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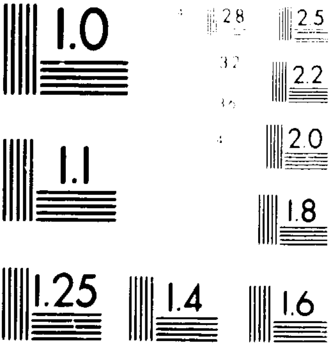
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org



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LURGI

TECHNO-ECONOMIC EVALUATION AND PROJECT REPORT

FOR THE

ESTABLISHMENT OF AN IRON AND STEEL INDUSTRY

IN

THE UNITED REPUBLIC OF TANZANIA

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UNIDO Project No. SM/URT/81/004

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A ADDENDUM

Comments derived from the Tripartite Report Meeting, Dar es Salaam, 23.03.84

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LURGI

Tanzania/Volume I

S E C T I O N 0

Executive Summary

0 Executive Summary

- National Development Corporation (NDC), Dar es Salaam is developing the project of an 500 000 tpy (1 000 000 tpy) integrated steelworks utilizing Tanzanian iron ore and coal as raw material basis.

  United Nations Industrial Development Organization (UNIDO), Vienna granted the funds for the evaluation of an techno-economic report for this project by LURGI Chemie und Hüttentechnik, Frankfurt under UNIDO Project No. SM/URT/81/004.

- The scope of work to be covered for this techno-economic study is as follows:

  - Consolidation and analysis of available studies to make maximum use of the already existing information.
  - Assessment of existing raw materials deposit information.
  - Visit to project area and sites by 5 experts as fact finding mission.
  - Performance of metallurgical testwork with Tanzanian raw materials to produce DRI.
  - Selection of route of technology for processing Mchuchuma coal and Liganga iron ore to steel.
  - Evaluation of a proposal for the development of the iron ore mine and for the beneficiation of the coal prior to its use in direct reduction, if required.

- Project engineering work for the route of technology finally selected, comprising plant description, block flowsheets and list of main equipment items with consumption figures for each process step of an integrated steel plant with an initial capacity of 500 000 tpy of finished product and with the potential of a future expansion to finally 1 000 000 tpy.
- Economical evaluation comprising investment cost estimates, operating cost and finished product cost estimates.

- The project of an integrated steelworks in Tanzania was examined in the past by external consultants in the following studies:

  " Feasibility Study on Iron and Steel Industry in Tanzania ", Norconsult, 1973.

  " Feasibility Study, Iron and Steel Industry based on Liganga Iron Ore and Mchuchuma Coal ", GTZ / Dr. Otto Gold / Saarberg Interplan, 1977/79.

  The findings of those studies are not transferrable to the present evaluations due to fundamental differences in project design.

- The LURGI fact-finding delegation visited the project area during 17th - 31st January, 1983.

- The Tanzanian market for steel products was examined by Tanzania Industrial Studies and Consulting Organization (TISCO) in a corresponding study executed for NDC in 1980. According to the findings of this market survey, in 1990 a demand/supply gap of 460 000 t of primary steel can be expected. This market potential justifies a design capacity of about 500 000 tpy of steel for the new integrated project, which at earliest will be in operation by 1990 - 1992.

- To meet the steel product demand of the Tanzanian construction sector, the product mix of the planned integrated steel plant was agreed upon with NDC as follows:

Stage 1:	500 000 tpy	
	20%	plates, 30 mm thick
	80%	hot rolled coils, 2-3 mm thick
Stage 2:	+500 000 tpy	
	10-15%	rails, 90 lbs/yard
	10-15%	beams, 12 inch max.
	10-15%	channels, 50 mm
	20-15%	angles, 120-150 mm max.
	60-40%	billets, 120 squares max.

Stage 2 has to be regarded as a potential future option, the impacts of which on the design considerations for Stage 1 had to be considered especially when fixing the general plant arrangement.

- Mchuchuma coal and Liganga/Maganga iron ore, both deposits located in the South of Tanzania, Ludewa District at a distance of approx. 80 km from each other, form the indigenous raw material basis for the NDC integrated steel project.

- The technical route selected for the NDC project is reliably secured by metallurgical testwork performed with Tanzanian raw material samples in the LURGI Research Centre, Frankfurt. The samples were taken and shipped by NDC.

- The non-availability of coking coal in Tanzania and severe restrictions imposed by the chemical composition of the Liganga/Maganga titanomagnetite iron ore led to the selection of the route of technology as follows:

1. Liganga/Maganga iron ore containing approx. 51.4% Fetot, 12.9% TiO_2, 0.5% V_2O_5, 8.8% Al_2O_3, 4.8% MgO and 0.19% Cr has to be beneficiated to decrease the excessive gangue content for further processing, yielding a concentrate containing approx. 53.3% Fetot, 6.5% TiO_2, 0.64% V_2O_5, 2.8% Al_2O_3, 1.75% MgO and 0.21% Cr.

2. From Liganga/Maganga concentrate fired pellets can be produced using Tanzanian limestone/ bentonite as binding agents.

3. Further processing of the pellets has to avoid the formation of carbon-containing hot metal as the transfer of the Cr contained in the pellets into the liquid metal would impose significant problems with regard to its further processing and finished product quality. Therefore the coal-based direct reduction route for producing DRI, which in turn is smelted to semi-steel in an electric smelter, has been selected. In a SL/RN DR plant using washed Mchuchuma coal as only energy source, direct reduced iron (DRI) with 92% metallization will be produced from the pellets.

4. The DRI is electrically smelted in an open bath submerged arc furnace under oxidizing conditions to transfer and eliminate V and Cr as oxides into the melting slag. The semi-steel is refined and treated in a separate ladle furnace to produce liquid steel for casting and rolling.

5. Recovery of V and TiO_2 as valuable by-products from the slag is not feasible. The low contents of these elements in the slag (V_2O_5 approx. 2.4%, TiO_2 approx. 25%) are prohibitive in respect of further processing.

- The NDC integrated steel project thus consists of following facilities and plants:

Liganga Iron Ore Mine	1.56 million tpy r.o.m. iron ore
Liganga Iron Ore Beneficiation	0.99 million tpy concentrate
Liganga Pelletizing	0.90 million tpy fired pellets
Mchuchuma Coal Mine	2.40 million tpy r.o.m. coal
Mchuchuma Coal Washing	0.50 million tpy washed coal
Mahanje DR Plant	0.66 million tpy DRI
Mahanje Smelting Plant	0.59 million tpy semi-steel
Mahanje Ladle Furnace Plant	0.584 million tpy liquid steel
Mahanje Continuous Caster	0.554 million tpy cast steel slabs
Mahanje Rolling Mill and Product Finishing	0.500 million tpy strips and plates

The facilities in Liganga, Mchuchuma and Mahanje are supplemented by the related offsites and auxiliary systems.

- The implementation of the NDC integrated steel project requires extensive infrastructure development efforts mainly comprising:

Mchuchuma Thermal Power Plant	300 MW
Mchuchuma Township	6 600 People
Liganga Township	3 000 People
Mahanje Township	12 000 People
Road	152 km
Railway line	320 km
Railway Rolling Stock	27/410 engines/waggons
Power Grid	140 km
Communication System	140 km

- The implementation of the project would require a total duration period of 64 months, comprising

  . a preparatory phase of 18 months for infrastructure development (road, railway, etc.)

  . a construction phase of 28 months and

  . a commissioning phase of 18 months

  as critical path periods.

- The direct net employment potential of the project is:

Mchuchuma	Coal	1 200	People
Liganga	Iron Ore	500	People
Mahanje	Steel	1 800	People
Total		3 500	People

Multiplicator effects for secondary employment effects are not included.

A total number of approx. 330 people key personnel of graduated or skilled level of education will have to be trained abroad.

- The investment cost estimates for the metallurgical facilities literally are as follows (1 US$ = 12.2 TSh):

		1 000 US$
Liganga	Iron Ore Mine	8 193
	Iron Ore Beneficiation	44 088
	Iron Ore Pelletizing	35 085
	Offsites	16 117
Mahanje	Direct Reduction Plant	161 731
	Smelting Plant	35 391
	Ladle Furnace Plant	17 810
	Continuous Caster	41 417
	Rolling Mill	128 941
	Offsites	82 789
Sub-Total		571 562
Spare Parts, Replacements		65 177
Cost before Start-up		20 078
Interest during Construction		58 884
Total		715 701

Beside the interest during construction no other financing charges for obtaining funds covering the investment and working capital are included in this estimate, which is based on cash terms of payment.

