO

Salaverry

A. EXISTING OPERATIONS

1. SETTING

As shown previously in Figure 1, the Port of Salaverry is located close to Trujillo, Peru's second largest city. The maritime terminal of Salaverry was established 110 years ago in 1870. Work was begun on the existing port infrastructure in 1956 and the new facilities were dedicated in 1965. Since January 1, 1970, the Port of Salaverry has been administered by ENAPU Peru. The port area contains warehousing and open storage areas and is protected by a breakwater 1,300 meters long and 6.5 meters high. Salaverry has two piers 225 x 25 meters and 230 x 30 meters, respectively. Each of these piers has two mooring berths for transoceanic vessels. Figure 2 shows a general plan of the port and adjacent town.

As shown in Figure 2, the MINPECO yard at Salaverry is located approximately 2.2 km from the mineral loading pier (Pier 1). The yard is divided into two distinct portions: the administrative area which contains office buildings, sampling stations and scale, located in an area of 3,000 m^2, and the larger storage yard located on a separate parcel of 7,000 m^2, across Pascamayo Street from the smaller lot.

2. OPERATIONS

Minerals and concentrates are brought to the MINPECO deposit in Salaverry directly from the individual mines – no satellite storage yards are utilized. The Salaverry deposit services mines located in the Peruvian Departments of La Libertad and Cajamarca. The deposit receives approximately 22 trucks/day from the mines each carrying an estimated average load of 11 tons. All material arrives by truck; no railroad serves the deposit area. Throughput at Salaverry for 1977 through 1979 is shown in Table 5.

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TABLE 5

SALAVERRY DEPOSIT THROUGHPUT, 1977 - 1979

Year	Received	Shipped
1977	81,868 MT	43,142 MT
1978	60,862	58,704
1979	54,410	52,577

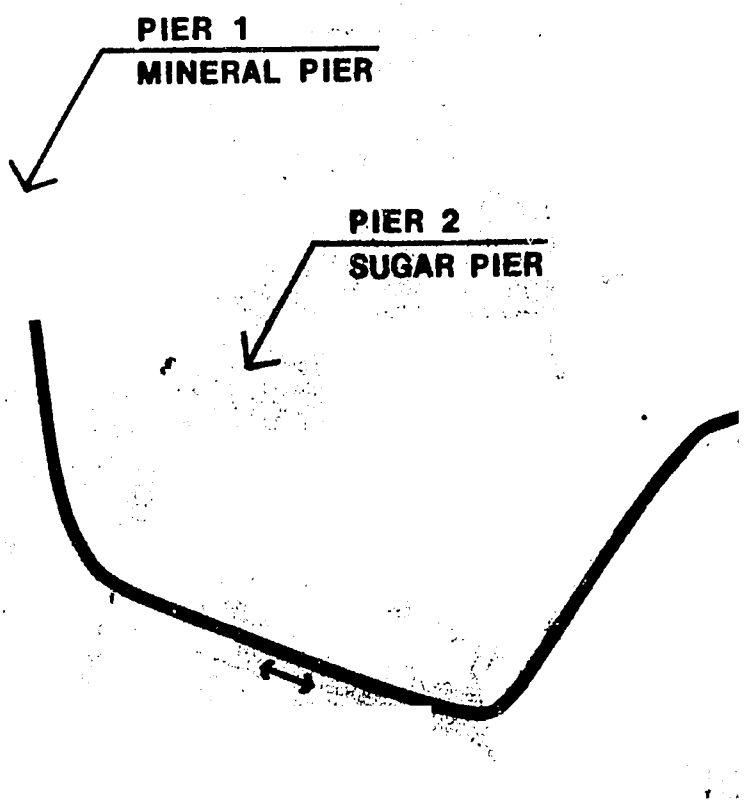
SOURCE: Department of Operations, MINPECO

No unconcentrated minerals are exported from the Salaverry port; all minerals received are weighed, sampled, bagged and forwarded overland by truck to Callao to be shipped from that port. In 1979, 3,087 MT of minerals were trucked in bags to Callao (a distance of 440 km) at a rate of approximately one truckload per week.

When materials arrive at the deposit, samples are taken from each lot for determination of moisture content and quality. The moisture testing is performed in-house at the MINPECO deposit in Salaverry, while other samples are sent to a private laboratory in Lima for assaying. Results are telexed back to Salaverry approximately 15 days after the samples are sent. Following receipt of assay result, the deposit can stockpile for shipment or mix materials of similar type and quality; mixing is done manually. Generally, only material from small and some mid-sized mines is blended. Production from large mines is generally handled in back-to-back sales and is not mixed with production from other mines. Sample preparation and some mixing take place in the front 3,000 m^2 parcel of the deposit while the larger area is generally used for mixing and storage. Total capacity of the deposit is estimated to be 14,000 MT; in late May 1980 during the visit of the CE Maguire, Inc. field team, the area was stockpiling approximately 13,000 MT.

For moving materials within the deposit, MINPECO owns three front end loaders. In late May 1980, at the time of the field visit, only one of the front end loaders was operable, and that was experiencing some mechanical malfunctions. The deposit employs a total of 24 people; a list of operating equipment owned by MINPECO in Salaverry and a breakdown by employee category appear in Table 6.

BREAKWATER



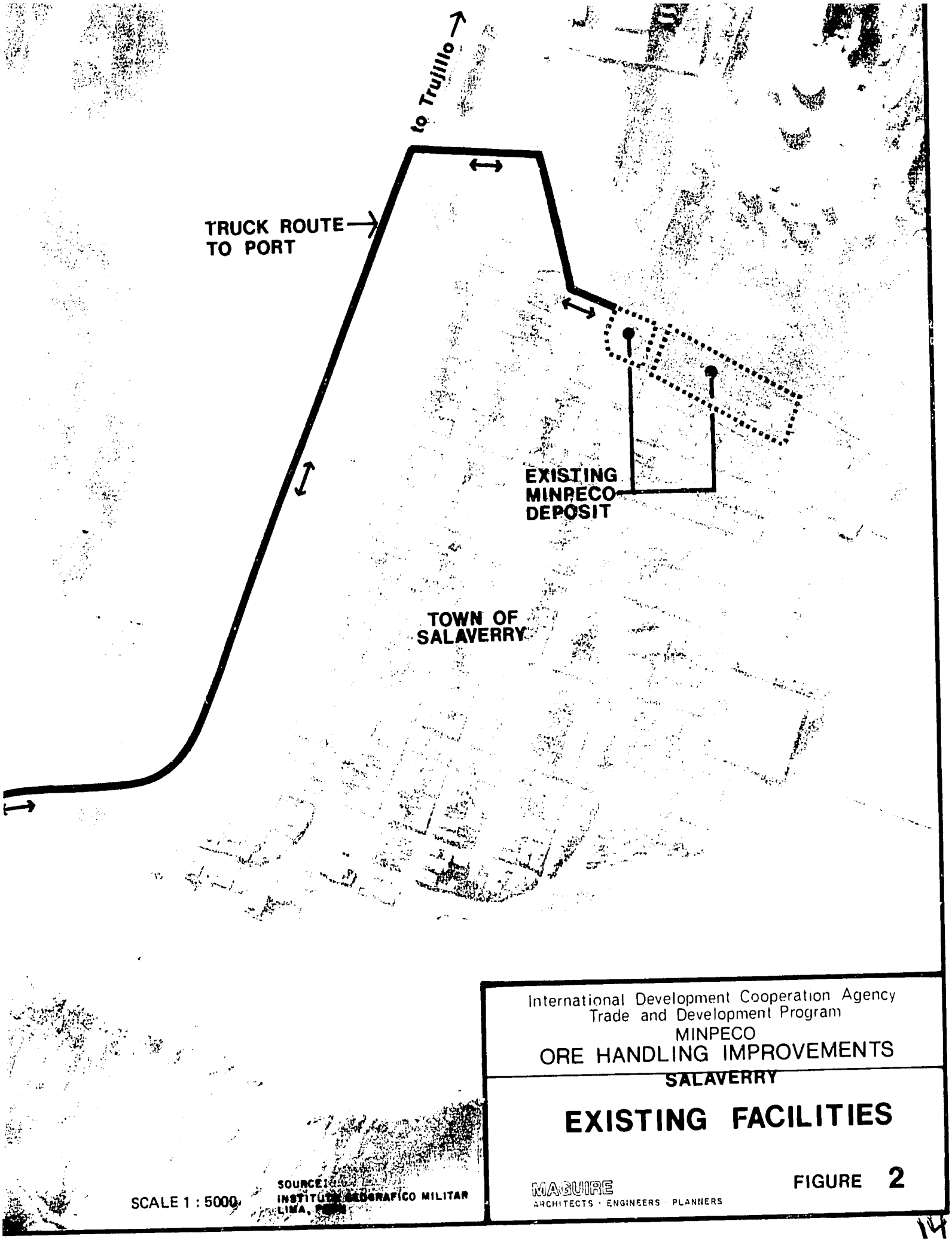

to Trujillo
TRUCK ROUTE
TO PORT
EXISTING
MINPECO
DEPOSIT
TOWN OF
SALAVERRY
SCALE 1 : 5000
SOURCE:
INSTITUTO GEOGRAFICO MILITAR
LIMA, PERU
International Development Cooperation Agency
Trade and Development Program
MINPECO
ORE HANDLING IMPROVEMENTS
SALAVERRY
EXISTING FACILITIES
MAGUIRE
ARCHITECTS · ENGINEERS · PLANNERS
FIGURE 2

TABLE 6

SALAVERRY DEPOSIT EQUIPMENT AND EMPLOYEES

EQUIPMENT

1 Payloader H-70
1 Payloader H-30
1 Electronic Group - D3400
* 15 KV Caterpillar
1 Dodge Pickup

EMPLOYEES

Office/Management Employees	6
Laborers	17
Apprentice	1
TOTAL	24

*This list of equipment from MINPECO indicates only two front loaders; however, three loaders were observed and were indicated by Salaverry deposit personnel.

SOURCE: Department of Operations, MINPECO

At a pre-determined time before a chartered vessel is due to arrive at the Salaverry port, MINPECO begins to transport the material to be shipped to the mineral pier. Rented dump trucks are used – generally ten for an average shipment (approximatley 3,800 MT). The trucks are loaded in the deposit using front end loaders (rented, if MINPECO's are not operable) and weighed as they leave the yard area. Each truck is weighed a second time when it arrives at the port. After the material is deposited on the pier adjacent to the berths, the trucks return to the deposit. On the return trip the trucks are again weighed twice, once when leaving the port and again when reentering the deposit yard. Costs for rental of equipment and for performance of transport and loading oeprations are shown in Table 7.

TABLE 7

EQUIPMENT RENTAL AND MATERIALS HANDLING CHARGES
SALAVERRY

	PERUVIAN SOLES DE ORO[1]	AMERICAN DOLLARS[2]
FROM DEPOSIT TO SHIPSIDE (per MT)		
Loading/Shipping Rights	S/. 467.00	$ 1.70
Transport	282.00	1.03
Truck Loading	40.00	.15
Stockpiling (Machinery)	40.00	.15
Cleanup & Salvage	6.00	.02
Supervision	8.00	.03
Stockpiling (Labor)	8.00	.03
Scales Service	7.50	.03
Export Controls	3.00	.01
	S/. 861.50	**$ 3.15**
FROM SHIPSIDE TO ONBOARD (per MT)		
Supervision	S/. 7.00	$ .03
Loading (Machinery)	162.00	.59
Trimming	278.00	1.01
Loading (Labor)	490.00	1.78
Loading Fee	5.00	.02
Protective Gear	1.20	Negligible
	S/. 943.20	**$ 3.43**
TOTAL COST FROM DEPOSIT TO ONBOARD (per MT)	**S/. 1,804.70**	**$ 6.58**
ADDITIONAL EQUIPMENT		
Front End Loaders (per hour)	S/. 6,300.00	$ 22.91
Bulldozers		
– Transport	140,000.00	509.09
– Per Day	34,650.00	126.00

[1]As of Mid-May 1980

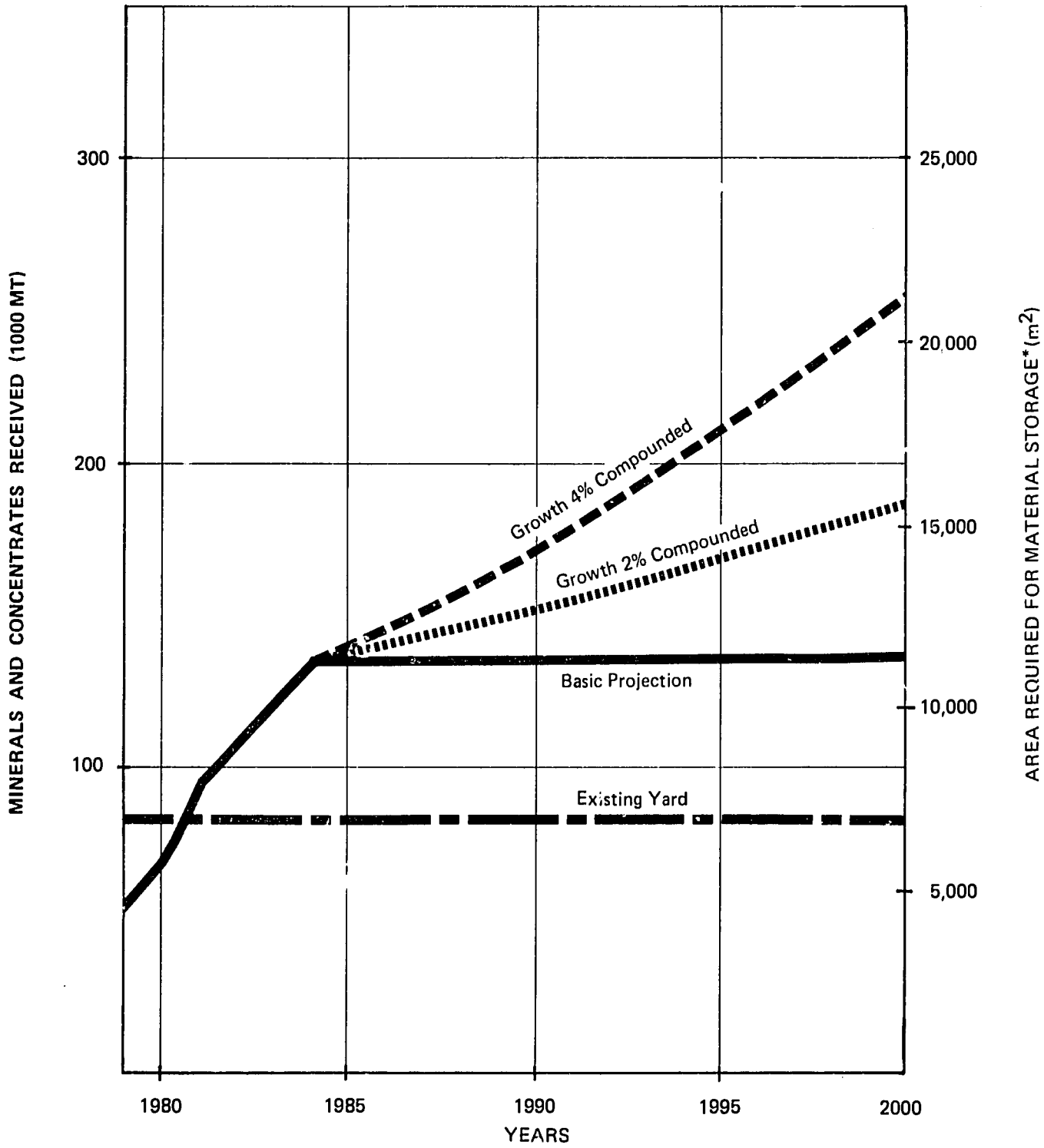
[2]Assuming S/ .275 = $1.00

SOURCE: Department of Operations, MINPECO.

When the ship has berthed and loading can begin, the concentrate is loaded into a two-ton skip using a front end loader and is hoisted aboard and deposited in the ship's hold using the ship's own gear. The skips are attached manually to the winch by a stevedore using chains and hooks. When the skip has been lifted into the ship's hold, another worker manually unhooks the skip for unloading, then hooks the empty skip back to the winch for return to the pier for the next load. Approximate time for an entire operation of loading and unloading one skip was measured at 2-1/2 to 4-1/2 minutes. The loading rate varies from 25 to 40 tons per hour per ship's winch. If two holds are being loaded simultaneously, two winches and skips are used, each requiring one front end loader. This effectively doubles the loading rate. The study team observed the loading of 740 tons of lead concentrate at Salaverry. Loading began at 3:00 p.m. on May 22 and finished at 4:00 a.m. on May 23 (a 13-hour period) for a gross average loading rate of 57 tons per hour. Two holds of the ship were being loaded simultaneously, resulting in a loading rate of 28.5 tons per hour per winch. Three eight-hour shifts of workers continue round the clock at Salaverry, each shift working seven out of eight hours. This results in a net loading rate for the observed shipment of 67 tons per hour or 33-1/2 tons per hour per winch (assuming 11 hours were worked out of the 13-hour loading period).

Projections of throughput at the Salaverry yard are presented numerically in Table 4 in Chapter One; the same information is presented graphically in Figure 3 on the following page. The basic projections obtained from MINPECO's Office of Planning and Statistics show a steady increase in throughput at Salaverry between 1980 and 1984. This growth is relatively evenly distributed over the lead, zinc and copper mining sectors in the area serviced by MINPECO's Salaverry operations. No growth is projected after 1984 due to the lack of proposed new mining projects after that year. To account for the possibility of presently unforeseen growth, two additional lines have been included on the graph to represent the possibility of two percent and four percent compounded annual growth of the throughput at Salaverry.

The vertical scale at the right side of the graph indicates storage area of the Salaverry yard in square meters, not including administrative buildings and other areas not used for stockpiling, which would be necessary to accommodate the various levels of annual throughput. These were calcualted based on the assumption that MINPECO would prefer to maintain a two-month inventory at Salaverry.



PROJECTED THROUGHPUT AND STORAGE AREA REQUIRED
SALAVERRY DEPOSIT YARD

*Area for administration, scales, laboratory, etc., not included.

FIGURE :

B. POTENTIAL PROBLEM AREAS AND ALTERNATIVE SOLUTIONS

1. PORT LIMITATIONS

a. Shoaling and Wave Motion

The port of Salaverry has widely recognized shoaling and wave motion problems requiring almost continuous dredging of the berths and channels and causing difficulty during ship loading due to excessive vessel movement. In regard to shoaling, the following problem definition was stated in an issue of "World Port Conditions:"

> ". . .A relatively short time after the harbor was completed (1964) problems began to arise within the harbor and studies showed that it was rapidly silting up. The Association of Peruvian Shipowners has reported that due to Salaverry's present conditions, ships' captains are offered no safety and must keep their engines on standby, being unable to moor to the pier adequately because of the silting and sea currents, which cause serious problems during discharge and loading."[1]

This problem has the potential for major limitations on the use of the port in terms of the size of ship that the port can accommodate, the movement of ships while berthed, and the loss of berthing time because a dredge frequently occupies side A of Pier 1.

In addition, the port of Salaverry periodically experiences extremely turbulent sea conditions which necessitate closing of the port. During the months of May, June and July, Salaverry is closed three to four days/month. This constraint reduces the amount of time available for the berthing of ships and hence the loading of minerals. Even when the port is not actually closed, wave motion in the harbor area can cause excessive movement of ships at the berth, resulting in reduced loading rates, increased loss of materials and other types of interference.

Based on instrumentation, flow measurements, sea floor samples and extensive bathymetric surveys in the Port of Salaverry (and as discussed in numerous previous studies of the port), it has been determined that the wave motion inside the harbor and at the berths is caused by wave refractions that occurs around the sand tongue formed on the interior of the breakwater peak and in wave reflection from numerous other areas in the port.

[1] World Port Conditions, William H. McGee and Co., Inc., New York, New York, June 1980.

Observations of a mineral loading operation at Salaverry in May 1980 indicated vessel movement impeding the loading concentrates. Excessive movement contributed to loss of material during loading and increased the time required to complete the operations.

Although the ship movement observed at Salaverry was not as violent as that found later at Matarani, heavy swells within the harbor area moved the vessel in excess of ten feet vertically and 15 to 20 feet horizontally. Mooring lines were maintained in a loosened condition to prevent obvious damage to hull plates of the vessel. Spring lines were employed fore and aft, with multiple bow and stern lines in position. Truck or tractor tires are positioned along the pier to act as a fender system. Photos 1 and 2 on the following page illustrate the problems described in this section.

Observations indicated that the lightened condition of the vessel during loading operations may be a major contributing factor to the excessive movement; however, cargo vessels must enter Salaverry with minimum draft due to shoaling of the harbor entrance channel.

Violent or excessive movement of the vessel during loading operations contributes to loss of material, is dangerous for the stevedores working the equipment, and is a major factor in gear damage and failure. While it is understood that MINPECO does not have jurisdiction of the vessel or port facility where loading is conducted, it is also clear that this phase of mineral transport is of vital interest to MINPECO in improving materials handling operations. Thus recommendations regarding in-port operations are included in this study, allowing MINPECO to request specific improvements of ENAPU Peru at Salaverry.

ENAPU Peru has recognized the severity of these problems and has undertaken a number of studies investigating possible solutions. References of some of these studies are contained in Appendix B of this report. At the present time further studies are being performed by the Dutch government, and improvements are planned as follows:

(1) A new dredge will be purchased which will begin operation in September 1980.

(2) A new channel will be dredged, 200 meters wide and 30 feet deep.

(3) A 300 foot extension of the existing breakwater is also contemplated.

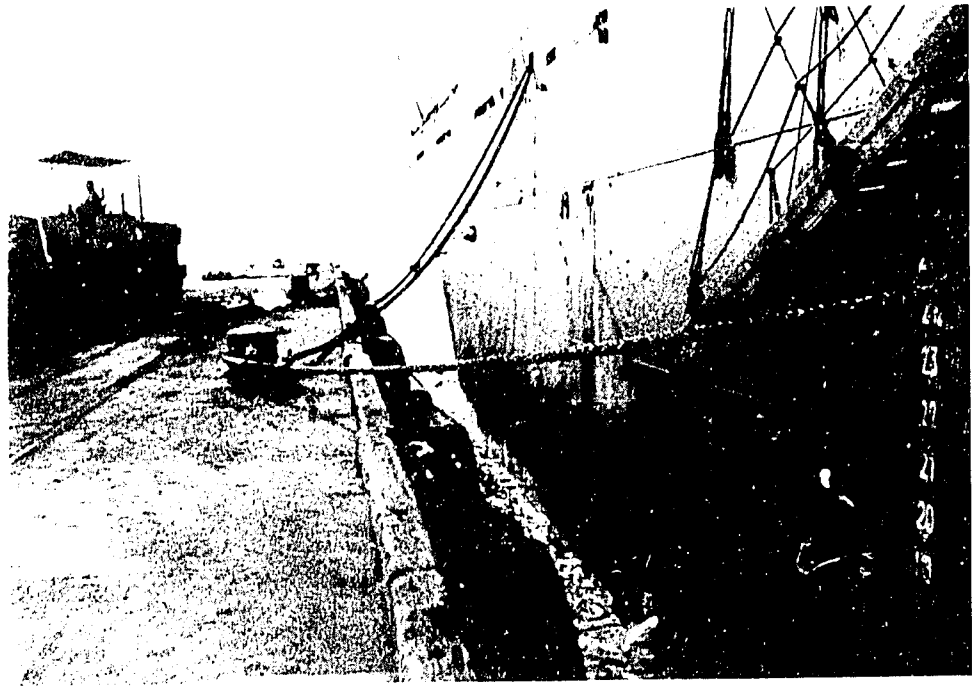


PHOTO 1 — Salaverry — Lateral movement of vessel resulting from wave action; material spillage on pier from loading operation.

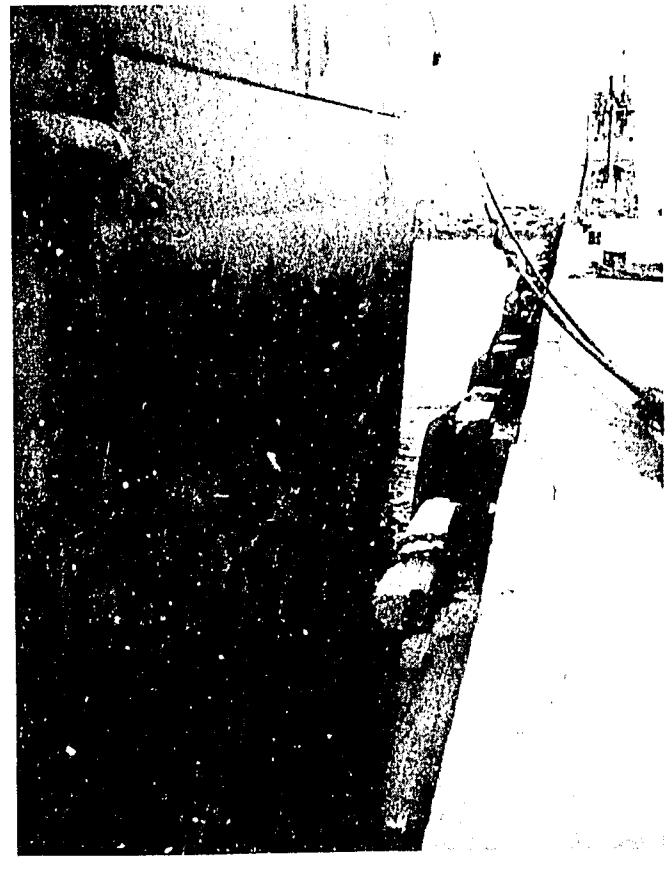


PHOTO 2 — Salaverry — Fender system of mineral berth — Pier 1.

Discussions with port and ship personnel indicate that two additional areas of concern should be addressed in regard to vessel movement during loading. The port director's primary concern is to prevent damage to pier and wharf structures from vessel pounding, while the ship's captain is concerned with the prevention of damage to vessel hull plates.

The truck and tractor tires employed as fenders on the Salaverry piers cannot provide the degree of protection required to alleviate both problems. A properly designed, modern energy absorption fender system meeting the conditions at each of the ports would be required to adequately solve the problem. The installation of such a system meeting the physical requirements of the range of vessels using the facilities is urgent. Minimizing impact forces from wave action would prevent or reduce potential damage to both vessel and pier. Several examples of energy absorption fender devices are shown in Appendix C of this report. These types of fender systems have been successfully employed throughout the port industry world-wide.

A mooring system is also essential to minimize vessel movement and prevent parting of lines. As such, the application of a constant tension mooring winch system warrants consideration at Salaverry. Under normal applications, constant tension winches are employed on vessels or barges. These types of winches are also employed on oil drilling floating rigs to secure them in position. In Salaverry the winches could be installed on the wharf to maintain vessel position during the loading cycle. For this type of application a recess would have to be constructed at the edge of the wharf to receive the winch installation. The winch mounting or frame would be designed to pivot or turn to align the wire rope properly on the drum. Constant tension winches are available with 50 ton capacity and can be operated locally or remotely as required. The installation would normally require only one winch per berth if the ship loader is movable to service different vessel holds. Two units would permit the vessel to be moved laterally to align with a fixed loading position. Use of this equipment would improve the efficiency and safety of loading operations in turbulent seas. Information on constant tension winches that can be employed for maintaining vessel position during loading operations at Salaverry can be found in Appendix D of this report.

b. Berth Occupancy

An existing problem, and one that could become increasingly critical in Salaverry is the availability of berthing space for mineral export vessels. Aside from turbulence or shoaling problems which make the berth unavailable at certain times or to certain vessels, a potential problem may also exist in the rate of activity experienced by the port. Pier 2 is utilized principally for the export of sugar, while Pier 1 is utilized for minerals and general cargo. Minerals cannot be loaded at the same time as sugar because of potential contamination of the products. Thus, mineral export operations sustain a period of shutdown during sugar loading which could potentially have severe impact on the shipment of minerals.

Although it is difficult to accurately quantify levels of port utilization, there are two methods that can be used as indicators. The first method uses the berth occupancy rate, or percent of time that a berth is occupied, while the second uses throughput of the berth in relation to its throughput capacity. A berth occupancy percentage rate of 30 percent to 50 percent for a general cargo berth is considered the maximum rate possible without significant delays for ships awaiting berthing space. Using the second method, 66,000 MT/year - 132,000 MT/year is considered the range of optimal berth throughput for a port such as Salaverry. These figures indicate a range of acceptable levels of utilization which can be achieved without reducing operating efficiency and increasing delays. A single value is impossible to determine without a detailed study, since it depends on a variety of factors, including types of vessels and cargoes, port facilities and the geography and economics of the port service area.[1]

Data for the Port of Salaverry (approximately 43 percent berth occupancy and 90,000 MT annual throughput/berth) indicate that it is currently operating at a moderate to moderately high level of utilization, particularly when the problems associated with shoaling and dredging requirements are considered. Increases in throughput or berthing time could result in reduced efficiency of port operations. MINPECO's projected increases in exports could contribute to such a problem, although improvements in loadingrates would offset the increases. Increases in the activities of other port users, however, could create inefficiencies of operation in the future. MINPECO should be aware of this potential problem and work closely with ENAPU Peru to develop solutions with enough lead time to avoid major delays or conflicts.

[1] Port Handbook of Estimating Marine Terminal Cargo Handling Capability, U.S. Maritime Administration, Washington, D.C., September 1979.

2. LOADING METHODS

One of MINPECO's most severe problems at Salaverry is the extremely slow rate of loading minerals. Most mineral ships must remain at Salaverry for more than three days to be loaded with an average shipment (approximately 3,800 MT). This results in additional direct or indirect costs to MINPECO, as the cost of detaining a ship in port for that length of time must be borne by the seller – either directly or through the price received for the concentrates.

Safety is also a factor in justifying improvements in the Salaverry loading methods. The manual attaching and detaching of the winch from the loading skips involves risk to the stevedore, particularly when the ship is experiencing considerable movement at the berth due to harbor turbulence or wave action.

Loss of concentrate by wind or spillage is another issue to be considered. The study team observed several loading attempts where the chains from the winch detached from the skip during hoisting, dropping the skip and scattering the contents to dock, wind, and water. Photos 3 through 7 on the following pages illustrate loading methods and resultant problems at Salaverry.

No significant improvement appears to be possible using the present loading equipment. Several alternative methods were investigated as part of this study. One of the major limitations to the type of loading operation is the narrow pier width of the mineral loading pier at Salaverry. (Width of Pier 1 is 25 meters.) Given this constraint, the most appropriate type of loading methodology at Salaverry would appear to be the use of a portable shiploader which would be fed by a portable conveyor. Both pieces of equipment would be stored elsewhere in the port area when not is use and transported to the pier head for each loading. Loading equipment of this type is already in use at Salaverry, as illustrated in Photos 8 and 9 which show the unloading of grain at the mineral berth.

Trucks would continue to transport the concentrates to the pier beginning at an appropriate period of time prior to ship arrival, and material would be stockpiled close to the hopper of the portable conveyor. Front end loaders would be used to feed the hopper, achieving a loading rate of 350 MT/hour, a significant improvement over the maximum 50-80 tons/hour now achieved by loading two hold simultaneously.

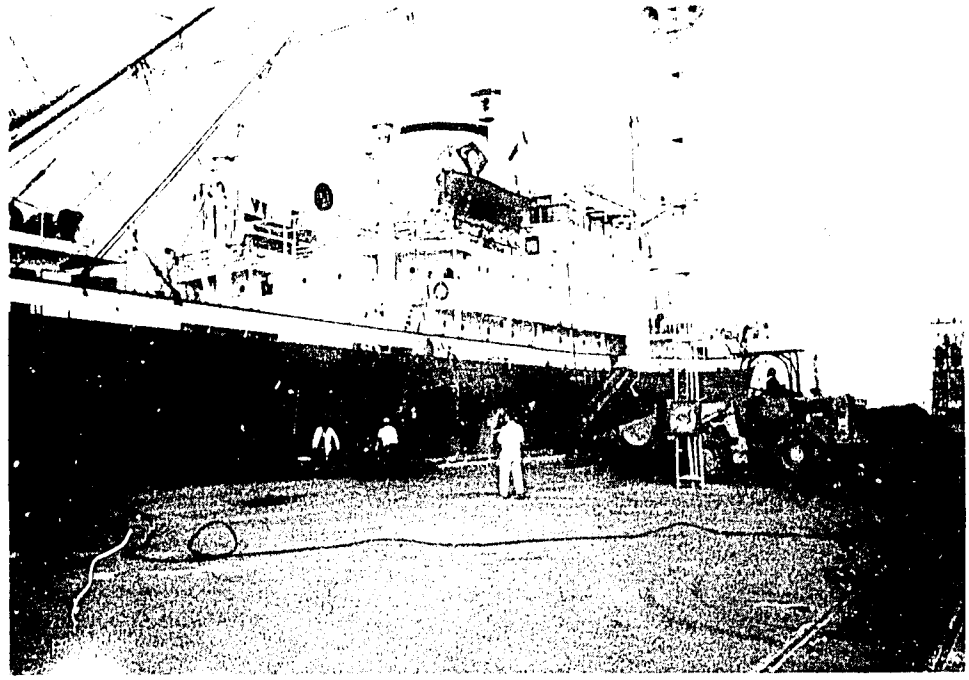


PHOTO 3 – Salaverry – Loading of ıineral concentrate at mineral berth.

PHOTO 4 – Salaverry – Loading skip with front end loader.

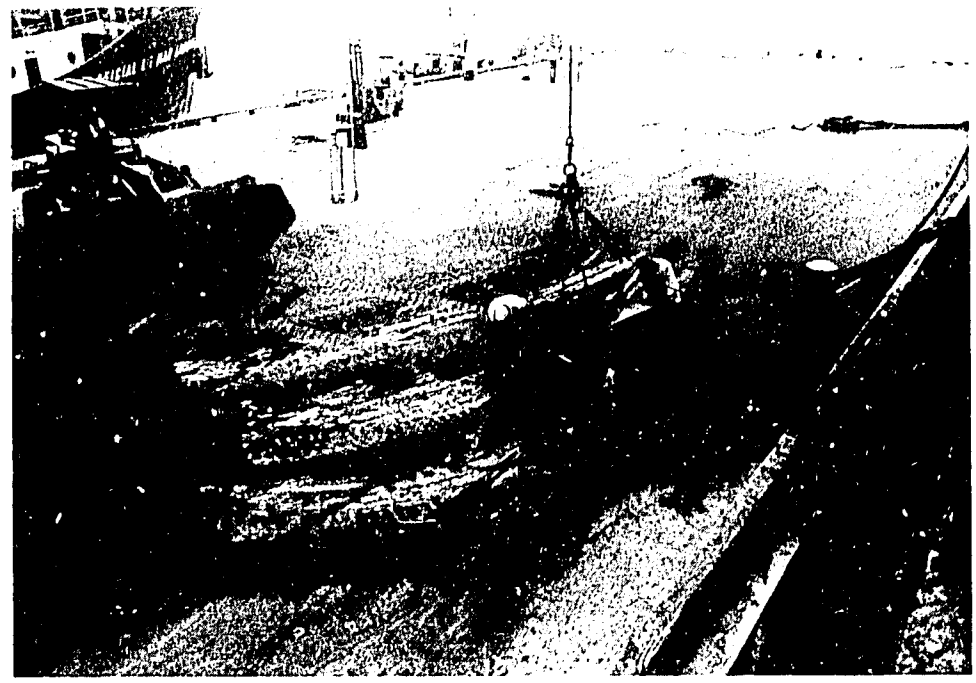


PHOTO 5 — Salaverry — Adjusting skip after spill.

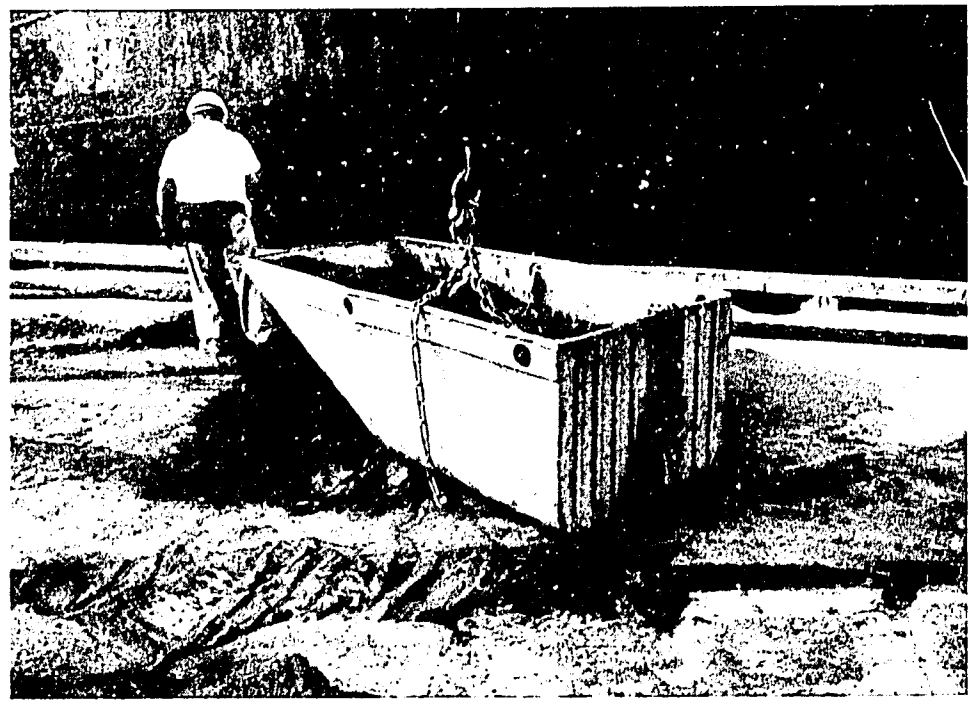


PHOTO 6 — Salaverry — Close up of skip used to load mineral concentrate.

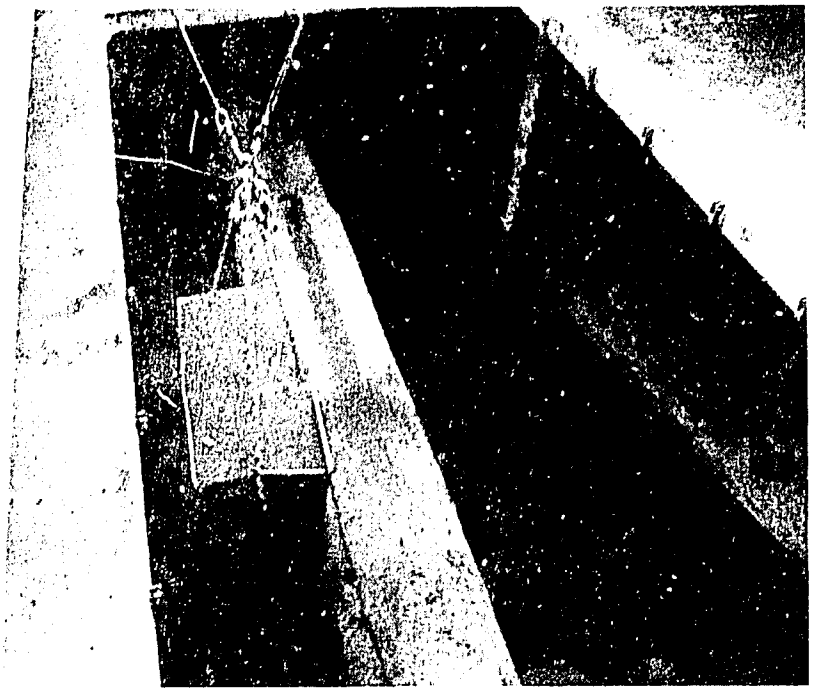


PHOTO 7 – Salaverry – Lowering skip into hold with ship's gear.

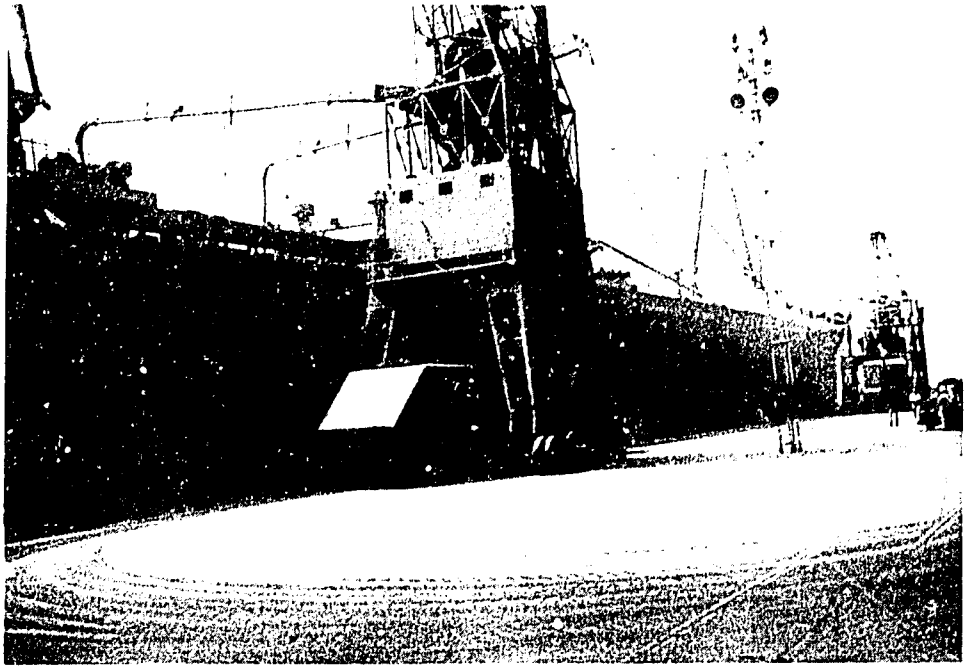


PHOTO 8 – Salaverry – Grain being unloaded utilizing mobile ship unloaders.

PHOTO 9 – Salaverry – Unloading grain at mineral berth. (Observe narrow width of Pier.)

3. LOSSES

Losses are a significant problem at all of the ports under study due to the high value of the mineral products. Losses occur at various points in the exportation process as follows:

(a) Between mine and deposit
(b) In the deposit yard
  – Wind loss
  – Theft
(c) Between deposit and port
(d) During ship loading
(e) Between port of origin and port of destination

In the case of Salaverry, all materials are brought to Salaverry directly from the mines, and MINPECO takes possession of the material at whatever weight is recorded on the scale in the deposit yard. Thus, any loss prior to that point represents a loss to the mining companies and indirectly to MINPECO. Losses within the deposit yards have not been measured by MINPECO at any deposit location and are estimated by MINPECO personnel to be low – from insignificant to two percent.

In Salaverry, the height of some of the mounds of concentrates exceeds the height of the perimeter security wall surrounding the deposit, allowing an unquantifiable amount of material loss by wind. This loss can be observed on a windy day and occurs despite efforts to prevent it (such as wetting the mound of concentrate to increase the moisture content and form a surface crust).

Losses due to theft from the Salaverry deposit have not been observed and also cannot be quantified; however, the possibility certainly exists for relatively easy theft of valuable concentrates or minerals. The wall surrounding the deposit could be scaled and materials removed; in addition, portions of the wall are open and subject to easy pilferage.

Material loss during ship loading and transport to destination occurs from wind loss, spillage, loss in the vessel and loss during unloading. MINPECO pays for the first one percent lost during these operations; the additional loss, if any, is covered by MINPECO's insurance. Loading loss is the only portion of this process which could be controlled to some extent by MINPECO. Again, however, loading loss at Salaverry cannot be accurately

quantified based on existing data, although it is clear that some wind loss on the pier is inevitable due to the method and rate of loading. Much of the considerable amount of concentate that is spilled during the loading of the skips is reportedly later swept up and salvaged as part of the shipment. Photos 1, 4, 5 and 6, included previously, show extensive spillage of concentrate on the pier during the observed loading operation.

The issue of material losses is addressed in Chapter Six of this report as a company-wide problem, not particular to any one location or operation. In Salaverry, however, some specific steps could be taken to minimize the losses. Alternatives include limiting the height of the stockpiles to match the height of the walls surrounding the deposit yard. Additional theft protection such as a wire fence at the top of the wall would provide extra security. In addition, in at least one location a break in a permanently closed gate in the wall allows concentrates to spill through to the outside. This amount will almost certainly be lost. Reinforcement of the gates or construction of a permanent wall (removal of the gates) would contain this spillage.

Any loss occurring at the pier is primarily a function of the loading methodology and the length of time required for loading. This problem would be greatly reduced if the loading improvements discussed earlier were to be implemented.

4. DEPOSIT YARD CAPACITY

Existing capacity of the Salavery deposit storage yard is estimated by MINPECO personnel at 14,000 MT of materials. This figure cannot be precisely quantified, as the presence of various types and qualities of minerals and concentrates is constantly changing and necessitates storage of materials in numerous separate mounds of varying size. In late May 1980 the quantity of materials stored was 12, 983 MT, broken down as follows:

TABLE 8

SALAVERRY DEPOSIT INVENTORY
MAY 1980

Material	Inventory (MT)
Lead Concentrate	1,978
Zinc Concentrate	9,412
Copper Concentrate	517
Lead/Silver/Gold Mineral	1,076
TOTAL	**12,983**

SOURCE: Department of Operations, MINPECO.

Since Salaverry does not ship mineral ore, but trucks it to Callao, the deposit held a net 11,907 MT of "shippable" material (i.e., concentrates). This total is slightly higher than MINPECO's stated preference of keeping approximately two month's shipment available in the depos' In 1979 MINPECO shipped an average of 4,400 MT/month from Salaverry. Current storage thus represents approximately 2.7 months of shipments.

The basic projected throughput of the Salaverry yard (see Figure 3) indicates a steady increase of throughput up to the year 1984 resulting in an increase in shipments from 4,400 MT/month in 1979 to 11,900 MT/month in the years 1984 through 2000, requiring a storage capacity of approximately 24,000 MT.

If the two percent or four percent scenario of compounded growth is assumed, however, these figures indicate that by the year 2000, the Salaverry deposit will be shipping an average of 16,300 MT/month (two percent) or 22,200 MT/month (four percent) requiring a storage capacity of 32,600 MT or 44,400 MT, respectively, to accommodate a two-month supply.

There are three basic alternatives for the solution of this problem:

a. Select a new deposit site large enough to meet MINPECO's needs to the target year 2000.

b. Expand the present deposit area to meet MINPECO's needs.

c. Reduce inventory.

These alternatives are discussed in the following subsections.

a. Select New Site

Three alternative new sites were identified and investigated for their potential to meet MINPECO's needs. These three sites are shown in Figure 4. Site 1 is located on the beach area (outside the port area) where the dredged spoil from the harbor is pumped; site 2 is the reclaimed area within the port across the road from the sugar warehouse; site 3 is also in the port area behind the molasses holding tank. All three of these sites are available for MINPECO's use immediately, and all would require the construction of concrete slabs and perimeter walls as well as the other structures required for MINPECO's operation. Upon investigation, however, it was determined that all three sites present potential contamination problems with the sugar industry and to themselves from adjacent sand dune or beach areas, which virtually precludes their use for mineral storage and transport.

b. Expand Existing Deposit

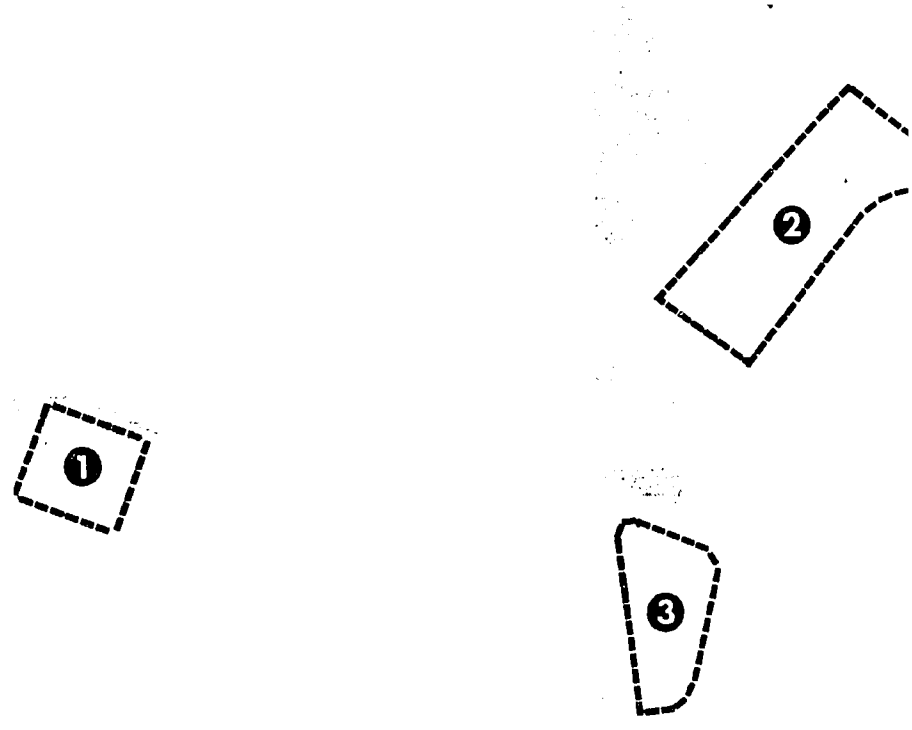
Expansion of MINPECO's existing facility could occur in two areas. Adjacent to the present yard are a coliseum and playground occupying approximately 1,800 m^2. If this area were to be acquired, MINPECO would have to compensate the Town of Salaverry by providing alternate playground facilities in the vicinity. For further expansion, MINPECO may be able to acquire the streets adjacent to the existing facility – particularly the street dividing the two portions of the existing deposit area (Pascamayo). See Figure 2 for deposit location and layout. These streets do not appear to be vital to the circulation patterns of the Town of Salaverry and could be closed without major disruption if adequate planning and coordination is maintained with Salaverry town officials. This alternative has the advantages of: (a) permitting operations to continue at the present deposit without interruption during the construction period, and (b) allowing MINPECO to continue using all the administrative and operational structures already in use. New construction would be limited to concrete slab and perimeter walls.

c. Reduce Inventory

If MINPECO is reluctant to acquire these areas, a third alternative is possible in the reduction of inventory held by the Salaverry deposit. Instead of keeping a two-month shipping inventory, Salaverry could lower their storage requirements by holding only a 30-day or 45-day inventory.

Upon closer examination, based upon information acquired late in this study, none of the above solutions appear workable or appropriate[1]. The three sites originally evaluated are inappropriate due to either contamination problems with the sugar industry or contamination of minerals from the extensive amounts of loose, fine sand found on several of the potential sites.

[1]The original projections of throughput received for Salaverry indicated virtually no growth between 1979 tonnages and the year 2000. Thus, the existing deposit area would have had sufficient capacity to accommodate MINPECO's operations for the twenty-year time frame of this study. Taking into consideration the two percent and four percent compounded growth scenarios calculated on the no-growth basic projection, expansion of the existing deposit area would have been a very viable alternative. This is no longer the case, as the revised projections for Salaverry render this area inadequate to meet MINPECO's storage needs. Thus, the second phase of this study will address alternate locations for the construction of a new deposit area in Salaverry.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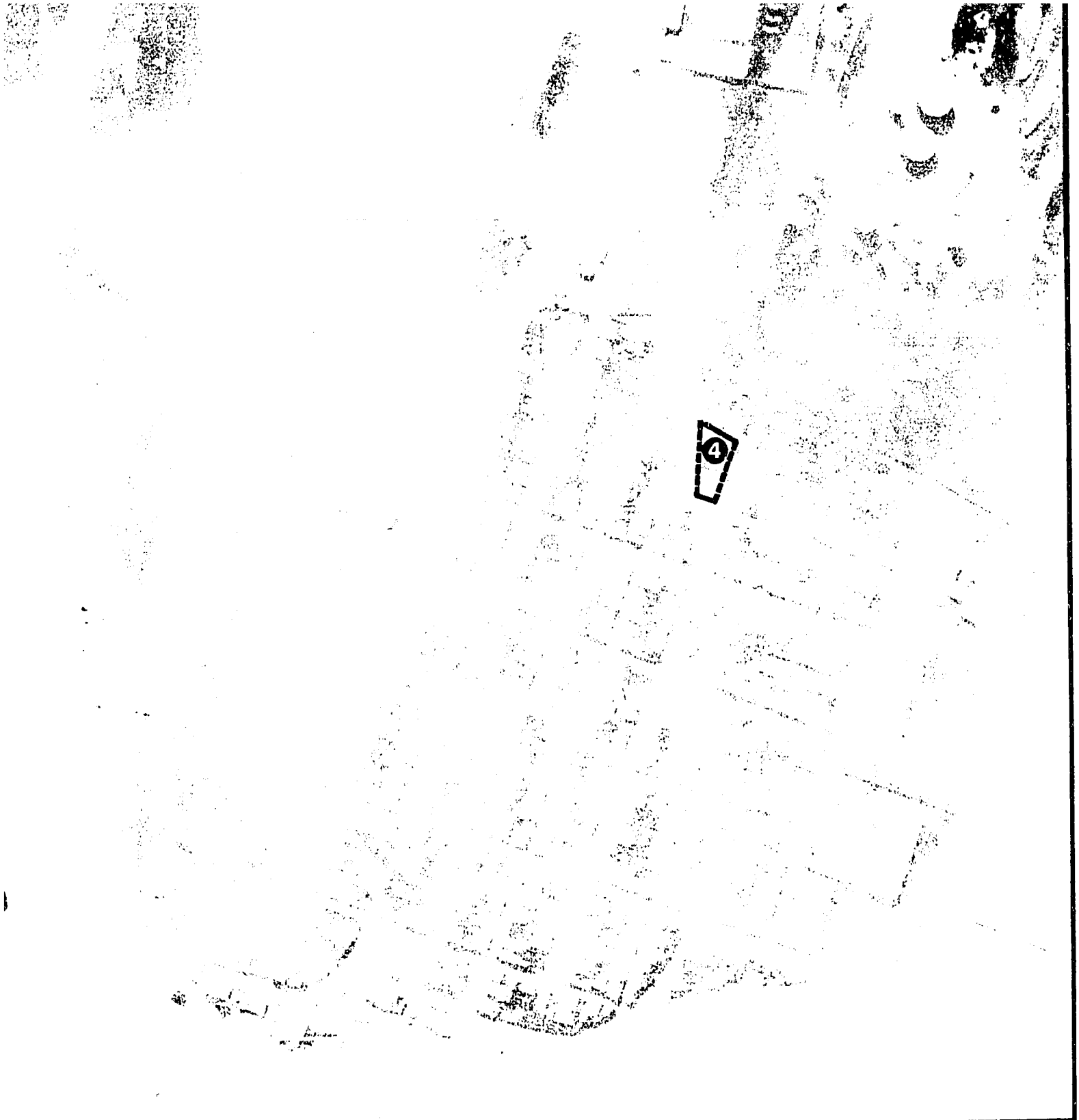


SCALE 1 : 5000

SOURCE: INSTITUTO GEOGRAFICO MILITAR LIMA, PERU

International Development Cooperation Agency
Trade and Development Program
MINPECO
ORE HANDLING IMPROVEMENTS

SALAVERRY

ALTERNATIVES

MAGUIRE
ARCHITECTS · ENGINEERS · PLANNERS

FIGURE 4

Expansion of the deposit area is no longer viable as it could accommodate only 19,400 MT even if fully expanded into the surrounding streets. The basic projection at Salaverry requires storage for 24,000 MT, with considerably more required for the two percent and 4 percent compounded growth scenarios. Reduction of inventory to less than a two-month supply does not seem to be an appropriate solution in light of the fact that Salaverry is served by a number of mid-sized and small mining companies, and one month may not be enough accumulation of any one material for an exportable shipment.

5. MINPECO OPERATING PROCEDURES

Although some company-wide operating procedures which are common to all the deposit areas under study are discussed later in Chapter Six of this report, several problems relevant only to Salaverry are discussed here.

a. Mineral Shipping To Callao

At the present time, all mineral ores are trucked from Salaverry due mainly to the relatively low quantity received at that deposit. Minerals received at Salaverry are sampled, bagged and shipped to Callao. Although no problem is seen with this basic operation, a number of improvements could be made to the procedures involved which would save time and money. Alternatives include palletizing the bags of minerals shipped to Callao; this would greatly decrease the amount of handling necessary to process the minerals. Handling of mineral ores is discussed as a company-wide issue in more detail in Chapter Six.

b. Equipment Maintenance

At the time the study team observed operations at the Salaverry deposit in May 1980, two of the three front end loaders had been non-operational since late 1979. Photos 10 and 11 show the inoperable equipment. The closest servicing personnel to Salaverry are located in Lima, and machinery must be sent to Lima for major repair and overhaul. This problem is compounded by the fact that MINPECO maintains no inventory or replacement parts for minor repairs in Salaverry. As a result, rented front end loaders must be used for many operations to replace "down" equipment, thus increasing the deposit's operating costs.

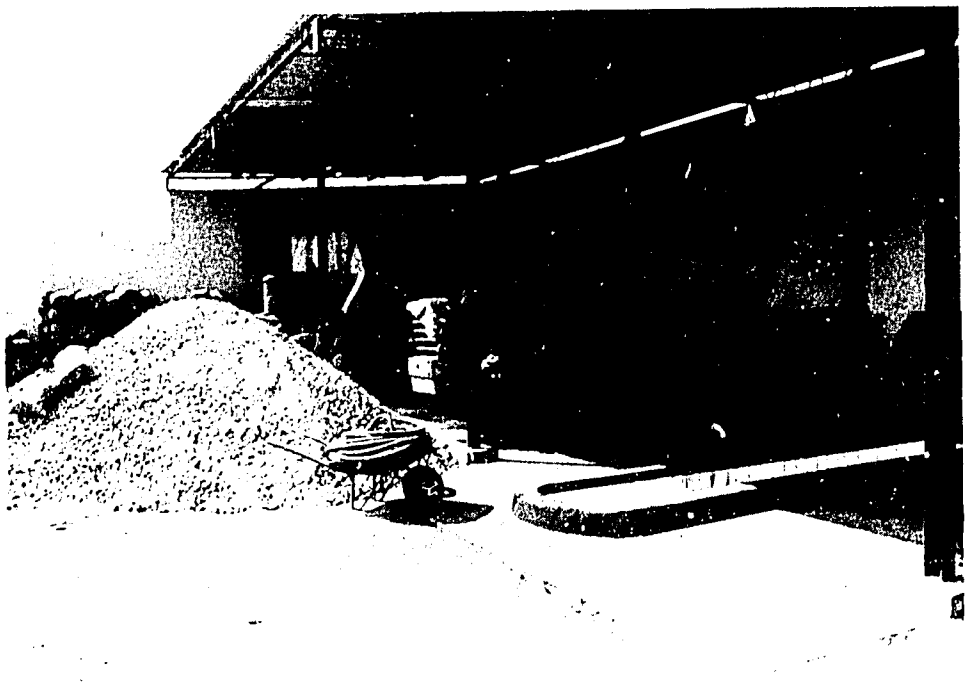


PHOTO 10 — Salaverry — Non-operational front end loaders.

PHOTO 11 — Salaverry — Maintenance area in deposit yard.

An inventory of vital parts in accordance with the equipment manufacturer's standards would reduce this problem. Purchase of new yard operating equipment should be scheduled if the present equipment is irreparable.

C. RECOMMENDED SOLUTIONS

1. RECOMMENDATION 1

The primary recommendation at Salaverry is purchase of a portable conveyor and shiploader for improved vessel loading. Such a system would significantly reduce loading time and, therefore, berth time of chartered vessels as well as reducing the amount of loss incurred during loading. Figure 5 shows a schematic drawing of a typical system, with more detailed information contained in Appendix E. The equipment illustrated and described in Figure 5 was selected in part because it can be utilized on the narrow mineral pier. An additional advantage of this equipment is that it is portable and could conceivably be utilized at another port, such as Chimbote or Callao.

When not in use the entire system would be stored off the pier in the port area, then moved into position when a mineral ship is ready for loading. The hopper of the conveyor would be fed by front end loaders; the conveyor in turn would feed the shiploader which would deposit material into the hold of the vessel. Maximum loading rate for this recommended system is 1,200 MT/hour, although the rate would be limited by the rate at which the hopper can be fed by front end loaders. Working capacity of the system is estimated at approximately 350 MT/hour. Cost of the proposed conveyor and shiploader is estimated at $305,000 with an additional cost of $59,000 for shipping and installation.

As mentioned above, use of the recommended conveyor and loader system would result in a reduction in total berthing costs borne by MINPECO at Salaverry and a reduction in material losses. Based on the assumption that vessel and shipment sizes will remain approximately the same as at present, savings to MINPECO in berth time and cost would be as presented in Table 9.

TABLE 9

REDUCTION IN BERTHING COSTS FOR MINERAL EXPORT SHIPS
SALAVERRY

Year[1]	Berth Days Saved	Cost Saved
1982	58 days	$ 30,000
1983	66	34,000
1984 - 2000 (17 years)	74	654,000[2]
TOTAL SAVINGS OVER STUDY PERIOD		$718,000

SOURCE: Data from ENAPU Peru, MINPECO and calculations by CE Maguire, Inc.

[1]Assumes equipment will be in palce by 1982.

[2]38,500/yr. x 17 years = $654,000

The considerable losses observed by the study team during loading could also be reduced by use of the proposed equipment. Estimated savings by use of an automated system are estimated at 0.5 percent. Actual savings may be considerably higher; however, for this analysis a conservative figure for savings has been used. Based on export projections and estimated 1980 mineral prices provided by MINPECO, reduction of losses by 0.5 percent by use of a conveyor - loader could amount to considerable annual savings as shown in Table 10.

TABLE 10

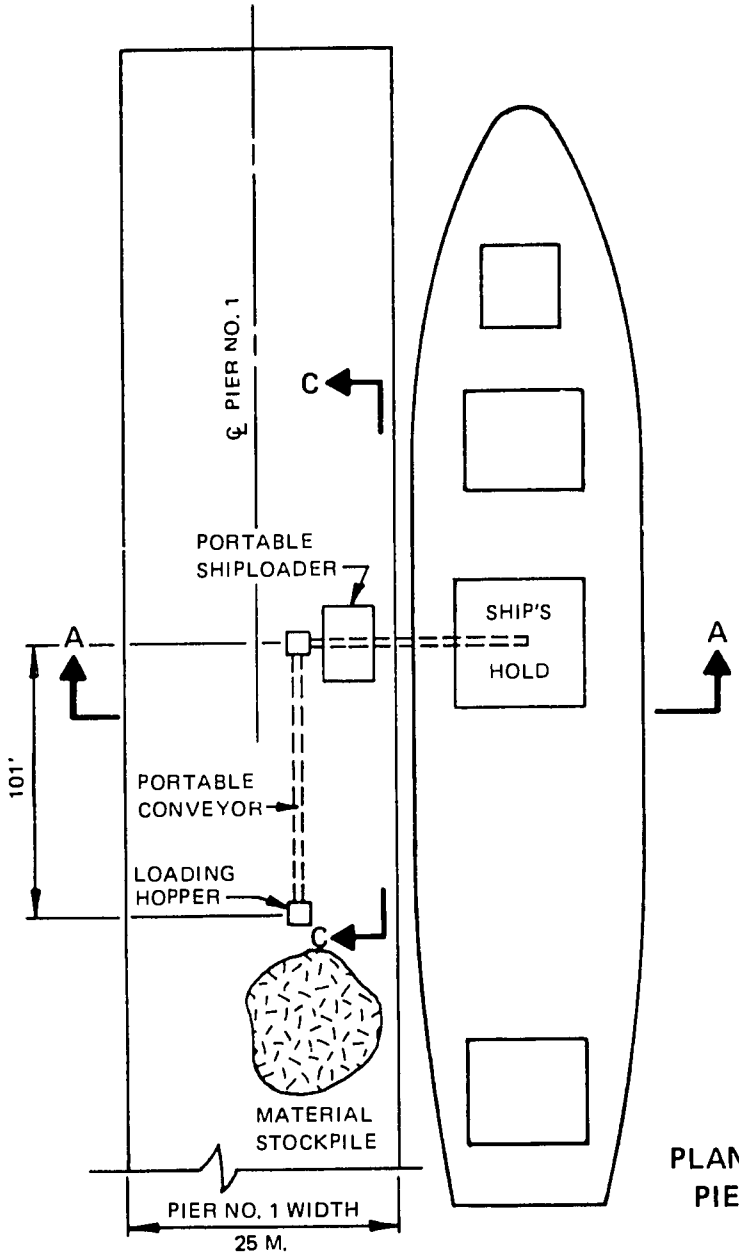
REDUCTION IN LOSSES DUE TO IMPROVED LOADING METHODS
SALAVERRY

Year[1]	Cost Savings
1982	$ 239,000
1983	271,000
1984 - 2000 (17 years)	5,158,000[2]
TOTAL SAVINGS OVER PROJECTED PERIOD	$5,668,000

SOURCE: Data from MINPECO and calculations by CE Maguire, Inc.

[1]Assumes equipment in place by 1982.

[2]$303,400/yr. x 17 years = $5,158,000.



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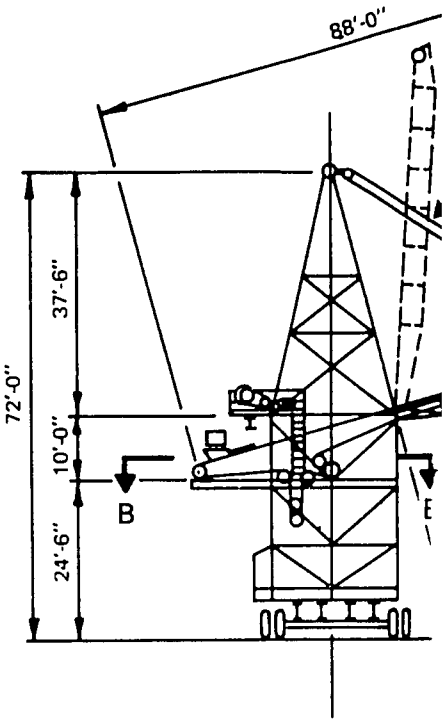
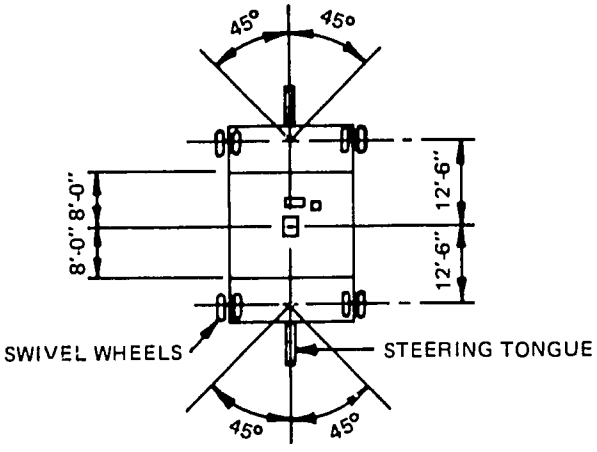
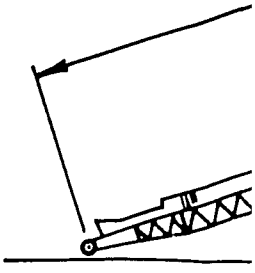




SECTION B-B



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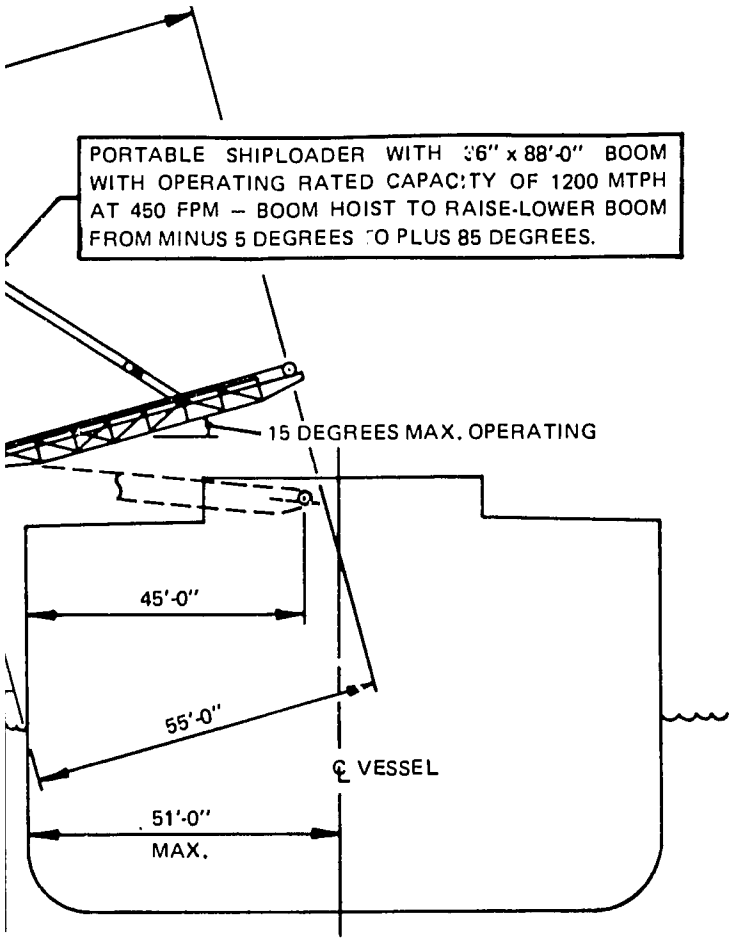


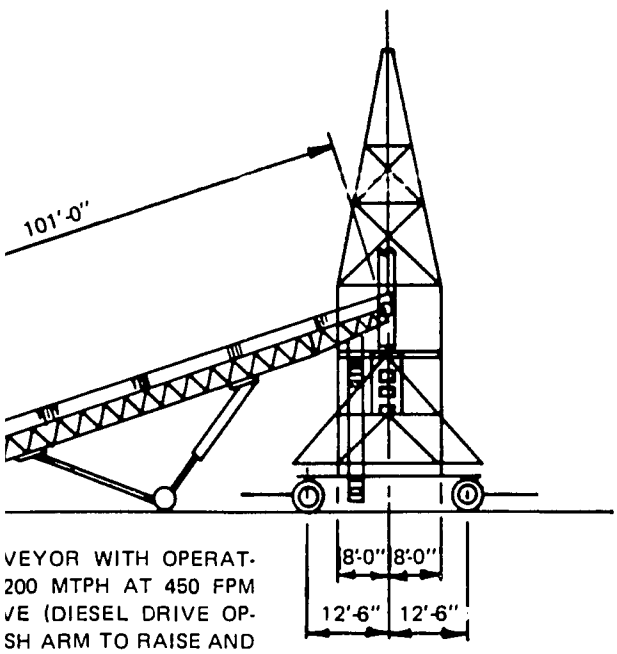
SECTION A-A

NOTE:
CONVEYOR FED BY FRONT END LOADER TYPE EQUIPMENT FROM STOCKPILE ON PIER SURFACE PAVEMENT.

PORTABLE SHIPLOADER SHOWN HERE CAN ALSO BE EMPLOYED ON PIER NO. 5 AT PORT OF CALLAO.

ALL DIMENSIONS SUBJECT TO CHANGE TO MEET FINAL DESIGN AND OPERATING CRITERIA.

*EQUIPMENT INFORMATION COURTESY OF BARBER-GREENE CO., AURORA, ILLINOIS, U.S.A.



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VIEW C-C

SALAVERRY
PROPOSED
PORTABLE SHIPLOADING EQUIPMENT

FIGURE 5

All initial costs, operating costs and operating savings are summarized later in this chapter in Table 12.

2. RECOMMENDATION 2

The second recommendation at Salaverry concerns location of an expanded MINPECO deposit yard. The recommendation is to relocate the MINPECO operation to a larger, more appropriate site, preferably closer to the port. For a variety of reasons, none of the original three sites investigated for MINPECO are appropriate. Therefore, this issue must be readdressed in the ensuing phase of this study.

3. RECOMMENDATION 3

Another problem faced by MINPECO at Salaverry is the lack of spare parts and experienced maintenance personnel for its yard equipment, particularly the front end loaders. At present, MINPECO must rent front end loaders and pay a rental cost as well as a transport charge to bring the equipment to the yard. Based on information provided by MINPECO, it costs $23.00 per hour for a small front end loader.

It is recommended that MINPECO purchase two front end loaders[1] and one forklift[2] for use in the Salaverry deposit yard. The front end loaders can also be used to load the hopper of the portable conveyor on the mineral pier. Costs for this equipment appear in Table 11.

TABLE 11

MOBILE EQUIPMENT COSTS
SALAVERRY

2 Front End Loaders at $122,000	$244,000
1 Forklift at $31,000	31,000
Shipping Costs	13,000
TOTAL COSTS	**$288,000**

SOURCE: International Liaison Office of Caterpillar; various other suppliers and shippers.

[1]Caterpillar Model 966 (See Chapter Six and Appendix F for specifications).

[2]Caterpillar Model V-80-D (See Chapter Six and Appendix F for specifications).

Operating and maintenance costs for the front end loaders are estimated at $28.00 per hour. This compares favorably with the cost of over $47.00/hour for renting a similarly sized front end loader in Callao. The rental costs for front end loaders at Salaverry provided by MINPECO are artifically low ($23.00/hour) as they apply to a smaller machine than the recommended equipment. These smaller machines would have to be rented for a longer period of time to move a corresponding amount of material and would not properly feed the conveyor hopper at a rate adequate to maintain the proposed loading rate of 350 MT/hour.

4. RECOMMENDATION 4

With regard to other problems at Salaverry harbor, turbulence and shoaling are the responsibility of ENAPU Peru. The shoaling problem is presently being studied, and ENAPU Peru has indicated that they will purchase a larger dredge and widen and deepen the channel later this year. These measures will only be interim, however, and it is recommended that MINPECO encourage ENAPU Peru to consider extending the existing breakwater as well.

It is also recommended that MINPECO urge ENAPU Peru to purchase and install an energy absorbing fender system and a tension winch system to reduce the problems caused by wave action in the harbor. Extension of the breakwater may also reduce the wave action, but installation of adequate fender and tension winch systems are needed to prevent damage to vessel hulls and the pier structure. Schematic diagrams and additional information regarding typical systems are shown in Appendices C and D. Costs for installation of these types of systems are not included here as they are not the responsibility of MINPECO and should be recommended to ENAPU Peru.

MINPECO should coordinate these proposals with ENAPU Peru officials to insure that the improvements to the harbor do not impact adversely on shipping schedules. More importantly, if costs of proposed improvements become too exorbitant for ENAPU Peru and relocation of the Port of Salaverry is considered, MINPECO will need to review and modify their total operations in the northern Departments of Peru.

5. COST ANALYSIS

Table 12 contains a summary of costs and savings that will result from implementation of the recommendations discussed above. These figures are based on a comparison of costs incurred under proposed operating methods versus continuing to operate as at present; 1981 is used as a starting point for the analysis, since it is unlikely that any of the recommendations could be implemented prior to that time.

Capital costs begin in 1981 with the purchase of two front end loaders and a forklift truck, costs of which are shown previously in Table 11. Life of the front end loaders is estimated at 10,000 hours. Thus, with an annual usage rate of 1,500 hours, these units would require replacement after approximately seven years. The life of the forklift truck is estimated at ten years, based on an annual usage rate of 500 hours and an operating life of 5,000 hours. Purchase, shipping, and installation costs for the conveyor and shiploader are estimated to occur in 1982, assuming that the equipment could be designed, purchased, shipped, and assembled by that time. Life of the conveyor and shiploader is estimated at 25 years; thus, no replacement costs are included during the time frame of this study.

Additional annual costs include maintenance and operation of the equipment and charges for storing the conveyor and loader in the port area. Labor costs for MINPECO personnel associated with operation of the equipment are not included, since it is assumed that labor costs will remain constant or decrease as the recommendations are implemented.

Resultant annual savings include savings in reduced losses and berth time, as shown previously in Tables 9 and 10. Savings also include reduced operating costs, based on reduction or elimination of some of the charges shown in Table 7. Savings will occur through use of MINPECO equipment, rather than leased equipment, for loading of both trucks at the deposit area and the conveyor system at the port. Costs associated with operation of MINPECO-owned equipment are included in the additional annual costs.

