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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

Final Report

14839

Mozambique.

TECHNOLOGICAL AND NON-METALLIC TESTING AND DEVELOPMENT LABORATORY

in

MOZAMBIQUE

Project ST/MOZ/82/001

Contract 83/44 SM

Prepared by

LKAB INTERNATIONAL

May 1985

TECHNOLOGICAL AND NON-METALLIC TESTING AND DEVELOPMENT LABORATORY IN MOZAMBIQUE

TABLE OF CONTENTS

TABLE OF CONTENTS cont.

TECHNOLOGICAL AND NON-METALLIC TESTING AND DEVELOPMENT LABORATORY IN MOZAMBIQUE

TABLE OF APPENDICES

TABLE OF APPENDICES cont.

EXECUTIVE SUMMARY

This report presents a proposal for a Technological and Non-Metallic Testing and Development Laboratory in Mozambique. The report constitutes a revision of an earlier delivered Draft Final Report, to which the views of UNDP, the Mozambican Government and an independant consultant have been added.

The laboratory comprises basically mineral dressing and hydrometallurgical batch-scale units. The laboratory is designed to treat most kinds of ore, even though the highest priority has been given to

* pegmatites
* iron ores
* apatite
* graphite and coal
* beach sands

The site for the laboratory is assumed to be Nampula, implying that offices and other administrative units have been included.

The fixed investment costs have been calculated at SEK million 25.3 (USD million 2.81) with the following breakdown:

	SEK million	USD million
Buildings	6.5	0.72
Equipment	6.3	0.70
Furnishings	1.2	0.13
Mechanical isntallations	0.8	0.09
Electrical installations	2.5	0.28
Ventilation, internal water supply, drainage	2.0	0.22
Engineering and project administration, etc	4.5	0.50
Contingency	1.5	0.17
Total	25.3	2.81

When converting SEK to USD an exchange rate of 9 SEK to the USD has been applied.

Out of the total, approximately 75 % or SEK million 19.0 (USD million 2.1) need to be spent on import of foreign equipment and installation material.

Costs for commissioning and required training of Mozambican personnel is not included in the above summary but are given separately in the report. Neither are overseas freight and insurance costs for imported equipment included, but these items can be roughly estimated at 15 % of the equipment costs.

It should be observed that this proposal includes the installation of a Scanning Electrone Microscope (SEM). It can, however, be questioned if such a sophisticated piece of equipment is justified in the initial phase of building up a mineral dressing laboratory in Mozambique. The postponement of this installation until phase 2 would mean a cost saving of SEK million 2.1 (USD million 0.23) in phase 1.

Cost savings could also be made if certain rooms and space in the office building could be deleted. This could, for instance, be achieved if the laboratory is located adjacent to existing units of a similar character in Mozambique. In such a case it would be possible to do without proposed lecture and conference rooms as well as without the restaurant, kitchen and auxiliary facilities. This would lead to a saving of approximately 450 m2 in building area corresponding to a cost saving in the order of SEK million 1.0 (USD million 0.11).

With the possible simplifications mentioned above the total fixed investment costs would amount to SEK million 22.2 (USD million 2.47), exclusive of commissioning, training, freight and insurance.

The following table shows other basic cost figures and requirements of the laboratory:-

* annual operating costs	SEK million 4.0 (USD million 0.44)
* area requirements	40,000 m2
* power consumption	400 kW
* water consumption	0.3 m3/min (design figure)

A preliminary time schedule for realization of the project shows that the laboratory could go on stream 17 months after a go-ahead decision.

TECHNOLCGICAL AND NON-METALLIC TESTING AND DEVELOPMENT LABORATORY IN MOZAMBIQUE

CHAPTER I - SUMMARY

1. Introduction and design criteria

As per Contract No. 83/44/SM between UNIDO and LKAB International AB (LKAB) signed December 6, 1983, LKAB has carried out basic design of a "Technological and Non-Metallic Testing and Development Laboratory" to be set up in the province of Nampula, Mozambique, by Ministério dos Recursos Minerais (MRM).

The laboratory is designed for testing on the laboratory scale, i.e. bench-and-batch scale testing, of mineral dressing as well as glass-and-bench scale of hydrometallurgical processes.

The laboratory is laid out in such a way that most kinds of ores could be treated. As discussed on LKAB's visit to Mozambique in September 1982 and in MRM's report of January 15, 1984, provision is to be made for the treatment of the following ore types and minerals:

High priority

pegmatites
iron ores
apatite
graphite and coal
beach sands

Medium priority

copper ores
feldspar
bentonite and other clay minerals
precious metal ores

Low priority

steel alloy metal ores
industrial minerals other than feldspar

The fundamental objective assumed in the design of the laboratory has been to provide a centre with the capacity to carry out investigations on the ore types mentioned above and, when required, to apply the results thereof in rough cost estimates and pre-feasibility studies. In order to fully utilize the capabilities of the new laboratory it is important that its personnel work closely together with those functions within Mozambique which cover such fields as geology, mining, transportation, industrial infrastructure, the metal market, etc. Only together can the different functions develop a mining project in a satisfactory way.

Another design objective was to create a laboratory for applied research and development rather than a basic research centre. This means that industrial experience among the key personnel to be recruited is important, as is a continuous dialogue between the laboratory and the Mozambique mining industry. International contacts are also vital.

On the technical point level, the laboratory will have the necessary facilities for bench-scale tests on kg-sized samples. Typical of this kind of investigation are samples from exploration work or samples from running ore dressing plants requiring process or product improvements.

Laboratory scale tests cannot normally serve any other purpose than to give preliminary results on mineral dressing characteristics. Before an industrial application can be made, pilot plant investigations are necessary. Such investigations are usually carried out on the 0.5-2 tph scale and do sometimes require tests of long duration to ensure that the influence of changing ore composition and of recirculated intermediate products are studied. No pilot plant is considered at this stage of the project, but it should be envisaged in an expansion stage to follow quite soon after start-up of the laboratory. Until a pilot plant is constructed it may be necessary to send ore samples abroad for pilot plant testing.

Pilot plant tests are not only needed to study various flowsheets and the resulting products; they also have an important rôle to play in the sizing of major equipment in mineral dressing plants. This is particularly important for grinding mill systems which, besides being the most cost-consuming unit operation in many mineral dressing plants, are also of the utmost importance for subsequent beneficiation systems. A third function of pilot plant testing is to produce sufficiently large quantities of mineral concentrates for tests by end-users.

Besides the testing laboratories, the report describes analytical facilities with a scanning electrone microscope and other service facilities.

A general description of the methodology of mineral dressing studies is presented in Chapter II, Section 1, "The rôle of mineral dressing in a mining project".

2. Layouts

A number of layout drawings have been prepared on the scales 1:50 and 1:100.

The complex is composed of three main units:

a) an outdoor small-scale crushing and storage unit

b) a laboratory building with mineral dressing and hydrometallurgical facilities

c) a change-house and office building

The arrangement of the main units is shown on the situation plan FM-2-84-21 (Appendix 1:2) and the persepctive drawing FM 1-84-22 (Appendix 1:3).

Basic layouts are made for the three main units, and for specific facilities more elaborate layouts have been prepared. A list of layout drawings is given in Appendix 1:1. These drawings are presented in A4-size in the report, while full size drawings are submitted separately.

It is anticipated that the structure of the buildings is made of concrete with columns in accordance with current practice. The roof and walls should preferably be of steel panels but local conditions and availability of construction materials may influence selection of material.

3. Description of facilities

For the reasons stated in Chapter II, the establishment of a technological laboratory in Mozambique should be divided into two phases:

Phase 1 with facilities for small scale tests (preferably <10 kg) within mineral dressing and hydrometallurgy;

Phase 2 with facilities for mineral dressing pilot plant tests on the continuous scale and larger scale hydrometallurgical tests.

Brief descriptions of phase 1 of the different facilities and their functions are included in Chapters III-IX.

The facilities allow the following types of test work on common ores, industrial minerals, etc.:

* Mineralogical investigations
* Mineral dressing bench and batch scale tests
* Hydrometallurgical glass and bench scale tests

It is assumed that all chemical analyses necessary for the work of the technological and non-metallic testing and development laboratory will be performed at the existing analytical laboratory at Nampula.

4. Method descriptions

Brief descriptions of the main test and determination methods proposed are included in Chapters IV-IX.

5. Main equipment specifications

To facilitate identification in the following text and drawings the specifications are numbered as follows:

201- Small scale crushing and storage unit
301- Mineral dressing pilot batch scale unit
401- Mineral dressing laboratory
501- Hydrometallurgical laboratory
601- Scanning Electrone Microscope (SEM) Unit
701- Auxiliary equipment

Preliminary specifications are given in the relevant chapters. Brochures with technical descriptions of main equipment are compiled in a separate file.

Preliminary installed power and main equipment costs are tabulated in Appendices 1:4:1-1:4:2.

6. Fixed investment estimates

Fixed investment estimates have been made for the following items:

* Buildings
* Equipment
* Furnishings
* Mechanical services
* Electrical services
* Ventilation, internal water supply and drainage
* Engineering and project administration
* Commissioning
* Training

The estimates, which are given in Swedish currency (SEK), are of a preliminary character and are based on data from equipment manufacturers and on LKAB's experience of similar projects. Local conditions in Mozambique may influence the actual costs.

Fixed investment estimates for earthworks, external power and water supply etc., are not included.

Buildings

Building costs have been estimated as follows:

Volume of laboratory building in m^3: 48x24x4.5 = 5,184

Cost per m^3 in SEK = 700

Building cost in SEK = 3,628,800

Volume of change house and office building in m^3: 2x35x11x3.5+ +23x17x3.5 = 4,064

Cost per m^3 in SEK = 600

Building cost in SEK = 2,438,400

Volume of small scale crushing and storage unit in m3:
18x12x7 = 1,512

Cost per m3 in SEK = 250

Building cost in SEK = 378,000

Total building cost:	SEK
Laboratory building	3,628,800
Change house and office building	2,438,400
Small scale crushing and storage building	378,000
Total	6,445,200
Total rounded to	6,500,000

Equipment costs

The budget prices for equipment are given in Swedish currency ex works, which means that the cost of insurance, overseas freight and domestic freight has to be added to the prices shown. Costs for insurance and overseas freight can be estimated at 15 % of equipment costs.

The budget prices reflect the price level of August 1984.

Costs of certain major spare parts and consumables that can be foreseen for the first two years are included.

The following costs have been estimated for the purchase of equipment etc.:

	SEK 1000
Small scale crushing and storage unit	524
Mineral dressing pilot batch scale unit	651
Mineral dressing laboratory	1,734
Hydrometallurgical laboratory	607
Scanning Electrone Microscope (SEM) Unit	2,065
Auxiliary equipment	725
Total	6,306
Total rounded to	6,300

Furnishings

The cost of furnishing the laboratories, the personnel facilities and the offices etc. has been estimated at SEK 1,200,000.

The above costs, however, depend to a large extent on the standard of the furnishings etc.

Mechanical installations

The equipment installation cost is estimated at SEK 800,000.

Electrical installations

The costs include distribution centres etc. but not the cost of power lines to the plant area and transformer; SEK 2,500,000.

Ventilation, internal water supply and drainage

The costs depend to some extent on local conditions but have been estimated at SEK 2,000,000.

Engineering and project administration

The costs of detailed engineering, procurement and project administration have been estimated at SEK 4,500,000.

Contingency

SEK 1,500,000

Summary of fixed investment costs

The above-mentioned costs are tabulated below:

Type of cost	SEK 1000	Estimated foreign currency %
Buildings	6,500	25
Equipment	6,300	100
Furnishings	1,200	100
Mechanical installations	800	90
Electrical installations	2,500	90
Ventilation, internal water supply, drainage	2,000	80
Engineering and project administration, etc.	4,500	90
Contingency	1,500	90
Total	25,300	75

Commissioning

The commissioning cost for the laboratories etc. is estimated to be in the order of SEK 300,000-500,000 (100 % foreign currency).

Travel and transportation costs and costs of board and lodging etc. are not included.

Training

The need for and cost of training is difficult to predict as it will depend on the level of education etc. of the personnel to be trained.

However, the following categories of personnel should receive special introductory training abroad at suitable research facilities:

- Department heads (2)
- Section heads (2)
- Project engineers (4)

Training programmes for mineral dressing and hydrometallurgy are included in Appendices 1:6-1:12.

Furthermore, one instrument technician and one operator for the scanning electron microscope should receive 3-4 weeks special training on the servicing and handling of the equipment.

The costs for the training abroad of the above-mentioned personnel are estimated at SEK 2,500,000. The cost estimate presupposes that training is carried out by LKAB in Sweden.

The costs include board and lodging for the trainees, but not travel and transportation costs, allowances and salaries.

During commissioning of the laboratory, "on-the-job" training should be provided in Mozambique for all personnel involved. This training should take place under the direction of foreign experts and MRM personnel trained abroad.

During the first year of operation of the laboratory, two foreign specialists should act as personnel training supervisors.

The specialists should cover the following fields:

* Mineral dressing 1 person
* Hydrometallurgy 1 person

This assumes that the scanning electron microscope is to be operated by experienced personnel from the existing laboratory at Nampula.

The costs for the three specialists to train personnel in Mozambique are (100 % foreign curency) SEK 1,900,000.

Travel and transportation costs and costs of lodging, allowances etc. are not included.

7. Operating cost estimates

To make adequate estimates of the operating costs of the laboratory is difficult as they depend to a rather large extent on the local conditions and the volume of work to be performed.

The main costs, however, are personnel salaries. If the employment of foreign experts is not contemplated and the costs per manyear given by MRM for different categories are used, the following preliminary estimates for full scale operation can be made (1 SEK equals about 5 MZM):

	SEK 1000/year
Mineral dressing laboratory	
Salaries	1,005
Consumables	100
Maintenance 1)	300
Chemical analyses	300
Subtotal	1,705

	SEK 1000/year
Hydrometallurgical laboratory	
Salaries	670
Consumables	150
Maintenance 1)	150
Chemical analyses	200
Subtotal	1,170
Administration and service 2)	
Salaries	1,150
Consumables	20
Subtotal	1,170
Total	4.045

1) Includes salaries and material in proportion to estimated needs.

2) Includes general manager, department heads, secretaries and clerical personnel.

Costs for canteen and cleaning personnel etc. are not included.

8. Total area required

The total ground area required for phase 1 is estimated to be in the order of 40,000-50,000 m2, with the possibility to expand to approximately 100,000 m^2 for phase 2.

9. Building volumes

The following estimates of building volumes have been made:

Laboratory building	
Mineral dressing laboratory	1,590 m^3
Mineral dressing pilot batch scale unit	650 m^3
Hydrometallurgical laboratory	930 m^3
Metallographic sample preparation and scanning electron microscope	540 m^3
Other spaces	1,474 m^3
TOTAL	5,184 m^3
Change house and office building	4,060 m^3
Small scale crushing and storage unit	1,510 m^3

10. Power and water consumption

10.1 Power consumption

Installed power for equipment	151 kW
Installed power for ventilation, lighting, etc.	250 kW
	401 kW

No switchgear has been suggested for phase 1. The power is distributed from the transformer directly to distribution centres strategically situated in the buildings.

An emergency diesel generator with a capacity of 200 kW, capable of supplying parts of the facilities in case of power failure, is housed in the laboratory.

10.2 Water consumption

For phase 1 the design flow rate should be 0.3 m^3/min.

11. Tailing disposal

The amounts of chemical reagents used in the laboratory and discharged into the tailings are negligible.

Possibly one should keep an eye on the cyanide solutions used for cyanide leaching (max. 50 litres/year). However, these solutions are normally also discharged without any extra precautions.

The sand bearing tailing flows to a "sand trap" where the sand settles and the water goes to the overflow. The "sand trap" must be emptied frequently.

12. Organization chart

An organization chart is shown in Appendix 1:5.

The chart covers the technical departments and maintenance and office services only and is shown as a line organization. The figures in parentheses show the numbers of people in the positions in question.

The entire operation is headed by a General Manager.

He is assisted by a chief secretary and by two department heads in charge of

* Mineral dressing
* Hydrometallurgy

There is also a maintenance section serving both departments.

In each department there are project engineers who initiate the work of the executive sections, each of which is led by a section head.

The executive sections are:

* Mineral dressing laboratory (including small scale crushing and storage unit, and pilot batch scale unit)

* Hydrometallurgical laboratory

Under the section heads there are foremen to organize the work to be performed by the laboratory workers.

13. Training programme

Programmes for special introductory training of different categories of personnel (page 14) are shown in Appendices 1:6-1:12. This personnel should also prepare and take part in the "on the job training" of other personnel before and during the commissioning of the laboratory.

14. Employment of foreign experts

For a successful operation of the laboratory it is of the utmost importance that its management as well as its operating personnel have adequate education and professional experience.

As the mining industry and thereto related institutional offices in Mozambique are at an early stage of development, it can be foreseen that certain managerial positions in the new laboratory have to be filled by foreign experts. This is also confirmed by MRM in their report to LKAB dated January 15, 1984.

Besides the foreign experts who will be engaged for the start-up of the laboratory and training of local personnel, it is presumed that also the department heads and the three section heads for a certain period of time should be expatriates. The duration of the occupancy of these positions by expatriates cannot be foreseen at this stage of the project. It is, however, likely that the rôle of the expatriates after a couple of years changes from direct operational to advisory responsibility. This implies the apparent advantage of a successive taking over of the laboratory by MRM.