- <u>The investment cost estimates for the secondary facilities</u>, such as coal mine, washing plant, power plant and other project area infrastructure is estimated as follows:

		1 000 US$
Mchuchuma	Power Station	258 000
	Coal Mine (average per year, 20 years)	12 350
	Coal Washing Plant	7 500
	Offsites	20 700
Township	Mchuchuma	65 595
	Liganga	35 289
	Mahanje	98 602
Road	Madaba/Mchuchuma	42 280
Railway	Mlimba/Mchuchuma	534 400
Railway	Rolling Stock	36 400
Electric Grid		30 100
Communication System		1 850
Total Secondary Investment		1 143 066

No financing charges for obtaining funds covering the investment and working capital are included in this estimate, which is based on cash terms of payment. This secondary investment was not considered in the economical projections as it is mainly but not exclusively related to the steel project.

- In the economic calculations, the project to be evaluated comprises the total iron and steel plant complex, that is the iron ore mine and the pelletizing plant in Liganga and the direct reduction and steel plant in Mahanje. The coal mine and the coal washing plant as well as the power plant and the general area infrastructure are not included in the economic evaluation. The main reason for this procedure was to avoid charging the project with installations, serving mainly but not exclusively the iron and steel production.

1. Investment Capital Requirement

   Total initial plant investment for the total project amounts to 6 973,071 million TSh. Replacement of equipment with a short lifetime adds 795,157 million TSh over the operating period of the project. Cost before start-up amount to 244,948 million TSh. Interest during construction is calculated at an interest rate of 10,0% applied to the total capital requirement and amounts to 718,379 million TSh.
   The total investment capital is estimated to be 7 936,398 million TSh.
   The figures are discussed in detail in Chapter V/2.

2. Working Capital Requirement

   The working capital comprises inventories for raw materials, intermediate and finished products and spare parts, treasury, accounts receivable and payable.
   The total working capital requirement was estimated to be 751,551 million TSh in Chapter V/3.

3. Operating and Production Cost

The operating and production cost are estimated for the total plant complex.

Total operating cost:	2 072,324 million	TSh per year
	4 144,65	TSh/t steel

Total production cost including depreciation and

interest:	2 965,075 million	TSh per year
	5 929,65	TSh/t steel

4. Annual Revenues

When Tanzanian domestic prices are applied, the revenue per t of average steel amounts to 8 250,5 TSh/t or 4 125 230 million TSh per year.

When import prices free Dar es Salaam without domestic duties are applied, the respective revenues amount to 4 737,2 TSh/t or 2 368,600 million TSh per year.

5. Results of the Profitability Estimation

The discounted cash flow rate of return before tax of 19,0% may look attractive and may be a good reason to encourage the investment in the project. One has to bear in mind, that the interest rate for investment in Tanzania, as given by NDC, lies at 10,0%. The difference of 9% may be high enough to cover the risk involved in such a large project.
The average ROI of 11,83% could also be considered as a good result.

A main objection may be found in the question of steel prices. As can be obtained from the results of the sensitivity analysis, the steel prices applied play the most important role to evaluate the project. Tanzanian domestic steel prices are nearly double compared with import prices. Therefore, the international steel price situation (CIF Dar es Salaam) should be taken as reference for the economical viability of the project. When these import prices are applied, the project will not be economically feasible. the DCFRR falls to negative values. Even a decrease of the price level down to 80 % of its original value (approx. 6 410 TSh/t for plates and 6 648 TSh/t for strips) will result in a downfall of the DCFRR to 10,19 % after tax and the average ROI to 3,35 %. It can be stated, that even a slight variation of the steel prices affect the profitability very seriously.

It could further be stated, that under these circumstances no export of surplus steel could be achieved under conditions assuring the economics of steel production.

Moreover, the considerations of the secondary investment - a highly political issue for this project - has been kept out of the picture and is critical in terms of strongly negatively influencing the project economics, in case these infrastructure development cost are mainly or fully charged to the project.

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SECTION 1

Introduction

1. Introduction

1.1 Project Background

The major tasks of the Government of the United Republic of Tanzania, as outlined in the long-term Industrial Development Plan 1975 - 1995, are to restructure the industrial sector by increasing domestic linkages in order to achieve a greater degree of economic and industrial self-sufficiency. The plan emphasises the promotion and establishment of various basic industries including the production of iron and steel based on the raw material ressources available in the country.

At present, Tanzania is a net-importer of steel products and scrap. Domestic steel is being produced by Aluminium Africa Ltd., Steelcast Division, Dar Es Salaam, on the basis of scrap.
This company with its own scrap collecting subsidiary collects approx. 7 000 tpy local scrap and operates a 10 t electric arc furnace with a 2-strand billet caster. ALAF produced 12 600 tons of cast steel in 1981 corresponding to a capacity utilization of the works of approx. 75 %. Production was hampered mainly by the import restrictions for ferrous scrap and inferior quality of the scrap collected domestically.

The Steel Rolling Mills Ltd., Tanga, are operating a merchant rolling mill of approx. 20 000 t annual capacity for the production of rounds and small structures. The mill is fed with billets produced by ALAF, Dar Es Salaam, as well as with imported billets/bars. Capacity utilization is poor due to strict import constraints.

The steel imports for the country are handled through National Steel Corporation (NSC), Dar Es Salaam. Due to a severe economic crisis continuing since 1980 and resulting in foreign exchange restrictions, steel imports by NSC totalled approx. 40 000 t in 1982 as compared to an overall demand estimated at 140000 tpy.

To substitute the major part of steel imports, for which a drastic increase can be expected with the country's economy picking up the growth rates of 1975/78, the Government of the United Republic of Tanzania has already decided to install an integrated works for the production of iron and steel using indigenous raw materials.

The project is in hands of National Development Corporation, Dar Es Salaam, who contacted The United Nations Industrial Development Organization (UNIDO), Vienna for financial assistance in the preparatory phase. Under UNIDO Contract 82/67, Project No. SM/URT/81/004, Lurgi Chemie und Hüttentechnik GmbH, Frankfurt, West Germany, were entrusted with the evaluation of the techno-economic study of this project. The corresponding scope of work is listed in the following paragraph.

1.2 Scope of Work

The scope of work to be covered under UNIDO Contract No. 82/67 for this techno-economic study is briefly outlined hereunder:

- Consolidation and analysis of available studies to make maximum use of the already existing technical and economical information.
- Assessment of existing raw materials deposit information and recommendation for further exploration work, if required.
- Visit to project area and sites by 5 experts as fact finding mission for data collection and assistance in connection with raw material sampling.
- Performance of metallurgical testwork with regard to raw materials preparation and direct reduction with representative raw material samples collected and shipped by NDC.
- Selection of route of technology for processing Mchuchuma coal and Liganga iron ore to steel.
- Evaluation of a proposal for the development of the iron ore mine and for the beneficiation of the coal prior to its use in direct reduction, if required.
- Project engineering work for the route of technology finally selected, comprising plant description, block flowsheets and list of main equipment items with consumption figures of each process step.
- Economical evaluation comprising investment cost estimates, operating cost and finished product cost estimates.

According to additional terms of reference, the capacity of the steel plant to be projected was fixed by NDC to be:

- 500.000 tpy of rolled steel in a first phase, leading to a
- final capacity of 1.000.000 tpy of rolled steel,
- with the possibility of an intermediate phase of about 750.000 tpy of rolled steel.

The cost calculation has to be carried out with a possible error of

± 30% for investment costs estimates,

± 25% for finished product costs estimates.

When the study work was started and especially also during the field visit, LURGI observed that this scope of work would not cover the variety of aspects to be considered, when one wants to arrive to a realistic picture of the project in its complexity. Accordingly, LURGI extended its evaluations towards indicating the immense infrastructural requirements involved and also outlining a possible project implementation strategy which takes into account the necessary regional development activities as a precondition for the implementation of such magnitude of technical project in a rural backward area.

Furthermore, the cost calculations were supplemented by elaborating the main economic coefficients for this project as well.

1.3 Executed Studies

1.3.1 Assessment of Main Existing Studies related to the Iron and Steel Project

1.3.1.1 "Feasibility Study on Iron and Steel Industry in Tanzania", Norconsult, 1973

This study consists of five parts and proposes electric smelting of pig iron from Liganga lump ore and pellets (fired and cold bonded). As reductant, alternatively charcoal and form coke produced from Mchuchuma coal were envisaged. The metallurgical concept as outlined by Norconsult in cooperation with Gränges Steel and Elkem, both of Norway, is based on the use of low shaft furnaces, operating with electric power inputs of between 1,400 kWh (prereduced hot charged pellets) and 3,000 kWh (cold charged lump ore). The economical and technical background for alternative annual pig iron smelting capacities of 0.2, 0.4 and 0.5 million tons of pig iron was evaluated in a preliminary way. As plant location (energy/customer-oriented) the area of Kidatu was proposed with approx. 500 km pipeline transport of beneficiated iron ore. Recovery of Ti and V was considered economically doubtful. The problem of Cr-content in Liganga iron ore - leading to Cr-carbides during smelting of pig iron - was not dealt with in the study. Also steelmaking from pig iron and rolling of finished products was not included in the scope of work. For the present study, mainly Norconsult's findings on Liganga iron ore beneficiation and Mchuchuma coal quality have been considered whereas the metallurgical concept and the economical evaluation are no longer applicable.