No attempt has been made in this analysis to include revenues that could accrue to MINPECO through the rental of the proposed equipment to other users. A potential source of income does exist in rental of this equipment, but it is difficult to quantify.

TABLE 12

SUMMARY OF COSTS AND SAVINGS
SALAVERRY

Year	Capital Costs[1]	Additional Annual Costs[2]	Resultant Annual Savings[3]	Net Annual Savings	Cumulative Savings	Remarks
1981	$288,000	$ 88,000	$163,000	$-213,000	$ -213,000	Purchase two front end loaders, and a forklift truck
1982	364,000	99,000	451,000	-12,000	-225,000	Purchase portable conveyor and ship-loader
1983		99,000	513,000	414,000	+189,000	
1984		100,000	542,000	442,000	631,000	
1985		100,000	542,000	442,000	1,073,000	
1986		100,000	542,000	442,000	1,515,000	
1987		100,000	542,000	442,000	1,957,000	
1988	255,000	100,000	542,000	187,000	2,144,000	Purchase two replacement front end loaders
1989		100,000	542,000	442,000	2,586,000	
1990		100,000	542,000	442,000	3,028,000	
1991	33,000	100,000	542,000	409,000	3,437,000	Purchase replacement forklift truck
1992		100,000	542,000	442,000	3,879,000	
1993		100,000	542,000	442,000	4,321,000	
1994		100,000	542,000	442,000	4,763,000	
1995	255,000	100,000	542,000	187,000	4,950,000	Purchase two replacement front end loaders
1996		100,000	542,000	442,000	5,392,000	
1997		100,000	542,000	442,000	5,834,000	
1998		100,000	542,000	442,000	6,276,000	
1999		100,000	542,000	442,000	6,718,000	
2000		100,000	542,000	442,000	7,160,000	

[1] Includes purchase, shipping, and assembly of equipment.

[2] Refers to additional costs incurred as a result of purchase and operation of recommended capital improvements; includes operating, maintenance, and storage costs.

[3] Refers to savings resulting from purchase and operation of recommended capital improvements; includes reduced operating costs, berth times and material losses.

CHAPTER THREE

Chimbote

A. EXISTING OPERATIONS

1. SETTING

The Port of Chimbote is located in the City of Chimbote, Department of Ancash, along the northern coast of Peru, approximately 130 km southwest of Trujillo. The port is a natural harbor at the north end of Ferrol Bay, protected by islands which form the two entrance channels. Figure 1 in Chapter One illustrates the regional location of the port.

As shown in Figure 6, Chimbote has three piers. Piers 1 and 2 were built in 1945 and were managed privately until ENAPU Peru took over port administration in 1970. Pier 3 was constructed in 1968 principally to serve the shipping requirements of SIDER Peru[1]. Pier 1 is used for fishmeal, minerals and general cargo; this pier operates on a first-come, first-served basis, and has two berths. The port authority is restricted by the environmental council and does not allow loading of minerals and fishmeal to occur simultaneously, due to potential contamination problems. Pier 3 is owned by SIDER Peru for the import of iron ore pellets; when not being used by SIDER Peru the two berths at Pier 3 are available for general cargo vessels. Pier 2 is not sufficiently large for ocean-going cargo vessels and is used primarily for smaller volume intercoastal shipping. General layout of the port and vicinity is shown in Figure 6.

2. OPERATIONS

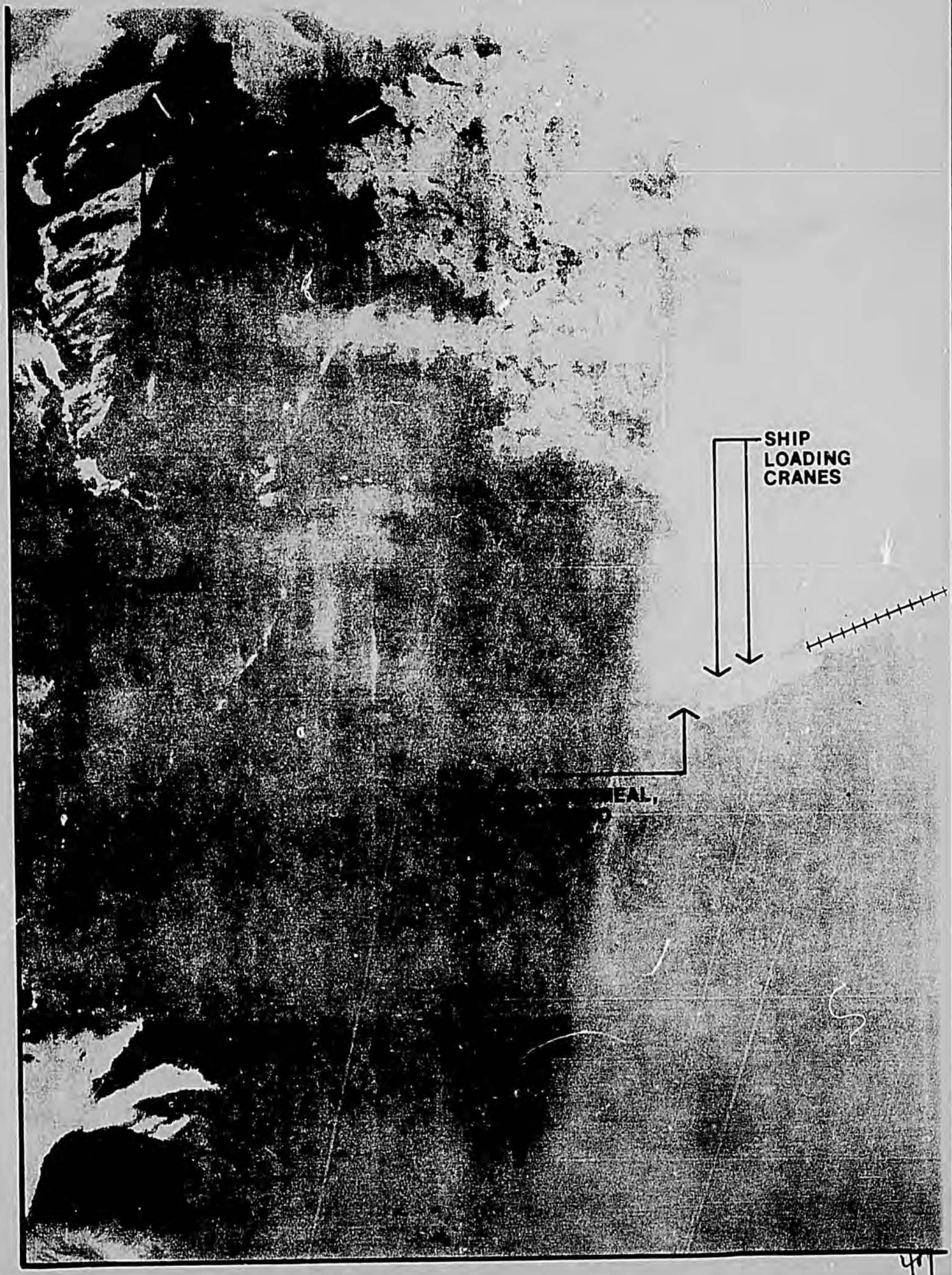
MINPECO operations at Chimbote are minimal at present, as only two mineral shipments have been made to date. The first shipment in late February 1980 consisted of approximately 8,000 tons of copper concentrate, and the second shipment in late May was approximately 5,900 tons of the same material. The copper is mined by the Mina Aguila mining company, then concentrated and trucked to Chimbote where it is stored for shipment at an area within the port. The present storage area used by MINPECO is also shown in Figure 6. Trucks arriving with copper concentrate are unloaded manually by Mina Aguila personnel. MINPECO employs no personnel and owns no equipment at Chimbote at the present time.

[1]SIDER Peru is Peru's national steel company.

Since the deposit yard is located within the port, MINPECO must pay ENAPU Peru for storage of all material; as indicated previously in Table 3, the first 15 days of storage are free, the next 30 days are at a rate of $0.01/ton/day, and each additional 30 day period is at a rate double that of the previous 30 day period. Because the copper concentrate contains quantities of sulfur, it is subject to spontaneous combustion and cannot be shipped at temperatures above 30 degrees C. Several days prior to the scheduled arrival of a vessel, employees from the Salaverry deposit yard travel to Chimbote and move the concentrate around within the storage area to aerate the material and cool it. Rented front end loaders are used for this operation. The concentrate is also dampened to bring the moisture content to the required level for shipping (eight percent) and to aid in the cooling process. During the interim period between the shipments, the concentrate is inspected periodically for temperature and moisture by personnel from Mina Aguila. Prior to the May 1980 shipment, temperature of the concentrate had reportedly risen as high as 63 degrees C.

Movement of concentrates to the pier for shipment is accomplished by an internal railroad system within the port area. ENAPU Peru at Chimbote has approximately 37 gondola cars and two small engines for this purpose. Typical gondola cars at Chimbote are shown in Photos 12 and 13. The cars are generally divided into three trains of 12, 12 and 13 cars each and shuttled between the deposit yard and the berth by the two engines. Two front end loaders are used to load the gondolas from the stockpiles. The train is pulled to the weighing station, where the cars are weighed in groups of four or five, then to the berth, where two cranes are used to lift the gondolas from the cars and lower them into the ship's hold(s) where they are opened and dumped. Only side B of Pier 1 (the north side) is used for loading of minerals, as it is the only berth serviced by the cranes (see Photo 14). Approximately 100 tons/hour can be loaded. ENAPU Peru charges MINPECO $0.60/ton for loading.

The projections of future throughput at Chimbote, presented in Table 4 in Chapter One and illustrated graphically in Figure 7 on the following page, show no increase in volume after 1980 due to the fact that in that year the Aguila mines will reach their maximum production. In order to account for the possibility of growth which is not presently programmed, however, two additional projection scenarios have been added to the graph, representing compounded growth rates of two percent and four percent respectively. Although the recommendations later in this chapter are based on the original projections, the contingency for futher growth has also been taken into account.


SHIP
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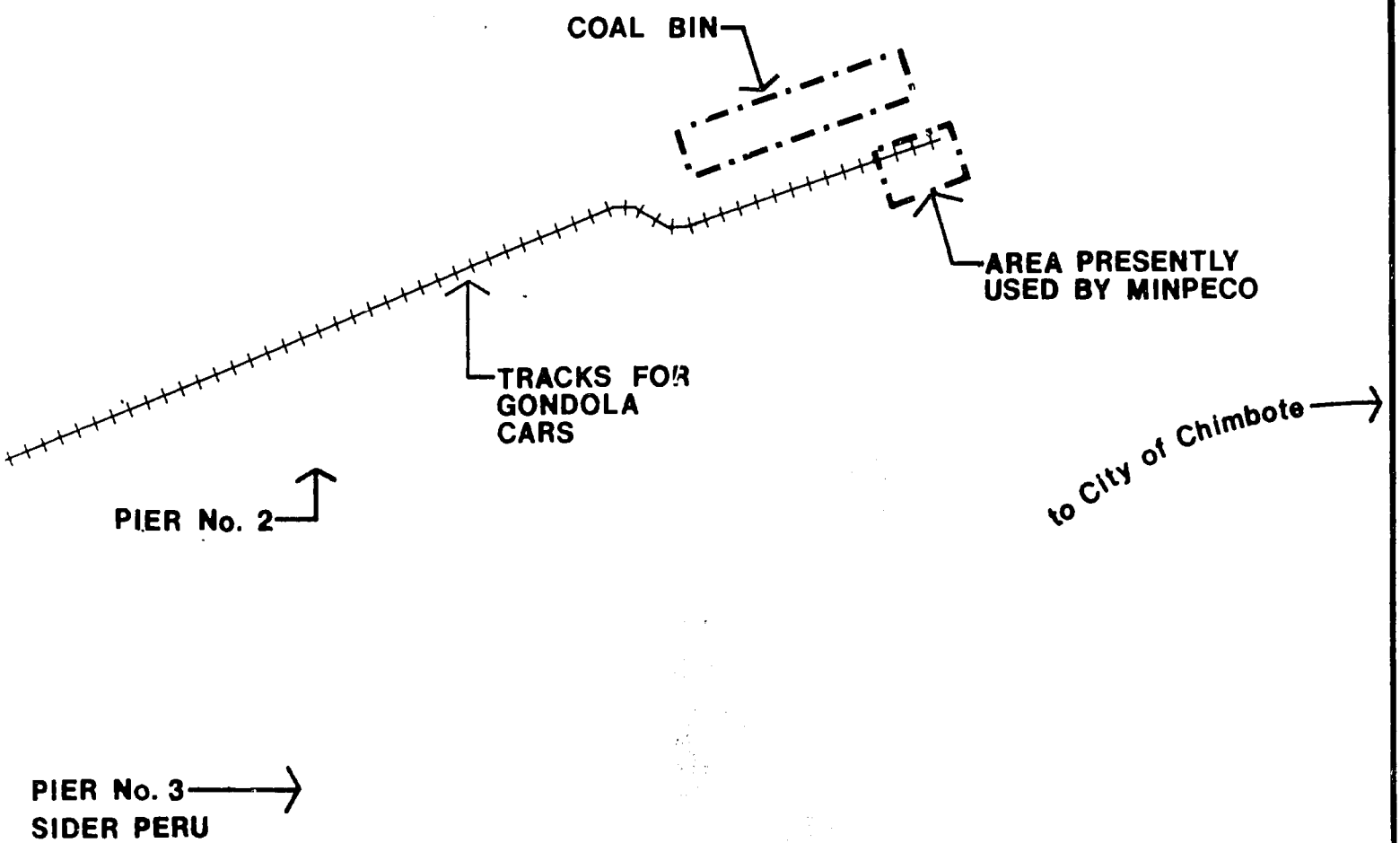


SCALE 1:5000

SOURCE: INSTITUTO GEOGRAFICO MILITAR LIMA, PERU

International Development Cooperation Agency
Trade and Development Program
MINPECO
ORE HANDLING IMPROVEMENTS

CHIMBOTE

EXISTING FACILITIES

MAGUIRE
ARCHITECTS · ENGINEERS · PLANNERS

FIGURE 6

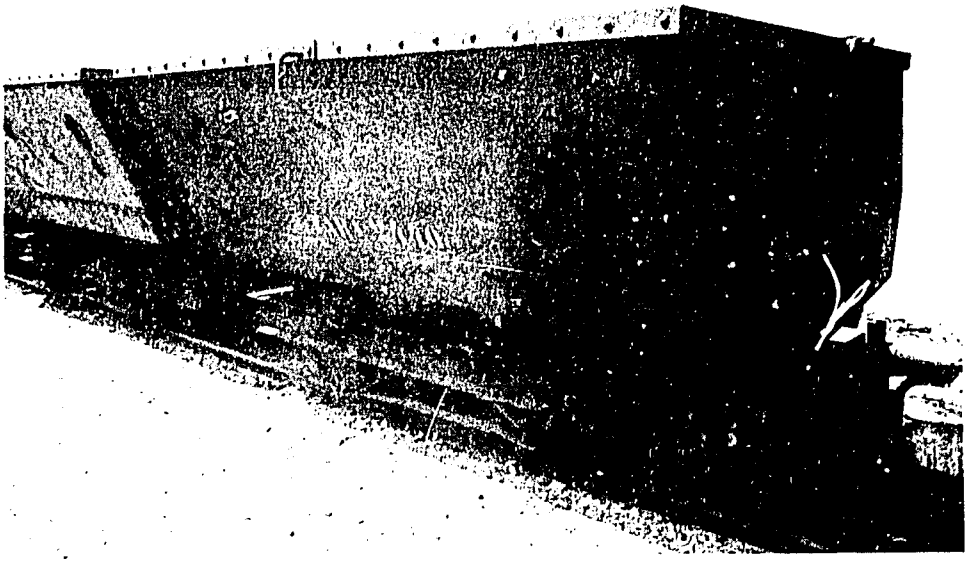


PHOTO 12 – Chimbote – Typical mineral gondola used at port.

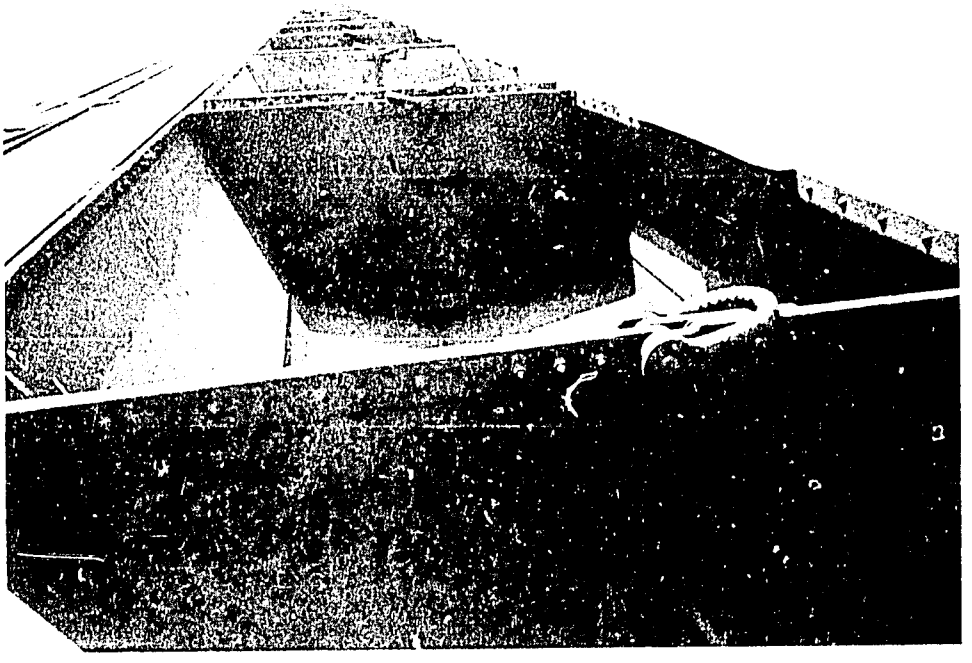


PHOTO 13 – Chimbote – Top of gondola cars showing lifting rings.

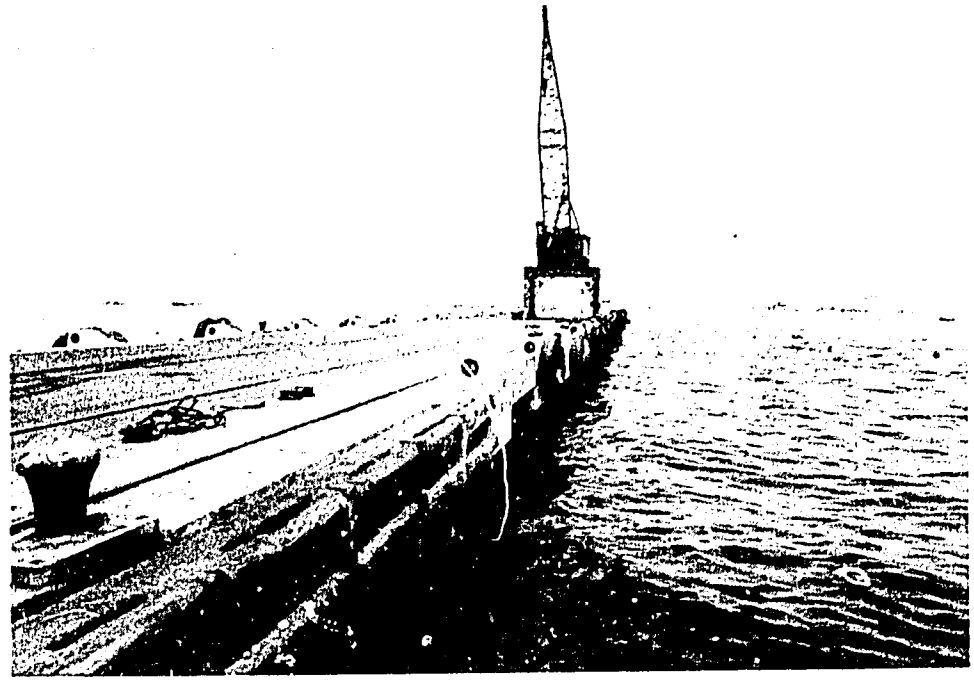
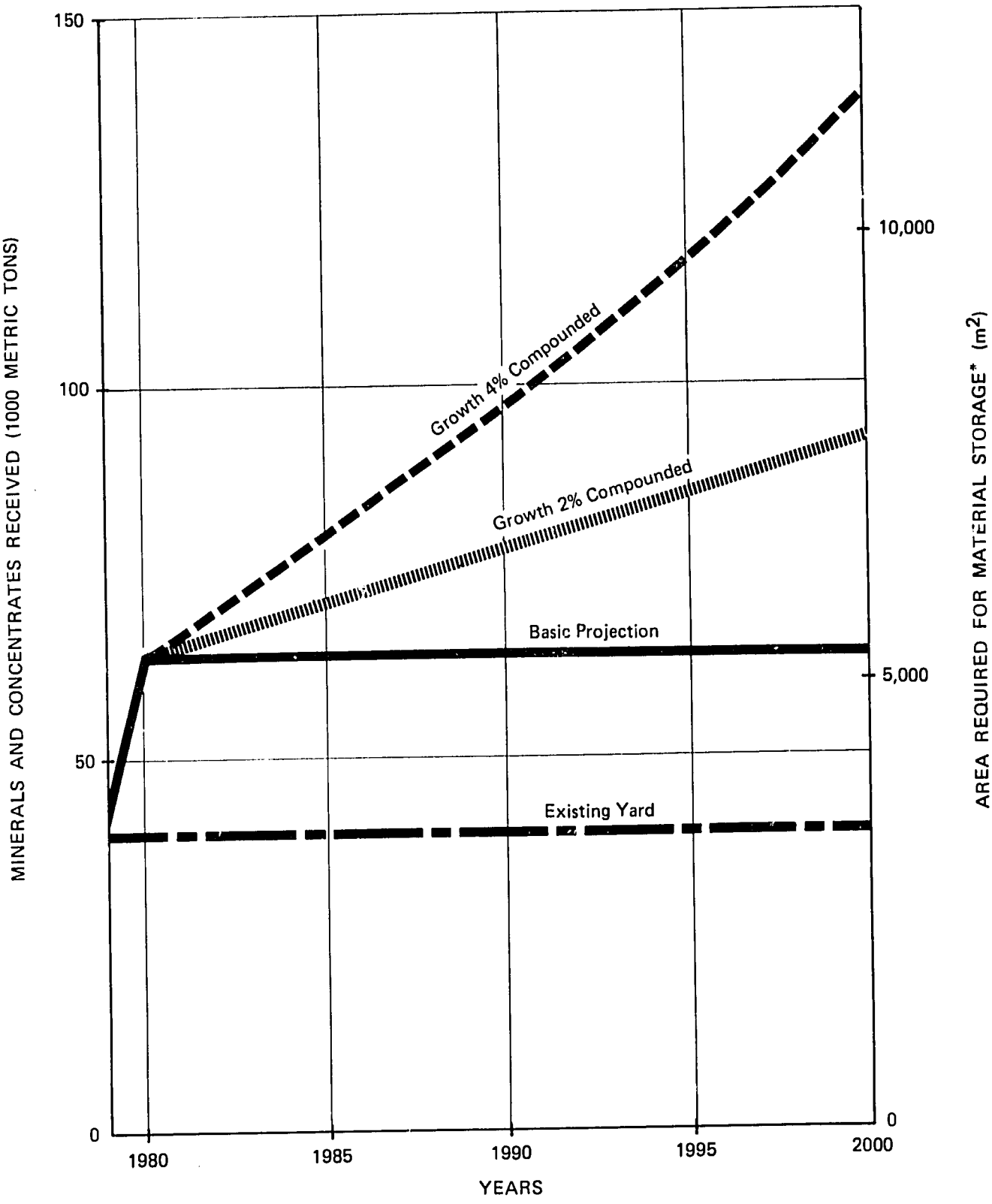


PHOTO 14. — Chimbote — Mineral pier - note ship loading crane and lack of fender system.



PROJECTED THROUGHPUT AND STORAGE AREA REQUIRED
CHIMBOTE DEPOSIT YARD

*Area for administration, scales, laboratory, etc., not included.

FIGURE 7

B. POTENTIAL PROBLEM AREAS AND ALTERNATIVE SOLUTIONS

1. PORT LIMITATIONS

a. Berth Occupany

As discussed previously there are two piers at Chimbote of sufficient length to allow berthing of vessels for export of minerals. Pier 1 with two berths is used for the export of fishmeal, general cargo and export of minerals; vessels are berthed on a first-come, first-served basis. Only one face of the pier can be used for loading of minerals because of the limited reach of the gantry cranes used for hoisting the gondolas. In addition, mineral loading cannot occur simultaneously with fishmeal loading due to the potential danger of contamination of the fishmeal, thus further limiting the total amount of time available for the export of minerals. The amount of time the pier is available for MINPECO's use is further limited by the fact that the port is generally closed a total of 10 to 15 days per year due to rough sea conditions.

Pier 3 is occupied by SIDER Peru and is used for the import of iron ore pellets, coking coal, coils, scrap metal, and alloys as well as the export of steel. SIDER Peru has primary rights for the use of Pier 3, although it can be used by others when not occupied by SIDER Peru.

As discussed in the chapter dealing with Salaverry, a berth occupancy rate in the range of 30 percent - 50 percent and a throughput of 66,000 MT/year - 132,000 MT/year are indications that a port is operating at optimal efficiency. At usage levels above these, operating efficiency is reduced and berthing delays can occur with increasing frequency.

During 1979 the berths at Pier 1 were occupied approximately 50 percent of the time, and approximatley 120,000 MT were handled at each of the general cargo berths. These figures indicate that the Port of Chimbote is operating at the upper end of the optimal utilization range. While MINPECO's minimal projected increases should not raise the rate above the optimal level, a combination of increases in the activities of MINPECO, SIDER Peru and the fishing industry could do so.

If the berthing space presently available is inadequate to meet the increasing demands of these three industries, there appear to be four possible areas in which additional berthing space could be acquired. The first is along the breakwater running perpendicular to the southeast of Pier 3. (All locations are indicated in Figure 8.) The area adjacent to Pier 3 is being filled and a pier or wharf could be constructed perpendicular to it. Two problems exist with this site: a) it is not apparent whether or not SIDER Peru would obtain rights to this berth (although that would depend on who paid for construction), and b) any material being stored on or loaded from the berth could be contaminated by dust from the unloading of iron ore pellets at Pier 3. (During this operation, a fine red dust settles over the area surrounding Pier 3.)

A second site would be in the area northwest of the port (also shown in Figure 8). Proposals have been made for expansion of the port into that area, and a berth could be constructed at that location. Development costs would be very high, however, and there is no indication that this expansion will take place in the foreseeable future.

The third alternative would be construction of a platform and mooring and breasting dolphins adjacent to the existing Pier 1 in the area of the pier causeway (see Figure 8). The dolphins would be located to provide adequate berthing length at a minimum cost.

The fourth alternative consists of the construction of a new pier or piers at the southern extreme of Ferrol Bay, a considerable distance from the existing Port of Chimbote. Two possible locations are shown in Figure 9. Development in this area is already being considered by ENAPU Peru.

In addition to the already high percentage of pier use, several other factors relating to port limitations or operations have the potential to inhibit the export of minerals from the Port of Chimbote. These are discussed in the following subsections.

b. Port Access and Harbor Turbulence

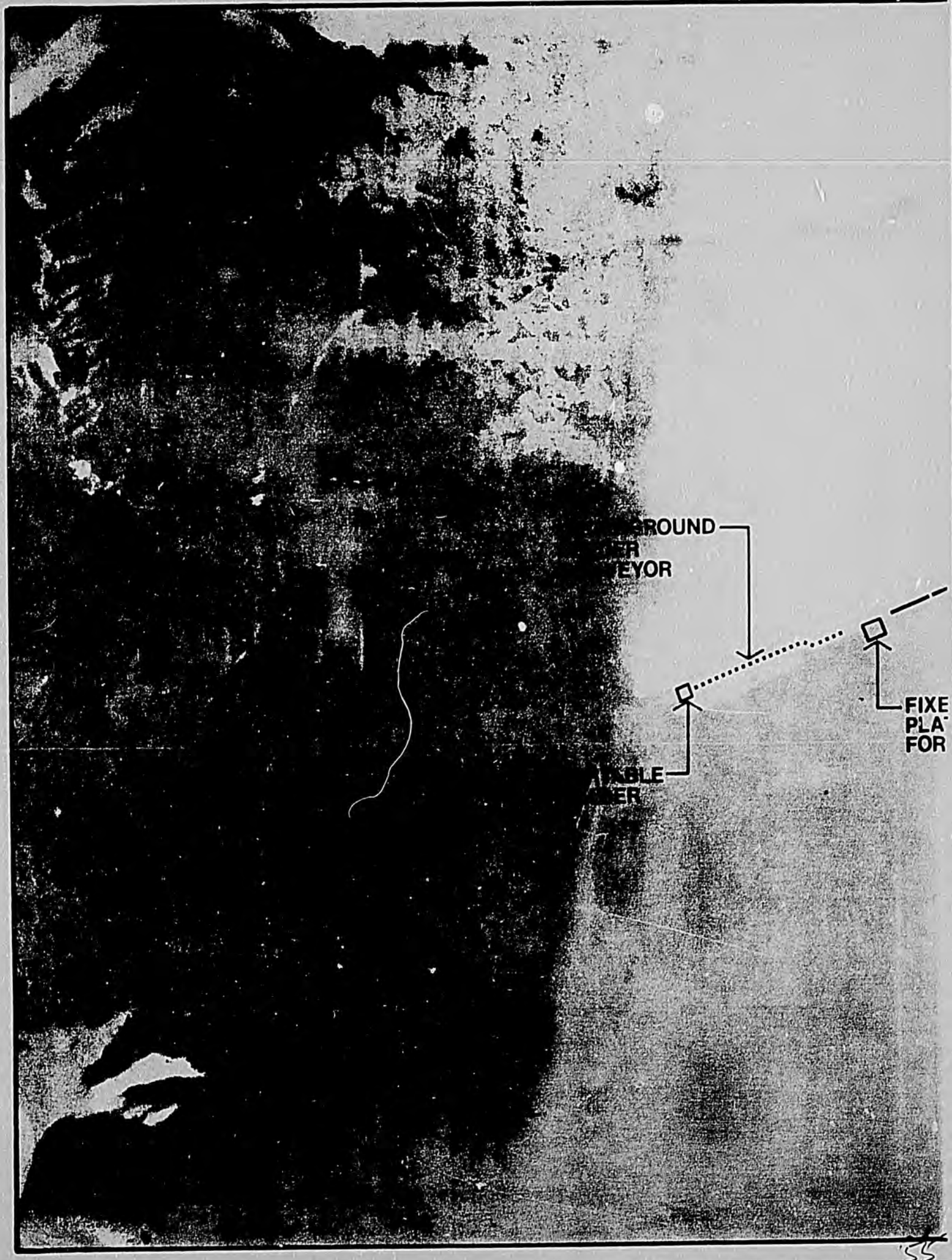
Access to the inner port area by large vessels is difficult due to a narrow channel approach from the north (see Figure 6) and a shallow approach from the south. Loaded ships must leave the port to the north due to the shallow conditions to the south. In addition, underwater currents occasionally make the narrow northern channel difficult to negotiate. The effect on MINPECO's operations is that the size and capacity of mineral-carrying vessels are limited by the channel depth restrictions and by the 30 foot berth depth at the piers.

At the present time, MINPECO's options in this matter are limited to discussions of the problem with ENAPU Peru and subsequent requests to that agency for port improvements. Dredging of the berths and channels would provide an improved operating situation, not only for MINPECO but for all users of the port.

Another problem experienced by port users at Chimbote is vessel exposure to wave action which becomes critical during certain months. The Port of Chimbote is generally closed a total of 10-15 days per year due to adverse sea conditions, mainly during April, May and June. In addition to interfering with the loading of mineral export vessels, this problem has the potential to damage both the pier and the vessel's hull plates.

A wave metering device is located at the end of Pier 1. According to port personnel, when wave conditions exceed 2-1/2 feet, the port is closed. The captain of any vessel in loading position during port closing has the option of stopping operations and moving his vessel off the pier if he considers that his vessel will sustain damage. It is understood that this action by vessel captains is common at Chimbote.

Truck and/or tractor tires are employed as pier fenders along both sides of Pier 1. As at Salaverry, this system cannot provide the degree of protection required to alleviate the problems of potential vessel or pier damage. A properly designed, modern, energy absorption fender system and constant tension mooring winches are needed to adequately solve this problem and to increase the ease, safety and efficiency of loading operations. These systems are discussed in detail in the Salaverry chapter and further detail is contained in Appendices C and D.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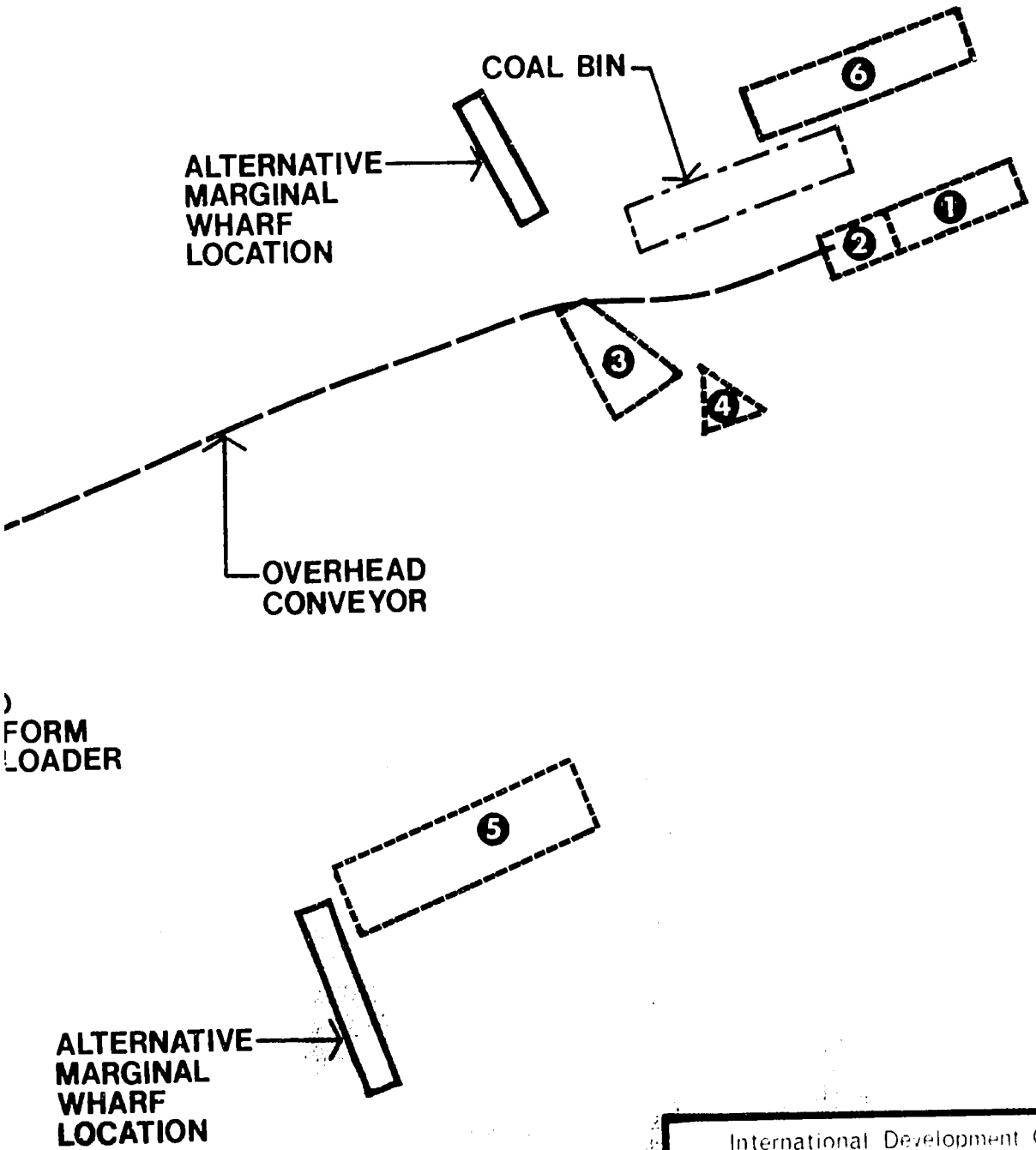


LEGEND

Alternative Deposit Locations

SCALE 1 : 5000

SOURCE: INSTITUTO GEOGRAFICO MILITAR LIMA, PERU

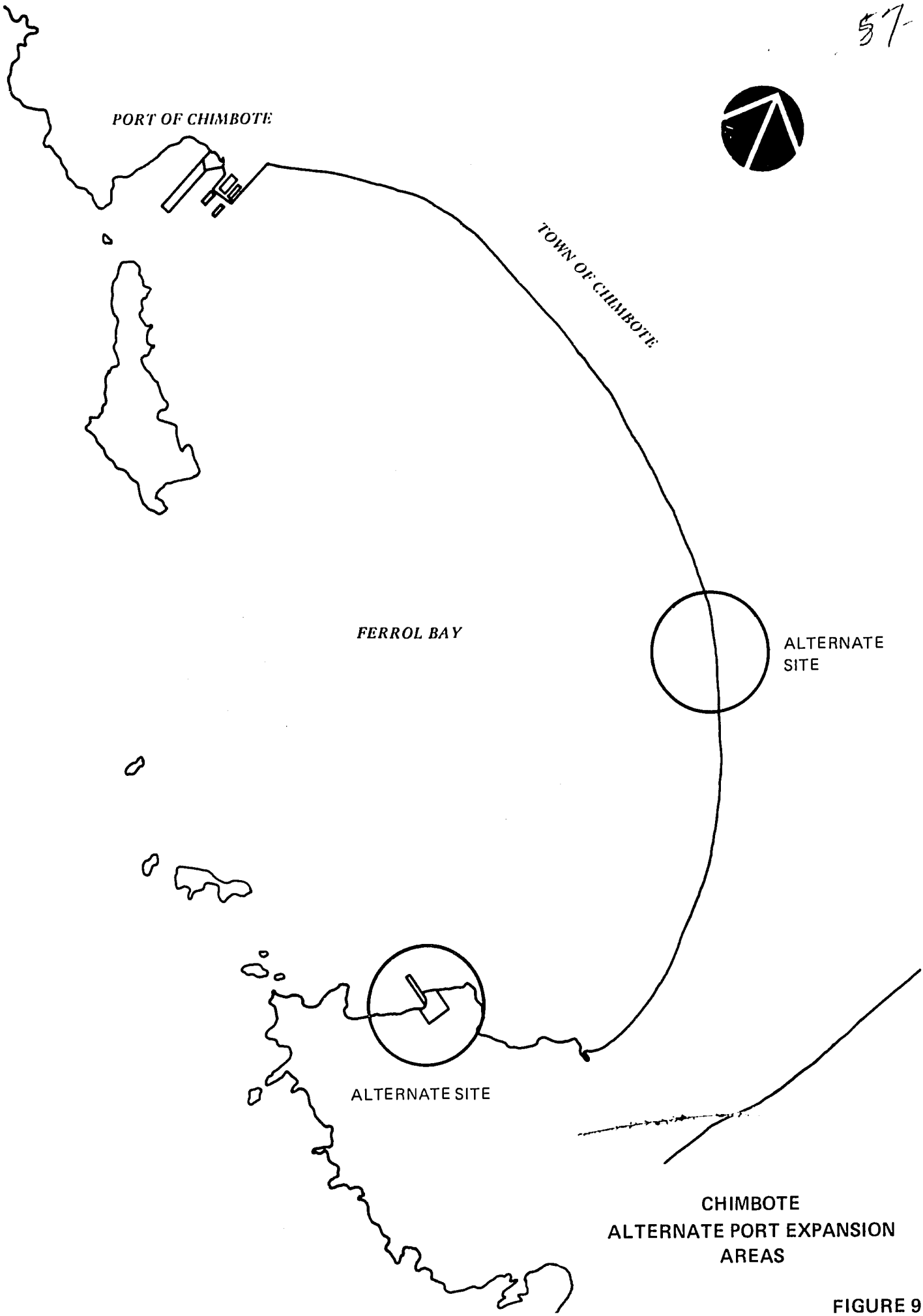
International Development Cooperation Agency
Trade and Development Program
MINPECO
ORE HANDLING IMPROVEMENTS

CHIMBOTE

ALTERNATIVES

FIGURE 8

ARCHITECTS ENGINEERS PLANNERS



CHIMBOTE
ALTERNATE PORT EXPANSION
AREAS

FIGURE 9

c. ENAPU Peru Operations

Two aspects of ENAPU Peru's operations or regulations have the potential to cause problems for future MINPECO exports through Chimbote. The first is the six day work week for port personnel at Chimbote. Normally, docking and loading operations are not carried out on Sundays or holidays except those times when a ship is already in port and being loaded, in which case work continues around the clock until the operation is complete. A ship arriving in the vicinity of the Port of Chimbote on Sunday, however, will not be allowed to dock until Monday. This operating procedure reduces the amount of time that the berth can be fully utilized.

Again, MINPECO's options in this case are limited to requesting seven-day port operation. This may not be too difficult to achieve, however, as Chimbote is the only port discussed in this study which presently operates in this manner.

Another potential problem at Chimbote is the environmental constraint that prohibits concurrent loading of fishmeal and minerals due to potential fishmeal contamination. This also reduces the amount of time available to MINPECO for the movement of minerals through Chimbote.

2. AVAILABILITY OF DEPOSIT AREA

At present, MINPECO stores its minerals within the port prior to shipment and pays a storage tariff to ENAPU Peru. This tariff is described previously. Since some of the material may remain in the yard for several months, tariff costs can be substantial. The projected output of Mina Aguila's mines to be shipped through Chimbote is 5,300 MT/month through the year 2000. Assuming MINPECO follows their policy of keeping a two-month supply at the site, storage costs could run as high as $3,000/month or $36,000/year. A storage area of approximately 5,500 m^2 is needed including a small area for administrative and maintenance buildings.

Six sites were identified by MINPECO as possible areas for use in the storage of materials. These areas are illustrated in Figure 8. All are within the limits of the port, causing MINPECO the same tariff problems as at present. It appears, therefore, that MINPECO should negotiate with ENAPU Peru for a long-term, low tariff, permanent arrangement for use of a storage site.

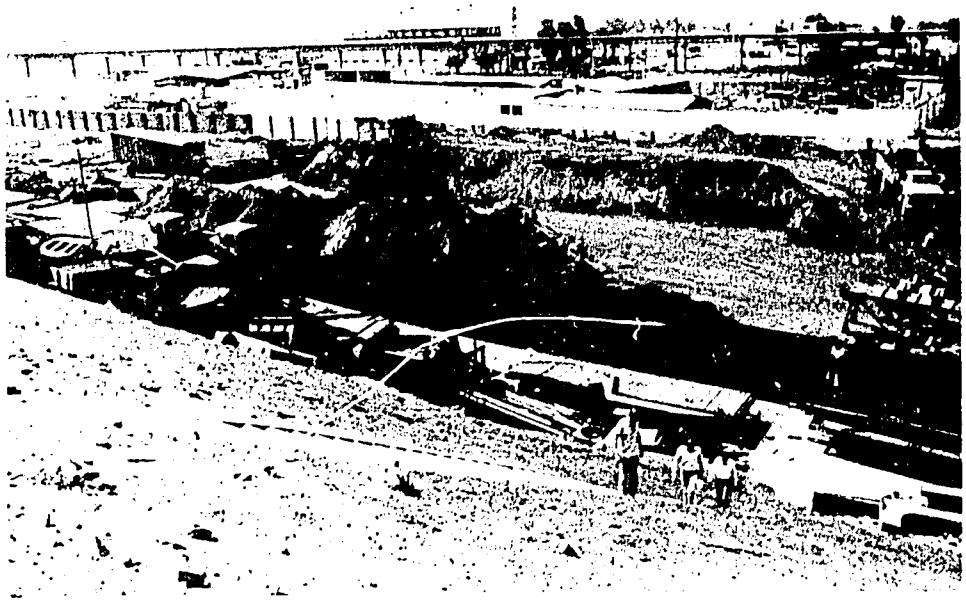


PHOTO 15 – Chimbote – Deposit yard presently used by MINPECO. Note railroad proximity to stockpile.

PHOTO 16 – Chimbote – Existing coal handling bin. Note loading gates.

Site 3 and 4 can be eliminated because they are too small, not served by rail lines and have no room for expansion. Site 3 is also subject to wave splash and spray and occasional flooding.

Site 5 appears to be adequate in size and could be developed in conjunction with construction of a berth perpendicular to Pier 3. Some filling of site 5 has taken place, but additional filling and construction of a concrete slab would be necessary if MINPECO were to use this area for storage. Use of this site creates the same problem as construction of a berth in this area. (i.e., contamination of MINPECO's minerals by iron ore dust during use of Pier 3 by SIDER Peru).

Site 6 would require extensive infrastructure development including an approach road, yard foundation slab, installation of railroad trackage and construction of security fencing.

Site 2 is the site presently used by MINPECO; this area is shown in Photo 15. Site 2 by itself appears to be inadequate in size for future operations as it consists of only 3,000 m^2, but additional space is available adjacent to the same area.

Site 1 is adjacent to site 2 to the north; use of this area as a storage yard would require some improvement, such as construction of concrete slab and security fencing.

A seventh site which received some consideration by the project team was the large coal bin located adjacent to sites 1 and 2. This facility is indicated in Figure 8 and is illustrated in Photo 16. Copper concentrate could be stored in the bin and loaded into the gondolas through loading gates located along the floor of the facility. However, there is some doubt as to whether or not the facility is presently in use.

3. LOSSES

Losses at Chimbote have been estimated by MINPECO personnel at 200-300 kg out of the first shipment of 8,000 tons, or less than 0.01 percent. These estimates are based on little or no hard data, however. Losses could take place in the deposit yard or in the transport of concentrate from the yard to the ship due to wind or to leakage of concentrate through a space in the bottom of the gondola where the two sides abut. The gondolas are lowered into

the ship's hold before they are opened and dumped, so there would appear to be little possibility of loss during that operation. Any substantive loss of material during operations would be readily apparent along the pier or adjacent to the deposit yard because of the green appearance of the copper concentrate when it oxidizes. Although little dust was visible outside the deposit area during the field team's visit to the port, it is hard to discount the probability of loss. The field team was not able to inspect this area immediately after a loading operation, when visible losses would be most apparent. Some concentrate was noted in the vicinity of the rail tracks between the storage area and the scales at the end of Pier 1.

Losses in the deposit yard could be minimized by construction of a solid wall, three meters high, around the selected permanent storage area with the tops of the piles of material kept below that level. Losses in the movement of the material from the deposit yard to the ship could be minimized by a regular maintenance program to ensure the proper operation of the gondolas and all other equipment.

4. LOADING METHODS

At the loading rate of 100 MT/hour presently achieved in Chimbote, a shipment of 7,000 MT of copper concentrate (an average load based on MINPECO's first two shipments) would take 3.3 days of continuous operation to complete. This rate is adequate to handle the projected future throughput. However, if MINPECO's throughput at the Port of Chimbote increases significantly beyond the levels indicated by the basic projections, an improved method of minerals loading may have to be implemented.

At the present time, MINPECO's projected throughput of 63,800 MT annually represents only a small portion of Chimbote's port activity and does not warrant any major expenditures for more sophisticated equipment; MINPECO should continue to utilize the pier cranes and gondolas. If mineral shipping increases significantly, however, two options are available to improve the loading rate and efficiency.

a. Fixed Conveyor to Loader on Pier 1

This option consists of a portable shiploader and conveyor similar to the system recommended for Salaverry. This equipment could be utilized at either side of Pier 1 and would be fed by a fixed conveyor running from the deposit area. Care would have to be taken during design of such a facility to avoid conflict with the existing pier cranes, perhaps through use of an underground feeder conveyor along Pier 1 (see Figure 8).

b. Construction of New Berth

A second option in this regard would be the construction of a priority mineral berth either at the existing port on a platform adjacent to Pier 1 (see Figure 8) or in one of the two locations at the southern end of Ferrol Bay (see Figure 9). Loading from the former would be by conveyor from the deposit area to a fixed shiploader on the platform. This type of loader is illustrated in Figures 10 and 11. Loading from the latter would be via an overwater conveyor system outboard to a series of mooring dolphins where the vessel would be berthed.

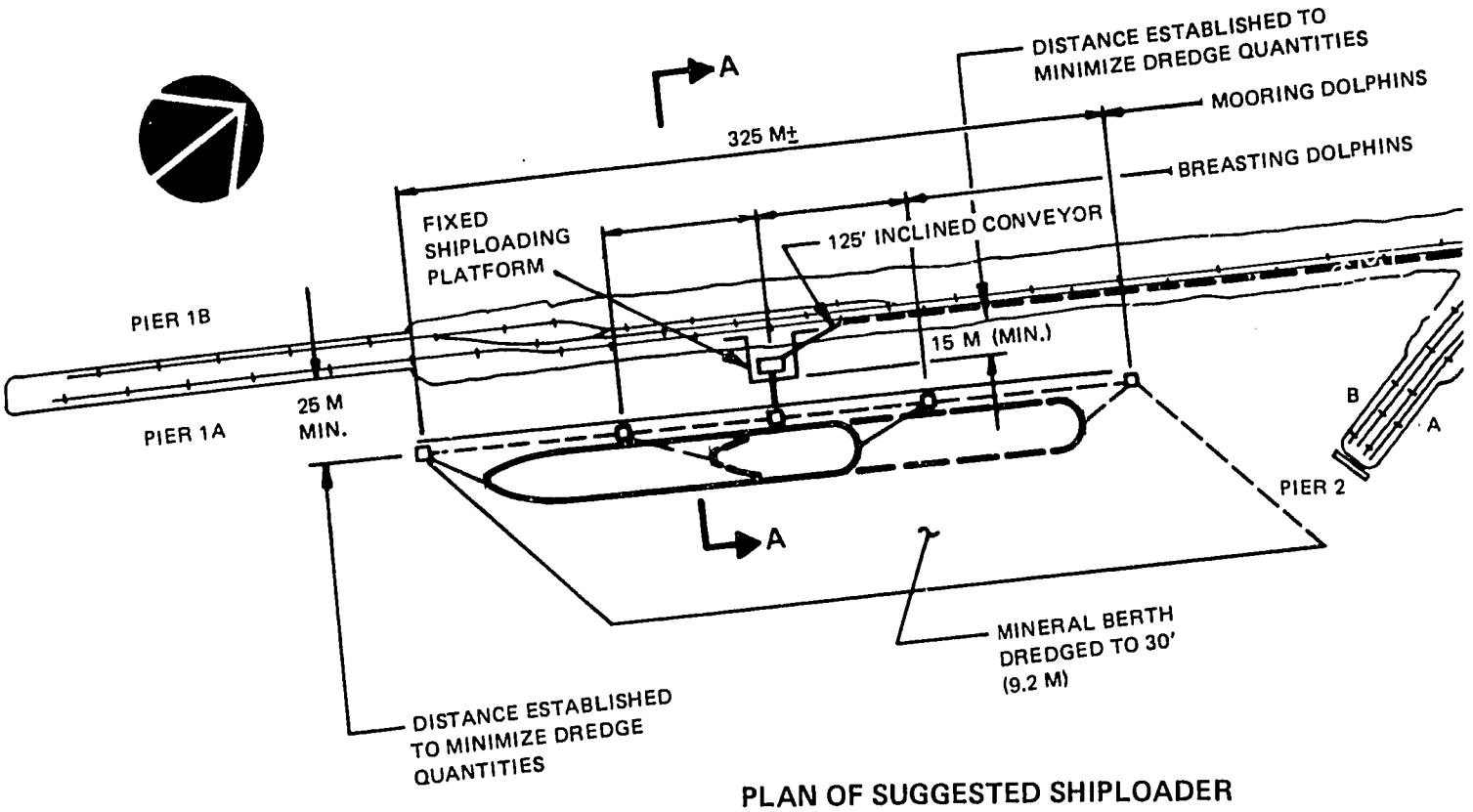
An additional advantage of the fixed platform option is that construction of such a fixed platform would be relatively inexpensive and the dredging required for construction and operation would involve a significant improvement to maneuverability within the harbor.

This option would only be appropriate if MINPECO's throughput increased significantly and if total activity at the port increased beyond optimum levels such that MINPECO was experiencing substantial delays in exporting operations.

C. RECOMMENDED SOLUTIONS

1. RECOMMENDATION 1

The principal problem to be resolved at Chimbote is acquisition and development of a permanent deposit yard. MINPECO should negotiate with ENAPU Peru for the permanent use of the site presently being used, as well as an additional 2,500 m^2 minimum in the area directly northeast of the present site. This area is shown in Figure 8 as site 2 and the adjacent half of site 1. This would provide a total of 5,500 m^2 for storage of concentrates and a small office. A large office will not be necessary since all sales through Chimbote will be back-to-back, from a single mine. The area should be enclosed by a three-meter concrete block wall. A security gate should be provided at the end of the yard closest to the pier to control entry and departure of trucks and rail cars. Approximate cost of this site development is estimated to be $75,000. MINPECO should negotiate with ENAPU Peru for the land, in order to obtain the most favorable tariff situation.



PLAN OF SUGGESTED SHIPLOADER AND FIXED PLATFORM

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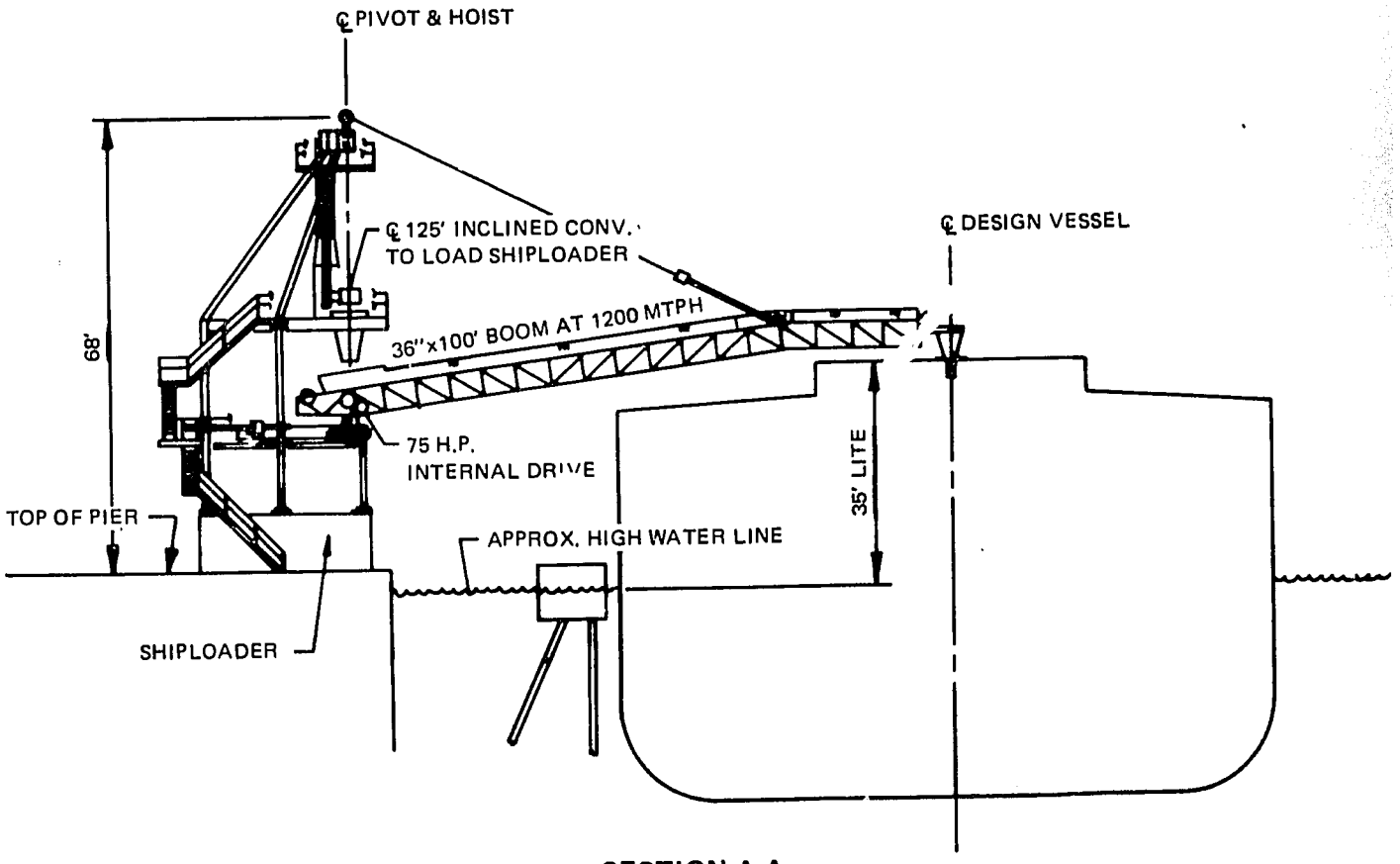
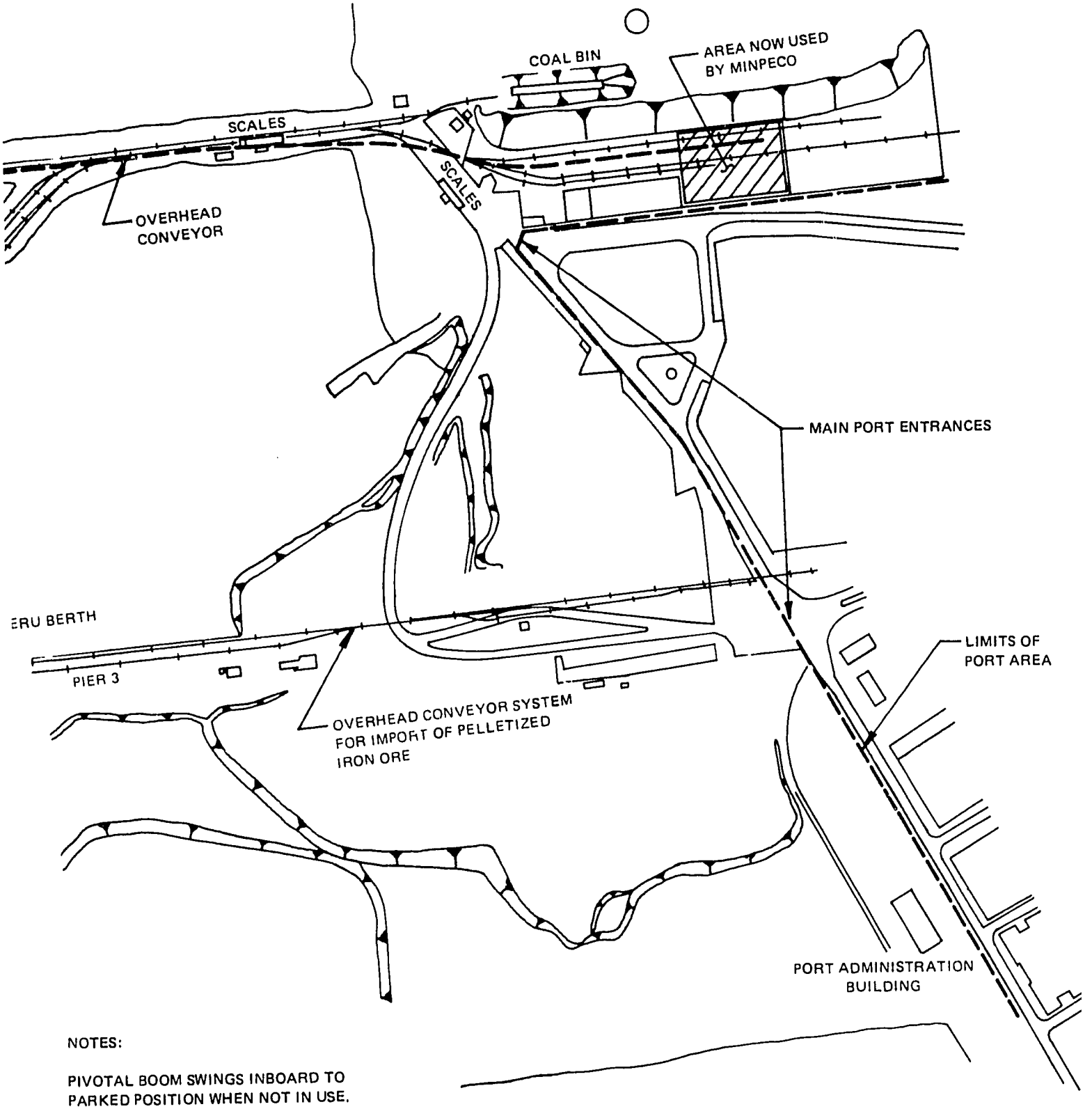


SECTION A-A



NOTES:

PIVOTAL BOOM SWINGS INBOARD TO PARKED POSITION WHEN NOT IN USE.

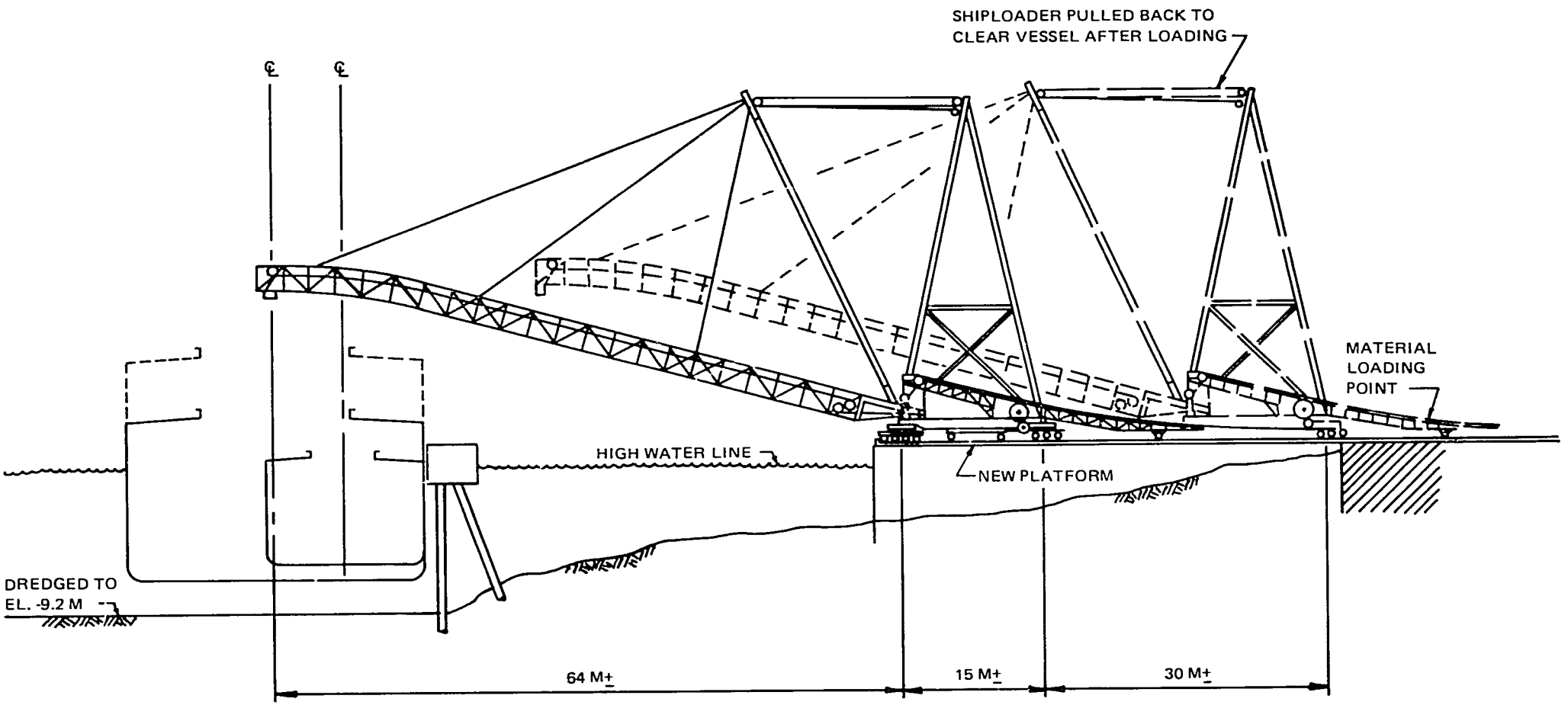
ALL DIMENSIONS SHOWN ARE PRELIMINARY AND SUBJECT TO CHANGE.

FIXED SHIPLOADER FED BY 125' INCLINED CONVEYOR WITH SAME RATED CAPACITY.

EQUIPMENT INFORMATION: COURTESY OF BARBER-GREENE CO., AURORA, ILLINOIS, U.S.A.

CHIMBOTE
SUGGESTED MINERAL BERTH
AND
SHIPLOADING EQUIPMENT

FIGURE 10



CROSS SECTIONAL VIEW

CHIMBOTE
ALTERNATE
SHIPLOADING EQUIPMENT FOR
SUGGESTED MINERAL BERTH

FIGURE 11

It is unlikely that ENAPU Peru would sell the land to MINPECO, thus a lease agreement (that would include storage charges) or a long-term use agreement should be made. According to the International Association of Port Authorities (IAPA), a typical arrangement between port and shipper consists of a throughput charge which includes both storage and handling. Whatever the specific agreements, MINPECO should ensure that the land is retained on a long-term basis.

If the two percent or four percent compounded growth rate of throughput should occur at Chimbote (see Figure 7), MINPECO should acquire the use of the remaining portion of site 1. If additional area is eventually needed for the storage of mineral products, MINPECO could either obtain use of a) the coal handling bin, or b) land owned by SIDER Peru outside the port area but adjacent to the recommended deposit area. If a mineral loading platform is constructed at the southern end of Ferrol Bay, a new deposit yard in that vicinity would have to be purchased and developed. If sufficient land is not available near the port to handle unforeseen growth in mineral exports, a mineral loading platform in the southern end of Ferrol Bay could become a necessity.

2. RECOMMENDATION 2

The second recommendation at Chimbote is that MINPECO continue to utilize the present loading methods but maintain awareness regarding the direction of future activity (i.e., adopt a "wait and see" attitude regarding potential improvements to loading methodology). If throughput increases significantly either from the opening of new mines or the movement through Chimbote of minerals that are currently exported from other ports, MINPECO will need to improve loading methods and may encounter a berth occupancy problem. Any of the alternates discussed in the section on loading methods are workable and could be the most appropriate depending on the circumstances. The solution to this potential problem would depend on an evaluation at that time of mineral exports, berth occupancy levels and the availability of sufficient land for a deposit yard.

3. RECOMMENDATION 3

A further recommendation for MINPECO operations at Chimbote is the purchase of two front end loaders (Caterpillar Model 966) for use in moving material within the yard and loading of the gondolas, thus eliminating rental charges. Cost of this equipment is estimated at $255,000 including shipping costs.

4. RECOMMENDATION 4

The fourth area of recommendation consists of suggestions that MINPECO should make to ENAPU Peru regarding improved port operations or loading efficiency. As fully discussed and described in the chapter on Salaverry, MINPECO should recommend to the port authority in Chimbote the installation of energy absorbing fender systems and constant tension winches in order to reduce the amount of time the pier is closed due to adverse sea conditions. More information regarding these systems can be found in Appendices C and D.

In addition, MINPECO should recommend to ENAPU Peru a regular maintenance program to replace or repair gondolas that are in poor condition. This action could help reduce costly losses of copper concentrate from the gondolas.

5. COST ANALYSIS

Since MINPECO does not presently operate a full scale mineral exporting facility at Chimbote, a costs/savings analysis such as that performed for the other three locations is not possible. Table 13 summarizes the total costs of all recommended improvements which are needed to develop Chimbote into a full scale mineral exporting port.

TABLE 13

SUMMARY OF COSTS – CHIMBOTE

Year	Capital Costs	Additional Annual Costs[1]	Remarks
1981	$330,000	$86,000	Development of deposit yard and purchase of two front end loaders.
1982		86,000	
1983		86,000	
1984		86,000	
1985		86,000	
1986		86,000	
1987		86,000	
1988	255,000	86,000	Purchase of two replacement front end loaders.
1989		86,000	
1990		86,000	
1991		86,000	
1992		86,000	
1993		86,000	
1994		86,000	
1995	255,000	86,000	Purchase of two replacement front end loaders
1996		86,000	
1997		86,000	
1998		86,000	
1999		86,000	
2000		86,000	

[1]Cost of operating two front end loaders.

CHAPTER FOUR

Callao

A. EXISTING OPERATIONS

1. SETTING

The Port of Callao is located 15 Km from the City of Lima and has served as Peru's largest and most important port facility since the days of the Conquest. The first facilities for berthing ships were constructed between 1870 and 1875, and the first steamship berthed at Callao in 1877. Figure 1 in Chapter One shows Callao's location with respect to Lima and other ports under study. Major products handled through Callao include minerals and mineral products, agricultural products, cattle, fishing products and oil.

The commercial Port of Callao has eight docks for cargo shipping, consisting of 21 berths, as well as area for a large fishing fleet. Callao also serves as home port for the Peruvian Navy. Figure 12 shows the port area and vicinity. Berths 2, 3, 4 and 5 on Pier 5 are utilized for the export of minerals. These berths are also utilized for general cargo operations. Virtually unlimited berth length is available at these locations with a depth of water of 33 feet. Typical vessels that visit these berths are of a 33,000 dead weight ton (DWT) class.

Figure 12 also shows the location of the MINPECO deposit area at Callao, situated approximately 1,200 meters from the closest port entrance. The Callao deposit is at the present time by far the largest and busiest of MINPECO's operations considered in this study. The Callao yard consists of 56,000 m^2 of area of which approximately 6,400 m^2 are occupied by office, parking area, scales and laboratory sampling operations.

2. OPERATIONS

Most of the material arrives at the Callao deposit directly from the mines with a small amount arriving from MINPECO's satellite deposit in Huancayo. Material may arrive either in trucks or by rail car; approximately 75 percent of the total arrives by truck. The deposit area receives approximately 130 loaded trucks and 12 loaded rail cars daily. Many of the trucks which arrive from the mines are fixed body rather than dump trucks and must be unloaded manually or with specially designed equipment, as shown in Photos 17 through 20.

Callao

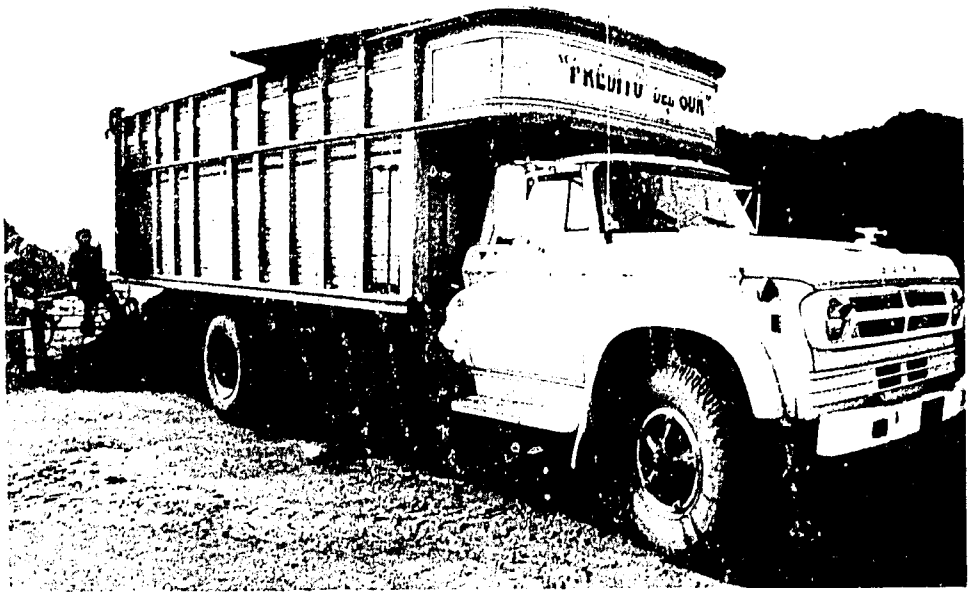
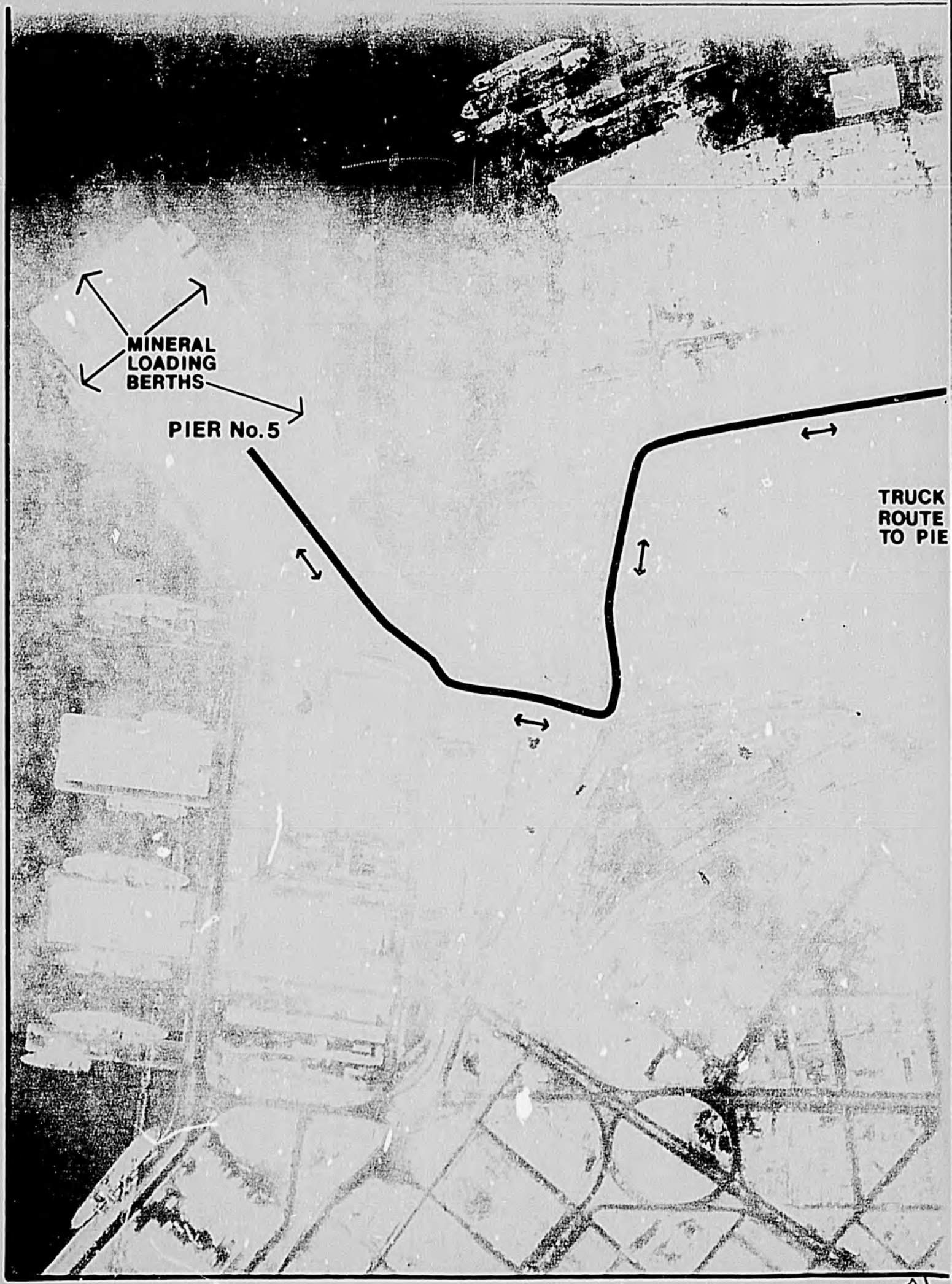
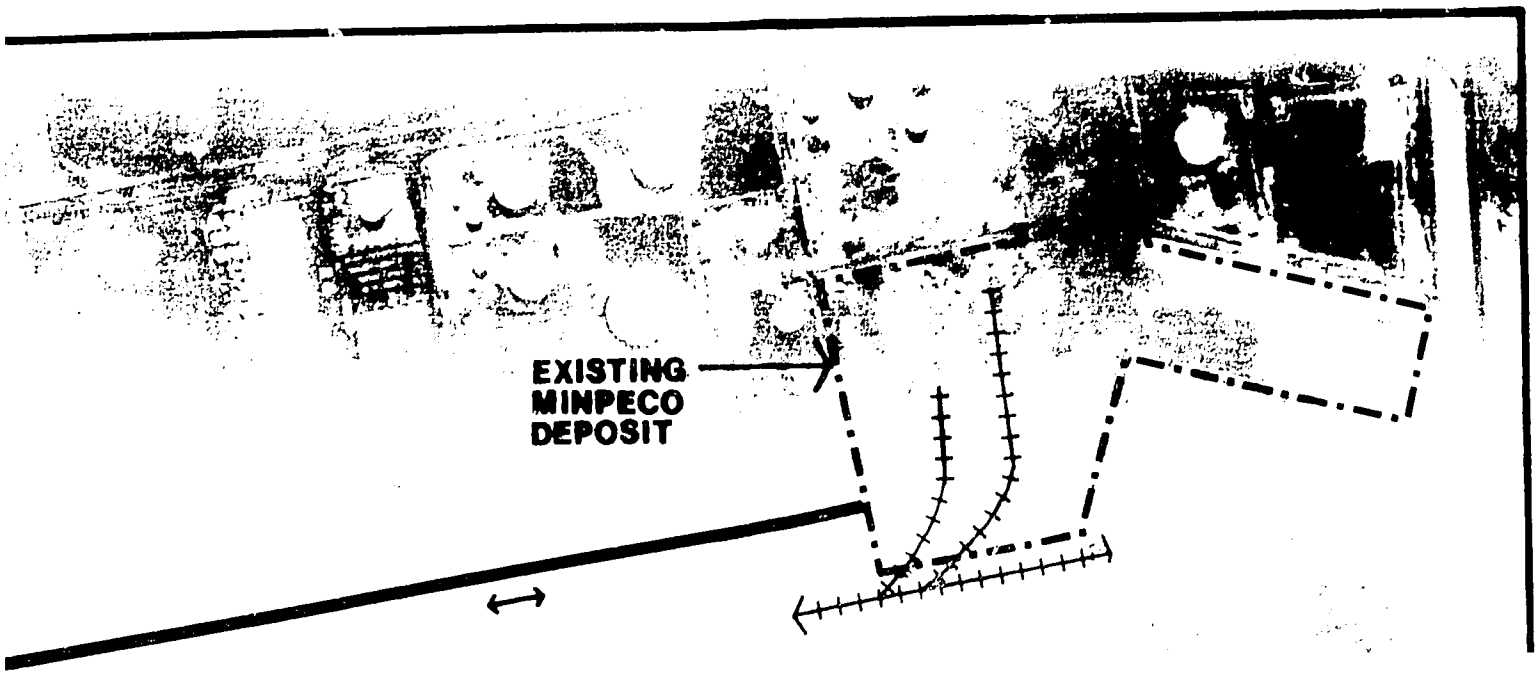


PHOTO 17 – Callao – Typical truck used by mines to deliver product to deposit yard.