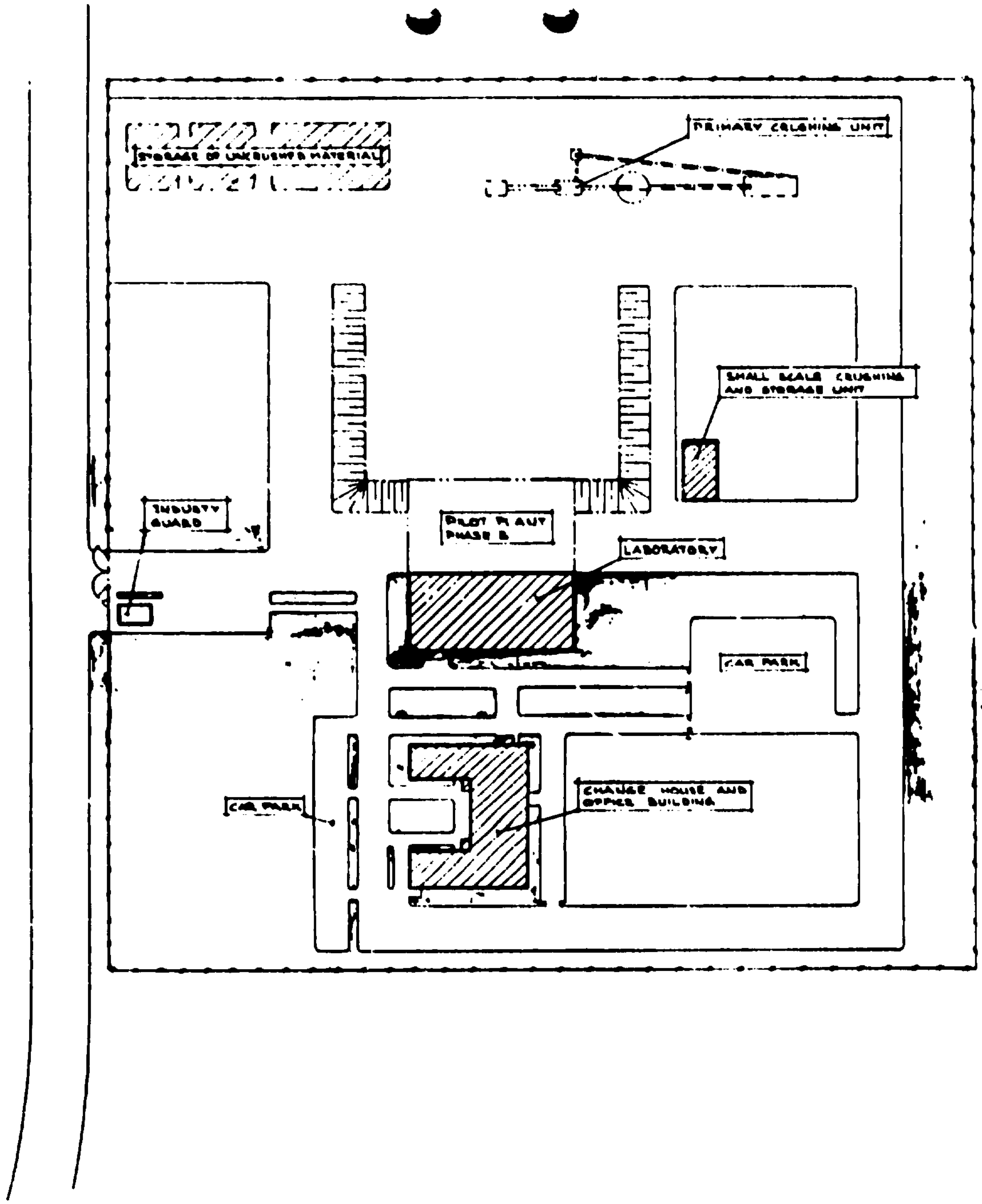
15. Time schedule for realization of the project

A preliminary time schedule for realization of the project has been worked out and is presented in Appendix 1:13. It should be observed, however, that the time schedule for obvious reasons have had to be prepared without having detailed information on local conditions. It is, therefore, possible that a detailed time schedule, where considerations are made to the need of utilizing local contractors and locally suppplied material will change the schedule now presented.

As shown in Appendix 1:13 it is now anticipated that the project, with reservations as per above, could go on stream 17 months after a go-ahead decision.

COLLOCATION OF LAYOUT DRAWINGS

Content	Drawing No.	Scale
Situation plan	FM 2-84-21	1:1000
Perspective drawing	FM 1-84-22	
Small scale crusing and storage unit		
Plan and section	FM 2-84-23	1:50, 1:100
Mineral dressing - Pilot batch scale unit		
Plan	FM 2-84-24	1:50, 1:100
Laboratories etc		
Plan - Laboratory floor	FM 1-84-25	1:100
Plan - Change house and office building	FM 1-84-26	1:100
Plan - Mineral dressing laboratory, Main hall	FM 2-84-27	1:50
Plan - Mineral dressing laboratory, Rooms 3-7	FM 2-84-28	1:50
Plan - Hydrometallurgical laboratory	FM 2-84-29	1:50
Plan - Scanning Electrone Microscope (SEM)-unit Rooms 19-21	FM 2-84-30	1:50



TECHNOLOGICAL AND NON-METALLIC TESTING AND DEVELOPMENT LABORATORY IN MOZAMBIQUE

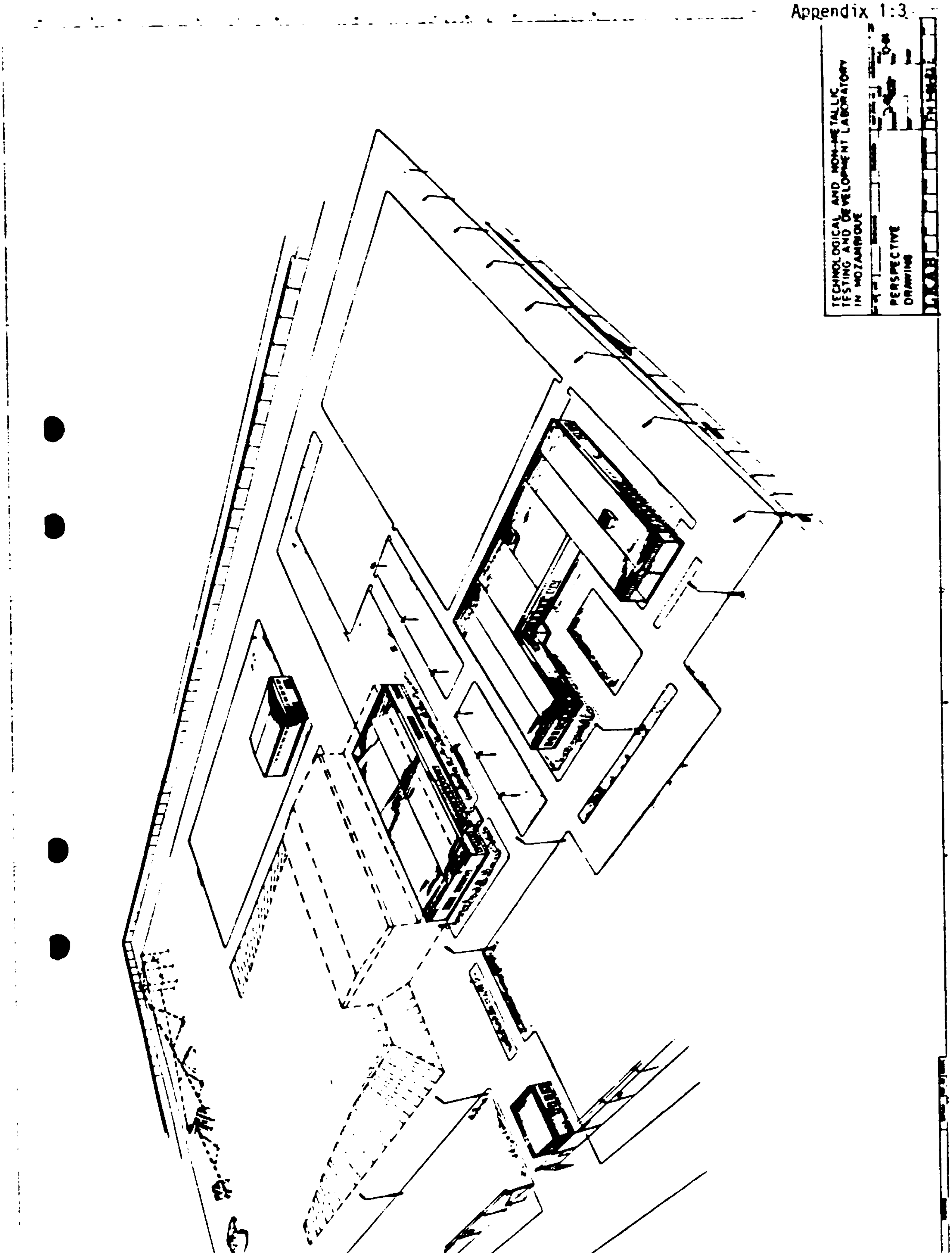
SITUATION PLAN

10-84

1:

LKAB

FM 2-84-21


TECHNOLOGICAL AND NON-METALLIC
TESTING AND DEVELOPMENT LABORATORY
IN MOZAMBIQUE
PERSPECTIVE
DRAWING

Appendix 1:4:1

TECHNOLOGICAL LABORATORY, MOZAMBIQUE

INSTALLED POWER AND MAIN EQUIPMENT COSTS

COST CENTRE	Installed power kW	Costs x 1000 SEK Equ.		Tot.
SMALL SCALE CRUSHING AND STORAGE UNIT				
- CRUSHING ETC	20	409		
- MISCELLANEOUS			115	
	20	409	115	524
MINERAL DRESSING PILOT BATCH SCALE UNIT				
- GRINDING, FRACTIONING, GRAVIMETRIC- AND MAGNETIC SEPARATION, DRYING OVENS	52	651		
	52	651		651
MINERAL DRESSING LABORATORY				
- GRINDING, FRACTIONING, GRAVIMETRIC SEPARATION	4	567		
- MAGNETIC SEPARATION, FLOTATION, PHYSICAL ANALYSES	4	819		
- OTHER EQUIPMENT	4	228		
- MISCELLANOUS			100	
	12	1634	100	1734
SUB TOTAL	84	2694	215	2909

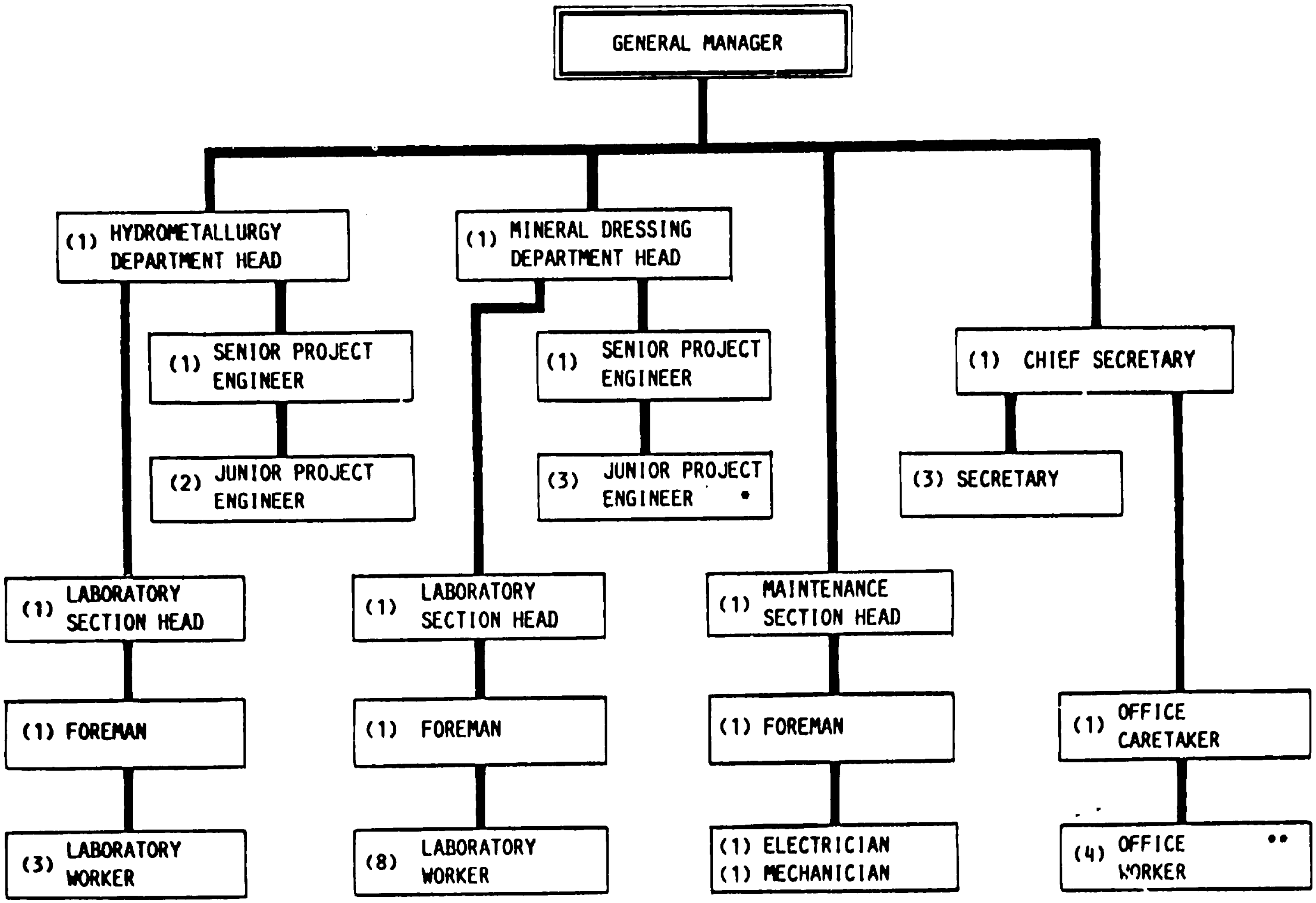
TECHNOLOGICAL LABORATORY, MOZAMBIQUE

INSTALLED POWER AND MAIN EQUIPMENT COSTS (CONT.)

COST CENTRE	Installed power kW	Costs x 1000 SEK Equ.		Tot.
HYDROMETALLURGICAL LABORATORY				
- GLASS SCALE EQUIPMENT	16	163		
- BENCH SCALE EQUIPMENT	8	214		
- MISCELLANOUS			230	
	24	377	230	607
SCANNING ELECTRONE MICROSCOPE (SEM) UNIT				
- METALLUGRAPHIC SAMPLE PREPARATION	8	392		
- SCANNING ELECTRONE MICROSCOPE UNIT	5	1479		
- SECTOR SYSTEMS	7	94		
- MISCELLANEOUS			100	
	90	1965	100	2065
AUXILIARY EQUIPMENT				
- DIESEL POWER GENERATOR		300		
- FORK LIFT		200		
- COMPRESSOR	30	125		
- NOT SPECIFIED			100	
	30	625	100	725
SUB TOTAL	144	2967	430	3397
TOTAL	318	5661	645	6306

DEVELOPMENT LABORATORY IN MOZAMBIQUE

ORGANIZATION CHART



* ONE OPERATOR OF SEM

** MAIL SERVICE, SWITCH BOARD, COPYING

Appendix 1:5

TRAINING OF PERSONNEL FOR A MINERAL DRESSING LABORATORY IN MOZAMBIQUE

PROGRAMME

Week 1 - General basic training

1	Introduction	2 days
2	Research strategy General introduction to development of mining projects - case stories	3 days

Week 2 - Introductory theoretical training

1	Detailed introduction on the job	1 day
2	Introduction to mineral dressing - Physical, chemical and other methods for determination of mineral characteristics - Theories for the chemistry of mineral surfaces and medias	4 days

Week 3 - Introductory on the job training

1	Routines and safety regulations - Sample preparation - Sample storage - Analyse ordering	1 day
2	Handling of equipment - Small scale crushing - Grinding . Bond's mill . Laboratory mill - Magnetic separation . Ding's Tube Tester . Wet low intensity magnetic separator . Dry high tension electrostatic separator . Dry high intensity magnetic separator . Dry low intensity magnetic separator - Flotation . Equipment . Technique . Reagents - Gravimetric separation . Shaking table . Laboratory jig . Sink-float batch testing unit	4 days

- Physical analyses
  . Test sieveshaker
  . Cyclosizer
  . Specific surface meter
  . Pycnometer

Week 4 - Pedagogical training

How to make instructions etc

- Learning methods - Theory and practical experience
- Producing instructions - Theoretically and practically
- Audio-visual means - Theory and practical experience
- Education methods - Choice of objectives. Education level of trainees. Training schedule.

Week 5 - Visit to other mines and laboratories

Week 6 - 13 Detailed mixed theoretical and on the job training

Day 1 — Theoretical training

Physical analyses
- Screan analyses calculations
- Cyclosizer calculations

Day 2-6 — On the job training

Physical analyses - Test work
- Screen analyses determination
- Cyclosizer determination
- Specific surface determination
- Specific gravity determination

Day 7 — Theoretical training

Crushing, grinding and classification

Day 8-11 — On the job training

- Crushing, splitting, grinding, sample preparation - Methods
- Study of grinding caracteristics for an ore sample
- Relations between size reduction ratio and grinding time (specific grinding energy)

Day 12-13 — Theoretical training

Magnetic separation
- Dry and wet low intensity magnetic separation
- Dry electrostatic separation
- Dry high intensity magnetic separation

Day 14-16	On the job training	
	Magnetic separation	
	- Dry low intensity magnetic separation,	1 day
	- Wet "-	, 1 day
	- Dry electrostatic + high intensity separation,	1 day
Day 17-18	Theoretical training	
	Flotation	
	- Methods	
	- Reagents etc	
Day 19-23	On the job training	
	Flotation	
	- Reagents preparation	
	- Flotation of different ore types	
	- Product studies in microscope	
Day 24	Theoretical training	
	Gravimetric separation	
	- Methods	
	- Different types of equipment	
Day 25-28	On the job training	
	Gravimetric separation	
	- Shaking table tests	2 days
	- Laboratory jig test	1 day
	- Sink-float tests	1 day
Day 29	Theoretical training	
	Media separation	
	- Thickening	
	- Filtering	
	- Drying	
Day 30-39	On the job training	
	Laboratory investigation of an ore sample	
	- Crushing, grinding	
	- Magnetic separation, flotation	
	- Physical and chemical analyses	
	- Evaluation of results	

Week 14 - Rehersal of performed training

TIME SCHEDULE FOR MINERAL DRESSING TRAINING

Programme	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
General basic training	—													
Introductory theoretical training		—												
Introductory on the job training			—											
Pedagogic training				—										
Visit to other mines and laboratories					—									
Mixed theoretical and on the job training														
Physical analyses						—								
Crushing, grinding etc							—							
Magnetic separation								—						
Flotation									—	—				
Gravimetric separation and media separation											—			
Laboratory investigation of an ore sample												—	—	
Rehersal of performed training														—

TRAINING OF PERSONNEL FOR A HYDROMETALLURGICAL LABORATORY IN MOZAMBIQUE

PROGRAMME

Week 1 - General basic training

1	Introduction	2 days
2	Research strategy	
	- General introduction to development of mining projects - case stories	3 days

Week 2 - Introductory theoretical training

1	Detailed introduction on the job	1 day
2	Introduction to hydrometallurgy	
	- Hydrometallurgical operations	1 day
	- Industrial uses	
3	Detailed description of basic techniques	
	- Leaching	
	- Filtration	
	- Precipitation	
	- Liquid-liquid extraction	
	- Crystallization	
	- Evaporation	2 days
4	Hydrometallurgical testing of material	
	- Description of technique	
	- Case stories	1 day

Week 3 - On the job training

Study of uranium ore in glass scale

- Preparation of sample for leaching tests
- Leaching tests
- Separation tests (filtering, liquid-liquid extraction)

Week 4 - Pedagogical training

How to make instructions etc

- Learning methods - Theory and practical experience
- Producing instructions - Theoretically and practically
- Audio-visual means - Theory and practical examples
- Education methods - Choise of objectives. Education level of trainees. Training schedule.