1.3.1.2 "Feasibility Study, Iron and Steel Industry based on Liganga Iron ore and Mchuchuma Coal" and "Transport Study", GTZ/Dr. Otto Gold / Saarberg Interplan/, RODECO, 1979/1977

This study covers - on the basis of an assumed plant capacity of 140.000 tpy of finished product - the essential metallurgical aspects involved in processing Liganga iron ore and Mchuchuma coal into steel. The coal-based direct reduction route -producing sponge iron out of Liganga iron ore pellets with Mchuchuma coal as the only energy source - was selected on the basis of comprehensive metallurgical testwork carried out in the Research Laboratories of LURGI Chemie und Hüttentechnik GmbH, Fried. Krupp GmbH and Saarbergwerke AG. The tests covered principal aspects of beneficiation of iron ore and coal, pelletizing and direct reduction and these test results can be considered reliable. However, various aspects such as details of recovery of Ti and V, optimized melting method for DRI and direct processing of Liganga lump ore to sponge iron have not been covered. The plant capacity of 140.000 tpy resulted in the project economics being marginal since size degression of investment costs could not be utilized. Project design including site selection and transport flow/infrastructure proposals have been adapted to the small sized 140.000 tpy mini-mill and accordingly cannot be transferred to the modified conditions of the present study.

The metallurgical testwork performed under the GTZ study formed the basis for LURGI's approach towards further detailed testwork with regard to evaluating an optimized metallurgical concept under the scope of this techno-economic study.

1.3.2 Bibliography

The documents on the Maganga/Liganga iron ore deposit and the Mchuchuma coal fields mainly from State Mining Corporation (Stamico) as well as the various studies already performed in the past in connection with the iron and steel project - all documents as made available by NDC - are listed in the bibliography hereunder:

Maps

1. Shell Map of Tanzania
   Scale 1 : 250 000

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   Dar Es Salaam, 1973;

2. Topographic Map of Tanzania
   Njombe, Sheet SC-36-8
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   Surveys and Mapping Division, Ministry of Lands,
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   Edition 1-TSD
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   Housing and Urban Development,
   Dar Es Salaam, 1975;

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7. Summary of the Geology of Tanganyika,
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Bulletin No. 21, Dar Es Salaam, 1954

10. The Coalfields and the Coal Ressources of
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Geological Survey of Tanzania
Bulletin No. 38

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11. Tanganyika Iron (Liganga)

Morris, H.R., Colonial Development Corporation, London, 1955

12. Geology of North, West and Central Njombe District, Southern Highlands Province, Bulletin No. 18,

Stockley, G.M., Tanganyika Territory Department of Lands and Mines, London, 1948

13. Project Findings and Recommendations in Coal Development

Turkowski, K., State Mining Corporation, United Republic of Tanzania, URT/74/024/01/37 Dar Es Salaam, 1980

Studies assessed:

1. "Iron and Steel Demand in Tanzania"

   Tanzania Industrial Studies and Consulting Organisation (TISCO), Dar Es Salaam, 1980

2. "Transport Study for Mchuchuma Coal and Liganga Iron Ore" (1 Vol.)

   GTZ/RODECO, 1977

3. "Feasibility Study, Iron and Steel Industry based on Liganga Iron Ore and Mchuchuma Coal" (3 Vol.)

   GTZ/Dr. Otto Gold, 1979

4. "Feasibility Study on Iron and Steel Industry in Tanzania"

   Norconsult A.S., 1973 (3 Volumes, Part 3 - 5)

5. "Preliminary Plant Design and Economics for the Reduction of Liganga Iron Ore using Mchuchuma Coal"

   Gregory Njau, Report M.S. Degree, University of Dar Es Salaam, 1982

6. "Aide Memoire on the Development of a 300.000 tpy Iron and Steel Works in Tanzania"

   National Development Corp., Dar Es Salaam, 1981

7. "Location Study of the 500.000 tpy Iron and Steel Plant"

   National Development Corp., Dar Es Salaam, 1982.

1.4 Summary Report of Visit to Project Area from January 17th to 31st, 1983 (Dar Es Salaam, 31.1.1983)

LURGI Field Team:

Dr. Detlev Schlebusch,	Metall. Eng., Teamleader
Dr. Eckhard Hilmer,	Mining Geologist
Dr. Erhard Weilandt,	Economist
Mr. Adolf Hans,	Mech. Eng. (Design)
Mr. Klaus Fritzsche,	Metall. Eng. (Mannesmann-Demag AG)

List of Main Activities in the Project Area during January 17th to 31st,1983

17th:
- Arrival DAR, Transfer
- General Introduction to NDC Facilities

18th:
- Kick-off Meeting with NDC/UNDP
- Inspection of raw material samples taken by NDC at Nat. Steel Corp., DAR

19th:
- General Introduction at Resident Officer UNDP
- General Introduction at German Embassy
- Plant visit and technical discussions at Aluminium Africa Ltd., Steelcast Division

20th:
- Mowlem Constructors, Visit to base camp DAR, technical discussions on local civil works and steel structure aspects
- Tanzanian Industrial Research and Development Organisation (TIRDO), General Introduction, Research Aspects
- University of DAR, Dept. Chem. Eng., General Introduction, Process Aspects.

21st: - Tanzania Electric Supply Co. Ltd.
Discussion on energy supply situation and network aspects in project area

- Ministry of Minerals and Mines
Discussion on Mchuchuma Coal development plans

- National Chemical Industries (NCI)
Discussion on by-products production and marketing aspects

- Preparation of field trip

22nd: - Field Trip 1st day, DAR-Iringa, approx. 400 km

23rd: - Field Trip 2nd day, Iringa-Ludewa, approx. 420 km

24th: - Field Trip 3rd day, Ludewa-Mchuchuma-Manda-Ludewa with visit to coal deposit, inspection of coal out-crops and sampling spots

25th: - Field Trip 4th day, Ludewa-Maganga-Liganga-Njombe with visit to iron ore deposits and inspection of sampling spots

26th: - Field Trip 5th day, Njombe-Mikumi,
Visit to Howard Humphries, Njombe; information on road construction and infrastructure cost aspects in the project area.
Return with one Landrover only due to lack of petrol in Iringa District.

27th: - Field Trip 6th day, Mikumi-DAR

28th: - Briefing at NDC, General Report

29th: - Ministry of Communication and Transport, Discussion on transportation aspects and site area intercommunication

- State Mining Corporation (Stamico) Request for additional information on Mchuchuma/Liganga deposits, discussion on Stamico's mine development plans for Mchuchuma.

30th: - Sunday (free)

31st: - TAZARA Headquarters DAR (cancelled)

- Ministry of Industries (cancelled)

- Final Meeting NDC

- Departure to Frankfurt.

1.5 Acknowledgements

LURGI Chemie und Hüttentechnik GmbH wishes to herewith express their sincere thanks for the kind assistance granted during the field visit in Tanzania by the Tanzanian Ministries, Institutions, Parastatals and the National Development Corporation.

UNIDO Vienna granted the funds for financing this study, UNDP, Dar Es Salaam efficaciously supported the activities of the field team in the project area.

S E C T I O N 2

Project Basis

SECTION 2.1

General Project Description

2.1 General Project Description

The coal deposits of Mchuchuma and the iron ore resources of Liganga/Maganga form the domestic raw material basis for the iron and steel project promoted by National Development Corporation of the United Republic of Tanzania. The deposits are located near to Lake Nyasa in the south of Tanzania. The distance to the main industrial centres of the country close to Dar es Salaam is approx. 860 km by road (Dar es Salaam / Morogara / Iringa / Njombe / Mahanje). The project area is a rural backward region with tropic climate conditions in the districts of Ludewa and Songea, altitude above sea level is approx. 1200 m average.

NDC is planning an integrated iron and steelworks with an initial capacity of 500 000 tpy finished steel products and the possibility of a future expansion to 1 000 000 tpy in a final stage. This industrial complex is to serve the domestic steel market of Tanzania, the requirements of which are mostly characterized by the typical steel grades needed for the building and construction industry. Thus, the first stage comprises the fabrication of 500 000 tpy of strips and plates, whereas in a second stage, 500 000 tpy of sections and bars are to be produced.