PHOTO 18 – Callao – Manual unloading of trucks at deposit yard.


MINERAL
LOADING
BERTHS
PIER No. 5
TRUCK
ROUTE
TO PIE



TOWN OF CALLAO

International Development Cooperation Agency
Trade and Development Program
MINPECO
ORE HANDLING IMPROVEMENTS

CALLAO

EXISTING FACILITIES

SCALE 1 : 5000

SOURCE:
INSTITUTO GEOGRAFICO MILITAR

FIGURE 12

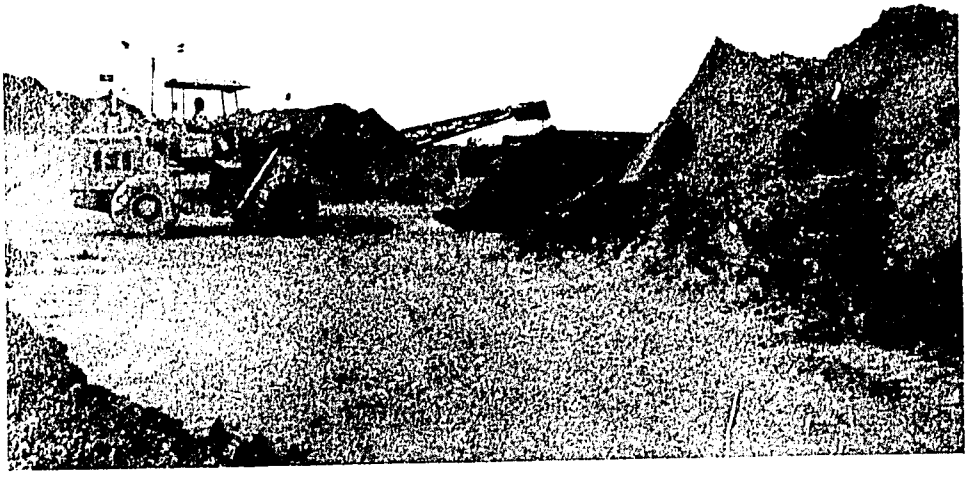


PHOTO 19 — Callao — Equipment used to unload trucks at deposit yard.

PHOTO 20 — Callao — Unloading railroad car.

Each arriving load which is not part of a back-to-back sale is weighed and sampled prior to unloading. (Back-to-back shipments are weighed and sampled only at the mine and at the destination end of the trip.) Testing for moisture content is done by MINPECO at its own laboratory facilities on the premises; assay samples (for material quality) are sent to a private laboratory in Lima, and results are received generally in seven to ten days. When results have been received from the laboratory and quality verified, shipments can be programmed and/or materials of similar quality can be blended into larger common piles, thus reducing the amount of storage area necessary for this material. At the time the study team visited Callao (mid-May 1980) the deposit area was holding approximately 84,000 MT of concentrates and mineral ores (Breakdown of materials stored appears in Table 14.) Total capacity of the deposit area is estimated at approximately 100,000 MT.

TABLE 14

MATERIAL STORED AT CALLAO DEPOSIT MID-MAY 1980

	Concentrate	Mineral
Lead	25,000 MT	12,200 MT
Zinc	40,700	3
Copper	4,500	210
Silver	–	1,400
Subtotal	70,200	13,813
	TOTAL 84,013 MT	

SOURCE: Department of Operations, MINPECO

Table 15 shows the throughput of the Callao deposit for 1977 through 1979 and the corresponding increase in the inventory of materials held at the deposit.

TABLE 15

CALLAO DEPOSIT THROUGHPUT 1977 - 1979

Year	Received	Shipped	Inventory Increase
1977	374,968 MT	362,636 MT	+ 12,332 MT
1978	377,114	370,183	+ 6,931
1979	437,801	409,363	+ 28,438

SOURCE: Department of Operations, MINPECO.

For materials handling operations within the deposit area in Callao, MINPECO employs 94 people and owns a number of pieces of operating equipment. A breakdown of equipment and category of employees is found in Table 16.

TABLE 16

CALLAO DEPOSIT EQUIPMENT AND EMPLOYEES

Equipment

3 Front End Loaders H-65
1 Front End Loader H-90
1 Caterpillar 966-C
1 Dump Truck - Volvo - 20 MT Cap.
1 Dodge Pickup
1 Dodge Double Cabin Pickup
1 Closed Land Rover

Employees

Office/Management Employees	25
Laborers	45
Part-time	23
Apprentice	1
	94

SOURCE: Department of Operations, MINPECO

Prior to the arrival of a chartered vessel for MINPECO's shipments at Callao, MINPECO begins to transport material to the appropriate berth at Pier 5 for stockpiling. Dump trucks are rented and are loaded in the deposit area using front end loaders. The trucks then proceed to the port along the route indicated in Figure 12. At the time of the study team's field visit this route was temporarily closed due to road construction, and the trucks en route to the pier had to follow a circuitous route through populated areas and over poorly maintained roadways.

The trucks are weighed as they leave the deposit area and are also weighed upon (a) entering the port, (b) leaving the port, and (c) arriving back at the deposit. During observation by the study team, however, trucks on that particular day were weighed only once – when leaving the deposit area loaded. The trucks are weighed empty at least once to determine the tare weight of the vehicles and, additionally, occasional checks are made between MINPECO's scales and ENAPU Peru's scales for comparison of results. A typical round trip from the deposit area to the pier including truck loading and unloading was timed at approximately 30 minutes by the study team.

When the ship has berthed and loading can begin at dockside, the concentrate is loaded by two front end loaders into the hopper of the portable loader that discharges the material into the ship's hold. This portable loader is the property of Centromin and is rented to MINPECO for S/.157.50 per metric ton (approximately $.57/MT). This portable equipment is stored on Pier 5 when not in use. Costs for the rental of this and other loading equipment are shown in Table 17. Photos 21, 22 and 23 illustrate several aspects of the shiploading process at Callao. Handling rate of the conveyor system was stated as 300-400 MT/hour. Loading at Callao takes place seven days per week between the hours of 6:00 a.m. and 11:00 p.m. only.

Projections of throughput at the Callao deposit are presented numerically in Table 4 in Chapter One; the same data is illustrated graphically in Figure 13. The basic projections obtained from MINPECO's Office of Planning and Statistics show a drop in throughput between 1980 and 1982 as a result of shipments to a large new zinc refinery at Cajamarquilla, north of Lima. This decrease is followed by a sharp growth between 1982 and 1983, due to increased amounts of copper concentrate shipped through Callao from new copper mines in central Peru. The 1983 throughput is constant through the year 2000, since no new mining prospects in the area serviced by Callao have been projected.

To account for the possibility of unforeseen growth, however, two additional forecasts have been included in the graph in Figure 13 that represent annual growth of throughput at Callao of two percent and four percent compounded.

TABLE 17

EQUIPMENT RENTAL AND MATERIALS HANDLING CHARGES
CALLAO

	PERUVIAN SOLES DE ORO[1]	AMERICAN DOLLARS[2]
FROM DEPOSIT TO SHIP SIDE (per MT)		
Loading/Shipping Rights	S/ . 984.38	$ 3.58
Transport	205.00[3]	.75
Truck Loading	53.00	19
Stockpiling (Machinery)	53.00	.19
Cleanup and Salvage	5.00	.02
Supervision	5.00	.02
Stockpiling (Labor)	14.00	.05
Scales Service	20.00	.07
Export Control	3.00	.01
	S/ . 1,342.38	**$ 4.88**
FROM SHIP SIDE TO ON-BOARD (per MT)		
Supervision	S/ . 5.00	$ .02
Rent Conveyor	157.50	.57
Loading (Machinery)	42.00	.15
Trimming	34.65	.13
Handling	40.00	.15
Shovellers (Stevedores)	40.00	.15
Loading (Labor)	31.00	.29
Loading Fee	3.50	.01
Protective Gear	1.20	Negligible
	S/ . 404.85	**$ 1.47**
TOTAL COST FROM DEPOSIT TO ON-BOARD (per MT)	**S/ . 1,747.23**	**$ 6.35**
ADDITIONAL EQUIPMENT COSTS		
Bulldozer Trimming Per Day	**S/ .34,650.00**	**$126.00**

SOURCE: Department of Operations, MINPECO

[1]As of Mid-May 1980.

[2]Assuming S/ .275 = $1.00

[3]Average of regular and overtime rates (S/ .165 and S/ .245, respectively).

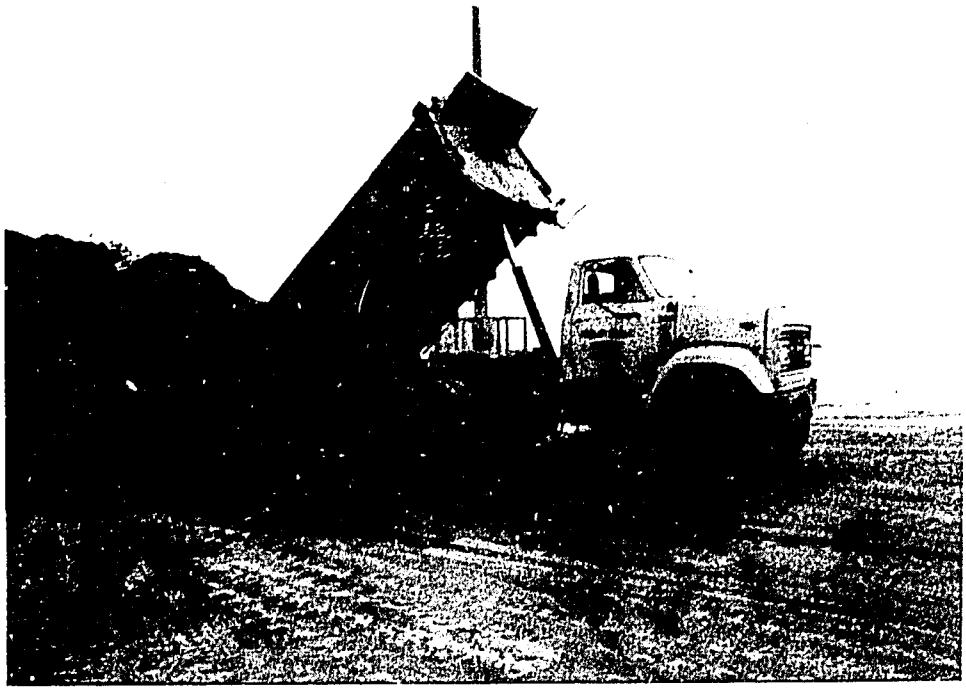


PHOTO 21 — Callao — Stockpiling at pier prior to loading aboard ship. (Note material movement by wind action.)

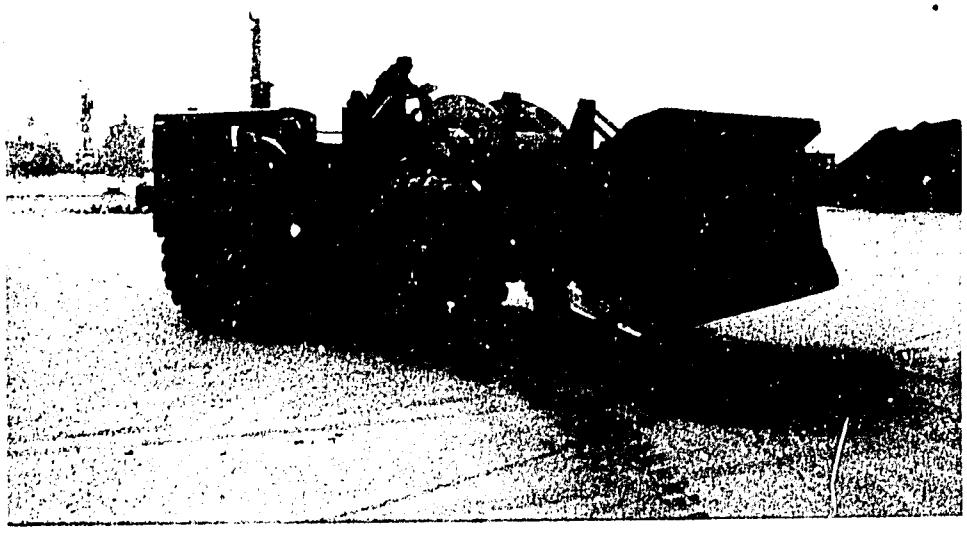
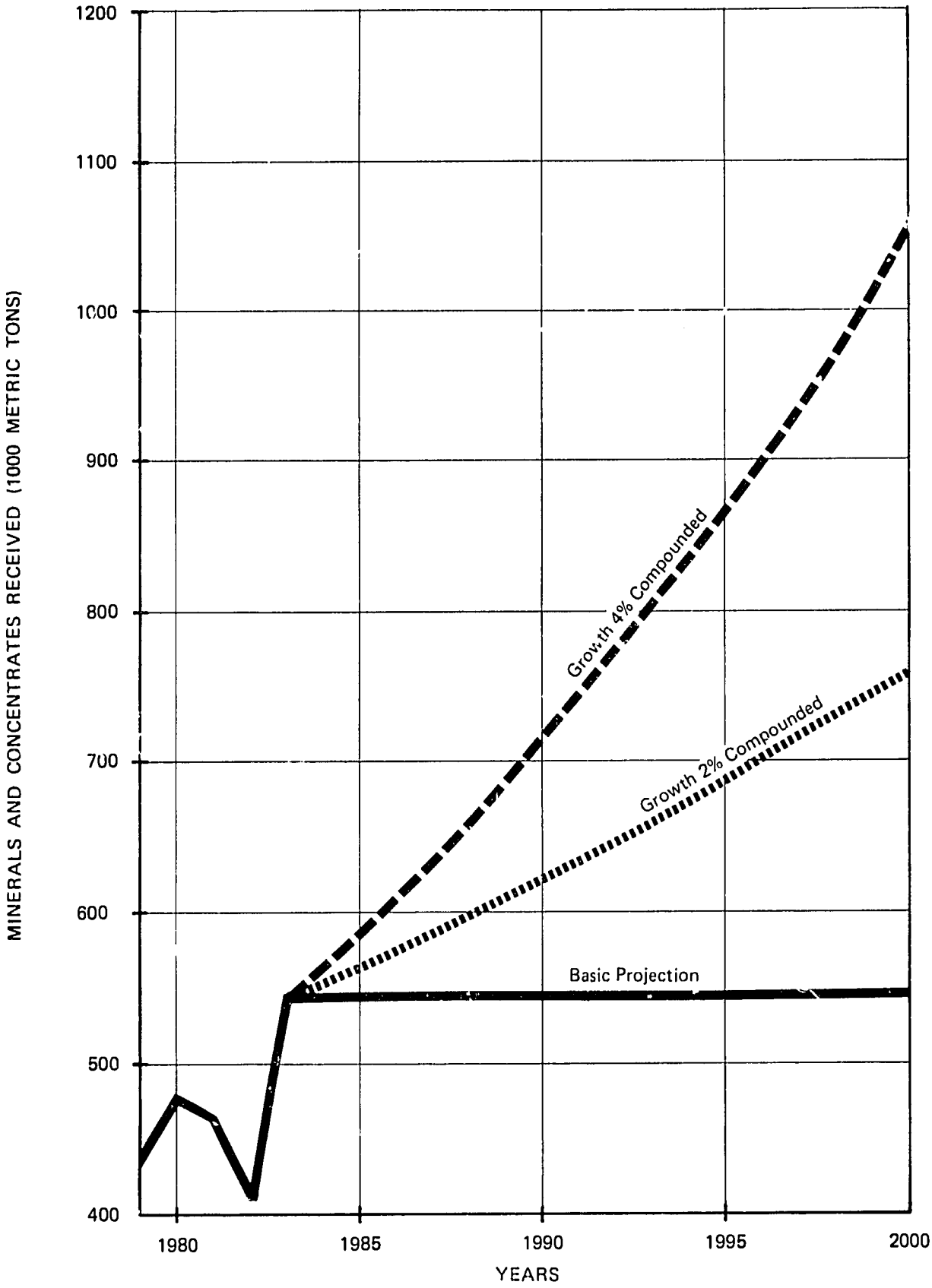


PHOTO 22 — Callao — Front end loader used to feed portable ship loader.

PHOTO 23 — Callao — Portable ship loader in use at Callao.



PROJECTED THROUGHPUT
CALLAO DEPOSIT YARD

FIGURE 13

B. POTENTIAL PROBLEM AREAS AND ALTERNATIVE SOLUTIONS

1. PORT LIMITATIONS

a. Berth Occupancy

MINPECO has not experienced a bottleneck at the mineral pier resulting from non-availability of berth space to date. The availability of four berths for mineral shipping allows great flexibility for MINPECO operations. It is not unreasonable to assume, however, that MINPECO's use of the berths (as well as that by other mineral shippers) will increase as production keeps pace with world consumption.

The potential problem related to berth availability at Callao for MINPECO will result if ENAPU Peru alters their present use of Pier 5 to accommodate container shipping and utilizes the pier area for container laydown and storage. This is not a currently programmed conversion, although ENAPU Peru has given this action some consideration. Should it occur, MINPECO and the other mineral exporters at Callao would have to relocate their bulk loading operations. Conversations with ENAPU Peru authorities indicate that a priority or exclusive mineral berth could be provided, most probable at the marginal wharf location as designated in Figure 14.

b. Loading Restrictions

The only other port limitation at Callao which constitutes a potential problem to MINPECO is the availability of loading personnel (stevedores) between the hours of 6:00 a.m. and 11:00 p.m. only. This practice increases MINPECO's berthing costs and could become a critical factor in port operations if berth occupancy approaches capacity or if mineral exporting operations are restricted to one berth.

If a critical situation arises due to this practice, MINPECO should request 24 hour loading daily by ENAPU Peru at Callao. Loading takes place 24 hours/day at Salaverry, Chimbote and Matarani; therefore, such a request would not be unreasonable.

2. Loading Methods

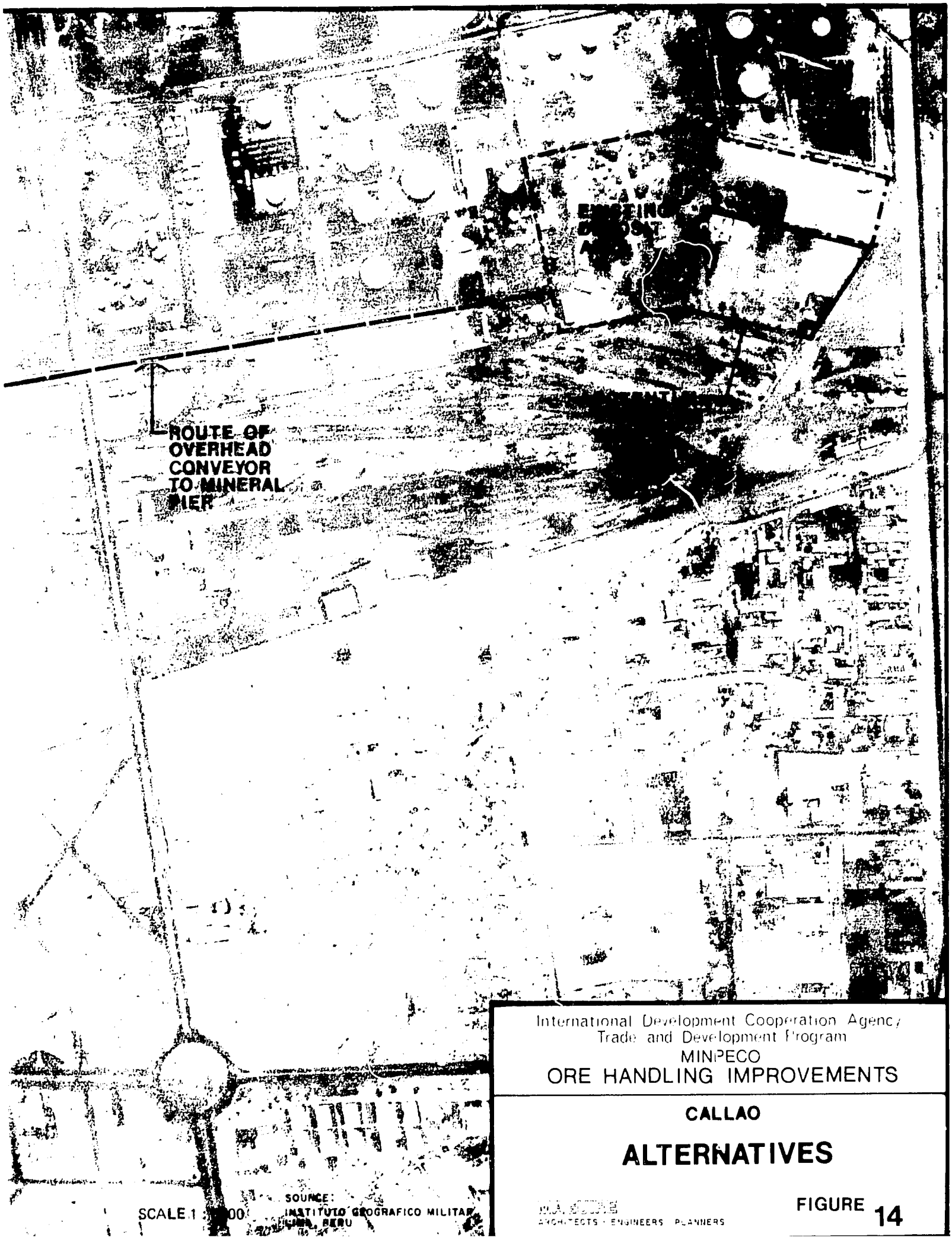
During 1979 MINPECO shipped 409,363 MT of materials or 34,144 MT/month. By the year 2000, according to the basic projections from MINPECO's Office of Planning and Statistics, the Callao deposit will be shipping 544,700 MT annually, or 45,400 MT/month. If the additional two percent or four percent growth rates are realized, this monthly shipping would increase to 63,600 or 92,000 MT/month, respectively. This potential large increase in tonnage handled warrants the consideration of alternative methods of transport of minerals to the pier and the subsequent loading of this material into the mineral export vessels.

The first consideration is the continued procedure of trucking the material to the pier, stockpiling it there and using the portable loader at dockside. During 1983, however, throughput at the Callao deposit is projected to increase sharply. Continuation of the present loading methods at that time may still be possible, although the logistics of more trucks, more space on the pier and more ships at berth make the entire situation less manageable. Using the present average shipment of approximately 4,000 MT and using the baseline projections from 1983 through 2000, MINPECO will be loading 11-12 ships per month.

If unforeseen growth occurs after 1983, as shown in the two percent and four percent growth lines in Figure 13, it is possible that MINPECO will be unable to continue the present loading methodology due to the number of trucks and front end loaders that would be necessary. In many cases, using this methodology, MINPECO would have to load two to three ships simultaneously, as 22 ships/month would have to be serviced by the year 2000 under the four percent growth scenario. Compounding this problem would be the increase of the berth use by other shippers. Even if physically able to continue the present methodology, it is expected that operating costs and material losses during loading operations would be significant and would negate the further use of this procedure.

A second loading option for MINPECO's future operation involves construction of a fixed conveyor system from the Callao deposit yard to Pier 5, where a portable loader would be utilized for discharge into the vessel's holds. Construction of such a conveyor would save MINPECO a considerable

PUERTO NUEVO



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CALLAO

ALTERNATIVES

ARCHITECTS · ENGINEERS · PLANNERS

FIGURE 14

amount of rehandling of material which is currently associated with the present loading methods, as well as the correspondingly high labor costs. The conveyor alignment would extend from the existing MINPECO deposit yard to the port as illustrated in Figure 14. Alternatively, the conveyor could be constructed over the open stretch of water near the pierhead; however, this alignment would interfere with small boat traffic and is less desirable from a port operations viewpoint. The possibility exists that other mineral exporters at Callao would utilize this conveyor system, thus providing operating revenue to MINPECO to help defray the capital outlay.

If, in the future, the mineral berth were to be relocated, as discussed in the previous section, the alignment of the conveyor system could be modified easily and the flights of the system dismantled and reinstalled to accommodate the new location. All excess equipment could be saved for repairs and spare parts.

A third alternative for improved loading of concentrates would be the construction of a number of storage silos in a relatively small area within or adjacent to the existing deposit area. This option is also discussed briefly in the following subsection concerning deposit yard capacity. These silos would be used only for the temporary storage of concentrates for back-to-back shipments from large producers which require no blending. Under this option, the silos would be loaded directly from incoming rail cars or trucks by conveyor or vacuum system and would be subsequently unloaded by conveyor into dump trucks bound for the pier or to a conveyor belt to the mineral berth as described in the previous paragraph.

In summary, the two basic methods for ship loading at Callao consist of (a) continuation of present procedure (i.e., trucking from deposit to ship side, then portable loader from ship side to on-board), or (b) use of a conveyor system from deposit to on-board.

3. Deposit Yard Capacity

Present holding capacity of MINPECO's Callao deposit is estimated at approximately 100,000 MT of concentrates and minerals. This area will be sufficient for the next several years due to a decrease in throughput resulting from operation of a new zinc refinery in Cajamarquilla. In 1979, MINPECO shipped 34,144 MT/month; by 1983 through the year 2000, however, MINPECO's throughput at Callao will increase sharply to 544,700 MT or 45,400 MT/month. This growth indicates the necessity for increasing the size of MINPECO's deposit yard at Callao. Several contingency factors add to the validity of this conclusion; these are briefly discussed below:

a. Using the basic projections, as shown in Figure 13, a two-month inventory of material at the deposit area (MINPECO's present operating preference) for 1983 through the year 2000 would be approximately 91,000 MT of materials. If this two-month inventory is adhered to MINPECO's Callao deposit will be close to its limit of operational efficiency. An additional factor which should be considered, however, is that the Callao deposit frequently holds more than a two-month supply of material for export. This results from the fact that Callao is the largest and most important deposit, and it is therefore more difficult to control or limit the amount of incoming material. At the end of 1979 for example, the deposit held a total of 96,755 MT of materials, the equivalent of 2.8 months of shipments or almost 50 percent more than theoretically necessary. As such, the Callao deposit appears to warrant additional space as a buffer against this contingency.

b. In addition, as MINPECO's principal deposit yard and port, the Callao yard often must hold small quantities of material for lengths of time until a shippable amount is accumulated. The presence of large amounts of unconcentrated minerals from small producers effectively reduces the overall capacity of the storage yard, as this type of material must be stockpiled in small lots which occupy a large amount of area at a low density.

c. Another important factor which must be considered at Callao is the possibility of unforeseen (presently unprogrammed) growth occurring after 1983. Referring to Figure 13, earlier, which shows the effect of two percent and four percent growth scenarios after 1983, it can be seen that for these examples by the year 2000 MINPECO would be shipping approximately 63,600 MT or 92,000 MT/month, respectively, (compared to 45,400 MT/month under the basic projection). This amount of throughput would necessitate storage yards of 64,000 m^2 or 92,000 m^2 respectively, to accommodate a two-month supply. Added to this needed storage area would be 8,500 m^2 of area for administrative and other non-storage needs for a total deposit area of approximately 73,000 m^2 or 101,000 m^2, respectively.

The contingency factors discussed above illustrate the large number of parameters that must be considered when determining the optimum size for future operation of MINPECO's deposit yard in Callao.

Figure 15 on the following page illustrates graphically the range in amount of storage area which would be needed at Callao if MINPECO continues to operate as at present (i.e., holding a two to three month inventory).

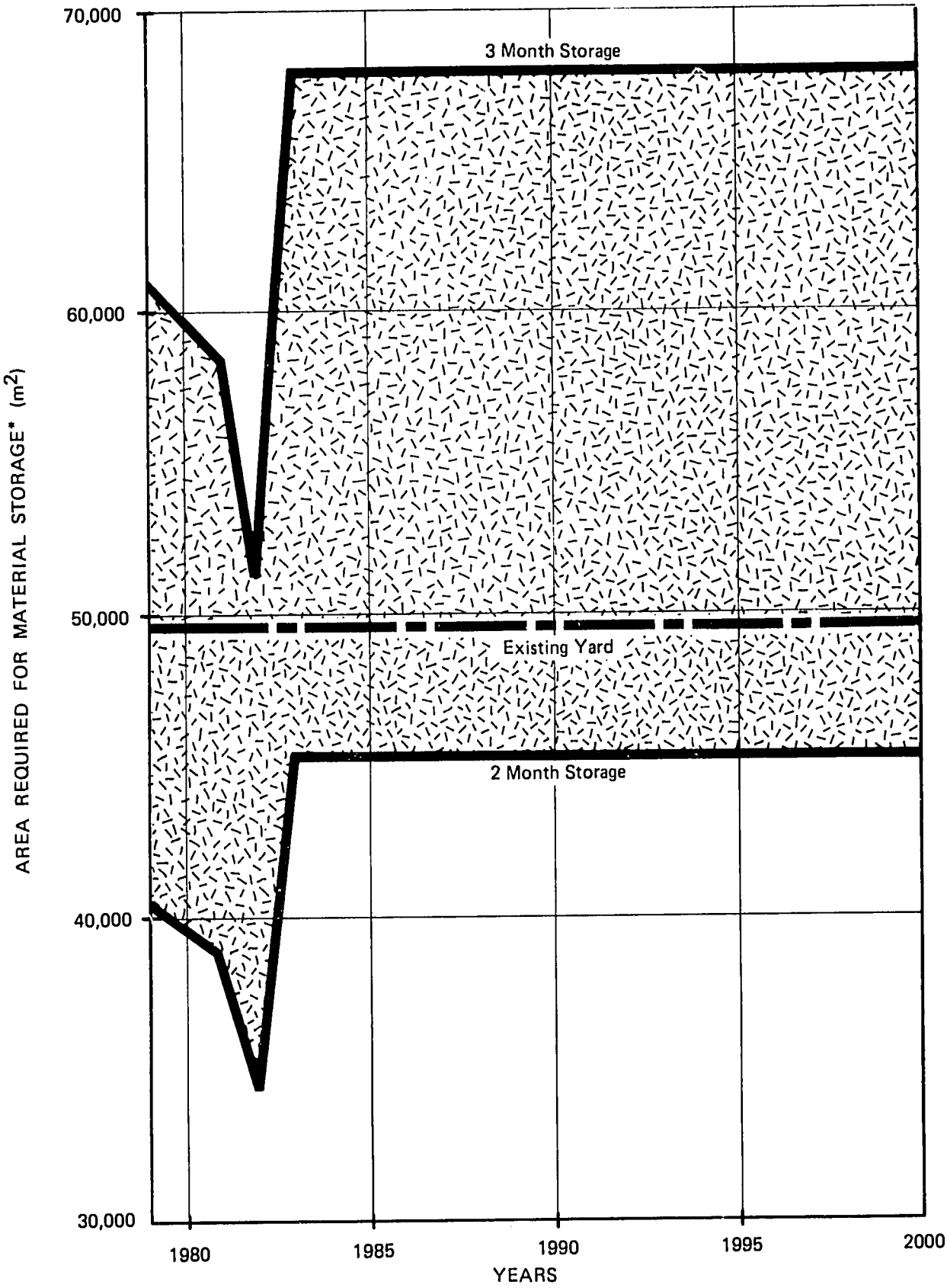
It is clear upon examination of operations at Callao and the contingency factors discussed above that the lower line on this graph represents an unrealistically low estimate of space needs. The upper line on the graph in Figure 15 is a more realistic projection of needed storage area, as it allows MINPECO more operational flexibility. A three month inventory may not always need to be stored at the Callao deposit, but the size of the future storage area should consider that contingency.

In conclusion, it is necessary that MINPECO acquire a larger operating area in Callao. Total area required consists of 68,000 m^2 (area needed for a three-month inventory) plus 8,500 m^2 for non-storage purposes for a total of 74,500 m^2. There are two basic options for this expansion; the first involves relocation of the deposit to a new, separate area at least as close to the port as the existing yard (and preferably closer), while the second consists of expansion of the present yard, if possible, to meet future needs.

It appears that the only area in Callao near the port to which MINPECO could possibly relocate is the area known as Puerto Nuevo, a slum area consisting of shanty-type dwellings and commercial establishments. If MINPECO were to acquire and occupy this area, it would have to assist in the relocation effort of the inhabitants by the government. Moreover, MINPECO would have to aid in the development of land for new housing.

Although this may not be as prohibitively expensive as it would appear, a time problem may arise in that the time required to purchase and develop land for relocation may extend past the date when MINPECO must have additional operating space. In addition, the Peruvian Navy, occupying a large portion of the Callao port area, has recently identified a portion of the Puerto Nuevo area for its proposed expansion plans, thus further compounding the obstacles to this course of action.

Under the circumstances, the second option appears to be more viable, involving the acquisition of a soccer field adjacent to the existing deposit. This would add approximately 21,440 m^2 to the presently used area of 56,000 m^2, making a total yard area of 77,440 m^2. This represents adequate space



STORAGE AREA REQUIRED
CALLAO DEPOSIT YARD

*Area for administration, scales, laboratory, etc., are not included.

FIGURE 15

for the basic projection. The two percent and four percent growth scenarios would necessitate a greater amount of storage area using standard uncovered stockpiling methods; however, construction of storage silos for export of products from major back-to-back producers could reduce the amount of space needed for storage, thus allowing the 77,440 m^2 to accommodate Callao's maximum growth scenario, should that situation occur.

C. RECOMMENDED SOLUTIONS

1. RECOMMENDATION 1

The principal recommendation at Callao is the construction as soon as possible of a fully automated bulk concentrate handling system. This system would consist of approximately 2 km of conveyor from the deposit yard to the middle of Pier 5, connecting to a portable conveyor and shiploader which could load ships directly at two berths. Connection at the pier end could either be to the rail mounted loader presently located on Pier 5 or to a portable loader such as that recommended for Salaverry. A schematic drawing of the proposed system, showing configuration and typical section appears in Figure 16. Additionally, more detailed information may be found in Appendix E. The bulk concentrate handling system could be elevated from the deposit area to the port, allowing free movement of vehicles and personnel beneath each span. At the deposit end, a feed conveyor would be loaded by large front end loaders into a movable (sliding) hopper from piles of concentrates stored alongside the conveyor. As expansion occurs, a portable loading "arm" to the feed conveyor can be acquired to facilitate and expedite loading. The bulk concentrate handling system would be designed and installed so as to allow deposit operations to proceed during construction. No interference with ongoing operations will occur.

Special attention will be required at the discharge point in the ship's hold to eliminate wind losses during loading operations. (Losses of this type at Callao during shiploading were observed by the study team.)

Maximum rated capacity for this recommended system is 1,200 MT/hour, although working capacity of the equipment will be 600 MT/hour. The conveyor can be equipped with scales to permit weighing of material being exported to an accuracy exceeding the presently utilized truck scales. Cost of the total bulk concentrate handling system is estimated at $3,110,000 with an additional cost for shipping and installation of $918,000. (No cost is included for an easement that may be required, as the conveyor alignment will be along a public thoroughfare, not private land.)

An additional advantage of the installation of a bulk concentrate handling system at the deposit end is the eventual possibility of a tie-in with Centromin's exporting operation. A short additional section of conveyor would allow Centromin to utilize the fully automated loading system. The resulting income would help MINPECO to defray the capital cost of the purchase and installation of the conveyor system[1].

Installation and use of this recommended system should result in a reduction of the material losses currently being experienced by MINPECO at Callao; savings in the use of an automated system are estimated at 0.5 percent of total throughput. Actual savings may be considerably higher; however, it is preferable to use a conservative estimate of losses saved. Based on export projections and estimated 1980 mineral prices provided by MINPECO, reduction of loss by 0.5 percent could amount to considerable annual savings as shown in Table 18.

TABLE 18

REDUCTION IN LOSSES DUE TO IMPROVED LOADING METHODS
CALLAO

Year[1]	Cost Savings
1987	$ 1,876,000
1983 - 2000 (18 years)	42,000,000
Total Savings Over Project Period	**$43,876,000**

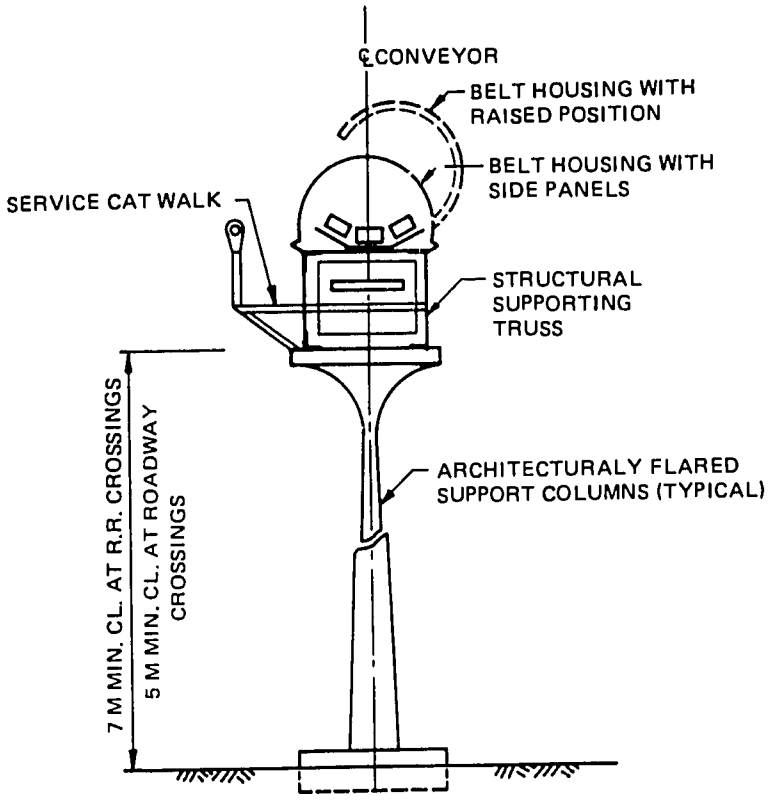
SOURCE: Data from MINPECO and calculations by CE Maguire, Inc.

[1]Assumes equipment in place by 1982.

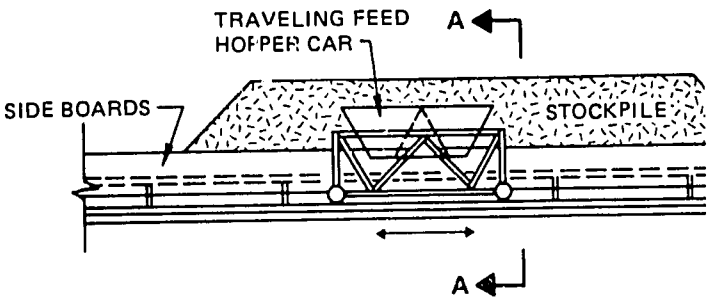
[2]$2,333,000/year x 18 years = $42,000,000

All initial costs, operating costs and operating savings associated with these recommendations are summarized at the end of this chapter in Table 20.

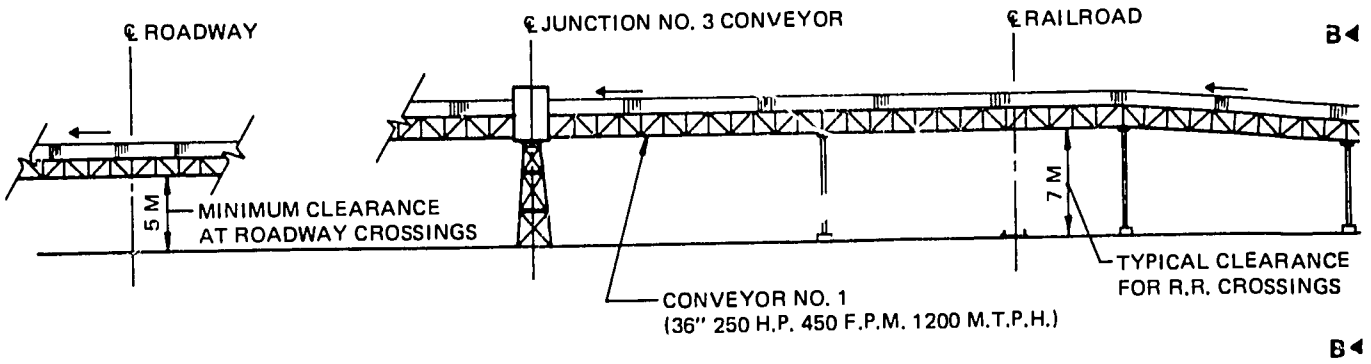
[1]In a further phase of this study, the project team will investigate the possibility of incorporating extensive barite exporting operations into MINPECO's total throughput. The conveyor equipment recommended here would also be sufficient to accommodate the barite exports.



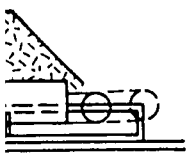
SECTION B-B

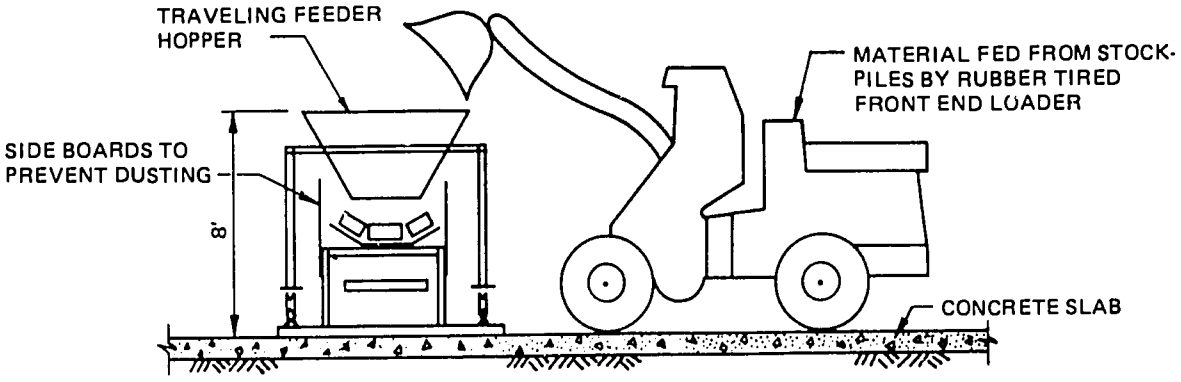


TRAVELING FEEDER HOPPER

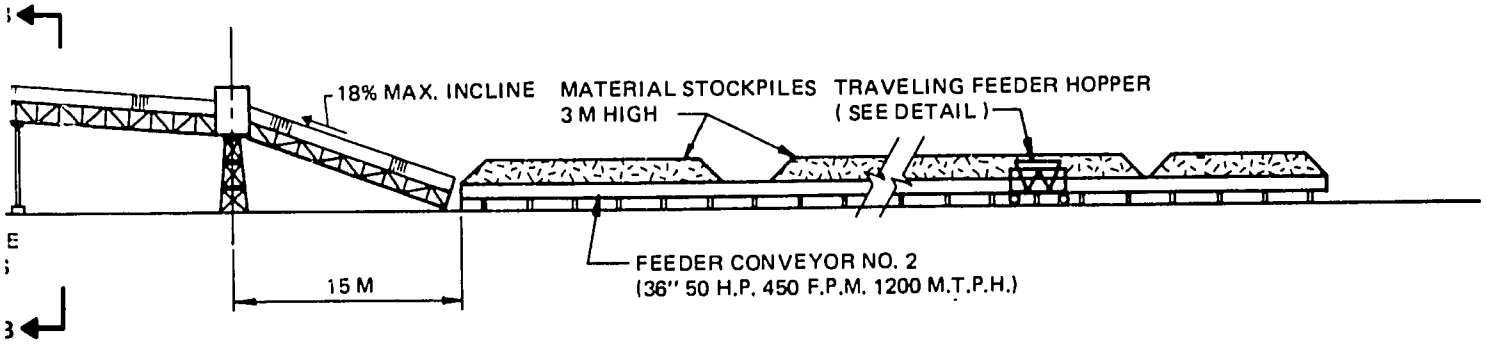


PROFILE OF ELEVATED CONVE





SECTION A-A



VEYOR FROM DEPOSIT YARD TO PORT

CALLAO
PROPOSED CONVEYOR SYSTEM – DETAILS

FIGURE 16

2. RECOMMENDATION 2

The second recommendation at Callao is that MINPECO continue to operate from the existing deposit yard provided that in addition to the 56,000 m^2 already utilized, MINPECO purchase the adjacent soccer field, thus expanding the deposit yard to 77,440 m^2. This recommendation is based on a number of factors taken under consideration of which the following are the most important:

a. Due to the fact that the Peruvian Navy plans to expand into the area presently occupied by Puerto Nuevo, it would appear that no area exists for MINPECO to relocate closer to the port than the existing deposit. Even if the land were available, however, the time required to relocate the inhabitants and improve the site would extend past the time when MINPECO needs the additional area. MINPECO must acquire expansion area almost immediately if it is to meet future throughput demands.

b. Ignoring for the moment the fact that Puerto Nuevo may not even be available to MINPECO for siting a new deposit yard, the costly prospect of providing land for an estimated 2,000 families that inhabit Puerto Nuevo with all appropriate services (water, electricity, police and fire protection) would appear to be a prospect which MINPECO should avoid, principally due to the many complications, costs and delays which could arise. In addition, the cost of transferring operations from one location to another would be high, even allowing for the fact that MINPECO would allow its inventory to drop considerably at the old deposit area.

c. A third consideration in this recommendation is the fact that the entire Puerto Nuevo area consists of 80,000 m^2 while the existing deposit area plus purchase of the soccer field totals over 77,000 m^2, not a significant size difference. Use of the present deposit area allows MINPECO to continue using all the existing administrative and scale areas, thus avoiding the considerable cost associated with construction of new facilities.

Layout of the expanded deposit yard is shown in Figure 17.

3. RECOMMENDATION 3

This recommendation concerns the purchase of mobile equipment for the handling of products within the Callao deposit yard. It is estimated that the

requirements will initially necessitate two front end loaders[1], with two additional loaders to be purchased when the conveyor extension and second hopper is installed within the deposit yard. In addition, four forklifts[2] should be purchased for use in transporting bagged materials. One additional recommendation for Callao is purchase of a hand pallet truck for use in shifting several pallets without diverting the mechanized forklifts from other operations. Total capital cost of this recommended equipment is shown below in Table 19.

TABLE 19

MOBILE EQUIPMENT COSTS
CALLAO

4 Front End Loaders	$488,000
4 Forklift Trucks	124,000
1 Hand Pallet Truck	1,000
Shipping Costs	31,000
	$644,000

SOURCE: International Liaison Office of Caterpillar Tractor Company and various other shippers and suppliers.

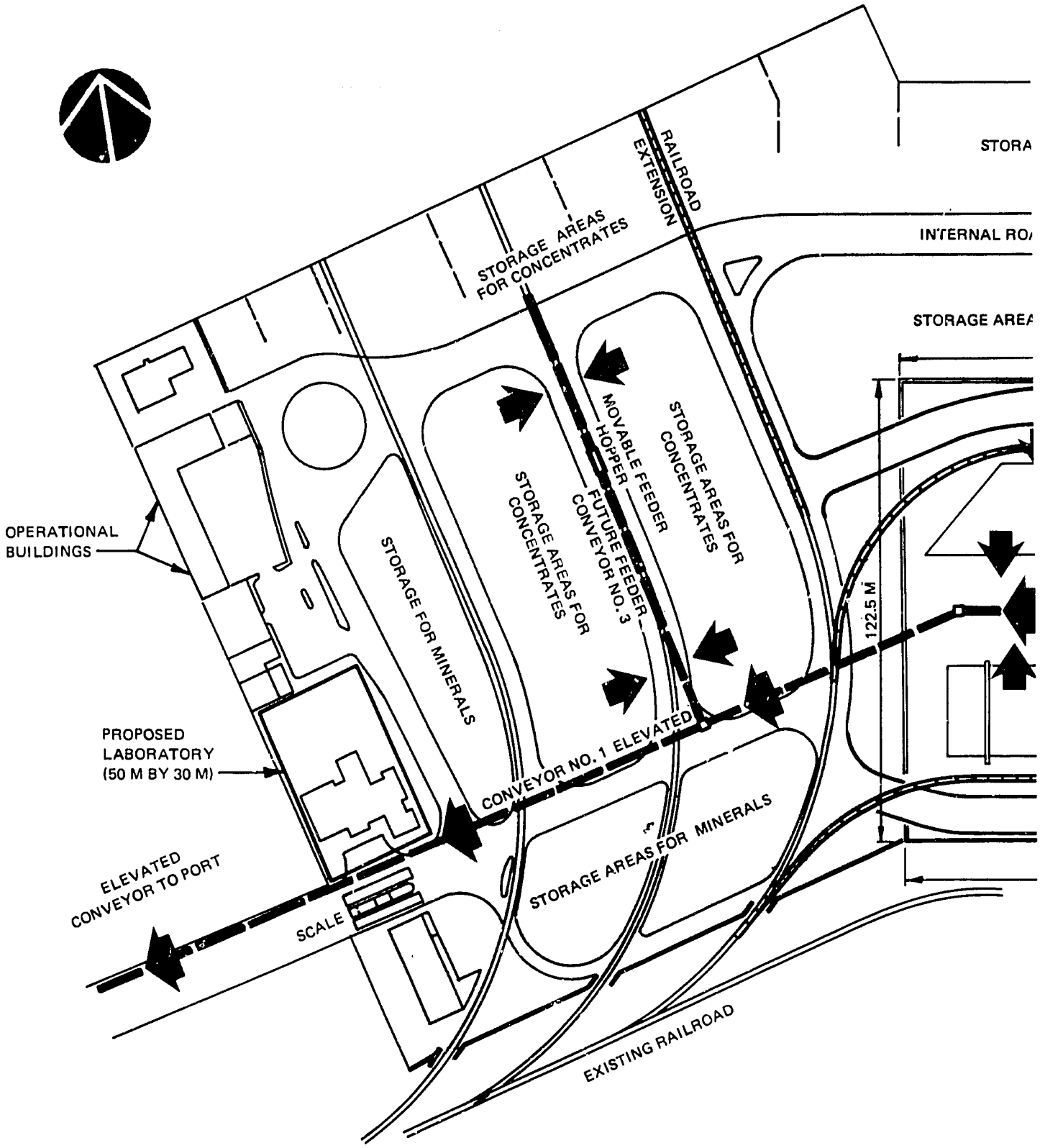
4. COST ANALYSIS

Table 20 contains a summary of costs and savings that will occur as the result of implementation of the recommendations for Callao. These figures are based on a comparison of operating costs of present and proposed methods of materials handling; 1981 has been used as a starting point for the analysis, since it is unlikely that any of the recommendations could be implemented prior to that time.

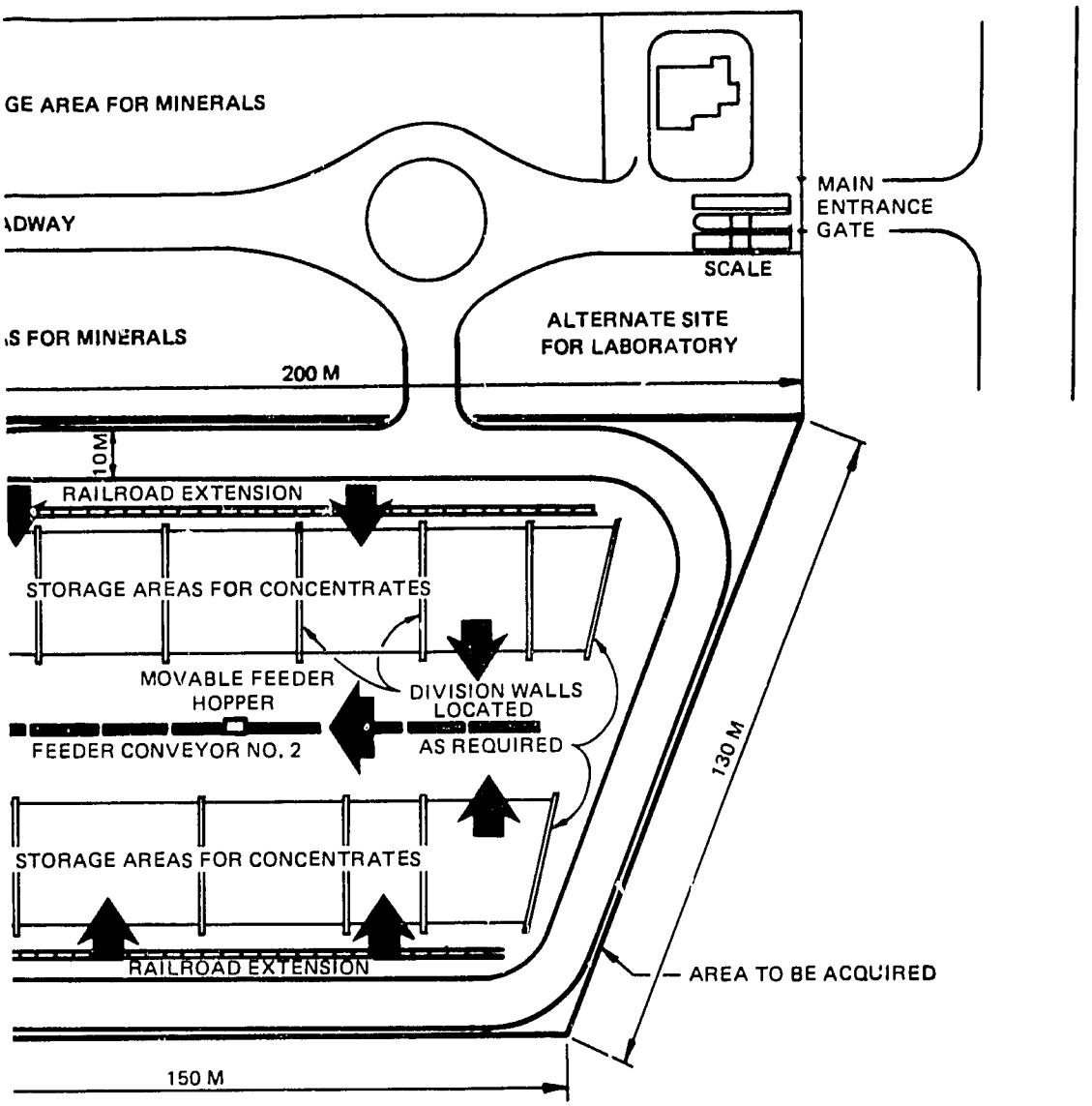
In 1981, capital costs include purchase of two front end loaders, two forklift trucks, and a hand pallet truck, as well as purchase of the soccer field adjacent to the MINPECO deposit. During that year, MINPECO should also negotiate easements for the proposed conveyor system to the port. Although the soccer field will not be developed until 1982, it should be purchased as soon as possible to prevent its purchase and/or development by any other individual or organization. Two additional front end loaders and forklift trucks should be purchased in 1983, as throughput increases. Purchase and shipping costs for the mobile equipment is shown in Table 19. In 1982 capital costs are shown for purchase and installation of the conveyor and ship loading system and development of the deposit expansion area. It is assumed that the ship loading equipment can be designed, purchased, shipped and

[1]Caterpillar Model 966. See Chapter Six and Appendix F for further information.

[2]Caterpillar Model V-80-D; see Chapter Six and Appendix F for further information.


STORA
INTERNAL RO
STORAGE AREA
RAILROAD EXTENSION
STORAGE AREAS FOR CONCENTRATES
MOVABLE FEEDER HOPPER
FUTURE FEEDER CONVEYOR NO. 3
STORAGE AREAS FOR CONCENTRATES
STORAGE AREAS FOR CONCENTRATES
STORAGE FOR MINERALS
OPERATIONAL BUILDINGS
PROPOSED LABORATORY (50 M BY 30 M)
CONVEYOR NO. 1 ELEVATED
STORAGE AREAS FOR MINERALS
ELEVATED CONVEYOR TO PORT
SCALE
122.5 M
EXISTING RAILROAD

95



CALLAO
PROPOSED DEPOSIT YARD EXPANSION
AND
ELEVATED CONVEYOR SYSTEM TO PORT

SCALE 1 : 30

FIGURE 17

96

TABLE 20
SUMMARY OF COSTS AND SAVINGS (U.S. $)
CALLAO

Year	Capital Costs[1]	Additional Annual Costs[2]	Resultant Annual Savings[3]	Net Annual Savings	Cumulative Savings	Remarks
1981	1,073,000	91,000	159,000	-1,005,000	-1,005,000	Purchase new area; purchase two front end loaders, two forklift trucks, and a hand pallet truck.
1982	4,578,000	173,000	1,846,000	-2,905,000	-3,910,000	Develop new area; Purchase and install conveyor.
1983	322,000	267,000	2,370,000	+1,781,000	-2,129,000	Purchase two additional front end loaders and forklift trucks.
1984		267,000	2,370,000	2,103,000	-26,000	
1985		267,000	2,370,000	2,103,000	2,077,000	
1986		267,000	2,370,000	2,103,000	4,154,000	
1987		267,000	2,370,000	2,103,000	8,308,000	
1988	255,000	267,000	2,370,000	1,848,000	10,156,000	Purchase two replacement front end loaders.
1989		267,000	2,370,000	2,103,000	12,259,000	
1990	255,000	267,000	2,370,000	1,848,000	14,107,000	Purchase two replacement front end loaders.
1991	68,000	267,000	2,370,000	2,035,000	16,142,000	Purchase two replacement forklift trucks and a hand pallet truck.
1992		267,000	2,370,000	2,103,000	18,245,000	
1993	66,000	267,000	2,370,000	2,037,000	20,282,000	Purchase two replacement forklift trucks.
1994		267,000	2,370,000	2,103,000	22,385,000	
1995	255,000	267,000	2,370,000	1,848,000	24,233,000	Purchase two replacement front end loaders.
1996		267,000	2,370,000	2,103,000	26,336,000	
1997	255,000	267,000	2,370,000	1,848,000	28,184,000	Purchase two replacement front end loaders.
1998		267,000	2,370,000	2,103,000	30,287,000	
1999		267,000	2,370,000	2,103,000	32,390,000	
2000		267,000	2,370,000	2,103,000	34,493,000	

[1] Includes purchase and development of new area; purchase, shipping, and installation of equipment.

[2] Refers to additional costs incurred as a result of purchase of recommended capital equipment; includes operating, maintenance, and storage costs.

[3] Refers to savings occurring as a result of purchase of recommended capital equipment; includes savings in operating costs and reduced losses.

installed by that time. MINPECO should take prompt action to initiate system design so that this 1982 deadline can be met. The life of the conveyor and ship loading system is estimated at 25 years so no replacement cost is shown during the time frame of this study. Replacement of the front end loaders is shown after seven years, based on a life of 10,000 hours and an annual usage of 1,500 hours. Replacement of the forklift trucks and hand pallet truck is shown after ten years, based on a life of 5,000 hours and an annual usage rate of 500 hours.

Additional annual costs include maintenance and operation of the capital equipment and storage of the portable conveyor on the pier. As discussed in the Salaverry chapter, labor costs for MINPECO personnel associated with operating the recommended equipment have not been included since it is assumed that labor costs will remain constant or decrease as the recommendations are implemented.

Resultant annual savings are calculated based on reduced losses and reduced operating costs. The reductions in losses are shown in Table 18. Reduced operating costs are a result of reduction or elimination of some presently incurred charges shown in Table 17. These eliminated charges include transport of the material by truck to the pier, stockpiling on the pier, rent of the present conveyor, and scale service at the port. Costs associated with operation of MINPECO-owned equipment are included in the additional annual costs.

CHAPTER FIVE

Matarani

A. EXISTING OPERATIONS

1. SETTING

The Port of Matarani is located in the southern portion of Peru, 95 km (linear) southwest of the City of Arequipa and 235 km north of the Chilean border (See Figure 1 in Chapter One for regional location of the port). Completed in 1947, Matarani replaced Mollendo as the principal port for the region. Matarani has three berths for cargo ships along a wharf[1]; each berth is 600 feet long with a depth of 30 feet. All bulk loading of mineral concentrates takes place at a bulk mineral berth, using a fixed conveyor system from a deposit area owned by ENAFER Peru located at an elevation of 75± meters above the port (see Photos 24 and 25). A general layout plan of the port area and vicinity appears in Figure 18. Bagged minerals, bulk minerals, and refined copper cathodes are loaded at Berths B or C. The Port of Matarani also handles most of Bolivia's mineral exports in addition to the Peruvian materials.

The deposit yard currently used by MINPECO at Matarani is located approximately one kilometer from the conveyor storage area, as shown in Figure 18. This is considered a temporary situation by MINPECO, as the deposit areas is owned privately and leased to MINPECO. This leased area consists of approximately 15,000 m^2, including open storage area, covered storage, scale, office space and sampling buildings. At present, only three persons are employed by MINPECO at Matarani – an administrator, an administrative assistant, and an operations assistant. All non-administrative work is contracted to ENAPU Peru which charges MINPECO a handling charge per ton of material. The only equipment owned by MINPECO at Matarani is a small Land Rover-type vehicle.

[1]As originally built, the wharf had three general cargo berths and one mineral berth. However, due to the larger size of vessels currently served in Matarani, the wharf effectively now has only three berths.

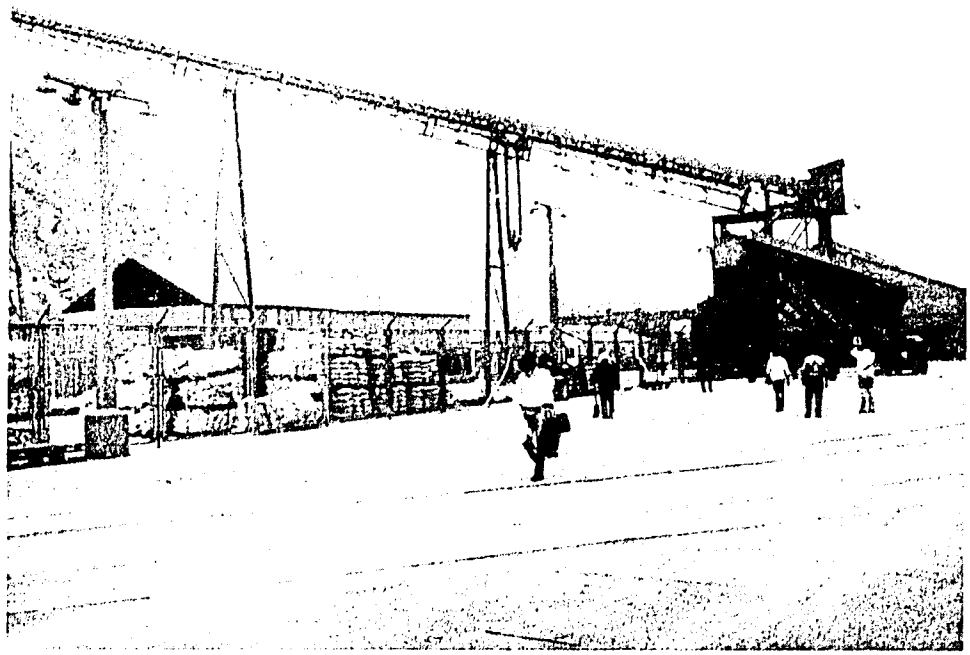


PHOTO 24 – Matarani – View of conveyor and shuttle conveyor on upland area of mineral berth.

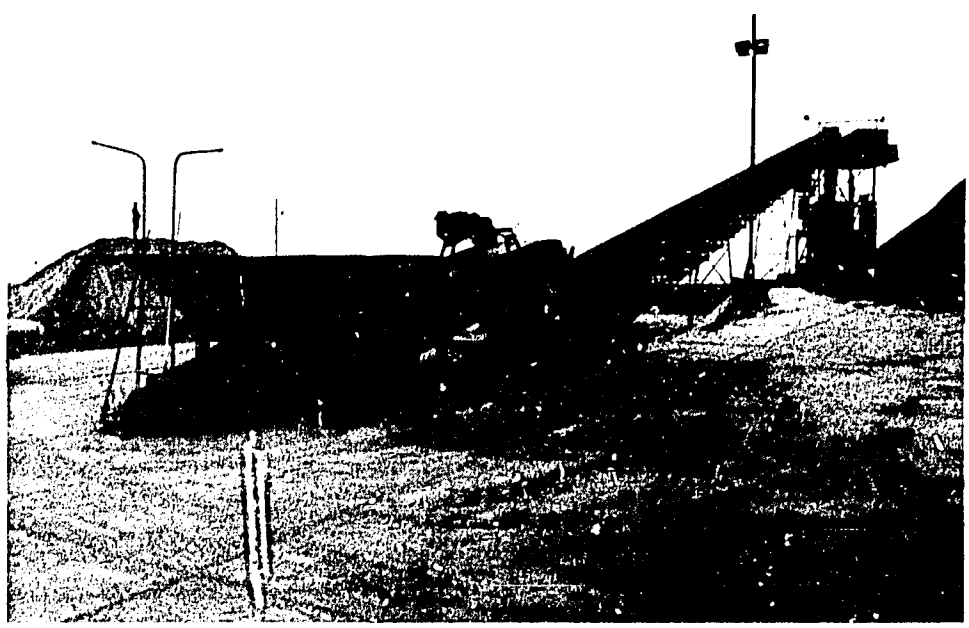
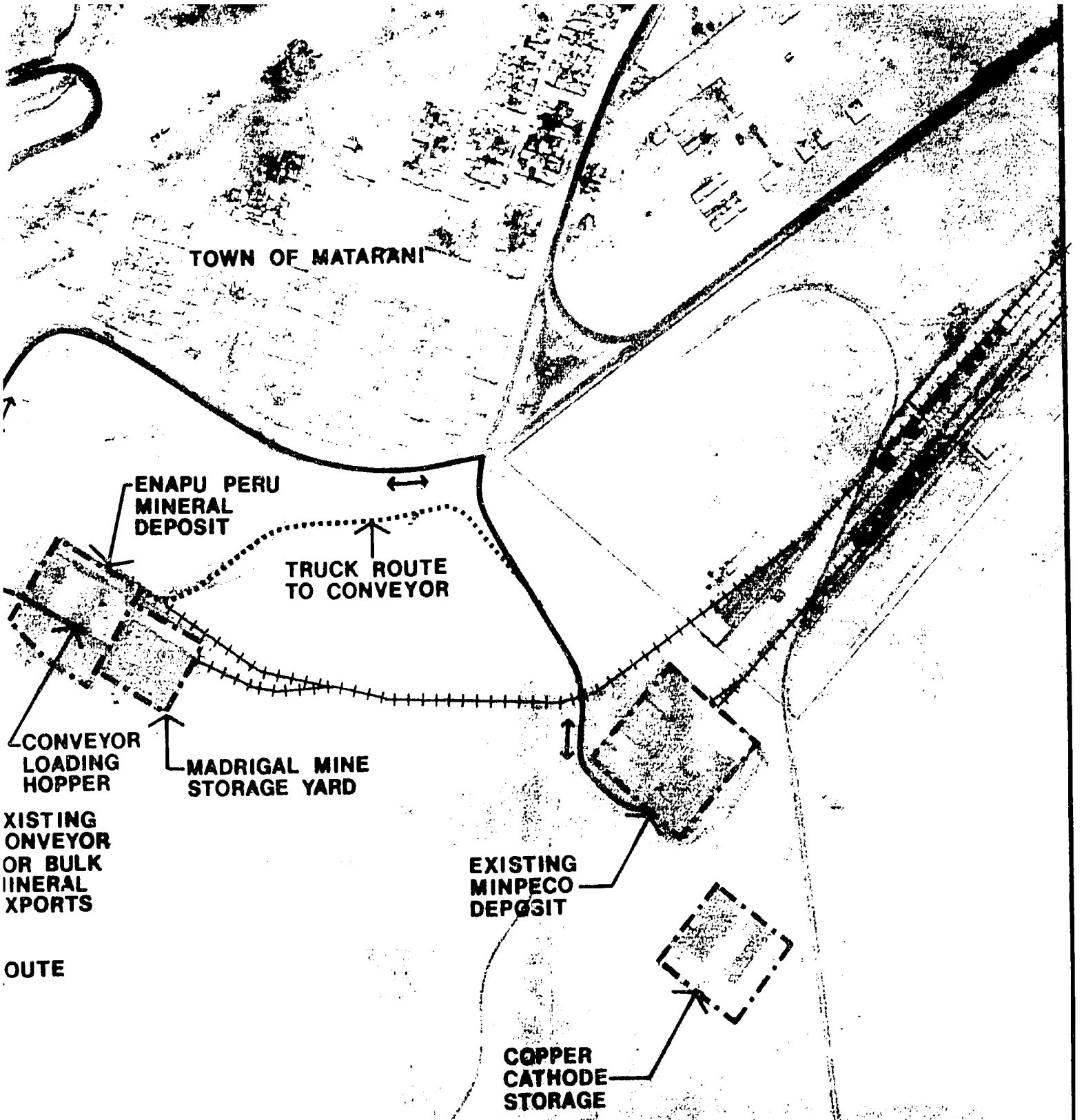


PHOTO 25 – Matarani – View of feed hopper and inclined conveyor feeding batch weigh bins.

BULK
MINERAL
BERTH
EXI
CO
FOI
Mil
EXI
TRUCK RO
TO PORT



International Development Cooperation Agency
Trade and Development Program
MINPECO
ORE HANDLING IMPROVEMENTS

MATARANI

EXISTING FACILITIES

FIGURE 18

SCALE 1 : 5000

SOURCE:
INSTITUTO GEOGRAFICO MILITAR
LIMA, PERU.

2. OPERATIONS

Minerals and concentrates are brought to the MINPECO deposit in Matarani from individual mines and also from the satellite storage yards of Juliaca, Tacna and Arequipa. Approximately 70 percent of the material arrives directly from larger mines with the remaining 30 percent from the satellite yards. Approximately 70 percent of the material arrives in rail boxcars and 30 percent by truck. Most of the trucked material is from smaller mines and is ore rather than concentrate. Arriving trucks are weighed on the scale in the deposit yard; railroad cars are weighed at a scale located approximately one kilometer from the deposit. Table 21 contains statistics of actual throughput at the Matarani deposit for 1977 through 1979. The table indicates that more material was shipped than received in both 1977 and 1978. The extra material shipped was taken from the stockpiles at the yard.

Samples are taken from each load immediately upon arrival at the deposit in a manner similar to the procedure at Salaverry or Callao. Samples are sent to Lima by "collectivo" for assaying for quality, while moisture content of the material is determined at a laboratory located in the Matarani yard. Results of the assay testing may not be received back in Matarani for 7-15 days.

TABLE 21

MATARANI THROUGHPUT

1977 - 1979

Year	Received	Shipped
1977	43,407	87,435
1978	128,776	131,188
1979	133,979	125,461

1979 Average Monthly Exports = 10,455 MT
1979 Average Load Per Ship = 3,921 MT

SOURCE: Control de Existencia, MINPECO

As in the Salaverry and Callao deposit yards, blending of minerals is done manually. The following materials were stored in the yard at the time the study team visited Matarani.

TABLE 22

MATARANI DEPOSIT INVENTORY
MAY, 1980

Copper Concentrate	4,850 MT
Copper Mineral	392 MT
Lead Concentrate	2,751 MT
Lead Mineral	1,013 MT
Zinc Concentrate	561 MT
Antimony Mineral*	60 MT
Tin Concentrate*	423 MT
TOTAL	**10,050 MT**

*All tin and antimony are received and exported in bags.

SOURCE: Department of Operations, MINPECO

This total of approximately 10,000 MT of materials indicates that in late May the deposit yard was at 50 percent capacity, based on an estimate of capacity of 20,000 MT, provided by MINPECO personnel at Matarani.

Approximately 4-5 days prior to the arrival of a ship for mineral export, MINPECO begins to transport the material to be shipped to the storage area at the ENAPU Peru conveyor. This operation is accomplished using rented dump trucks and front end loaders. Trucks are weighed as they leave the deposit. This work is all contracted to ENAPU Peru, which provides the necessary equipment and personnel. Cost to MINPECO for equipment rental and materials handling is shown in Table 23.

At the port, the portable loader is aligned with the end of the fixed conveyor and positioned over the ship's hold by ENAPU Peru personnel when loading is ready to begin. Two large front end loaders are then used to feed the conveyor's hopper with concentrates. The fixed conveyor/portable loader system is used only for the export of concentrates; minerals are brought to the port by truck.