Week 5 - Visit to other mines and laboratories

Week 6-7 - On the job training

Continuation from week 3

- Chemical analyses
- Evaluation of results

Study of gold ore

- As for uranium ore

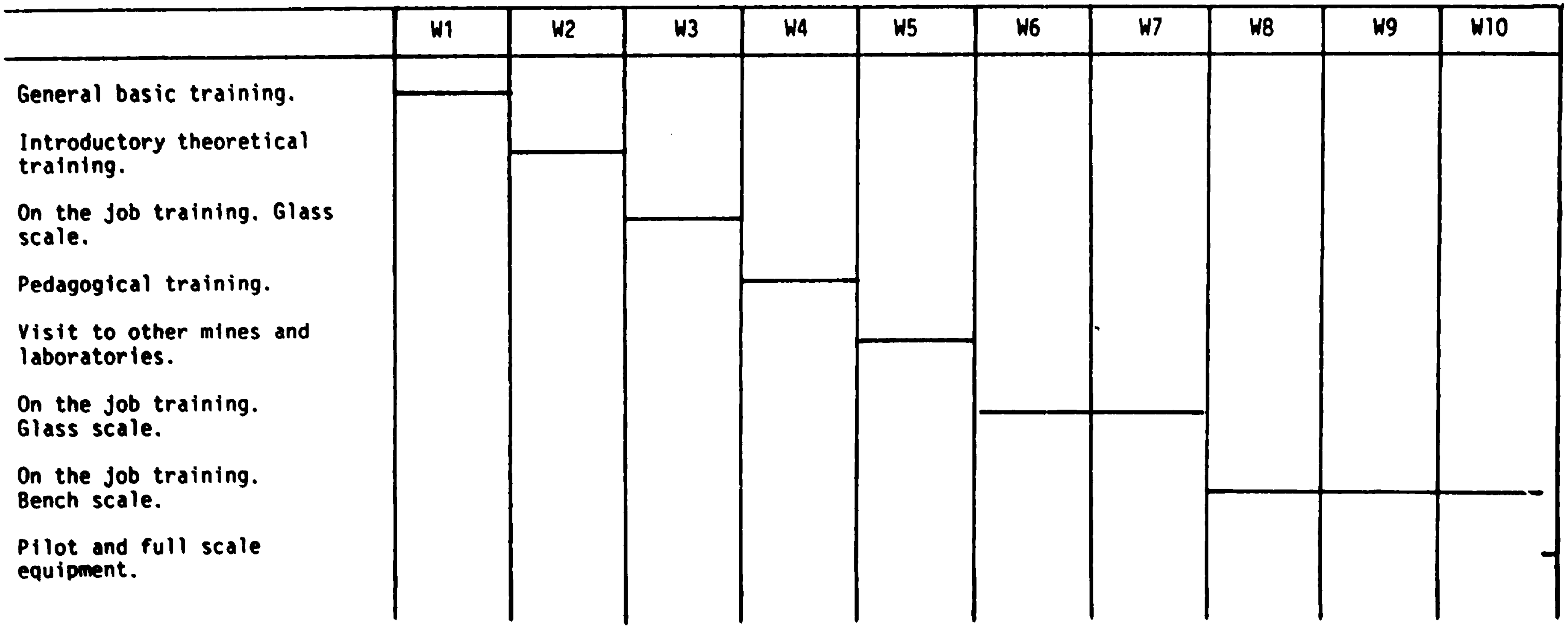
Week 8-10 - On the job training

Study of uranium ore in bench scale

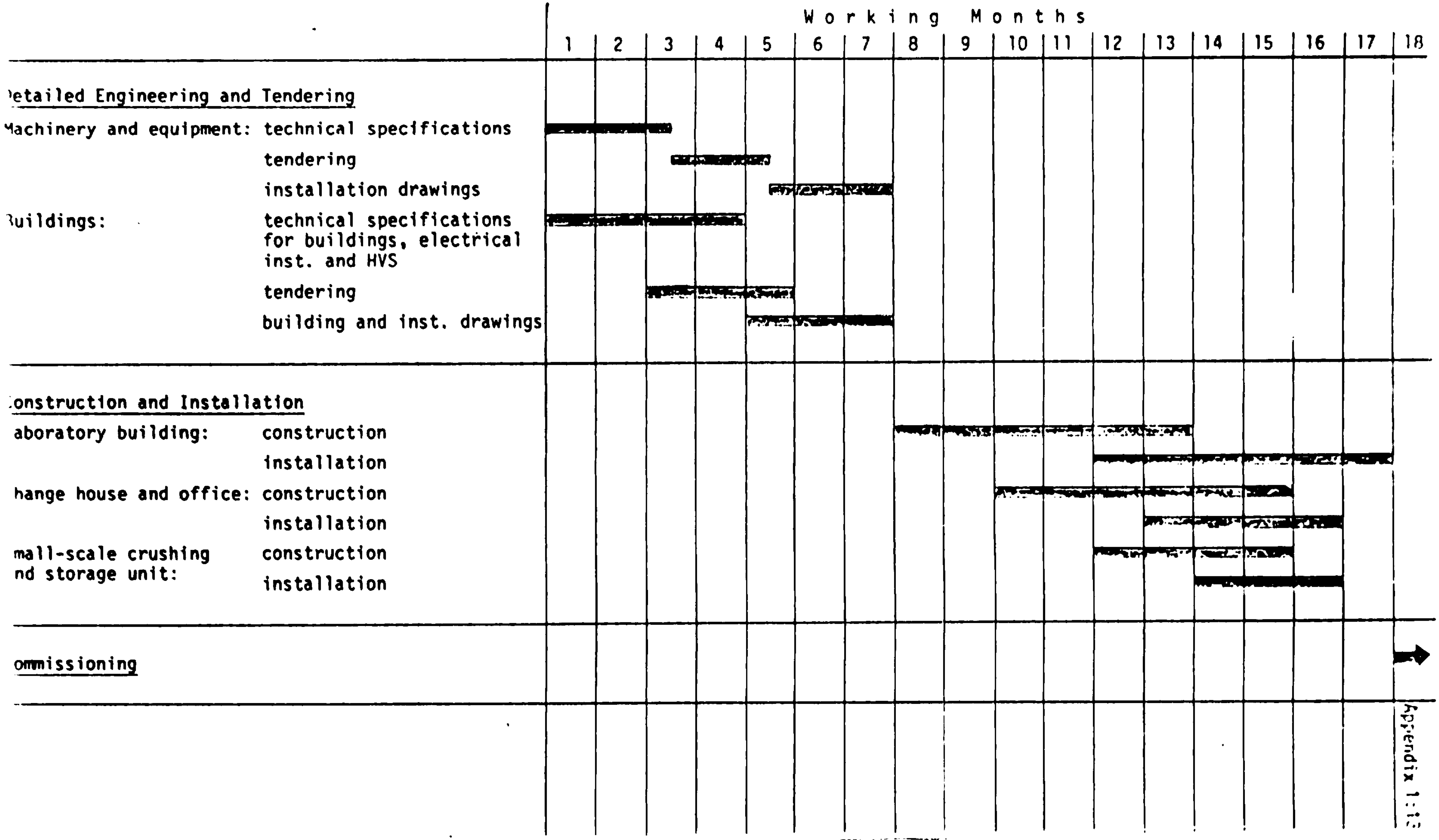
- Sample preparation
- Leaching
- Liquid-liquid extraction
- Precipitation 14 days
- Evaluation of results

Pilot and full scale equipment. General description of the technique. Short summary of how the test results are used in feasibility studies. 1 day

TIMESCHEDULE FOR HYDROMETALLURGY TRAINING



T I M E   S C H E D U L E   for realization of a Technological and Non-Metallic Testing and Development Laboratory



Appendix 1:13

2

TECHNOLOGICAL AND NON-METALLIC TESTING AND DEVELOPMENT LABORATORY in MOZAMBIQUE

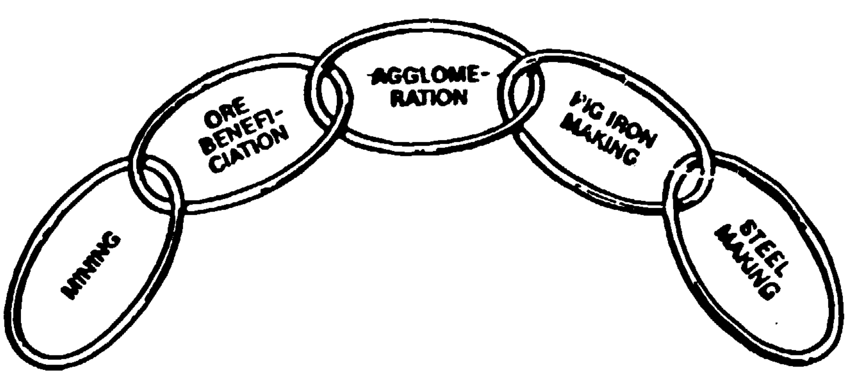
RESEARCH STRATEGY

1. THE ROLE OF MINERAL DRESSING IN A MINING PROJECT

Introduction

A mining project comprises several different operations to be combined into an economically optimized whole. In most projects mining, dressing and transportation are the three main operations with their own, but interrelated techno-economic conditions. Of utmost importance is also that the demands of the market are taken into account.

The all-important objective of optimizing an ore dressing process is that the ultimate result is the best that can be attained. To consider an iron ore project, for example, what has to be optimized is the quality and cost of the steel or whatever product is to be marketed, and not any of the various operations in the process. This approach which is quite self-evident, could be compared to a chain which can never be stronger than its weakest link.



This principle is of course true also for other projects than iron ore projects, though the last phases have to be replaced by other phases.

Ore dressing studies

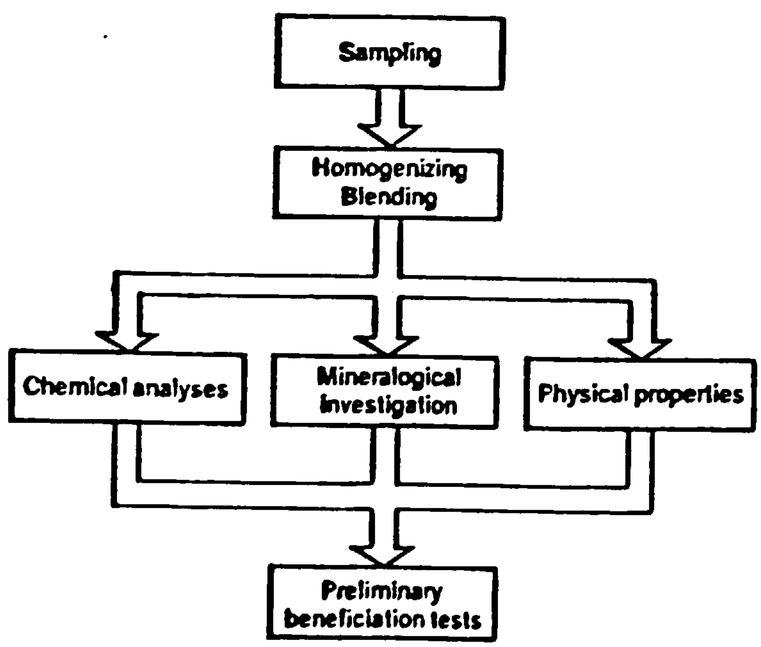
When carrying out ore dressing studies, systematics and a stage-wise approach are vital. The following work procedure is adopted by the Contractor in its own operations.

a. Preliminary investigation
b. Detailed laboratory investigation
c. Pre-feasibility study
d. Feasibility study

It is important to observe that the costs to carry through these studies increase from a to d. Therefore, it is essential that initial studies are done with utmost care and accuracy to avoid unnecessary expenditures and delays in later studies.

a. Preliminary investigation

The purpose of the preliminary investigation is to provide a general knowledge of the ore in question. The illustration below shows the activities that should be included in this phase:



The figure is quite self-explanatory, but a few extra comments on some of the squares should be made.

Sampling

Since the preliminary investigations lay the foundation for later work it is most important that the samples collected should be as representative of the ore as possible. Naturally, the representativeness of the beneficiation tests can never be better than what the samples allow for. This often involves problems, as the only ore available, at least in completely new projects, is the outcropping ore or core material. Still, the difficulties can be overcome with a knowledge of the geological conditions and a preliminary idea of how the ore is to be mined. Testing of several different samples from the same object is also a way to minimize uncertainties.

Since most mining methods result in some dilution of the ore with country rock, the latter should also be sampled and the effects of dilution on various beneficiation processes tested.

Mineralogical investigation

This is most important and is decisive for the coming benefici-ation tests. Without a careful mineralogical investigation it is very difficult to plan beneficiation tests or interpret the results of them.

The mineralogical investigation is to give the beneficiation engineer a variety of data on the character of the ore, after which the orientation of the beneficiation tests can be decided. Some important factors that must be considered are:

* occurring minerals
* grain size
* grain shape and boundaries
* structure
* inclusions

A large number of samples are necessary to ensure that the mineralogical investigation will be reasonably dependable. The microscope for polarized and reflected light is the usual tool, but in some complicated cases scanning electron microscopes may be necessary. This is particularly the case when it is required to show the presence of sparsely occurring elements.

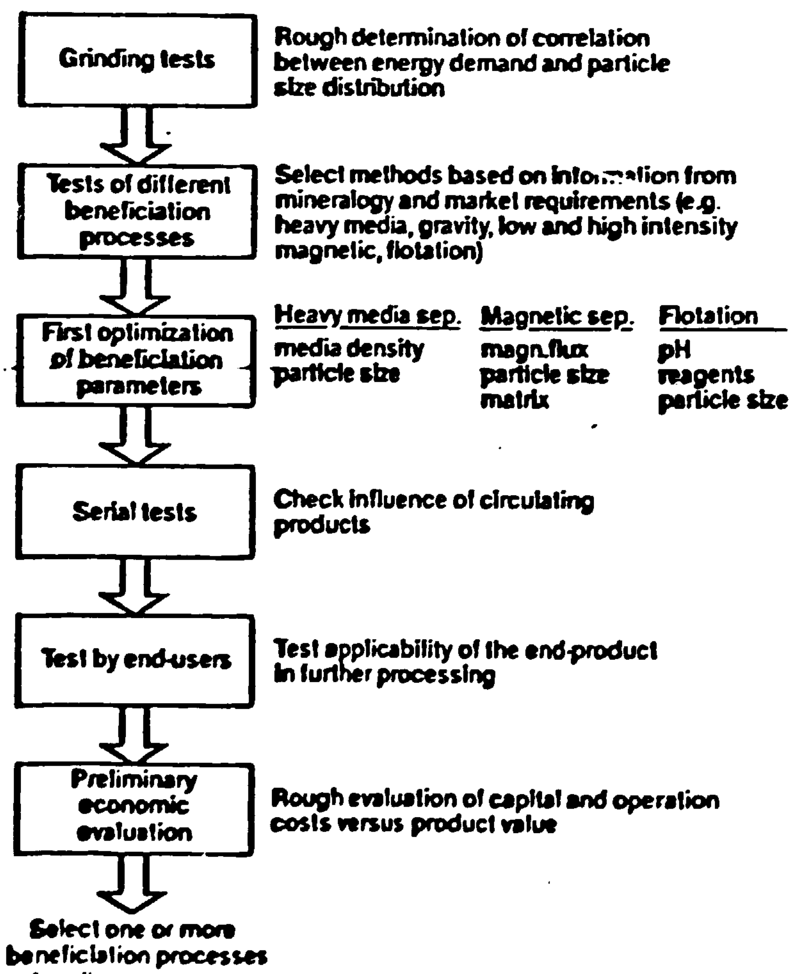
As the mineralogical investigation shall be focused on aspects relevant to beneficiation we would emphasize that it must be carried out by the same organization that will handle the beneficiation tests.

Preliminary beneficiation tests

The nature of the first round of beneficiation tests on a bench scale is of course dependant on the character of the ore in question. The aim should be to select possible beneficiation methods which in following phases will be subject to detailed investigations.

b. Detailed laboratory investigation

Based on the outcome of the preliminary investigation, detailed beneficiation tests in the laboratory (bench-scale) have to be carried out. The following procedure is suggested.



The figure shows what activities the investigations should include and the purpose of each activity. As a result of this phase one or more possible ore dressing processes are selected for further study on a larger scale (the pre-feasibility phase).

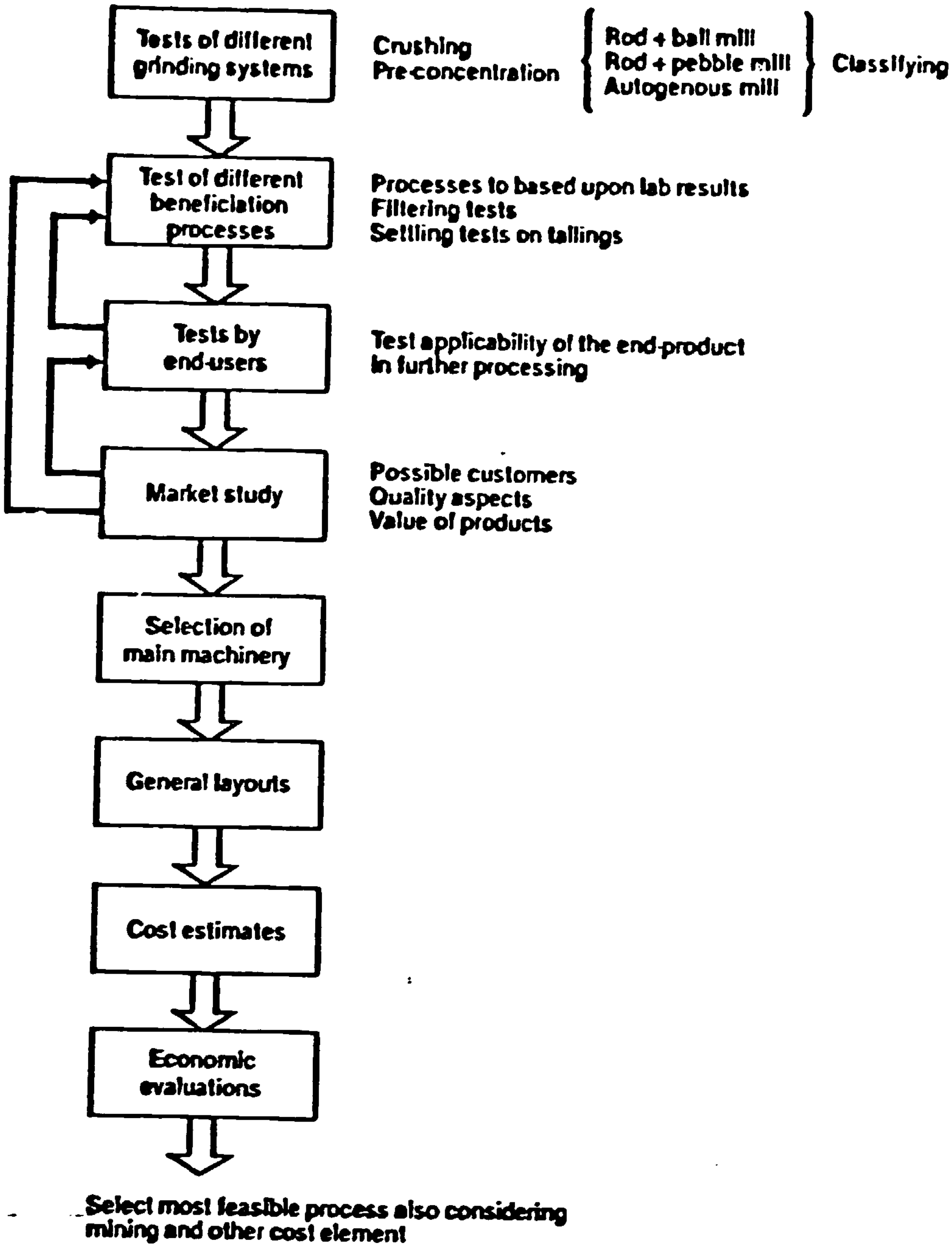
c. Pre-feasibility study

While the laboratory-scale investigations give a good idea of the beneficiation conditions the data obtained are not sufficient to base an investment decision on. The process or processes selected must therefore be tested on a larger scale, so that process conditions over a longer period of continuous running can be studied.