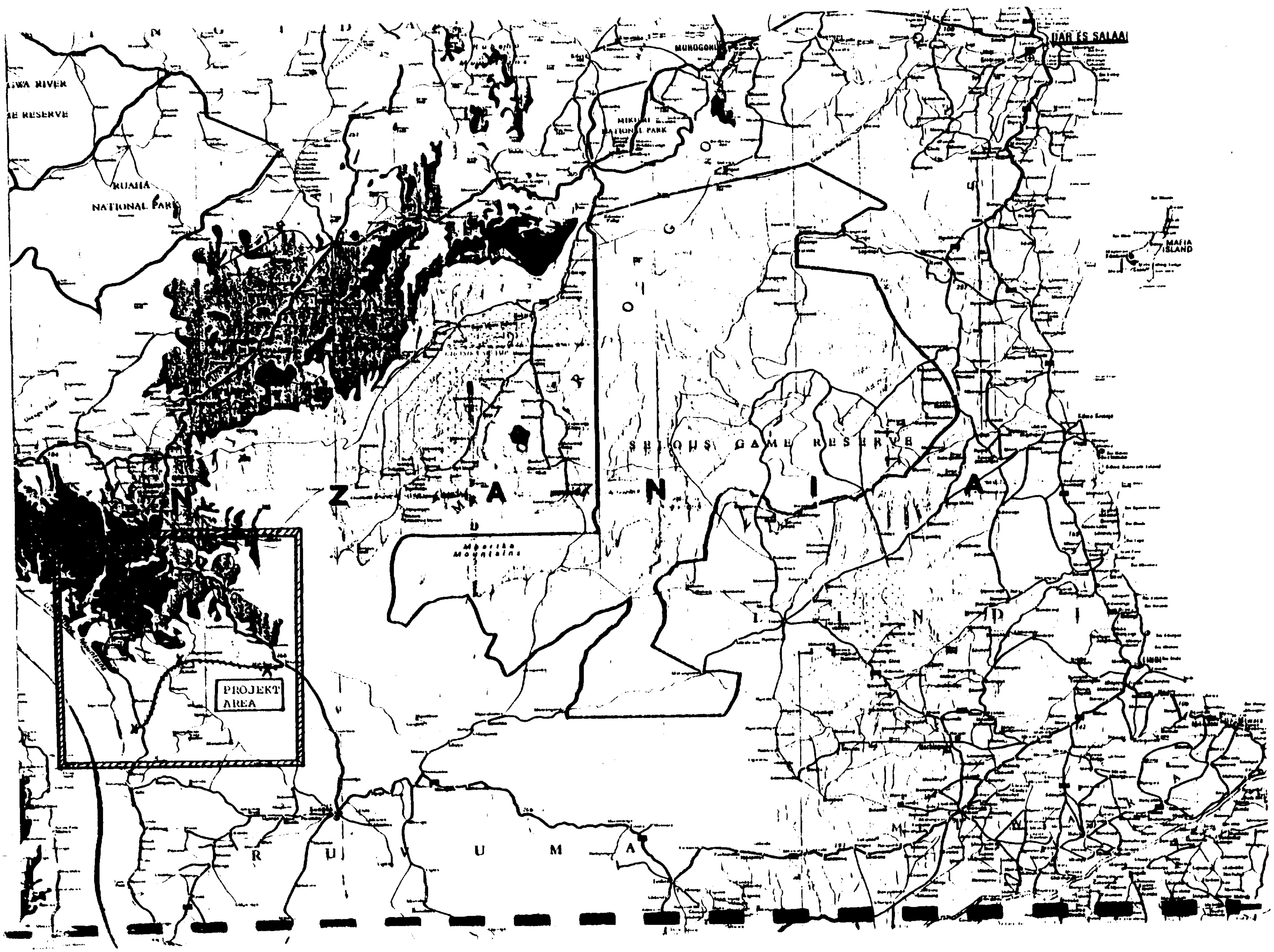
The raw material basis for the integrated steel project is formed by the coal deposits of Mchuchuma (Ludewa district) and the titanomagnetite iron ore deposits of the Maganga/Liganga Hills.

Both deposits require further detailed exploration programmes to assess the raw material reserves and allow justifying the investment connected to the implementation of industrial mining facilities.

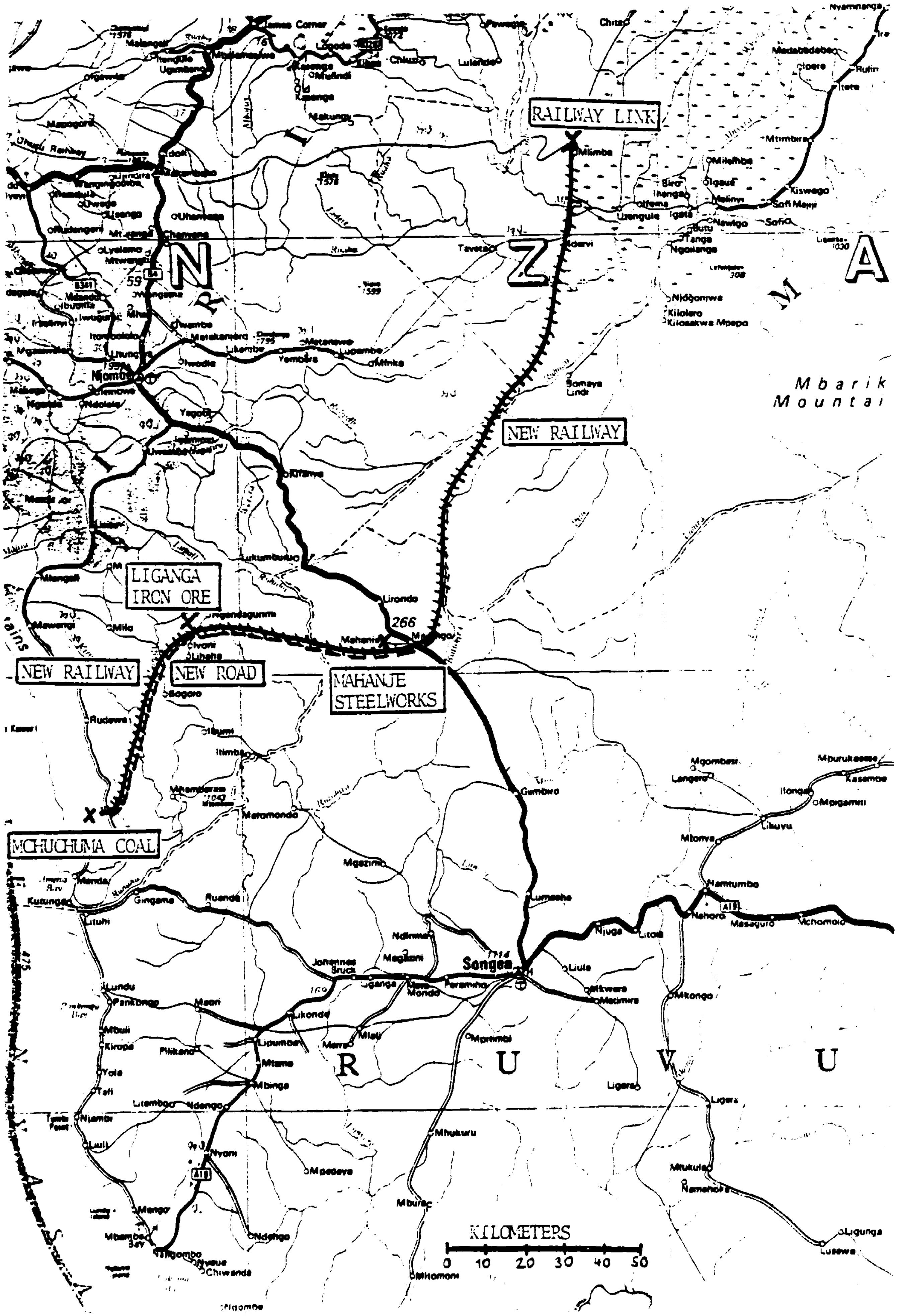
The raw materials mentioned above - Mchuchuma coal and Liganga iron ore - represent the largest input flows of material for the planned integrated steel-works with corresponding impact on the selection of the site for the steelworks.

From the site selection options - customer or raw materials oriented - NDC selected the latter alternative due to transportation aspects and taking into account the development potential of the new industrial complex for southern Tanzania. In a site selection study prepared by NDC in January, 1983, the Mahanje area close to the new allweather road Songea/Njombe was proposed as main site for the new steelworks and thus forms the basis of this project planning.

As shown in the enclosed maps, comprehensive infrastructure facilities will have to be provided for the project, related to three different sites.