TABLE 23

EQUIPMENT RENTAL AND MATERIALS HANDLING CHARGES
MATARANI

	PERUVIAN SOLES DE ORO[1]	AMERICAN DOLLARS[2]
FROM DEPOSIT TO SHIPSIDE (per MT)		
Loading/Shipping Rights	S/. 211.50	$ .77
Transport	105.00	.38
Stockpile (Machinery)	150.00	.55
Cleanup & Salvage	5.00	.02
Supervision	7.50	.03
Export Control	3.00	.01
	S/. 482.00	**$ 1.76**
FROM SHIPSIDE TO ON-BOARD (per MT)		
Supervision	S/. 7.00	$ .03
Loading (Machinery)	150.00	.55
Trimming	418.00	1.52
Loading (Labor)	185.00	.67
Loading Fee	5.00	.02
Protective Gear	1.20	Negligible
	S/. 7.66	**$ 2.79**
TOTAL COST FROM DEPOSIT TO ON-BOARD (per MT)	**S/. 1,248.20**	**$ 4.55**
ADDITIONAL EQUIPMENT COSTS		
Bulldozer		
— Transport	S/. 280,000.00	$1,018.18
— Per Day	34,650.00	126.00

[1] As of Mid-May 1980

[2] Assuming S/. 275 = $1.00

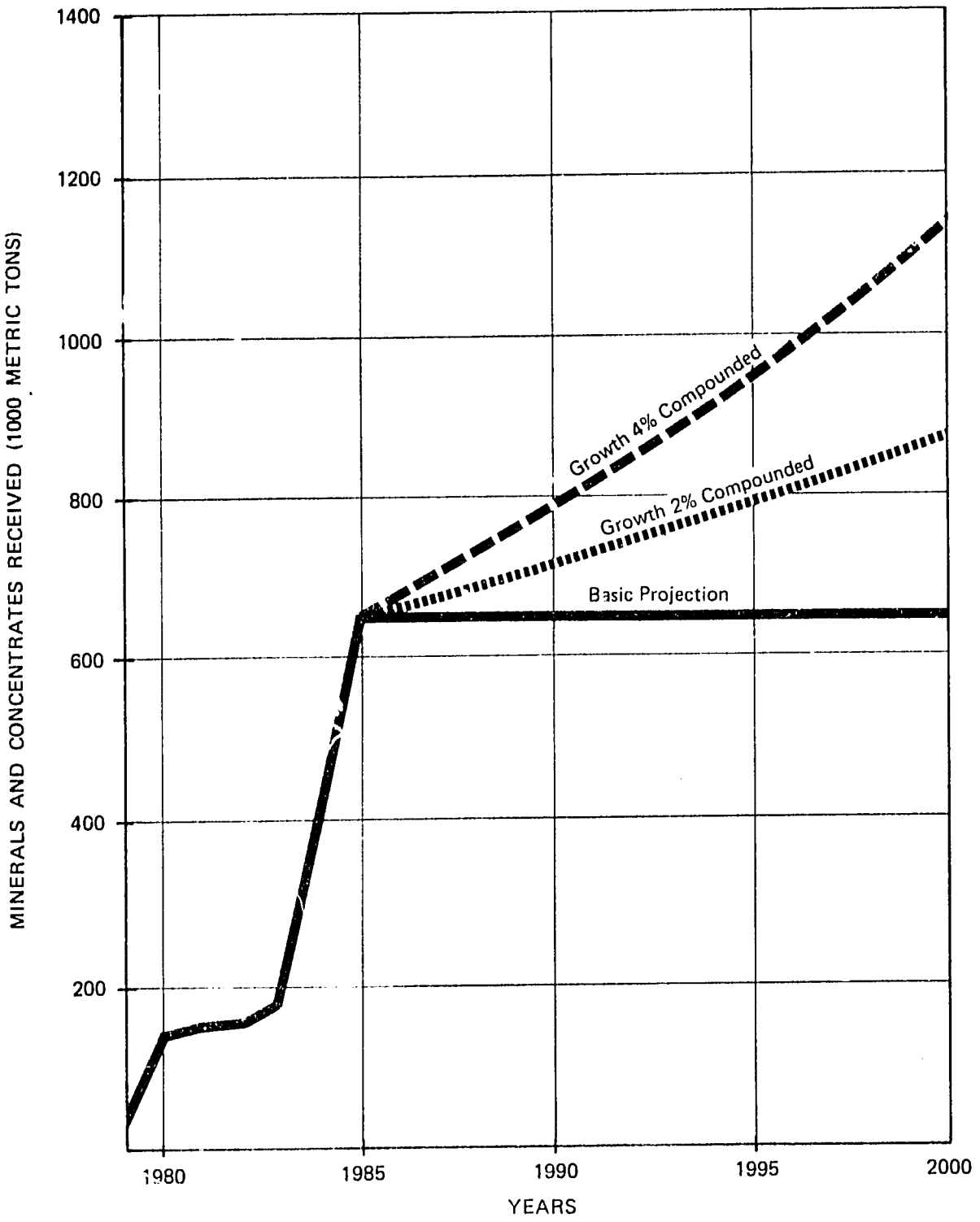
Manufacturer's design capacity of the conveyor is 1,200 tons/hour; however, it reportedly generally operates at about 300-350 tons/hour, primarily due to the method used to feed the system. The material is weighed by the conveyor. The study team observed the loading of 2,000 MT of zinc concentrate while in Matarani. Loading began at 8:00 p.m. on May 29, and was completed at 5:00 a.m. on May 30, for a gross average loading rate of 222 MT/hour, considerabley lower than that stated in the normal average. In reviewing the statistical data provided by MINPECO, it was noted that the average loading rate on two previous shipments from Matarani was only 155-165 tons/hour.

Matarani is projected to experience by far the largest growth in mineral exports of the ports studied. This is due almost entirely to growth in the copper mining sector and largely to the anticipated growth of the new Cerro Verde and Tintaya mines. Projections of materials passing through all the deposits are shown in Table 4 in Chapter One. Figure 19 of this chapter presents this material graphically for Matarani. By the year 1985, mineral exports through Matarani will surpass Callao as MINPECO's largest mineral handling operation. This considerable growth has the potential to cause a number of problems in MINPECO operations at Matarani. The following section of this chapter discusses these actual or potential problems at Matarani as well as some generalized alternative solutions. A later section presents specific recommendations for improvements, including schematics, cost estimates and scheduling.

B. POTENTIAL PROBLEM AREAS AND ALTERNATIVE SOLUTIONS

1. PORT LIMITATIONS

As at several of the other ports, the Port of Matarani has a number of limitations which have the potential to eventually affect the export of minerals by MINPECO. These problems are not a product of MINPECO operations, but of general port design, operation and circumstance. As such, these problems cannot be directely solved by MINPECO actions and are, therefore, out of the immediate scope of this study; however, it is appropriate to identify these issues so that MINPECO is aware of the situation and can request their resolution by ENAPU Peru.



PROJECTED THROUGHPUT
MATARANI DEPOSIT YARD

FIGURE 19

a. Berth Occupany

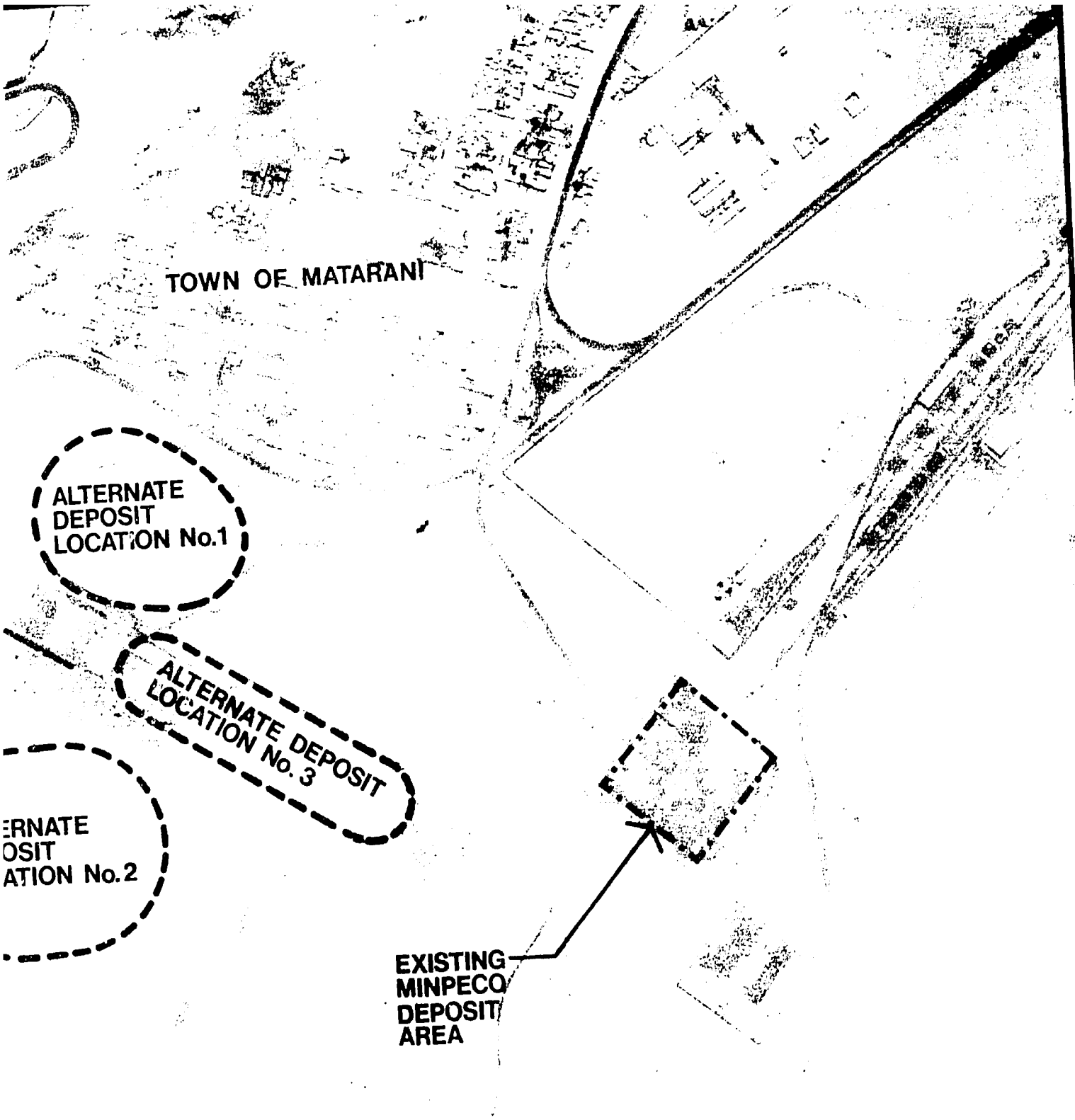
At the time the study team visited Matarani, the port was fully occupied by three large vessels, with another vessel anchored outside the port awaiting berthing space. This is reportedly not an unusual occurrence and serves to illustrate a potential capacity problem at Matarani which could significantly affect the efficiency of MINPECO's mineral exporting operations (i.e., the conflict at Berth C which serves as both a general cargo and bulk mineral berth).

Due to the fixed location of the conveyor, only Berth C can be used for the loading of bulk mineral concentrate cargo. In addition to MINPECO's operation, which exported 125,461 MT of materials in 1979, Matarani also serves as the port of exportation for much of Bolivia's mineral products.

Figures obtained from ENAPU Peru indicate that during 1978 Matarani experienced a total tonnage throughput of 603,141 MT and a berth occupancy rate of 46 percent. Based on MINPECO's projections and assuming no change in the activities of other users, the Port of Matarani would be handling over 1,000,000 tons annually by 1985. These figures indicate a level of port utilization approaching the upper limits of optimal efficiency. Although the time required for loading mineral ships may not increase if loading methods are improved, the increase in the number of mineral ships (approximately 100 more vessles in 1985 than in 1979) will affect the efficiency of port operations. Should the activities of other port users increase, the Port of Matarani will face severe problems in the future.

In discussion with ENAPU Peru personnel at Matarani, it was determined that ENAPU Peru is considering expansion of the port. Two potential locations for new berths have been identified and are shown in Figure 20. Site 1 is adjacent to the mineral berth, in the area presently used as an anchorage for fishing vessels. Site 2 is outside the immediate port area and south of the existing breakwater.

EXISTING
CONVEYOR
FOR BULK
MINERALS
ALTE
DEPC
LOCA



International Development Cooperation Agency
Trade and Development Program
MINPECO
ORE HANDLING IMPROVEMENTS

MATARANI

ALTERNATIVES

FIGURE 20

MAGUIRE
ARCHITECTS · ENGINEERS · PLANNERS

SCALE 1 : 5000

SOURCE:
INSTITUTO GEOGRAFICO MILITAR
LIMA, PERU

b. Channel and Berth Depths

Although the berth length available at Matarani is 600 feet, the berth depth is limited to vessels with a 30 foot draft. This limitation will become increasingly critical when Cerro Verde and Tintaya mines increase production and larger shipments (i.e., larger vessels) become desirable. MINPECO should request that ENAPU Peru consider dredging berths and channels to 33 feet. This would allow larger vessels with greater capacity and result in a smaller increase in the number of ship visits that the port would have to accommodate for mineral exports.

c. Harbor Turbulence

Within the harbor area at Matarani, considerable turbulence occurs, at times causing substantial movement of the vessels at berths and a substantial reduction in the efficiency of loading operations. During the study team's visit to the port, a 450 foot berthed vessel was experiencing violent horizontal and vertical movement. Two hawser lines holding the vessel at berth snapped during a two to three hour period of observation because of this extreme movement. In addition, great difficulty was observed with the unloading of containers at an adjacent berth due to excessive ship movement. Photos 26 and 27 illustrate the problem of harbor turbulence.

As discussed in detail in the chapter on Salaverry, ENAPU Peru should consider the installation of constant tension winches at the berths to reduce this movement and allow more efficient and safer loading. An evaluation of the existing fender system should also be made and, if necessary, a new energy absorption fender system installed to reduce damage to both the vessel and the wharf. Futher information regarding these fender and winch systems is found in Appendices C and D, respectively.

2. DEPOSIT LOCATION

As discussed in the text under "Existing Operations," MINPECO does not own the deposit area presently utilized in Matarani. This deposit yard has several detrimental features which preclude its use in the long term as the deposit yard for MINPECO operations in Matarani.

PHOTO 26 — Matarani — Violent movement of vessel during loading operations.

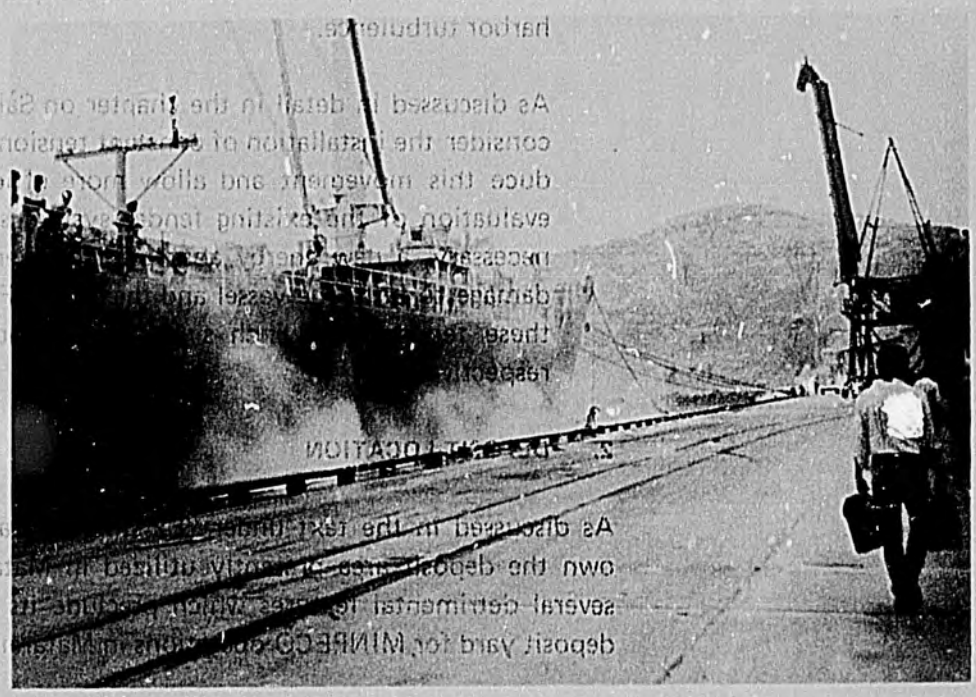


PHOTO 27 — Matarani — Violent movement of vessel during loading operations.

First, the area will not be large enough to meet MINPECO's expanding storage needs. Figure 21 indicates the future requirement at Matarani of open storage alone, not including other necessary storage and operational areas. Moreover the area is located at a distance of 2.2 km from the port entrance and, more importantly, .5 km from the storage yard containing the hopper to the ENAPU Peru conveyor. This means that several days before a mineral ship is due at Matarani, the concentrate to be exported must be trucked to the conveyor storage yard and stockpiled until loading can begin. This problem, which involves additional expense to MINPECO and double handling of the material, could be avoided by the acquisition of a deposit yard adjacent to the conveyor. Fortunately, adequate and appropriate land is easily available for MINPECO's use that would eliminate unnecessary and costly rehandling of the concentrate.

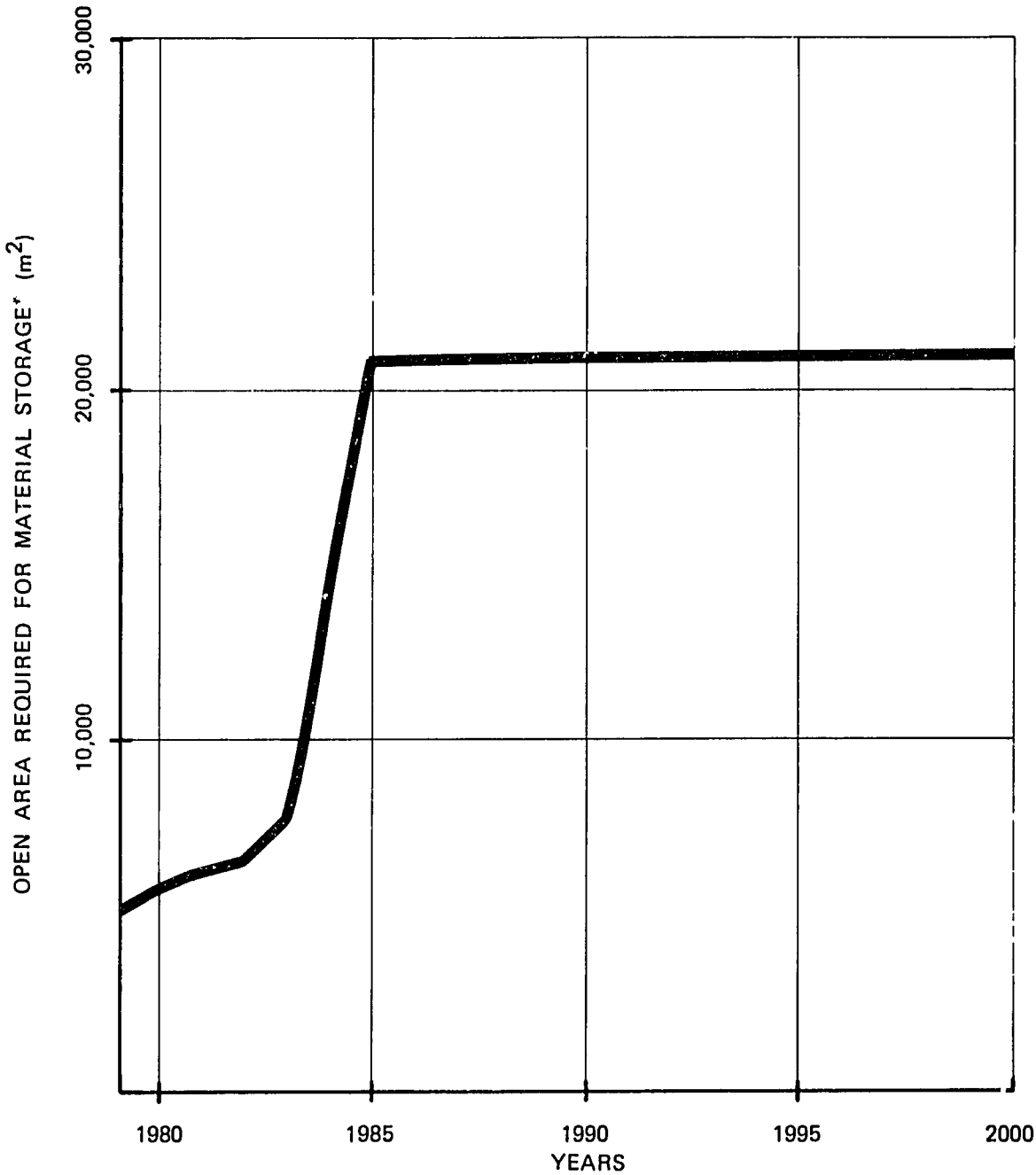
Several viable alternative locations exist for the relocation of MINPECO's deposit; these are shown in Figure 20. Location 1 is directly west of the ENAPU Peru conveyor storage yard, adjacent to both this yard and the deposit area belonging to Mina Madrigal. This site has good access to the roadway running parallel to the shore in this vicinity.

Location 2 is adjacent to the conveyor storage area on the east side, closer to the Town of Matarani. This site has relatively good roadway access and also has existing rail access – a considerable benefit in Matarani as 70 percent of the material arrives in rail cars.

Location 3 consists of the area to the south of the ENAPU Peru storage yard and incorporating the Madrigal area, as indicated in Figure 20. This area also has rail access and is located close to an access roadway.

Another alternative would be to maintain the present yard for storage of mineral ores and various other materials, while acquiring a site adjacent to the conveyor for storage of concentrates. Administrative and laboratory facilities would remain at the rented yard, while the site near the conveyor would be utilized solely for storage and loading of concentrates.

An additional problem with the present deposit is the lack of adequate water supply. In addition to normal sanitary needs, the MINPECO deposit utilizes large amounts of water to keep the concentrates at a constant mositure content in order to prevent excessive wind loss. At the present time the Matarani deposit has access to only 40 percent of its water needs. While this will also be a problem at any potential site due to the general shortage of water in the Matarani area, MINPECO is understandably reluctant to take measures to increase the water supply at a deposit area they do not own and which is inconveniently located for efficient operations.



OPEN STORAGE AREA REQUIRED
MATARANI DEPOSIT YARD

*Does not include covered storage for material from Cerro Verde, ores, bagged concentrates, and copper cathodes, or area for administration, scales, vehicle maintenance, laboratory, etc.

FIGURE 21

There is no easy solution to the problem of water availability. One potential long term solution exists in the proposed method of transporting large amounts of copper concentrate from the expansion at Cerro Verde mines. A slurry pipeline from the mine to Matarani is proposed which will transport the concentrate with 30 percent water content. This could provide a substantial quantity of water for operating purposes, although the water would have to be filtered to remove contaminants. A second alternative is a comprehensive investigation of groundwater potential in the Matarani area, while a third alternative is the construction of a small desalinization plant for the conversion of sea water or salt groundwater. Such an option would entail considerable expense and should be considered only if other alternatives are not possible. However, if this option is feasible, it could provide water for MINPECO, as well as the town and port.

3. LOADING OPERATIONS

A number of problems exist with the methods or equipment presently used to handle concentrates as follows:

(a) As in Callao, where a conveyor is also utilized, visible wind losses can be observed during loading at the point of deposit into the ship's hold. This could be corrected by an "elephant trunk" or "sleeve" attached to the end of the loader that would channel the concentrates into the ship's hold, thus minimizing exposure of concentrates to the wind.

(b) The shuttle conveyor on the wharf, which has to be aligned properly to deposit material into the ship's hold, comes easily out of alignment as it is being maneuvered. This lengthens the period necessary for loading preparation. This is currently in the process of being corrected by ENAPU Peru through the installation of tracks on the dock. Currently, the shuttle conveyor is aligned by two small tractors.

(c) At the main hopper of the conveyor, concentrates are deposited by two large front end loaders (see Photo 28). Due to properties of the material, bridging occurs, clogging the grates and preventing the concentrates from dropping onto the conveyor belt continuously. As a result, the material must be manually rodded through the grates; this procedure is not only inefficient and costly, but highly dangerous to the personnel involved. The solution to this problem lies in the installation of a vibrating hopper or a reciprocating feeder, that would allow the smooth flow of concentrates onto the conveyor belt and eliminate the need for manual rodding.

PHOTO 28 – Matarani – Front end loaders employed to feed mineral concentrates to ENAPU Peru conveyor system.

(d) The conveyor was designed in 1968 to load vessels of 8,000 - 20,000 tons and is now somewhat strained by the necessity of loading the 30,000 ton vessels commonly arriving in Matarani. While the conveyor's capacity is adequate, its physical dimensions are strained trying to load the longer, wider vessels. Installation of tracks for movement of the shuttle conveyor and the installation of an "elephant trunk" to the conveyor end should alleviate this problem. Photos 29 and 30 show the port end of the conveyor/loader system.

(e) Examination of the deposit yard and adjacent areas exposed to the overhead conveyor to the port indicate loss of material being conveyed to export vessels. This loss is primarily attributed to wind effect. Further investigation indicated that the prevailing wind at the deposit area is in approximately the same alignment as the axis of the inclined conveyor. The corrugated metal cover that partially covers the travelling belt literally acts as a wind tunnel under the conditions described. Additional problem areas appeared to be at transfer stations and at the point of discharge into the vessel's cargo hold. The wind effect was particularly prevalent at the point of discharge, where a plume of material was exposed to wind forces. In discussing these apparent problem areas with the original supplier of the Matarani bulk concentrate handling facility, it was learned that the supplier was not required to totally enclose the belt to eliminate or minimize wind effect. Wind boards are normally employed along the conveyor frame to handle this condition. In addition to skirt boards, the entrance to the covered belt above the feed hopper can be provided with wind baffles to prevent wind tunnel effects.

A dust collector could be added at the discharge points to minimize problems in these areas. At discharge points, the dust hoods and skirt boards could be totally enclosed for a sufficient distance to allow for the material being transported to completely settle down. The type of dust hood most appropriate in this situation usually mounts on the discharge hood and has a fan that creates a draft that pulls the dust along in the direction of the material flow. This type is less costly than equipment made up of duct work and baghouses external to the conveyor system. Belt housing that would totally enclose the belt could be provided for approximately $55 per lineal foot; wind boards could be added to the existing conveyor frame for approxiamtely $25 per lineal foot. It should be clear that the entire belt system does not necessarily have to be enclosed. This corrective measure would only be employed

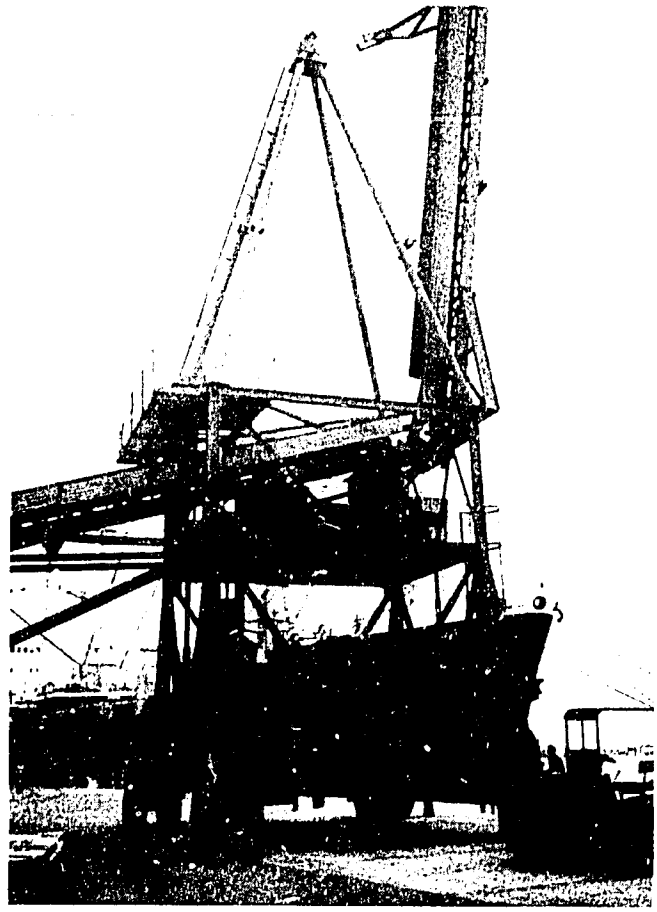


PHOTO 29 – Matarani – ENAPU Peru shiploader in stowed position on mineral berth.

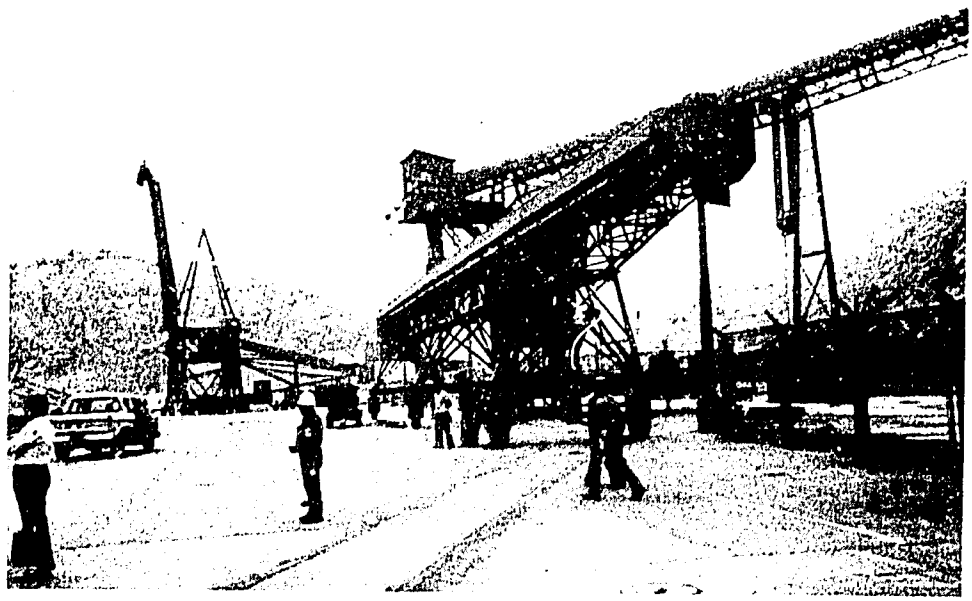


PHOTO 30 – Matarani – View of shuttle conveyor and shiploader on mineral berth.

in problem areas. For more definite corrective measures, other than those described above, equipment specialists will be required to visit the site to determine the exact extent of the problem areas and determine corrective action at minimum cost. The additional weight of the equipment required to enclose the conveyor to resolve the wind problems may also require some additional support bents to be added at specific points to support the conveyor.

(f) The conveyor itself is showing signs of wear and needs preventative maintenance if the system is to last to the year 2000. The equipment is already 12 years old and should be examined and appropriate portions overhauled when needed, rather than waiting for malfunction to occur.

C. RECOMMENDED SOLUTIONS

1. RECOMMENDATION 1

The principal problem to be resolved at Matarani is acquisition of a deposit yard in a suitable location. It is recommended, therefore, that MINPECO acquire the area shown on Figure 20 as Location 3, south of the conveyor terminal point and including the Mina Madrigal yard. A plan of the proposed yard is shown in Figure 22. Approximately 59,000 m^2 is required, including 15,000 m^2 for storage of concentrates (see Figure 21), 4,600 for covered storage, 2,200 for storage of Cerro Verde material, and 6,000 m^2 for offices, sampling lab, parking, vehicle maintenance and storage, scales, etc. The additional area is necessary to allow for efficient circulation of material by rail, truck and mobile equipment and would also allow area for storage of additional material. The yard should be enclosed by a four meter concrete block wall and paved with 20 cm thick concrete floor slab. There should be entry/exit gates for trucks and an entry and spur line for rail cars, as shown on Figure 22. Construction costs are estimated at approximately $1,430,000. Acquisition costs are difficult to determine, since negotiations among ENAFER, Mina Madrigal, and MINPECO must be arranged and may involve compensation, transfer, etc., rather than outright purchase. Based on local costs, however, market value of the site is approximately $70,000, bringing total cost for purchase and development of the site to $1,500,000.

2. RECOMMENDATION 2

The new deposit yard will be connected to the ship-loading conveyor by a fixed conveyor system, also indicated in Figure 22. A schematic of this new system is shown in Figure 23, with additional manufacturer's information contained in Appendix E. Estimated cost of this system is $589,000 (including shipping and installation), resulting in a total development cost of $2,089,000.[1]

Implementation of this recommendation will result in reduced losses and operating costs. Reduction in losses have been estimated at 0.25 percent of total material handled, based on elimination of truck transport, increase in wall height, enclosure of the ENAPU Peru conveyor and use of an elephant trunk at the ship end of the system during loading. Savings due to loss reduction are shown in Table 24.

TABLE 24

REDUCTION IN LOSSES DUE TO IMPROVED LOADING METHODS
MATARANI

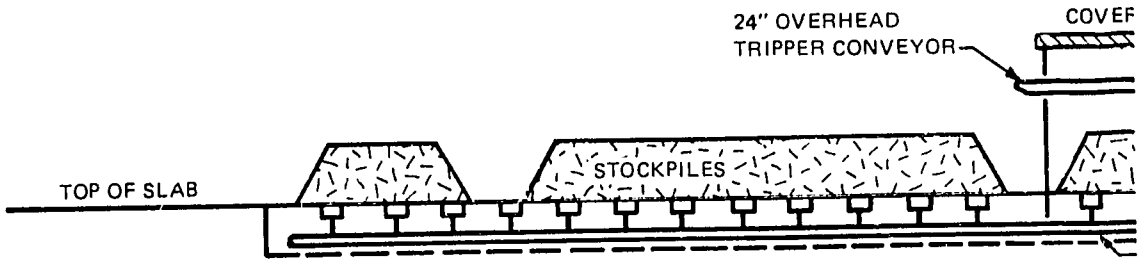
Year[1]	Cost Savings
1982	$ 115,000
1983	137,000
1984	358,000
1985 - 2000 (16 years)	8,741,000[2]
Total Savings Over Project Period	$9,351,000

[1]Assumes equipment in place by 1982.

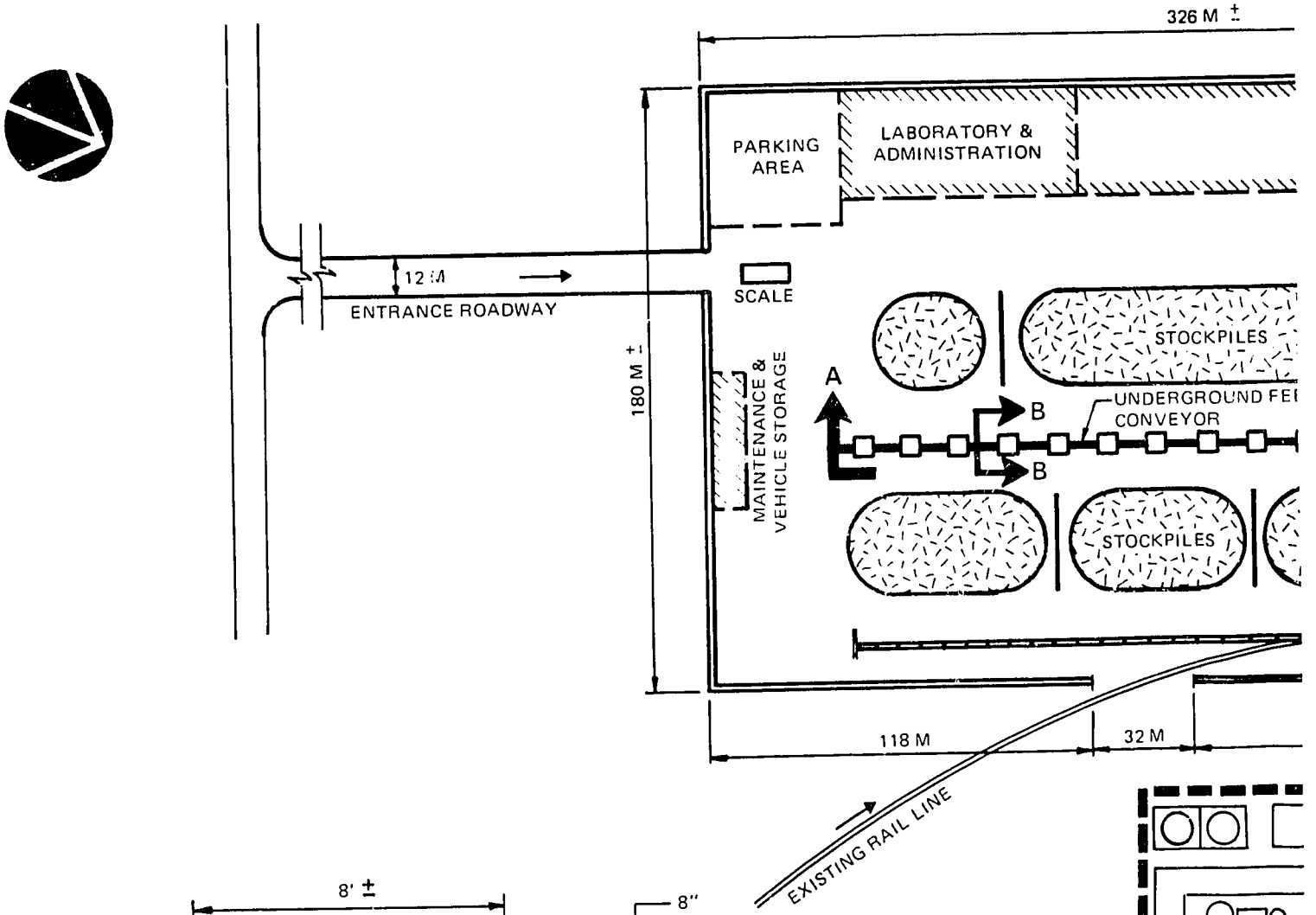
[2]$546,300/year x 16 years = $8,741,000

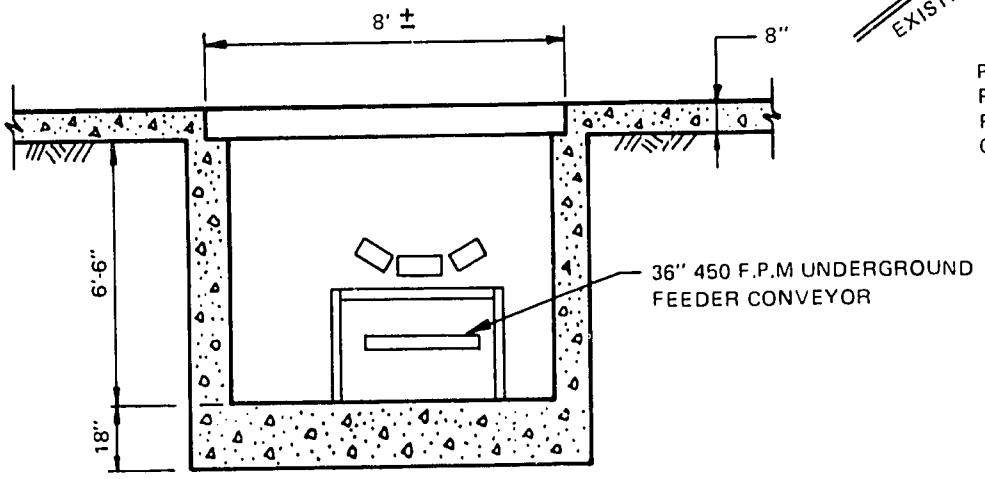
SOURCE: Data from MINPECO and calculations by CE Maguire, Inc.

[1]This total does not include cost for improving the existing conveyor equipment as these improvements would be made only where necessary as determined through close examination by an equipment specialist.



SECTION A-A





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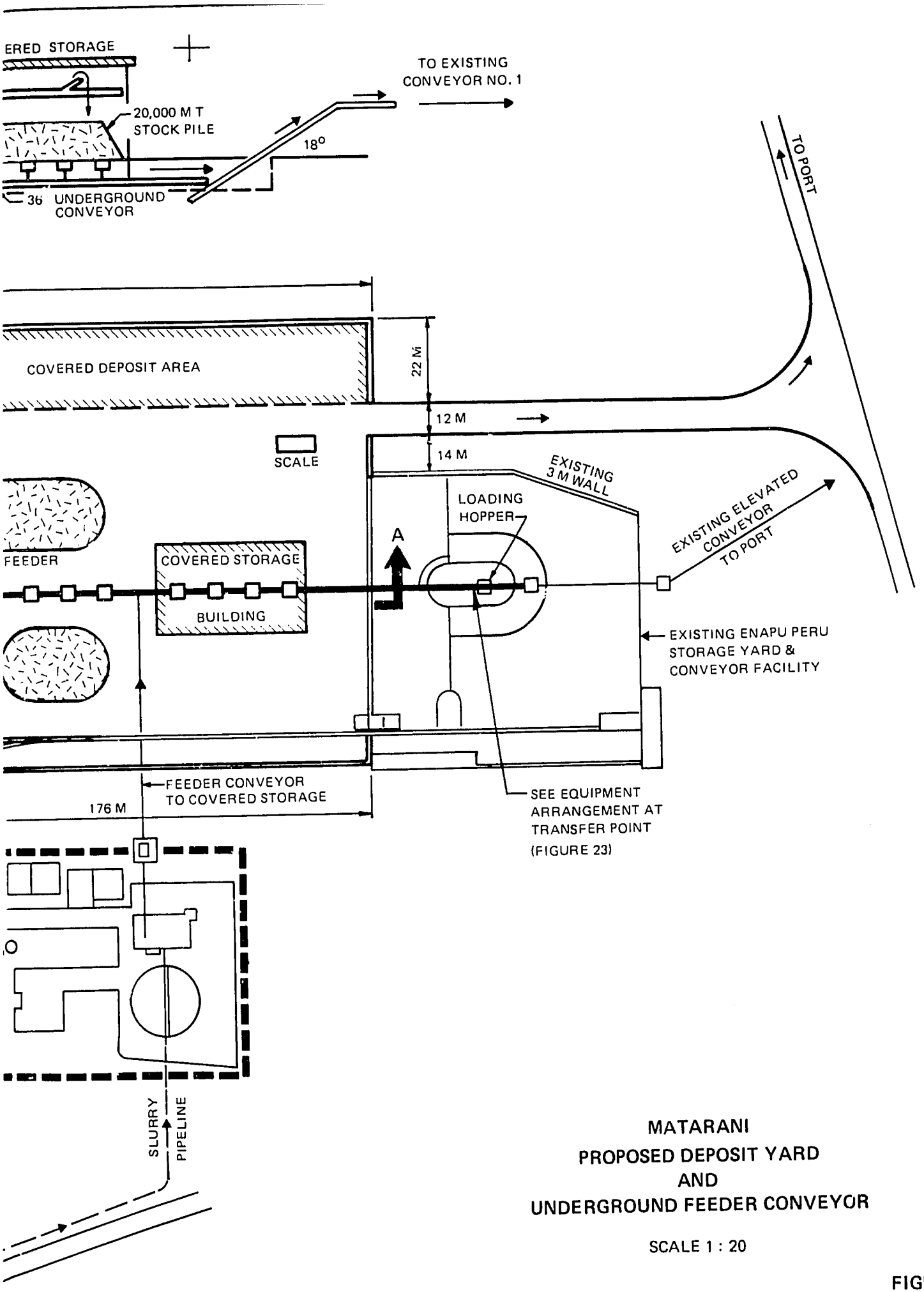
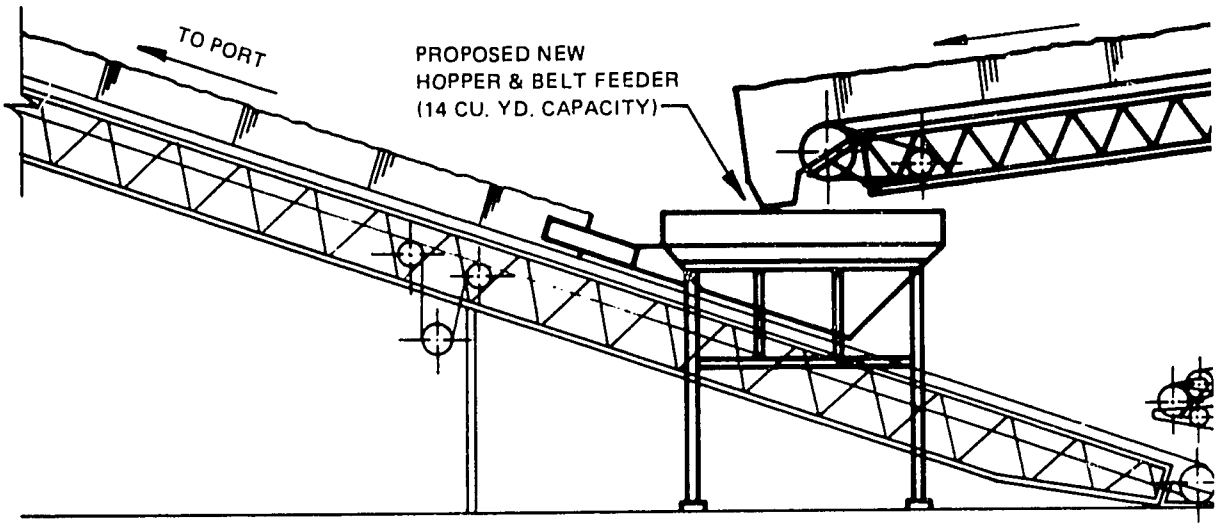


MATARANI
PROPOSED DEPOSIT YARD
AND
UNDERGROUND FEEDER CONVEYOR

SCALE 1 : 20

FIGURE 22



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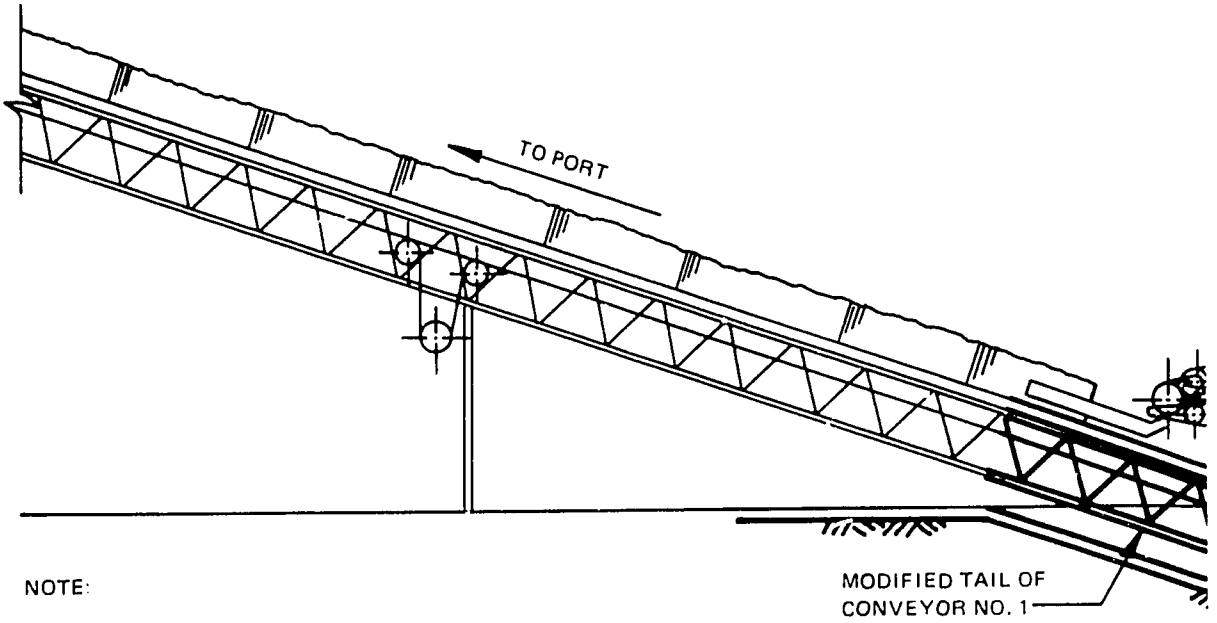
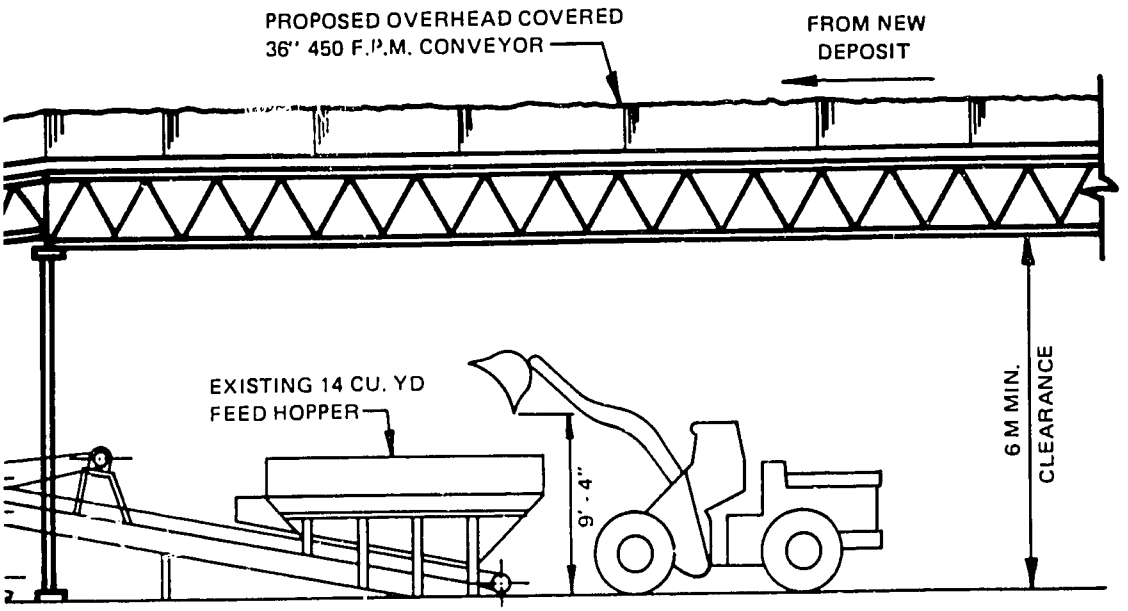


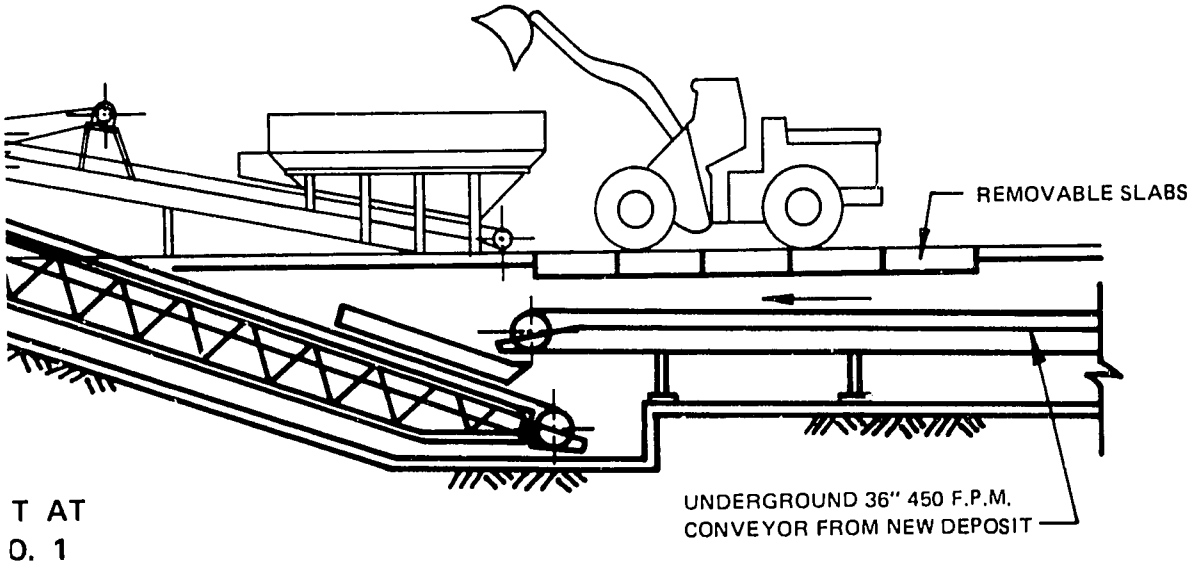
NOTE:

EQUIPMENT INFORMATION: COURTESY OF
BARBER-GREENE CO., AURORA, ILLINOIS, U.S.A.

POSSIBLE UNDERGROUND ARRANGEMEN
TRANSFER TO EXISTING CONVEYOR N



NGEMENT AT TRANSFER
; CONVEYOR NO. 1



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O. 1

MATARANI
ALTERNATE ARRANGEMENT AT PROPOSED
TRANSFER TO EXISTING CONVEYOR NO. 1

FIGURE 23

3. RECOMMENDATION 3

MINPECO presently owns no equipment at Matarani. As quantities through the yard increase, and MINPECO acquires its own yard, it will be preferable that MINPECO purchase its own equipment.

Two front end loaders (Caterpillar Model 966), two forklift trucks (Caterpillar Model V-80-D), and the hand pallet truck should be purchased in 1982, with two additional front end loaders and forklift trucks purchased in 1984. Cost of this mobile equipment is shown in Table 25. At the time of purchase, a preventive maintenance schedule should be developed and either a maintenance contract let or a trained mechanic hired. In addition, an inventory of common replacement parts should be acquired and maintained. Specifications and additional information are contained in Appendix F.

TABLE 25

MOBILE EQUIPMENT COSTS
MATARANI

4 Front End Loaders	$488,000
4 Forklift Trucks at $31,000	124,000
1 Hand Pallet Truck at $1,250	1,250
Shipping Costs	31,000
	$644,250

SOURCE: International Liaison Office, Caterpillar Tractor Company and various other shippers and suppliers.

4. RECOMMENDATION 4

As a principal user of the port, MINPECO should seek to obtain priority rights for bulk mineral loading at Berth C if berth availability becomes a problem. With regard to possible port expansion, MINPECO should negotiate with ENAPU Peru to maintain the mineral berth at its present site. If it is necessary for ENAPU Peru to relocate the mineral berth, site 1 (as shown on Figure 20) is the preferred area, since it is adjacent to the present mineral berth and would require only an extension to the existing conveyor system, in addition to a marginal wharf for berthing space. Construction of a mineral berth at site 2 would require construction of a new wharf, protective breakwater, and complete infrastructure, as well as a complete new conveyor system.

MINPECO should also encourage ENAPU Peru to purchase and install energy absorbing fender systems and constant tension winches, at least at Berth C, to allow more efficient loading under adverse sea conditions and as a safety measure. Further information regarding both systems are included in Appendices C and D.

5. COST ANALYSIS

Table 26 contains a summary of costs and savings that will occur as the result of implementation of the recommendations for Matarani. These figures are based on a comparison of operating costs of present and proposed methods of materials handling; 1981 has been used as a starting point for the analysis since it is unlikely that any of the recommendations could be implemented prior to then.

In 1981, capital costs include purchase of two front end loaders, two forklift trucks and a hand pallet truck, as well as purchase and development of a deposit yard. Two additional front end loaders and forklift trucks should be purchased in 1984, when Cerro Verde and Tintaya mines come on-line. Purchase and shipping costs for the mobile equipment are shown in Table 25. In 1982, capital costs are shown for purchase and installation of the conveyor system. It is assumed that this system can be designed, purchased, shipped, and installed by this time, although MINPECO must initiate action toward system design in late 1980 or early 1981. The life of the conveyor system is estimated at 25 years, so no replacement costs are included during the course of this study. For the mobile equipment, replacement costs for the front end loaders are shown after seven years and for the forklift trucks and hand pallet truck after ten years, based on a 10,000 hour and a 5,000 hour life, respectively, and annual usage rates of 1,500 hours and 500 hours.

Additional annual costs include maintenance and operation of the capital equipment. Costs of handling Cerro Verde and Tintaya materials have been included, although these quantities were not included in MINPECO's throughput in determining resultant annual savings, since MINPECO would not handle the output from those mines if they continued to operate as at present. The additional costs will be offset by revenues obtained by MINPECO for storing and handling the Cerro Verde and Tintaya products.

TABLE 26

SUMMARY OF COSTS AND SAVINGS (U.S. $)
MATARANI

Year	Capital Costs[1]	Additional Annual Costs[2]	Resultant Annual Savings[3]	Net Annual Savings	Cumulative Savings	Remarks
1981	1,823,000	91,000	295,000	-1,619,000	-1,619,000	Purchase and develop new yard; purchase two forklift trucks, two front end loaders and a hand pallet truck.
1982	589,000	103,000	466,000	-226,000	-1,845,000	Purchase and install conveyor system.
1983		104,000	548,000	+344,000	-1,501,000	
1984	322,000	196,000	901,000	383,000	-1,118,000	Purchase two additional front end loaders and forklift trucks.
1985		197,000	1,202,000	1,005,000	-113,000	
1986		197,000	1,202,000	1,005,000	+892,000	
1987		197,000	1,202,000	1,005,000	1,897,000	
1988	255,000	197,000	1,202,000	750,000	2,647,000	Purchase two replacement front end loaders.
1989		197,000	1,202,000	1,005,000	3,652,000	
1990		197,000	1,202,000	1,005,000	4,657,000	
1991	323,000	197,000	1,202,000	682,000	5,339,000	Purchase two replacement front end loaders and forklift trucks, and a hand pallet.
1992		197,000	1,202,000	1,005,000	6,344,000	
1993		197,000	1,202,000	1,005,000	7,349,000	
1994	66,000	197,000	1,202,000	939,000	8,288,000	Purchase two replacement forklift trucks.
1995	255,000	197,000	1,202,000	750,000	9,038,000	Purchase two replacement front end loaders.
1996		197,000	1,202,000	1,005,000	10,043,000	
1997		197,000	1,202,000	1,005,000	11,048,000	
1998	255,000	197,000	1,202,000	750,000	11,798,000	Purchase two replacement front end loaders.
1999		197,000	1,202,000	1,005,000	12,803,000	
2000		197,000	1,202,000	1,005,000	13,808,000	

[1] Includes acquisition and development of new deposit area; purchase, shipping and installation of conveyor; and purchase, shipping, and assembly of mobile equipment.

[2] Refers to additional costs incurred as a result of purchase of recommended capital equipment; includes operating and maintenance costs.

[3] Refers to savings occurring as a result of purchase of recommended capital equipment; includes savings in operating costs, reduced losses, and rental of present yard or a similar facility.

Resultant annual savings are due to reduced losses (shown in Table 24) and reduced operating costs, based on the charges shown in Table 23. Reduced operating costs are a result of elimination of charges for such services as truck transport of the material to the ENAFER Peru yard and stockpiling there, use of rented equipment for feeding the conveyor, and rental of the present yard or a similar facility. Costs associated with the of MINPECO-owned equipment to feed the conveyor are included in additional annual costs.

CHAPTER SIX

General Issues

A. ASSAY LABORATORY

Numerous assays of incoming and outgoing minerals and concentrates must be performed by MINPECO. For back-to-back shipments, assaying is generally performed by the buyer and/or seller and is not the responsibility of MINPECO. For regular purchases and sales, however, MINPECO must assay the incoming material in order to determine its quality, and hence its purchase price, and the classification of the material for resale. Outgoing material must be assayed to insure that it meets the qualities specified in the sale contract. Within the yard, MINPECO must assay blended material to determine its new properties. At present, MINPECO does not operate an assay laboratory, but has assays performed by a private laboratory in Lima. Each deposit visited, except Chimbote, had a laboratory to determine moisture content, but samples to determine quality are sent from the deposits to the laboratory in Lima by "collectivo." In discussions with MINPECO personnel at Salaverry and Matarani, the time required to send a sample to Lima and receive the results via teletype was estimated to range from 7 to 15 days. MINPECO generally tests for six or seven elements in each sample, at a cost of $5.50 per element, or $33.00 to $38.50 per sample. Information provided by personnel at MINPECO's Callao deposit indicates that approximately 50 samples per day are sent to the laboratory. Cost of testing these samples for six or seven elements each would amount to between $1,500 and $2,000 per day, or almost $500,000 per year. The number of samples tested for the other deposits is not known at this time. Although the assaying problem is not strictly within the scope of this study, it was considered to have a significant impact on the improvement of MINPECO's handling and storage operations and has, therefore, been included.

Based on the significant cost of use of an outside laboratory, as well as the length of the time required to receive the results, it is recommended that MINPECO construct and equip an assay laboratory at the Callao deposit for company-wide use. This would eliminate the delay experienced at a private laboratory because of other customers, provide ready information to the commercial department for sales and to the operations department for blending. Depending on the volume of internal use, MINPECO could also perform assay tests for other mineral exporters throughout the mining industry (i.e., back-to-back shippers who must assay their products), thus defraying some of the operating costs.

The central component of a modern assay lab is atomic absorption (AA) spectroscopy equipment. Several models of this type of equipment, manufactured by Perkin-Elmer Corporation of Norwalk, Connecticut, were reviewed to determine the best selection for the type and size of laboratory MINPECO requires. Only Perkin-Elmer equipment was considered, because of the quality of this product and their local presence in Lima; but this equipment, as well as all other equipment discussed, is also available from other suppliers. The costs of the AA units considered are shown in Table 27.

TABLE 27

ATOMIC ABSORPTION UNIT COSTS

	Basic Costs	Accessories	Total
Model ICP/5000	$90,000	$ 725	$91,000
Model 5000	39,000	1,750	40,750
Model 4000	24,500	7,200	31,700
Model 2380	18,000	3,200	21,200

The major difference between these units is the degree of automation built into the system. For MINPECO's operations, the Model 5000 is recommended. This unit allows a microprocessor to store up to six element tests without manual entry. Since MINPECO routinely tests for seven elements, this unit would provide nearly automatic operation. The Model 5000 allows up to 50 samples to be tested for a single element, with an average cycle of ten seconds per sample or 500 seconds for all 50. Including time for the machine to adjust between element tests, 50 samples could be tested for six elements in under 30 minutes.

Due to the high assay rates available with this type of analyzer, MINPECO would have the capability of performing assays for other mineral exporters, which would provide additional revenues.

Although this equipment is relatively sophisticated, an operator need not be a formally educated chemist although that would be advantageous. In MINPECO's situation, where a limited number of elements will be tested in a repetitive routine, a person with some laboratory background and a basic understanding of chemistry would be capable of operating this equipment after completion of the one week training course conducted by the manufacturer. Normal equipment maintenance and service, as well as equipment set-up, would be performed by the local representative in Lima.

In addition to the atomic absorption unit, other laboratory equipment will be required to calibrate the AA and crush, pulverize, split, and dry samples. A list of this necessary equipment is summarized in Table 28, with a suggested source and approximate cost. Additional information on this equipment is contained in Appendix G.

TABLE 28

MISCELLANEOUS ASSAY LABORATORY EQUIPMENT COSTS

Equipment	Source	Approximate Cost
Gas Regulators	Perkin-Elmer	$ 1,000
Air Compressor	Perkin-Elmer	700
Fume Vent & Blower	Perkin-Elmer	500
Glassware	Fisher Scientific*	1,700
Analytical Balance	Fisher Scientific	3,100
Pulverizer and Plates	Denver Equipment**	4,500
Sample Splitters (2)	Fisher Scientific	800
Jaw Crusher	Denver Equipment	5,100
Ro-Tap and Sieves	Fisher Scientific	1,600
Sieve Analytical Balance	Fisher Scientific	1,450
Calibration Standards	Fisher Scientific	350
Glassware for AA	Perkin-Elmer	600
Misc. AA Accessories	Perkin-Elmer	6,600
Voltage Reg. & Power Supply	Perkin-Elmer	2,200
Element Lamps	Perkin-Elmer	4,200
		$34,900

*Fisher Scientific Corporation, Pittsburgh, Pennsylvania.
**Denver Equipment Division, Colorado Springs, Colorado.

Additional information on this equipment is contained in Appendix G.

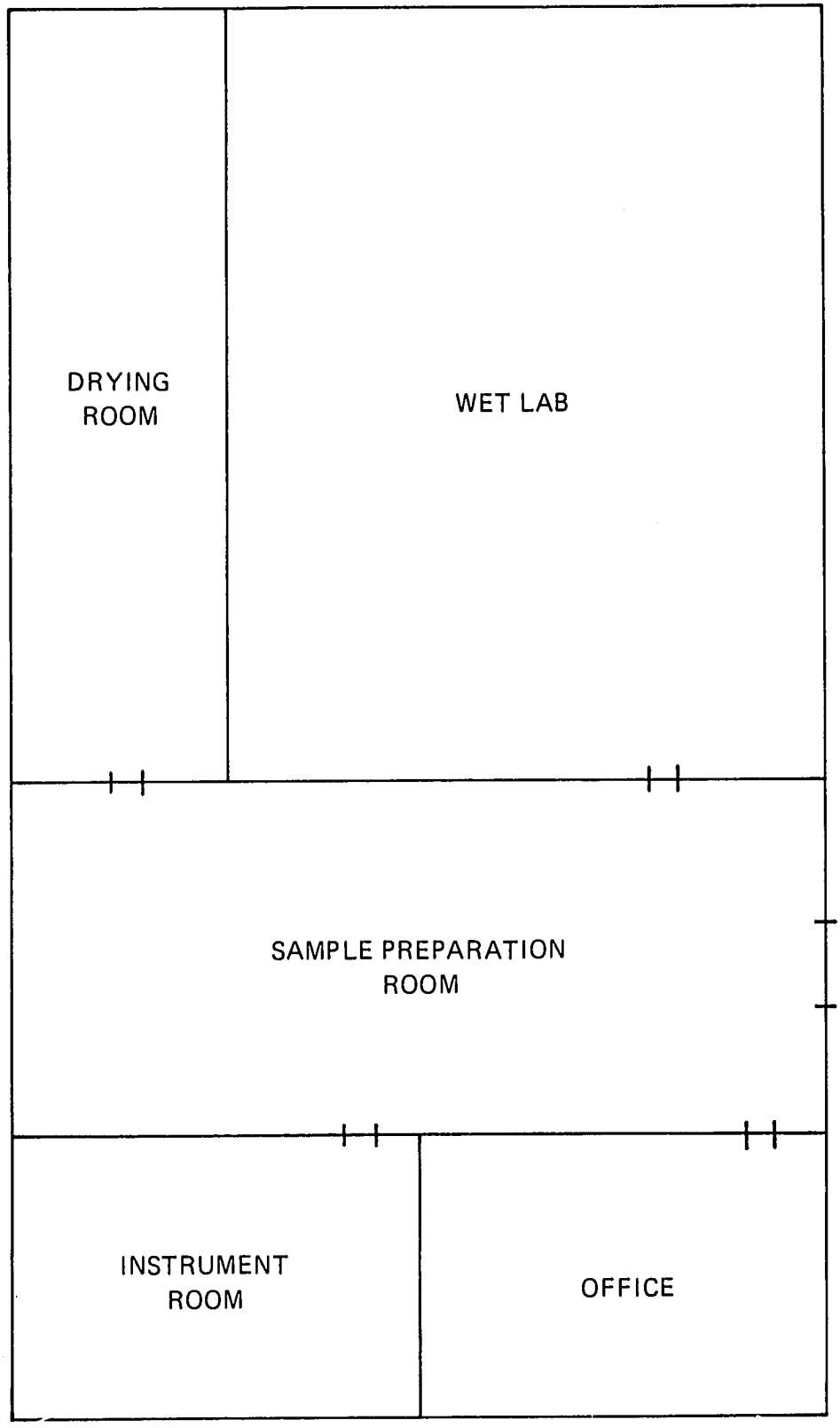
An oven would also be required for drying samples. The oven presently in use at the Callao deposit laboratory appeared to be in good condition and could be used in the new laboratory. Including the AA unit, therefore, purchase cost for laboratory equipment would be approximately $75,650.

In addition to purchase of equipment, it will be necessary to construct a building to house the laboratory. Figure 24 shows a typical floor plan of such a building containing 1,500 m^2. This configuration allows approximately ten percent of the area for an office; ten percent for a temperature/humidity-controlled instrument room to house sensitve equipment such as the AA unit and balances; 25 percent for sample preparation, including sorting, crushing, and pulverizing, 40 percent for a wet laboratory and acid room; and 15 percent for a drying room, containing ovens and sieves. Provisions must also be made for an area to store samples for up to two years as required by some MINPECO customers. Storage would require approximately 50 m^2 and could be located adjacent to the laboratory or the existing laboratory at the Callao deposit could be used. The laboratory building would involve approximate construction costs of $150,000, bringing the total cost of the assay laboratory to $225,650. As discussed earlier, MINPECO presently pays almost $500,000 annually to a private laboratory for assay services, so it is apparent that construction of the laboratory is cost-justified.

B. LOSSES

Losses incurred in handling of minerals and concentrates are difficult to accurately quantify but are an important factor to consider in improving MINPECO's operational efficiency. Some losses are unavoidable and must be considered as a type of operating cost, but several areas were observed by the study team where losses could be reduced with considerable resultant savings for MINPECO. Some of these areas have been discussed within the chapters dealing with each of the individual ports. This section presents some general, company-wide recommendations to reduce losses.

Losses occur throughout the transport of material from source to destination, including transport from the mine or concentrator to the deposit yard, within the yard, between the deposit and the vessel of embarkation, during ship loading, and during unloading or transport of the material to its final destination. Some of these losses are not the responsibility or at the expense of MINPECO. Prior to the weighing of material at the deposit yard at the time of purchase, losses are at the expense of the miners. Once the material has been weighed for shipping and until it has been weighed in off-loading, insurance (at a premium of .225 percent of shipment value) covers losses above one percent, up to a maximum of five percent. On a shipment of 2,000 MT of lead concentrate, however, if the deductable one percent loss occurs during vessel loading, it would amount to over $18,000. In the course of a year, this one percent loss would amount to almost $3 million for the four ports studied.



SAMPLE FLOOR PLAN FOR
ASSAY LABORATORY

(1500 m^2)

FIGURE 24

Losses within the yard are a result of wind, handling, or theft. MINPECO personnel are cognizant of losses in areas where they have operational control, such as deposit yards, and have attempted to minimize losses there by erection of perimeter walls, as wind barriers and for security, and by keeping the surface of the piles damp to reduce wind loss. In some cases, however, it may be necessary to increase the height of the walls. Aerial photographs of Matarani, for example, reveal a dark-colored area downwind of both the MINPECO deposit yard and the land terminus of the conveyor yard, due to wind-dispersed concentrate. Some losses within the yard are "paper" losses, in that they result from changes in the moisture content of the concentrates rather than in the actual amount of material handled. Another record keeping problem is the fact that no actual inventory of material in the deposit yards is made. The difference between the incoming and outgoing material is assumed to be remaining in the yard, but this balance could have been considerably eroded over a period of time.

In addition to losses in the deposit yard, considerable losses appear to occur during transport and loading of concentrates. Transport in open trucks or rail cars allows loss due to wind if the surface of the material is not kept damp. Transport in old trucks or rail cars allows the material to fall through gaps, particularly when the material is vibrated as the vehicle passes over rough sections of road or rail. The greatest portion of the transport, between the mine or concentrate and the deposit yard is the responsibility of the miner rather than MINPECO. It should be pointed out, however, that the export of minerals is vital to the Peruvian economy. Since MINPECO is a national enterprise, any measures which could be introduced to reduce losses would be in the national interest and within the pervue of MINPECO's responsibility. In addition, reduction of losses in the transport of material would result in increased quantities of material available for export by MINPECO, and therefore increased revenues.

Considerable losses were observed at Callao and Salaverry during loading of vessels. At Callao, the installation of a simple "elephant trunk" attachment at the delivery end of the conveyor would reduce wind losses during ship loading, while at Salaverry it appears an entirely new loading method is justified. Although insurance covers losses above one percent after the material has been weighed entering the port, even one percent amounts to a considerable saving, as discussed earlier. Insurance premiums are based on the history of previous loss claims, and reductions of losses could, therefore, result in a reduction of premiums.

A final recommendation with regard to losses deals with statistical and accounting procedures. Although a great deal of information is compiled by MINPECO, it not coordinated in a manner useful for reducing losses. Record keeping procedures should emphasize detection of losses. This could be accomplished by incorporation of pertinent data into the computer system presently being adapted by MINPECO. This data should include elements that the Operations Department could use to trace the complete shipment of each mine through the system. It should also allow quick retrieval of data regarding the status of all material handled by MINPECO. With correct use, the computer system can be an important factor in improving efficiency and reducing losses.

Specific recommendations to reduce losses at each port were presented earlier. To summarize the recommendations on a company-wide basis:

- improvement of statistical record keeping procedures to allow easy identification of high loss phases in MINPECO operations
- increasing wall heights where necessary in deposits to reduce wind loss
- improvement of material transport and loading equipment.

C. MOBILE EQUIPMENT

Equipment recommendations for each deposit yard have been presented in the preceeding sections. Specifications for this equipment are contained in Appendix F. This section discusses considerations with regard to purchase, maintenance and repair of the various mobile systems.

As MINPECO's operations expand in the future, it will become increasingly economical to own and operate, rather than lease, mobile equipment. Selection of proposed mobile equipment has been based on the following:

1. Feed the recommended conveyor system at adequate rates of operation.
2. Provide back-up equipment where failure or breakdown of primary equipment would seriously effect operations.
3. Minimize training, spare parts, and maintenance problems.

FRONT END LOADERS

Two basic types of mobile equipment are involved in this discussion – front end loaders and forklift trucks. Front end loaders have been sized to supply a constant stream of material to the 600-1,200 tons per hour design capacity of the recommended conveyor systems. Since all four ports have the same conveyor design capacity, only one unit, or multiples of that unit, can be used on a company-wide basis. Use of the same manufacturer's unit also reduces maintenance and repair problems and allows the possibility of a reduced purchase price through negotiations for several units. Choice of a manufacturer, in this case Caterpillar, has been based on cost, quality, and specifications of the equipment, as well as availability of local service representatives.

In sizing the loaders, discussions with equipment manufacturers noted that to handle materials of heavy density, it is recommended to use the smallest bucket available. This reduces wear on the loader and allows lifting of loads which does not exceed rated capacity. A review of projected minerals to be handled in Table 4 indicates that zinc concentrate with a weight of 2.14 tons/cubic yard is the largest quantity of material by volume to be handled and will be used in sizing machines selected. Further, to comply with SAE[1] standards, the operating load should not exceed 50 percent of the rated static tipping weight of the machine. In most cases, this rated weight can be increased somewhat by adding counterweights and/or hydroflating the tires and filing with Calcium Chloride (CaCl).

a. Loader Selection

The following parameters are considered for machine selection:

(a) Production Required
Fixed by conveyor capacity of 600 to 1,200 tons per hour
(b) Mineral
Zinc, with a weight of 2.14 tons per cubic yard
(c) Loader Cycle Time

A cycle time of one minute or 60 cycles per hour was selected based on a simulated movement observed at equipment dealers and includes load, dump, four reversals of direction and movement of 100 feet. This value appears consistent with manufacturers specifications for handling loose materials on hard surfaces.

[1]Society of Automotive Engineers.

(d) Bucket Fill Factor

Due to the nature of concentrates, which have negligible voids and are loose, moist aggregates, a bucket fill factor of 100 percent is achievable and no degradation of rated budket capacities is required.

Using this criteria, the loading rates of several equipment manufacturers were calclulated with the following being representative:

Model	Bucket Size Yd^3	Operating Load Tons	50% Static Tipping Weight Tons	Ton/Hr. Load X No. of Cycles/Hr (60)
Cat 966	3.04	6.5	6.48	390
IH 540	3.1	6.3	6.0	398

Either of these machines would yield a loading capacity when used in pairs of approximately 800 tons per hour. Similar calculations were made for larger and smaller machines and are included below for comparison. As noted, it is deemed more advantageous to have two machines providing a capacity of 800 tons per hour instead of one, in case of equipment failure.

Since the weight of a full bucket in the cases above are near or slightly in excess of the static tipping weight, it would be advisable to add counterweights in the form of CaCl tires to increase the material handling capacity. For the example, this would alter the static tipping as follows:

1.	Increase by adding CaCl tires	4,090 pounds
2.	Increase by adding counterweight	3,670
	Total	**7,760 pounds**
	50% x 7,760	3,880 pounds or 1.94 tons

This increases the SAE rated capacity of the Cat 966 to 8.42 tons, well above the operating load required for handling of zinc concentrate.

For three ports, Matarani, Salaverry and Callao, lead concentrates with a density of 2.67 tons per yard is handled. Using similar calculations for bucket sizes and loading cycles, it is determined that the 3.0 cubic yard machines must be counterbalanced to prevent the heavier material from exceeding the static tipping weight.

Using the previous Cat 966 as an example, the operating load with this material is calculated to be 8.12 tons and does not exceed the rated capacity of 8.42 tons as determined above.