The pre-feasibility stage also comprises the study of the properties of the finished product as used by the buyers, and an outline market analysis to indicate the product's marketing potential and price. These studies may lead to changes in the process to match the product better to the needs of the market.

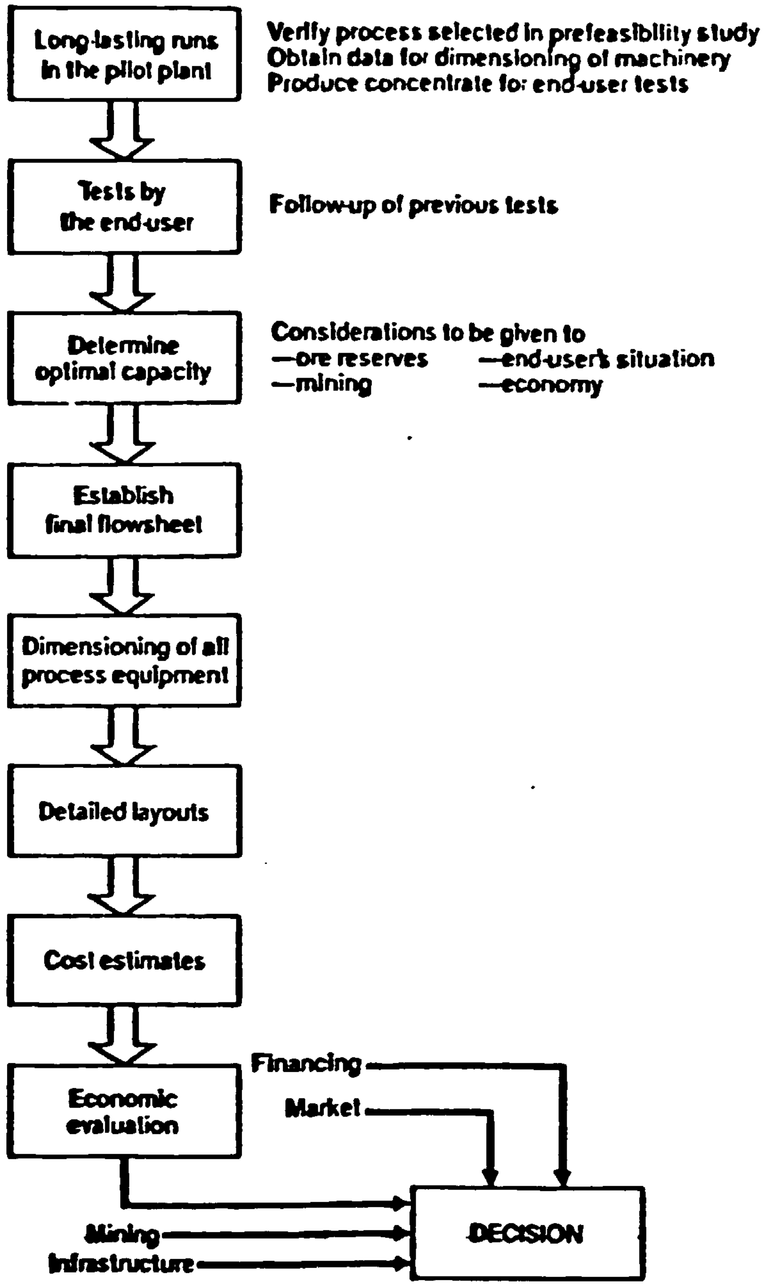
Since the pre-feasibility study is to lead to the final choice of process and provide data for a preliminary decision on whether to proceed with the project, the type and size of all the main machinery items must be decided at this stage, general layouts drawn up, and cost estimates prepared. This work plus the price information obtained from the market analysis provide the data for economic estimates and the final decision on the process. Obviously, allowance has to be made in these estimates for similar pre-feasibility studies on mining, infrastructure and other cost elements of the project.

The following figure shows the activities normally involved in the ore dressing phase of a pre-feasiblity study.



d. Feasibility study

For several reasons the process arrived at in the pre-feasibiltiy study must be tested further before making the definitive decision to proceed. We call this the feasibility phase, and the activities normally included are shown in the following figure.



It will be noticed that the activities are much the same as in the pre-feasibility phase, but a good deal more detailed. To begin with, continuous pilot-scale trials of long duration are required for the purpose of:

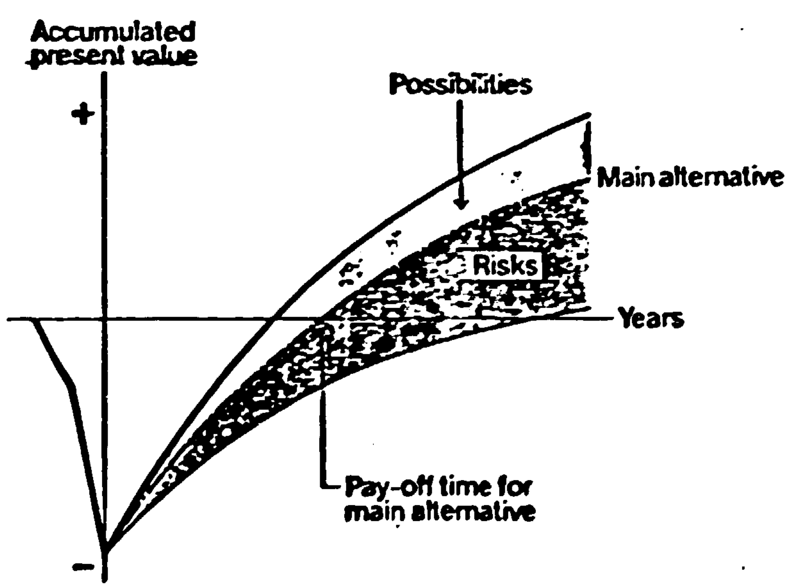
* verifying and adding to the process data already available
* obtaining design data for machinery and equipment
* producing concentrates for tests by buyers

After these activities are completed the optimal capacity of the dressing plant can be determined, taking into account the size of the ore reserves, the mining conditions, the needs of the market and the effects of plant size on the economics of the project. Given the size of the plant it is possible to draw up flowsheets, select machinery and equipment, draw up layouts and prepare a detailed cost estimate.

The feasibility study concludes with a careful investment evaluation, which will of course take the chosen process as its basic option. However, it is most important also to carry out sensitivity analyses to show the effects of deviations from the basic assumptions used. Factors that should be investigated by sensitivity analyses include:

* deviations in cost of capital and operating costs
* limited utilization of capacity (technical troubles and market restrictions)
* changes in the composition of the run-of-mine ore
* changes in metal recovery
* changes in the prire of the product
* changes in exchange rates

These sensitivity analyses may be presented in graph form, as shown below, which gives a clear picture of the possibilities and risks of the project.



2. PRIORITY MINERALS

Based on the Contractor's visit to Mozambique in September 1982 and the Government's report of January 15, 1984 provisions should be made for treatment of the following ores/minerals:

High priority

pegmatites
iron ores
apatite
graphite and coal
beach sands

Medium priority

base metal ores
feldspar
bentonite and other clay minerals
precious metal ores

Low priority

steel alloy metal ores
industrial minerals other than feldspar

3. STRATEGY WITH RESPECT TO SHORT AND LONG TERM PLANNING

We anticipate that the laboratory in due time will possess capability for laboratory- and pilot scale investigations.

We suggest that the necessary facilities, in principle, are established in two phases where phase 1 shall provide the capacity for comprehensive laboratory scale testing of most ore/mineral types, and phase 2 shall provide the capacity for pilot scale testing of selected ore/mineral types according to demands and possibilities registered during the first years of phase 1 operations.

The major reason for this phased establishment is cost-effectiveness. - Phase 2 will certainly be less expensive and more effective when it is based on observed requirements compared to predictions made today.

Another important reason is that on-the-job training of the laboratory personnel can be more complete and pedagogic when a 2-phase development strategy is adopted.

It is important to observe that any comprehensive ore/mineral beneficiation investigation in laboratory scale will require the availability of a complete variety of testing equipment. In consequence, it can be concluded that the laboratory would be equally equipped, had the number of priority ores/minerals been only half, and also that the laboratory has the capacity of testing minerals not included in the priority list.

It should also be born in mind that several investigations can be carried out simultaneously in the new laboratory. As each individual investigation does not normally cover more than a 2-4 months period, flexibility in respect of changes of priorities is obvious.

The conceptual design of the labcratory is made in such a way that it is possible to treat most of the ore/mineral types listed above regardless of other on-going investigations.

When planning of the first year(s) of operation in the new laboratory eventually is to be made, the following aspects have to be considered:

* needs arising from on-going exploration programmes in Mozambique
* needs arising from already operating mines
* needs arising from pure training purposes

When the laboratory and its personnel are operational, the possibility of offering services to companies and institutions in neighbouring countries should also be considered.

Even though the laboratory will be equipped with the most modern and reliable beneficiation test machines available on the market today, we know that new beneficiation methods continuously are developed. Provisions are therefore made in the layout for future installations of new testing units.

3

CHAPTER III - SMALL-SCALE CRUSHING AND STORAGE UNIT

For crushing of "small-scale" samples, less than 5 tonnes, a separate building is proposed and located some 40 m from the main laboratory building.

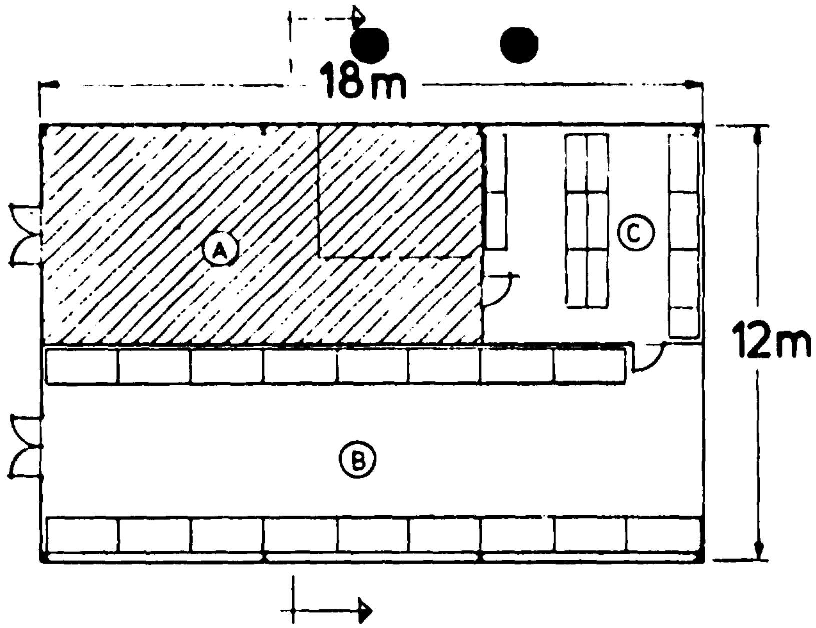
This unit will also house storage facilities, and thus contain the following:

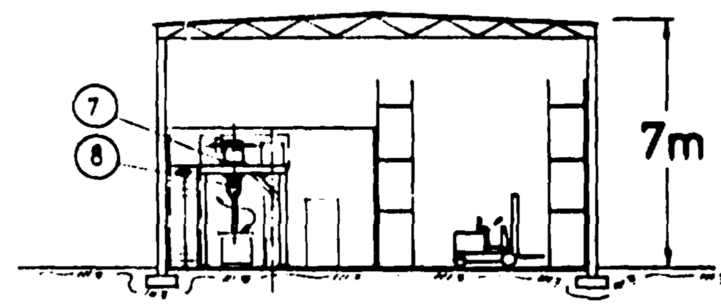
* small-scale crushing and sample preparation
* box and barrel storage
* bag sample storage

When Phase 2 is established the building can be converted into a storage unit, and the crushing unit be moved to the new pilot plant building.

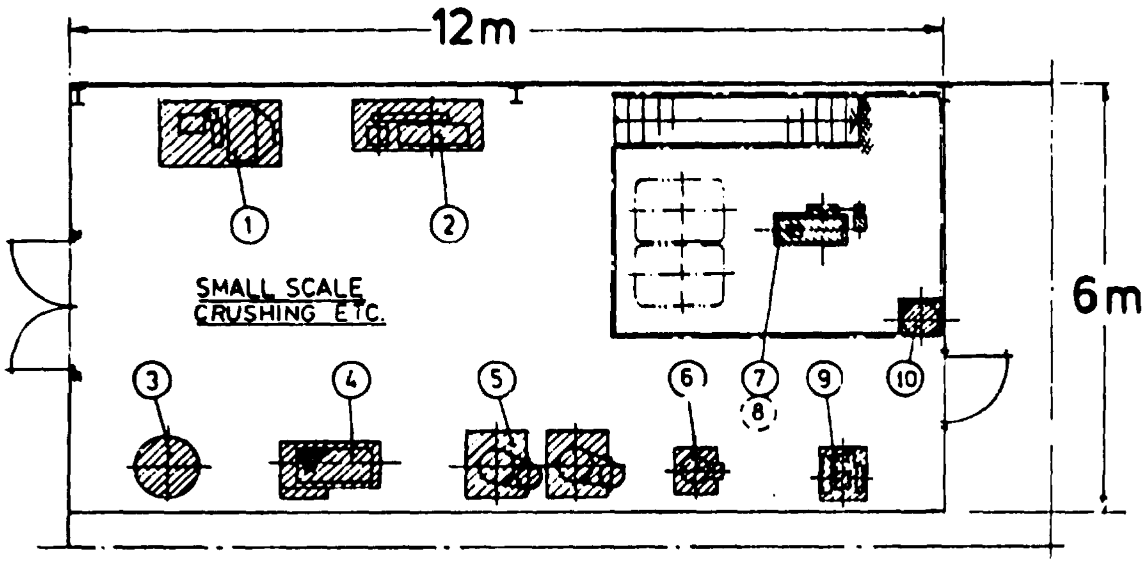
The layout of the small-scale crushing and storage unit is shown on drawing FM 2-84-23 (Appendix 3:1). Further descriptions of installed equipment and its funtion are given in Appendix 3:2 and an equipment specification in Appendix 3:3.

Equipment costs	SEK 524,000
Installed power	20 kW





SCALE 1:100



SCALE 1:50

A	SMALL SCALE CRUSHING ETC
B	BOX- AND BARREL STORAGE
C	SMALL BAG SAMPLE STORAGE

1	CONCRETE MIXER	(ITEM NO. 207)
2	TUMBLER TEST DRUM	(ITEM NO. 209)
3	CAROUSEL SPLITTER	(ITEM NO. 208)
4	SHAKING SCREEN	(ITEM NO. 206)
5	SECONDARY CRUSHER	(ITEM NO. 204)
6	SAMPLE PREPARATION CRUSHER	(ITEM NO. 205)
7	PRIMARY CRUSHER	(ITEM NO. 201)
8	SPLITTING DEVICE	(ITEM NO. 202)
9	PRIMARY CRUSHER	(ITEM NO. 203)
10	MARK 7 SPIRAL	(ITEM NO. 520)

TECHNOLOGICAL AND NON-METALLIC TESTING AND DEVELOPMENT LABORATORY IN MOZAMBIQUE

SMALL SCALE CRUSHING AND STORAGE UNIT
PLAN AND SECTION

10-84

1:100 1:50

LKAB

FM 2-84-23

ORIGINALFORMAT A2

SMALL SCALE CRUSHING AND STORAGE UNIT

METHOD DESCRIPTION

Small scale crushing

	Small scale crushing (≤ 5 tonnes) is preferably made in the so-called small scale crushing and storage unit.
Item No. 201 " " 202	In the jaw crusher AR 25 (250 x 150 mm) the material can be crushed to 10-25 mm with a capacity of about 1.2 m^3/h.
	As the largest feed opening for this crusher is 250 x x 150 mm, coarser material has to be precrushed either in the pilot plant jaw crusher.
Item No. 203	In the jaw crusher AR 12 (120 x 80 mm) the material can be crushed to 3-12 mm. The crusher is preferably used for small samples up to 50 kg's.
Item No 204	The secondary cone crusher B90 (30 mm) should be used for the final crushing to < 3 mm before laboratory grinding tests or other tests are carried out. Suitable sample size is up to 200 kg's.
	The MK 25 mortar crusher has a max feed opening of 25 mm and can be used for crushing up to 5 kg's samples to about 1 mm especially for analyse sample preparation.
Item No. 208 a.o.	In connection with the different crushing stages suitable splitting devices are used.