DAR ES SALAA
MUNOGONI
MIKUMI NATIONAL PARK
RUAHA NATIONAL PARK
MAFIA ISLAND
SELOUS GAME RESERVE
Mbarika Mountains
PROJEKT AREA
T A N Z A N I A
R U V U M A


RAILWAY LINK
NEW RAILWAY
LIGANGA
IRON ORE
NEW RAILWAY
NEW ROAD
MAHANJE
STEELWORKS
MCHUCHUMA COAL
KILOMETERS
0 10 20 30 40 50
Njombe
Songea
Mbarik
Mountai
Lirondo
Gembwo
Lumecha
266

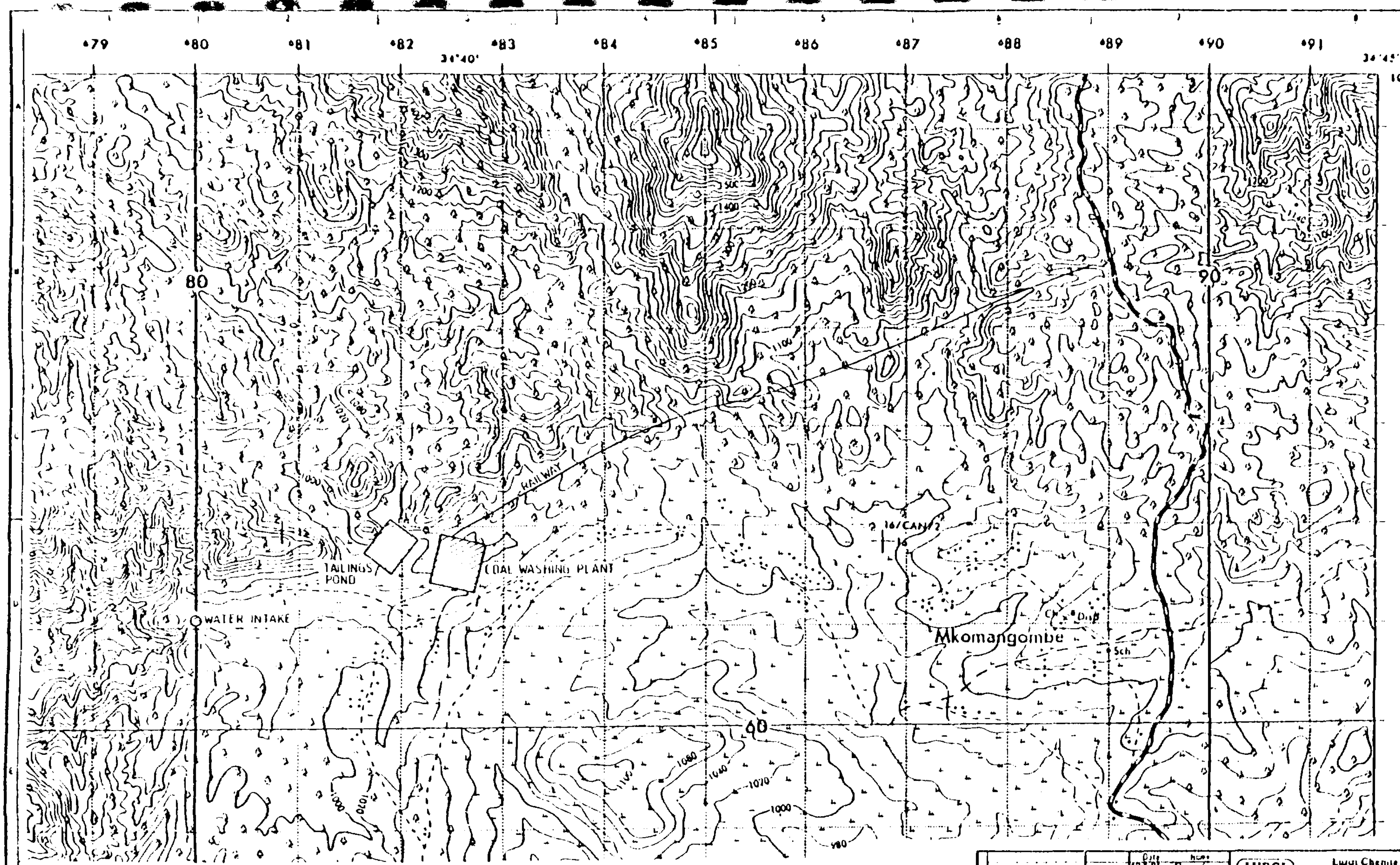
2.1.1 Mchuchuma Area

The coal deposit of Mchuchuma will have to be opened by a new underground coal mine with an annual capacity of approx. 2.4 million tons of run of mine coal.

The portion of low ash coal from the lower seam which is to supply the energy for the Mahanje steelworks, will be washed in an adjacent coal washing plant, yielding approx. 500 000 tpy of washed coal in the grain size of 0 - 10 (15) mm to be transported by railway to Mahanje, the site of the steelworks.
The mining facilities represent a new industrial complex to be installed in the Mchuchuma region of Ludewa district with a direct railway and road connection extending across the Liganga/Maganga area to the Mahanje steelworks.

At the same time, Mchuchuma coal fields will represent the source of energy supply for a new 300 MW thermal power station to be erected close to the coal mine. The new power station is absolutely necessary to meet the electric power requirements of the neighbouring industries and will be fired with run of mine Mchuchuma coal. The area of Mchuchuma has to be developed initially installing the necessary transport infrastructure, such as a new road connection Mchuchuma/Liganga of 80 km length for bringing in the necessary supplies and equipment during the construction phase and a new railway for coal transports to the Mahanje steelworks as well as to the other areas of consumption with a length of the railway section Mchuchuma/Liganga of 80 km.

Mchuchuma coal mine, washing plant and power station will represent an employment potential of approx. 1200 people and can form the nucleus for a new concept of self-sufficiency in energy supplies for the south of Tanzania.



NOTE.
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MANDA MAP EDITION 1-TSD,
SERIES Y742, SHEET 285/3