A summary of the operating parameters for the size machine selected is shown below:

b. Comparison of Front End Loader Loading Capacities

To size front end loaders the following assumptions are necessary:

1. Material to be handled, zinc and lead concentrate with a weight of 2.67 tons/m^3 or 2.14 tons/yd^3.

2. A cycle time of one minute average per complete cycle of loader making four reversals of movement, load and dump and an average traverse of 30 M or 100 feet from pick-up to dump. (60 per hour).

3. Ultimate load per lift is determined using SAE rated of 50 percent of the rated static tipping weight.

International Harvester

Model	Bucket Size Yd^3	Load/Cycle Tons	50% Static Tip Tons	Load Rate Per Hour	Cost Approx. 1,000 U.S. $
510	1.0	2.14	2.1	128.	
60	1.75	3.75	3.4	225.	
530	2.14	4.6	4.5	257.	
540	3.1	6.6	6.0	398.	115.
100	3.6	7.7	7.0	462.	150.
560	5.6	12.0	11.7	718.	215.
400	9.4	20.0	19.1	1204.	410.
580	18.0	38.5	42.3	2311.	1,000.

Note: Tipping Moment is uncounterweighted.

Caterpillar

920	1.2	2.6	3.1	154.	
950	2.1	4.4	5.0	266.	86.
966	3.04	6.5	6.5	390.	116.
980	4.5	9.6	8.3	578.	182.
988	5.9	12.6	11.2	758.	263.
992	10.7	22.9	24.2	1,374.	541.

Front end loader costs were obtained from several manufacturers for a 3.0 cubic yard diesel machine with roll-over protection. Base prices were nearly identical at $115,000 per machine with approximately $5,000 additional for the bucket. Charges for fixed counterweights are $1,500 for the size noted, while addition of CaCl in the tires can be done locally at a nominal charge. Manufacturers noted that these prices are "list" and could be reduced for the quantities required.

2. FORK LIFT TRUCK

Two forms of material, bagged minerals and copper cathodes, have been recommended to be handled in a palletized form. Noting the bagged material being handled at Callao, 27-60 kg. bags would be handled in each pallet, or a total of 3,564 pounds.

It was also noted in Matarani that copper cathode bundles weighed approximately two tons per package with each package consisting of twenty to twenty-two cathodes. Assuming a maximum of two bundles would be raised in any one lift, a maximum lift capacity of four tons would be desirable.

As for the front end loaders, several manufacturers were contacted for pricing and the cost per machine for a diesel, 8,000 pound truck was found to be $31,000 on average, F.O.B. Gulfport, Mississippi. Specifications for the front end loaders are contained in Appendix F.

For the storage yards of Matarani and Callao, which handle the largest quantities of bagged palletized materials, it is further recommended that hand pallet trucks be purchased. In any warehouse type operation of this nature, it is frequently desirable or necessary to shift several pallets but not divert the mechanized forklifts from other operations. Hand operated pallet lifters are available with capacities up to 6,000 pounds at a nominal cost of $1,250. or smaller units of 2,000 pound capacity for $550.

It is recommended that a minimum of one of these units be purchased for both Callao and Matarani to minimize the hand movement of small quantities noted during the field inspection.

Maintenance and repair can be discussed in terms of order of difficulty. First order maintenance is performed by the equipment operator and involves inspection and basic preventive maintenance that would include maintaining proper fluid levels, observing gages, etc. Second order maintenance is somewhat more sophisticated but should still be performed by MINPECO personnel. This involves lubrication, filter changes, and minor repairs that can be accomplished without special tools or facilities perhaps up to the level of general motor tune-ups and trouble-shooting. Third order maintenance involves major repairs or other work requiring special tools or facilities. MINPECO should not attempt to do this type of work, but should, upon purchase of the mobile equipment, arrange for repair work to be performed at the closest authorized service center. In order to perform the necessary maintenance, it is recommended that MINPECO purchase an inventory of basic spare parts, such as filters, belts, etc., for each deposit yard and should also purchase an inventory of less commonly replaced parts, such as electrical equipment, gaskets, etc., for storage at Callao. Equipment operators should be instructed in preventive maintenance. MINPECO should provide basic maintenance training to Callao personnel, who could then be used to travel to other deposits and perform maintenance.

For all four storage yards, provisions have been made to have an on-site maintenance building. This facility is intended to provide MINPECO with the capability for first and second level maintenance of equipment and storage capacity for the required spare parts. Third level maintenance should be handled by authorized service representatives, perhaps on a contract or warranty basis.

Due to the variation in labor and parts costs in Peru compared to the United States, it is impossible to itemize the maintenance and spare parts required. In lieu of this, manufacturers were asked to give a value, based on their experience, for their 3.0 cubic yard machines and 8,000 pound forklifts. It was further noted that the storage yards consisted of a highly dustry environment, use on a concrete pad with an estimated 2,000 hour per year duty cycle. Based on these conditions, manufacturers suggested spare parts inventory costing five to ten percent for the first two years with heavy emphasis on replacement filters for both loader and forklifts.

It should be noted at this point, that in contacting mobile equipment suppliers Caterpillar Corporation had the largest number of dealers located throughout Peru. They currently maintain a main office in Lima with authorized dealers in Chimbote, Chicalayo, Cuzco, Ica, Iquitos and Piura. Other manufacturers only had offices in Lima. Because of the critical nature of spare parts and maintenance, it is recommended that strong consideration be given to selecting the Caterpillar front end loader, Model 966, and forklifts, Model V80-D. In addition, Caterpillar can supply a schedule of preventative maintenance routines and supply a basic parts inventory necessary which would be coordinated with their office in Lima and take into account local conditions. Since similar manufacturer's equipment for both loaders and forklifts will be used at all ports, and with the large number of Caterpillar deals throughout Peru, it is believed this approach to equipment maintenance would alleviate major maintenance problems in the future.

D. HANDLING OF MINERAL ORES

Study effort and attention has been primarily focused on the handling and transport of mineral concentrates, which make up the greater part of MINPECO's operation. However, the handling and shipment of ore is also an important aspect of the total operation, and should be addressed as part of the overall material handling at deposits and aboard ship to destination. This is of special importance since it appears that some efficiency can be readily achieved in the greater usage of pallets to handle these particular types of materials.

The maritime industry classification and general definition of General Cargo-Break Bulk on a world-wide basis is accepted as miscellaneous goods and commodities in small packages, bags or boxes, non-containerized and which are usually loaded and unloaded on small pallets by ships' gear. This classification and practice in handling bagged material has become standard operating procedure in marine transportation for some 20 years. The handling of palletized material is also prevalent in all ports in Peru. Observation, however, indicated an apparent inconsistency in the MINPECO requirements to handle and ship individual bagged or sacked mineral ores.

The study team witnessed the handling of sacked material at deposit areas in Callao, Salaverry, Arequipa, and Matarani. Handling of MINPECO sacked ores was also observed during ship loading operations at the Port of Matarani. At this location sacked material was handled in single units using longshoremen's hooks. The routine usually consisted of two laborers using hooks to grab, lift and position each separate bag. Rail flat cars loaded with bagged products at the deposit were positioned alongside the vessel. Port stevedoring personnel hooked individual bags for lifting and deposit in the ship's cargo net. Individual bags were removed in the same manner from the cargo net in the ship's hold and stowed. It is assumed that the same procedure must be utilized in reverse at ports of destination to unload the bags.

This type of material handling usually results in tearing of the bags with loss of product, and occasional loss of an entire sack or sacks, falling from cargo nets and dock surfaces or into the water alongside the vessel. These types of losses were observed and are documented in MINPECO records. Typical handling of bagged products at Matarani and at Salaverry is shown in Photo 31 and Photo 32. The unusual method employed to place bags on flat cars at Matarani is shown in Photo 33.

In seeking to determine why MINPECO did not palletize bagged or sacked material for transport to minimize damage and facilitate handling, the study team was advised that wooden pallets were not economically feasible for this operation, particularly due to the fact that pallets were not reusable. A cost of approximately $25.00 U.S. was related to usage of a pallet.

The inconsistency continues to develop at this point due principally to the fact that the handling of palletized, bagged, or sacked material is standard operating procedure of the Port of Callao and Matarani. To further confuse the issue, the palletized material handled is not as valuable a product as MINPECO's ore shipments. In addition, it would appear that the additional labor cost in handling and loading/unloading individual sacks in the maritime transport alone would exceed the cost of employing a pallet specifically for export operations. It should be noted here that some pallets are in use at the MINPECO deposit at Callao, although it was observed that strapping was not employed.

PHOTO 31 — Matarani — Loading sacked ore in deposit for movement to ship side.

PHOTO 32 — Salaverry — View showing typical bagging of ore prior to shipment to Callao from Salaverry.

PHOTO 33 – Matarani – Dumping bags of ore on flat car with bucket loader.

Inconsistency was noted in the method employed in handling of copper cathodes by MINPECO and the handling of the same product from Bolivian sources at Matarani. Copper cathodes in the MINPECO Matarani operation are received from the mine in strapped bundles. A typical bundle is shown in Photo 34. In the deposit area bundles are stacked as shown in Photo 35, employing wood dividers between bundles to permit handling by a forklift. Cathodes are transported to the port for loading aboard vessels by truck. A chain sling is employed to hoist bundles from the bed of the truck and into the cargo hold of the vessel, Photo 36. Handling of the bundles in the ship's hold, employing wood separators, is shown in Photo 37. The unloading of cathodes at destination would require the same operation in reverse order.

The handling and storage of copper cathodes as described above, appeared inconsistent with the handling of the same types of Bolivian material at Matarani. Cathode bundles are especially suited for palletizing to facilitate handling and storage in deposit areas, at port of embarkation, and at debarkation points. Investigation and observations revealed that Bolivian produced copper cathodes being loaded aboard the same transport at Matarani were palletized. Handling of these pallets alongside the same vessel is shown in Photo 38. (Bundles of copper cathodes are shown strapped and covered on wooden pallets.) Notice that two (2) pallets are being lifted in one operation employing one stevedore. The ease and improvement in handling and transporting copper cathodes employing this world-wide material handling technique is obvious.

It is suggested and recommended that MINPECO investigate expanded usage of handling and transporting sacked mineral ore and copper cathodes employing pallets. Expanded usage of pallets would warrant an effort to acquire suitable wood pallets at a more reasonable cost than the $25.00 U.S. quoted. This price per pallet appears excessive for the quantity that would be required in the total MINPECO operation.

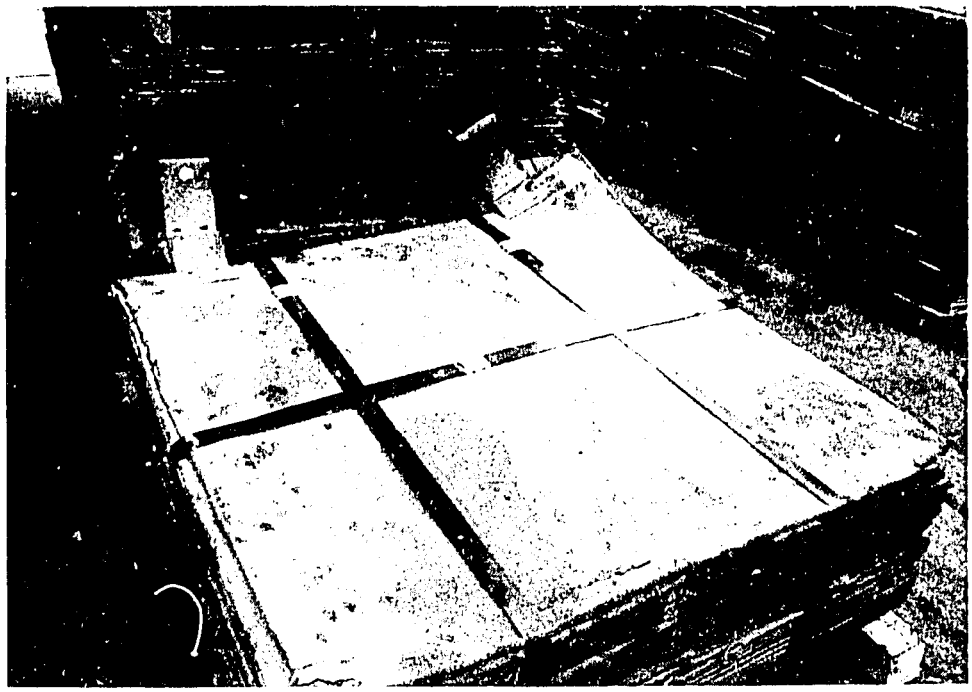


PHOTO 34 — Matarani — Copper cathode bundles in deposit area.

PHOTO 35 — Matarani — Copper Cathode storage and handling at deposit area.

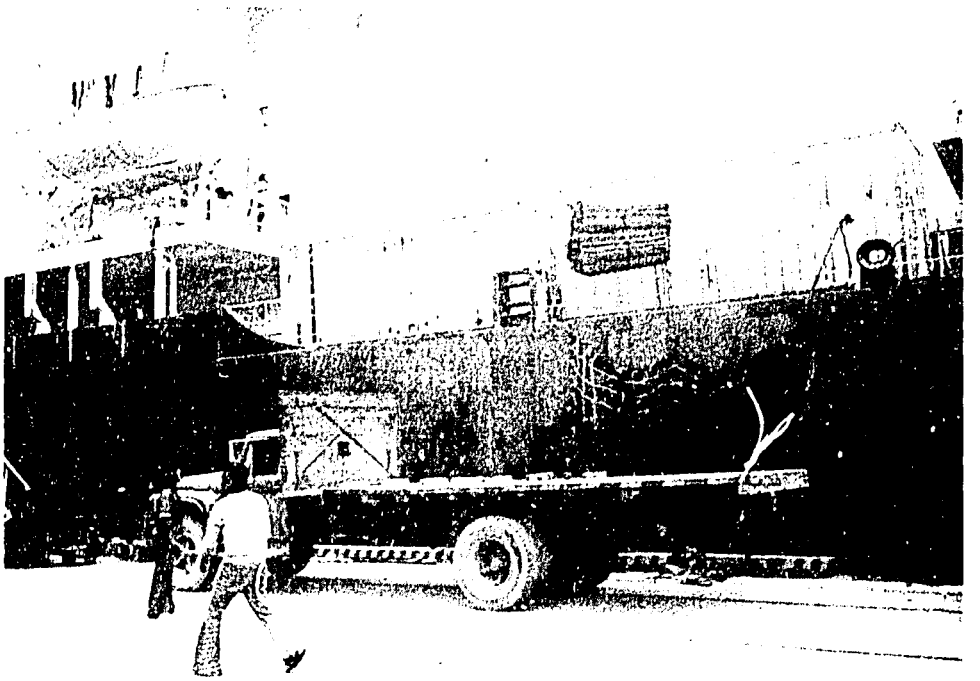


PHOTO 36 – Matarani – Copper cathodes being loaded at ship side.

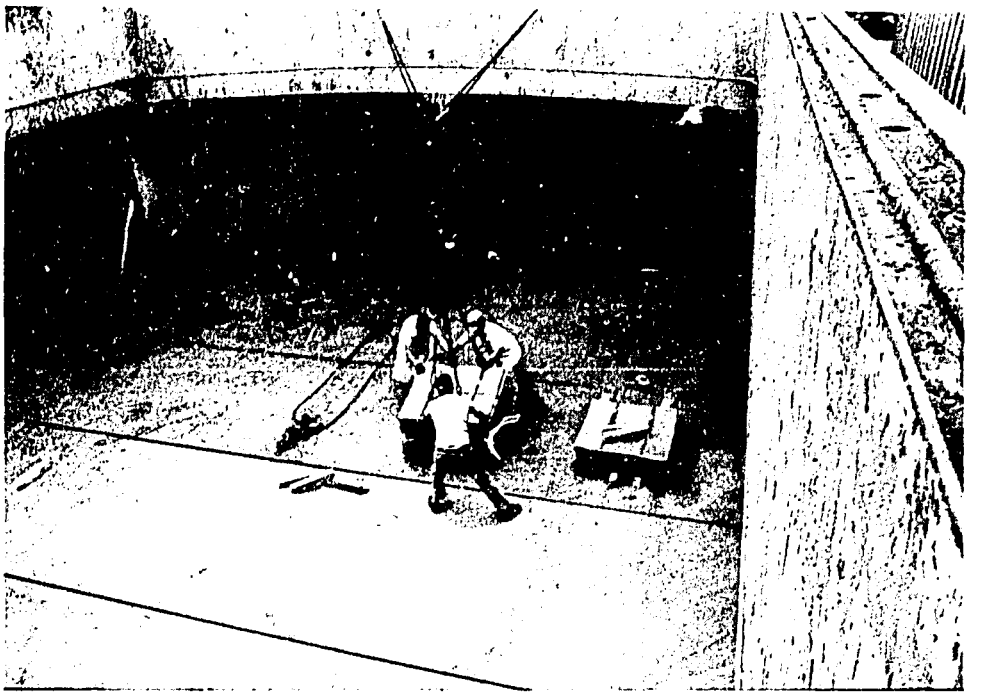


PHOTO 37 – Matarani – Copper cathodes being handled in ship's hold.

PHOTO 38 – Matarani – Bolivian pallets being loaded aboard ship at Matarani.

CHAPTER SEVEN

Summary of Recommendations

In order to maximize savings and minimize costs, MINPECO should begin to implement the recommendations contained in this report as soon as possible. Several recommendations, particularly those involving purchase and installation of automated equipment, will require significant lead time, while purchase of mobile equipment can be accomplished much sooner. Table 29 contains a year-by-year summary of recommendations on a company-wide basis. Specifications for the mobile and conveying/loading equipment are contained in Appendices E and F, respectively.

TABLE 29

SUMMARY OF RECOMMENDATIONS

YEAR	ACTION	ESTIMATED COSTS[1]
1981	Purchase eight front end loaders, five forklift trucks, and two hand pallet trucks.	$1,191,000
	Begin negotiations for purchase of automated conveying/loading systems at Callao, Matarani, and Salaverry.	See 1982
	Purchase and develop new areas for deposit yard at Matarani and Chimbote.	$1,575,000
	Purchase expansion area for deposit yard at Callao.	$ 750,000
	Negotiate easement for automated conveyor system at Callao between deposit and port.	No Cost
1982	Purchase and install automated conveying/loading systems at Callao, Matarani, and Salaverry.	$4,981,000
	Develop deposit expansion area in Callao.	$ 550,000
1983	Purchase two front end loaders and two forklift trucks.	$ 322,000
1984	Purchase two front end loaders and two forklift trucks.	$ 322,000
1985	No action required.	
1986	No action required.	
1987	No action required.	
1988	Purchase eight front end loaders.	$1,024,000
1989	No action required.	
1990	Purchase two front end loaders.	$ 256,000
1991	Purchase five forklift trucks, two hand pallet trucks, and two front end loaders	$ 425,000
1992	No action required.	
1993	Purchase two forklift trucks.	$ 66,000
1994	Purchase two forklift trucks.	$ 66,000
1995	Purchase eight front end loaders.	$1,024,000
1996	No action required.	
1997	Purchase two front end loaders	$ 256,000
1998	Purchase two front end loaders.	$ 256,000
1999	No action required.	
2000	No action required.	

[1]All costs are in 1980 U.S. dollars.

APPENDIX A

PROJECTION METHODOLOGY

The projections used in this report are based on figures provided by MINPECO's Office of Planning and Statistics. Tables A-1 through A-12 include this information, as well as adjustments to that data that have been made, in accordance with MINPECO directives, for humidity, statistical discrepancies, and contingencies. Tables A-1 through A-3 present data for exports at Salaverry, Table A-4 at Chimbote, Tables A-5 through A-8 at Callao, and Tables A-9 through A-12 at Matarani.

MINPECO provided projections of dry quantities of lead, zinc, and copper concentrate, by individual mine, that are expected to be throughput at each of the four port areas under study, as shown in lines 1 through 7 in Table A-1. Line 8 is a sub-total of these quantities, and line 9 illustrates the conversion for an 8% moisture content. Line 10 is an adjustment for statistical discrepancies between the information provided by mine operators and that provided by MINPECO's Control de Existencia. In some cases, this factor is unnecessary, or equal to 1.0. Line 11 contains a contingency factor, and line 12 is the total of projected export quantities of lead concentrate that will pass through Salaverry based on current operating procedures. For lead concentrate at Salaverry, there is expected to be no increase in export quantities through the year 2000, however, in other cases, such as zinc concentrate through Callao shown in Table A-5, the quantities change from year to year, as indicated. Tables A-3, A-4, A-8, and A-12 contain totals of material through each port, including the adjusted figures for lead, zinc, and copper concentrate, as well as a figure for minerals and other concentrates, based on export figures provided by MINPECO's Control de Existencia.

TABLE A-1

SALAVERRY

PROJECTED LEAD CONCENTRATE EXPORTS

	PRODUCER	000's MT/YR.				
		1980	1981	1982	1983	1984-2000
1.	Colquirrumi	2.9	4.6	4.6	4.6	4.8
2.	Chuvilcas	1.8	1.8	1.8	1.8	1.8
3.	Los Mantos	1.7	1.7	2.6	6.5	10.3
4.	Montoya Zambrano	0.9	0.9	0.9	0.9	0.9
5.	Northern Peru	6.0	8.4	10.7	10.7	10.7
6.	Saya Pullo	0.2	0.2	0.2	0.2	0.2
7.	Other	0.0	6.5	6.5	6.5	6.5
8.	Pequena Mineria	0.2	0.2	0.2	0.2	0.2
9.	Sub-Total (thousand metric tons, dry)	13.7	24.3	27.5	31.4	35.2
10.	Sut-Total (thousand metric tons, wet)	14.7	26.1	29.6	33.8	37.8
11.	Conversion based on actual exports	16.8	29.8	33.7	38.5	43.1
12.	4% Contingency	.7	1.2	1.3	1.5	1.7
13.	Total (thousand metric tons, wet)	17.5	31.0	35.0	40.0	44.8

TABLE A-2

SALAVERRY

PROJECTED ZINC CONCENTRATE EXPORTS

PRODUCER	000's MT/YR.				
	1980	1981	1982	1983	1984-2000
Colquirrumi	6.5	10.4	10.4	10.4	10.4
Chuvilcas	1.8	1.8	1.8	1.8	1.8
Malaga Santolalla	0.2	0.2	0.2	0.2	0.2
Montoya Zambrano	1.1	1.1	1.1	1.1	1.1
Northern Peru	13.8	17.8	21.8	21.8	21.8
Saya Pullo	1.0	1.0	1.0	1.0	1.0
Los Mantos	3.3	3.3	5.0	12.4	19.8
Sub-Total (thousand metric tons, dry)	27.7	35.6	41.3	48.7	56.1
Sub-Total (thousand metric tons, wet)	29.8	38.3	44.4	52.3	60.3
Conversion based on actual exports	37.3	48.0	55.6	65.5	75.5
4% contingency	1.5	1.9	2.2	2.6	3.0
Total (thousand metric tons, wet)	38.8	49.9	57.8	68.1	78.5

TABLE A-3

PROJECTED TOTAL EXPORTS - SALAVERRY

	000's MT/YR.				
	1980	1981	1982	1983	1984-2000
Zinc Conc.	38.8	49.9	57.8	68.1	78.5
Copper Conc.	11.8	13.4	13.4	13.4	13.4
Lead Conc.	17.5	31.0	35.0	40.0	44.8
Sub-Total	58.1	94.3	106.2	121.5	136.7
Other Materials	5.5	5.5	5.5	5.5	5.5
Total	73.6	99.8	111.7	127.0	142.2

TABLE A-4

CHIMBOTE

PROJECTED COPPER CONCENTRATE EXPORTS

PRODUCER	000's MT/YR. 1980-2000
Aguila	57.0
Sub-Total (thousand metric tons, dry)	57.0
Sub-Total (thousand metric tons, wet)	61.3
Conversion based on actual exports	61.3
4% contingency	2.5
Total (thousand metric tons, wet)	63.8
Other materials	0
Total Chimbote	63.8

TABLE A-5
CALLAO
PROJECTED ZINC CONCENTRATE EXPORTS
(000's MT/YR.)

PRODUCER	1980	1981	1982	1983	1984	1985	1986	1987-1990	1991-2000
Austria Divaz	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Alianza	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.1
Atacocha	30.0	22.0	-	-	-	-	-	-	-
Buenaventura	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Canaria	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Caudalosa	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Centraminas	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Cochas	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Condor	-	-	-	4.2	4.2	4.2	4.2	4.2	4.2
Chungar	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
El Baron	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Gran Bretana	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Huampar	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Huaron	40.0	28.9	-	-	-	-	-	-	-
La Virreyna	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Los Mantos	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Milpo	51.4	57.2	57.2	57.2	57.2	57.2	57.2	57.2	57.2
Pacococha	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Raura	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
Rio Pullanga	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.2
Santa Rita	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
Santa Toribio	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Yauli	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Brocal	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Chavin	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2
Pequena Mineria	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Sub-Total (thousand metric tons, dry)	289.7	276.4	225.5	229.7	229.7	229.7	229.7	229.7	229.7
Sub-Total (thousand metric tons, wet)	311.4	297.1	242.2	246.9	246.9	246.9	246.9	246.9	246.9
Conversion based on actual exports	311.4	297.1	242.4	246.9	246.9	246.9	246.9	246.9	246.9
4% Contingency	12.5	11.9	9.7	9.9	9.9	9.9	9.9	9.9	9.9
Total (thousand metric tons, wet)	323.9	309.0	252.1	256.8	256.8	256.8	256.8	256.8	256.8

TABLE A-6

CALLAO

PROJECTED COPPER CONCENTRATE EXPORTS

(000's MT/YR.)

PRODUCER	1980	1981	1982	1983	1984	1985	1986	1987-1990	1991-2000
Caridad	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Condestable	-	-	-	8.2	8.2	8.2	8.2	8.2	8.2
Millotingo Llipa	-	-	-	1.0	1.0	1.0	1.0	1.0	1.0
Patavilca	-	-	-	22.1	22.1	22.1	22.1	22.1	22.1
Sub-Total (thousand metric tons, dry)	1.2	1.2	1.2	32.5	32.5	32.5	32.5	32.5	32.5
Sub-Total (thousand metric tons, wet)	1.3	1.3	1.3	34.9	34.9	34.9	34.9	34.9	34.9
Conversion based on actual exports	4.7	4.7	4.7	127.2	127.2	127.2	127.2	127.2	127.2
4% Contingency	.2	.2	.2	5.1	5.1	5.1	5.1	5.1	5.1
Total (thousand metric tons, wet)	4.9	4.9	4.9	132.3	132.3	132.3	132.3	132.3	132.3

TABLE A-7
CALLAO
PROJECTED LEAD CONCENTRATE EXPORTS
(000's MT/YR.)

PRODUCER	1980	1981	1982	1983	1984	1985	1986	1987-1990	1981-2000
Austria Duvaz	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Alianza	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4
Atacocha	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.8
Canario	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
Caudalosa	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Centraminas	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Cochas	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Condor	-	-	-	1.2	1.2	1.2	1.2	1.2	1.2
Malaga Santolalla	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Milpo	18.2	20.4	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Pacococha	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Rio Pallanga- Carhuacayan	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
- Alpamarca	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Santa Rita	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Santo Toribio	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Caridad	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Chavin	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
El Brocal	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Pequena Mineria	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
Sub-Total (thousand metric tons, dry)	93.2	95.8	95.8	97.0	97.0	97.0	97.0	97.0	97.0
Sub-Total (thousand metric tons, wet)	100.2	102.9	102.9	104.3	104.3	104.3	104.3	104.3	104.3
Conversion based on actual exports	139.3	144.2	144.2	145.9	145.9	145.9	145.9	145.9	145.9
4% Contingency	5.6	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
Total (thousand metric tons, wet)	144.9	150.0	150.0	151.7	151.7	151.7	151.7	151.7	151.7

TABLE A-8

PROJECTED TOTAL EXPORTS - CALLAO

(000's MT/YR.)

	1980	1981	1982	1983	1984	1985	1986	1987-1990	1991-2000
Zinc Conc.	323.9	309.0	252.1	256.8	256.8	256.8	256.8	256.8	256.8
Copper Conc.	4.9	4.9	4.9	132.3	132.3	132.3	132.3	132.3	132.3
Lead Conc.	144.9	150.0	150.0	151.7	151.7	151.7	151.7	151.7	151.7
Sub-Total	473.7	463.9	407.0	540.8	540.8	540.8	540.8	540.8	540.8
Other Materials	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Total	477.6	467.8	410.9	544.7	544.7	544.7	544.7	544.7	544.7

TABLE A-9

MATARANI

PROJECTED ZINC CONCENTRATE EXPORTS

PRODUCER	000's MT/YR. 1980-2000
Colquiminas	0.4
Del Madrigal	22.1
El Altiplano	5.5
Pequena Mineria	0.1
Sub-Total (thousand metric tons, dry)	28.1
Sub-Total (thousand metric tons, wet)	30.2
Conversion based on actual exports	30.2
4% Contingency	1.2
Total (thousand metric tons, wet)	31.4

TABLE A-10

MATARANI

PROJECTED COPPER CONCENTRATE EXPORTS

(000's MT/YR.)

PRODUCER	1980	1981	1982	1983	1984	1985	1986	1987-1990	1991-2000
Atalaya	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Cobre Chapi	16.5	20.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Del Madrigal	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7
Katanga	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
Tintaya	-	-	-	-	52.5	175.0	175.0	175.0	175.0
Cerro Verde	-	-	-	-	150.0	200.0	200.0	200.0	200.0
Cata Acari	-	-	-	4.1	4.1	4.1	4.1	4.1	4.1
Condoroma	-	-	-	9.2	9.2	9.2	9.2	9.2	9.2
Locumba	-	-	-	7.0	7.0	7.0	7.0	7.0	7.0
Sub-Total (thousand metric tons, dry)	41.6	45.1	48.1	68.4	270.9	443.4	443.4	443.4	443.4
Sub-Total (thousand metric tons, wet)	43.3	48.5	51.7	73.5	291.2	476.7	476.7	476.7	476.7
Conversion based on actual exports	51.3	55.7	59.4	84.4	334.4	547.3	547.3	547.3	547.3
4% Contingency	2.0	2.2	2.4	3.4	13.4	21.9	21.9	21.9	21.9
Total (thousand metric tons, wet)	53.4	57.9	61.7	87.8	347.7	569.3	569.2	569.2	569.2

TABLE A-11

MATARANI

PROJECTED LEAD CONCENTRATE EXPORTS

PRODUCER	000's MT/YR. 1980-2000
Colquiminas	2.4
Del Madrigal	9.3
El Altiplano	2.5
Pomasi	2.6
Pequena Mineria	1.7
Sub-Total (thousand metric tons, dry)	18.5
Sub-Total (thousand metric tons, wet)	19.9
Conversion based on actual exports	19.9
4% Contingency	.8
Total (thousand metric tons, wet)	20.7

TABLE A-12

TOTAL PROJECTED EXPORTS - MATARANI

(000's MT/YR.)

	1980	1981	1982	1983	1984	1985	1986	1987-1990	1991-2000
Zinc Conc.	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4
Copper Conc.	53.4	57.9	61.7	87.8	347.7	569.2	569.2	569.2	569.2
Lead Conc.	20.7	20.7	20.7	20.7	20.7	20.7	20.7	20.7	20.7
Sub-Total	105.5	110.0	113.8	139.9	399.8	621.3	621.3	621.3	621.3
Other Materials	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2	39.2
Total	144.7	149.2	153.0	179.1	439.0	660.5	660.5	660.5	660.5

APPENDIX B

SALAVERRY STUDIES

The following articles can be found in the quarterly Bulletins issued by ENAPU Peru and concern the problems of wave action and siltation within the Port of Salaverry.

Year VII, No. 33, Sept./Oct. '77, pp 14-17,
"Use of the ByPass System to Impede the Entry of Sand into the Port of Salaverry",
by: Roberto Gutierrez B.

Year VIII, No. 36, Mar./May '78, pp 29-31,
"Salaverry: Important Port of Peru's Northern Coast"

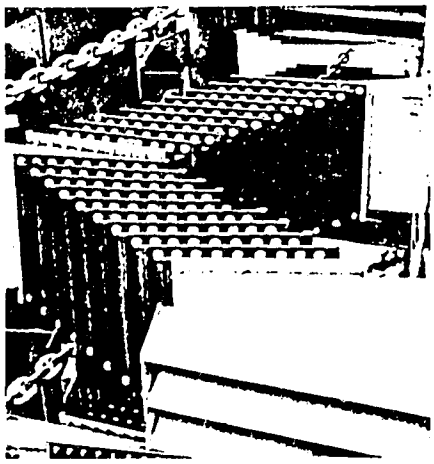
Year VIII, No. 36, July/Sept. '78, pp 10-13,
"Wave Action within the Port of Salaverry"
by: J. Kaemingk

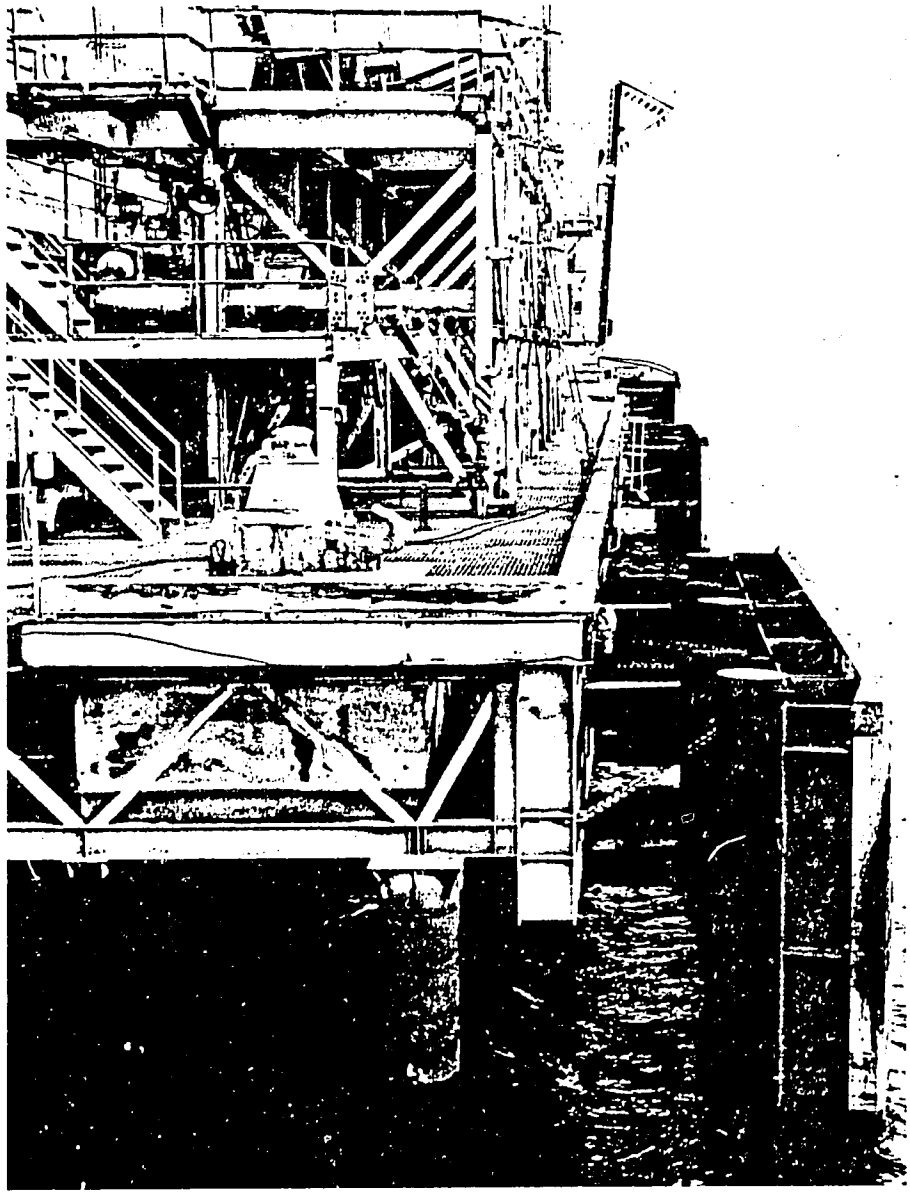
Year VIII, No. 38, Oct./Dec. '78, pp 9-13,
"The Morphological Process at Salaverry"
by: Ronald Moor V.

Year 10, No. 41, July/Dec. '79, pp 4-9
"The Project of Optimization of the Dredge 'Marinero Rivas' and its Interrelationship with the Solution of the Silting Problem in the Port of Salaverry."

GENERAL

RAYKIN® MARINE DOCK FENDERS





Raykin installation on Gulf Oil wharf in Port Hawkesbury, Nova Scotia, Canada.

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For many years the demand for efficient, high-capacity marine fendering has been growing along with the increase in tonnage of modern cargo vessels and the costs for construction and repair of port berthing facilities. Durable, multi-purpose RAYKIN MARINE FENDERS have been supplying that demand for years, just as they meet it today by providing lasting, economical protection for installations and hulls in ports all around the world.

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GENERAL TIRE ENGINEERED CONSTRUCTION PRODUCTS

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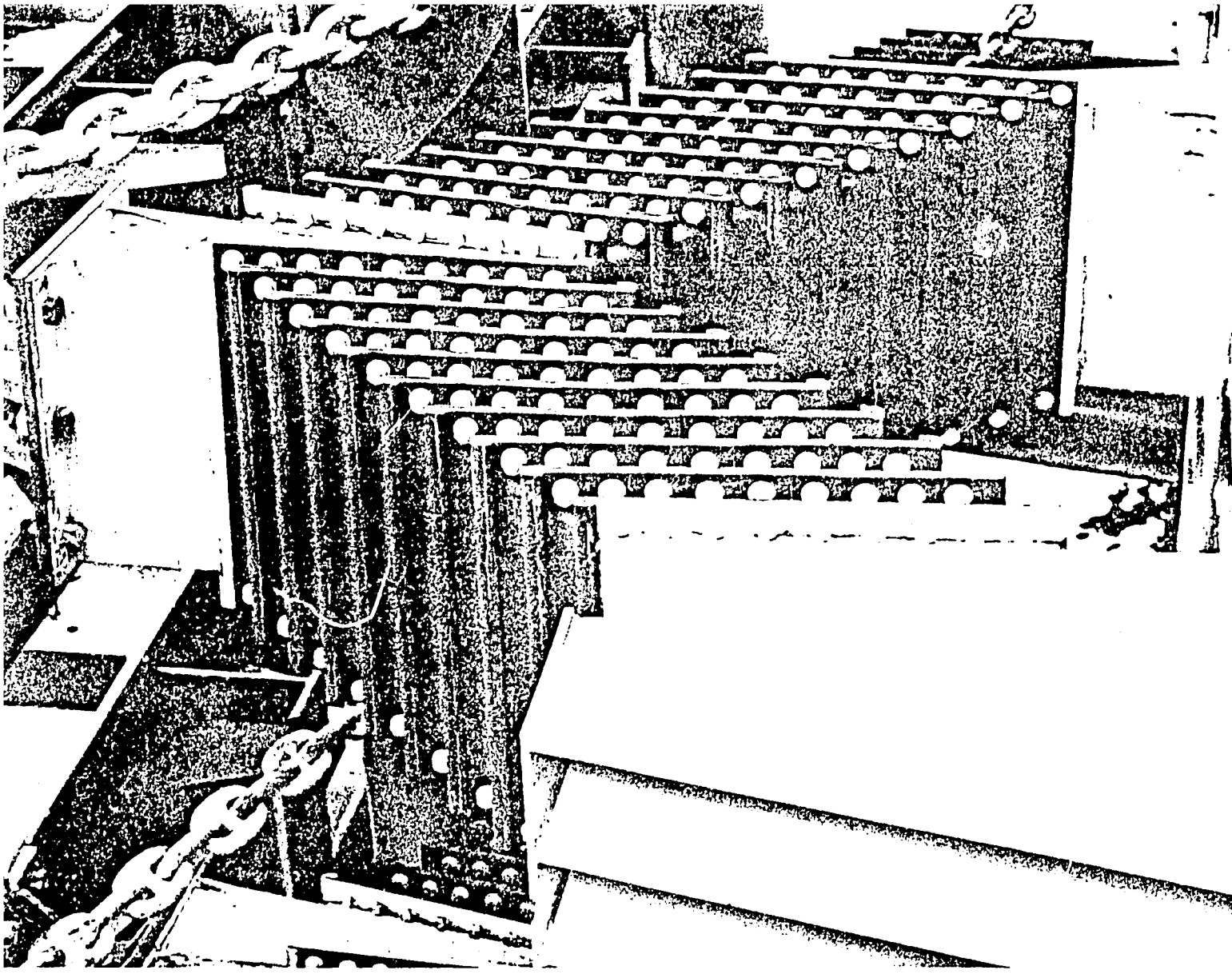
165



Raykin Marine Dock Fenderin

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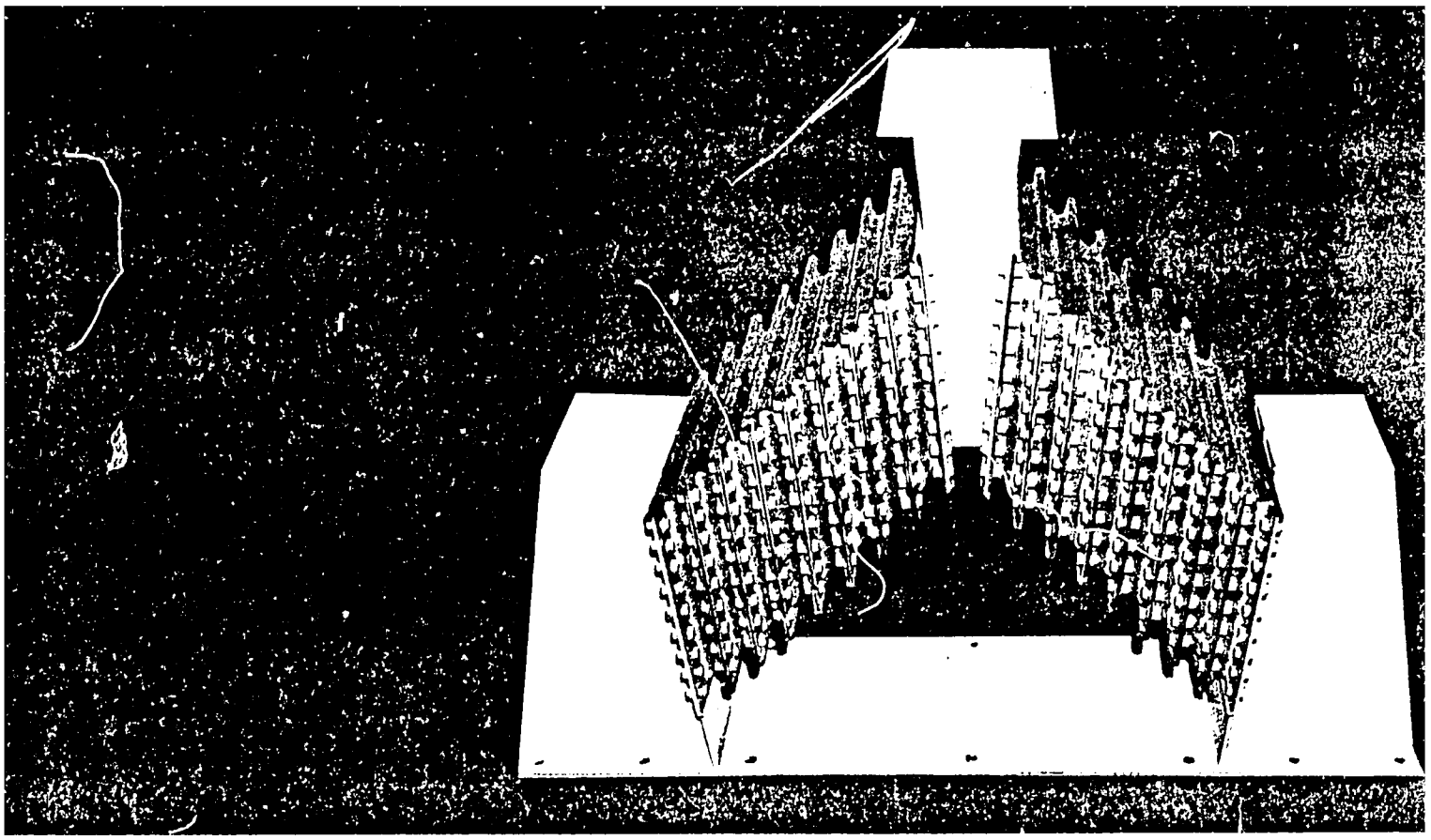


Raykin®

Marine Dock Fendering

Product Description

The improved Raykin Marine Dock Fender is a high capacity, flexible unit for use with a waling system. It is comprised of three basic sub-assemblies:

A. The OUTER SUPPORT, a steel weldment, is the primary structural member of the Raykin assembly. The outer support is designed to withstand the internal forces of the working sandwich stack and to resist such external forces as suspended dead load and those frictional forces generated by a moving vessel.

The support unit is attached to the adjacent structure with anchor bolts or by peripheral welding around the base. When anchor bolts are to be used, the number, size and general location of bolt holes will be shown on preliminary factory drawings. Though the purchaser will determine final positions, it is recommended this pattern be followed. When peripheral welding is used, the center section of the base plate may be eliminated.

B. The SANDWICH STACK is the "working" member of the Raykin Marine Dock Fender. When load is applied the sandwiches are forced into a combination of shear and compression strain. In shear the rubber components are deflected laterally in relation to the metal components. In compression the rubber is deflected perpendicular to the metal components. This action produces a highly efficient, energy-absorbing capacity.

C. The CENTER WEDGE, a steel weldment, is the apex keystone joining the two sandwich stacks. It also serves as the fastening medium for the remaining adjacent structure. The methods of fastening the center wedge are the same as for the outer support.

The marine engineer is faced with a difficult task. He must design a berth which will function under "ordinary"* operating conditions for the expected life of the structure. He must also include as many safety factors as possible against "extraordinary" berthings. In other words, he must protect both vessel and structure and still maintain a competitive cost. Over 40 efficient combinations of energy capacity, terminal load, and deflection enable him to select the Raykin Marine Dock Fender best suited to his design criteria. In addition, outer supports and center wedges can be specially designed to meet unique structural or loading requirements.

**An ordinary berthing is not to be regarded as an "ideal" berthing. An ordinary berthing occurs when the vessel approaches the structure under the maximum conditions as specified in the design criteria. Berthings exceeding these maximums would be considered extraordinary or collision conditions.*

Design Considerations

There are numerous design criteria involved in planning an efficient fendering system. No "rule of thumb" solutions can be assumed to be completely valid. When questions arise concerning the performance of Raykin Marine Dock Fenders is it recommended the factory be contacted for clarification and specifics.

For purposes of illustrating the problems and procedures involved, we will work through a simplified fendering problem using a set of assumed design criteria:

CRITERIA

Vessel Size
DWT — 85,000 long tons
Displacement — 113,000 long tons or 126,500 short tons

Max Forward Velocity — 1.97 ft./sec. (.6 meters/sec.) includes consideration of tides, wind, waves, etc.

Max Approach Angle — 15°

Max Velocity Normal to Pier — .51 ft./sec.

Type of Structure — breasting dolphin, 47.5 ft. (14.5 meters)

Loading not to exceed 6.1 long tons per linear ft. (20 long tons per running meter)

CALCULATIONS (1 ton = 2,000 lbs.)

Max Kinetic Energy Normal to Breasting Dolphin—

$$KE - 1/2 \times \frac{126500 \text{ short tons}}{32.2 \text{ ft./sec.}^2} \times .51 \text{ ft.}^2 = 510 \text{ ton ft. or } 6120 \text{ ton inches.}$$

Assume 1/2 of Kinetic Energy is dissipated in rotation of the vessel. Kinetic Energy to be absorbed by the fendering system is 3060 ton inches.

Due to length of the breasting dolphin, at least four fenders will be needed.

The F-45 overtravel Raykin Marine Dock Fender has the following characteristics:

	Energy	Load	Deflection
Design	760	60	22-1/2
Collision Overtravel	1,020	70	27

The four fenders required will produce a total design energy capacity of 3,040 ton inches at 240 tons terminal load and an additional reserve energy capacity of 1,040 ton inches in case of minor collision conditions. Total terminal load at full overtravel is 280 tons. Both conditions meet the loading requirement of structure. The resistance to lateral forces of four F-45 Raykin Marine Dock Fenders at 22-1/2" normal deflection will be 80 tons with 1/4" lateral deflection.

It appears that all conditions have been met. If it could be guaranteed that the impact of the vessel would always be applied against the middle third of the structure (A), then this is true. However, let us assume that the center of load is applied at a distance of eight feet from the end of the structure (B). Now we must make some simplifying assumptions:

1) The waler is considered rigid and is free to rotate in a horizontal plane.
2) The waler is bottomed-out against the outboard fender (1).
3) An Angle of rotation must be assumed and a summation of moments* taken around point B.

Position	X	X Sin Θ	Fender Deflection	Fender Load	Y	Moment	Energy
1	24"	1.75"	25.25	66	2'	132–	920
2	168"	12.25"	14.75	42	10'	420+	360
3	312"	22.75"	4.25	16	22'	352+	50
4	456"	33.25"	6.25	(t)-18 (t)	34'	612–	55
				106 tons		+28 ft. tons	1385 ton inches

X The distance from the bottomed-out waler to the center line of each fender.

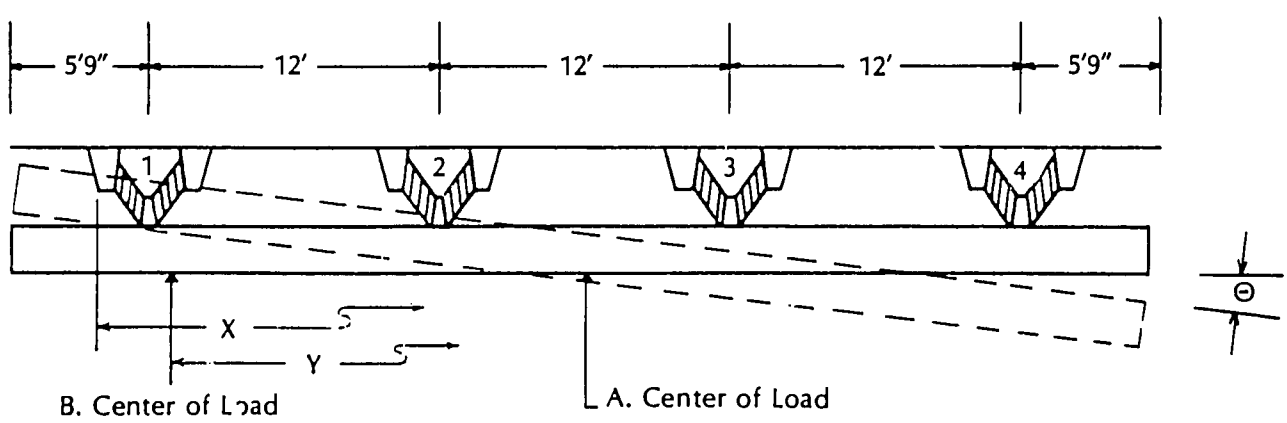
Θ Angle of waler rotation after several trial calculations is revealed as approximately 4.2°.

X Sin Θ self-explanatory.

Fender Deflection is calculated in the following manner:

Total deflection of the fender (in this case 27") minus the value of X Sin Θ. When the value of X Sin Θ exceeds the value of the total deflection, the fender is in tension (t).

A moment is a term indicating the product of a Force multiplied by the Distance (from point of summation to point of force). F x D = Moment.



Design Considerations *(Continued)*

Fender Load — Taken from the appropriate fender load curve.

Y = The distance from the center of load to the fender

Moment = Y times fender load.

Energy — self-explanatory.

Note that the summation of moments (see Moment column) does not equal zero. We can disregard this, however, as a very slight change in assumed angle of rotation produces a large change in moments.

It is now apparent that the fender arrangement which appeared to satisfy the design requirements actually is capable of only 45% of design requirements. The remaining 1,655 ton inches of Kinetic Energy will be dissipated in the damaging of the structure, fenders, wale and/or vessel. This situation is not unique with Raykins, but would apply to all flexible fender systems.

Theoretically, the ideal arrangement would be to have sufficient capacity fenders only at pier ends and bridged by a rigid waler. This is impractical. It is practical, however, to group the fenders toward the ends of the structure, or to use higher capacity fenders on corners with other fenders along the center section of the pier.

The drawing below offers one possible solution that could solve the problem and satisfy design criteria, regardless of where impact occurs. For the solution we have selected five H-60 overload Raykin units.

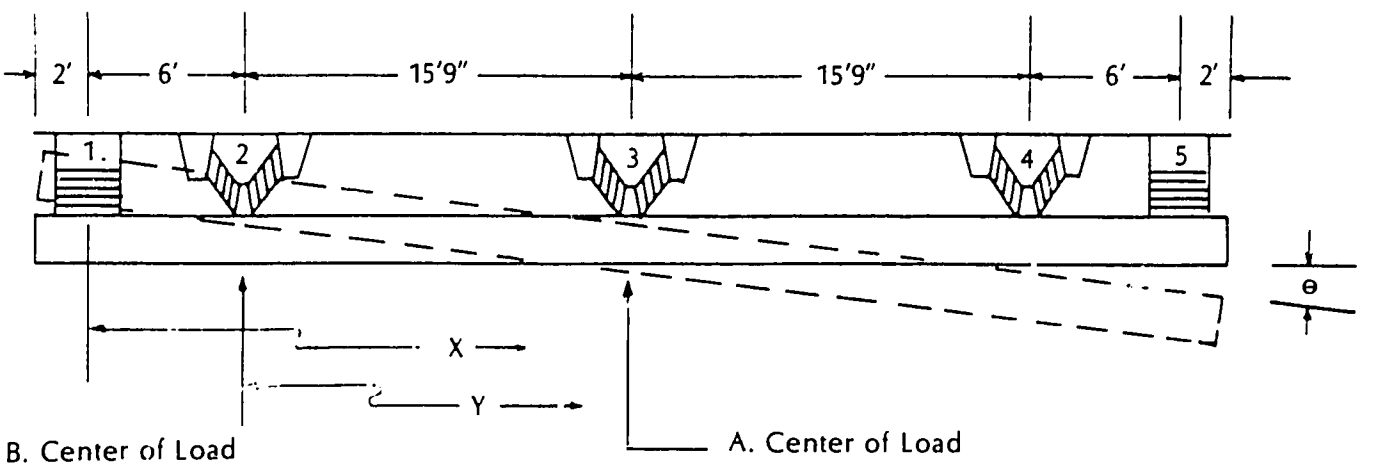
In this improved installation, if the load is applied at point A the five Raykin Marine Dock Fenders will absorb 3060 ton inches at a total terminal load of 265 tons. If the load is applied at point B the units will absorb 3360 ton inches at 186.5 tons. The following table is the summation of moments around point B and reveals just how we are able to satisfy the design criteria.

Position	X	X Sin ⊖	Fender Deflection	Fender Load	Y	Moment	Energy
1	0	0	36	78	6	460–	1650
2	72	5.3	30.7	68	0	0	1250
3	261	19.3	16.7	47	15.75	740+	430
4	450	33.3	2.7	9	31.5	283+	12
5	522	38.5	2.5(t)	15.5	(t)37.5	580–	18
				186.5		25–	3360

⊖ Angle of waler rotation after several trial calculations is found to be 4.25°.

To summarize, the following points should be considered before finalizing a fendering design:

1) All flexible fendering will rotate in a vertical plane perpendicular to the face of the pier unless restricted. Chains, mechanical stops, fender piles, or a vertical spacing of the fenders eliminate the possibility of a rotating movement.
2) The Raykin Marine Dock Fender can sustain continuous loading parallel to the length of the unit, but should not exceed the values listed in the End Loading Chart.
3) The Raykin Marine Dock Fender can be deflected due to side loading without damage, but should not be required to resist prolonged forces in this direction.
4) The fenders should be of sufficient size and located in such a manner that the total design energy can be absorbed without damage, regardless of where the point of berthing impact might occur.
5) The size and location of the reactions must be compatible with the strength of the structure and vessel.



Engineering Data

Four tables were utilized to assist in the previous design computations:

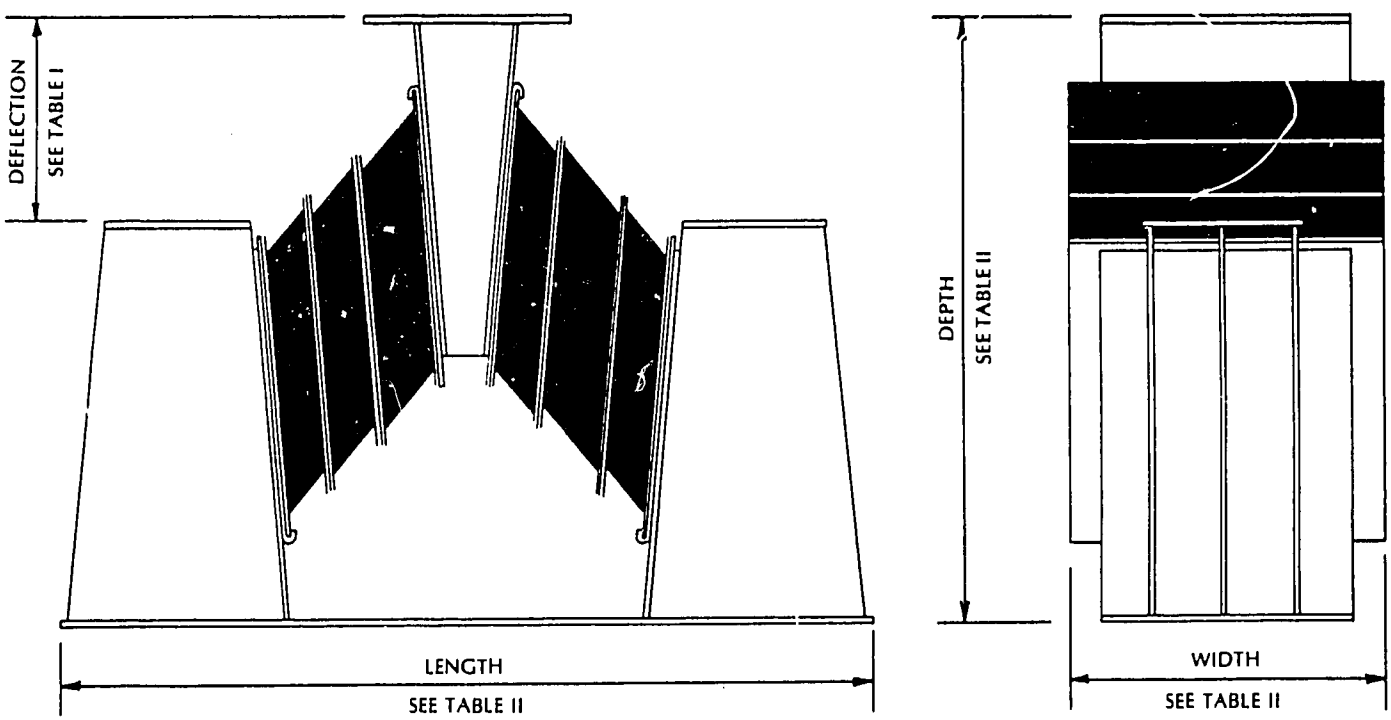
Table I (pg. 6) indicates Raykin unit characteristics arranged horizontally in fifteen energy capacity groups rather than by part number sequence. Each group contains from two to five fender sizes and is so arranged that the lower cost fender is listed first, the next more expensive second, etc. The chart has also been arranged vertically into two major columns, Standard Unit and Collision Overtravel Unit. Energy capacity, terminal load and maximum deflection for each of the fenders is indicated.

The marine designer should use only the values listed in the Standard Unit column in determining the size of fenders required. The Collision Overtravel Unit is intended to provide an additional 30% to 50% energy capacity for "extraordinary" berthings. This is not to be misconstrued as meaning the Raykin will continue to perform efficiently with consistent "extraordinary" berthings; rather, that this degree of protection is afforded in the event of occasional collision. Actual Load Deflection and Energy Deflection Curves for a particular unit will be supplied by the factory upon request.

Table II (pg. 6) gives overall dimensions and approximate weights of each size of Raykin Marine Dock Fender.

Table III (pg. 7) indicates End Loading without rotation at the center wedge. It is divided into two groups: Zero Normal Deflection to be used in determining the amount of dead load the fenders will support without benefit of fender pilts; and, Full Normal Deflection for use in determining the resistance to lateral forces due to friction.

Table IV (pg. 7) shows Tension Loading and Side-and End-Loading with rotation of the center wedge allowed. This chart to be considered for occasional dynamic loading only.



FOR APPROXIMATE WEIGHTS SEE TABLE II

TABLE I
ENERGY, LOAD & DEFLECTION CHART
(All Ton units are Short tons)

	STANDARD UNIT			COLLISION OVERTRAVEL FEATURE		
PART NO.	ENERGY	LOAD	DEFLECTION	ENERGY	LOAD	DEFLECTION
C-20	150 Ton"	30 Tons	11-1/4"	200 Ton"	36 Tons	13-1/2"
C-25	185	36	11-1/4"	250	43	13-1/2"
D-20	215	29	15"	310	35	18"
C-30	220	44	11-1/4"	305	53	13-1/2"
D-25	285	36	15"	420	43	18"
C-35	260	52	11-1/4"	360	62	13-1/2"
E-20	270	23	18-3/4"	350	27	22-1/2"
C-40	295	62	11-1/4"	410	76	13-1/2"
F-20	280	19	22-1/2"	360	20	27"
E-25	330	29	18-3/4"	430	34	22-1/2"
D-30	355	44	15"	500	52	18"
C-45	330	69	11-1/4"	450	85	13-1/2"
F-25	350	23	22-1/2"	450	25	27"
C-50	370	76	11-1/4"	515	92	13-1/2"
D-35	410	51	15"	580	61	18"
E-30	400	36	18-3/4"	540	43	22-1/2"
F-30	425	30	22-1/2"	550	32	27"
E-35	460	42	18-3/4"	610	50	22-1/2"
D-40	485	61	15"	720	75	18"
C-60	440	93	11-1/4"	605	115	13-1/2"
G-30	460	26	26-1/4"	620	26	31-1/2"
D-45	535	69	15"	760	85	18"
F-35	500	34	22-1/2"	650	37	27"
G-35	535	30	26-1/4"	720	31	31-1/2"
E-40	600	58	18-3/4"	820	72	22-1/2"
D-50	600	75	15"	860	91	18"
E-45	675	66	18-3/4"	920	82	22-1/2"
D-60	695	91	15"	975	110	18"
F-40	675	52	22-1/2"	920	62	27"
G-40	710	44	26-1/4"	960	51	31-1/2"
F-45	760	60	22-1/2"	1020	70	27"
E-50	770	74	18-3/4"	1090	95	22-1/2"
H-40	775	39	30"	1050	42	36"
G-45	790	50	26-1/4"	1070	57	31-1/2"
F-50	835	67	22-1/2"	1130	81	27"
E-60	880	90	18-3/4"	1240	105	22-1/2"
H-45	890	44	30"	1170	48	36"
G-50	920	63	26-1/4"	1250	75	31-1/2"
F-60	1030	83	22-1/2"	1440	100	27"
H-50	1020	54	30"	1360	61	36"
G-60	1140	79	26-1/4"	1600	97	31-1/2"
I-50	1079	48	33-3/4"	1409	50	40-1/2"
H-60	1210	67	30"	1650	78	36"
I-60	1284	57	33-3/4"	1679	60	40-1/2"

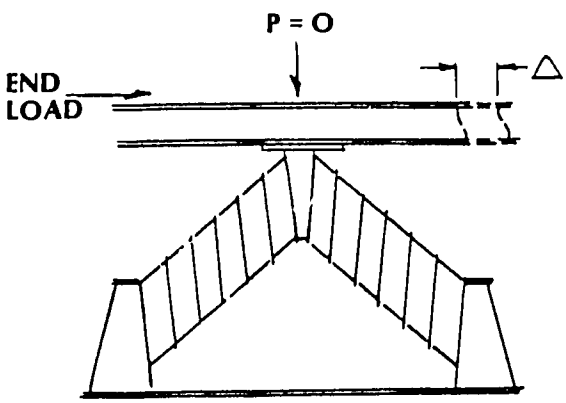
TABLE II
DIMENSION & WEIGHT CHART
(Dimensions in Inches, Weight in Lbs.)

	STANDARD UNIT				OVERTRAVEL			
PART NO.	LENGTH	WIDTH	DEPTH	WEIGHT	LENGTH	WIDTH	DEPTH	WEIGHT
C-20	50-1/2	18-1/2	32	1020	53	18-1/2	36-3/4	1060
C-25	50-1/2	18-1/2	32	1020	53	18-1/2	36-3/4	1060
D-20	57-1/2	18-1/2	36-1/4	1180	60	18-1/2	42-1/2	1225
C-30	54	21-1/2	35-1/2	1470	55	21-1/2	40	1520
D-25	57-1/2	18-1/2	36-1/4	1180	60	18-1/2	42-1/2	1225
C-35	54	21-1/2	35-1/2	1470	55	21-1/2	40	1520
E-20	64-1/2	18-1/2	40-1/2	1350	67	18-1/22	48-1/2	1400
C-40	59	25	37-3/4	1980	60	25	42-1/4	2050
F-20	71-1/2	18-1/2	44-3/4	1510	74	18-1/2	54	1565
E-25	64-1/2	18-1/2	40-1/2	1350	67	18-1/2	48-1/4	1400
D-30	61	21-1/2	39-3/4	1720	62-1/2	21-1/2	45-3/4	1780
C-45	59	25	37-3/4	1980	60	25	42-1/2	2050
F-25	71-1/2	18-1/2	49-3/4	1510	74	18-1/2	54	1565
C-50	67-1/2	27-1/2	40-1/2	2460	68	27-1/2	45-3/4	2550
D-35	61	21-1/2	39-3/4	1720	62-1/2	21-1/2	45-3/4	1780
E-30	68	21-1/2	44	1960	69-1/2	21-1/2	51-1/2	2030
F-30	75	21-1/2	48-1/4	2190	77	21-1/2	57-1/4	2270
E-35	68	21-1/2	44	1960	69-1/2	21-1/2	51-1/2	2030
D-40	66	25	42	2300	67	25	48	2390
C-60	67-1/2	27-1/2	40-1/2	2460	68	27-1/2	45	2550
G-30	82	21-1/2	52-1/2	2400	84	21-1/2	63	2490
D-45	66	25	42	2300	67	25	48	2390
F-35	75	21-1/2	48-1/4	2190	77	21-1/2	57-1/4	2270
G-35	82	21-1/2	52-1/2	2400	84	21-1/2	63	2490
E-40	73	25	46-1/4	2640	74	25	53-3/4	2740
D-50	74-1/2	27-1/2	44-3/4	2850	75	27-1/2	50-3/4	2950
E-45	73	25	46-1/4	2640	74	25	53-3/4	2740
D-60	74-1/2	27-1/2	44-3/4	2850	75	27-1/2	50-3/4	2950
F-40	80	25	50-1/2	2960	81-1/2	25	59-1/2	3070
G-40	87	25	54-1/4	3290	88-1/2	25	65-1/4	3410
F-45	80	25	50-1/2	2960	81-1/2	25	59-1/2	3070
E-50	81-1/2	27-1/2	48-3/4	3240	82	27-1/2	56-1/4	3350
H-40	94	25	59	3620	96	25	71	3750
G-45	87	25	54-3/4	3290	88-1/2	25	65-1/4	3410
F-50	88-1/2	27-1/2	53	3650	89	27-1/2	62	3780
E-60	81-1/2	27-1/2	48-3/4	3240	82	27-1/2	56-1/4	3350
H-45	94	25	59	3620	96	25	71	3750
G-50	95-1/2	27-1/2	57	4050	96	27-1/2	67-1/2	4200
F-60	88-1/2	27-1/2	53	3650	89	27-1/2	62	3780
H-50	102-1/2	27-1/2	61-1/4	4460	103	27-1/2	73-1/4	4620
G-60	95-1/2	27-1/2	57	4050	96	27-1/2	67-1/2	4200
I-50	109-1/2	27-1/2	65-1/4	4870	110	27-1/2	78-3/4	5040
H-60	102-1/2	27-1/2	61-1/4	4460	103	27-1/2	73-1/4	4620
I-60	109-1/2	27-1/2	65-1/4	4870	110	27-1/2	78-3/4	5040

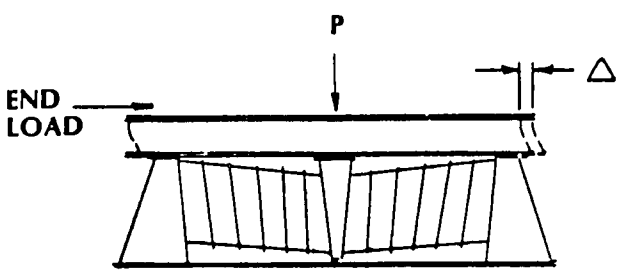
TABLE III
MAXIMUM DESIGN END LOADS AND DEFLECTIONS CHART
(All Ton units are Short tons)

PART NO.	DEAD LOAD* ZERO NORMAL DEFLECTION		DYNAMIC LOADING** FULL NORMAL DEFLECTION	
	LOAD TONS	DEFL. INCHES	LOAD TONS	DEFL. INCHES
C-20 & 25	3-1/4	3/8	10	1/4
D-20 & 25	3	1/2	10	3/8
E-20 & 25	2-3/4	5/8	10	1/2
F-20 & 25	2-1/2	3/4	10	5/8
C-30 & 35	5	3/8	15	1/4
D-30 & 35	4-3/4	1/2	15	5/16
E-30 & 35	4-1/2	5/8	15	3/8
F-30 & 35	4-1/4	3/4	15	7/16
G-30 & 35	4	7/8	15	1/2
C-40 & 45	6-1/4	3/8	20	1/16
D-40 & 45	6	1/2	20	1/8
E-40& 45	5-3/4	5/8	20	3/16
F-40 & 45	5-1/2	3/4	20	1/4
G-40 & 45	5-1/4	7/8	20	5/16
H-40 & 45	5	1	20	3/8
C-50 & 60	12	3/8	25	1/16
D-50 & 60	11	1/2	25	1/8
E-50 & 60	10	5/8	25	1/8
F-50 & 60	9	3/4	25	3/16
G-50 & 60	8	7/8	25	1/4
H-50 & 60	7	1	25	5/16
I-50 & 60	7	1-1/8	25	3/8

*Do not exceed when using suspended waler.
**Resistance values for frictional force.



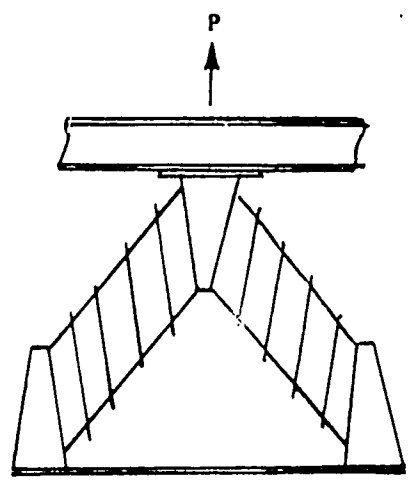
NO DEFLECTION



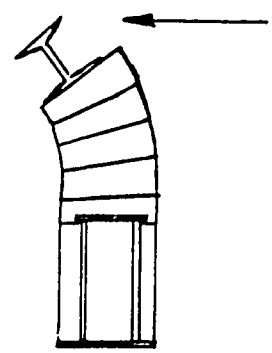
FULL DEFLECTION

TABLE IV
TENSION, SIDE, AND END LOADING CHART
(All Ton units are Short tons)

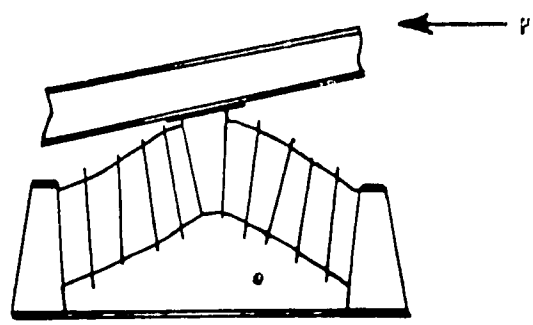
PART NO.	TENSION LOAD		SIDE LOAD— ROTATION ALLOWED		END LOAD— ROTATION ALLOWED	
	LOAD TONS	DEFL. INCHES	LOAD TONS	DEFL. INCHES	LOAD TONS	DEFL. INCHES
C-20 & 25	10	4	1/2	1-1/2	2	1-3/4
D-20 & 25	10	5	1/2	2-1/4	2	2
E-20 & 25	10	6-1/2	1/2	3	2	2-1/4
F-20 & 25	10	8	1/2	4-1/2	2	2-3/4
C-30 & 35	15	4-1/2	3/4	1-1/2	4	2-3/4
D-30 & 35	15	5-1/2	3/4	2	4	3
E-30 & 35	15	7	3/4	3	4	3-1/2
F-30 & 35	15	8-1/4	3/4	4-1/2	4	4-1/4
G-30 & 35	15	10	3/4	6	4	5-1/4
C-40 & 45	20	4	1	1-1/2	5	1-3/4
D-40 & 45	20	5	1	1-3/4	5	2
E-40 & 45	20	6-1/2	1	2-1/4	5	2-1/2
F-40 & 45	20	8	1	3-1/4	5	3-1/4
G-40 & 45	20	9-3/4	1	4-1/2	5	3-3/4
H-40 & 45	20	11-1/2	1	6	5	4-1/4
C-50 & 60	25	4	1-1/2	1-3/4	7	2
D-50 & 60	25	5	1-1/2	2	7	2-1/2
E-50 & 60	25	6-1/2	1-1/2	2-1/2	7	3
F-50 & 60	25	8	1-1/2	3-1/2	7	3-1/2
G-50 & 60	25	9-1/2	1-1/2	4-1/2	7	4
H-50 & 60	25	10-3/4	1-1/2	6	7	4-1/2
I-50 & 60	25	12-1/4	1-1/2	7-1/2	7	4-3/4



TENSION LOAD



SIDE LOAD



END LOAD

Corrosion Protection

Due to the natural environment of fendering systems, corrosion is an ever-present problem. In an effort to reduce this condition, the Raykin Marine Dock Fender is manufactured with major consideration given to corrosion protection. All steel on the assembled sandwich stack is covered. The individual sandwich has a layer of bonded rubber. This rubber layer is an integral part of each sandwich and is bonded to the plates during the vulcanization process. It proves complete corrosion protection for the critical "working" members. The steel structural members (outer support and center wedge) are painted with a zinc based primer and an outer coat of red lead to provide similar protection. Any indication of corrosion on these structural parts will be readily apparent and corrective action should be taken before the problem becomes serious.

Maintenance

The efficient functioning of each fender is essential to the economical operation of a fendering system. A complete fendering system represents a large investment. For these reasons a maintenance program should be instituted. We recommend a semi-annual visual inspection for:

1. Permanently deformed sandwich metals or structural members resulting from excessive overload.
2. Corrosion of exposed metal parts, including fasteners.
3. Torn, cut, or gouged rubber on sandwiches.