UNIDO, TECHNOLOGICAL LABORATORY, MOZAMBIQUE

SMALL SCALE CRUSHING AND STORAGE UNIT

Preliminary main equipment specification

Item No.	Type of equipment	No. of	Specification	Installed power kW	Manufacturer	Budget price, kSEK Pce	Budget price, kSEK Tot.	Remarks
	Crushing etc							
201	Primary crusher	1	Jaw crusher AR 25	7.5	Centro-Morgårdshammar AB	109	109	Feed opening = 250 x x 150 mm.
202	Splitting device	1	Stainless steel	-	LKAB	27	27	
203	Primary crusher	1	Jaw crusher AR12	4.0	Centro-Morgårdshammar AB	43	43	Feed opening = 120 x x 80 mm.
204	Secondary crusher	2	Cone crusher B90	2 x 2.2	Centro-Morgårdshammar AB	43	86	Feed opening = 30 mm
205	Sample preparation crusher	1	Mortar crusher Mk 25-U2	0.5	Sala International AB	38	38	Feed opening = 25 mm
206	Shaking screen	1	800 x 500 mm	1.5	LKAB	35	35	Screen openings 100 -1 mm
207	Concrete mixer	1	225 l	0.9	Lescha	4	4	
208	Carousel splitter	1	Stainless steel	0.5	LKAB	39	39	Incl. vibr. feeder
209	Tumbler test drum	1	Ø 1x0.5 m, 2 chambers, 2 lifters	0.7	LKAB	28	28	
	Not specified			0.5			115	(Includes steel frame construction for box- and barrel samples)
	SUB TOTAL			~20			524	

Appendix 3:3

4

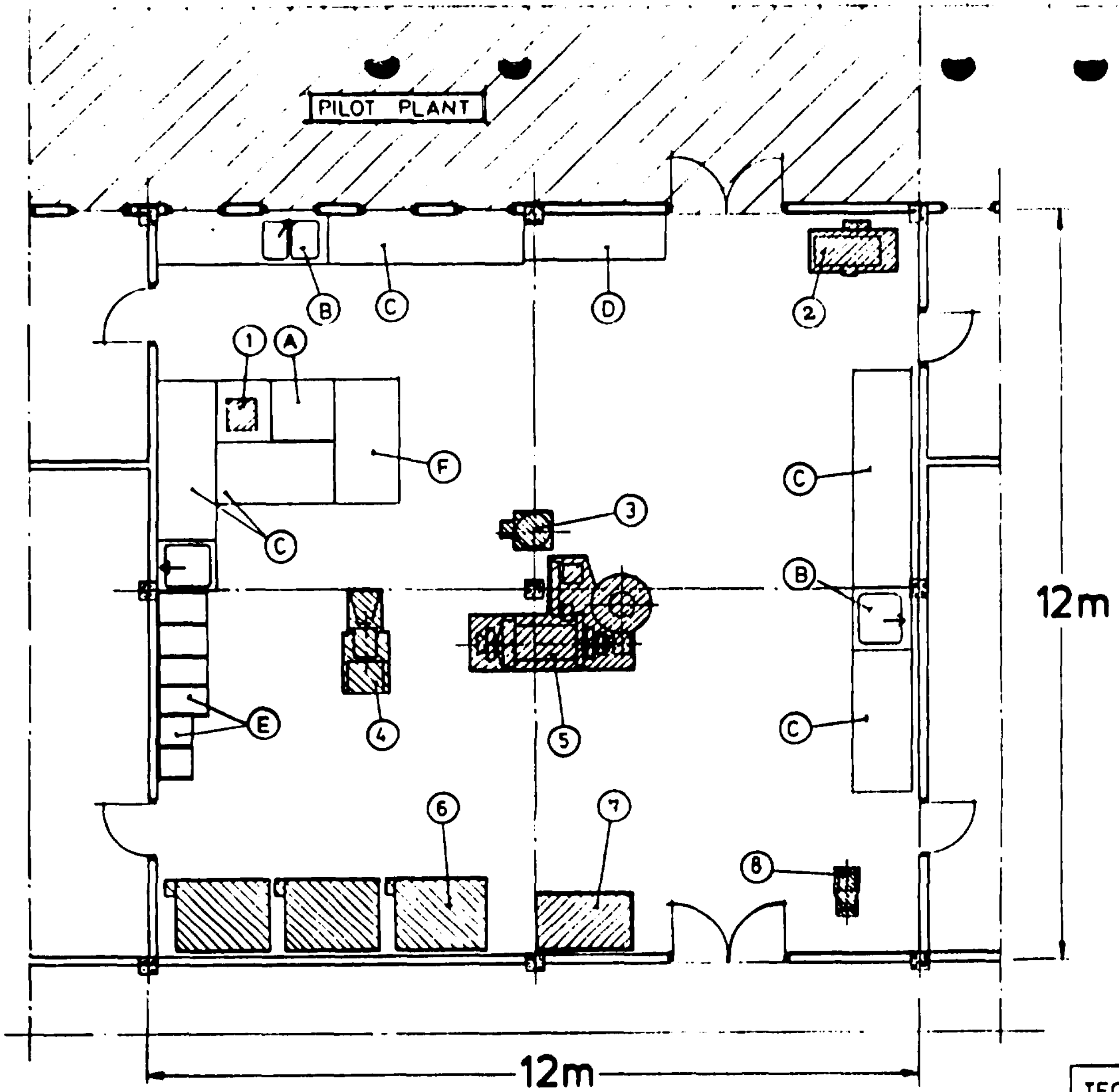
CHAPTER IV - MINERAL DRESSING PILOT BATCH-SCALE UNIT

As earlier described the construction of a pilot plant for continuous test-runs is proposed as an expansion (Phase 2) to follow upon the primary installation of the laboratory units. There is, however, a need for installation of some pilot-sized machineries to be used on a batch-wise scale.

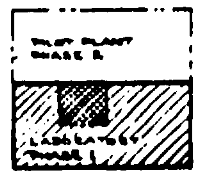
The pieces of equipment included in this unit are a batch grinding mill, a so-called Bond's mill for grinding investigations, a so-called Mörtsell separator for dry, low intensity magnetic separation, a concentrating spiral (Mark 7) and a concentrating table (Bartles Mozley) for gravity separation. Descriptions of the equipment are given in Appendices 4:2-4:3.

Drawing FM 2-84-24 (Appendix 4:1) shows the layout of the unit, while the location of the unit is shown as room 1 on drawing FM 1-84-25 (Appendix 5:1). An equipment specification is given in Appendix 4:4.

Equipment costs	SEK 651,000
Installed power	52 kW



A	FUME CUPBOARD		
B	WASH UP SINK		
C	LABORATORY TABLE		
D	SHELF FOR BUCKETS ETC		
E	SHELFS FOR GRINDING MEDIA		
F	FUME HOOD		
1	BALANCE		
2	VIBRATING SCREEN	(Item No. 510)	
3	VIBRATING SCREEN	(Item No. 511)	
4	BOND'S MILL	(Item No. 501)	
5	BATCH MILL	(Item No. 502)	
6	DRYING OVENS	(Item No. 540)	
7	BARTLES MOZLEY TABLE	(Item No. 570)	
8	DRY LOW INTENSIVE MAGNETIC DRUM SEPARATOR	(Item No. 530)	



SCALE 1:1000

TECHNOLOGICAL AND NON-METALLIC TESTING AND DEVELOPMENT LABORATORY IN MOZAMBIQUE

MINERAL DRESSING – PILOT BATCH SCALE UNIT-PLAN

10-86

1:50

LKAB

FM 2-84-24

ORIGINALFORMAT A2

Appendix 4:1

MINERAL DRESSING PILOT BATCH SCALE

METHOD DESCRIPTIONS

Grinding tests in Bond's mill (Item No. 301)

The mill dia. 300 x 450 mm:s a batch mill also called Bond's mill.

Suitable material batch charge is about 3 l depending on the type of material to be ground.

The mill can be run wet or dry and be charged with rods or balls. Suitable grinding media weight is about 50 kg.

In order to facilitate charging or discharging the mill is raised or lowered pneumatically and locked in desired position.

The drive consists of a 0,55 kW drive motor, a mechanical variator and a speed reducer. In this way mill speed can be varied continiously within desired speed range.

By connecting a revolution counter and a pulse counter (giving the energy consumption), run for a certain number of revolutions and then determine the screen analyses of the product it is possible to achieve grinding test results corresponding to those obtained in pilot- or full scale operation.

Dry low intensity magnetic separation (Item No. 330)

The Mörtsell separator is preferably used for dry magnetic separation of relatively coarse-grained magnetites.

The separator has a drum of stainless steel with dimensions dia 270 x 125 mm with an adjustable magnet yoke using permanent magnets with manual adjustment.

The separator drum with a variable peripheral speed from 0 to 5,5 m/sec is fed with material from a feed unit with vibrating feeder and feed launder.

The particle size of fed material should not exceed 4 mm and should not contain more than 1 % moisture. For finer material the maximum allowed moisture is 0,5 %.

In the separator house of non-magnetic stainless steel the concentrate and tailings are adjusted by means of an adjustable divider plate. The divider plate should be placed according to the magnetic properties of the material, moisture, required grade and recovery.

To optimize results the following parameters are studied:

- Peripheral speed
- Position of magnet yoke
- Position of divider plate

Depending on the required products, i.e. grade and recovery, the concentrate and/or the tailings can be recleaned by repeated runs.

Concentrating spiral - Mark 7 (Item No. 320)

The Reicherts Mark 7 spiral concentrator is designed for efficient metallurgical performance for material within the size ranges of about 0,044-1,0 mm.

This spiral does not include any parts along the turns of the spiral trough (as a Humphrey spiral does), and no wash water has to be added throughout the length of the spiral channel. The concentrator is equipped with a single set of product splitters, positioned at the discharge point of the trough. Concentrate, middlings, tailings and a water fraction are discharged separately. The spiral trough profile and slope varies in each turn to promote the separation forces.

For laboratory applications the concentrator can operate in a close circuit together with a slurry pump allowing for realistic concentration results even for a limited quantity of the ore. The pulp should be of 20-60 W-% solids and the maximum capacity of the spiral is appr. 3 ton/h.

Note! Due to lack of height in the pilot batch scale unit the spiral will be installed in the small scale crushing and storage unit.

Concentrating table - Bartles Mozley (Item No. 321)

This slime-concentrating-table includes a tray, which is reciprocated on a transverse plane by a low-frequency vibrator.

To meet the demand of different concentrating purposes, the tray can be of a flat type for -0,1 mm particles, and of a riffeled v-type-tray for -2 mm particles.

The operation is of batch-type and the cycle is appr. 10 min. A slurry of 60-75 w % solids is suitable and each batch can comprice appr. 100 g of solids. The material is introduced on the upstream end of the tray and during operation the lightest particles will follow the water stream and leave the tray over the edge. The heavier particles will remain for a longer time on the tray allowing for separate washing and collecting.

It is an advantage to have flat trays of different materials - wood, steel, plastics etc, because the tray roughness will affect the concentration results.

UNIDO, TECHNOLOGICAL LABORATORY, MOZAMBIQUE

MINERAL DRESSING PILOT BATCH SCALE

Preliminary main equipment specification

Item No.	Type of equipment	No. of	Specification	Installed power kW	Manufacturer	Budget price, kSEK Pce	Budget price, kSEK Tot.	Remarks
	Grinding							
301	Bond´s mill	1	Ø 0.3x0.45 m	0.55	Sala International AB	88	88	
302	Batch mill	1	SRR Ø 0.6x0.9 m	2.2	"	105	105	Possibly smaller
	Fractioning							
310	Vibrating screen	1	VF 15-6 US	4	Svedala Arbrå	68	68	Double decked
311	"	1	SWECO 450 LS18S333	0.2	Thurne Teknik AB	40	40	
	Gravimetric separation							
320	Concentr.spiral	1	Reichert Mark 7 Single start	-	Mineral Deposits Ltd	30	30	Installed in small scale crushing and storage unit
321	Concentr. table	1	C 800	0,5	Mozley Ltd.	60	60	Incl. 3 tables
	Magnetic separation							
330	Dry low intes.magn. drum separator	1	Mörtsell Ø270x125 mm	0.1	Sala International AB	110	110	Variable 0-5.5 m/s
340	Drying ovens	3	TuH 100/150	3x15	Leybold Heraeus	50	150	
	SUB TOTAL			~ 52			651	

5

CHAPTER V - LABORATORY FACILITIES, GENERAL

The two main buildings of the complex are the laboratory building (drawing FM 1-84-25/Appendix 5:1) and the change house and office building (drawing FM 1-84-26/Appendix 5:2).

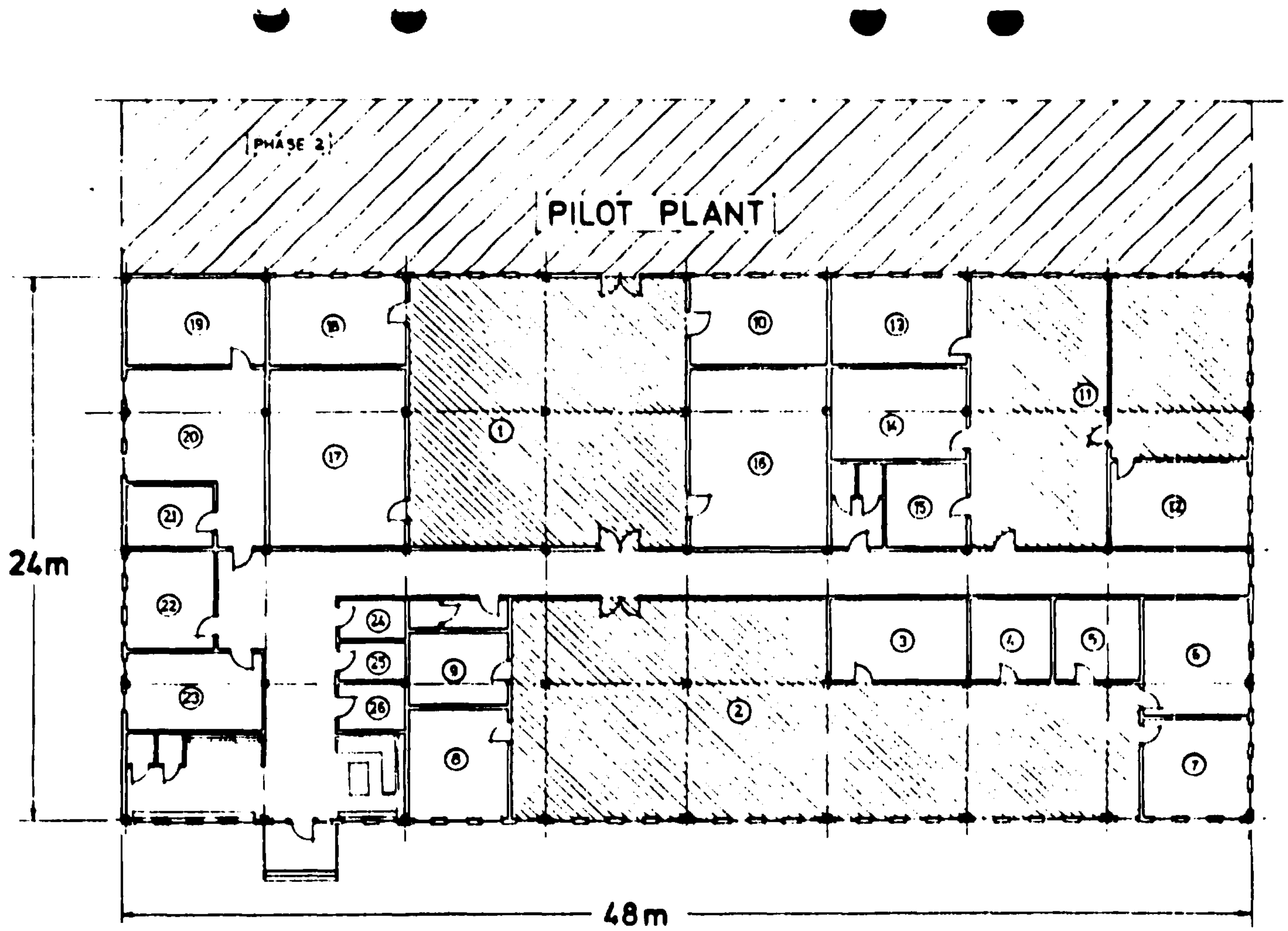
The details of the laboratory building are given under Chapter VI. The change house and office building contains, besides locker and shower rooms and offices, also lecture and conference rooms, a library, a restaurant, and general office facilities.

The costs for furnishing the laboratory offices, and personnel facilities are given under "Furnishings" on page 12 in the summary (SEK 1,200,000).

In Appendix 5:3 is listed some auxiliary equipment which is needed for the operation of the laboratory (emergency generator, fork lift, and compressor). The costs for these outfits amount to:

Equipment costs SEK 725,000

As shown on the general layout drawing of the laboratory building (drawing FM 1-84-25/Appendix 5:1) the building also houses a mechanical workshop (17), an instrument workshop (18), a waiting lounge, wash-rooms and toilets, and other general facilities (pentry, first aid, and cleaning room).



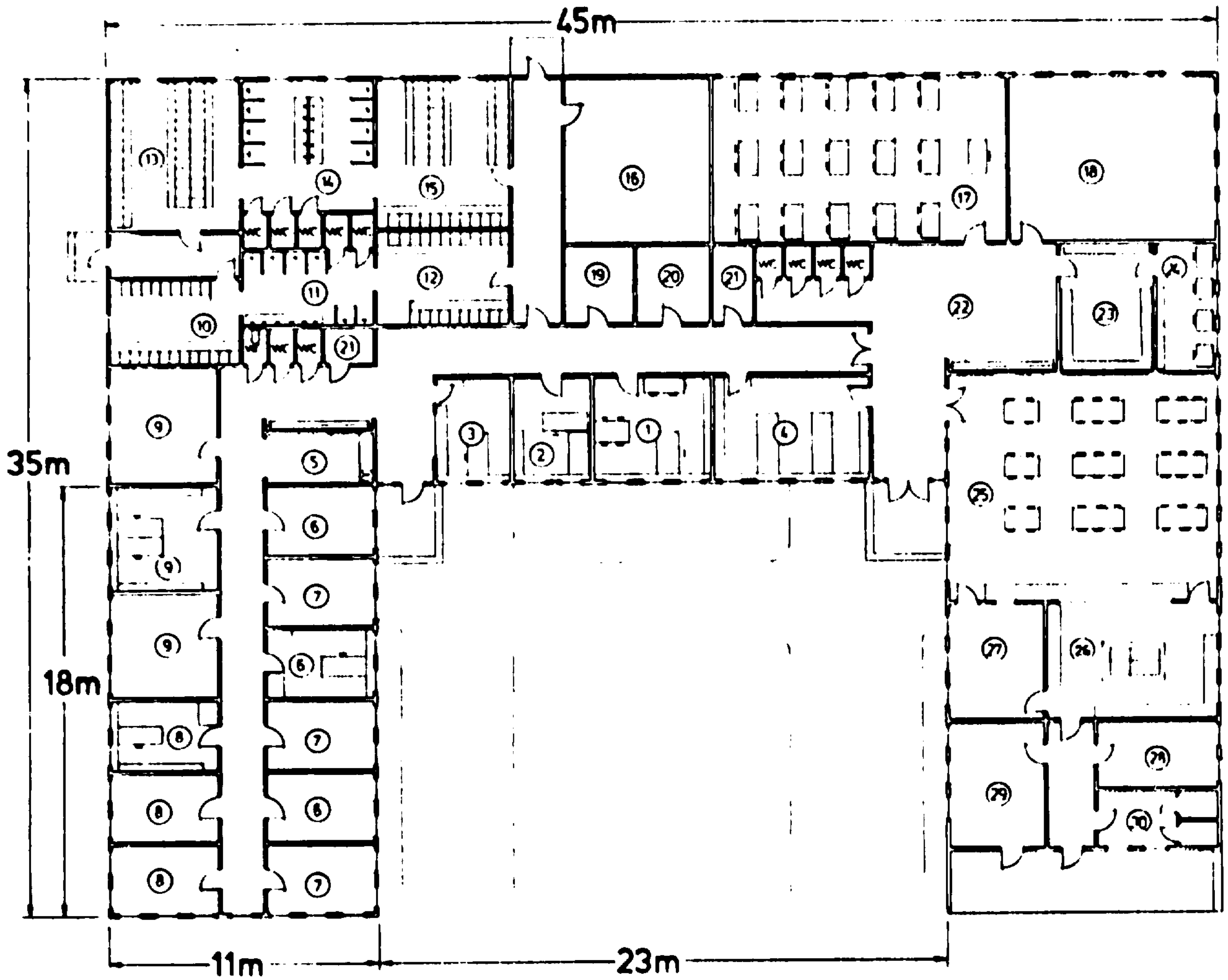
1 [illegible]
2 [illegible]
3 [illegible]
4 [illegible]
5 [illegible]
6 [illegible]
7 PARTICLE SIZE [illegible]
8 OFFICE
9 OFFICE FOR CALCULATIONS
10 [illegible]
11 [illegible] LABORATORY
12 CHEMICALS STORAGE
13 OFFICE
14 GLASS WARE STORAGE
15 OFFICE FOR CALCULATIONS
16 VENTILATION
17 MECHANICAL WORK SHOP
18 [illegible] WORK SHOP
19 SCANNING ELECTRONE MICROSCOPE (SEM) UNIT
20 METALLOGRAPHIC SAMPLE PREPARATION
21 STEREO MICROSCOPE
22 OFFICE FOR CALCULATIONS
23 [illegible] COMPUTER ROOM
24 [illegible]
25 FIRST AID
26 CLEANING ROOM

TECHNOLOGICAL AND NON-METALLIC TESTING AND DEVELOPMENT LABORATORY IN MOZAMBIQUE

LABORATORY FLOOR - PLAN

LKAB

Appendix 5:1



TECHNOLOGICAL AND NON-METALLIC TESTING AND DEVELOPMENT LABORATORY IN MOZAMBIQUE

CHANGE HOUSE AND OFFICE BUILDING – PLAN

LKAB

LABORATORY FACILITIES, GENERAL

Main equipment specification

Item No.	Type of equipment	No. of	Specification	Installed power kW	Manufacturer	Budget price, kSEK Pce	Budget price, kSEK Tot.	Remarks
	Auxiliary equipment							
701	Diesel power generator	1	SC 434 D, 200 kW		Elektromatik AB	300	300	Incl. fuel tank 10 m^2 x
702	Fork-lift	1	Clark E M 15-20		Clark International	200	200	1.5 ton x
703	Compressor	1	GA 408 PACK E	~30	Atlas Copco	125	125	Incl. air dryer FC 504 and tank LDA 1510 x
	Not specified					100	100	
	TOTAL			~30			725	

6

CHAPTER VI - MINERAL DRESSING LABORATORY

The mineral dressing laboratory consists of a main hall and a number of service rooms. In the main hall (drawing FM 2-84-27/ Appendix 6:1) there are permanent installations of flotation machines and magnetic separators, but space is also provided for setting up of equipment for temporary test-work.