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Prepared: 12.1.84 Pu

Scale: 1:25000

Title: COAL WASHING PLANT
MCHUCHUMA
TOPOGRAPHICAL MAP

Process: HAA

Job/Proposal No: 0 1 2 2 3 8

Job Title: TANZANIA

Drawing No: L2A0122380009

2.1.2 Liganga/Maganga Area

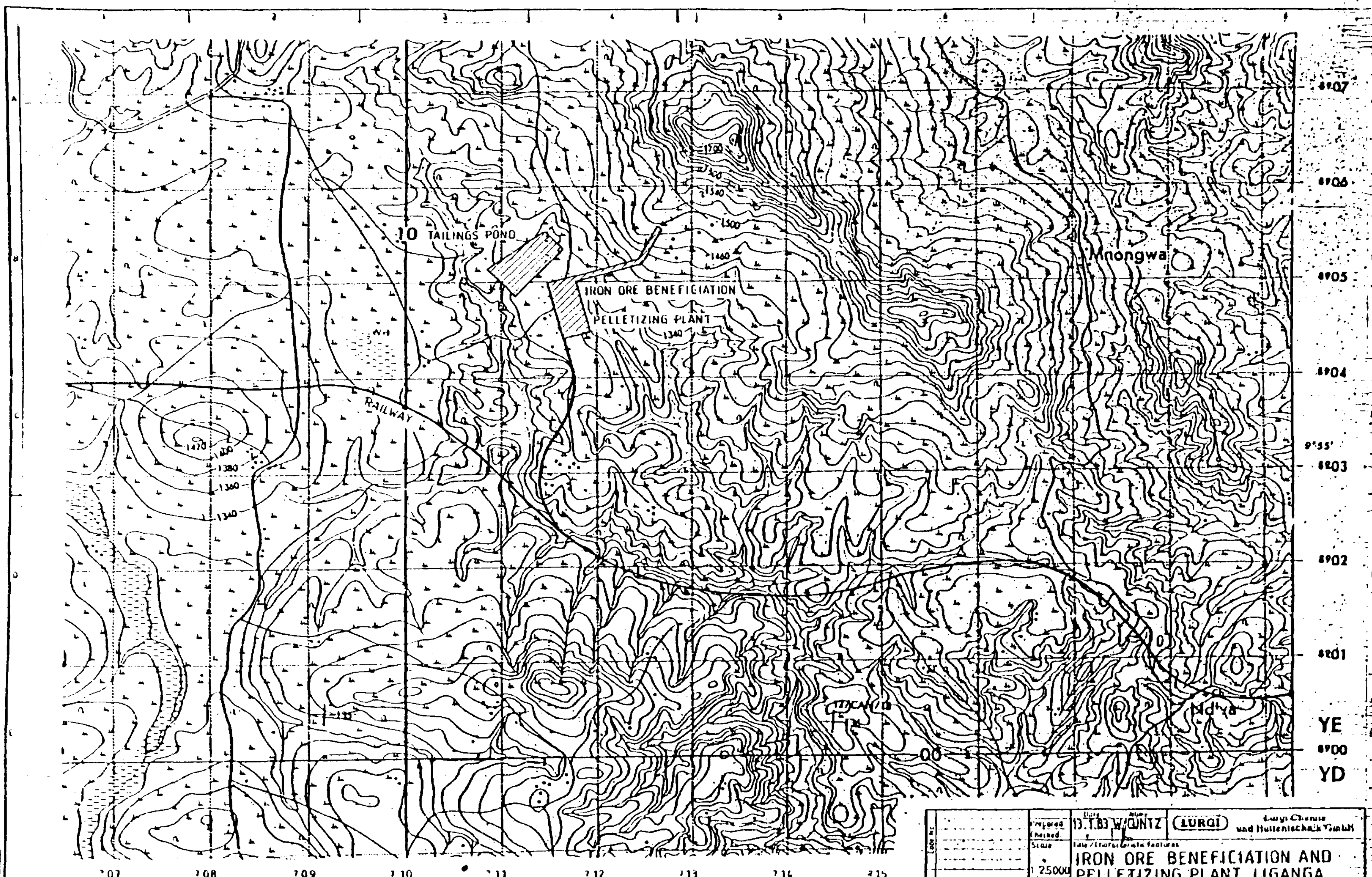
The iron ore deposit of Liganga contains estimated reserves of around 30 million tons of mineable titano-magnetite iron ore with an Fe content of approx. 51%. This is sufficient for a project life time of approx. 19 years at a plant capacity of 500 000 tpy steel products. The inferior deposits in the close neighbourhood are not yet reliably explored, exact reserve estimates for these potential iron ore sources are not possible at the present state of information. The iron ore of Liganga can be mined in open pit mining operations and has to be beneficiated prior to processing in the Mahanje steel plant. The iron ore will be mined at an annual capacity of 1.56 million tpy via explosion/excavation and will be transported by trucks to a precrushing unit. The iron ore lumps (size -800 mm) will then be transferred to a wet beneficiation plant where by crushing/grinding and multiple stage magnetic separation 999 000 tpy iron ore concentrate with above 61% Fe content will be produced for feeding the pelletizing plant. Using domestic limestone and bentonite as binding agents, the filtered concentrate will be formed into green pellets on pelletizing discs and will be heat hardened on an oil-fired travelling grate to produce 990 000 tpy fired pellets suitable for further processing in the direct reduction plant of Mahanje steelworks.

Mining operation, iron ore beneficiation and pelletizing plant form one industrial complex in the Liganga area, which will employ approx. 500 people, not inclusive general servicing functions for social and infrastructural needs.

The Liganga facilities will be connected with Mchuchuma and Mahanje by road and railway, i.e. a new road connection from Mchuchuma via Liganga to Mahanje, length of section Liganga/Mahanje approx. 60 km, and a new railway track from Mchuchuma via Liganga to Mahanje, length of section Liganga/Mahanje approx. 60 km, will have to be implemented as a first step of project development.

The Liganga industrial complex - similar to the Mchuchuma mining and power generation facilities - will have to be installed following the concept of island industries, which means maximum self-sufficiency in terms of available utilities for managerial, social and infrastructural functions.

Pellets produced from Liganga/Maganga titanomagnetite iron ore will be transported by train (4 transits per day) to Mahanje steelworks; limestone, bentonite, fuel oil and other non-regional inputs will be brought in from Dar es Salaam via Mahanje. Electric power supply from Mchuchuma power station will be provided by means of a new 220 kV grid connecting the various sites of the project area.



NOTE:
ENLARGED SECTION MADE FROM
MKUTANO MAP: EDITION 1-TSD
SERIES Y 742, SHEET 274/4

Prepared	13.1.83 W. GUNTZ
Checked	
Scale	1:25000
Title	IRON ORE BENEFICIATION AND PELLETIZING PLANT LIGANGA TOPOGRAPHICAL MAP
Process	HAA
Job / Proposal No	0 1 2 2 3 8
Job Title	TANZANIA
Drawing No	L 2 A U 1 2 2 3 8 0 0 0 1 0

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2.1.3 Mahanje Steelworks

The new steelworks to be installed at Mahanje will form the largest industrial implementation in the scope of the project. Located approx. 12 km west of the Madaba junction of the Songea/Njombe all-weather road, Mahanje steelworks will be designed to produce

- 500 000 tpy of strips and plates in a first stage

- additional 500 000 tpy of bars and sections in a future expansion step.

Approx. 990 000 tpy of iron ore pellets from the Liganga facilities and 500 000 tpy of washed coal from Mchuchuma will be received by rail, connecting Mahanje with Mchuchuma via Liganga.

The product of the steelworks will be sent to the areas of consumption on a new railway track connecting the project area with the existing TAZARA railway of Mlimba station, approx. 180 km north-east of Mahanje, whereas the new road connection to the Njombe/Songea road will have a length of approx. 12 km.

The operations of Mahanje steelworks comprise in the first stage:

- Direct reduction of Liganga pellets with Mchuchuma coal in a 4-strand rotary kiln plant, 660 000 tpy DRI.

- Open bath submerged arc electric smelter plant for the production of semi-steel, 590 000 tpy.

- Ladle furnace plant for steel refining, 584 000 tpy.

- Continuous casting plant for the production of slabs, 555 000 tpy.

- Rolling mill for the production of 400 000 tpy hot strip and 100 000 tpy heavy plate.

- Related utility plants, such as limestone/ dolomite calciner, air fractioning plant, water treatment, central workshop, laboratory, main administration center, etc.

The outdoor infrastructure in Mahanje will have to be developed - similar to the installations of Liganga and Mchuchuma - by providing the necessary township for approx. 12 000 people with all related services like sewage treatment, fresh water system, communication, roads, electric power grid, social buildings, etc.

2.1.4 Summary

In total, the integrated steel project will require the development and installation of

1.	Mchuchuma:	Coal Mine Coal Washing Plant 300 MW Power Plant Township
2.	Liganga:	Iron Ore Mine Beneficiation Plant Pelletizing Plant Township

3.	Mahanje:	Integrated Steelworks
		Auxiliary System
		Township

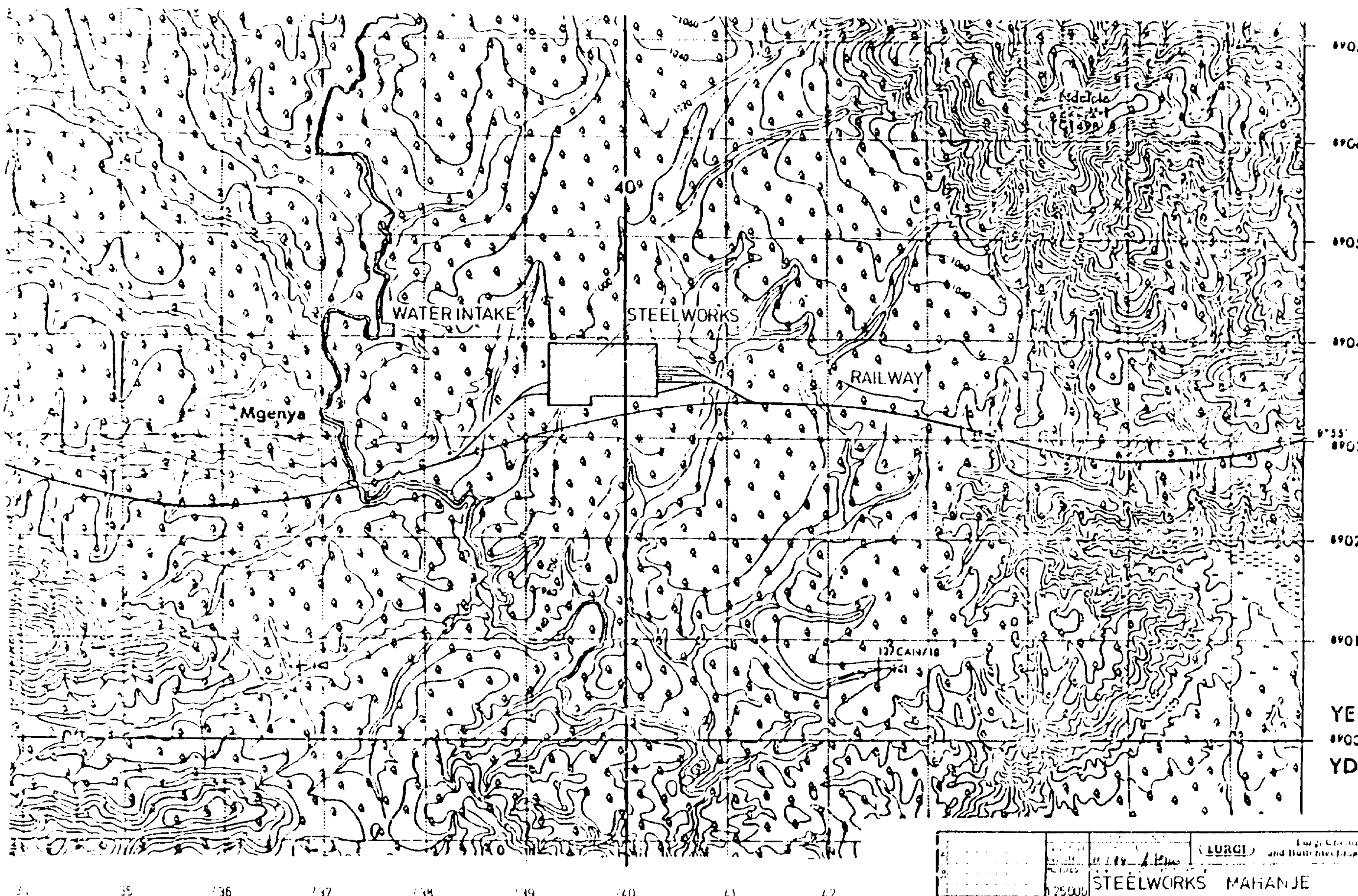
with a related transportation, energy supply and communication system, comprising