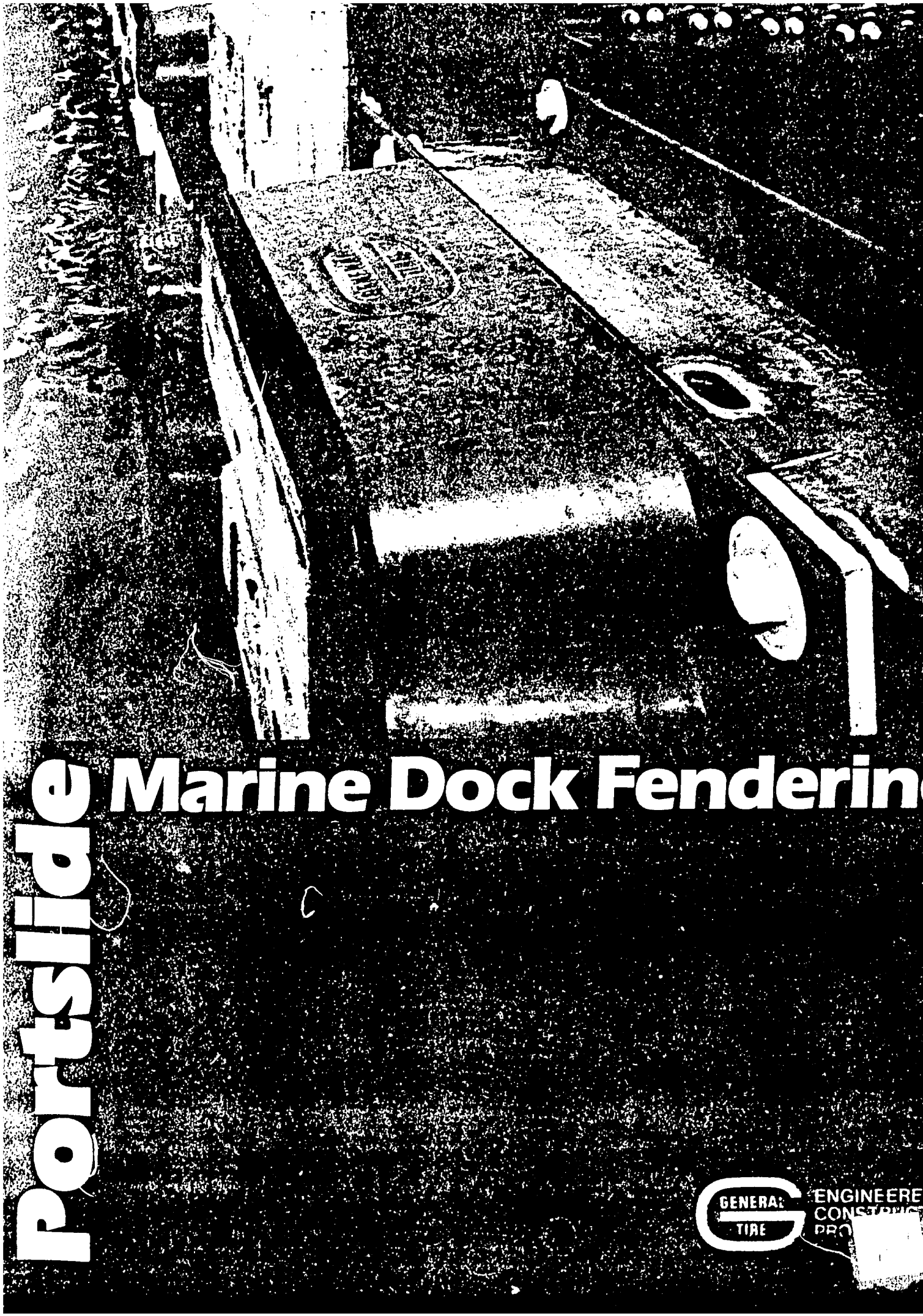
Corrective action: Repair or replace.

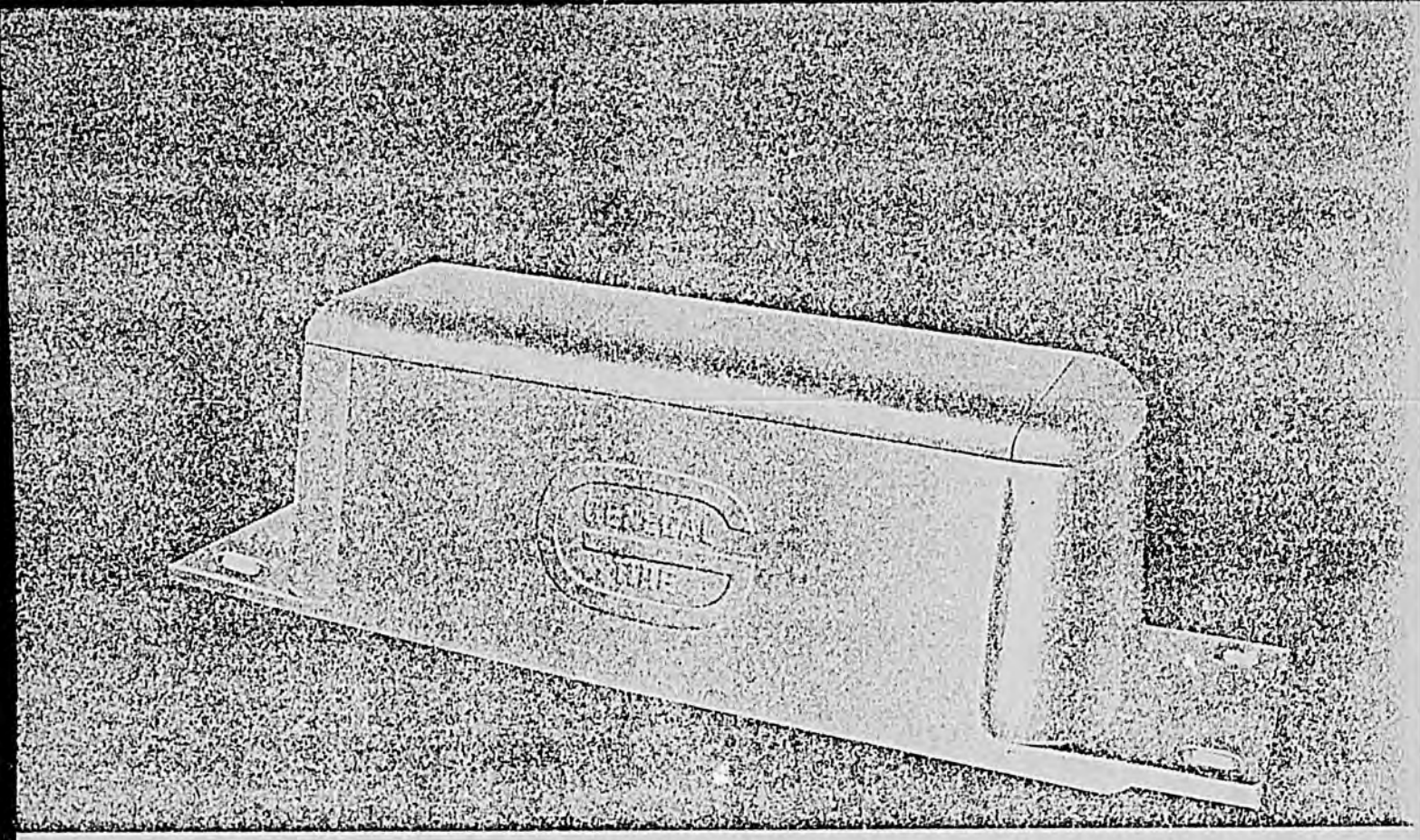
Note

The information herein will suffice for planning and initial design work. Engineers contemplating specification of a Raykin fendering system should refer specific questions on the performance of the fenders to The General Tire & Rubber Company, Engineered Construction Products, Wabash, Indiana 46992.

GENERAL TIRE ENGINEERED CONSTRUCTION PRODUCTS

One General Street, Wabash, IN 46992


Portslide
Marine Dock Fenderin
GENERAL TIRE
ENGINEERED



Portslide

Marine Dock Fendering

Product Description

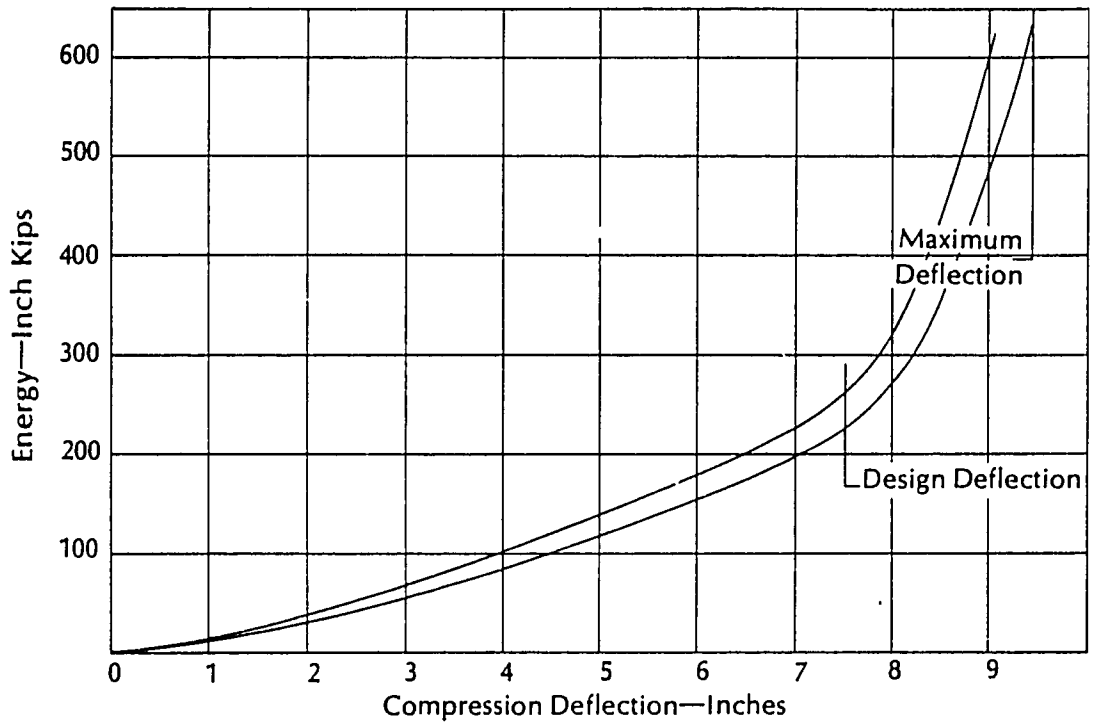
The Portslide Marine Dock Fender is a medium capacity, flexible unit that can be used with or without a waling system. It is comprised of three basic components:

A. The Butyl RUBBER BODY is specifically designed to give the highest energy capacity at the lowest terminal load and to provide for heavy overloads. It is resistant to all corrosive elements.

B. The steel MOUNTING PLATE is an integral part of the fender. It is permanently bonded to the rubber body and provides a convenient method by which to fasten the Portslide to dock structures. One end is offset to allow the use of common anchor bolts. Except for these anchor bolts, the mounting plate is the only metal utilized with the Portslide. It is completely covered by a layer of butyl rubber against corrosive elements.

C. The URETHANE CAP is mechanically fastened to the body of the fender and provides a low friction, non-marking wear surface. Urethane is one of the most abrasion-resistant elastomers known to industry. Its use on the face of the Portslide transforms the unit into the most durable and functional fender yet devised for marine purposes.

Portslide Energy Deflection Curve



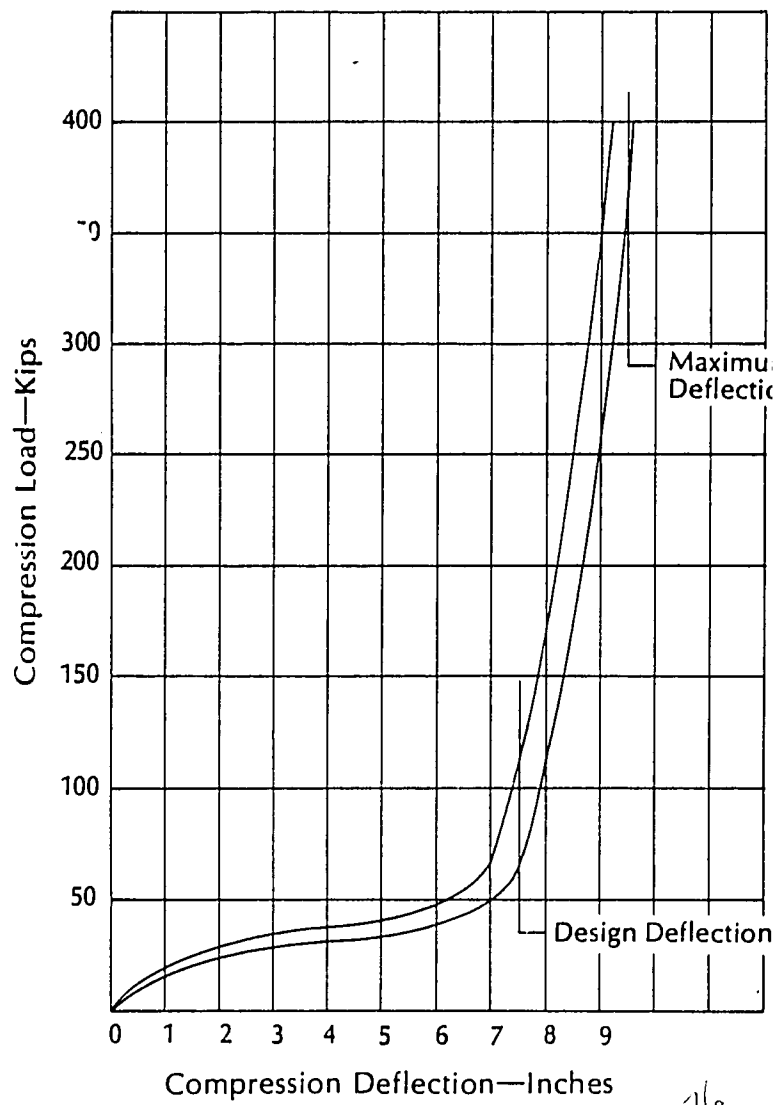
Design Considerations

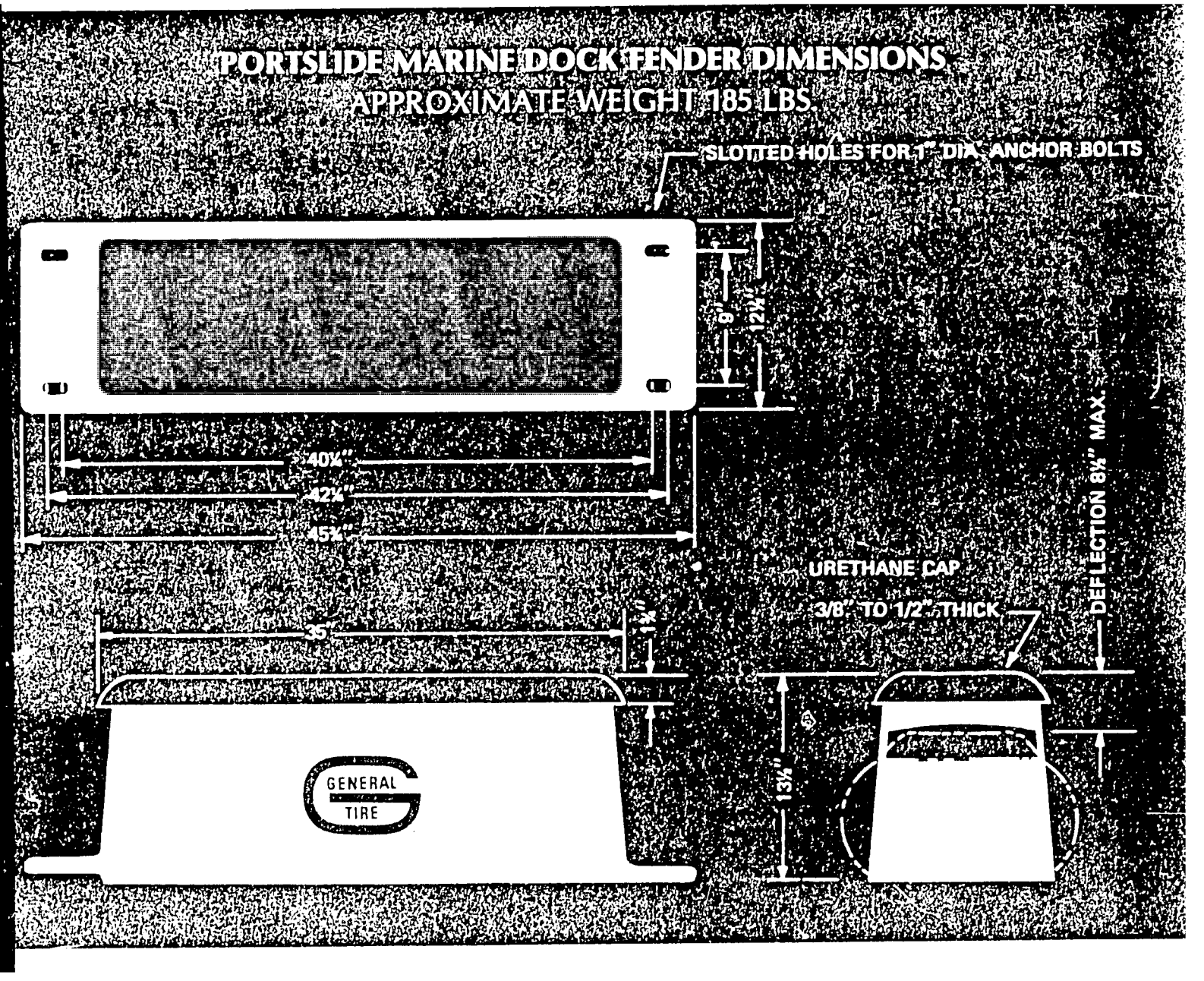
The Portslide Marine Dock Fender was primarily designed to be used without a waler and in direct contact with the berthing vessel. Depending upon requirements, it may be used along a harbor structure in a continuous line, spaced laterally and/or vertically, or grouped at intervals. However, caution must be exercised where grouping or spacing is used. Consideration must be given to the possibility of a vessel approaching at an angle which would cause it to miss the fenders and contact the dock directly.

To determine the number of Portslide Marine Dock Fenders required for an installation, divide the total Kinetic Energy to be absorbed by 220 kip inches (design energy capacity of the unit). The number of fenders determined by this calculation are then positioned on the structure to insure a required minimum being in contact with the berthing vessel.

The Portslide Marine Dock Fender could be used with a waler system to fender a corner or a length of pier. In both instances the waler must be mechanically fastened to the dock as the Portslide is a compression fender and is not designed to transfer other than compression loadings.

Portslide Load Deflection Curve





Ordering

The following information should accompany all purchase orders for Portslide Marine Dock Fenders:

1) Quantity

2) Domestic or export* packaging

All quotations are FOB Wabash, Indiana.

TERMS: Net 10th Prox.

Delivery time will vary with the quantity. Orders up to one hundred units will be shipped within six weeks of receipt of order. Anchor bolts are not included.

An additional charge will be made for export crating.

GENERAL TIRE
ENGINEERED CONSTRUCTION PRODUCTS

[illegible] Street Wabash, IN 46992

APPENDIX D
Constant Tension Winches

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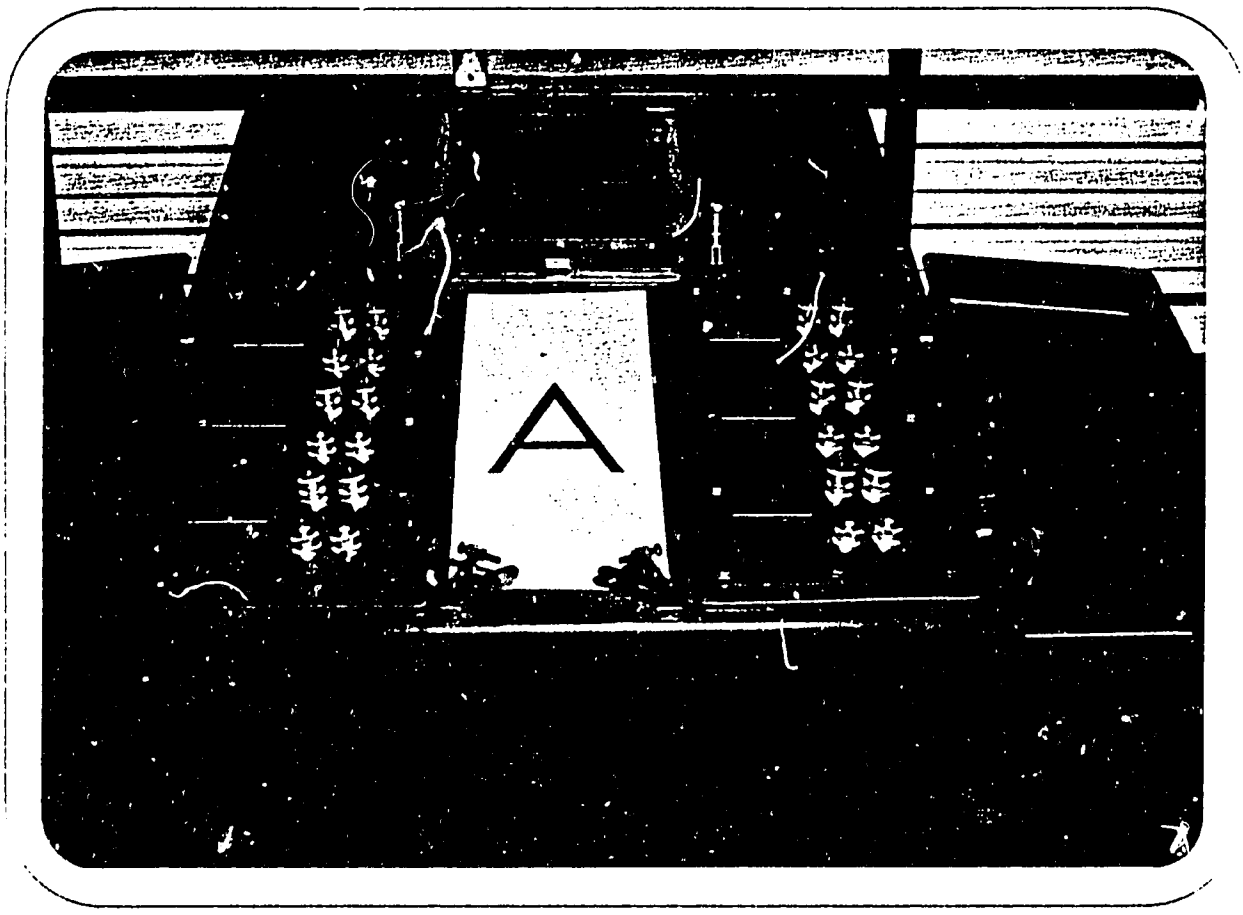

mooring system control console

In addition to a wide range of winches, windlasses, cranes, and special heavy duty deck gear, Appleton Marine designs and manufactures the complete control systems that accompany them. Shown here is a watertight local control and monitoring system for a pair of mooring windlasses on a drillship. Pushbuttons and pilot lights control and indicate a variety of functions necessary to the operation of the system, including readouts of chain tension when moored. The blank center section will house a motor control center.

APPLETON MARINE
Division of Appleton Machine Co.
P.O. Box 2339 · Appleton, WI 54911
Phone (414) 733-7361

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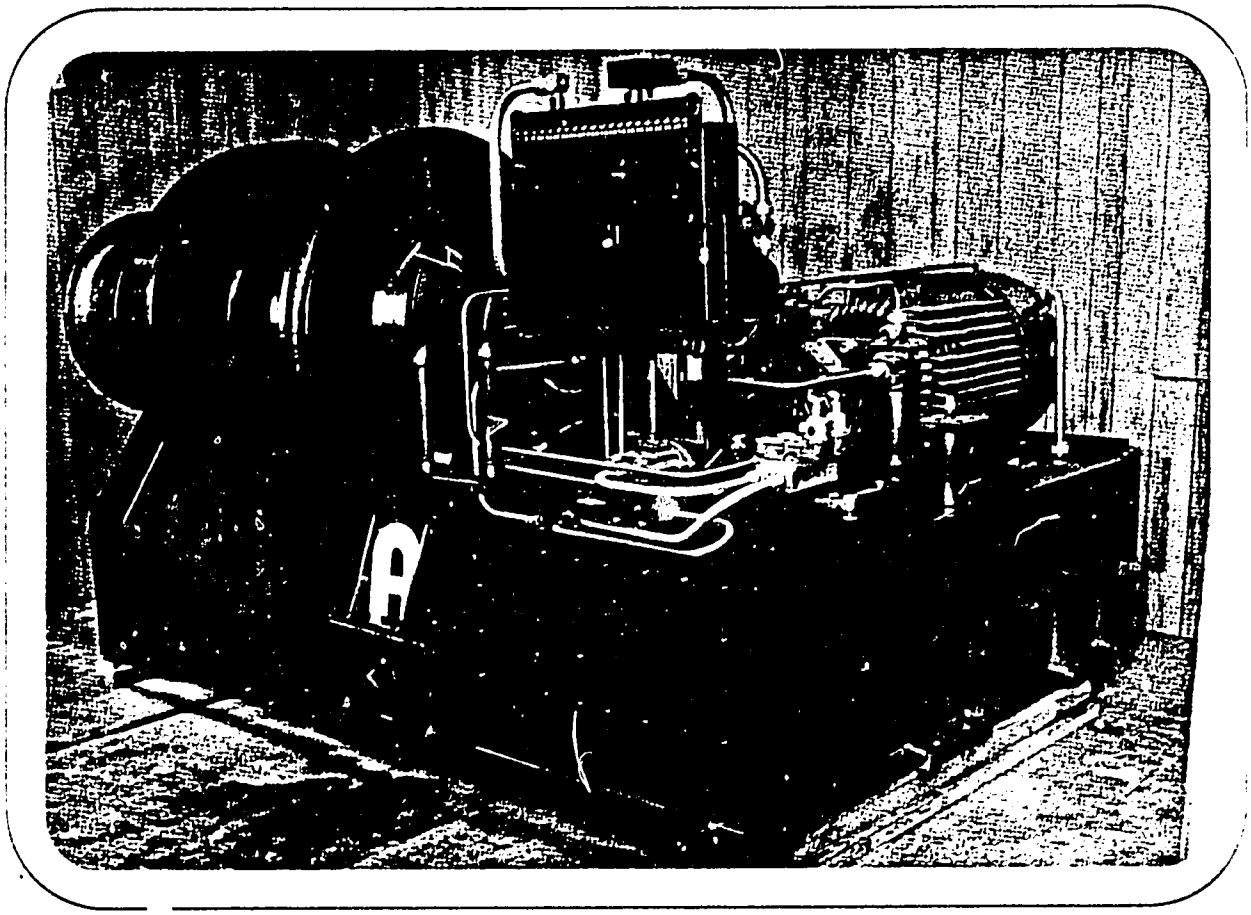

constant tension mooring winch

The electro-hydraulic constant tension mooring winch shown here features dual ratings of 30,000 lbs. line pull at 0 to 45 fpm and 15,000 lbs. line pull at 0 to 90 fpm. The winch is designed for continuous operation, and has a heat exchanger on the hydraulic system. Shown here with the cover removed, the hydraulic system is hard piped with stainless steel tubing. Explosion proof solenoid valves, remotely operated, control the dual rating and operate the spring set hydraulic released brake. A manual band brake is also provided.

APPLETON MARINE

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APPENDIX E

Automated Equipment Systems Specifications

OUTLINE SPECIFICATION

PORTABLE SHIPLOADER FOR PORT OF SALAVERRY
TO HANDLE 1200 MTPH OF ORE CONCENTRATES

36" wide x 88' long boom mounted on a portable tower with boom designed to raise-lower between -5° and $+15^{\circ}$ from horizontal for operating up to $+85^{\circ}$ to clear ship's breasting line. The conveyor drive will be a 60 H.P. internal wrapped drive through a 60 H.P., 1800 RPM TEFC motor for 3 phase, 60 hertz, 460 volt power and a parallel shaft reducer. Belt take-up will be through a vertical gravity take-up near the tail. The boom will be hinged approximately 55' from the end to raise under the power of an electric hoist; boom will have 5" diameter (Barber-Greene or equal) roller bearing idlers conforming to CEMA Class C specifications; conveyor belting selected on the basis of the maximum operating belt tensions with 3/16" top and 1/16" bottom Grade 2 rubber covers; belt housing with removable side panels to prevent the material from blowing off the belt; the boom will be mounted on a structural steel tower which will be mounted on pneumatic tired trucks with a steering tongue on either end for towing.

Approximate weight: 80,000 lbs.

OUTLINE SPECIFICATION

36" x 101' ADJUSTABLE HEIGHT PORTABLE CONVEYOR
FOR PORT OF SALAVERRY
TO HANDLE 1200 MTPH OF ORE CONCENTRATES

36" x 101' portable conveyor (Barber-Greene PK 101 or equal) complete with guarded v-belt drive from 60 H.P., 1800 RPM, TEFC motor for 3 phase, 60 hertz, 460 volt power to shaft mounted reducer, lagged drive pulley, nip guards, roller bearing pillow blocks, belt scraper, backstop, screw take-up at tail end at drive snub, 36" deep Warren type truss with self-shedding decking, tail and pivot, 5" diameter, 35° roller bearing idlers conforming to CEMA Class A specifications, hydraulic powered push arm cylinder with 7-1/2 H.P. motor raising and lowering conveyor; conveyor belting selected on the basis of maximum operating belt tension with 3/16" top and 1/16" bottom Grade 2 rubber covers; swivel wheel frame with 2 pneumatic tires; belt housing with removable side panels to prevent material from blowing off the belt; hinged head and tail sections to fold the conveyor for transporting.

Approximate weight: 31,000 lbs.

OUTLINE SPECIFICATION

EQUIPMENT

CALLAO BULK CONCENTRATE HANDLING SYSTEM

(A). Two - 36" wide x 440' long belt feeder conveyors horizontal for approximately 380' with about 440' horizontal centers and a lift of approximately 22' at head, handling, with continuously and informily loaded, 1200 MTPH uniformly loaded, 1200 MTPH of one concentrate weighing 125-175 lbs./cu. ft. at a belt speed of 450 FPM. The Feeder conveyors will be located approximately 4' above ground and equipped with side boards to prevent dusting. A Travelling hopper car with electric propelling drive will be positioned on rails over the Feeder Conveyor to permit loading of material along the length of the belt. Layout is shown on MAGUIRE Figure 17.

Drive Terminal; Each Feeder Conveyor

1 - 50 H.P. head end drive Terminal 30" diameter x 38" face, welded steel, drive pulley with vulcanized rubber logging; shafting mounted on roller bearing pillow blocks.

1 - 18" diameter x 38" face, welded steel snub pulley.

1 - Structural steel frame with nip guards.

1 - Shaft mounted torque arm speed reducer with motor mount V-belt drive with guard from motor to reducer.

1 - 50 H.P. 1800 RPM, TFC normal torque motor for 460 volts, 3 phase, 60 hertz current.

Tail Terminal; Each Feeder Conveyor

1 - Fixed Tail Terminal with 20" diameter x 38" face, welded steel, pulley shafting mounted on roller bearing pillow blocks.

1 - Structural steel tail frame with nip guards.

Vertical Gravity Take-Up; Each Feeder Conveyor

1 - Vertical gravity take-up located near the drive with 24" diameter x 38" face, welded steel, take-up pulley with 2 - 20" diameter x 38" face bend pulleys.

1 - Take-up carriage with carriage tracks providing 36" of carriage movement, carriage track safety fencing, pull back sheaves and wire rope with fittings.

1 - Counterweight tower with safety fencing and steel counter-weight box.

Conveyor Idlers; Each Feeder Conveyor

All idlers shall be equipped with 5" diameter rolls, Barber-Greene Series R, or equal, with 3/4" diameter shafts and roller bearings conforming to CEMA Class C.

Return idlers shall be equipped with 5" diameter rolls, 3/4" diameter shafts and roller bearings, Barber-Greene Series R, or equal, conforming to CEMA Class C.

Conveyor Belt; Each Feeder Conveyor

903' - Lineal feet of 36" wide conveyor belt with 3/16" thick top rubber cover and 1/16" thick bottom rubber cover, RMA grade 1.

1 - Item of Flexco clamps and Tools.

Conveyor Intermediate Frame; Each Feeder Conveyor

60 - Lineal feet of welded steel truss frame 24" deep without decking.

60 - Lineal feet of 2'-0" wide walkway on one side including handrails, midrails, toe guards and supports and expanded metal flooring.

380 - Lineal feet of 7" channel frame without decking, cross members and supporting legs 3 feet high.

Traveling Hopper Car; Each Feeder Conveyor

1 - Traveling Hopper Car designed to handle 1200 MTPH of one concentrate when loaded by a Cat 966 front end loader or equipment of similar dimensions. Hopper will have propelling drives to 2 double flanged steel wheels mounted on purchaser's rail.

Side Boards; Each Feeder Conveyor

Horizontal run of conveyor to be supplied with side boards, on each side, to prevent dusting during loading of belt using Traveling Hopper Car.

(B). One - 36" wide x 4800' long belt conveyor horizontal for 4800' with about 4800' horizontal centers and a lift of approximately 7' at head, handling, when continuously and uniformly loaded, 1200 MTPH of one concentrate weighing 125-175 lbs./cu. ft. at a belt speed of 450 FPM. The conveyor will be designed to handle material that consists of lumps mixed with fines with a maximum lump size of 1". This conveyor layout is labeled Conveyor No. 1 on MAGUIRE Figure 17.

Drive Terminal

1 - 250 H.P. head end drive terminal with 30" diameter x 38" face, welded steel, drive pulley with vulcanized rubber lagging, shafting mounted on roller bearing pillow blocks.

1 - 18" diameter x 38" face, welded steel, snub pulley.

1 - Structural steel frame with nip guards.

1 - Direct connected parallel shaft gear reducer.

1 - 250 H.P. 1800 RPM, TEFC normal torque motor for 460 volt, 3 phase, 6 hertz current.

Tail Terminal

1 - Fixed Tail Terminal with 24" diameter x 38" face, welded steel, pulley shafting mounted on roller bearing pillow blocks.

1 - Structural steel tail frame with nip guards.

Horizontal Gravity Take-Up

1 - Horizontal gravity take-up located near the drive with 24" diameter x 38" face, welded steel, take-up pulley with 2 - 20" diameter x 38" face bend pulleys.

1 - Take-up carriage with carriage tracks providing minimum 36" of carriage movement. Carriage truck safety fencing, pull back sheaves and wire rope with fittings.

1 - Counterweight tower with safety fencing and steel counterweight box.

Conveyor Idlers

All idlers shall be equipped with 6" diameter rolls, 3/4" diameter shafts and roller bearings, Barber-Greene Series R, or equal, conforming to CEMA Class C.

Return idlers shall be equipped with 6" diameter rolls, 3/4" diameter shafts and roller bearings, Barber-Greene Series R, or equal, conforming to CEMA Class C.

Conveyor Belt

9800 - Lineal feet of 36" wide conveyor belt with 3/16" thick top rubber cover and 1/16" thick bottom cover, RMA Grade 2.

1 - Item of Flexco clamps and tools.

Conveyor Intermediate Frame

4800 - Lineal feet of welded steel box truss frame and

elevated above ground level to provide 7 meters clearance at rail crossings, supported along the entire length by bents as shown on MAGUIRE Figure 16. Intermediate frame will consist of 41" box truss, 50' standard lengths except at crossings where 100'-66" box trusses will provide required horizontal clearance.
4800 - Lineal feet of 2'-0" wide walkway on one side including handrails, mid-rails, toe guards and supports and expanded metal flooring.

Belt Housing

All exposed belt areas shall be totally covered with a belt housing consisting of covered sections supported on bands spaced at 4'-8" centers. Cover sections shall be 20 gauge corrugated tunnel stock with extra heavy galvanizing. Cover section shall be able to be raised for access to belt for inspection or repairs. Troughing idlers shall be greased by removing side panels. A length of chain shall be furnished to hold each section of cover in raised position.

(C). One - 36" wide x 350' long belt conveyor with about 350' horizontal centers and a lift of approximately 2' at head, handling, when continuously and uniformly loaded, 1200 MTPH of one concentrate weighing 125-175 lbs./cu. ft. at a belt speed of 450 FPM. The conveyor will be designed to handle material that consists of lumpbs mixed with fines with a maximum lump size of 1".

Drive Terminal

1 - 40 H.P. head end drive terminal with 30" diameter x 38" face, welded steel, snub pulley.

1 - 18" diameter x 38" face, welded steel snub pulley.

1 - Structural steel frame with nip guards.

1 - Shaft mounted torque arm speed reducer with motor mount V-blet drive with guard from motor to reducer.

1 - 40 H.P. 1800 RMP, TEFC normal torque motor for 460 volts, 3 phase, 60 hertz current.

Tail Terminal

1 - Fixed Tail Terminal with 20" diameter x 38" face, welded steel, pulley shafting mounted on roller bearing pillow blocks.

1 - Structural steel tail frame with nip guards.

Horizontal Gravity Take-Up

1 - Horizontal gravity take-up located near the drive with 24" diameter x 38" face, welded steel, take-up pulley with 2 - 20" diameter x 38" face bend pulleys.

1 - Take-up carriage with carriage tracks providing 36" of carriage movement, carriage track safety fencing, pull back sheaves and wire rope with fittings.

1 - Counterweight tower with safety fencing and steel counterweight box.

Conveyor Idlers

All idlers shall have 5" diameter rolls, 3/4" diameter

rolls, 3/4" diameter shafts and roller bearings, Barber-Greene Series R, or equal, conforming to CEMA Class C.

Return idlers shall have 5" diameter rolls, 3/4" diameter shafts and roller bearings, Barber-Greene Series R, or equal, conforming to CEMA Class C.

Conveyor Belt

719 - Lineal feet of 36" wide conveyor belt with 3/16" thick rubber cover and 1/16" thick bottom rubber cover, RMA grade 2.

1 - Item of Flexco clamps and tools.

Conveyor Intermediate Frame

350 - Lineal feet of welded steel box truss frame, 42" deep, on A-frame type supports on 50 foot centers, without decking. 66" deep welded steel box frame will be employed where spans in excess of 50 feet are required.

350 - Lineal feet of 1'-0" wide walkway on one side including handrails, midrails, toe guards and supports and expanded metal flooring.

Belt Housing

All exposed belt areas shall be totally covered with a belt housing consisting of covered sections supported on bands spaced at 4'-8" centers. Cover sections shall be 20 gauge corrugated tunnel stock with extra heavy galvanizing. Cover section shall be able to be raised

for access to belt for inspection or repairs. Troughing idlers shall be greased by removing side panels. A length of chain shall be furnished to hold each section of cover in raised position.

(D). One - 36" x 550' long belt conveyor with about 550' horizontal centers and a lift of approximately 7' at head, handling, when continuously and uniformly loaded, 1200 MTPH of one concentrate weighing 125-175 lbs./cu.ft. at a belt speed of 450 FPM. The conveyor will be designed to handle material that consists of lumps mixed with fines with a maximum lump size of 1".

Drive Terminal

1 - 50 H.P. head end drive terminal with 30" diameter x 38" face welded steel, drive pulley with vulcanized rubber lagging; shafting mounted on roller bearing pillow blocks.

1 - 18" diameter x 38" face, welded steel, snub pulley.

1 - Structural steel frame with nip guards.

1 - Shaft mounted torque arm speed reducer with motor mount V-belt drive with guard from motor to reducer.

1 - 50 N.P. 1800 RPM, TEFC normal torque motor for about 460 volts, 3 phase, 60 hertz current.

Tail Terminal

1 - Fixed Tail Terminal with 20" diameter x 38" face, welded steel, pulley shafting mounted on roller bearing pillow blocks.

1 - Structural steel tail frame with nip guards.

Horizontal Gravity Take-Up

1 - Horizontal gravity take-up located near the drive with 24" diameter x 38" face, welded steel, take-up pulley with 2'-20" diameter x 38" face bend pulleys.

1 - Take-up carriage with carriage tracks providing 36" of carriage movement, carriage track safety fencing, pull back sheaves and wire rope with fittings.

1 - Counterweight tower with safety fencing and steel counterweight box.

Conveyor Idlers

All idlers shall have 5" diameter rolls, 3/4" diameter shafts and roller bearings, Barber-Greene Series R, or equal, conforming to CEMA Class C.

Return idlers shall have 5" diameter rolls, 3/4" diameter shafts and roller bearings, Barber-Greene Series R, or equal, conforming to CEMA Class C.

Conveyor Belt

1127 - Lineal feet of 36" wide conveyor belt with 3/16" thick rubber belt with 3/16" thick rubber cover and 1/16" thick bottom rubber cover, RMA grade 2.

1 - Item of Flexco clamps and tools.

Conveyor Intermediate Frame

550 - Lineal feet of welded steel box through frame, 42" deep on A-Frame type supports on 50 foot centers,

without decking. 66" deep welded steel box truss frame will be employed where spans in excess of 50 feet are required.

550 - Lineal feet of 1'-0" wide walkway on one side including handrails, midrails, to guards and supports and expanded metal flooring.

Belt Housing

All exposed belt areas shall be totally covered with a belt housing consisting of covered sections supported on bands spaced at 4'-8" centers. Cover section shall be 20 gauge corrugated tunnel stock with extra heavy galvanizing. Cover section shall be able to be raised for access to belt for inspection or repairs. Troughing idlers shall be greased by removing side panels. A length of chain shall be furnished to hold each section of cover in raised position.

(E). One - 36" wide x 425' long belt conveyor with about 425' horizontal centers and a lift of approximately 7' at head, handling, when continuously and uniformly loaded, 1200 MTPH of ore concentrates weighing 125-175 lbs./cu.ft. at a belt speed of 450 FPM. The conveyor will be designed to handle material that consists of lumps mixed with fines with a maximum lump size of 1".

Drive Terminal

1 - 40 H.P. head end drive terminal with 30" diameter

x 38" face, welded steel, drive pulley with vulcanized rubber lagging, shafting mounted on roller bearing pillow blocks.

1 - 18" diameter x 38" face, welded steel, snub pulley.

1 - Structural steel frame with nip guards.

1 - Shaft mounted torque arm speed reducer with motor mount V-belt drive with guard from motor to reducer.

1 - 40 H.P. 1800 RPM, TEFC normal torque motor for 460 volts, 3 phase, 60 hertz current.

Tail Terminal

1 - Fixed tail terminal with 20" diameter x 38" fan, welded steel pulley shafting mounted on roller bearing pillow blocks.

1 - Structural steel tail frame with nip guards.

Horizontal Gravity Take-Up

1 - Horizontal gravity take-up located near the drive with 24" diameter x 38" face, welded steel, take-up pulley with 2-20" diameter x 38" face bend pulleys.

1 - Take-up carriage with carriage tracks providing 36" of carriage movement, carriage track safety fencing, pull back sheaves and wire rope with fittings.

1 - Counterweight tower with safety fencing and steel counterweight box.

Conveyor Idlers

All idlers shall have 5" diameter rolls, 3/4" diameter

shafts and roller bearings, Barber-Greene Series R, or equal, conforming to CEMA Class C. Return idlers shall have 5" diameter rolls, 3/4" diameter shafts and roller bearings, Barber-Greene Series R, or equal, conforming to CEMA Class C.

Conveyor Belt

872 - Lineal feet of 36" wide conveyor belt witn 3/16" thick rubber cover and 1/16" thick bottom rubber cover, RMA grade 2.

1 - Item of Flexco clamps and tools.

Conveyor Intermediate Frame

425 - Lineal feet of welded steel box truss frame, 42" deep, on A-Frame type supports on 50 foot centers, without decking. 66" deep welded steel box truss frame will be employed where spans in excess of 50 feet are required.

425 - Lineal feet of 2'-0" wide walkway on one side including handrails, mid rails, toe guards and supports and expanded metal flooring.

Belt Housing

All exposed belt areas shall be totally covered with a belt housing consisting of covered sections supported on bands spaced at 4'-8" centers. Cover section shall be 20 gauge corrugated tunnel stock with extra heavy galvanizing. Cover section shall be able

to be raised for access to belt for inspection or repairs. Troughing idlers shall be greased by removing side panels. A length of chain shall be furnished to hold each section of cover in raised position.

(F). One - 36" wide x 800' long belt conveyor with about 800' horizontal centers and lift of approximately 7' at head, handling, when continuously and uniformly loaded, 1200 MTPH of ore concentrate weighing 125-175 lbs./cu.ft. at a belt speed of 450 FPM. The conveyor will be designed to handle material that consists of lumps mixed with fines with a maximum lump size of 1".

Drive Terminal

1 - 60 N.P. head end drive terminal with 30" diameter x 38" face, welded steel, drive pulley with vulcanized rubber lagging; shafting mounted on roller bearing pillow blocks.

1 - 18" diameter x 38" face, welded steel, snub pulley.

1 - Structural steel frame with nip guards.

1 - Shaft mounted torque arm speed reducer with motor mounted V-belt drive with guard from motor to reducer.

1 - 60 N.P. 1800 RPM, TEFC normal torque motor for 460 volts, 3 phase, 60 hertz current.

Tail Terminal

1 - Fixed tail terminal with 20" diameter x 38" face, welded bearing pillow blocks.

1 - Structural steel tail frame with nip guards.

Horizontal Gravity Take-Up

1 - Horizontal gravity take-up located near the drive with 24" diameter x 38" face, welded steel, take-up pulley with 2 - 20" diameter x 38" face bend pulleys.

1 - Take-up carriage with carriage tracks providing 36" of carriage movement, carriage track safety fencing, pull back sheaves and wire rope with fittings.

1 - Counterweight tower with safety fencing and steel counterweight box.

Conveyor Idlers

All idlers shall have 5" diameter rolls, 3/4" diameter shafts and roller bearings, Barber-Greene Series R, or equal, conforming to CEMA Class C.

Return idlers shall have 5" diameter rolls, 3/4" diameter shafts and roller bearings, Barber-Greene Series R, or equal, conforming to CEMA Class C.

Conveyor Belt

1637 - Lineal feet of 36" wide conveyor belt with 3/16" thick rubber cover and 1/16" thick bottom rubber cover, RMA grade 2.

1 - Item of Flexco clamps and tools.

Conveyor Intermediate Frame

800 - Lineal feet of welded steel box truss frame, 42" deep, on A-frame type supports on 50 foot centers,

without decking. 66" deep welded steel box truss frame will be employed where spans in excess of 50 feet are required.

800 - Lineal feet of 1'-0" wide walkway on one side including handrails, mid rails, toe guards and supports and expanded metal flooring.

Belt Housing

All exposed belt areas shall be totally covered with a belt housing consisting of covered sections supported on bands spaced at 4'-8" centers. Cover section shall be 20 gauge corrugated tunnel stock with extra heavy galvanizing. Cover section shall be able to be raised for access to belt for inspection or repairs. Troughing idlers shall be greased by removing side panels. A length of chain shall be furnished to hold each section of cover in raised position.

(G). Dust Collectors

Discharge points of the Callao Bulk Concentrate Handling System will be totally enclosed for a sufficient distance to allow for material being transported to completely settle down. Dust hoods will mount on discharge hoods and be equipped with a fan that creates a draft that pulls the dust along in the direction of the material flow.

OUTLINE SPECIFICATION

36" x 125' ADJUSTABLE HEIGHT PORTABLE CONVEYOR

TO HANDLE 1200 MTPH OF ORE CONCENTRATES AT CALLAO

36" x 125' portable conveyor (Barber-Greene PK 125 or equal) complete with guarded v-belt drive from 75 H.P., 1800 RPM, TEFC motor for 3 phase, 60 hertz, 460 volt power to shaft mounted reducer, lagged drive pulley, nip guards, roller bearing pillow blocks, belt scraper, backstop, screw take-up at tail end at drive snub, 36" deep Warren type truss with self-shedding decking, tail and pivot, 5" diameter, 35° roller bearing idlers conforming to CEMA Class A specifications, hydraulic powered push arm cylinder with 7-1/2 H.P. motor raising and lowering conveyor; conveyor belting selected on the basis of maximum operating belt tension with 3/16" top and 1/16" bottom Grade 2 rubber covers; swivel wheel frame with 2 pneumatic tires; belt housing with removable side panels to prevent material from blowing off the belt; hinged head and tail sections to fold the conveyor for transporting.

Approximate weight: 50,000 lbs.

PORTABLE CONVEYOR - 36" x 31'-0" LONG AT CALLAO

Conveyor boom to be placed on the deck of ships to load ore concentrates delivered to it by an adjustable height portable conveyor complete with a 15 H.P. low profile head end drive with 15 H.P., 1800 RPM TEFC motor for 3 phase, 60 hertz, 460 volt power connected to a shaft mounted torque arm reducer through a guarded v-belt drive; loading hopper; belt housing with removable side panels; 5" diameter 35° roller bearing idlers (Barber-Greene or equal) conforming to CEMA Class C specifications, belt selected on the basis of maximum operating belt tension, with 3/16" thick top and 1/16" thick bottom Grade 2 rubber covers; lifting bales to move the conveyor and tail end bolster to bolt the tail end to the ship's deck.

Approximate weight: 8,000 lbs.

EQUIPMENT

OUTLINE SPECIFICATION

MATARANI BULK CONCENTRATE HANDLING SYSTEM

(A) One - 36" wide x 1100' Reclaim long belt conveyor horizontal for approximately 850' with about 1100' horizontal centers and a lift of approximately 22' at head, handling, when continuously and uniformly loaded, 1200 MTPH of ore concentrates weighing 125 - 175 lbs/cu.ft. at a belt speed of 450 FPM. The conveyor will be designed to handle material that consists of lumps mixed with fines with a maximum lump size of 1". The Reclaim conveyor will be located in an underground gallery fed by a series of underground hoppers, rising above ground to discharge onto the existing 36" wide ENAPU conveyor to the Port of Matarani as shown on schematic equipment drawings in report, MAGUIRE Figure 23.

Drive Terminal

1 - 125 H.P. head end drive terminal with 30" diameter x 38" face, welded steel, drive pulley with vulcanized rubber lagging; shafting mounted on roller bearing pillow blocks.

1 - 18" diameter x 38" face, welded, snub pulley.

1 - Structural steel frame with nip guards.

1 - Shaft mounted torque arm speed reducer with motor mount V-belt drive with guard from motor to reducer.

Tail Terminal

1 - Fixed tail terminal with 20" diameter x 38" face, welded steel, pulley shafting mounted on roller bearing pillow blocks.

1 - Structural steel tail frame with nip guards.

Vertical Gravity Take-Up

1 - Vertical gravity take-up located near the drive with 24" diameter x 38" face, welded steel, take-up pulley with 2-20" diameter x 38" face bend pulleys.

1 - Take-Up carriage with carriage tracks providing 36" of carriage movement, carriage track safety fencing, pull back sheaves and wire and rope with fittings.

1 - Counterweight tower with safety fencing and steel counterweight box.

Conveyor Idlers

All idlers shall be 5" diameter rolls, Barber-Greene Series R, or equal, 3/4" diameter shafts and roller bearings, conforming to CEMA Class C. Return idlers shall be 5" diameter rolls, Barber-Greene Series R, or equal, 3/4" diameter shafts and roller bearings, conforming to CEMA Class C.

Conveyor Belt

2250 - Lineal feet of 36" wide conveyor belt with 3/16" thick top rubber cover and 1/16" thick bottom rubber cover, RMA grade 2.

1 - Item of Flexo clamps and tools.

Conveyor Intermediate Frame

150 - Lineal feet of welded steel truss frame 42" deep without decking.

100 - Lineal feet of welded steel truss frame 66" deep without decking.

250 - Lineal feet of 2'-0" wide walkway on one side including handrails, midrails, toe guards and supports and expanded metal flooring.

850 - Lineal feet of 7" channel frame without decking, cross members and supporting legs 3 feet high.

Belt Housing

All exposed belt areas exposed to the environment shall be totally covered with a belt housing consisting of covered sections supported on bands spaced at 4'-8" centers. Cover sections shall be 10 gauge corrugated tunnel stock with extra heavy galvanizing. Cover sections shall be able to be raised for access to belt for inspection or repairs. Troughing idlers shall be greased by removing side panels. A length of chain shall be furnished to hold each section of cover in raised position.

Reclaim Hoppers

16 - Underground feed hoppers to reclaim the materials onto the underground conveyor. Hoppers to be designed to feed material onto belt traveling at a rate of 450 FPM. Hoppers to be fed outside of storage building in open storage area by front end loading equipment.

(B). One - 24" wide x 230' long tripper conveyor with a power propelled tripper with a two-way chute to be supported by the structural system of the covered concentrate storage building, with about 230' horizontal centers and a lift of approximately 7' of head, ha-dling, when continuously and uniformly loaded, 1000 MTPH of copper concentrates at a belt speed of 450 FPM.

Drive Terminal

1 - 20 H.P. head end drive terminal with 24" diameter x 26" face, welded steel, drive pulley with vulcanized rubber lagging; shafting mounted on roller bearing pillow blocks.

1 - 18" diameter x 26" face, welded steel, snub pulley.

1 - Structural steel frame with nip guards.

1 - Shaft mounted torque arm speed reducer with motor mount V-belt drive with guard from motor to reducer.

1 - 20 H.P. 1800 RPM, TEFC normal torque motor for 460 volts, 3 phase, 60 hertz current.

Tail Terminal

1 - Fixed tail terminal with 20" diameter x 26" face, welded steel, pulley shafting mounted on roller bearing pillow blocks.

1 - Structural steel tail frame with nip guards.

Horizontal Gravity Take-Up

1 - Horizontal gravity take-up located at the tail pulley on a sliding frame.

1 - Take-up carriage with carriage tracks providing 36" of carriage movement, carriage track safety fencing, pull back sheaves and wire rope with fittings.

1 - Counterweight with safety fencing.

Tripper

1 - Tripper with 20" diameter discharge pulley and 20" diameter snub pulley with a 7' lift, and will be mounted on rails and have four single flange wheels with a 3 N.P. drive and right angle discharge.

Conveyor Idlers

All idlers shall be 6" diameter rolls, Barber-Greene Series R, or equal, 3/4" diameter shafts and roller bearings, conforming to CEMA Class C.

Return idlers shall be 5" diameter rolls, Barber-Greene Series R, or equal, 3/4" diameter shafts and roller bearing, conforming to CEMA Class C.

Conveyor Belt

475 - Lineal feet of 24" wide conveyor belt with

3/16" thick top rubber cover and 1/16" thick bottom rubber cover, RMA Grade 2,

Conveyor Intermediate Frame

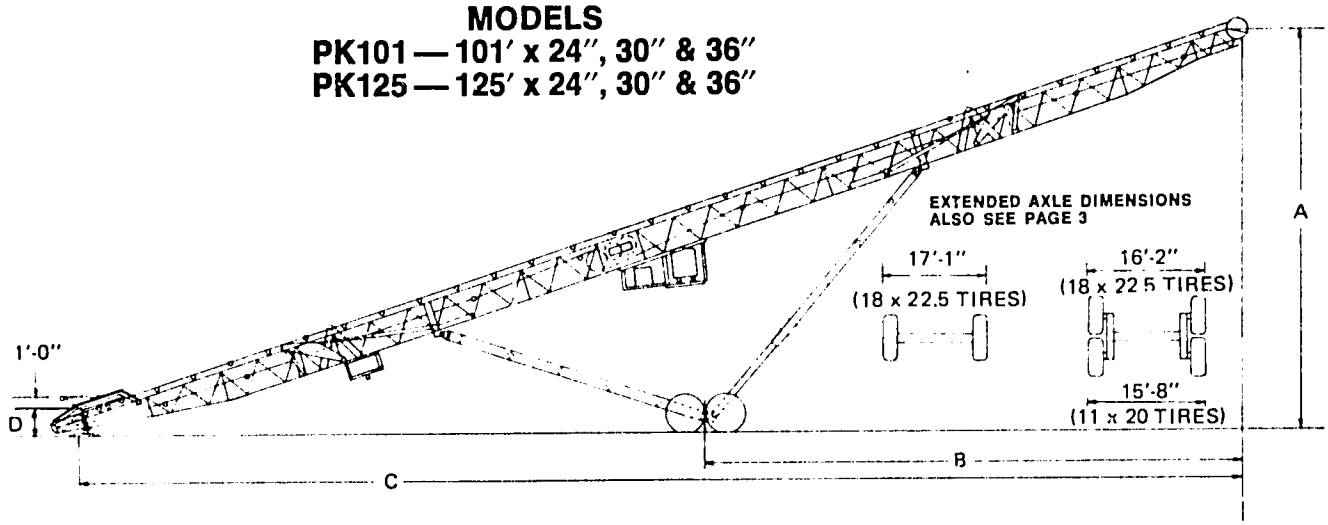
230 - Lineal feet of welded steel frame 24" deep without decking.

230 - Lineal feet of 2'-0" wide walkway on one side including handrails, mid rails, toe guards and supports and expanded metal flooring.

MODEL PK 100 SERIES PORTABLE CONVEYOR WITH DYNA-FOLD™

ELECTRIC, GAS, or DIESEL DRIVE

MODELS
PK101 — 101′ x 24″, 30″ & 36″
PK125 — 125′ x 24″, 30″ & 36″



Dimensions—Operating

Belt Width	Conveyor Length	Dimension A			Dimension B			Dimension C			Dimension D @ 18°
		Min. (10°)	18°	Max. (20°)	Min. (10°)	18°	Max. (20°)	Min. (10°)	18°	Max. (20°)	
24″	101′	18′-7″	32′-3″	35′-11″	45′-5″	43′-10″	43′-8″	99′-0″	96′-3″	94′-11″	2′-9″
	125′	22′-10″	39′-6″	44′-2″	56′-8″	54′-11″	54′-6″	122′-4″	119′-0″	117′-6″	2′-9″
30″	101′	18′-7″	32′-3″	35′-11″	45′-5″	43′-10″	43′-8″	99′-0″	96′-3″	94′-11″	2′-10″
	125′	22′-10″	39′-6″	44′-2″	56′-8″	54′-11″	54′-6″	122′-4″	119′-0″	117′-6″	2′-10″
36″	101′	18′-7″	32′-3″	35′-11″	45′-5″	43′-10″	43′-8″	99′-0″	96′-3″	94′-11″	2′-11″
	125′	22′-10″	39′-6″	44′-2″	56′-8″	54′-11″	54′-6″	122′-4″	119′-0″	117′-6″	2′-11″

HORSEPOWER AND CAPACITY (T.P.H.) SELECTION TABLE

Belt Width	Electric H.P.	101′-0″		125′-0″	
		300 F.P.M.	450 F.P.M.	300 F.P.M.	450 F.P.M.
24″	15	310	285	250	230
	20	365	400	345	325
	25		520		425
	30				520
30″	20	415	385	340	310
	25	535	505	435	410
	30	600	625	535	510
	40		865	600	705
	50				900
36″	25	525	495	430	400
	30	645	610	525	495
	40	885	850	720	690
	50		1090		885
	60		1330		1080

Capacities are based on continuously and uniformly fed material weighing 100 lbs./cu. ft. (2000#/Ton) on 35° idlers and conveyor at 18° incline, with 3 phase, 60 Hertz current.

GENERAL SPECIFICATIONS COMMON TO GAS, DIESEL AND ELECTRIC DRIVE

HEAD END: 5'-0" long all-welded construction with flat decking welded in place. 16" or 24" diameter crowned face steel pulley with high strength steel shaft and anti-friction bearings. Factory assembled.

FOOT END: 7'-6" long, all-welded construction with solid plate sides and flat decking. 12" diameter crowned face steel pulley with high strength steel shaft and anti-friction take-up bearings. Factory assembled. Acme thread take-up bolts allow 18" adjustment and are easily accessible. Self-relieving loading hopper has rubber flashing held in place by means of a clamp arrangement for easy adjustment. Hopper is hinged to swing 180° when the truss is folded. Dust cover encloses and protects tail pulley from material buildup.

WRAP DRIVE: Wrap drive includes torque arm gear reducer, backstop, 16" or 24" diameter drive pulley with ¼ inch "Rough Top" Rubber lagging and a 16" or 20" diameter snub pulley with 18" available belt take-up.

PULLEY DIAMETERS

Electric H.P.	Head Pulley Diameter	Drive Pulley Diameter	Snub Pulley Diameter	Tail Pulley Diameter
15, 20, 25 HP	16"	16"	16"	12"
30, 40, 50, 60 HP	24"	24"	20"	12"

WHEEL TRUCK: Heavy V-type truck has heavy-duty tubular designed axle and push arms and removable swivel spindles with 10-bolt Budd wheels.

AXLE: Both single axle and tandem beam axle are available. Tandem beam axle is required for travel speeds over 5 MPH. For operation, axle telescopes out 2'-2" on each side.

HOIST: Hydraulic cylinder is pinned at axle for raising conveyor boom. Mechanical lock holds boom in fixed position during operation. Hydraulic cylinder is powered by pump which is driven either from the engine or by 7½ HP motor on electric machines.

TRUSS: 36" deep Warren type heavy-duty all welded truss, with 18 gauge self-shedding decking welded in place to protect the return run of the belt. Joint frames are welded to the truss for additional rigidity. Corbels for wheel truck are welded in place at the factory. Two adjustable support legs are optionally available to support truss after tractor has disconnected from fifth wheel.

FOLD: Truss is hinged at both head and tail ends for either manual or hydraulic (optional) fold. With hydraulic fold, two hydraulic cylinders operate at each hinge point. Valves controlling the cylinders are located for access from the ground.

TOWING: Lifting eyes are provided at the tail end as standard equipment for in plant moving. Fifth wheel is available as an option.

BELT: Multiple ply construction, synthetic fabric carcass. Tensile strength of covers is 2500-3000 psi. Friction pull between plies is 16-19 pounds per inch.

IDLERS: Barber-Greene Series Q ball bearing 35° troughing idlers and return rolls. Idlers have ¾" diameter through shafts in 4" diameter heavy gauge steel rolls. Multipass labyrinth grease seals include powdered metal shield nut, zero clearance face seal, and Buna-N lip seal. Carrier stand is all steel, welded construction with self-shedding base angle. All troughing and return idlers are factory installed.

TIRE CHART

Size	Single Axle Tires	Tandem Axle Tires	Tandem Axle (Optional) Tires
24" x 101'	18:00 x 22.5 16 Ply	11:00 x 20 12 Ply	18:00 x 22.5 16 Ply
30" x 101'	18:00 x 22.5 16 Ply	11:00 x 20 14 Ply	18:00 x 22.5 16 Ply
36" x 101'	18:00 x 22.5 16 Ply	11:00 x 20 14 Ply	18:00 x 22.5 16 Ply
24" x 125'	18:00 x 22.5 16 Ply	11:00 x 20 14 Ply	18:00 x 22.5 16 Ply
30" x 125'	18:00 x 22.5 16 Ply	18:00 x 22.5 16 Ply	N.A.
36" x 125'	18:00 x 22.5 16 Ply	18:00 x 22.5 16 Ply	N.A.

ELECTRIC DRIVE

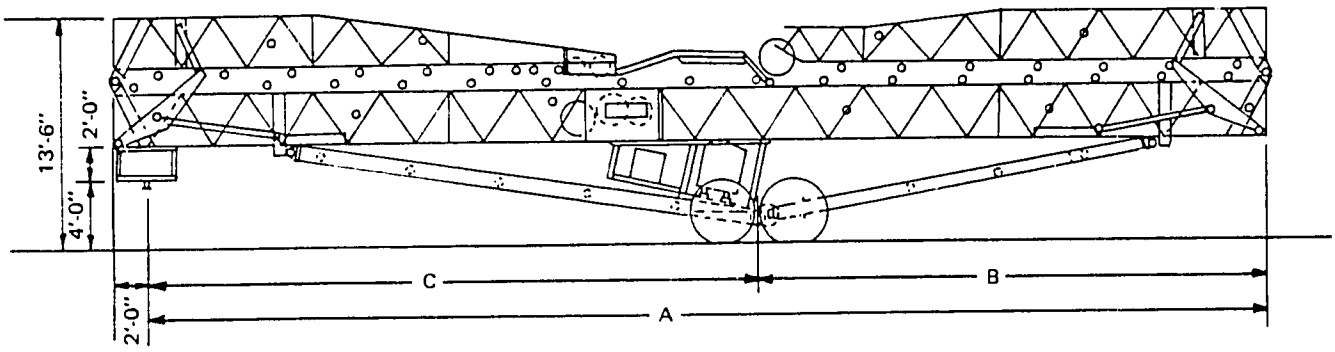
POWER UNIT: 15, 20, 25, 30, 40, 50, or 60 H.P. electric motor, depending on belt width, length and capacity required. Motor is mounted below wrap drive section. Open drip-proof or totally enclosed, fan cooled available. Motors are 3 phase, 60 hertz, 460 volt.

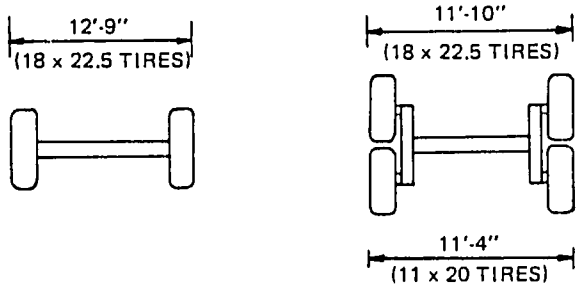
GAS OR DIESEL DRIVE

POWER UNIT: All engines include power takeoff clutch, electric start, battery, battery box, cables, fuel tank, air cleaner, muffler and instrument panel.

ENGINE SELECTION:	REPLACES THESE ELECTRIC MOTORS — See Capacity Chart
GAS ENGINES:	
Wisconsin VH4DU, 28 H.P.	15, 20
Wisconsin VG4DU, 37 H.P.	25
White G1600, 62 H.P.	30, 40
White G2300, 84 H.P.	50, 60
DIESEL ENGINES:	
Deutz F2L912	15, 20
Deutz F3L912	25, 30, 40
Deutz F4L912	50
White D2300, 72 H.P.	15, 20, 25, 30, 40, 50, 60
General Motors 3-53, 78 H.P.	40, 50, 60

TOWING DIMENSIONS





DIMENSIONS

Conveyor Length	Dimension A	Dimension B	Dimension C
101'	54'-6"	26'-1"	28'-5"
125'	66'-6"	30'-3"	36'-3"

ACCESSORIES

Belt Scraper
Self-cleaning tail pulleys
Radial Receiving Hopper
Tail End Bolster Unit
5" diameter impact idlers
3 Ply Belt
Power Propelling
High Flotation Tires
Electric Motor Controls
Hydraulic Boom Fold
(Head and Tail Ends)
Fifth Wheel

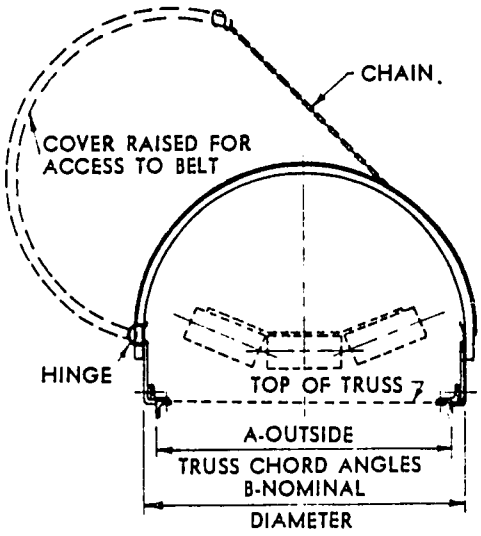
Tandem Axle
Totally enclosed fan cooled motors
Engine access platform and ladder
Truss support legs

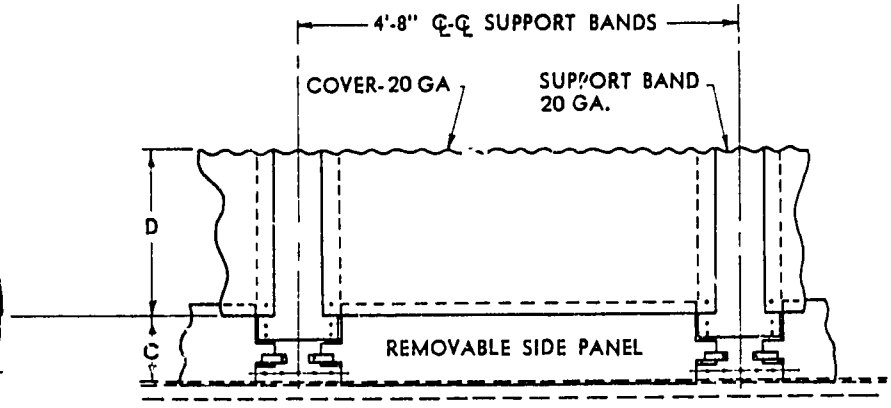
HIGHWAY TOWING KIT (Required to meet Government Standards for movement on Public Roadways).

1. Lights—Brake, Tail, Clearance and Turn Signals.
2. Fenders and Mud Flaps.
3. Brakes—Air over Hydraulic.

TYPE M3 BELT HOUSING

(WITH REMOVABLE SIDE PANELS)





SPECIFICATIONS

The B-G belt housing consists of cover sections supported on bands spaced at 4'-8" centers. The total length of housing should be in multiples of 4'-8". The number of support bands required is always one more than cover sections. If total required length is not exactly in 4'-8" multiples, one cover section can be cut in the field to a shorter length as required.

Top of removable side panels slip under the cover section. Each side panel is furnished with a projection on each end that is supported on a key stock mounted on the support plate. A latch also mounted on the support plate folds down and locks the side panels in position.

Cover sections are 20 gauge corrugated tunnel stock with extra heavy galvanizing. Support bands are 20 gauge. Adjustable supporting clips bolt to top chord angles of either 24" or 42" truss without interfering with troughing idlers. Cover sections can be raised for access to belt for inspection or repairs. Troughing idlers can be greased by removing side panel. All clips and bolts furnished. Two lengths of chain furnished with each order for holding raised cover in place.

HOUSING NO.	BELT WIDTH	DIMENSIONS			
		A	B	C	D
M3-18	18"	2'- 5½"	2'-8¾"	10¼"	1'- 4½"
24	24"	2'-11½"	3'-2¾"	11"	1'- 7½"
30	30"	3'- 5½"	3'-8¾"	11¾"	1'-10½"
36	36"	3'-11½"	4'-2¾"	1'- 1⅛"	2'- 1½"
42	42"	4'- 5½"	4'-8¾"	1'- 1⅞"	2'- 4½"
48	48"	4'-11½"	5'-2¾"	1'- 3⅝"	2'- 7½"

ORDERING INSTRUCTIONS:

Housing includes covers, supports, side panels, clips, etc. In ordering, specify total length in feet in multiples of 4'-8" and conveyor belt width.

Catalog numbers indicate type of housing and width of belt.

EXAMPLE:

56'-0" of M3-24 (Belt housing for 24" belt).

Belt housing protects the belt from snow, ice, rain, sun and wind.

NOTE:

For complete enclosure of carrying belt, including flat decking, contact Aurora.

BARBER-GREENE®

With Barber-Greene's policy of constantly improving its products, specifications are subject to change without notice. Actual dimensions, clearances, weights, and other specifications may vary due to fabrication variables, options, or custom engineering.

APPENDIX F
Mobile Equipment Specifications

913

OUTLINE SPECIFICATION

FRONT END LOADER

Supply a front end loader diesel with a 3.0 cubic yard general purpose bucket, (struck capacity), suitable for handling minerals and concentrates with the following ratings:

Capacity, struck	Min. 3.0 yds.
Capacity, rated	Min. 3.5 yds.
Operating Wgt. W/ROPS	Min. 35,000#
Static Tipping Load, Straight	Min. 26,000#
Full Load	24,000#
Breakout Force	Min. 28,000#
Width	Min. 9'-6"

Additional features should include Rollover Protection (ROPS), fully hydraulic operation and four wheel breaking system.

The following options shall be available:

Capability of filling tires with a 75% CaCl solution with a net change in articulated static tipping load of a minimum of 4,000#.

Capability of adding a counterweight with a net change in articulated static tipping load of a minimum of 3,600#.

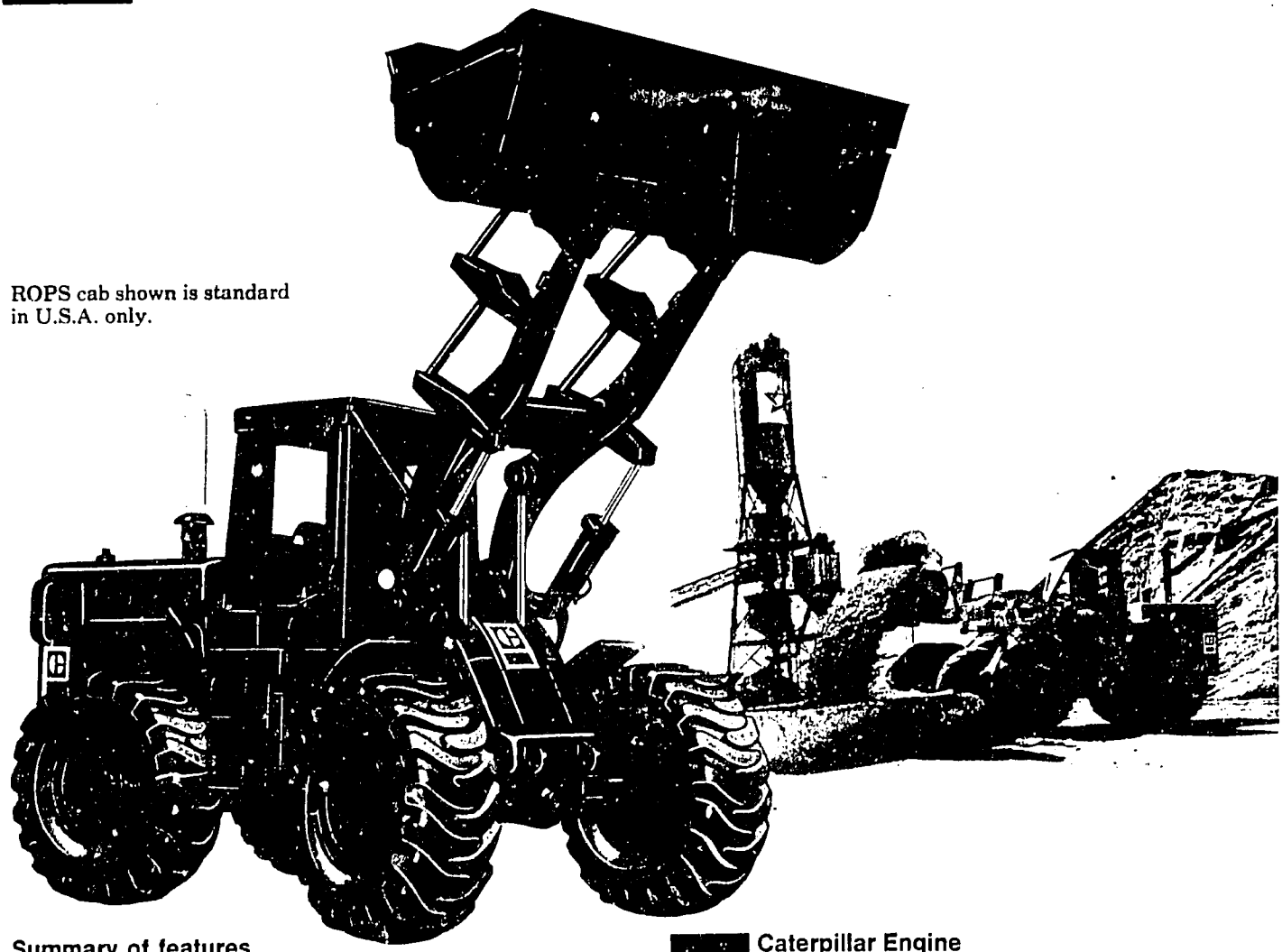
OUTLINE SPECIFICATION

FORK LIFT TRUCK

Supply a fork lift truck, diesel, with the following characteristics:

Rated Capacity @ 24" Load Center	8,000#
Top Travel Speed Loaded	14 mph
Carriage Lift Speed - Empty/ Loaded	100/95 FPM
Transmission Type	Power Shift-Two Speed
Weight	Min. 12,500
Outside Turning Radius	Min. 106"

CATERPILLAR



ROPS cab shown is standard in U.S.A. only.

Summary of features

- **Cat 3306 Engine** . . . with 638 cu. in. (10.5 litres) displacement.
- **Bucket options** . . . from 3.0 to 4.5 cu. yd. (2.29 to 3.44 m³).
- **Cat designed and manufactured power train** . . . for optimum match, performance and efficiency.
- **Planetary power shift transmission** shifts on-the-go . . . four speeds forward, four reverse . . . for greater operator efficiency and machine productivity.
- **Articulated frame steering** turns short . . . rear wheels track front for reduced rolling resistance and to help avoid road hazards.
- **Sealed loader linkage** eliminates daily maintenance on lift arms and bucket hinge pins.
- **Automatic bucket controls** kick out at pre-set dump height . . . bucket positioner automatically returns bucket to pre-set digging angle . . . no need for visual spotting.
- **CAT PLUS** . . . from your Caterpillar Dealer . . . the most comprehensive, total support system in the industry.