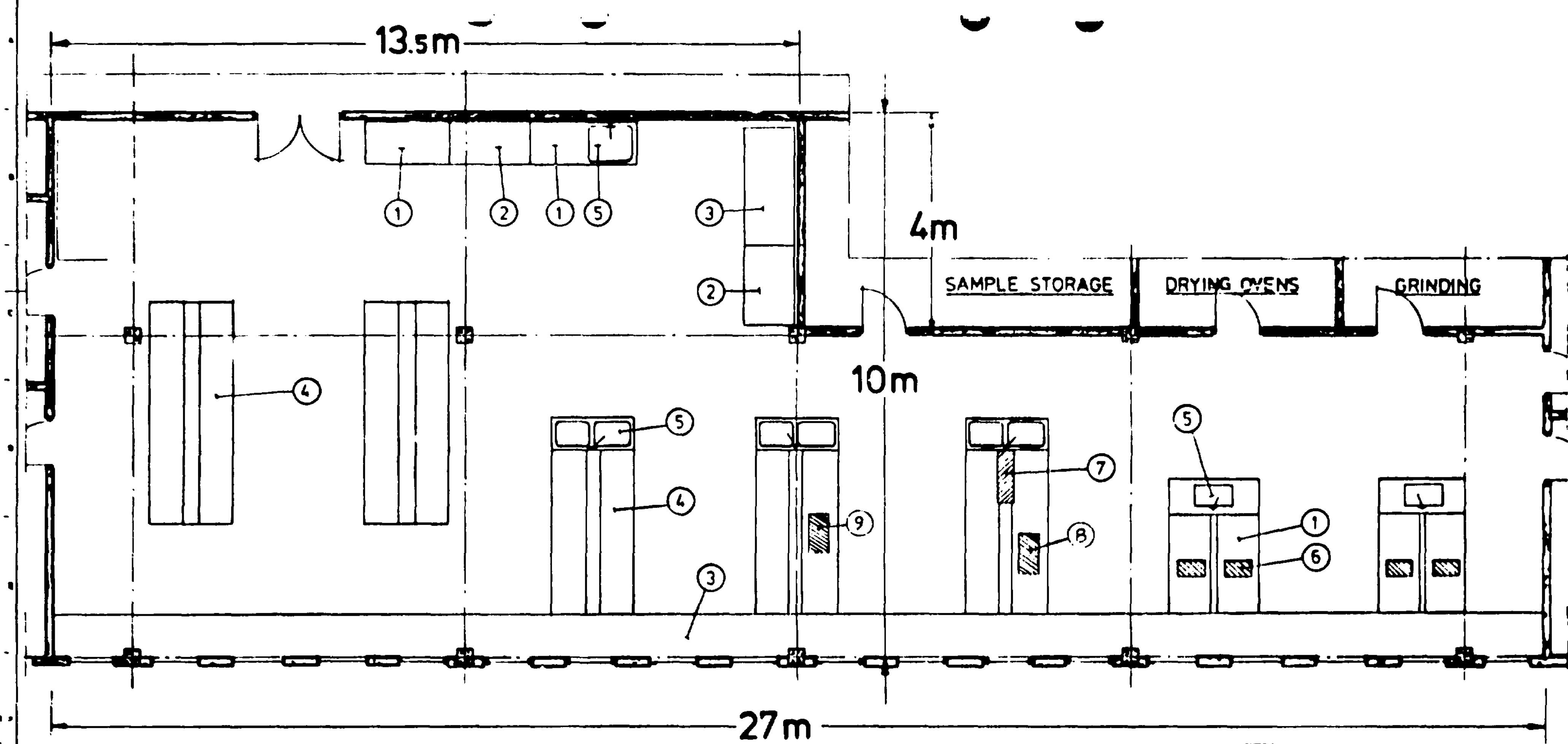
There are five service rooms which contain the following main installations:

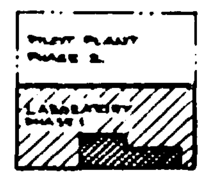
Room 3:	Sample storage
Room 4:	Dry high intensity magnetic separator and dry high tension separator
Room 5:	Grinding mills and jig
Room 6:	Reagent preparation
Room 7:	Screening and specific surface measurement

The layout for rooms 3-7 is shown on drawing FM 2-84-28 (Appendix 6:2). Adjoining the mineral dressing laboratory are also a section head office and a room for calculations etcetera (rooms 8 and 9 on drawing FM 1-84-25/Appendix 5:1).

Method descriptions of the main processes to be tested in the mineral dressing laboratory are given in Appendices 6:3-6:8, and specifications of installed equipment in Appendices 6:9-6:12.

Equipment costs	SEK 1,734,000
Installed power	12 kW





SCALE 1:1000

1 LABORATORY TABLE WITH STAINLESS STEEL COVER
2 FUME CUPBOARD
3 LABORATORY TABLE
4 LABORATORY TABLE WITH DETACHED SHELFS
5 WASH UP SINK
6 FLOTATION MACHINE (ITEM NO. 449)
7 DING's MAGNETIC TUBE TESTER (ITEM NO. 430)
8 WET LOW INTENSITY MAGNETIC SEPARATOR (IT[illegible] . 431)
9 WET HIGH INTENSITY MAGNETIC SEPARATOR (IT[illegible] NO. 434)

TECHNOLOGICAL AND NON-METALLIC TESTING AND DEVELOPMENT LABORATORY IN MOZAMBIQUE

MINERAL DRESSING LABORATORY, MAIN HALL

09-84

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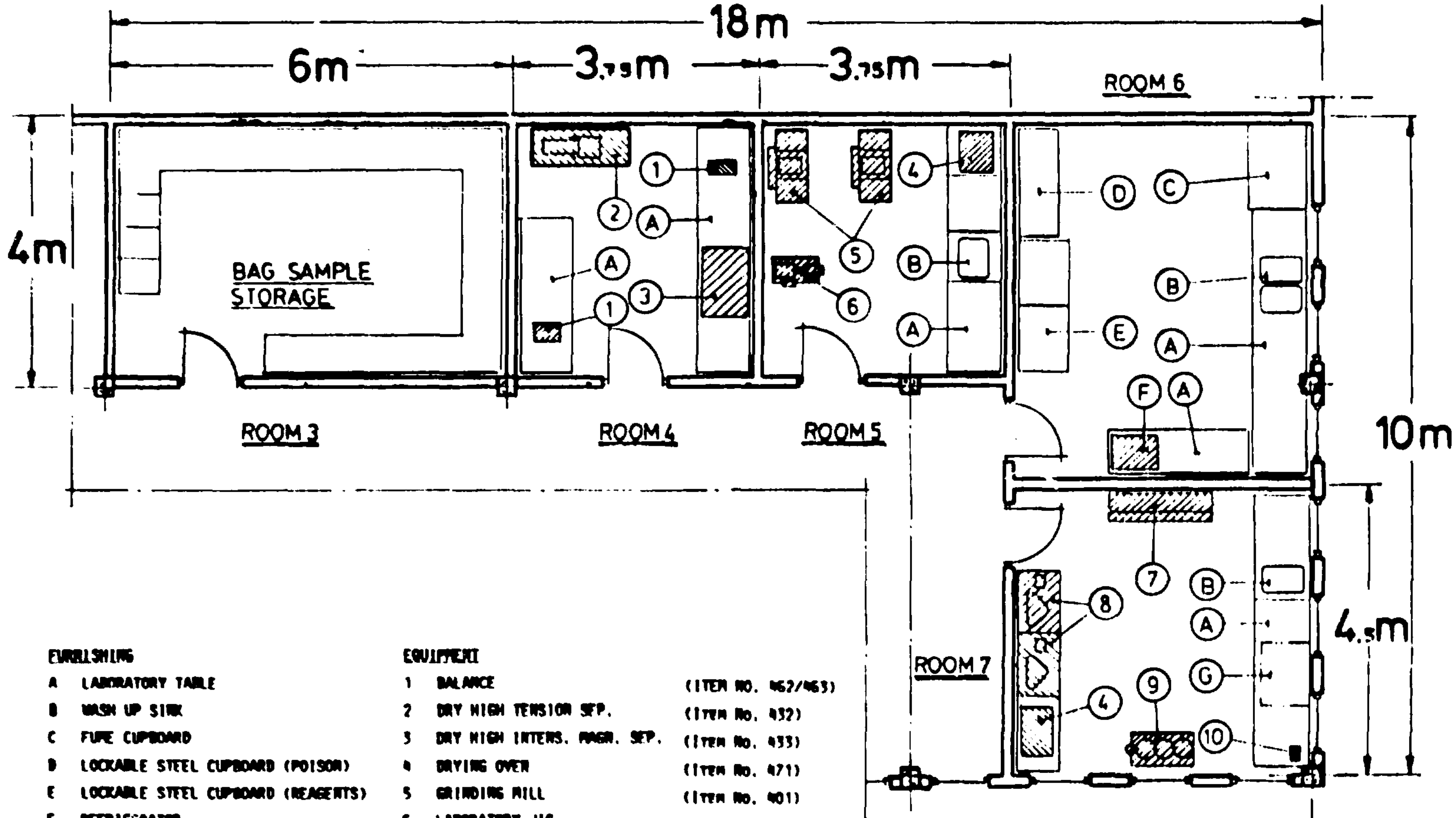
FM 2-84-27 E

Appendix 6.1

ORIGINALFORMAT A2

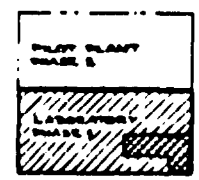


FURNISHING

A	LABORATORY TABLE	
B	WASH UP SINK	
C	FUME CUPBOARD	
D	LOCKABLE STEEL CUPBOARD (POISON)	
E	LOCKABLE STEEL CUPBOARD (REAGENTS)	
F	REFRIGERATOR	
G	FUME HOOD	

EQUIPMENT

1	BALANCE	(ITEM NO. 462/463)
2	DRY HIGH TENSION SEP.	(ITEM No. 432)
3	DRY HIGH INTENS. MAGN. SEP.	(ITEM No. 433)
4	DRYING OVEN	(ITEM No. 471)
5	GRINDING MILL	(ITEM No. 401)
6	LABORATORY JIG	(ITEM No. 420)
7	CYCLO SIZER	(ITEM No. 414)
8	TESTING SIEVE SHAKER	(ITEM No. 414)
9	WET SIEVE EQUIPMENT	(ITEM No. 413)
10	SPECIFIC SURF:METER	(ITEM No. 450)



TECHNOLOGICAL AND NON METALLIC TESTING AND DEVELOPMENT LABORATORY IN MOZAMBIQUE

MINERAL DRESSING LABORATORY ROOMS 3-7 PLAN

09-84

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FM 2-84-28

Appendix 6:2

ORIGINALFORMAT A2

MINERAL DRESSING LABORATORY

METHOD DESCRIPTION

Grinding tests in laboratory mill (Item No. 401)

The laboratory mill, type SBB 23, is used for grinding of material for beneficiation tests. Normally it can not be used for determination of full scale operation grinding data.

The mill has the inner dimensions Ø 210 x 320 mm and is rotated on a drum bench driven by a motor.

Variables used for this mill are mainly:

- Grinding time
- Coarseness of feed
- Type of grinding media

The grinding is made batch wise and can be performed dry or wet. In the latter case the pulp density should be ~ 35 volume-% of solids.

There are two standard steel charges belonging to the mill (~ 17 kg each), one rod charge and one ball charge.

For coarse grinding the rod charge is used and the feed material is then crushed to < 3 mm. For fine grinding the ball charge is used.

This type of mill is used especially for laboratory flotation tests when it is of interest to find out the flotation properties at different size reductions of the material.

The standard procedure is then to make a graph on the relation between the grinding time and the size reduction ratio for one or two kg´s batches ground with rods and balls. After that it is easy to choice the right grinding time for a certain size reduction ratio.

Laboratory jig tests (Item No. 420)

The test unit is suitable for batch tests with samples 3-4 l. The particle size should be 1-10 mm.

To obtain an efficient separation the density difference between the material components must be at least 0.3-0.4 g/cm^3.

The speed of the jig is continously controlled between 120-295 rpm and the stroke between 0-15 mm.

During the jig test water should be continously added through the inlet. The overflow water from the plexiglass cylinder is collected by the water launder and led away.

The jigged material can be removed layer wise as the plexiglass cylinder consists of several separate rings.

Tabling tests (Item No. 421)

The concentrating table comprises a table (deck), which is reciprocated on a longitudal plane by a vibrator.

The deck is fitted with series of tapered strips known as "riffles".

The riffles are tapered downwards from the feed end of the table. This provides decreasing heights for the particles to pass over and assures positive separation all along the deck.

The feed to the table is pre-mixed with water. The solid/ /water ratio may vary a great deal but 25 % solids is a good average.

As the feed pulp flows over the table it reaches the riffles at which point the lighter particles tend to be washed over and the heavier particles sink to the surface of the deck and are propelled forward by the shaking of the table.

Concentrates come over the further end of the deck and tailings are washed over at the front end of the deck. A middlings product is taken out between the concentrates and tailings.

In addition to the water in the feed, extra wash water for dressing water flows over the table to help the separation process.

The concentration is influenced by the speed of the table, length of stroke, inclination of the deck, height of riffles and volume of wash water.

The size of feed should not exceed 2 mm and the capacity not exceed 0.5 tph.

Laboratory sink-float tests (Item No. 422)

The test unit is a self-contained flow-system consisting of a base mounted, cast-iron pump; control valve; feed funnel; sink and float product baskets; overflow funnel; and associated piping.

The feed for sink-float testing should be wet screened on 10 mesh (approx. 1.65 mm). The fines should be reserved for jigging or other treatment. The top size of the feed should not exceed 1/4 inch (6.1 mm). As heavy medium ferro-silicon is used.

The unit is started and water and ferrosilicon are added until the medium reaches the desired specific gravity (generally 2.8 g/cm^3).

The product collecting baskets should be in place before adding the ferrosilicon to prevent possible lumps from clogging the impeller. The dry ferrosilicon should be minus 65 mesh (0.208 mm) and have a specific gravity of about 6.8 g/cm^3.

After establishing the desired media condition and with the wire baskets in place, the screened feed material is wetted and carefully fed to the upper pool of circulating media.

The circulating media is of a specific gravity sufficient to overflow the gangue (float) into the lower basket and permit the concentrate particles (sink) to settle into the upper feed basket. Note, that the opposit is valid for coal.

The product baskets are then removed and subsequently washed in clean water for removing of adhering particles of medium from the sample.

The two products are then removed from their respective baskets and transferred to pans for drying.

Wet low intensity magnetic separation

Ding's Tube Tester (Item No. 430)

The DTT consists of an electromagnet between the poles of which a glass tube is set at an angle of approx. 45° (angle is adjustable). The tube is supported by an agitating mechanism, which is simultaneously rotated and agitated between the magnetic poles when the apparatus is in operation. The speed of agitation can be changed according to the setting made on the governor-controlled constant speed motor.

The DTT is a wet magnetic separator intended for preliminary investigations of beneficiation characteristics of highly magnetic ores (mainly magnetites).

A Suitable sample size is 10-50 g (depending on the magnetic content of the sample), where the grain size should never exceed 3 mm, which is the opening of the lower end of the tube.

Normally the DTT is run with a water flow of 0.6 l/min and agitated at 80 strokes/min for 2 minutes.

The magnetic field strength is variable up to 6600 gauss, which gives about equal results as 3-stage wet magnetic separation on the laboratory separator, item NO. 431.

During operation the non-magnetics is cleansed from the agitated magnetics between the poles and either disposed or collected in a bucket.

After the test is finished the magnet is turned off and the magnetics is washed to a pan.

Laboratory separator (Item No. 431)

This separator is e.g. used to verify DTT results, or to produce larger quantities of products for subsequent lab-testing on other types of equipment.

It has a drum of stainless non-magnetic material with the dimensions dia 200 x 100 mm. The permanent magnets are mounted to an adjustable yoke, which can be turned up to a neutral position when the tank needs to be cleaned.

The magnetic field strength is approx. 1000 gauss at the drum surface.

The maximum allowable particle size is 2 mm but normally the material should be minus 1 mm.

The capacity depends on the material. Normal feeding rate is about 1 kg solids per minute.

The material is agitated with water for a few minutes in a mixer at a pulp density of about 35 % solids.

The separation is then started and the concentrates can be recleaned by repeated runs. 3-stage separation gives about the same results as DTT-separation at 6600 gauss.

The test results correspond closely to those obtained in full scale oepration.

Dry high tension separation

(Item No. 432)

An interesting way of separating different minerals is to use the difference in electric conductivity between the minerals.

The separation is possible due to the fact that different electric charges attracts each other and equal charges repells each other.

In principle the high tension separator consists of a ground rotating drum and two electrodes. One electrode is a s.c. Corona-electrode or pinning electrode and the other one is a type of lifting electrode.

The Corona-electrode creates an electro-dynamic mode and the lifting electrode a static mode. The dynamic mode involves a measurable flow of ionic current (ion bombardment) whereby all particles receive a positive or negative charge and separation oaccurs by leakage of this assumed charge by the conductive materials compared to a retention of charge by the non-conductors. Static mode separations employ a non-discharging plate electrode to attract selectivety charged particles of the opposite polarity or neutral particles, which exhibit dielectric shape or polarizable differences. Combined dynamic and static separation modes can be used to maximize product purity and recovery.

The typical laboratory separation would proceed as follows:

The sample, usually five hundred grammes or less of material 0.1-1 mm, is placed in the top hopper of the separator. The material is passed over the feed drum and the separation characteristics noted as the conditions are varied.

Drum speed, point at which the feed discharges onto the rotor, feed rate, voltage and electrode position are usually the most important factors to be considered when making separation.

The conductive and non-conductive products are collected in two product hoppers.

Normally, the higher the voltage used the higher the degree of separation when only pinning is done. The Corona electroce would probably be best tried at 2 o´clock position to the drum with the wire pointing directly at the drum at the outset. The electrode is kept at the minimum distance where no sparking occurs.

If the sample is constituted entirely of materials of low conductivity, then separacion in an electrostatic field is worth investigation. The drum speed may be limited in this case to the very low range of from 10 to 100 RPM. The Corona electrode is rotated so that the fine wire is pointed directly away from the drum. The lifting electrode position may be as low as 3 o´clock. The electrode may be placed very close to the drum without any danger of sparking.