-	roads	approx.	152 km
-	railway	approx.	320 km
-	power grid	approx.	140 km

The project represents a direct employment potential as below:

1.	Mchuchuma	approx.	1 200
2.	Liganga	approx.	500
3.	Mahanje	approx.	1 800

not included multiplicator effects created by the small scale industries, service sector, social functions, craftmanship, etc.



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LURGI

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STEELWORKS MAHANJE
TOPOGRAPHICAL MAP

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SECTION 2.2

Market and Plant Capacities

2.2.1 Evaluation of Market Potential of Steel Products in Tanzania

2.2.1.1 General Remarks

2.2.1.2 Projected Demand for Iron and Steel in Tanzania

2.2.1.2.1 Basic assumption

2.2.1.2.2 Results of the Projections of Iron and Steel Demand

2.2.1.3 Supply of Iron and Steel

2.2.1.4 Gap between Demand and Supply of Primary Steel

2.2.2 Projection of an Optimal Capacity of the New Plant

2.2 Market and Plant Capacities

2.2.1 Evaluation of market potential of primary steel production in Tanzania

2.2.1.1 General remarks

In 1980, the Tanzania Industrial Studies and Consulting Organization (TISCO) has prepared a survey for the National Development Corporation (NDC) and National Steel Corporation (NSC) on the iron and steel demand in Tanzania.

In this study, TISCO has investigated the demand for the various steel products in different sectors of the economy as well as in the main geographical and politic regions of the United Republic of Tanzania.

As clearly indicated, this study was regarded as a basis for any future planning of primary production of iron and steel in the country. Due to the fact that no other study of such profoundness and reliability exists and that the results will fit very well in the technological concept of the project under investigation, Lurgi and Mannesmann-Demag have decided in accordance with NDC, that the results of the study by TISCO will be the basis of the market considerations of the project.

In the following, the main results of the market analysis of TISCO will be reviewed.

Although world steel production in 1983 differs considerably from the forecasted figures in the TISCO study, we believe that demand and supply of steel products in Tanzania will remain rather unaffected of the world steel crisis since Tanzania is an importer of steel and the world steel market is characterized by an over-supply in general.

2.2.1.2 Projected Demand for Iron and Steel in Tanzania

2.2.1.2.1 Basic Assumptions

TISCO has set some basic assumptions for the projection for a ten years time period of 1980 to 1990 called "practical approach" which were as follows:

1.) The rise in capacity utilisation of the manufacturing industries will be linear over the next decade and only to 60 % maximum utilisation from 35 % will be achieved and

2.) the implementation of some of the planned new projects will not be on schedule.

3.) Stocks needed for proper maintenance purposes is assumed to be at 5 %,

4.) the growth rate of 6 % has been applied,

5.) inventory levels kept for maintaining the economic growth is taken to be at 20 % and allowance for contingency purposes at 3 %.

During the TFYP, the following projects have been implemented.

- Expansion of Steel Rolling Mills for nuts, bolts and wire/rod products.
- Expansion of ALAF by a continuous billet casting plant of 10 tph capacity.
- Expansion of UFI and Tanzania Crown Corks Company.
- Commissioning of a bicycle manufacturing company (NABICO).

The above were the major users of iron and steel as a raw material for production. Others in the pipeline and should be in production by 1985/86 are:

- Farm implements and machinery manufacturing in Mbeya and Mwanza.
- Machine tools manufacturing in Moshi.
- Motor vehicles assembly at Kibaha.
- A billet casting plant in Tanga (expansion of SRM) and
- Cement producing plants in Mbeya and Tanga and the expansion of the Dar es Salaam plant.

The following projects are expected to be in production by 1990/91:

- Railway Wagons.
- Tractors Assembling and Manufacturing.
- Electrical Machinery.
- Central Foundry and Forge shops.
- Expansion and rehabilitation of NECO and Mang'ula.
- Heavy structural and boiler workshops.
- Other metal working industries.

2.2.1.2.2 Results of the projections of iron and steel demand

In the following, the results of the TISCO-survey are quoted.

In tables 2.2/1 to 2.2/8 the iron and steel consumption according to the main sectors of the national economy is analysed.

In table 2.2/1, the sectoral demand for 1978/79 is also listed according to the main categories of finished steel products.

The demand projection is based upon the expected growth rate of the different sectors as well as on the expected changes of sectoral demand for iron and steel products. The result is shown in table 2.2/2 giving the demand projections for iron and steel from 1980 to 1990.

A detailed analysis of the future demand according to the main categories of finished iron and steel products has been added.

Table 2.2/3 shows the iron and steel consumption for finished steel products from 1974/75 until 1978/79. In 1978/79, a total of 104,000 t was produced in Tanzania, the same amount which has also been given in table 2.2/1.

The demand projection of main categories of finished iron and steel products is shown in table 2.2/4 which figures correspond to those in table 2.2/2.

Table 2.2/1, Sector Consumption of Iron and Steel
Steel 1978/79

(tons)

S. No.	Sector	Light Structurals	Heavy Structurals	Plate Sheets	Pipes Tubes	Castings	Totals
01.	Agriculture and Natural Resources	7119	1537	1071	3609	264	13600
02.	Manufacturing and Mining	5674	1649	7785	233	1159	16500
03.	Transport & Communications	1944	739	2948	244	2025	7900
04.	Building and Construction and						
	Social infrastructure including health, education and administration	19134	21900	18108	5906	952	66000
	Total consumption	33871*	25825*	29912	9992	4400	104000

Source: TISCO

*Special alloy steel of 8000 tons form part of rounds, squares and flats.

Table 2.2/2, Sectoral Demand Projections of Iron and Steel 1980-90

S.No	Sector	Demand ('000 tons)		
		1980	1985	1990
01.	Agriculture and and Natural Resources	24	43	78
02.	Manufacturing and Mining	29	54	114
03.	Transport & Communications	15	30	66
04.	Building and Construction and	57	84	128
05.	Social services	40	58	89
06.	Total	165	269	475

Source: TISCO

Assumptions and Methodology on Projections

The following basic assumptions have been made when deriving the above projections;

(a) the annual growth rate of 6 % has been taken as average for the economy,

(b) capacity utilisation in the various productive industries is to be increased uniformly from 35 % to a modest 60 % in 10 years time. The respective values are therefore 12.5 % and 25 % in 1985 and 1990,

(c) the actual requirements of iron and steel for new projects have been allocated to their respective sectors, and

(d) the demand for maintenance, inventory and contingency have been assumed to be constant at 5, 20 and 3 percentages respectively during the whole decade.