Caterpillar Engine

Flywheel horsepower @ 2200 RPM	170
Displacement	638 cu. in. (10.5 litres)

The net power at the flywheel of the vehicle engine operating under SAE standard ambient temperature and barometric conditions, 85° F. (29° C) and 29.38" Hg (995 mbar), using 35 API gravity fuel oil at 60° F. (15.6° C). Vehicle engine equipment includes blower fan, air cleaner, water pump, lubricating oil pump, fuel pump, muffler, air compressor and alternator. Engine will maintain specified power up to 10,000 ft. (3000 m) altitude.

Cat 4-stroke-cycle diesel Model 3306 with six cylinders, 4.75" (121 mm) bore, 6.0" (152 mm) stroke and 638 cu. in. (10.5 litres) displacement.

Precombustion chamber fuel system with individual adjustment-free injection pumps and valves.

Turbocharged. Stellite-faced valves, hard alloy steel seats, valve rotators.

Cam-ground and tapered aluminum alloy pistons with 3-ring design and cooled by oil spray. Steel-backed aluminum bearings, Hi-Electro hardened crankshaft journals. Pressure lubrication with full-flow filtered and cooled oil. Dry-type air cleaner with primary and safety elements.

Uses economical No. 2 fuel oil (ASTM Specification D396), often called No. 2 furnace or burner oil, with a minimum cetane rating of 35. Premium quality diesel fuel can be used but is not required.

Two 24-volt direct electric starting systems — standard or low temperature. Glow plugs for preheating precombustion chambers included with both.

966C

Wheel Loader

transmission

Full power shift in four forward and four reverse speeds. Provides on-the-go shifting for greater operator efficiency and machine productivity.

Single lever on left side of steering column controls both speed and direction. Rotate the handle for four speed ranges in each direction. Move the lever forward or back for directional change. A safety lever locks the transmission control in neutral.

Single-stage, single-phase torque converter.

Maximum speeds with 23.5-25, 12 PR (L-2) tires:

	1st	2nd	3rd	4th
Forward, MPH:	4.8	8.5	14.3	23.6
(km/h):	(7.7)	(13.7)	(23.0)	38.0)
Reverse, MPH:	5.7	10.2	17.0	28.0
(km/h):	(9.2)	(16.4)	(27.4)	(45.1)

axles

Front axle fixed. Rear axle oscillates ± 17°, total of 34°, for greater machine stability. One rear wheel can drop or rise a total of 24.8" (630 mm) with all wheels remaining on the ground for maximum traction. Free-floating axle shafts carry torque, not machine weight, for long life. Axle shafts can be removed independently of wheels and planetaries for servicing ease.

Conventional differentials. Torque-proportioning differentials, recommended for slippery underfoot conditions only, are optional.

final drives

All-wheel drive with planetary reduction in each wheel. Torque is developed at the wheel, putting less stress on axle shafts. Planetary units may be removed independently of wheels and brakes for servicing ease.

brakes

(System meets OSHA regulations.)

Service – Four-wheel, full-air-system actuating S-cam operated shoes. Fade-resistant, with smooth modulation. Two brake pedals; right pedal brakes only; left pedal brakes while neutralizing transmission.

Parking – Uses service brakes' spring-loaded, brake-chamber system.

Emergency – Spring-loaded brake chambers actuate brakes in case of air failure.

tires

Tubeless, nylon, loader-dozer design.

Choice of:

23.5-25, 12 PR (L-2) Traction
23.5-25, 12 PR (L-3) Rock
23.5-25, 16 PR (L-3) Rock
23.5-25, 20 PR (L-3) Rock
20.5-25, 12 PR (L-3) Rock

steering

Center-point frame articulation. Rear and front wheels track at all times, for greater operator efficiency, lower rolling resistance, reduced tire wear. Full hydraulic power with flow-amplified system. Full-flow filtering and oil cooled.

Minimum turning radius (over tires) (§)	20'9" (6320 mm)
Steering angle (each direction)	35°

Hydraulic system – Two 4.0" (102 mm) bore, double-acting cylinders powered by vane-type pump. Pump sized for excellent steering response at all engine speeds.

Output @ 1965 RPM with 1000 psi (69 bar)	40 gpm (151 litres/min)
Relief valve setting	2500 psi (172 bar)

bucket controls

Lift circuit – Positions: raise, hold, lower and float. Automatic kickout adjustable from horizontal to full lift height.

Tilt circuit – Positions: roll back, hold and dump. Automatic bucket positioner adjustable to desired loading angle.

No visual spotting required.

lift arms

Sealed pins in lift arms and bucket hinge points for longer pin and bushing life, lower maintenance costs. Grease once every 100 service meter units, except lower bucket hinge pins, which need grease every 50 SMU.

loader hydraulic system

Sealed with valves enclosed in reservoir to keep out dirt and other contaminants.

Pump output @ 1965 RPM and 1000 psi (69 bar), with SAE No. 10 oil @ 150° F. (66° C)	90 gpm (341 litres/min)
Relief valve setting	2200 psi (152 bar)
Cylinders (double-acting):	
Lift – bore and stroke	6.5" x 36.2" (165 x 920 mm)
Tilt – bore and stroke	6.0" x 19.0" (152 x 483 mm)

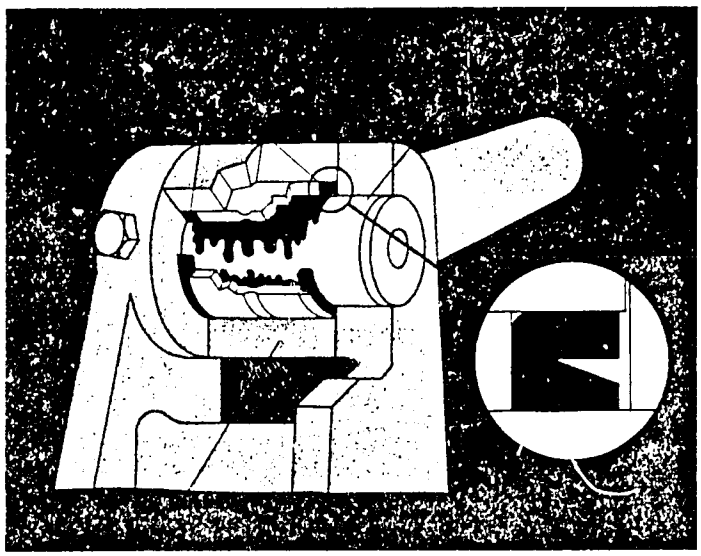
Hydraulic cycle time, rated load in bucket, in seconds (§):

Raise	Dump	Lower (empty, float down)	Total
6.2	1.6	3.8	11.6

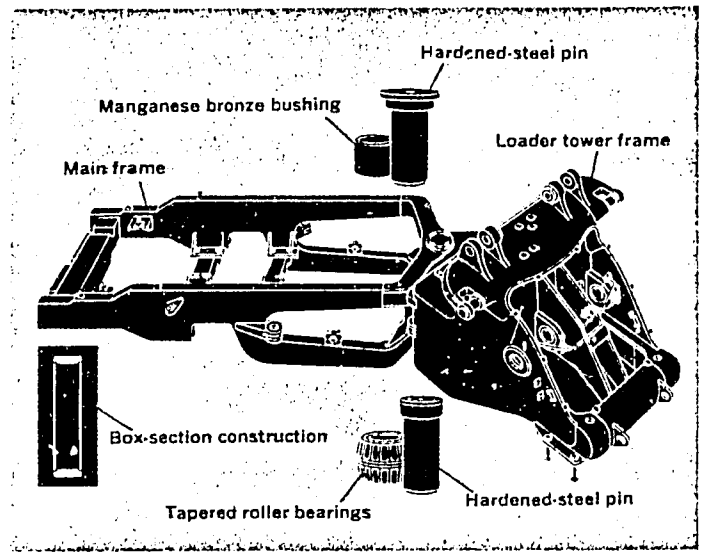
service refill capacities

	U.S. Gallons	(litres)
Cooling system	13.0	(49.2)
Crankcase	7.5	(28.4)
Transmission and torque converter	8.2	(31.0)
Differentials and final drives:		
Front	8.0	(30.3)
Rear	9.0	(34.1)
Hydraulic system	52	(197)
Hydraulic tank	27.0	(102)
Fuel tank	65	(246)

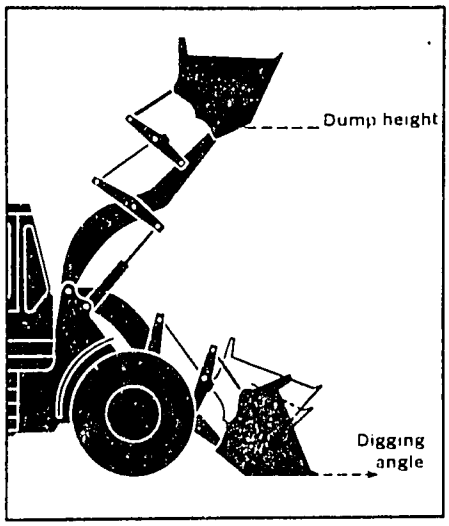
Specifications and ratings conform to all applicable standards recommended by the Society of Automotive Engineers. SAE Standard J732c (1969) and SAE Standard J742b (1969) govern loader ratings, denoted in the text by (§).



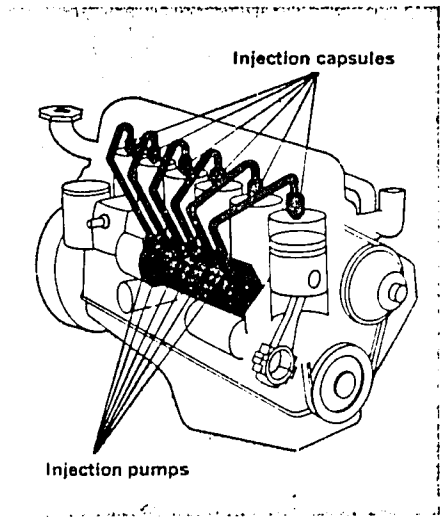
Sealed linkage reduces regular greasing of lift arm pivot points to once every 100 service meter units. (Lower bucket hinge pins need grease every 50 SMU.) Lip-type seals on each pin hold the lubricant in and hold out wear-causing grit. Pins and bushings last longer, and less time and money are spent for routine maintenance.



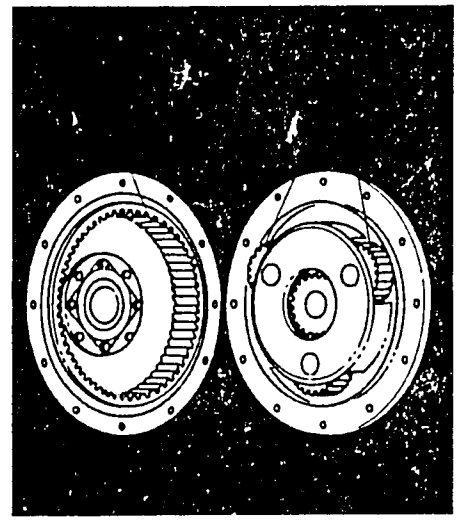
Box-section main frame and loader tower resist twisting and bending on rough ground. Two hardened-steel pins couple the front and rear frames. The bottom pin rides in double-tapered roller bearings; the upper, in a wide-contact manganese bronze bushing. Bucket lift arm pins and hydraulic cylinder mounting pins are supported on both ends by steel plates in the loader tower, rather than on a single side, as with cantilever mounting.



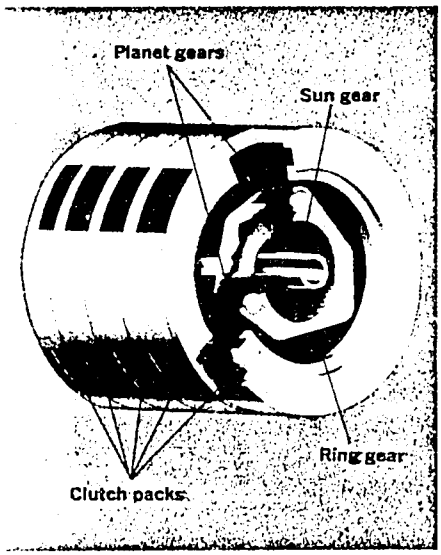
Automatic bucket controls let the operator concentrate on fast maneuvering. The lift lever automatically "holds," then kicks out to stop the hoisting action at a pre-set dump height. The tilt lever also holds when engaged, then kicks out when empty bucket returns to the desired digging angle. Both are adjustable and can be manually overriden.



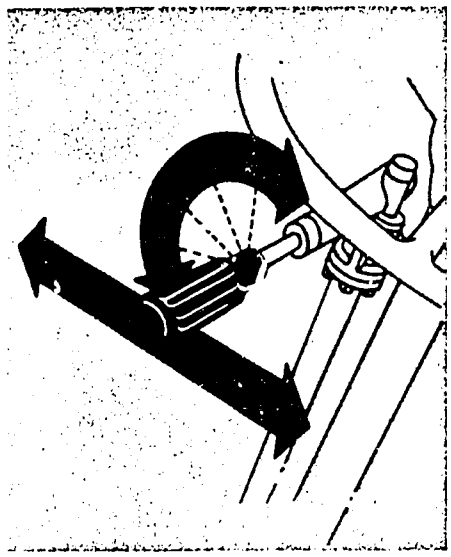
Cat 3306 Diesel Engine . . . with 638 cu. in. (10.5 litres) displacement . . . delivers reliable power to keep your job moving. The adjustment-free fuel system has individual fuel injection pumps and valves to meter fuel precisely for efficient performance. Turbocharging packs more air into cylinders for more complete combustion, more power. Camground and tapered aluminum alloy pistons expand during the heat of combustion to fit snugly in the cylinders for smooth, even power flow.



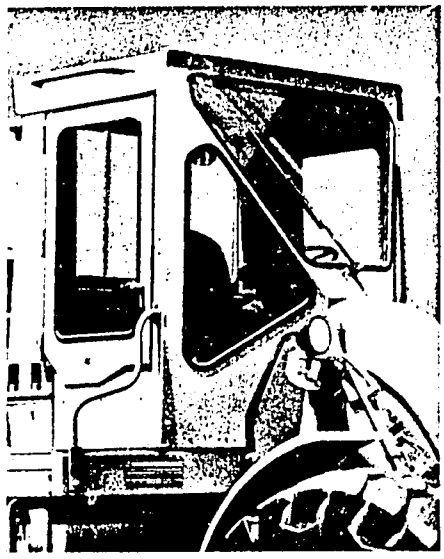
High-reduction planetary final drives multiply torque at the wheels through rugged gear sets. They reduce torque loads on axles and drive shaft for longer component life. Wheels, axles and final drives remove independently for fast servicing.



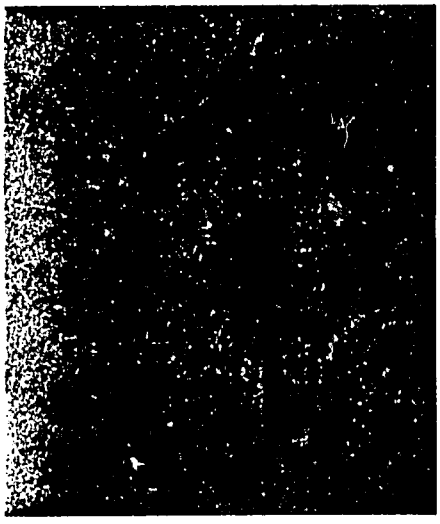
Planetary power shift transmission is designed for tough work . . . with big clutch packs. Hydraulic modulation cushions clutch engagement for full-power, on-the-go shifting. Planet gears spaced 120° apart spread out stresses for longer life. Oil cooling and lubrication reduce heat and wearing friction.



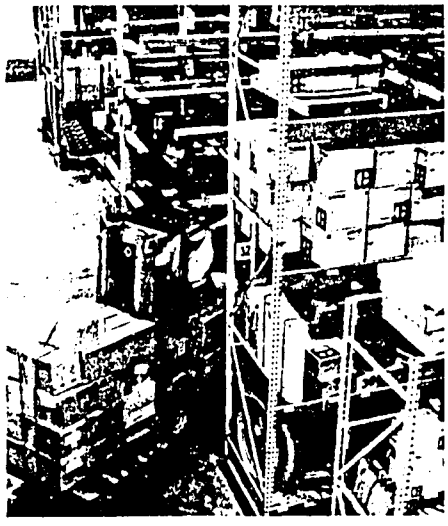
A single lever on the steering column controls both speed and direction. Rotate it to select four speeds forward and four in reverse . . . move it forward or back for directional change. It's simple, convenient and quick.



ROPS cab (standard in U.S.A.) offers operator protection, plus comfort and convenience. It gives excellent visibility, both front and rear, and includes windshield washer and wiper and seat belt. Optional sound suppression, suspension seat and Cat air conditioner/heater/defroster add to operator comfort, encourage maximum production.

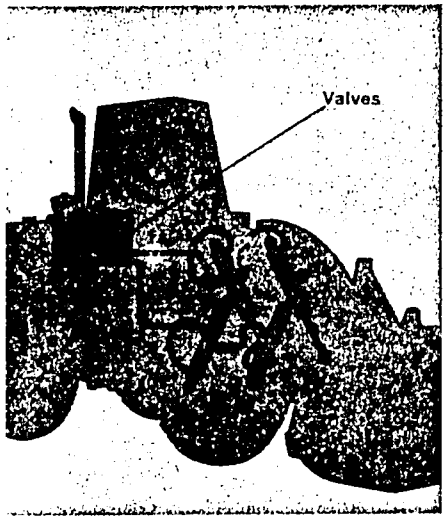


35° articulated steering provides quick, efficient maneuvering. The 966C can load, maneuver and dump in less than two machine lengths. With exact center-point articulation, the front and rear wheels always track, reducing tire wear and rolling resistance.



CAT PLUS – the most comprehensive, total product support system in the industry – comes with every 966C Wheel Loader. Your Caterpillar Dealer provides product application counseling and flexible finance planning before you buy, and these services after:

- Planned inspection programs.
- Preventive maintenance programs.
- Parts support.
- Parts Exchange Service.
- In-field service.
- Machine customizing services.
- Complete range of technical assistance.
- Personnel training for operators and mechanics.
- Cat Care seminars.



Sealed hydraulics keep out dirt and grime that can damage hydraulic components. There are no breathers to let in contaminants.

CAT PLUS ™

Operating Specifications

Bucket Type Capacity, Rated (§) (nominal heaped)	General Purpose 3.5 cu. yd. (2.68 m³)	General Purpose 4.0 cu. yd. (3.06 m³)	General Purpose 4.5 cu. yd. (3.44 m³)	Rock 3.5 cu. yd. (2.68 m³)	General Purpose 3.0 cu. yd. (2.29 m³)	Side Dump 3.0 cu. yd. (2.29 m³)
Capacity, struck (§)	3.04 cu. yd. (2.32 m³)	3.43 cu. yd. (2.62 m³)	3.89 cu. yd. (2.97 m³)	—	2.56 cu. yd. (1.96 m³)	—
Cutting edge, type	Straight	Straight	Straight	Modified V	Straight	Straight
Width (§)	115″ (2920 mm)	115″ (2920 mm)	115″ (2920 mm)	113″ (2870 mm)	113″ (2870 mm)	127″ (3230 mm)
Dump clearance @ full lift and 45° discharge (§)	9′10″ (3000 mm)	9′8″ (2950 mm)	9′5″ (2870 mm)	9′3″ (2820 mm)	9′0″ (2740 mm)	9′7″ (2920 mm)
Side Dump clearance	—	—	—	—	—	12′1″ (3680 mm)
Reach @ 45° discharge angle, 7′0″ (2130 mm) clearance (§)	4′6″ (1370 mm)	4′8″ (1420 mm)	4′9″ (1450 mm)	4′10″ (1470 mm)	4′3″ (1300 mm)	4′8″ (1420 mm)
Reach @ full lift and 45° discharge (§)	31.0″ (790 mm)	34.0″ (860 mm)	36.0″ (910 mm)	39.0″ (990 mm)	33.0″ (840 mm)	34.0″ (860 mm)
Digging depth (§)	2.0″ (51 mm)	2.0″ (51 mm)	2.0″ (51 mm)	2.0″ (51 mm)	8.2″ (208 mm)	1.9″ (48 mm)
Overall length (§)	22′5″ (6830 mm)	22′6″ (6860 mm)	23′0″ (7010 mm)	23′3″ (7090 mm)	23′1″ (7040 mm)	22′9″ (6930 mm)
Overall height (§)	17′7″ (5360 mm)	17′9″ (5410 mm)	18′2″ (5540 mm)	18′2″ (5540 mm)	17′8″ (5380 mm)	17′7″ (5360 mm)
Loader clearance circle (bucket in carry position (§)	44′4″ (13.5 m)	44′6″ (13.6 m)	44′8″ (13.6 m)	44′6″ (13.6 m)	44′8″ (13.6 m)	45′4″ (13.8 m)
Static tipping load ** Straight (§)	28,170 lb. (12 770 kg)	27,930 lb. (12 660 kg)	27,670 lb. (12 550 kg)	27,650 lb. (12 540 kg)	22,910 lb. (10 390 kg)	26,220 lb. (11 890 kg)
Full 35° turn (§)	25,900 lb. (11 740 kg)	25,670 lb. (11 640 kg)	25,420 lb. (11 530 kg)	25,390 lb. (11 510 kg)	20,930 lb. (9490 kg)	24,070 lb. (10 910 kg)
Breakout force * (§)	28,150 lb. (12 770 kg)	25,900 lb. (11 750 kg)	23,660 lb. (10 730 kg)	22,300 lb. (10 120 kg)	23,450 lb. (10 640 kg)	25,190 lb. (11 430 kg)
Operating weight **	36,900 lb. (16 740 kg)	37,100 lb. (16 830 kg)	37,300 lb. (16 920 kg)	37,300 lb. (16 920 kg)	38,400 lb. (17 420 kg)	37,400 lb. (16 960 kg)

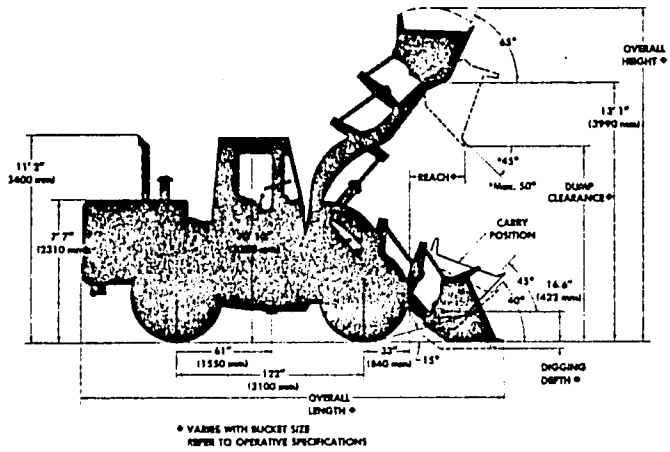
*Measured 4″ (102 mm) behind tip of cutting edge with bucket hinge pin as pivot point, in accordance with SAE J732c (1969).
**Static tipping load and operating weight include lubricants, coolant, full fuel tank, 23.5-25, 12 PR (L-2) tires, ROPS cab and operator. Machine stability is affected by tire size, tire ballast and attachments. For selected items, add the following to machine operating weight and static tipping load:

	Change in Operating Weight	Change in Articulated Static Tipping Load
20.5-25, 12 PR (L-3) tires	–620 lb. (–281 kg)	–489 lb. (–222 kg)
20.5-25, 12 PR (L-3) tires with 75% $CaCl_2$	1,200 lb. (540 kg)	2,130 lb. (960 kg)
23.5-25, 12 PR (L-3) tires	480 lb. (217 kg)	381 lb. (172 kg)
23.5-25, 12 PR (L-3) tires with 75% $CaCl_2$	3,050 lb. (1380 kg)	4,190 lb. (1900 kg)
23.5-25, 12 PR (L-2) tires with 75% $CaCl_2$	2,580 lb. (1170 kg)	4,090 lb. (1850 kg)
23.5-25, 16 PR (L-3) tires	600 lb. (272 kg)	470 lb. (213 kg)
23.5-25, 16 PR (L-3) tires with 75% $CaCl_2$	3,170 lb. (1430 kg)	4,190 lb. (1900 kg)
23.5-25, 20 PR (L-3) tires	730 lb. (331 kg)	580 lb. (263 kg)
23.5-25, 20 PR (L-3) tires with 75% $CaCl_2$	3,300 lb. (1490 kg)	4,290 lb. (1940 kg)
Counterweight	950 lb. (431 kg)	1,800 lb. (810 kg)
Counterweight	1,850 lb. (830 kg)	3,670 lb. (1660 kg)
Without ROPS cab, with brackets	–1,340 lb. (–610 kg)	–1,670 lb. (–760 kg)
Canopy, ROPS	–375 lb. (–170 kg)	–483 lb. (–219 kg)

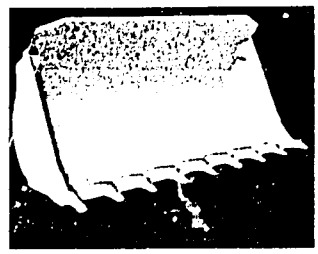
dimensions (approximate) (§)

	20.5-25 Tires
Tread width	85″ (2160 mm)
Width over tires	106″ (2690 mm)
Ground clearance	15.6″ (396 mm)
Decrease in vertical dimensions	2.0″ (51 mm)

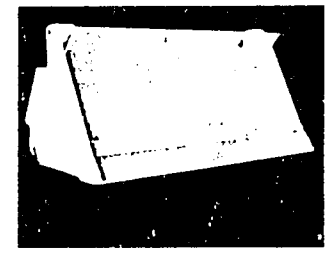
	23.5-25 Tires
Tread width	85″ (2160 mm)
Width over tires	109″ (2770 mm)
Ground clearance	17.6″ (447 mm)
Decrease in vertical dimensions	None



General Purpose Buckets, used for most applications, are available in three sizes – 3.5 cu. yd. (2.69 m³), 4.0 cu. yd. (3.06 m³) and 4.5 cu. yd. (3.44 m³). Bolt-on teeth or bolt-on cutting edges are optional. A 4.0 cu. yd. (3.10 m³) bucket with nine weld-on teeth (including corner teeth) is also available. Teeth are flush with the bucket bottom, so material flows into – not under – the bucket. Corner tooth design improves bucket penetration, reduces corner wear and extends cutting edge life.

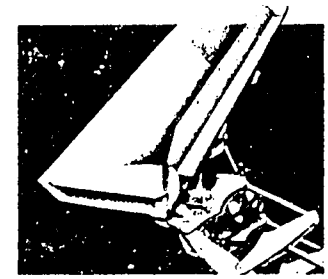


Rock Bucket is made from heat-treated steel. Bottom has replaceable wear bars with high abrasive resistance for longer life. Modified V edge aids penetration. Can be equipped with six optional teeth.



Multi - Purpose Bucket bulldozes, strips top soil, cleans up debris, etc. Additional hydraulic valve required. Optional teeth aid digging.

Side Dump Bucket dumps forward or to the left. Reduces turning, aids close-quarter loading. Additional hydraulic valve required.



standard equipment

Alternator, 19 amp.
Blower fan.
Fuel priming pump.
Muffler.
Electric starting.
Hydraulic steering.
Power shift transmission.
Torque converter.
Fenders.
Lighting system.
Dry-type air cleaner.
Adjustable seat.
ROPS cab (U.S.A. only).
Seat belt.
Warning horn.
Gauges and indicators:
Engine water temperature.
Ammeter.
Engine oil pressure.
Torque converter oil temperature.
Fuel pressure.
Low brake pressure.
Parking brake.
Hour meter.

optional equipment

(with approximate installed weights)

Air conditioner/heater/defroster	300 lb. (136 kg)
Compressor only	68 lb. (31 kg)
Alternator, 50 amp	15 lb. (7 kg)
Buckets	see Operating Specifications
Bucket cutting edges (bolt-on) for General Purpose Buckets:	
Flat, reversible, with interchangeable ends	275 lb. (125 kg)
Half arrow	325 lb. (147 kg)
Bucket teeth (bolt-on) for Multi-Purpose and General Purpose Buckets:	
Long tip, each	37 lb. (17 kg)
Short tip, each	36 lb. (16 kg)
Cab, ROPS, includes windshield washer and wiper (standard in U.S.A.)	1,630 lb. (750 kg)
ROPS, sound-suppressed	1,860 lb. (840 kg)
Canopy, ROPS	1,270 lb. (580 kg)
Clamp, top, for log fork	950 lb. (431 kg)
Counterweights	950 lb. (431 kg)
	1,850 lb. (830 kg)
Defroster, fan	3 lb. (1 kg)
Differential, torque proportioning:	
Front axle	10 lb. (5 kg)
Front and rear axles	20 lb. (9 kg)
Extensions, bucket spill plate, Side Dump Bucket	130 lb. (59 kg)
Fan, reversible blade	15 lb. (7 kg)
Fork, log	3,110 lb. (1410 kg)
Guard, power train	380 lb. (172 kg)
Heater, cab	30 lb. (14 kg)
Heater, engine coolant	3 lb. (1 kg)
Hydraulic systems:	
For Multi-Purpose Bucket	270 lb. (122 kg)
For Side Dump Bucket or top clamp	203 lb. (92 kg)
Lighting system, two lights	7 lb. (3 kg)
Mirror, for cab	25 lb. (11 kg)
Seat, suspension type	30 lb. (14 kg)
Starting motor, low temperature	47 lb. (21 kg)
Steering system, supplemental	113 lb. (51 kg)
Tire inflation kit	6 lb. (3 kg)
Tires	see Operating Specifications
Tool kit	18 lb. (8 kg)
Vandalism protection:	
Instrument panel guard	3 lb. (1 kg)
Cap locks for:	
Oil filler	3 lb. (1 kg)
Oil dipstick	4 lb. (2 kg)
Fuel tank	1 lb. (0.5 kg)
Hydraulic tank	3 lb. (1 kg)
Radiator	4 lb. (2 kg)

Materials and specifications are subject to change without notice.

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AEHQ9261 (2-76)
(Replaces AEQ49125)

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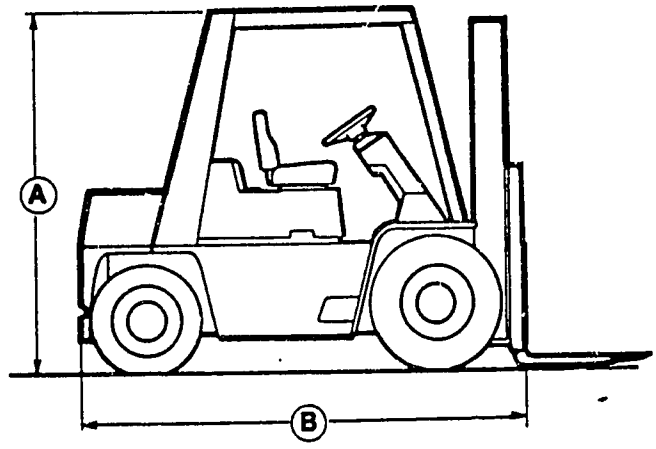
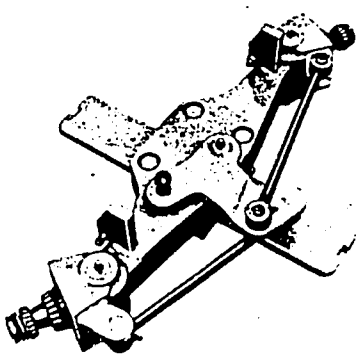
Lift Trucks



GAS/LP/DIESEL, PNEUMATIC TIRES

SPECIFICATIONS:	V30B	V35B	V40B	V45B
Rated Capacity @ 24" (500 mm) Load Center	3,000 lb. (1500 kg)	3,500 lb. (1750 kg)	4,000 lb. (2000 kg)	4,500 lb. (2250 kg)
Top Travel Speed: Maximum Loaded in MPH and (km/h)	11.5 (18.5)	11.5 (18.5)	11.5 (18.5)	11.5 (18.5)
Carriage Lift Speed: in FPM and (m/sec) **Empty/Loaded**	100/90 (0.52/0.45)	100/90 (0.52/0.45)	100/90 (0.52/0.45)	100/90 (0.52/0.45)
DIMENSIONS: **A**—Floor to Top of Overhead Guard	87" (2215 mm)	87" (2215 mm)	87" (2215 mm)	87" (2215 mm)
B—Length to Fork Face	90" (2290 mm)	91" (2310 mm)	93" (2355 mm)	94" (2390 mm)
Overall Width	47.5" (1205 mm)	47.5" (1205 mm)	47.5" (1205 mm)	47.5" (1205 mm)
Outside Turning Radius	85" (2160 mm)	86" (2180 mm)	87" (2200 mm)	92" (2340 mm)
Min. Aisle—Right Angle Stack*	103" (2620 mm)	104" (2640 mm)	105" (2660 mm)	106.5" (2700 mm)
Transmission	Manual Shift 2-Speed	Manual Shift 2-Speed	Manual Shift 2-Speed	Manual Shift 2-Spee
Type	Hydrostatic	Hydrostatic	Hydrostatic	Hydrostatic
Shipping Weight (Approx.)	7,600 lb. (3425 kg)	7,800 lb. (3550 kg)	8,300 lb. (3750 kg)	8,600 lb. (3900 kg

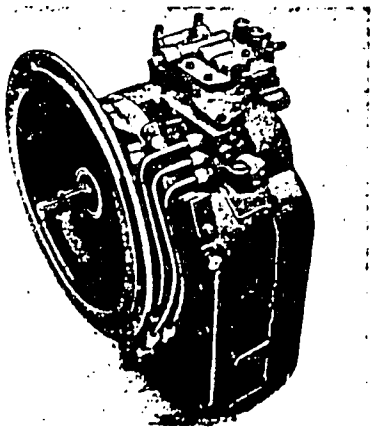
*Allow for load length when calculating aisle dimension.



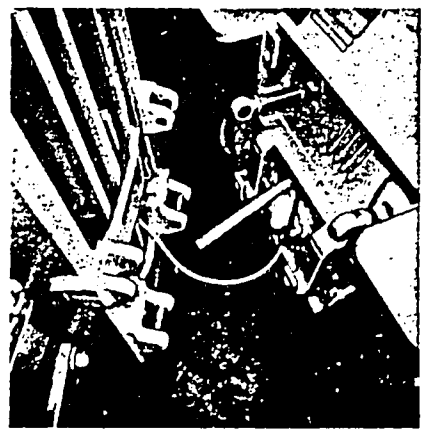
Trunnion Steer Axle...combines both spring and trunnion design features for better handling. Spring action absorbs shock to protect components and increase operator comfort ...trunnion action gives articulation for improved traction over uneven surfaces. Fixed-length tie rods need no adjustment. **T&V models 3,000-6,000 lb.; M models 2,000-10,000 lb.**

Hydrostatic Transmission . . . delivers instant response forward and reverse with an infinite range of speed selection. Engine can be operated at high RPM for maximum lifting speed while inching the truck...or. direction may be changed quickly and easily. Designed for lift truck applications. **T models 3,000-12,000 lb.; V models 3,000-6,000 lb.**

V50B	V55B	V60B	V60C	V70C	V80C
5,000 lb. (2500 kg)	5,500 lb. (2500 kg)	6,000 lb. (3000 kg)	6,000 lb. (3000 kg)	7,000 lb. (3500 kg)	8,000 lb. (4000 kg)
11.5 (18.5)	12.5 (20.0)	12.5 (20.0)	14.5 (23.5)	14.5 (23.5)	14.5 (23.5)
100/90 (0.52/0.45)	90/80 (0.46/0.40)	90/80 (0.46/0.40)	135/125 (0.68/0.64)	100/95 (0.51/0.48)	100/95 (0.51/0.48)
88" (2235 mm) 96" (2440 mm)	88" (2235 mm) 104" (2645 mm)	88" (2235 mm) 106" (2700 mm)	88" (2235 mm) 113" (2880 mm)	88" (2235 mm) 114" (2910 mm)	88" (2235 mm) 117" (2960 mm)
47.5" (1205 mm) 89.5" (2275 mm)	47.5" (1205 mm) 98" (2480 mm)	47.5" (1205 mm) 100" (2540 mm)	52" (1320 mm) 100" (2550 mm)	52" (1320 mm) 102" (2600 mm)	52" (1320 mm) 106" (2690 mm)
108" (2735 mm)	116" (2940 mm)	118" (3000 mm)	122" (3100 mm)	124" (3150 mm)	128" (3250 mm)
Manual Shift 2-Speed	Manual Shift 2-Speed	Manual Shift 2-Speed	—	—	—
Hydrostatic	Hydrostatic	Hydrostatic	Power Shift 2-Speed	Power Shift 2-Speed	Power Shift 2-Speed
9,100 lb. (4125 kg)	9,200 lb. (4175 kg)	9,800 lb. (4450 kg)	10,900 lb. (4950 kg)	11,700 lb. (5300 kg)	12,500 lb. (5700 kg)



Two and Three Speed Power Shift transmissions are combination transmissions which include torque converter and constant mesh gear section. Multiple clutches are oil cooled, pressure lubricated, and self-adjusting. "Creeper" pedal allows precise inching in close quarters. **V models 6,000-30,000 lb.; AM-AH models 36,000-60,000 lb.; T models 16,500-30,000 lb.**

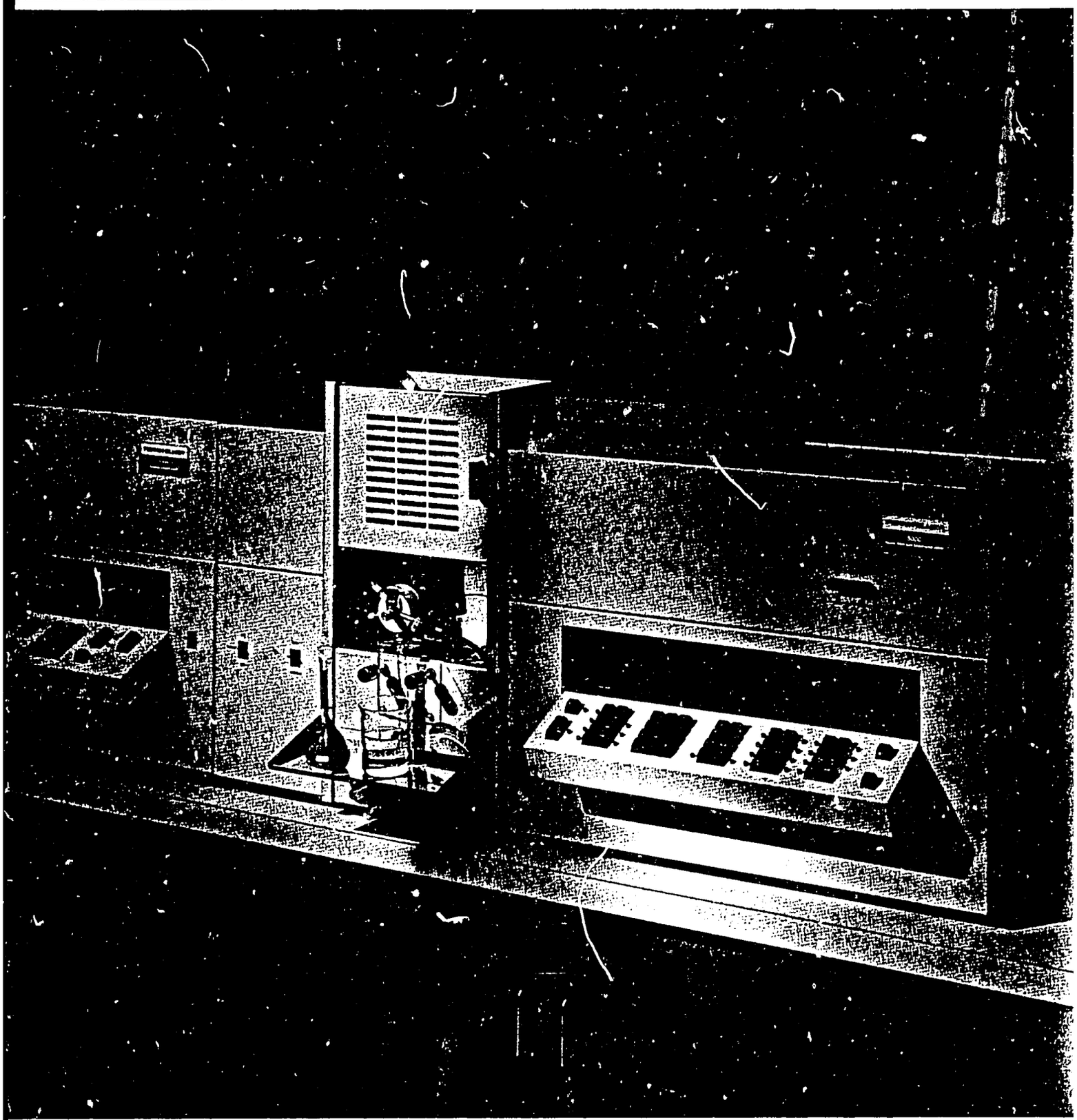


Sturdy Mast Hangers are ba welded to frame so load sho is transmitted to the hea structural frame, not axl Hanger-type mounting allov fast mast removal. Spheric bushings in tilt cylinder en prevent binding and damage cylinder rod. **All except T16 T300, AM-AH Models.**

APPENDIX G
Assay Laboratory Equipment Specifications

ATOMIC ABSORPTION

MODEL 5000 ATOMIC ABSORPTION SPECTROPHOTOMETER



PERKIN-ELMER

A New Era in Atomic Absorption . . .

"TOP-OF-THE-LINE" NOW MEANS MORE THAN EVER BEFORE WITH THE PERKIN-ELMER MODEL 5000 . . . UNEQUALLED

- NUMBER 1 IN SIMPLICITY where routine analyses by laboratory personnel with minimum training is the primary concern.
- NUMBER 1 IN PERFORMANCE for applications requiring the ultimate in precision and detection limits.
- NUMBER 1 IN AUTOMATION AND SPEED for laboratories where time is valuable and many samples must be analyzed for several elements on a routine basis.
- NUMBER 1 IN FLEXIBILITY with variable modes of data output and two-way interfacing for externally programmed instrument control.

THE MICROCOMPUTER COMES OF AGE IN THE MODEL 5000

Since 1975, the application of microcomputers in atomic absorption has been steadily growing. By 1977, Perkin-Elmer was offering the first complete line of microcomputer-controlled atomic absorption spectrophotometers which provide the benefits of microcomputer technology. The instruments are easier to use; calibration is more accurate.

The Model 5000 is the first analytical instrument to utilize the microcomputer so fully. *Every* instrument operation is monitored and controlled by the internal microcomputer. As a result, the improved ease-of-operation realized with the previous microcomputer-based instruments is now present in *every* step of instrument setup and analysis. A new concept built around the latest in microcomputer technology and a totally new and unique high-energy optical system have resulted in a complete analytical system with capabilities never before imagined—The Model 5000.

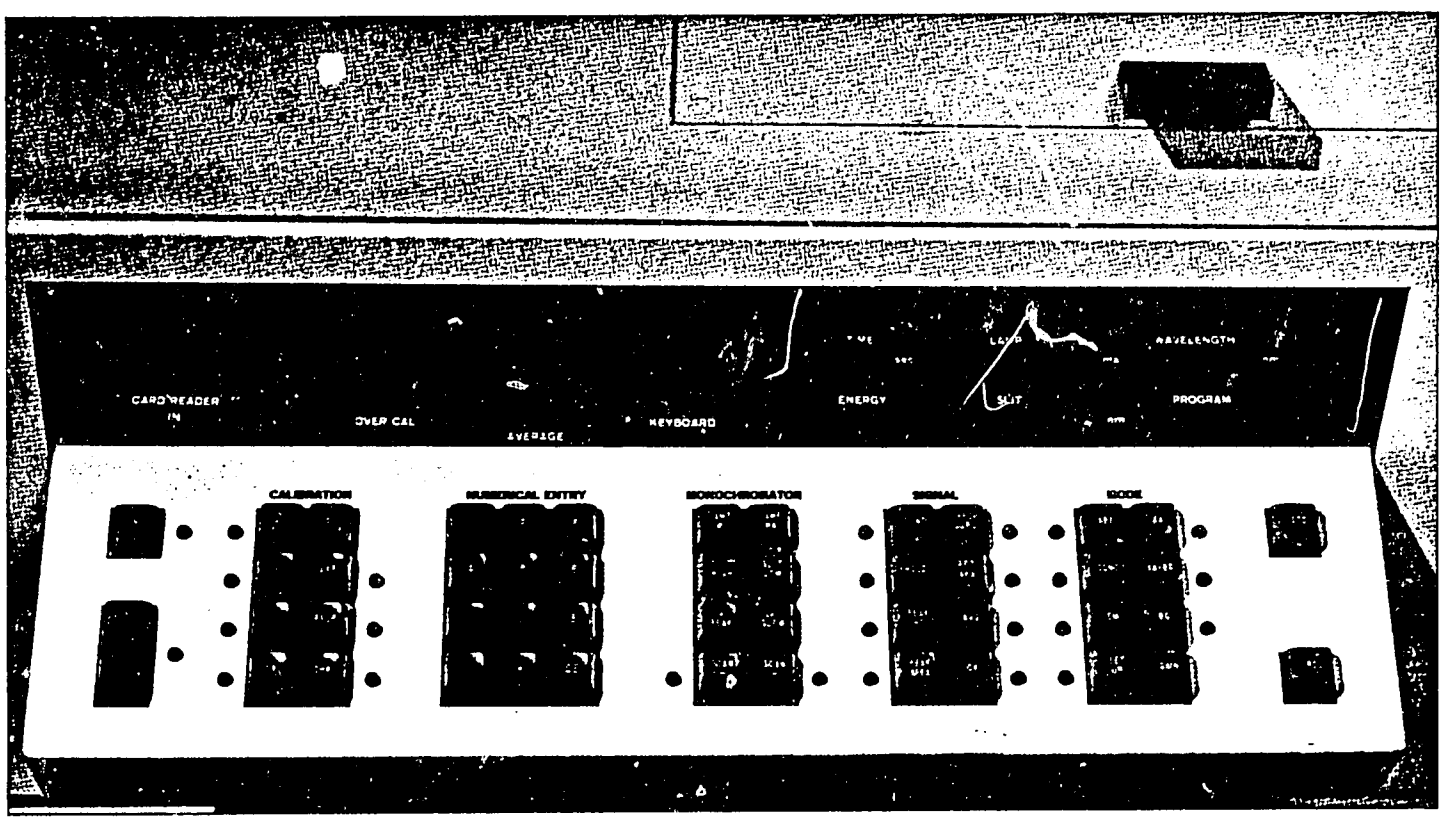


Figure 1. Model 5000 Atomic Absorption Spectrophotometer, Control Panel.

Number 1 in Simplicity

"Microcomputer Control" means that preprogrammed instructions from a tiny internal computer cause the instrument to do for itself what you would otherwise have to do manually. The instrument will still respond to the wishes of the operator. However the microcomputer is informed of the operator's wishes by a simple keystroke and the computer does the rest. The result is an easier setup of precisely reproducible instrument conditions.

Operator commands are entered into the microcomputer from the control panel (Figure 1). Keys for indicating operator instructions are arranged in clearly labelled groups according to their function. Instrument setup is begun by selecting the desired operational MODE from the group of keys on the far right of the panel, and then moving left to the next group. *Only those keys which select or control desired operational parameters need to be depressed.* To show the Model 5000's simplicity, the table below lists the few actions needed to set up for the determination of cadmium.

If the setup procedure looks familiar, it is not surprising. Everything is done in the same order as on a conventional atomic absorption instrument. Select the operational modes; select the lamp, lamp current, slit and wavelength; enter integration time and standard concentrations; select optimum gas flows; and you are done. With the clearly labelled, single-function keys of the Model 5000, even the terminology is the same. The computer talks *your* language. Tell it what you want done and it makes the adjustments for you. Precisely! Automatically!

CADMIUM DETERMINATION, SETUP PROCEDURE USING THE MODEL 5000.

OPERATION	DEPRESS KEYS	DISPLAY	EFFECT
Select mode	AA, CONC	Indicators beside depressed keys illuminate.	Atomic absorption mode with direct concentration readout is selected.
Select signal handling	HOLD	Indicator beside depressed key illuminates.	Each reading is displayed until new measurement is requested.
Select Cd lamp	6, LAMP #	LAMP 6	Lamp turret rotates to position #6 where Cd lamp has been placed and prealigned.
Set Cd lamp current	4, LAMP MA	LAMP 6 4 ma	The specified current of 4 milliamps is applied and the Cd lamp lights.
Select slit width	0, •, 7, SLIT HI	SLIT H 0.7 nm	The requested 0.7-nm slit for flame AA is set.
Set wavelength	2, 2, 8, •, 8, λ PEAK	WAVELENGTH 228.8 nm	Within seconds, the grating is automatically driven to the proper position and the microcomputer fine-tunes the wavelength precisely to the requested 228.8 nm.
Set integration time	1, t	TIME 1.0 sec	One-second integrated readings will be displayed.
Enter standard concentrations	1, •, 0, 0, S1	Concentration values may be checked on main display. Indicator beside standard key illuminates after calibration.	The concentration of the first standard (1.00 μg/ml) is entered into the microcomputer memory to be used for concentration calibration. If desired, two more standards may be used by entering their concentrations in "S2" and "S3".
Set gas flow rates	3, 5, ACET	FUEL FLOW 35	Optimum flow rates for selected fuel and oxidant are programmed on optional Automatic Burner Controls (Figure 2).
	5, 5, AIR	OXIDANT FLOW 55	

AUTOMATIC SETUP—THE ULTIMATE IN SIMPLICITY AND SPEED

The Model 5000 contains a truly revolutionary feature, the ultimate in simplicity and speed of instrument setup. We can store, in one of six available program memories, the entire analytical program for cadmium which we just set up. Select a program number from 1 to 6. To store the instrument conditions in memory, simply enter the program number and press "STO". Five other elements may be set up and their conditions stored in the remaining five program memories of the Model 5000

To recall one of the analytical programs stored, enter the program number and press "RCL". Every instrumental parameter is recalled and the instrument is automatically set up precisely to the conditions originally programmed. Optimum conditions are set up at the push of a button. A highly skilled operator is *not* required for quality analyses on the Model 5000.

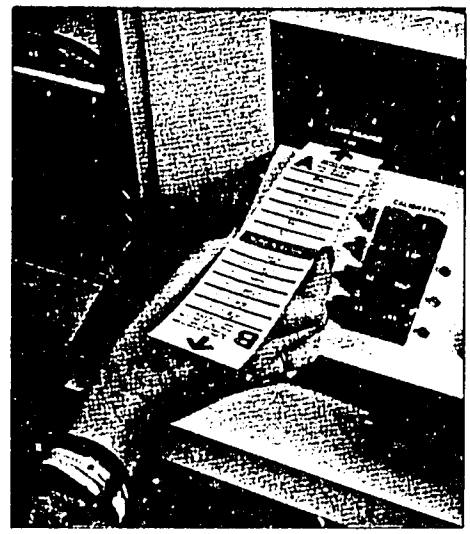


Figure 3. *Model 5000 Atomic Absorption Spectrophotometer Magnetic Card Reader*

PERMANENT STORAGE AND INSTANT RECALL OF ANALYTICAL PROGRAMS

Do you need to store analytical conditions for more than six elements? With the accessory Magnetic Card Reader (Figure 3) all information stored in all six program memories of the Model 5000 can be recorded on a magnetic card. Just insert the card and press "STO". A permanent record is instantly produced. Turn over the card, and conditions for another six elements can be stored on that side. When a particular analysis is required, just select the right card, insert it in the card reader and press "RCL". Six analytical programs are recalled from the card and transferred to the instrument's internal program memory. Just select the desired element, and automatic setup begins.

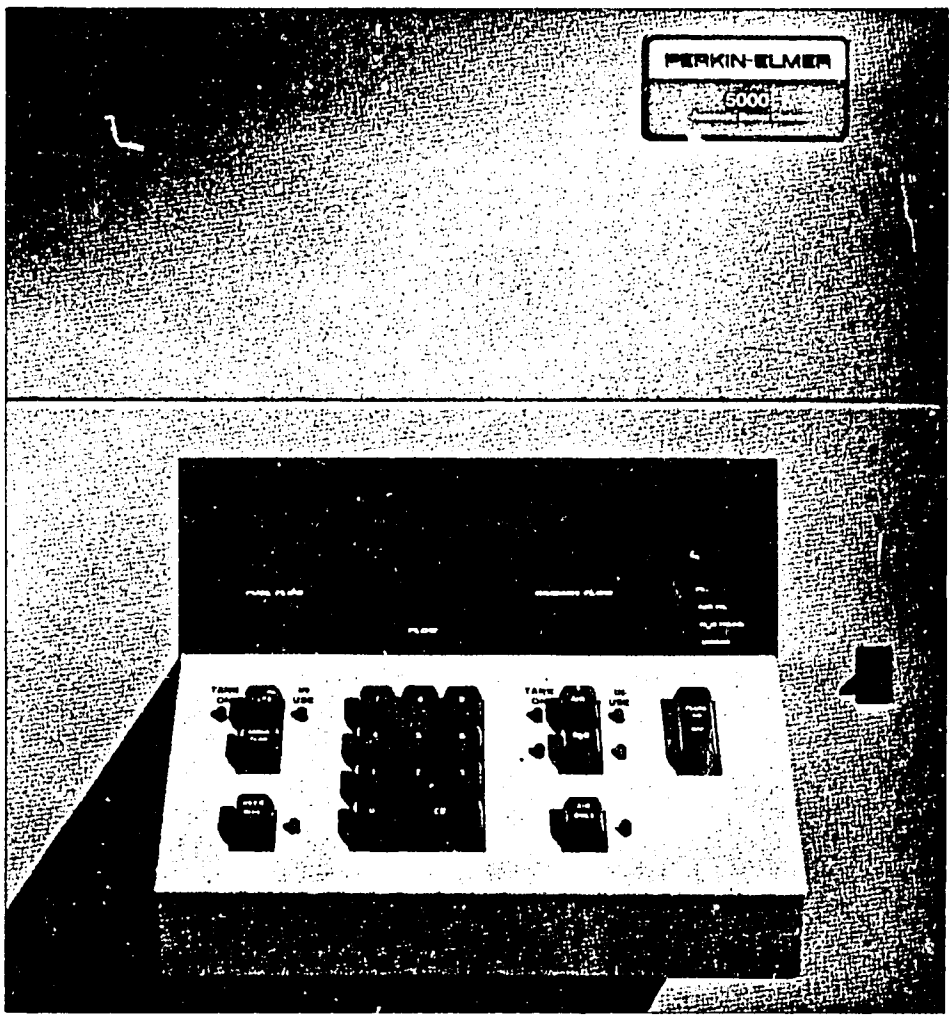


Figure 2. *Model 5000 Atomic Absorption Spectrophotometer, Automatic Burner Control*

Number 1 in Performance

"Can a computer possibly do as good a job at selecting the wavelength as a trained operator?" That is a logical question to ask. "It can" is the answer. It does so by using the same procedure a trained operator would use for precise selection of the wavelength. When a wavelength is requested, a two-step selection process is initiated. First, the grating is driven to the proper position for the selected wavelength. Then, a computer-controlled peaking operation steps the grating back and forth within a 0.2-nanometer window, searching for the peak emission intensity. When the peak is located, the grating is locked into the exact position, centering on the specified emission line. A grating rotation of only 0.00075 degrees per step (over 64,000 grating steps from 180 to 900 nanometers) provides the necessary stepping resolution to assure precise fine tuning of the wavelength.

The accuracy of wavelength selection from a complex spectrum of closely adjacent lines of varying intensity is illustrated in Figure 4. The two bismuth lines, 222.83 nanometers and 223.06 nanometers, were alternately selected. The absorbance of a 20 micrograms-per-milliliter bismuth solution was measured after each wavelength change to verify the selection of the proper wavelength. The precision of absorbance readings at each wavelength was within the precision expected for replicate measurements if the wavelength had not been changed, and the relative sensitivity observed for the two lines agreed with the expected values. The automatic selection of the two bismuth lines, only 0.23 nanometers apart, was precise and reproducible, and accurate selection of the weaker, 222.8-nanometer line was achieved in the presence of the brighter adjacent line. Thus, accurate wavelength selection even in a complex spectrum can be achieved at the push of a button.

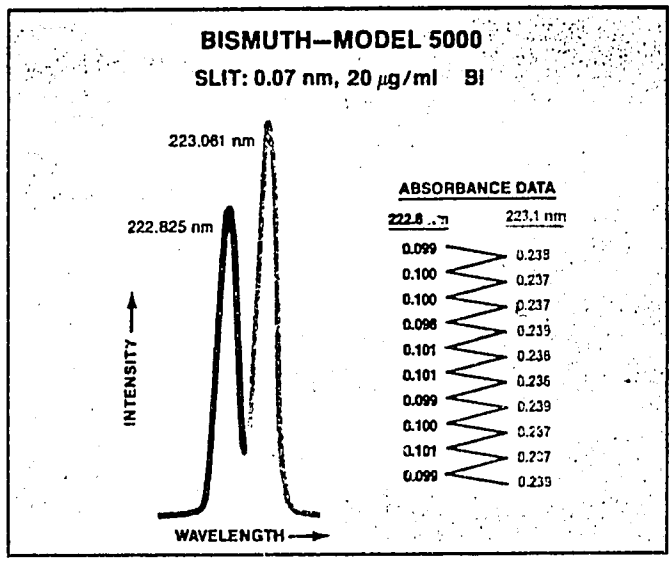


Figure 4. Accuracy of Wavelength Selection from a Complex Spectrum of Closely Adjacent Lines of Varying Intensity—Bismuth.

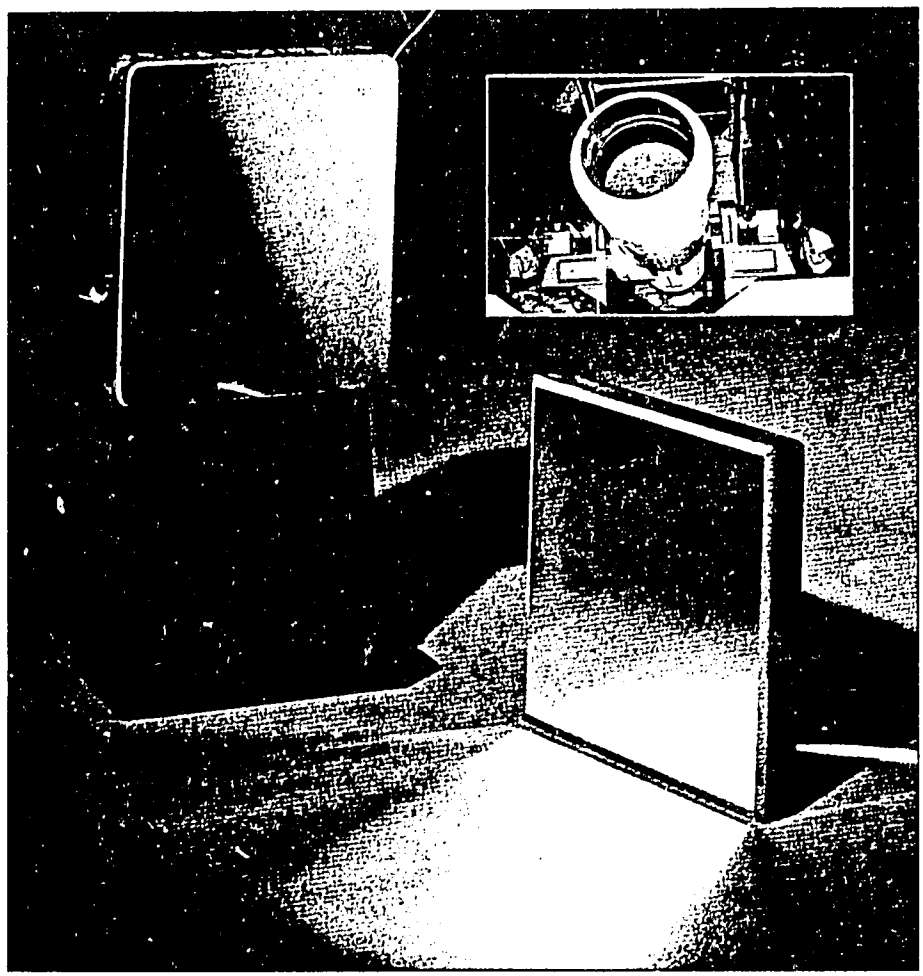


Figure 5. Mirrors for Deep-space Telescopes and Spectrophotometer Applications are Products of Perkin-Elmer Optical Technology

THE BEST PERFORMANCE AND THE MOST CONVENIENCE—TOGETHER FOR THE FIRST TIME

In the past, optical energy considerations in instrument design have often required a compromise between energy-costly convenience features and maximum energy throughput for optimum precision and detection limits. This need to compromise no longer exists, thanks to a totally new optical system designed to meet the requirements of unmatched convenience and performance, all in one package. To make up for the optical energy consumed by the convenience of a totally double-beam system, greater use is made of the available light energy with an unequalled high-energy optical system. Highly reflective toroidal mirrors, larger than ever before, are used to capture and focus the total emission intensity of even large image sources through the entire optical system. The highly efficient, 0.4-meter Czerny-Turner monochromator is designed to take full advantage of the optical design. Two gratings, one blazed in the ultraviolet range and the other in the visible, provide high-energy diffraction over the entire wavelength range. Of course, the most efficient grating for the wavelength being used is automatically selected by the instrument microcomputer. Reciprocal linear dispersion, of 0.65 nm/mm in the ultraviolet and 1.3 nm/mm in the visible, makes it possible to use wider slits without sacrificing resolution or sensitivity. Wider slits capture more source energy, and the unequalled 84-mm x 84-mm gratings take full advantage of the large slit images.

NEW CAPABILITIES IN BACKGROUND CORRECTION

The benefits realized from the unmatched optical system include detection limits better than previously achievable for many elements. The improved performance is particularly noticeable when background correction is being used. The unique dual-chopper assembly is utilized to alternately direct the total light energy from the primary and continuum sources through both sample and reference beams (Figure 6). No beam-splitting occurs prior to the sample compartment, and thus double-beam, drift-free background correction is accomplished with little or no deterioration in detection limits, compared to measurements without background correction.

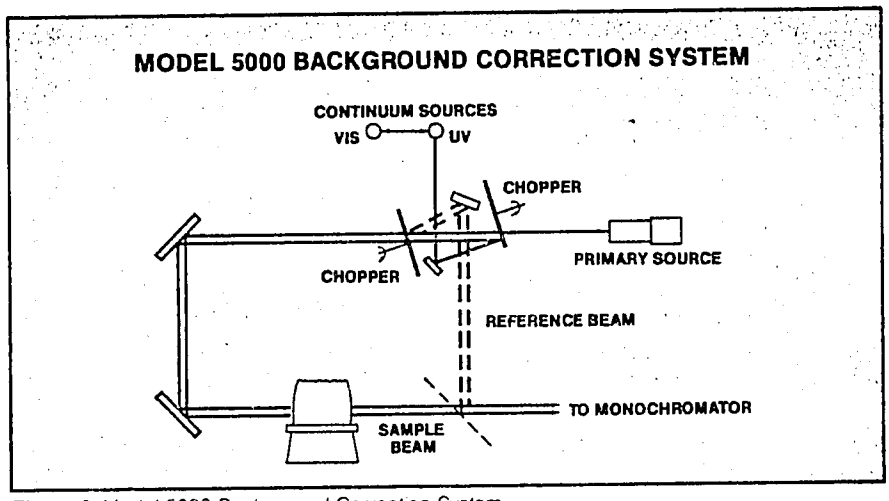


Figure 6. Model 5000 Background Correction System.

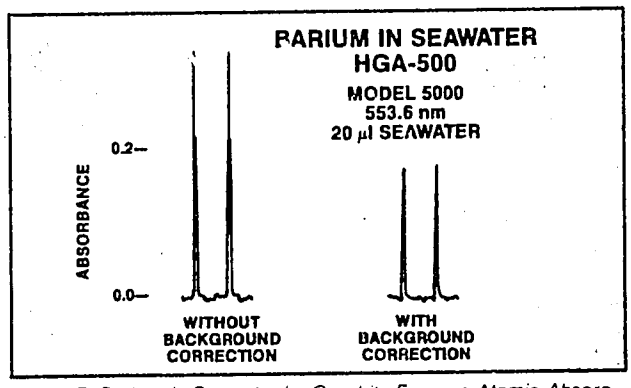


Figure 7. Barium in Seawater by Graphite Furnace Atomic Absorption—Visible Background Correction Using Tungsten Iodide Source.

Interfering background absorption is usually more severe for elements determined at ultraviolet wavelengths. The deuterium arc lamp provides intense continuum energy for background correction with these elements. However, for certain elements with intense line sources at intermediate wavelengths (e.g., chromium at 357.9 nm), simultaneous background correction is possible with the deuterium arc lamp only by compromising slit width or line source intensity conditions. Further into the visible region of the spectrum where some sample matrices may still cause background absorption, the deuterium arc lamp is not usable at all.

To provide *uncompromised*, simultaneous, continuum-source background correction for *all elements*, the Model 5000 background correction system utilizes *two* continuum sources, a deuterium arc lamp for the ultraviolet and a tungsten iodide source for the visible region of the spectrum. Selection of the most intense source at the working wavelength is automatic. Figure 7 illustrates visible background correction using the tungsten iodide source for the graphite furnace determination of barium in seawater on the Model 5000.

Number 1 in Automation and Speed

AUTOMATED SEQUENTIAL MULTI-ELEMENT ANALYSIS

Today's analytical laboratory must analyze more samples for more elements than ever before. This increased sample load demands an increase in analytical speed and automation if serious impact on time and personnel is to be avoided. At the same time, care must be exercised so that standards of precision and accuracy are not sacrificed for speed. To meet these challenges, Perkin-Elmer introduces the concept of Sequential Multi-Element Analysis by Atomic Absorption.

The concept utilizes the fully automated Model 5000 System shown in Figure 8 (fold out). Up to 50 samples plus standards are automatically presented by the AS-50 Auto Sampler to the Model 5000, which has been preprogrammed with the analytical conditions for up to six elements. For automated sequential multi-element analysis, the instrument automatically sets itself up for the determination of the first element. Then automatic standardization and sample analysis is performed under the first set of conditions. After the last sample has been analyzed, automatic setup begins for the second element, and analysis of standards and samples is repeated. This sequence continues until all 50 samples have been analyzed for all six elements—all automatically, without operator attention and at record speed.

WHY SEQUENTIAL ANALYSIS?

Using sequential multi-element analysis, each element can be determined under optimum conditions for that element. No instrumental compromises need be made, thus analytical accuracy and precision for multi-element analysis is the same as for a single determination.

Many elements are *flame sensitive* and show varying performance depending on the fuel/oxidant mixture. The effect of flame condition on the atomic absorption sensitivity for a few of these elements is illustrated in Figure 9. It is clear from this figure that simultaneous analysis under one set of flame conditions will lead to serious analytical compromises. However, by sequentially analyzing each element individually, the optimum flame condition for each element can be utilized, and no analytical sacrifice is required for multi-element analysis. With the optional Automatic Burner Control, flame conditions are part of each element's analytical program stored in the Model 5000. Automatically optimum gas flows are recalled and the flame is adjusted for uncompromised analytical performance.

What about the speed of a sequential analysis? The unique automatic setup and analysis for six elements makes the Model 5000 the fastest system available for multi-element analysis by atomic absorption. Sequential analysis by atomic absorption on the Model 5000, where signal integration times of one second are common, is even faster than large simultaneous systems requiring 60-second readings of each sample for acceptable precision.

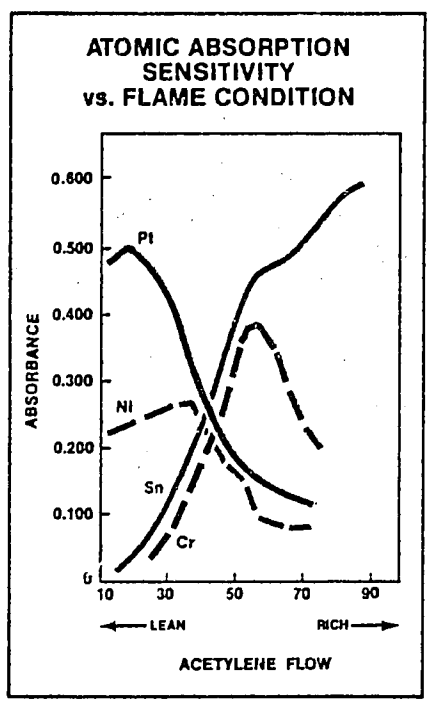


Figure 9. Atomic Absorption Sensitivity Versus Flame Condition.

WHY ATOMIC ABSORPTION?

The Model 5000 is the first instrument optimally designed for multi-element analysis by atomic absorption. It introduces to the field of multi-element analysis the BENEFITS OF ATOMIC ABSORPTION including:

- *SIMPLICITY.* Ease-of-operation is one of the characteristics responsible for the wide-spread popularity of atomic absorption for the determination of metals. Automatic setup of the Model 5000 just makes it that much easier.
- *PERFORMANCE.* Even under the most favorable conditions, competing techniques for multi-element analysis cannot match the analytical precision routinely achievable by atomic absorption.
- *ESTABLISHED METHODOLOGY.* The successful history of atomic absorption has produced a vast reservoir of documentation on analytical procedures. Existing atomic absorption methodology may be transferred directly to the Model 5000 for multi-element analysis.
- *INSTANT PRODUCTIVITY.* The large, complex multi-element systems not only require highly skilled operators but often take many months of installation and adjustment before meaningful data are produced. The Model 5000 will begin working for you immediately. Install today . . . run samples tomorrow!

And of course, there is one other advantage of atomic absorption. The totally automated Model 5000 System is but a fraction of the price of competing multi-element techniques.

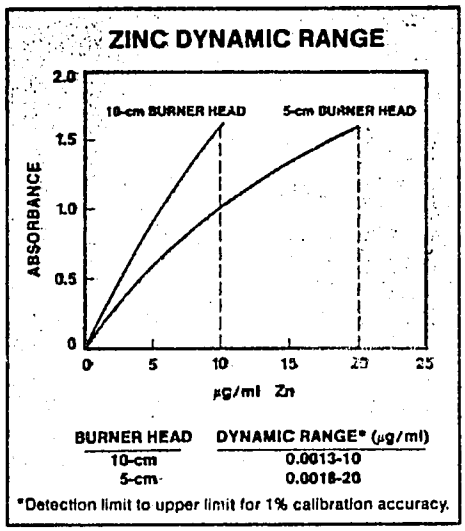


Figure 10. Dynamic Range of Zinc Using 10-cm and 5-cm Burner Heads.

MULTI-ELEMENT ANALYSIS WITH NO RESTRICTIONS

The Model 5000 can carry out an automated analysis for six elements—any six—in any combination of operational modes. How about zinc at the detection limit, copper at 150 µg/ml, nickel in a lean flame, chromium in a rich flame, sodium by flame emission and aluminum in nitrous oxide-acetylene? No problem! Because all instrument parameters are part of each individual element's analytical program stored in the instrument's memory, mixing atomic absorption and flame emission does not bother the Model 5000. And of course, with the Automatic Burner Control, elements requiring fuel-lean and those requiring fuel-rich flames can be determined together with precisely the optimum flame for each. You can even mix air-acetylene and nitrous oxide-acetylene elements, and the Automatic Burner Control will make the necessary flame changes at the proper time. By using the five-centimeter burner head at optimized flows, both air-acetylene and nitrous oxide-acetylene can be used in an automated analysis, and the dynamic range (detection limit to the upper limit of determinable concentration) is significantly extended (Figure 10). This allows trace constituents and major components to be determined in the same automated analysis.

THE FULLY AUTOMATED MODEL 5000

The fully automated Model 5000 (Figure 8) consists of the basic instrument including the built-in memory for six analytical programs and optional features including the magnetic card reader, the motorized six-lamp turret, the Automatic Burner Control, and the AS-50 Auto Sampler. UV/Visible background correction may be included if required. Start-up procedure for automated multi-element analysis on the complete Model 5000 System includes the following:

1. Select the magnetic card which has been prerecorded with all of the analytical conditions for the six desired elements.
2. Insert the card in the card reader and push "RECALL" to program the Model 5000 for the selected determinations.
3. Push "FLAME ON" on the gas controls to light the flame.
4. Place the sample tray containing a blank, from one to three multi-element standards, and up to 50 samples on the AS-50 Auto Sampler.
5. Enter on the AS-50 control unit the order in which the six elements are to be determined.
6. Enter on the AS-50 control unit the number of the last sample to be analyzed (if less than the maximum number of 50)
7. Push the "START" button on the auto sampler and the analysis begins.

The rest is automatic. While other samples are being prepared or additional tasks are performed, the Model 5000 will analyze 50 samples for six elements in as little as 30 minutes. When the analysis is complete, an audible alarm will signal that the data from 324 determinations, including standardization and sample analysis, are waiting on the PRS-10 Printer-Sequencer. Place a new tray of samples on the auto sampler and again press "START", and 50 additional samples can be automatically analyzed for the same six elements. Or, slip on a new turret with six more prealigned lamps, insert a new magnetic card into the card reader and restart the auto sampler to analyze the same samples for six more elements.

Figure 11. Model 5000/HGA-500 Graphite Furnace System

MULTI-ELEMENT GRAPHITE FURNACE ATOMIC ABSORPTION

The HGA-500 Graphite Furnace extends the multi-element capabilities of the Model 5000 to graphite furnace analysis. Six different furnace heating programs can be stored in the six internal program memories of the HGA-500 controller. Furnace heating rates and temperatures, selection from two different purge gases, gas flow rates, and even remote control of an accessory recorder and spectrophotometer calibration and read functions can be programmed for each of up to nine steps of furnace treatment per program. Using the AS-1 Auto Sampler with the Autocalibrate accessory and Multi-element Interface, optimum graphite furnace as well as spectrophotometer conditions can be automatically recalled in corresponding sequence for the automated multi-element graphite furnace analysis of 30 samples for six elements. More information on the HGA-500 Graphite Furnace is available from Perkin-Elmer.

THE MODEL 5000/HGA-500 . . . GRAPHITE FURNACE ANALYSES WHILE YOU SLEEP

Graphite furnace atomic absorption requires no combustible gases for analysis. Built-in interlocks of the HGA-500 which monitor the graphite tube, furnace temperature, and inert purge gas pressure will shut down the instrument system if a problem develops with any of the supporting utilities. Thus, totally unattended operation of graphite furnace atomic absorption is feasible and safe.

Analyze 30 samples by graphite furnace AA; make duplicate determinations for confidence; and determine six elements. That is 360 determinations. At an average of two minutes per determination, 12 hours are required to complete the analyses. Start the AS-1 Auto Sampler as you turn out the lights in the evening; the data will be waiting for you in the morning. The Model 5000/HGA-500 System can turn your laboratory downtime into analytically productive hours.

Number 1 in Flexibility

Today's analytical requirements are not the same as yesterday's, and it is unlikely that tomorrow's needs will be the same as today's. Not only do individual requirements change but so does technology. Recently, technological improvements in analytical instrumentation have been occurring at a particularly rapid rate. The Model 5000 was designed with varying requirements and an expanding technology in mind.

The basic Model 5000 includes total microcomputer control with six internal program memories for storage, instant recall, and automatic setup of analytical conditions for six elements. The most powerful optical system available in any atomic absorption instrument combined with the stable electronic system provides the basic Model 5000 with the ultimate in precision and detection limit capabilities . . . exactly what you would expect from the top-of-the-line AA from Perkin-Elmer.

Optional features for the Model 5000 include UV/Visible background correction, the magnetic card reader, the motorized six-lamp turret, a choice of gas control systems, and the AS-50 Auto Sampler. Of course, the Model 5000 will readily accept either the HGA-2200 or the HGA-500 Graphite Furnace. Any of these optional features can be included initially or added later as requirements change.