To obtain good test results the amount of highly magnetic material, as magnetite, should not exceed 0.5-1 %.

Dry high intensity magnetic separation

(Item No. 433) By using new high energy-product permanent magnetic materials in a suitable configuration, the Permroll can be designed to generate magnetic attraction-forces for processing anything from ferro magnetic to very weakly magnetic para-magnetic minerals.

The machine is a self -contained bench top unit.

External to the machine casing is a short belt conveyor, which has the Permroll magnet as its head pulley. Material to be separated is fed onto the rotating conveyor via a feed hopper and vibro-feeder. As material is conveyed over the Permroll, ferromagnetic and para-magnetic particles adhere to the conveyor belt whilst non-magnetic particles stream freely off the end of the conveyor.

Arranged below the conveyor is a hopper which collects the discharging material and by means of two adjustable splitter blades the different products are diverted into collection pans placed beneath the hopper.

The particle size range for operation is from -45 microns up to 25 mm. The Permroll magnet has a field strength of 1.5 Tesla.

Wet high intensity magnetic separator

(Item No. 434)

For wet separation of weakly magnetic material a so-called Ferrous Wheel wet high intensity magnetic separator is proposed. A vertical matrix-carrying ring (wheel) rotates through a magnetized zone, where slurry is fed by gravity into the inner side of the ring. Magnetic particles adhere to the matrix elements and the nonmagnetic particles pass through the matrix and are discharged at the bottom of the ring. Permanent magnets generate the horizontally oriented field over an air-gap that can be adjusted for a particular application.

The matrix with the collected magnetic product may be rinsed while it is in the magnetic zone to displace nonmagnetic particles, but often the matrix is drained only and excessive amount of nonmagnetic particles washed out at a different location, see below. As the ring continuously moves out from the magnetic zone, the magnetic product remains in the matrix pocket until it is washed out at the top position. Hence, the magnetics are washed out in an opposing direction compared to the feed flow direction. Consequently, any oversize or tramp particles will also be easily washed out. Since there is no significant magnetic flux leakage to the washing position, even ferromagnetic particles are easily flushed out.

The Ferrous Wheel separator can be used for separation of weakly magnetic iron ores as well as for cleaning of other types of ores from magnetic constituents (e.g. cleaning of sand, kyanite, talc, wollastonite, calcite, clay).

Flotation

Material to be flotated should be crushed and ground to a suitable grain size, where as many as possible of the particles to be flotated are liberated.

Item No. 440

The flotation machine, Agitair LA-500, has three different cell sizes, 1.5 l, 3 l and 6 l. Dependint on the size of the sample to be tested, the pulp density etc, one of the three flotation cells is chosen for rougher flotation. For cleaning of rougher concentrates a smaller cell is normally chosen.

Item No. 441

For pH.measurement of the pulp to be flotated a pH-meter with electrodes is used. Depending on the reading and the pH-value that is chosen addition of pH-regulating reagents can be made.

Before use, the pH-meter should be calibrated towards a buffer solution within the pH-range to be used.

The flotation froth product is removed from the flotation cell with a froth paddle into a stainless steel bowl of suitable size.

There is a large variety of reagents and reagent combinations that ca be used for flotation. Therefore only some examples of the main groups of reagents used in a mineral dressing laboratory are shown below:

Collecting reagents	- Xantates - Fatty acids - Amines
Activating reagents	- Copper sulphate
Modifying reagents	pH-regulators - Sulphuric acid - Lime - Sodium hydrate (NaOH) Dispersing agents - Water glass - Soda ash
Depressing reagents	- Lime - Zink sulphate - Sodium cyanide - Water glass - Sodium hydrate - Starch
Frothers	- Pine oil - MIBC (Methyl Isobutyl Carbinol) - TEB (Tri Etoxy Butane)

As the lokal concentrations of flotation agents in the cell must not be to big, dissolved solutions of reagents are added during mixing of the pulp.

Item No. 464

Flotation product studies can be made by putting a small sample of the product on a micro slide and studying it in an optical microscope.

UNIDO, TECHNOLOGICAL LABORATORY, MOZAMBIQUE

MINERAL DRESSING LABORATORY

Preliminary main equipment specification

Item No.	Type of equipment	No. of	Specification	Installed power kW	Manufacturer	Budget price, kSEK		Remarks
						Pce	Tot.	
401	Grinding							
	Grinding mill	2	SBB-23 incl. drive	2x0.55	Centro Morgårdshammar AB	27	54	
	Fractioning							
411	Testing sieve shaker	2	Rotap	2x0.5	CE Tyler IP	26	52	
412	Screen sets	4	15 pcs (4-325 mesh)		" " "	21	84	Tyler screen scale
413	Wet sieve equipment	1	Incl. vibrator and 6 sets of screens 325 mesh	PS=220V	LKAB a.o.	18	18	
414	Cyclosizer	1	Warman M-4	0.75	Warman Int.	205	205	
	Gravimetric separation							
420	Laboratory jig	1	Type MN 922/4	0.3	Klöckner Hubolt Wedag	45	45	
421	Lab.concentrating table	1	Wilfley size 13B	0.2	Denver Equ.Div.	46	46	
422	Lab. sink-float batch testing unit	1	Denver	0.5	" " "	63	63	
	SUB TOTAL			~4			567	

NIDO, TECHNOLOGICAL LABORATORY, MOZAMBIQU

INERAL DRESSING LABORATORY

-eliminary main equipment specification

tem o.	Type of equipment	No. of	Specification	Installed power kW	Manufacturer	Budget price, kSEK		Remarks
						Pce	Tot.	
	Magnetic separation							
.30	Dings magn. tube tester	2	Std. duty electro incl. rectifier	2x1,0	Dings Magn.sep. Co	56	102	10 g samples
131	Wet magnetic separator	1	WS 201, Ø 200 x x 100 mm	0.1	Sala International AB	34	34	
132	Dry high tension electrostatic sep.	1	HT 111-15	PS=220V	Carpco Manuf. Inc.	184	184	
133	Dry high intensity magnetic separator	1	Laboratory Permroll Drum Width = 100 mm	PS=220V	Bateman Eng. Corp	210	210	1.5 Tesla
134	Wet high intensity magnetic separator	1	Ferrous Wheel bench tester	PS=220 V	Bateman Eng. Corp.	20	20	
	Flotation							
140	Flotation machine	4	Agitair LA 500	PS=220 V	Galigher Company	50	200	Three in one
141	pH-meter	4	Beckman 3550	" "	LKB Beckman	7	28	
142	Emulsifier	1	Minisonic 4	" "	Ultrasonic Ltd.	27	27	
	Physical analyses							
180	Specific surface meter	1	Blaine		L Farnell Co. Ltd.	4	4	
151	Pycnometer	1	Beckman M 930		LKB Beckman	30	30	
	SUB TOTAL			~ 4			839	

Appendix 6:11

UNIDO, TECHNOLOGICAL LABORATORY, MOZAMBIQUE

MINERAL DRESSING LABORATORY

Preliminary main equipment specification

Item No.	Type of equipment	No. of	Specification	Installed power kW	Manufacturer	Budget price, kSEK Pce	Budget price, kSEK Tot.	Remarks
	Other equipment							
460	Dispersion mill	2	5 1		KEBO AB	5	10	
461	Balance	2	PE 24 S2	PS=220 V	Mettler Instr. AG	10	20	0-24 kg
462	"	5	PE 3600	" "	" "	11	55	0-3.6 kg
463	"	1	PE 360	" "	" "	11	11	0-360 g
464	Stereo microscope	2	Cycloptic 56 M-1	" "	Reichert/Ao	10	20	
465	Automatic splitter	1	PTL	" "	Retsch GmbH	16	16	
466	" "	1	PKZ	" "	" "	15	15	
467	Manual splitter	5	1/2" stainless steel		Endecott Ltd.	2	10	
469	" "	5	1/4" stainless steel		"	2	10	
470	Magnetic stirrer	2	RMH	PS=220 V	KEBO AB	2	4	
471	Drying owen	4		4x0.7	"	6	24	
472	Top desk computer	1	Epson Hx20	PS=220V	Epson Corp.	8	8	
	Not specified						25	
	SUB TOTAL			~4			228	
	TOTAL			~12			1634	

UNIDO, TECHNOLOGICAL LABORATORY, MOZAMBIQUE

MINERAL DRESSING LABORATORY

Preliminary main equipment specification

Item No.	Type of equipment	No. of	Specification	Installed power kW	Manufacturer	Budget price, kSEK Pce	Budget price, kSEK Tot.	Remarks
	Miscellanous							
	Glass ware		Pipettes, beakers etc		KEBO AB			
	Porcelain ware		Funnels etc		"			
	Stainless steel ware		Bowles, buckets etc		Prefab AB			
	Paper ware		Filter paper, bags etc		KEBO AB			
	Plastic ware		Hoses, jars etc		"		100	
	Grinding media		Rods, balls etc					
	Standard chemicals		Various		KEBO AB			
	" reagents		"		Different			
	Trolley	3	M 143450		KEBO AB			
	SUB TOTAL						100	
	GRAND TOTAL			12			1734	

Appendix 6-13

7

CHAPTER VII - HYDROMETALLURGICAL LABORATORY

The hydrometallurgical laboratory consists of two main rooms, one for glass scale tests and one for bench scale tests. There are also storage rooms for glassware and chemicals and two offices, one for the section head, one for personnel making calculations. The layouts of these facilities are shown on drawing FM 2-84-29 (Appendix 7:1).

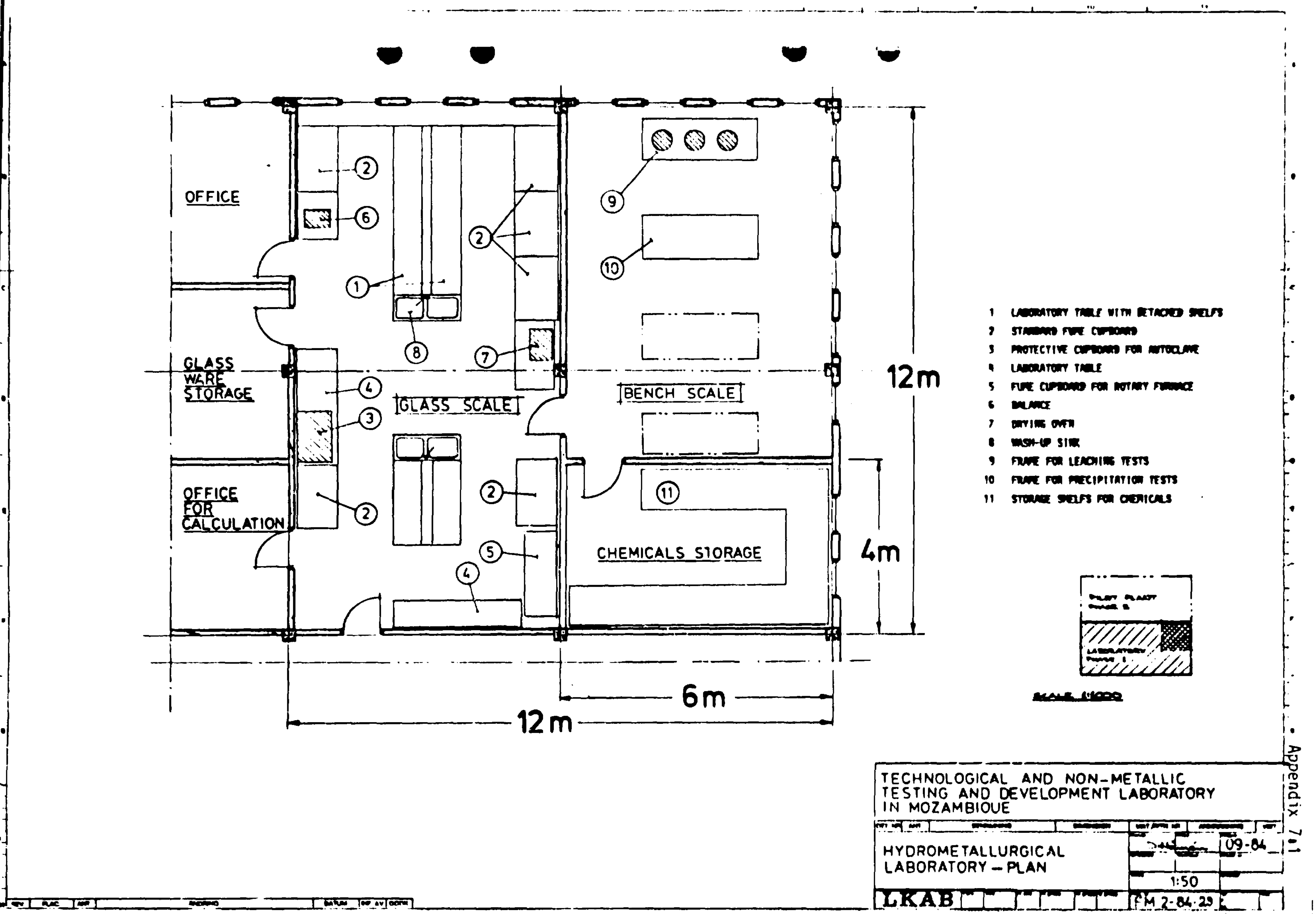
Glass scale tests (normally up to 1 litre) are carried out to investigate the chemistry of the ore or mineral, e.g. how much of an element can be leached by different techniques.

If the results of the glass scale tests seem interesting, the experiments are continued on the bench scale (25-50 litres). On this scale the chemical properties of the system are studied, but it is now also possible to begin studying the physical properties, e.g. filterability of precipitates and crud formation in liquid-liquid extraction.

Ordinarily glass scale and bench scale tests both have to be performed.

Method descriptions of the main operations in the hydrometallurgical laboratory including a prediction of chemicals consumption are given in Appendices 7:2-7:8. Specifications of main equipment are compiled in Appendices 7:9-7:13.

Equipment costs	SEK 607,000
Installed power	24 kW


OFFICE
GLASS WARE STORAGE
OFFICE FOR CALCULATION
GLASS SCALE
BENCH SCALE
CHEMICALS STORAGE
12m
4m
6m
12m
1 LABORATORY TABLE WITH DETACHED SHELFS
2 STANDARD FUME CUPBOARD
3 PROTECTIVE CUPBOARD FOR AUTOCLAVE
4 LABORATORY TABLE
5 FUME CUPBOARD FOR ROTARY FURNACE
6 BALANCE
7 DRYING OVEN
8 WASH-UP SINK
9 FRAME FOR LEACHING TESTS
10 FRAME FOR PRECIPITATION TESTS
11 STORAGE SHELFS FOR CHEMICALS
TECHNOLOGICAL AND NON-METALLIC TESTING AND DEVELOPMENT LABORATORY IN MOZAMBIQUE
HYDROMETALLURGICAL LABORATORY – PLAN
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FM 2-84-29

Appendix 7:1

HYDROMETALLURGICAL LABORATORY

METHOD DESCRIPTIONS

Leaching

In a leaching test the following parameters are normally studied:

- Fineness of grinding
- Leaching time
- Strength of leaching solution

Items No. 501-507
" " 560-567

The experiments are made in an equipment as in attached figures 1 and 2. In every serie of experiments one of the parameters is varied, keeping the others constant.

As an example, for a gold leaching experiment with cyanid leaching the following experimental points should be studied.

Fineness of grinding

Four different materials with for example, k_{80} = 0.100 mm, k_{80} = 0.070 mm, k_{80} = 0.050 mm and k_{80} = 0.040 mm.

Leaching time

Times: 15 h, 30 h, 48 h, 72 h and 96 h.

Strength of leaching solution

NaCN kg/t:	0.5, 1, 2.5 and 5.
pH:	9, 10, 11 and 12.

Other factors

The factors above are the main factors in this scale, glass-scale. In the next bigger scale, bench-scale (volumes about 50 l) many more factors dealing with the physical properties of the system should be studied.

One factor which could be studied in this scale is the pulp density with testing points between 40 and 60 % solids.

The example above has been given for a gold leaching test with cyanid leaching. For other types of leaching other factors can be of interest, for instance redox in leaching of uranium.

Figure 1

Leaching - Glass scale

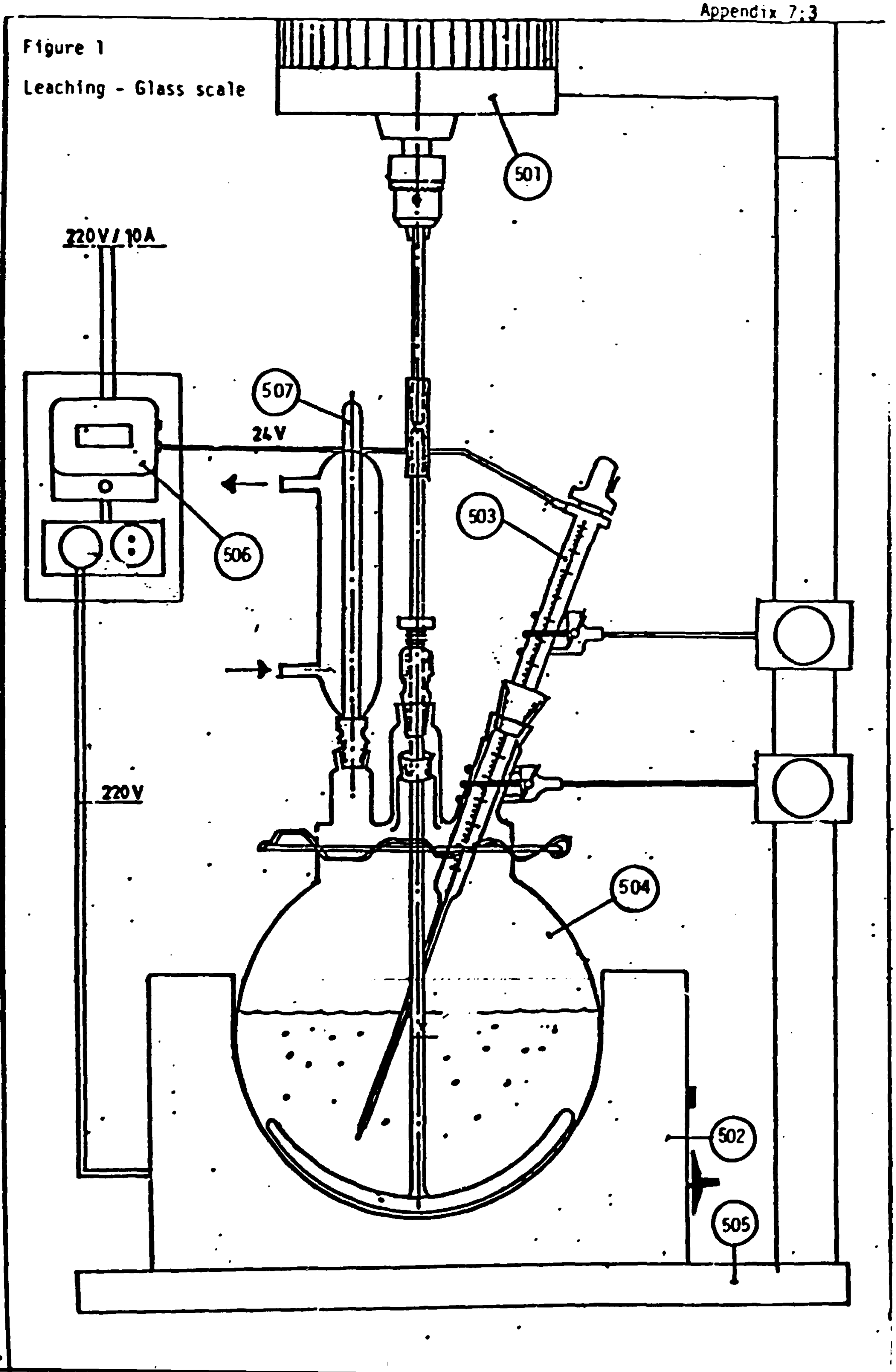
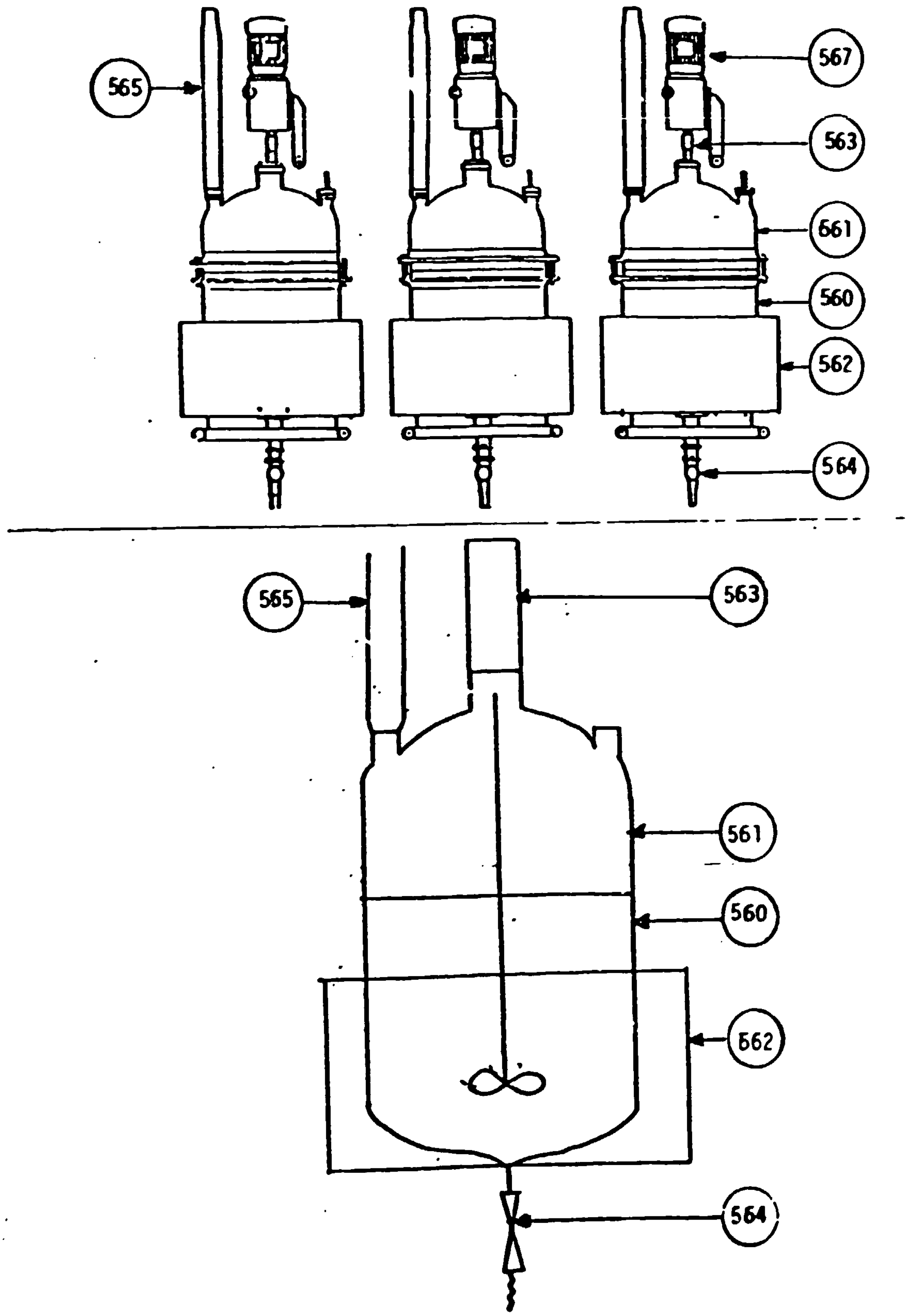


Figure 2

Leaching - Bench scale

Three glass vessels, 80 litres each, equipped with agitators and external oil bath heating.



Extraction

For some metals e.g. uranium and molybdenum, separation with liquid-liguid extraction can be of interest.

The leach solution is turned into equilibrium with an organic phase e.g. kerozene in which an extracting reagent has been dissolved. The extracting reagent then creates a complex with the metal.

The relation between the metal content, the organic phase and the leach solution is called distribution factor.

Some extraction reagents give more favourable distribution factors for certain metals than others and in this way it is possible to create selectivity in the extraction process.

In an extraction test the following parameters can be studied;

- Different ions influence
- Temperature influence
- pH
- Extracting reagents

Extracting reagents can be:

- Alamine 336
- HDEHP
- TOPO
- Mix of different types

Item No. 510

The extraction is performed in a separatory funnel where the separation takes place.

Pressure leaching

Pressure leaching is often performed at relatively high temperatures.

Item No. 520 — The leaching is performed in an autoclave. By using different inserts in the autoclave may types of acids and basis can be useo in the leaching tests.

Process parameters to be studied are the same as for conventional leaching at atmosphere pressure.

Roasting

A roasting operation before leaching can be of interest for very complicated ores, e.g. some tungsten ores.

The roasting operation is supposed to create a change of the material structure that should simplify the leaching operation.

Item No. 530 — The material to be roasted is passing through the rotary furnace at heat treatment (1200-1300^{0}) and in oxidizing atmosphere.

HYDROMETALLURGICAL LABORATORY

Chemicals consumption

It is impossible to forsee the chemicals consumption in the laboratory as long as the extensiveness of the activities is not known.

However, to get an apprehension it can be mentioned that one hydrometallurgical laboratory had the following chemicals consumption for glass scale tests during a five year period:

Chemical	Consumption
$FeCl_3$	2.6 kg
$CaCl_2$	5 kg
KCl	6 kg
$NiCl_2$	1 kg
$NiCO_4$	1 kg
$CoCl_2$	1 kg
$Na_2S_2O_8$	1 kg
KOH	1 kg
Fe	1 kg
NaOH	35 l
HCl	15 l
$BaSO_4$	1 kg
$CaSO_4$	1 kg
NH_3	15 l
Na_2CO_3	5 kg
H_3PO_4	5 l
Zn	6 kg
$ZnCl_2$	5 kg
$ZnSO_4$	1 kg
$FeCl_2$	0.5 l
Acetone	10 l
$MgCl_2$	5 kg

Chemical	Consumption
$NaCl$	1 kg
NH_4Cl	5 kg
$Na_3(PO_4)_2$	0.5 kg
$Pb\ Cl_2$	0.5 kg
$Pb(NO_3)_2$	1 kg
$NaClO$	1 l
Na_2SO_3	1 kg
H_2SO_4	1 kg
Buffer solutions:	
pH 1	0.5 l
pH 4	1 l
ph 7	1 l
pH 9	0.5 l
pH 10	0.5 l
pH 11	0.5 l

UNIDO, TECHNOLOGICAL LABORATORY, MOZAMBIQUE

HYDROMETALLURGICAL LABORATORY (Glass scale)

Preliminary main equipment specification

Item No.	Type of equipment	No. of	Specification	Installed power kW	Manufacturer	Budget price, kSEK		Remarks
						Pce	Tot.	
	Leaching							
501	Motor for mixer	10	Type RW 18.25-2000 rpm	10x0.6	Janke & Kunkel KG IKA Werk	2.7	27	
502	Heating jacket	10	EM 1000/1, max 150°C	10x0.3	Electro thermal	1.0	10	
503	Thermometer regulating the temperature	10	TGL 4850		Made in GDR	0.3	3	
504	Reaction vessel with five necks	10	FRILF and MAF 2/41 1 l		Quickfit	0.7	7	
505	Stand	10				0.5	5	
506	Circuit breaker relay for temperature contr.	10	TGU 10		Jumo	0.4	4	
507	Cooler	10				0.2	2	
508	pH-meter	2	E610		Metram Herisan	8.0	16	
	Not specified						25	
	SUB TOTAL			~10			99	

Appendix 7:9

UNIDO, TECHNOLOGICAL LABORATORY, MOZAMBIQUE

HYDROMETALLURGICAL LABORATORY (Glass scale)

Preliminary main equipment specification

Item No.	Type of equipment	No. of	Specification	Installed power kW	Manufacturer	Budget price, kSEK Pce	Budget price, kSEK Tot.	Remarks
	Extraction							
510	Separatory funnel	10	106, 400-1000		KEBO AB	0.1	1	
	Autoclaving							
520	Autoclave	1	Volume 3 l, Max pressure 25 bar El.heating	1.5	Special design	29.0	29	
521	Motor for agitator	1	Variable speed 50--250 rpm VDE 0530//72	0.2	Bauknacht	3.0	3	
522	Hydraulic agregate for	1	Type HAG-4-0.75-30	1.0	Ceve Hydraulic	4.0	4	
	Roasting							
530	Rotary furnace	1	Tube diam=0.75 m Tube length=0.5 m Max.temp. 1350°C	2.8	Grănges Engineering	17.0	17	
	Not specified			0.5			10	
	SUB TOTAL			~ 6			64	
	TOTAL			~16			163	

Appendix 7:10

UNIDO, TECHNOLOGICAL LABORATORY, MOZAMBIQUE

HYDROMETALLURGICAL LABORATORY (Bench scale)

Preliminary main equipment specification

Item No.	Type of equipment	No. of	Specification	Installed power kW	Manufacturer	Budget price, kSEK Pce	Budget price, kSEK Tot.	Remarks
	Leaching							
560	Reactor vessel	3	Glass, VZ 100/450 spec.		Quickfit	7	21	
561	Cover to item 660	3	Glass, VZA 450/2		"	6	18	
562	Heating jacket	3	BHD 50, oil heated		"	21	63	
563	Bearing and agitator	3	RAL 3/055		"	5	15	
564	Valve	3	PV 1.5/1		"	1.3	4	
565	Cooler	3	HE 1½, water		"	4.6	14	
566	Oil bath and pump	1	For heating oil passing through item 562	6.5	Lauda Thermostate	23	23	
567	Motor for agitator	3	VDE 0530/72	0.55	Bauknacht	6	18	
	SUB TOTAL			~7			176	

UNIDO, TECHNOLOGICAL LABORATORY, MOZAMBIQUE

HYDROMETALLURGICAL LABORATORY (Bench scale)

Preliminary main equipment specification

Item No.	Type of equipment	No. of	Specification	Installed power kW	Manufacturer	Budget price, kSEK Pce	Budget price, kSEK Tot.	Remarks
	Precipitation by pH-adjustment							
570	Reaction vessel	3	Glass, VSC 50 spec. Volume 25 l		Quickfit	3	9	
571	Connecting tube	3	KBA 45/3A		"	0.3	1	
572	Valve	3	PV 1.5/1		"	1.3	4	
573	Motor for agitator	3	RF 0.18/4-7 Variable 0-1370 rpm	3x0.2	Bauknacht	5	15	
574	Pump	1	GBV 3/25, $3m^3/h$		Quickfit	9	9	
	SUB TOTAL			~1			38	
	TOTAL			~8			214	

Appendix 7.12

UNIDO, TECHNOLOGICAL LABORATORY, MOZAMBIQUE

HYDROMETALLURGICAL LABORATORY

Preliminary main equipment specification

Item No.	Type of equipment	No. of	Specification	Installed power kW	Manufacturer	Budget price, kSEK Pce	Budget price, kSEK Tot.	Remarks
	Miscellanous Balances Glassware Porcelain ware Stainless steel ware Paper ware Plastic ware Chemicals		PE2452, PE6, PE360 Pipettes, beakers etc Funnels etc Bowles, buckets etc Filter paper, bags etc Hoses, jars etc Various		KEBO AB " Prefab AB KEBO AB " Different		230	
	SUB TOTAL						230	
GRAND TOTAL				24			607	

Appendix 7:13

8

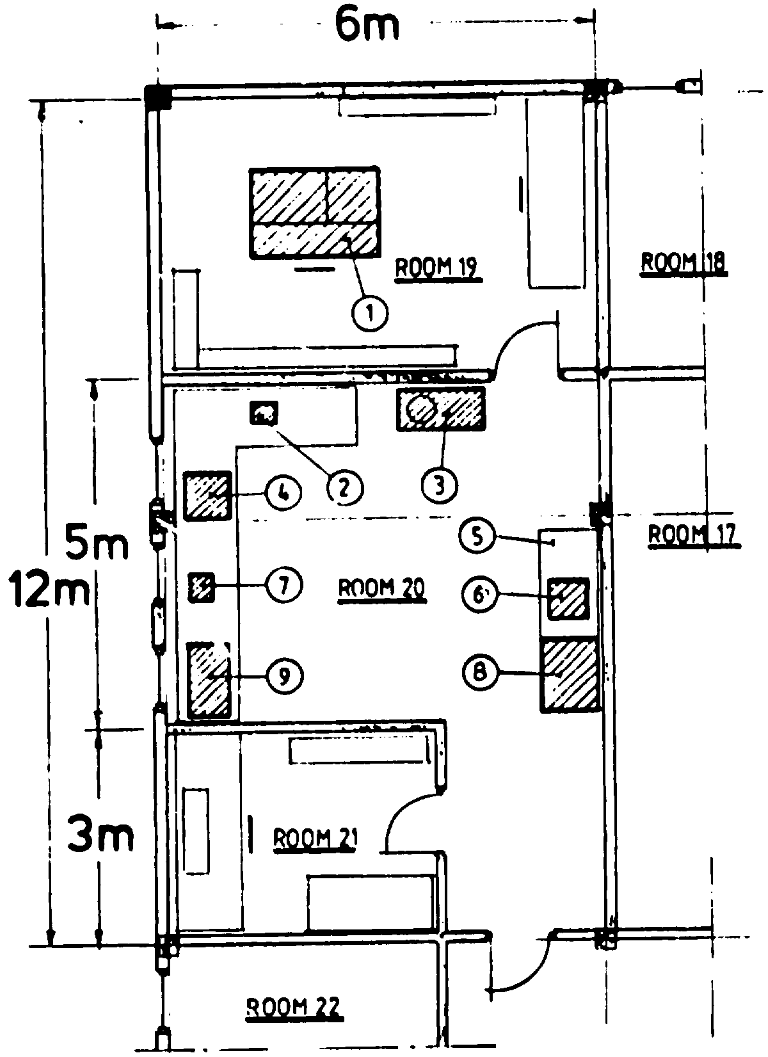
CHAPTER VIII - SCANNING ELECTRONE MICROSCOPE (SEM) UNIT

To be able to study chrystal structures and how different elements are bound to minerals, a Scanning Electrone Microscope (SEM) has been suggested.

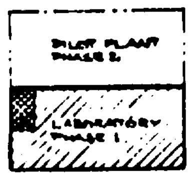
The SEM should also be supplemented with a microsond equipment for determination of chemical compositions.

Drawing FM 2-84-30 (Appendix 8:1) shows the layout of the unit while the location of the unit is shown as rooms 19-21 on drawing FM 1-84-25 (Appendix 5:1). An equipment specification is given in Appendices 8:2-8:3.

Equipment costs SEK 2,065,000
Installed power 13 kW



1	SCANNING ELECTRONE MICROSCOPE	(Item No. 620)
2	CUT OFF MACHINE	(Item No. 602)
3	EVAPORATION UNIT	(Item No. 607)
4	GRINDER	(Item No. 603)
5	LABORATORY TABLE	
6	SAMPLE HOLDER	(Item No. 605)
7	ULTRASONIC CLEANER	(Item No. 606)
8	POLISHER	(Item No. 604)
9	VACUUM IMPREGNATION DEVICE	(Item No. 608)



SCALE 1:1000

TECHNOLOGICAL AND NON METALLIC TESTING AND DEVELOPMENT LABORATORY IN MOZAMBIQUE

SCANNING ELECTRONE MICROSCOPE UNITS ROOM 19-21 PLAN

09-84

1:

LKAB

FM 2-04-30

Appendix 8:1

SEM - UNIT

Preliminary main equipment specification

Item No.	Type of equipment	No. of	Specification	Installed power kW	Manufacturer	Budget price, kSEK Pce	Budget price, kSEK Tot.	Remarks
	Metallographic sample preparation							
601	Vacuum impregnation device	1	Wacim No. 26.3 AN18	0.5	Struers A/S	7	7	x
602	Cut off machine	1	Discotom 2	3	"	42	42	x
603	Grinder	1	DR-U4	0.5	"	22	22	x
604	Polisher	1	Planopol	0.5	"	16	16	x
605	Sample holder etc	1	PDM-Force	0.1	"	12	12	x
606	Ultrasonic cleaner	1	Metason 60	0.1	"	4	4	x
607	Evaporation unit	1	Polaron M 6000	3	Polaron Equip. Ltd	116	116	
608	Microscope incl. camera equipment	1	Olympus V -T	0.5	Olympus Optical Co	173	173	x
	Scanning electrone microscope unit							
620	Base instrument	1	SEM 505	3	Philips Analytical	640	640	x
621	Brightness System	1	LAB_6	..	"	142	142	x
	SUB TOTAL			~ 11			1174	

Appendix E:2

SEM- UNIT

Preliminary main equipment specification

Item No.	Type of equipment	No. of	Specification	Installed power kW	Manufacturer	Budget price, kSEK Pce	Tot.	Remarks
	Scanning electrone microscope (Cont.)							
622	Split Screen/Data/ Rotation Unit	1			Philips Analytical Systems AB	45	45	
623	Polaroid Camera	1			"	9	9	
624	Backscatter detector	1			"	103	103	
625	Edax system 50 analyser	1			"	278	278	
626	Econ detector	1			"	223	223	
627	HP Printer/plotter	1			"	39	39	
	Detector systems							
628	Assembly	1	PW 6765/00		"	33	33	
629	MFD Mounting kit	1	PW 6766/00		"	5	5	
630	Multi-Video control unit	1	PW 6769/00		"	12	12	
631	Specimen current detection system	1	PW 6718/00		"	44	44	
	Miscellanous						100	
	SUB TOTAL			~ 2			891	
	TOTAL			~ 13			2065	

9

CHAPTER IX - PHASE 2

Phase 2 is at present assumed to include the construction of a mineral dressing pilot plant for continuous tests. The hydrometallurgical laboratory will be completed with more equipment for bench scale tests. Furthermore, a primary crushing unit shall be installed with additional material handling/storage equipment to cope with the larger sample volumes.

As the operation of a mineral dressing plant, where tests may last for weeks, creates large quantities of tailing products a tailings disposal system also needs to be installed in Phase 2.

Additional change house and office facilities will be needed in Phase 2 and can be located on top of the laboratory building.

A larger diesel power generator should also be installed in order to supply the facilities with power in case long duration failures will occur on the regular power supply.