Several options for data output are available for the Model 5000. The PRS-10 Printer-Sequencer produces a printed record of analytical data identified by a programmable sequence number. The printout identifies all calibrations, and it records any error conditions encountered during the course of an analysis, and automatically displays average and coefficient of variation of replicate measurements. One of two available data formats may be selected and printed out on the TR-2 Teletypewriter, and ASCII-encoded punched paper tape can also be generated using the TR-2. The optional Communications Interface for the Model 5000 provides standard RS-232C interfacing for easy hookup to a variety of teleprinters and makes possible direct data transfer to in-house computer equipment.

With Model 5000s equipped with the Communications Interface, a High Speed Data Output mode may be selected. In this mode, unprocessed absorbance data are delivered to the interface 60 times each second. With this output option, special purpose data processing can be employed for studying graphite furnace peak shapes or any other application requiring high-speed data monitoring.

REMOTE CONTROL OF THE MODEL 5000

One of the many unique features offered only by the Model 5000 is the capability of external control. The RS-232C interface of the Model 5000 is *two-way*. That is, not only can data be sent *out from* the spectrophotometer to an external device but also operational instructions can be sent *into* the instrument from an outside controller. Instrument control from an external *intelligent* device vastly extends the application possibilities of the Model 5000 beyond the already unequalled flexibility built into the instrument.

The potential application of external control is illustrated by the "Methods File" program available for the Perkin-Elmer AA Data System 1, which plugs directly into the Model 5000 interface. Using "Methods File", up to *120* different analytical methods used in your laboratory can be programmed on the Model 5000 and recorded on a cassette tape in the Data System 1. When a particular method is desired, the method file number is entered on the Data System 1. The method is then automatically located on the tape, the conditions are transferred to the Model 5000 through the two-way interface, and the instrument is automatically set up to the specified parameters.

The possibilities for externally programmed instrument control are almost limitless. Imagine an externally controlled Model 5000 where instrument conditions are altered based on an intelligent evaluation of the data—automatically. Imagine programmed scanning flame emission searching for the presence of several selected elements while correcting for background emission—automatically. Take an external computer which is RS-232C compatible, write your own control program, and turn the Model 5000 into *your* instrument, controlled by the computer to meet your special purpose needs. Imagine. . . .

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A Summary of the Benefits

SIMPLICITY

Place a good lamp here, with no lamps installed in the instrument. Insert a magnetic card into the card reader and push one button. The AA instrument [illegible] automatically.

Unique [illegible] programming is not required. The operator is free to perform other tasks.

Results: [illegible] SAVED.

PERFORMANCE

The most powerful AA optical system available. Delivers [illegible] PRECISION and DETECTION LIMITS.

The double beam, UV and VISIBLE background corrector ELIMINATES ERRORS due to background absorption for ALL AA ELEMENTS.

Six complete program memories make automated analysis under OPTIMUM conditions for ALL elements possible. No compromise in conditions. NO COMPROMISE IN PERFORMANCE.

AUTOMATION and SPEED

Today's analytical laboratory must analyze more samples for more elements and THIS TREND WILL CONTINUE.

Time costs money. People cost money. The Model 5000 can analyze 50 samples for 6 elements in 30 minutes, WITHOUT OPERATOR ATTENTION.

Results: MONEY SAVED.

FLEXIBILITY

Starting with the basic instrument and building to the fully automated system as requirements change is easy with the Model 5000. Many accessories simply plug in.

TWO-WAY RS-232C interfacing means that the instrument can send data to a computer and a computer can talk to and control the instrument.

Software control makes today's instrument work with tomorrow's technology.

The Model 5000—a SHREWD INVESTMENT for today . . . and tomorrow.

Questions and Answers on the Model 5000

Q: Must all of the keys on the Model 5000 control panel be used each time a new analytical program is set up, and must the keys be pushed in any particular order?
A: Only those keys which select or control the operational parameters to be changed need be depressed. For the most accurate wavelength selection, the lamp current should be entered before the wavelength. The order for other parameter selections is not critical. Some order-sensitive parameter adjustments are automatic. For instance, if the slit width is changed after the wavelength has been selected, the wavelength is automatically re-peaked. And of course, after an analysis is originally set up and stored, only the numerical keypad and the "RECALL" key need be used for a totally automated setup sequence.

Q: How is the wavelength selected for flame emission where there is no source lamp for wavelength peaking?
A: There are two ways. One is to aspirate the most concentrated standard solution to be used and then enter the wavelength using "λ PEAK". The wavelength will be peaked on the emission line from the standard solution, and automatic gain control will adjust the photomultiplier voltage. A second way is to enter the wavelength using "λ SLEW", instead of "λ PEAK". Wavelength selection is then entirely mechanical, and no emission source is required for wavelength selection. The λ SLEW function has many uses, including driving the monochromator to any desired wavelength to begin scanning flame emission.

Q: I only determine six elements. Do I need the magnetic card reader to store my programs for automatic setup?
A: No. The basic version of the Model 5000 includes the program memory for storing all of the conditions for six different analyses and a "STANDBY" mode for preserving the program memory and conserving power while the instrument is not in use. When the instrument is switched from "STANDBY" to "RUN", all six programs are available for immediate recall and automatic setup.

Q: How many standards should I use for the most accurate calibration?
A: A blank and up to three standards may be used to calibrate the Model 5000. One standard is sufficient when sample concentrations fall in the linear working range. Where the calibration becomes nonlinear, two or three standards should be used, depending on the degree of curvature. With the proven equations used in the Model 5000, three standards will provide excellent calibration accuracy even for severely curved atomic absorption and flame emission calibrations. Naturally, excellent calibration accuracy is obtained for furnace analyses as well.

Q: For automated multi-element analysis, must standard solutions be analyzed in order of increasing concentration?
A: No. In fact, the order can differ for each element in the multi-element analysis. It is not even required that the same number of standards be used for each element. This allows standard reference materials with varying analyte concentrations to be used as standards for automated multi-element analysis.

Q: Can I recalibrate during the course of an automated analysis?
A: Yes, up to three times for each element if desired. Just enter on the AS-50 Auto Sampler keyboard the position number where a series of standards begins.

Q: Must I use the same number of standards for recalibration as I used for the original calibration?
A: No. You may elect to use the "RESLOPE" feature which re-establishes the original calibration by using only one standard.

Q: If a flame change from air-acetylene to nitrous oxide-acetylene is made during an automated analysis, how does the sudden increase in flame temperature affect the analysis?
A: Not at all. A "FLAME DELAY" can be programmed on the AS-50 Auto Sampler. When a new analytical program involving a flame change is recalled, the auto sampler will wait for the prescribed period of time before the next analysis is begun. This will allow for temperature equilibrium to be established.

Q: I do not have hundreds of samples a day, so I do not require automated analysis. What would the Model 5000 do for me?
A: Automation and speed for multi-element analysis is only one of the Model 5000's many benefits. Its easy programmability and one-button automatic setup make it the instrument of choice for routine analyses by laboratory personnel with limited technical background. And the unequalled performance of the Model 5000 makes it *the one* to turn to in research and other applications which demand the utmost in precision and detection limit capabilities.

Q: How can I see the Model 5000 in action?
A: The easiest way is to view the 20-minute color/sound movie on the Model 5000 and its capabilities. Contact your nearest Perkin-Elmer office to arrange for a showing and to find out more about the benefits the Model 5000 can offer you.

Model 5000 Specifications

PHOTOMETER

Double-beam, time-shared and space-shared system. Light from the lamp is optically chopped and passed alternately through and around the flame; the beams are then recombined and travel through the monochromator onto a single photomultiplier detector. Vapor-tight photometer cover with fused silica UV transmitting windows. "AC" system (lamp emission chopped by rotating sector mirror while flame light is unchopped).

Optional double beam UV/visible background corrector. Operates in a time-shared and space-shared mode, with primary and continuum source emission passed alternately through sample area and around sample area for simultaneous background-corrected atomic absorption measurements or background-only measurements. Deuterium arc lamp used for UV measurements and tungsten halide lamp for visible measurements. Source selection is automatically controlled by the microcomputer depending on the wavelength selected. Power to the source is automatically adjusted by the microcomputer to be in optimum range for operation.

MONOCHROMATOR

Czerny-Turner design, 408-mm focal length. Spectral range at least 180 to 900 nm covered by two gratings, each used in the first order. Grating selection is automatically controlled by the microcomputer depending on the wavelength range selected. UV grating: 2880 lines/mm (73,000 lines/in.), ruled area 84 x 84 mm blazed at 210 nm. Visible grating: 1440 lines/mm (36,500 lines/in.), ruled area 84 x 84 mm, blazed at 580 nm. Reciprocal linear dispersion approximately 0.65 nm/mm in UV, 1.3 nm/mm in visible.

Five separate slits microcomputer-selectable with approximate spectral bandwidths of 0.04, 0.07, 0.2, 0.7, and 2.0 nm in the UV, 0.08, 0.14, 0.4, 1.4 and 4.0 nm in the visible. Two separate slit heights available for each slit, one height optimum for flame work and the other optimum for use with the HGA Graphite Furnace.

Wavelength read directly in nm over the entire wavelength range. Automatic wavelength scanning built-in. Scanning rates approximately 0.25, 0.50, 1.0, 2.5, 5.0, 10, 25, 50 nm/min. Wavelength slewing speed less than one minute from 190 to 850 nm. Grating changeover at 450 nm. Photomultiplier detector: Multi-alkali cathode with UV transmitting window (wavelength range 185-930 nm).

READOUT

Controlled by keyboard with digital microprocessor electronics. Results shown on a six-digit electronic display with polarity indication and adjustable decimal. Linear in absorbance, concentration or emission intensity. Absorbance readings to 2.000A; concentration readings to 9999 with two additional decimal-locating zeros available and continuously variable scale expansion from 0.01 to 100X.

Integration/peak monitoring times variable from 0.2 to 99 seconds in less than 0.2-second intervals. Time-averaged integration, non-averaged integration (peak area) and peak height measurement modes with a choice of automatically updated readings ("Continuous") or individual readings with time-averaged integration. Ability to take a number of readings and average them, display the average and calculate and display the coefficient of variation or standard deviation built-in.

Fully automatic pushbutton zero calibration and concentration calibration (including automatic curvature correction) with as many as three standards in all operational modes. Ability to reslope calibration curve with a single additional standard also built-in. Automatic gain control. Automatic keyboard entry of integration time, scale expansion, lamp current, lamp number (with optional turret accessory), wavelength, slit width, slit height.

Ability to store instrument conditions in memory for six elements built-in, and display indication of program in use. Display indicates about 25 different error messages to illustrate such conditions as overabsorbance, overexpansion, incorrect calibration and other conditions which might cause errors. Lighted indicators show overcalibration, keyboard entries and averaged results. Lighted indicators show calibration functions, modes selected, and type of signals being measured. Check mode allows verification of all entries which do not have a lighted display.

All electronic functions, including calibration, wavelength selection, error messages are controlled by the microcomputer. Direct connection provided for 0-10 mV or 0-1V laboratory recorders with independent recorder control allowing continuous or "noise free" integrated readings on recorder (as per the digital display) or continuous readings with display calibration and variable time constant independent of display mode of operation. Built-in flame emission mode.

☐ I do; ☐ do not use atomic absorption

Type: _____

I may require AA equipment in:
☐ 3 months; ☐ 6 months; ☐ 9 months; ☐ 12 months

Please send me information on the
☐ 5000; ☐ 703; ☐ 560; ☐ 373/372; ☐ 272.
☐ HGA-2200 Graphite Furnace.
☐ HGA-500 Graphite Furnace.
☐ AS-1 Auto Sampler.
☐ AS-50 Auto Sampler.
☐ MHS-1 Automated Mercury/Hydride System.
☐ MHS-10 Automated Mercury/Hydride System.
☐ PRS-10; ☐ TR-2.
☐ EDLs; ☐ Intensitron® HCLs.
☐ 056 Recorders; ☐ 023 Recorders.

AA Reprints: _____

Other: _____

☐ Please have sales engineer call.
☐ Please send prices.

Name _____

Dept. _____

Institution _____

Address _____

City _____

State/Province _____ Zip _____

Telephone (_____) _____ Ext. _____

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☐ I do; ☐ do not use atomic absorption

Type: _____

I may require AA equipment in:
☐ 3 months; ☐ 6 months; ☐ 9 months; ☐ 12 months

Please send me information on the
☐ 5000; ☐ 703; ☐ 560; ☐ 373/372; ☐ 272.
☐ HGA-2200 Graphite Furnace.
☐ HGA-500 Graphite Furnace.
☐ AS-1 Auto Sampler.
☐ AS-50 Auto Sampler.
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☐ MHS-10 Automated Mercury/Hydride System.
☐ PRS-10; ☐ TR-2.
☐ EDLs; ☐ Intensitron® HCLs.
☐ 056 Recorders; ☐ 023 Recorders.

AA Reprints: _____

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Specifications (Contd.)

Direct compatibility with PRS-10 Printer-Sequencer and TR-2 Teletypewriter Readout Systems. Optional Communications Interface provides two-way EIA RS-232C output. Standby mode to retain programs in memory while power to other functions is shut down.

FLAME GAS CONTROLS

Standard gas controls containing individual pressure, flow control and metering for fuel and oxidants. Oxidant selection valve to change from air to nitrous oxide. Nitrous oxide safety interlock allows ignition only on air-based flame with pushbutton actuated remote ignition system. Also contains burner head safety interlock system and automatic fuel flow change when switching to a nitrous oxide-acetylene flame.

Optional Gas Control System also includes automatic gas sequencing, pushbutton operation, automatic pressure and flame sensing, provision for three oxidant and two fuel gases, and lighted indicators showing the status of the gases, burner head, and flame.

Automatic Burner Control includes microprocessor-controlled oxidant and fuel flow, automatic pressure, burner head, flame, and burner drain sensing with lighted status indicators. Automatic gas sequencing and remote control from main instrument keyboard in addition to the features of the standard gas control system.

BURNER

Premix design, angled to ensure proper drainage. Auxiliary oxidant inlet; inert plastic-coated flow spoiler; adjustable stainless steel nebulizer (accessory corrosion-resistant adjustable nebulizers available); 10-cm all-titanium single-slot burner head; burner mount adjustable vertically and horizontally with scale reading provision, and angularly without scale. Stainless steel mixing chamber coated with inert plastic with spring-loaded safety valve for burner and operator protection in the unlikely event of flashback.

SAMPLE AREA

25 cm wide, 18 cm deep. Open to the front through a hinged and removable flame shield of about 10% visible transmission (potentially hazardous UV radiation not transmitted). Sample tray 27 cm wide and 12 cm deep, adjustable to five separate heights.

WEIGHT

Approximately 173 kg (380 lb) net.

DIMENSIONS

61 cm high, 75 cm deep, 119 cm wide (without gas controls). Standard gas controls (32 cm wide); optional gas controls (32 cm wide); automatic gas controls (45 cm wide).

POWER REQUIREMENTS

105-125 or 200-240 volts, 50 or 60 Hz, 250 watts (300 watts with background corrector).

MAGNETIC CARD READER

Accessory for the Model 5000 which permits 2 sets of 6 programs to be stored on a magnetic card and read into the instrument memory at a later time.

MOTORIZED TURRET ACCESSORY

Six-lamp turret which is controlled from the instrument keyboard. Keystroke directs the turret to rotate to bring a specific lamp into operating position.

AS-50 AUTO SAMPLER

Sampling table that presents 50 samples, plus blank and up to three standards to the instrument for analysis. AS-50 keyboard controls the element sequencing when the instrument is running in the fully automated mode.

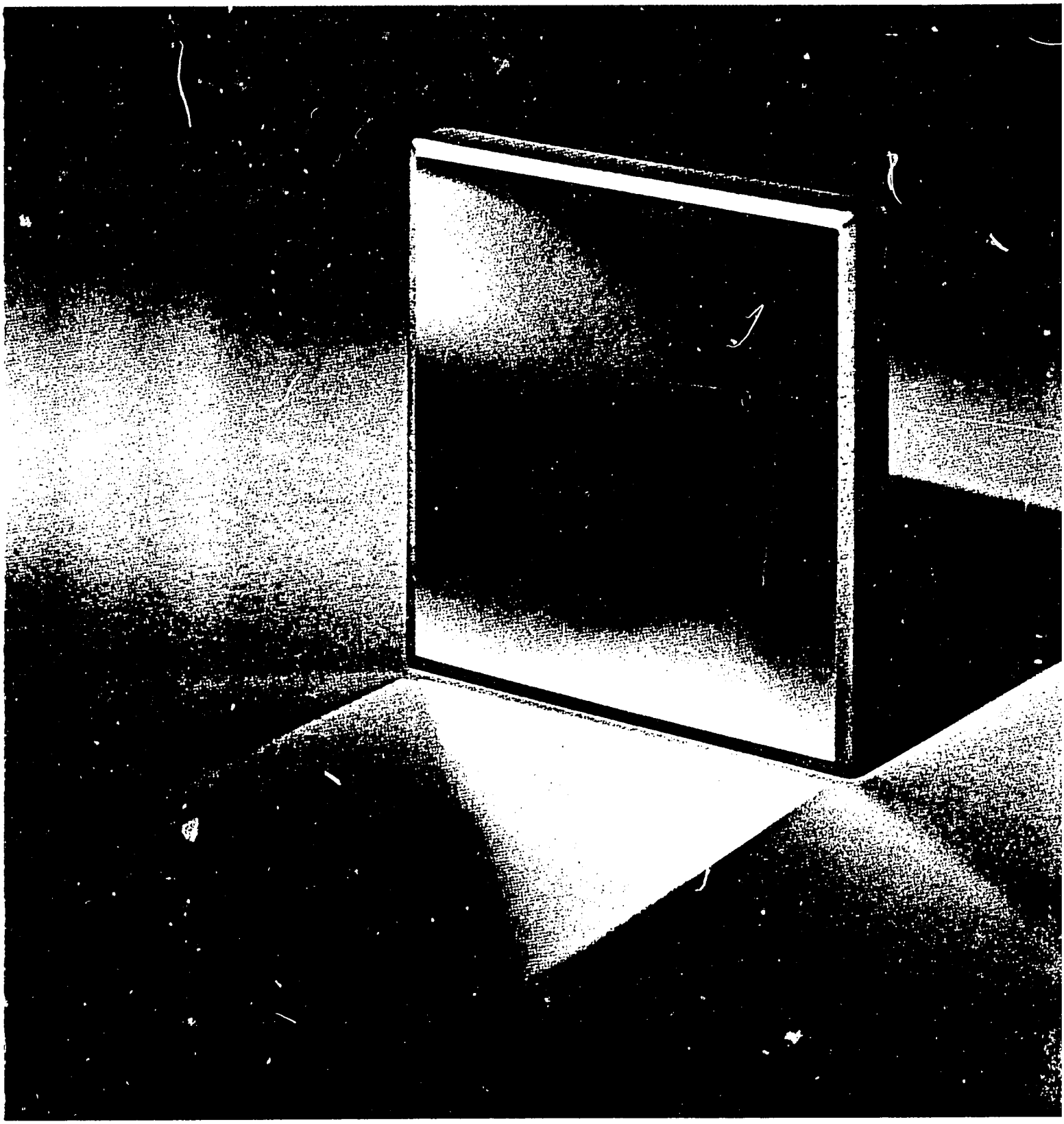
LITERATURE

In addition to normal instruction manuals, each instrument comes with a copy of the A.A. "Cookbook" (Analytical Methods for Atomic Absorption Spectrophotometry), which gives detailed instructions for 70 elements and over 400 analyses. The Cookbook is furnished in loose-leaf format and is updated periodically free-of-charge. Also supplied with each instrument is a free, one-year subscription to the Atomic Absorption Newsletter, devoted to atomic absorption and allied fields and published bimonthly.

TRAINING COURSE

Purchase of an atomic absorption spectrophotometer from Perkin-Elmer entitles the purchaser to send one operator to a free training course. Courses are given in fourteen different locations in the U.S., Canada and Europe by Perkin-Elmer atomic absorption specialists on a regularly scheduled basis.

MODEL 5000 ATOMIC ABSORPTION SPECTROPHOTOMETER



PERKIN-ELMER

Order No. L-566 December 1978 DP-12/78 20

Perkin-Elmer Corporation, Instrument Division, Norwalk, Connecticut 06856 USA
Coleman Instruments Division, 2000 York Road, Oak Brook, Illinois 60521 USA
Bodenseewerk Perkin-Elmer & Co. GmbH, D-7770 Ueberlingen, West Germany
Perkin-Elmer Limited, Beaconsfield, Buckinghamshire HP9 1QA, England

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The Completely Automated Model 5000 Atomic Absorption Spectrophotometer

1 BURNER SYSTEM
Gas pressures, flame, burner head and drain are all monitored for the safest system ever.

2 STANDBY MODE
Conserves power and preserves memory while instrument is not in use.

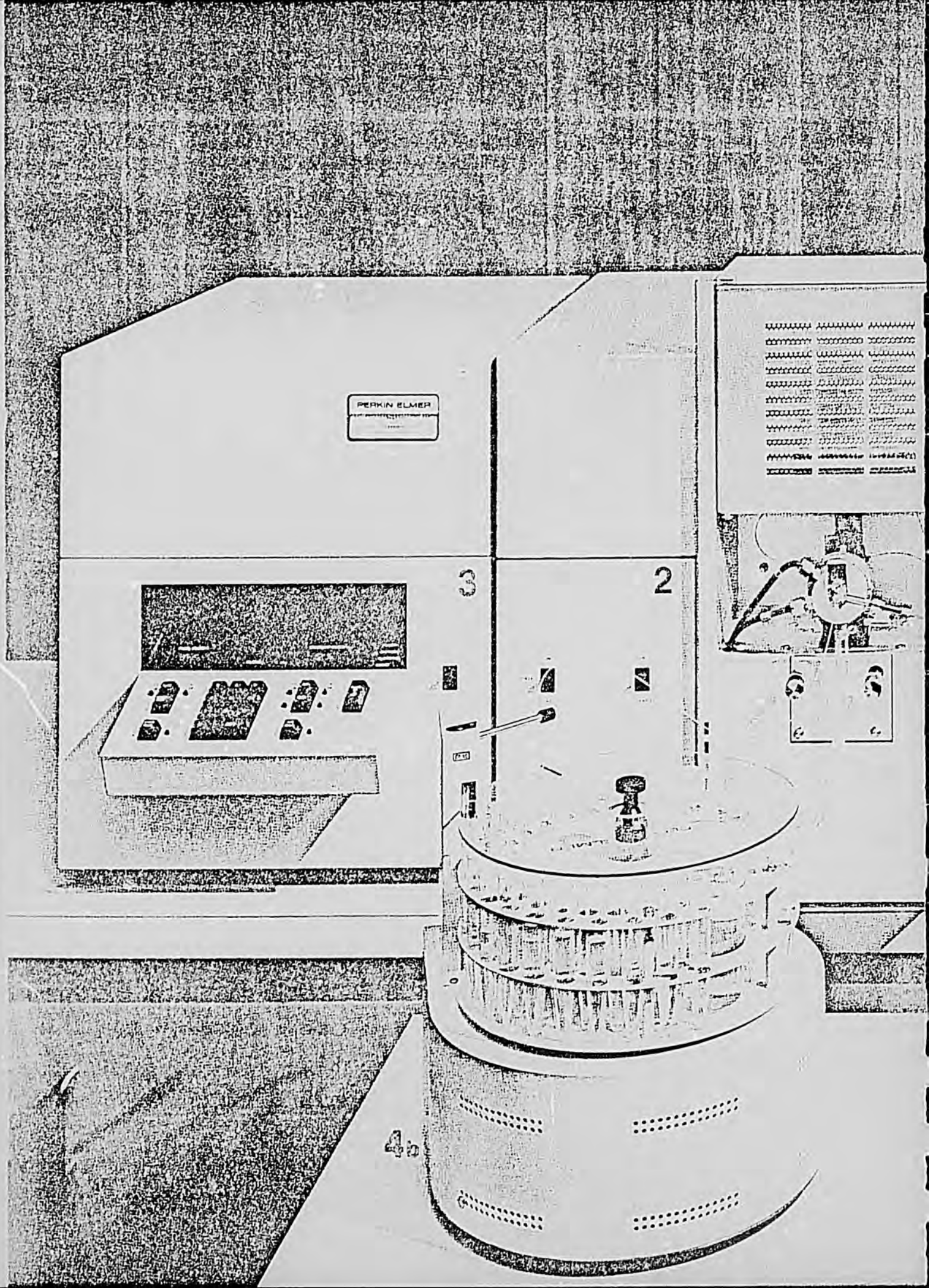
3 AUTOMATIC BURNER CONTROL
Optimum gas flows are automatically set for each element for uncompromised performance.

4 AS-50 AUTO SAMPLER
a. Microprocessor Control Unit.
b. Circular Sampling Table.
Microprocessor-controlled auto sampler provides centralized system control and automatic standardization for automated multi-element analysis.

5 HIGH-ENERGY OPTICAL SYSTEM
Provides the ultimate in performance, high precision and low detection limits with or without UV/Visible background correction.

6 MOTORIZED 6-LAMP TURRET
Prealigned sources are automatically selected for multi-element analysis.

239


PERKIN ELMER
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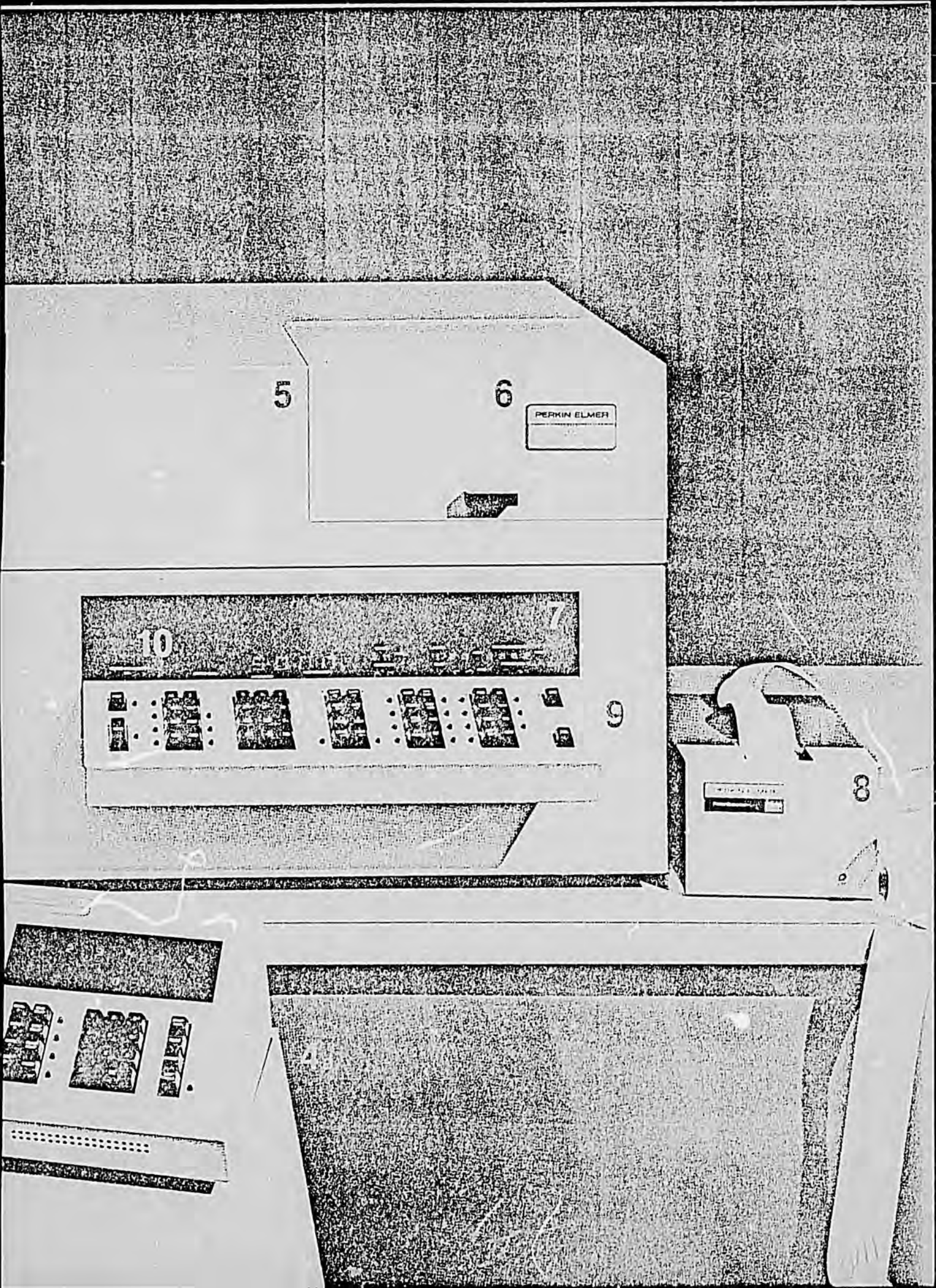
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6
PERKIN ELMER
7
10
9
8

7 **INSTRUMENT CONTROL PANEL**
Systematically organized, clearly labelled keys and displays provide easy setup and verification of instrumental parameters.

8 **PRS-10 PRINTER-SEQUENCER**
Provides a complete printed record of analytical data and sample identification.

9 **SIX COMPLETE PROGRAM MEMORIES**
Retains complete analytical programs for six different elements; provides precise, automatic instrument setup for the selected element at the push of a button.

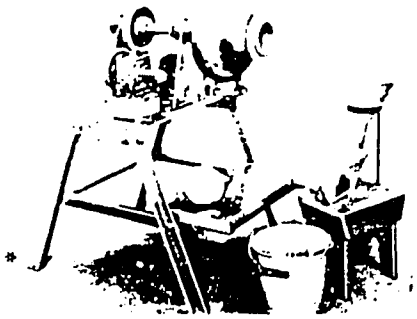
10 **MAGNETIC CARD READER**
Allows permanent storage and instant, push-button recall of an unlimited number of analytical programs.

COMMUNICATIONS INTERFACE (Not Shown)
Two-way RS-232C interface for versatility and adaptability to data terminals and external computer control.

Figure 8. *The Completely Automated Model 5000 Atomic Absorption Spectrophotometer*

DENVER

12"x5" DENVER LABORATORY BATCH BALL MILL



The DENVER Laboratory Batch Ball Mill makes possible simulation of grinding in a ball mill-classifier circuit. Grinding is conducted for a fixed time, then the materal is discharged and classified. The material is then returned to the mill for further grinding.

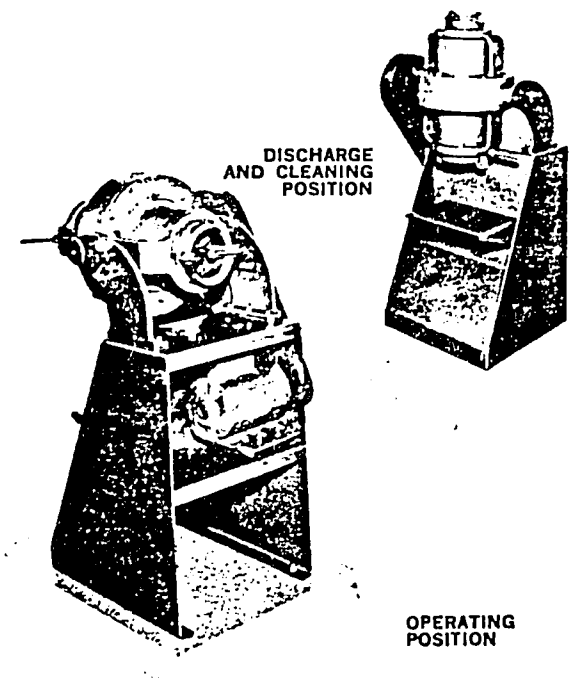
The cast steel grinding drum has a 2-4 kg. capacity, depending on material, and is driven by a ¼ h.p. motor with gear reducer and V-belt. A recommended 40 lb. mixed size ball charge is available. The steel stand is supplied.

Unit can be used for the amalgamation of table and flotation concentrates by using one 4" ball during the grinding cycle.

Machine* Size	Steel Stand	Dimensions			Approx. Shpg. Wt. Lbs.
		L	W	H	
12"x5"	With	39"	25"	42"	340
12"x5"	Without	30"	19"	18"	280

*A recommended 40 pound charge of assorted alloy steel grinding balls is available at a small additional cost.

7"x14" DENVER LABORATORY ROD MILL (Batch)



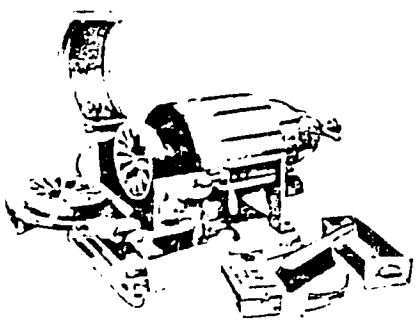
The capacity of the 7" x 14" DENVER Laboratory Rod Mill is 3 kg. (6.6 lbs.). The unit comes complete with a 58-lb. mixed size rod charge, steel base, motor, V-belt drive, and drive guard.

Wet or dry grinding is accomplished with the mill operating locked in the horizontal position. The mill is tilted on its axis for charging and emptying. The mill stand has an adjustable shelf so that containers of varying size can be used for holding mill discharge. Single-piece construction permits easy cleaning and eliminates contamination.

The mill can be used as a ball mill by replacing the rods with either steel or ceramic grinding balls.

Compactness makes this grinding unit a most useful tool in the testing laboratory.

Size	Drum Capacity	Motor	R.P.M.	Dimensions			Approx. Shpg. Wt. Lbs.
				L	W.	H	
7"x14"	3 kg.	½ H.P.	1200	21"	20"	36"	550



BRAUN PULVERIZER PLATES

MODEL	MATERIAL
Standard 51-52	Alloy Steel
81-82	Low phos. steel
83-84	Mn. steel
85-86	Hardened plate
87-88	For coal grind.
92-93	Ceramic
97-98	High Mn. steel

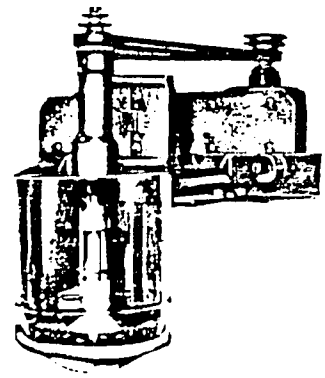
LABORATORY PULVERIZER, BRAUN

Extensively used in assay offices, metallurgical, chemical, and industrial laboratories. A self-locking device holds the hinged grinding chamber in place and affords easy and quick access to the chamber for cleaning. The adjustment of the grinding discs to control product size can be made while the machine is in operation by simply tightening or loosening the adjusting handwheel. This model has sealed ball bearings permanently lubricated at the factory.

MODEL	TYPE	HP	RPM	CAPACITY	OVERALL DIMENSIONS
242-67	Direct	2	900	100-150±hr.	33"x16"x15"
242-67S	Direct	3	900	100-200±hr.	33"x16"x15"

*WARNING
To Illustrate Mechanical Operations

DENVER LABORATORY SUPER AGITATOR AND CONDITIONER (Batch)



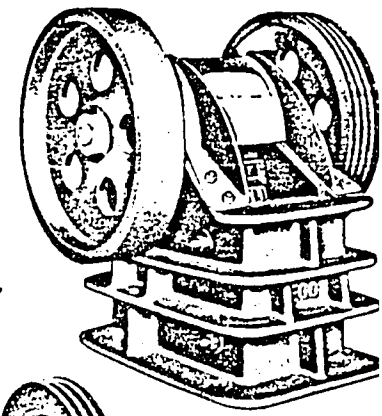
These single unit DENVER Laboratory Super-Agitators and Conditioners (Batch) are available for use in metallurgical, chemical and process laboratories to mix, agitate, condition, scrub or aerate any combination of liquids and solids. This machine is particularly well suited for jobs requiring intense agitation and aeration of high density pulps and/or high specific gravity pulps.

Motor and vari-speed drive is supplied. Units are compact, efficient, and easily cleaned. The results of test work conducted by these units may be closely approximated in commercial practice. The central standpipe provides positive and controlled recirculation and aeration. Feed enters the standpipe and is positively circulated by the propeller. There is no possibility of material short circuiting across the agitator or of solids settling out.

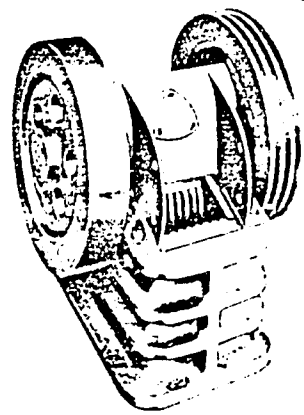
One size of heavy cast, spherical bottom Pyrex jar is furnished as standard equipment with each unit. The jar has a capacity of 1.64 gals. (6.2 liters).

Machine Size	Dimensions			Motor H.P.	Approx. Shpg. Wt. Lbs.
	L	W	H		
No. 1	25"	15"	47"	¼	245

DENVER LABORATORY JAW CRUSHERS



3¼"x4½"



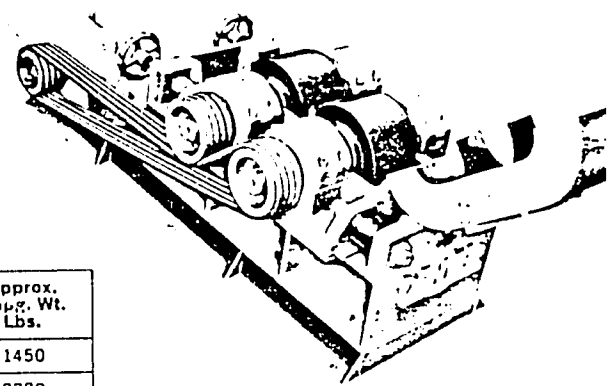
5"x6"

These units are ideal for laboratories and sampling plants where small volumes of material must be crushed. Anti-friction bearing design permits 24-hour continuous operation as is required in sampling tower installations. These crushers are easily installed and are of rugged design for dependable crushing of all types of materials encountered in laboratory and sample preparation work. The 3¼" x 4½" crusher is furnished with a cast alloy iron frame. The 5" x 6" crusher is furnished with a cast steel frame. DENVER Laboratory Jaw Crushers have anti-friction bearings throughout which are grease lubricated. They are easy to clean and simple to operate and maintain.

Size	Movable Jar Depth (In.)	Stationary Jaw Depth (In.)	Side Bearings 1D (In.)	Bumper Bearings 1D (In.)	Flywheel Dia. x Face
3¼"x4½" 5"x6"	8¾" 14"	7½" 12 - 1/6"	1¼" 1⅝"	1¾" 2⅝"	13⅛"x2½" 18"x3¼"

Size	Capacity Lbs./Hr.	Motor H.P.	Crusher R.P.M.	Dimensions			Approx. Shpg. Wt. Lbs.
				L	H	W	
3¼"x4½" 5"x6"	500 600	2 5	350-425 325-375	19" 28"	20" 30"	15" 22"	313 630

DENVER Laboratory Anti-Friction Bearing Crushing Rolls are designed for rugged batch or continuous service. They are easy to operate and a hinged cover simplifies cleaning. Protected anti-friction bearings are held by carriers. Bearings remain in the carriers even though the roll is removed during maintenance. They are never exposed to the dirt and dust of the crushing room. A heavy fabricated feed hopper is supplied. The unit is self-contained and mounted on a structural steel base. Units are gearmotor driven and are designed for attachment of dust enclosure for feed and discharge hoppers.

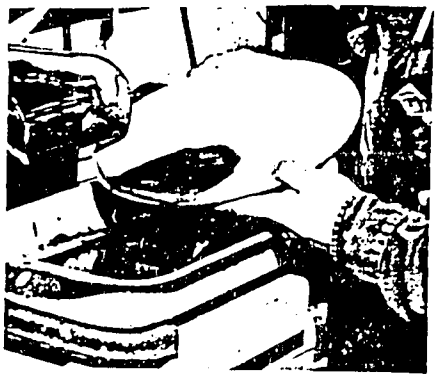


SPECIFICATIONS AND CAPACITIES

Roll Size Dia. x Face	Horsepower Motor	RPM Rolls	Capacity			Approx. Shpg. Wt. Lbs.
			Feed Size	Prod. Size	Tons/Hr.	
10"x6"	3	250-300	0.37"	0.10"	2	1450
12"x8"	5	250-280	0.63"	0.16"	4	2320

*WARNING
To Illustrate Mechanical Operations

DENVER



DENVER LABORATORY VANNING PLAQUE

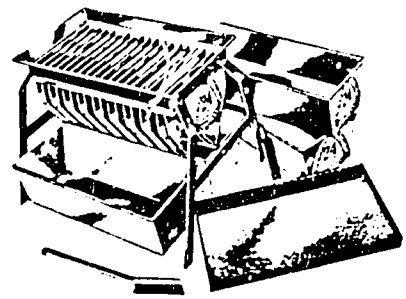
The DENVER Vanning Plaque is ideal for panning small amounts of fine material. This plaque is useful for laboratory work in studying the products from concentrating tests.

Available in durable, non-magnetic stainless steel which permits removal of magnetic materials from the concentrate before microscopic examination.

(Minimum order of 5.)

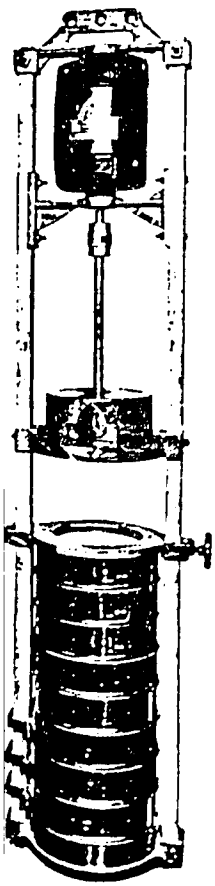
DENVER LABORATORY (RIFFLE) SAMPLE SPLITTER

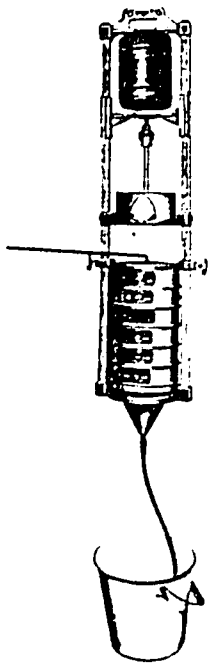
The DENVER Laboratory (Riffle) Sample Splitter is designed to reduce a sample to a convenient size for laboratory analysis. The hopper is divided into several equal compartments. The compartments discharge in alternate direction to provide two portions of the feed. Heavy galvanized steel construction is used. The unit consists of hopper, a four-legged steel support stand, scoop, four sample pans, and a cleaning brush.



Size at Top of Riffles	Riffle Width	Shipping Wt. Lbs.
6" x 8"	½"	35
8" x 10"	¾"	50
10" x 18"	1"	90

DENVER LABORATORY SCREEN ANALYSIS UNIT (WET OR DRY)





The efficient control of grinding and milling operations depends upon accurate screen analyses. The DENVER Laboratory Screen Analysis Unit has a gyrating motion in the suspended shaking mechanism. The sample passes through rapidly and three spring attachments tap the sides of the sieves to prevent particles from adhering or agglomerating. The standard shaking unit consists of the vibrator mechanism and rack which is suspended to provide full gravity action in the screening process. The mechanism is powered by a 1/6 H.P. motor.

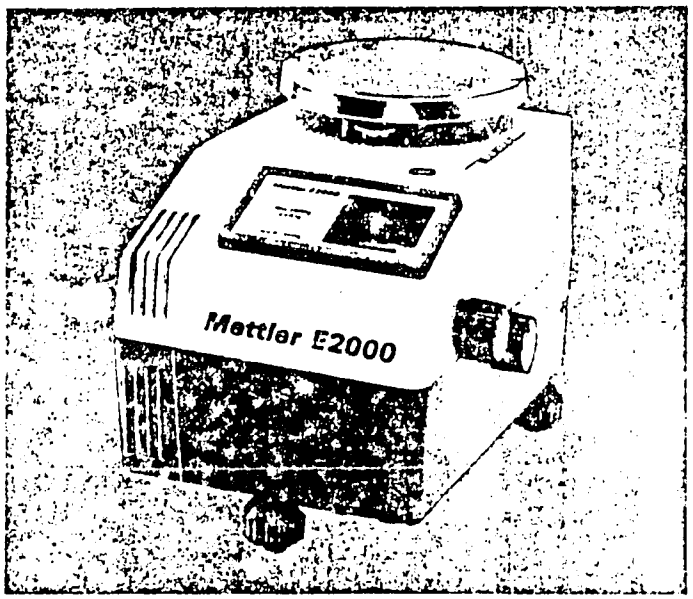
The unit accommodates eight full-height or sixteen half-height standard 8-inch sieves, with cover and bottom pan. The standard screening set includes the following mesh sizes: 3, 4, 6, 8, 10, 14, 20, 28, 35, 48, 65, 100 and 200, together with a top cover and bottom pan and can be supplied with the unit.

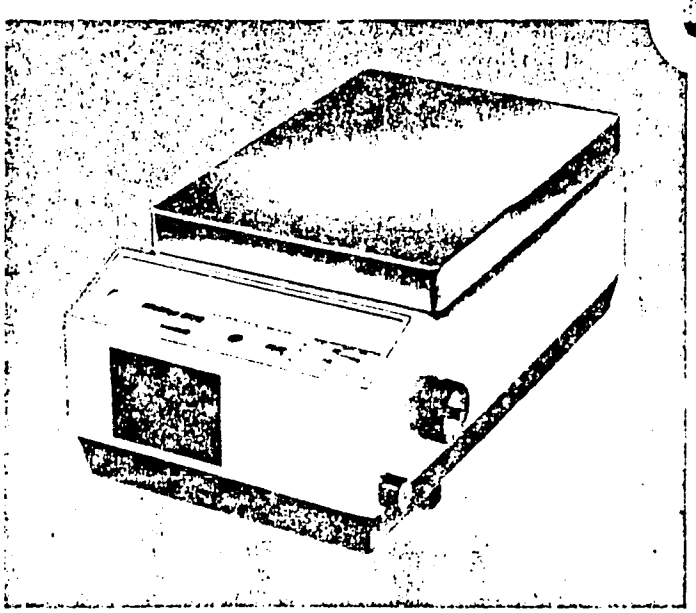
The wet screen analysis adapter kit consists of a special top cover and a funnel attachment replaces the bottom pan.

A time switch can be supplied for stopping the mechanism at any pre-determined time interval.

Size Sieve	Cap. No. Screens*		Dimensions			Motor H.P.	Approx. Shpg. Wt. Lbs.
	Full Height	Half Height	L	W	H		
8"	8	16	12"	9"	54"	⅙	140
*Including bottom pan and cover.							

Mettler Top-Loading Mechanical Balances Cont'd.





E200 and E2000:

- **Low-priced**
- **Ideal for students**

Compact economy-size top loaders with capacity from 300 to 2600g and readability from 0.1 to 0.01g. Ideal for schools where students can easily learn how to use and read them. A good choice for the lab with a large workload and limited budget. Useful in industrial control applications where speed and ruggedness are important.

Mettler E Balances work quickly and efficiently. Just tare off container weight. Add substance to container. Set digital readout on Model E200 and E2000. In 1.5 seconds, read results.

Mettler E200 and E2000 are fully digital, producing easy-to-read weighing results down to the last decimal.

Knife edges and bearing-load supports combined with tension-spring-force compensation systems. With filling guide, fine zero adjustment, hanger for below balance weighing.

Mettler E20: High-Capacity Platform Balance

- **25kg capacity**
- **Readable to 2g**

Weighing range 20kg, for bulky loads encountered in quality control, production and plant use. Taring range 5kg by re-zeroing optical scale with side knob . . no calculations.

Projected scale is distortion-free, digital to nearest 50g, with analog scale in 10g divisions, estimable to 2g. Air-damped. Result in 3 seconds. Reproducibility ±1g.

Weighing pan is a big, accessible platform 33x46cm, suitable for large containers, bulky articles. Portable. Net weight, 19kg.

Equipped with tare indicator and filling guide (shows approximate weight continuously). 110-240V 50/60Hz.

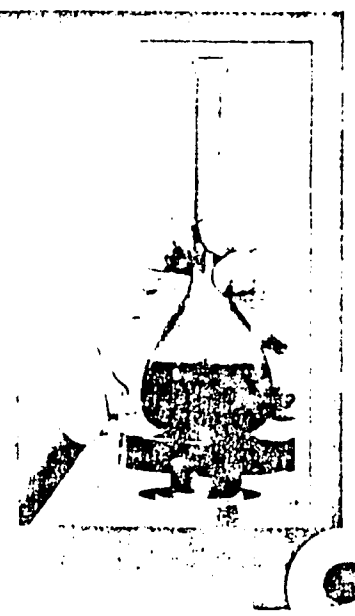
1-913-73 .....2585.00

Item 42

Mettler E Balance Performance Data

Model	E200	E2000
Capacity (g)	300	2600
Precision (g)	±0.02	±0.2
Readability (g)	0.01	0.1
Weighing Range (g)	200	2000
Taring (g)	100	600
Optical Scale Range (g)	200	2000
1 Scale Div (g)	1	10
Filling Guide, 1 Scale Div (g)	20	200
Digital Micrometer, 1 Div (g)	0.01	0.1
Weighing Pan (mm)	130	130
Balance Housing		
L (mm)	240	240
W (mm)	200	200
H (mm)	195	195
Power Supply	110-240V 50-60Hz	110-240V 50-60Hz
Weight		
Net (kg)	4.6	4.7
Shp (kg/lb)	9/20	9/20
Cat. No.	**1-913-70**	**1-913-71**
Ea	1125.00	1065.00

Lint-Free Nylon Gloves



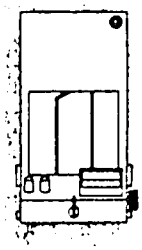
White nylon gloves are lint-free, flexible. Recommended for handling balance weights and samples. Size 9.

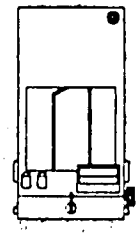
1-912-5 .....Pk of 3 pr/10.50

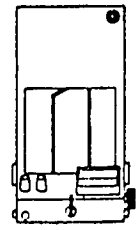
Performance Data For Mettler Analytical Balances

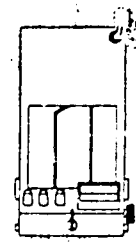
DISCONTINUED

All Series H balances are equipped with high-speed filling guide and weight knob direction indicator. Other design data on preceding page.









Model	H31AR	H33AR	H35AR	H51AR
Description	Basic micro balance with readout to 0.1mg. Protective air release system. Optical tare over 0-1000mg range: 161g capac.	Same as H31AR except with preweighing feature.	Macro balance with rapid taring over full 160g weighing range; readout to 0.1mg; 170g capac. Protective air release system and preweighing feature.	Semi-micro balance with readout to 0.01mg: 160.1g capac; 125mg optical range; protective air release system; taring over optical range.
Item 29				
Special Features				
Air Release System	■	■	■	■
Automatic Preweighing		■	■	
Optical Range Taring	■	■		■
Full Range Taring			■	
Capacity				
Weighing Range (g)	0-160	0-160	0-160	0-160
Taring in Optical Range (g)	1	1	1	0.1
Additional Tare Weight (g)	—	—	10	—
Total (g)	161	161	170	160.1
Precision				
Standard Deviation (mg)	±0.05	±0.05	±0.05	±0.01
Readability				
Analog Scale-Est. (mg)	—	—	1	—
Digital Reading Device-Direct (mg)	0.1	0.1	0.1	0.01
Optical Scale				
Range (mg)	0-1000	0-1000	0-1000	−5 to +25
1 Scale Div (mg)	10	10	10	1
1 Digital Step (mg)	0.1	0.1	0.1	0.01
Filling Guide				
1 Scale Div (mg)	100	100	100	10
Built-In Weights				
Set of Wts (g)	159	159	159	159.9
Additional Tare Wt (g)	—	—	10	—
Accuracy: Ea Wt Comb. (mg)	±0.18	±0.18	±0.18	±0.1
1 Dialing Step (g)	1	1	1	0.1
Taring System				
Max Tare (g)	160	160	160	160
By Setting Optical Scale to zero (g)	1	1	1	0.1
By Use of Built-In Wts (g)	159	159	159	159.9
Pan Dia x Bow H (cm)	8.9x18	8.9x18	8.9x18	8.9x18
Housing				
LxW (cm)	46x24	46x24	51x24	51x24
H (cm)	41	41	42	41
Chamber				
LxW (cm)	17x20	17x20	17x20	17x20
H (cm)	20	20	20	20
Shp Wt (kg/lb)	18/40	18/40	19/42	18/40
Net Wt (kg/lb)	11/24	11/24	12/26	11/24
Cat. No.	1-909-31AR	1-909-33AR	1-909-35AR	1-909-51AR
Ea	1875.00	2135.00	2350.00	2350.00

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Cathetometers

Low-Priced Model

For reading thermometers and barometers. Measures vertical and horizontal distance with moderate precision. Guide bar is 120cmL (47") with 100cmL (39") scale. Readable to 0.5mm with integral vernier. Spirit level and horizontal tilting device on telescope carriage permit instrument adjustment.

Telescope has 23.5mm aperture. Achromatic objective has a draw tube for 60cm focus. Auxiliary lens allows focusing to 32cm. Telescope rotates 360°. Vernier remains on scale for readings at any angle.

For coarse adjustments to telescope height, raise or lower sleeve by hand. Make fine adjustments with knob.

4-725.....1025.00

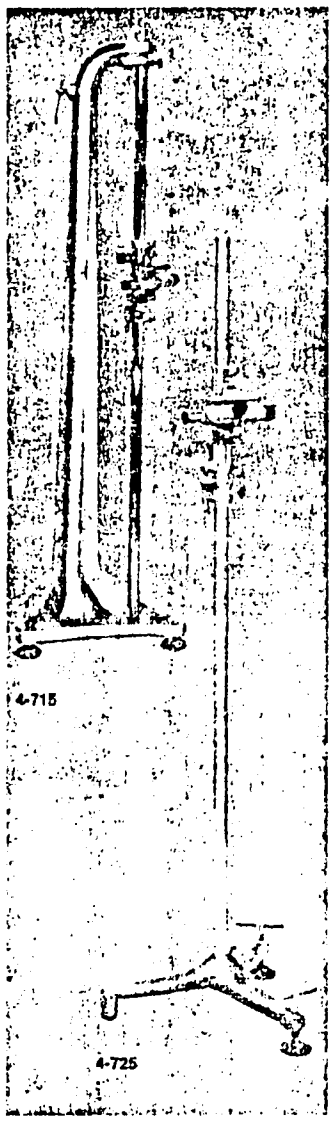
Max Accuracy Model

Ideal for reading thermometers and barometers, measuring objects too big for calipers or micrometers.

Consists of support stand, locking device (for horizontal and vertical measurements), spirit level (preset for leveling accuracy), 100cm scale bar (graduated in 0.5mm increments, readable to 0.01mm with vernier) and Reed-mounted telescope (accepts standard microscope eyepieces and objectives).

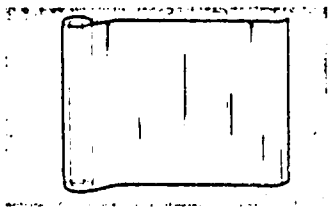
Telescope carriage fully adjustable. With 10 power scale magnifier. Working distance from 32cm to infinity.

4-715.....1609.00



Dust covers to draft shields. Can be cemented with celluloid cement. Can also be rolled to make cylinders or funnels. Lightweight, 0.1" (0.25mm) thick. Sheet 50Lx20"W (127Lx51cmW).

4-740-5.....Per sheet 5.80
Pk of 15/74.00



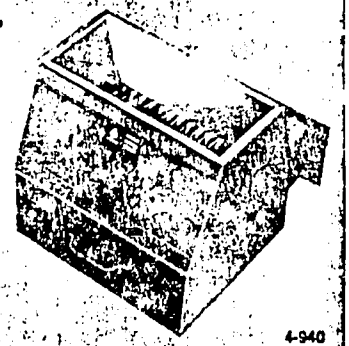
Cement Testing Apparatus

Riffle Sampler

Prepares coal and coke for tests in accordance with ASTM D271.

Material poured in top of sampler is divided by 24 slots and halved into representative samples. Material is then removed from drawers where it has collected. Collected materials are repoured until desired number of samples is obtained.

Entirely enclosed except on top. Full length hinges and pressure latches on doors contain the dust. Stainless steel, 15Lx11½Wx14"D (38Lx29Wx36cmD). With scoop and cleaning brush.



Shipping wt 23kg (50 lb).

4-940.....248.00

Drawers for 4-940.

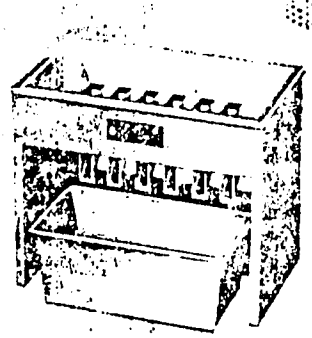
4-940-5.....26.00

Riffle Samplers

With open pan receivers

Sample poured into funnel-shaped trough is divided into 2 parts by 2 series of chutes which discharge alternately in opposite directions into separate pans.

Ordering Information: With collecting pans, scoop, and brush for collecting fine material and cleaning riffle after use. Available in 4 chute widths.



Riffle LxW	Chutes No./W	No. of Pans	Cat. No.	Ea
25x15cm (10x6")	24/0.9cm (⅜")	4	4-942A	147.00
15x15 (6x6)	12/1.3 (½)	4	4-942B	158.00
25x20 (10x7⅞)	12/1.9 (¾)	4	4-942C	58.00
50x24 (19 11/16x9 7/16)	16/2.5 (1)	3	4-942D	202.00

Replacement riffle pan for 4-942. Heavy tin plate. Top edges bound over heavy wire.

For Riffle Size	Cat. No.	Ea
15x15cm	4-942-5B	£.25
25x15, 25x20	4-942-5C	10.85
50x24	4-942-5D	21.00

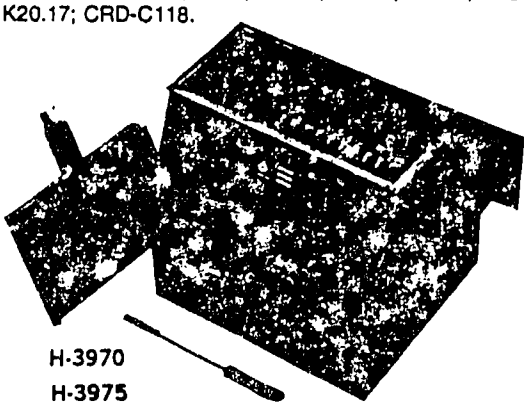
Replacement riffle brush.

For Riffle Size	Cat. No.	Ea
15x15cm	4-942-10	4.75
25x20		
42x23		

ENCLOSED SAMPLE SPLITTER

H-3975 Riffle-type, enclosed, for reduction of pulverized coal and coke to laboratory samples. Sample enters series of 24 slots, each ⅜" (10mm.) wide. Each slot continues into a correspon ing chute, consecutive chutes deliver alternately into one of the other of two sample receiving drawers. Doors fitted with full-length hinges and pressure latches to contain the dust. Interchangeable sample drawers. Constructed entirely of stainless steel. Size 15"H x 11-½"W x 14"D (381mm. x 292mm. x 356mm.). Complete with scoop and cleaning brush.

Meets ASTM C702, D410, D2013, D3176, D3180; ANS K18.1, K20.8, K20.17; CRD-C118.



H-3970
H-3975

SAMPLE SPLITTERS

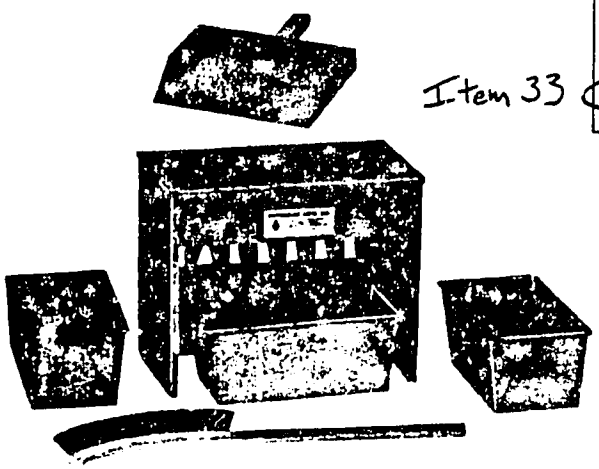
Riffle-type, for dividing or halving dry materials, such as cement, gravel, powdered ores, coal and coke, sand, soils, etc. Material poured into hopper is divided into two equal portions by two series of chutes which discharge alternately in opposite directions into separate pans. Includes pans, scoop, and cleaning brush. All hoppers and chutes are stainless steel; also pans for H-3966.

Meets ASTM B215, C136, C702, D421, D424, D457, D806; AASHTO T27, T144, T248; ANS A38.8, K18.1; AOCS Meth Abl49: CRD-C103.

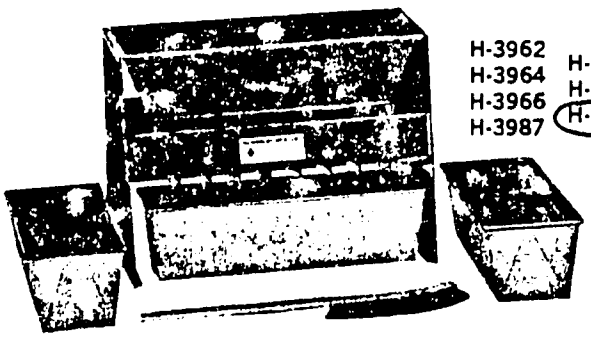
Model	No. of Chutes	Width of Chutes		Hopper Size	Pans Furn.	Ship Wt.		Cube. cont.
		In.	mm			lbs.	kg.	cu. ft.
H-3962	14	⅛	10	6¾" x 8" (172mm. x 203mm.)	4	14	6.2	2.0
H-3964	14	½	13	6¾" x 11" (172mm. x 279mm.)	4	17	7.7	3.5
H-3966	14	¾	19	6¾" x 14¾" (172mm. x 375mm.)	4	21	9.5	3.5
H-3970	14	⅛	10	6½" x 8" (165mm. x 203mm.)	2	22	10.0	1.5
H-3975	24	⅛	10	4½" x 11" (114mm. x 279mm.)	2	25	11.4	3.5
H-3980	12	½	13	8½" x 11" (216mm. x 279mm.)	4	15	6.8	1.5
H-3985	12	¾	19	8½" x 14" (216mm. x 356mm.)	4	21	9.5	1.5
H-3987	16	1	25	9" x 20" (229mm. x 508mm.)	4	31	14.1	4.5
H-3989	8	2	50	9½" x 19½" (241mm. x 495mm.)	4	27	12.3	4.5
H-3990	10	1½	38	9" x 20½" (229mm. x 520mm.)	4	50	22.7	4.5
H-3992	8	2½	65	9" x 24" (229mm. x 610mm.)	4	50	22.7	8.5

Item 33

(Replacement Pans for Sample Splitters are listed on page 36)

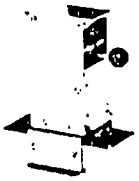


H-3980 H-3985



H-3962
H-3964
H-3966
H-3987
H-3989
H-3990
H-3992

H-3998 BRUSH only. Same as originally furnished with all the above Sample Splitters except H-3970 and H-3975.



H-3973

H-3971C

MICROSPLITTERS

For fine materials that segregate easily, particularly low-grade and radio-active ores. Ruggedly constructed of stainless steel and aluminum alloys made entirely of non-magnetic metals. Furnished with deep-drawn aluminum alloy sample pans with rounded corners and no seams to trap the materials. The hopper is designed with a cut-off gate that stops flow of materials from the hopper (prevents possible errors normally caused by pouring out of a corner of a pan into riffles).

MODELS

HP-3971C 16 - ⅛" (3mm.) chutes with 2 pans.
Hopper size 4¼" X 4¼" X 3½" D (108mm. X 108mm. X 89mm.).
Pan size 2" W X 3½" L X 1¾" D (51mm. X 89mm. X 45mm.).
Overall dimensions 4½" X 4½" X 8" H (115mm. X 115mm. X 203mm.).

Shpg. wt. 7 lbs. (3.2kg.).

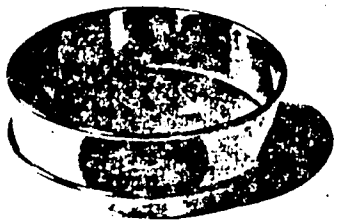
H-3973 32 - ¼" (6mm.) chutes with 2 pans.
Hopper size 7" X 8¼" X 3½" D (178mm. X 210mm. X 89mm.).
Pan size 5¾" W X 9¾" L X 4" D (146mm. X 248mm. X 102mm.).
Overall dimensions 9½" X 12" X 11½" H (241mm. X 305mm. X 292mm.).

Shpg. wt. 23 lbs (10.4kg.). Cube. cont. 1.7 cu. ft.

MICROSPLITTER REPLACEMENT PANS

H-3972 PAN — same as furnished with H-3971C Microsplitter.
H-3973.1 PAN — same as furnished with H-3973 Microsplitter.

U.S. Standard Sieves



Fine

Made in accordance with specifications outlined in ASTM E-11, USA Standard Z23.1, AASHO M92, and Fed Spec RR-S-366b. Sieve opening sizes follow recommendations of the International Standards Organization. Sieves marked with US sieve number and opening size in mm and inches. Seamless 20.3cm (8") dia frames. Wire cloth carefully soldered to frame. Supplied in individual corrugated cartons.

U.S. Series Designation Standard (=Sieve Opening)	Alternate	Wire Dia (Nominal)	Tyler Screen Scale Equiv. Desig.	Cat. No. Brass Frame 5.1cm (2") H	2.5cm (1") H	Ea 4-881 and 4-881-5	Cat. No. Stainless-Steel Frame 5.1cmH	Ea 4-881-10
5.6mm	3½"	1.68mm	3½ mesh	4-881A	4-881-5A	25.50	4-881-10A	46.50
4.75	4	1.54	4	4-881B	4-881-5B	25.50	4-881-10B	46.50
4.00	5	1.37	5	4-881C	4-881-5C	25.50	4-881-10C	46.50
3.35	6	1.23	6	4-881D	4-881-5D	25.50	4-881-10D	46.50
2.80	7	1.10	7	4-881E	4-881-5E	23.50	4-881-10E	42.75
2.36	8	1.00	8	4-881F	4-881-5F	23.50	4-881-10F	42.75
2.00	10	0.900	9	4-881G	4-881-5G	23.50	4-881-10G	42.75
1.70	12	0.810	10	4-881H	4-881-5H	23.50	4-881-10H	42.75
1.40	14	0.725	12	4-881J	4-881-5J	23.50	4-881-10J	42.75
1.18	16	0.650	14	4-881K	4-881-5K	23.50	4-881-10K	42.75
1.00	18	0.580	16	4-881L	4-881-5L	23.50	4-881-10L	42.75
850µm	20	0.510	20	4-881M	4-881-5M	23.50	4-881-10M	42.75
710	25	0.450	24	4-881N	4-881-5N	23.50	4-881-10N	42.75
600	30	0.390	28	4-881P	4-881-5P	23.50	4-881-10P	42.75
500	35	0.340	32	4-881Q	4-881-5Q	23.50	4-881-10Q	42.75
425	40	0.290	35 Item	4-881R	4-881-5R	23.50	4-881-10R	42.75
355	45	0.247	~~42~~ 36	4-881S	4-881-5S	23.50	4-881-10S	42.75
300	50	0.215	48	4-881T	4-881-5T	23.50	4-881-10T	42.75
250	60	0.180	60	4-881U	4-881-5U	23.50	4-881-10U	42.75
212	70	0.152	65	4-881V	4-881-5V	23.50	4-881-10V	42.75
180	80	0.131	80	4-881W	4-881-5W	23.50	4-881-10W	42.75
150	100	0.110	100	4-881X	4-881-5X	24.25	4-881-10X	43.50
125	120	0.091	115	4-881Y	4-881-5Y	24.90	4-881-10Y	43.85
106	140	0.076	150	4-881Z	4-881-5Z	26.50	4-881-10Z	45.75
90	170	0.064	170	4-881AA	4-881-5AA	29.90	4-881-10AA	48.7[illegible]
75	200	0.053	200	4-881BB	4-881-5BB	33.00	4-881-10BB	51.00
63	230	0.044	250	4-881CC	4-881-5CC	39.00	4-881-10CC	57.50
53	270	0.037	270	4-881DD	4-881-5DD	50.25	4-881-10DD	73.75
45	325	0.030	325	4-881EE	4-881-5EE	58.35	4-881-10EE	84.50
38	400	0.025	400	4-881FF	4-881-5FF	85.90	4-881-10FF	117.00

5.1cm (2") Deep Receivers

Brass for 4-881 and 4-881-5. Stainless steel for 4-881-10.

Type	Cat. No.	Ea
Brass	4-886B	13.00
Stainless-steel	4-887B	30.25

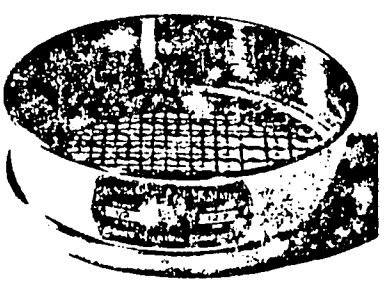
4.75 (1¼") Deep Separator Pan

Brass. ½ height with extended rim. Place between stacked 20.3cm (8") dia sieves for sieving two or more samples simultaneously. 4.75Dx20.3cm dia (1⅞x8").
4-887-10 .....15.65

Sieve Covers

Brass for 4-881 and 4-881-5. Stainless steel for 4-881-10.

Type	Cat. No.	Ea
Brass	4-886A	7.75
Stainless-steel	4-887A	16.00



Coarse

Made in accordance with specifications outlined in ASTM E11, USA Standards Z23.1, AASHO M92, and Fed Spec RR-S-366b. Sieves marked with size of opening in mm and inches. Seamless brass frames. 5.1cmH (2") above brass wire cloth. Supplied in individual corrugated cartons.

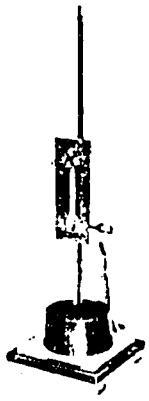
U.S. Series Designation Standard (=Sieve Opening)	Alternate	Nominal Wire Dia	Tyler Screen Scale Equivalent Designation	Cat. No.	Ea
25.0mm	1"	3.80mm	---	4-882A	25.50
19.0[2]	¾	3.30	.742"	4-882C	25.50
16.0[2]	⅝	3.00	.624	4-882D	25.50
12.5[1]	½	2.67	----	4-882E	25.50
9.5[2]	⅜	2.27	.371	4-882G	25.50
8.0[2]	5/16	2.07	2½ mesh	4-882H	25.50
6.3[1]	¼	1.82	----	4-882J	25.50

[1]*These sieves are not in the fourth root of 2 series, but they have been included because they are in common use.*
[2]*These sieves have opening sizes following recommendations of the International Standards Organization.*

Brass sieve covers for 4-882.
4-886A 7.75

Brass 5.1cm deep receivers for 4-882.
4-886B 13.00

Mesh Series Sieve
See 14-295, 14-305, page 1068.



Vicat Cement Consistency Tester

Determines normal consistency and time of setting of hydraulic cement in accordance with ASTM C187 and AASHO Method T-129.

With plastic mold for holding cement pat, rod with removable needle and plunger, and scale graduated from 0-50mm.

4-835 ..... 100.00

Plastic mold for 4-835. 7 dia at base x 6 at top x 4cmH (2¾x2⅛x1½"). Guaranteed to pass inspection of Cement and Concrete Reference Laboratory.

4-836 ..... 7.75

Stainless-steel Vicat needles. For 4-835. 1mm dia x 5cmL (.04x2"). Guaranteed to pass inspection of Cement and Concrete Reference Laboratory.

4-837 ..... Ea/ 7.75

Cement Sand

For making standard briquets and pats

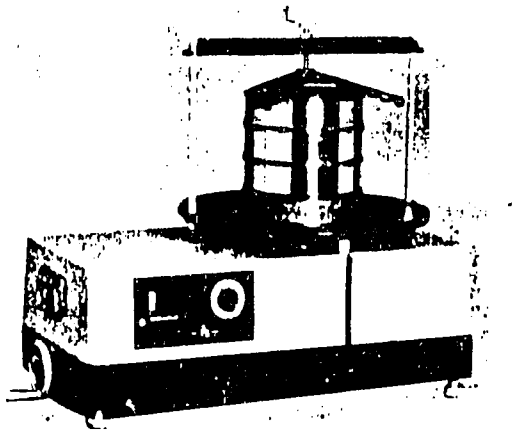
Pure silica sand. Particle size, 850-600μm (20-30 mesh). Specially prepared to conform to ASTM C190 and AASHO T-132

S-23 ..... 5 lb (2.3kg)/9.70

Case of 4:
5 lb units/31.00
25 lb (11.3kg)/26.25
100 lb (45.4kg)/91.25

Fisher-Wheeler Sieve Shaker

Adjustable for 15-30cm sieves



Handles entire stack of sieves at once and shakes sieves identically on each run. Ideal for cement, coal, glass, metallurgy, graphite, pigments, detergents, dry chemicals, pharmaceuticals.

Unique patented design produces combined vertical and horizontal motion. Sieves 6-16" (15-40cmH) and 6-12" dia (15-30.5cm) are held in place by 3 notched legs which screw down on top of sieve stack.

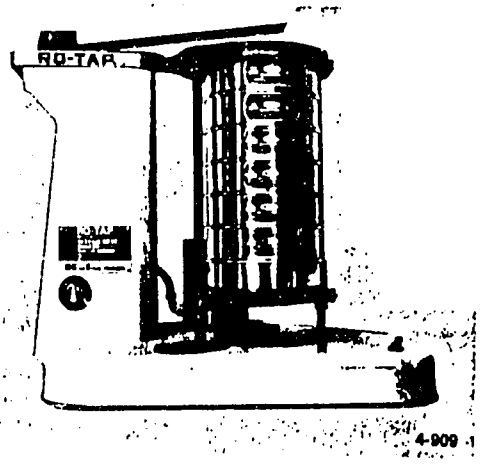
Shaking rate adjustable from 500-900 vibrations/min. Control switch allows continuous shaking or activates an automatic timer that can be set for shaking periods of 1-30min duration.

Ordering Information: Finished in chemical-resistant enamel. 34Lx13½Wx11"H (86Lx34Wx28cmH). With carrying handles; without sieves. For 115V 60Hz. Shipping wt 61kg (135 lb).

4-907 ..... 1295.00

Automatic Ro-Tap Sieve Shaker

For 20.3cm (8") sieves



Electric sieve shaker reproduces circular and tapping motion used in hand sieving. Uniform mechanical action assures accurate, dependable results.

Handles 20.3cm dia (8") sieves. Six 5.1cmH (2") or thirteen 2.5cmH (1") sieves with different size openings can be shaken at one time.

With automatic timer. 186.5W (¼hp) motor for 115V 60Hz. 25Hx28Wx21"D (63.5x71x53cm). Without sieves. Shipping wt 90kg (200 lb).

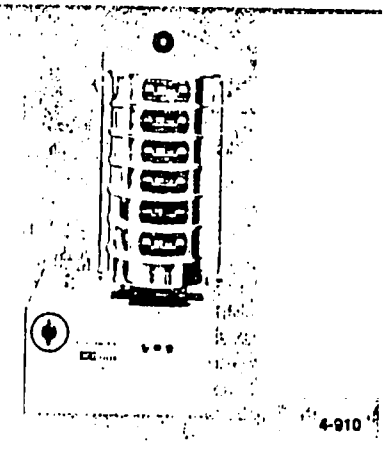
4-909 ..... 935.00

For 230V 50Hz.

4-909-2 ..... 935.00

Portable Sieve Shaker

For 20.3cm (8") Sieves



Motor-driven shaker is rugged, yet light enough for transporting from place to place. Handles six 5.1cmH (2")or thirteen 2.5cmH (1") sieves with pan and cover. Sieves are actuated by specially designed mechanism to provide correct shaking action. Without sieves. For 115V 60Hz.

4-910 ..... 255.50

For 230V 50Hz.

4-910-1 ..... 303.00

951