Table 2.2/3, Consumptions by Categories 1974 - 79

S.No..	Category	Consumption tons				
		1978/79	1977/78	1976/77	1975/76	1974/75
1.	Non-flats:					
	Light structurals,	33,000	17,000	25,500	19,000	37,000
	heavy "	14,000	3,500	11,000	6,000	19,000
	Sub-total 1.	47,000	20,500	36,500	25,000	56,000
2.	Flat products;					
	plates	6,000	4,000	6,000	5,500	12,500
	sheets	29,000	29,000	16,500	26,000	35,500
	pipes	10,000	12,000	24,000	11,000	18,000
	Sub-total 2.	45,000	45,000	46,500	41,500	66,000
3.	Castings (Mostly grey iron)	4,000	2,500	3,500	2,000	4,000
4.	Alloy steels	8,000	3,000	6,500	3,000	9,000
5.	Total	104,000	71,000	93,000	71,500	135,000

Source: TISCO-survey

V 43!)80

Table 2.2/4, Projections by Product Categories
Categories 1980 - 90

		Demand ('000 tons)		
S. No.	Sector	1980	1985	1990
1.	Non-flats	74	137	230
1.1	light structurals	46	90	135
1.2	heavy structurals	28	47	95
2.	Flat products	75	110	210
2.1	plates	12	23	41
2.2	sheets	51	69	140
2.3	pipes	10	15	24
2.4	tubes	2	3	5
3.	Castings	4	8	17
3.1	iron castings	3.5	6.0	13.5
3.2	steel castings	0.5	2.0	3.5
4.	Alloy steels	12	14	18
	Total	165	269	475

Source: TISCO-Projections

The demand of flat products to non-flat products is expected to change from 1:1 to 1:1.1.

During 1980-90, iron and steel castings and forgings will be required in the cement plants, machine tools, tractors, vehicles, trailers, farms implements and other manufacturing plants. In motor and other vehicle plants, especially railway wagon parts, steel castings are mostly required.

Alloy and special steel will remain to be mainly imported and used for special parts, where some particular properties i.e. corrosion resistance, wear resistance, strength, etc. are required. The alloy steels are specially used as cutting tools, utensils, food processing and chemical industries.

The non-flats and flat products are used evenly in all economic sectors. The increase in economic activities, construction etc. will have an impact in the consumption of non-flats and flat products.

It will be noted that the demand growth for flats, non-flats and alloy steels will be about 10 % per annun, while castings and forgings will grow at 5 % per annum. The growth of castings and forgings will very much depend on the setting-up of the central foundry and forge-shop.

As a result derived from tables 2.2/1 to 2.2/4, it can be stated that total steel demand will rise from 1978 to 1990 from 104,000 mt to 475,000 mt. In the tables figure, 18,000 mt of alloy steel and 17,000 mt iron and steel castings are included.

2.2.1.3 Supply of Iron and Steel

The supply of iron and steel in Tanzania is managed by three organisations, Aluminium Africa Company Ltd. (ALAF) based in Dar es Salaam, Steel Rolling Mills (SRM) Ltd. based in Tanga and The National Steel Corporation (NSC) with head office and a steel yard in Dar es Salaam.

2.2.1.3.1 Aluminium Africa Company Ltd. (ALAF)

ALAF was established in the early sixties in Dar es Salaam to develop systematically the aluminium and steel sheet industry in Tanzania. Over the last two decades it has developed from sheet and pipes galvanising to casting of billets (backward linkages). It has 5 divisions; ALUCO, GLACO, PIPECO, STEELCO and STEELCAST of which the last four divisions produce iron and steel products.

The pipes division (PIPECO) fabricates pipes of varying diameters by a continuous seam welding process. the imported materials are hot coil hoops. The types of pipes made are pressure pipes for water development, furniture tubes and sections for construction industry.

The actual capacity of the division varies from 15,000 to 18,000 tons depending on the size of pipes manufactures. About 10,000 tons were produced in 1979.

The galvanising division GALCO galvanises cold rolled steel sheets from the cold reversing mill and pipes from PIPECO division.

STEELCO division uses a cold reversing mill for rolling 2-3 mm hot rolled coils into sheets of various gauges, both corrugated and plain. The installed capacity is 75,000 tons. Production in 1979 was 29,000 tons. The gauges produced are 18, 20, 22, 24, 26, 30 and 32. More than 95 % of production is for gauge 26, 30 and 32.

STEELCAST division melts scrap by a 10 tons charge nominal capacity electric arc furnace. The melt is continuously casted into billets of sizes 180 x 80 mm and 6 m length. At present, only mild steel billets are produced from locally available steel scrap. On three shifts, the capacity installed is about 20,000 tons per annum. In 1979, about 8,000 tons were produced due to scrap shortages.

Table 2.2/5, Production of ALAF 1979 ('000 tons)

Division	Products	Installed Capacity	Output in 1978/79	Capacity utilized % 1978/79
PIPECO	pipes	18,000	10,000	55.6
STEELCO	sheets	75,000	29,000	58.7
STEELCAST	billets	20,000	8,000	40.0
Total		113,000	47,000	41.6

Source: TISCO

Only 8,000 t billets of STEELCAST-Division were produced from domestic scrap, the raw material of all the other products (pipes and sheets) has to be imported.

2.2.1.3.2 Steel Rolling Mills (SRM) Tanga

SRM was incorporated as NDC's group of companies in 1966 and commissioned in 1971 for production of various reinforcement bars and other constructional steels.

SRM imports mild steel, spring steel and high tensile steel billets. Some mild steel billets are from ALAF in Dar es Salaam.

Mild steel billets are rolled into round bars (5 - 25 mm), and equal sided angles (50 x 50 x 6 and 40 x 40 x 4.75 mm), spring steel billets are rolled into 16 mm diameter round bars while high tensile steel billets into round bars and flats.

The installed capacity at SRM is 30,000 tons per annum and a total of 18,000 tons was produced in 1979.

Further plans include a 60,000 tons billet casting plant, 18,000 tons wire rod, and expansion of rolling mill to 60,000 tons. Drawn wire capacity will be 11,000, secondary wire products for 7,000 tons and nuts and bolts plant 2,000 tons.

Table 2.2/6, Production of SRM 1979

Product	Quantity	Remarks
Mild Steel Round Bars 5.5 - 25 mm	11,007	Billets imported
Mild Steel Angles	1,092	except 8,000
Spring Steel Round Bars 16 mm.	5	from ALAF
High tensile Steel Bars 10 - 25 mm	6,407	
High tensile Steel Flats 50 x 6 mm	55	
Total structurals	18,636	Capacity utilized 62%

Source: TISCO-survey

In 1977, a wire rod section with a capacity of 2,000 tons double shift was established.

After all expansions, the capacity of SRM will be as follows:

Table 2.2/7, Further capacity of SRM - Tanga

Products	Capacity tons
1. Billet Casting	60,000
2. Rolling mill	60,000
3. Wire Rod	18,000
3.1 drawn wire	11,000
3.2 secondary products	7,000
4. Bolts and Nuts	2,000
Total	140,000

Source: TISCO-survey

2.2.1.3.3 National Steel Corporation NSC

The NSC is the national organization engaged with importation of steel products in the country. Most individual consumers are supposed to have their import requirements of iron and steel from NSC. Some consumers are exempted from importing their requirements through the confinee (NSC). These include ALAF and SRM.

The source of domestic steel supply is given in table 2.2/8.

Table 2.2/8: Source of Supply

('000 tons)

Category	Source	Capacity	Supply	Remarks
A. Non-Flats	SRM	30	18	18 includes 8
	ALAF (billets)	20	(8)	from
	Imports		29	ALAF.
	TOTAL	50	47	
B. Flats	ALAF	75	39	
	Imports	-	6	
	TOTAL	75	45	
C. Casting	Casting grey iron	4	3	
	Import pipes	-	0.5	
	Steel	0.5	0.5	
	TOTAL	4.5	4.0	
D. Alloy Steels	Imports	-	8	
	TOTAL	129.5	104	

Source: TISCO-survey.

According to table 2.2/8, the domestic supply and import of finished iron and steel products in 1979 could then be summarized:

Domestic supply	60,500 t
Import	43,500 t
Total	104,000 t

The raw materials for the domestic supply have to be imported as semifinished products except the 8,000 tons that ALAF STEELCAST will produce as billets from locally allocated scrap. Thus, totally imported iron and steel in finished and semi-finished form will turn out to be as follows:

Imports semifinished products	52,500 t
Imports finished produts	43,500 t
Domestic semifinished products	8,000 t
Total	104,000 t

2.2.1.4 Gap between demand and supply of primary steel

At present, the supply of primary steel is only 10,000 tons in the form of billets from ALAF and castings.

Table 2.2/9: Demand/Supply Gap of Primary Steel

Demand ('000 tons)

Year	1980	1985	1990
Demand	165	269	475
Supply	10	15	15
Gap	155	254	460

Source: TISCO-Projection.

The projected iron and steel plant in Mahanje will produce semi-finished products for the production of flats and non-flats.
The production of alloy steels and castings is not envisaged.

The respective gap, which can be stopped by the new plant, may then be determined by the projected demand for flat and non-flat products (see table 2.2/4) and the projected domestic primary steel production from ALAF-STEELCAST.

2.2.2 Projection of an Optimal Capacity of the New Plant

The construction of the steel plant at Mahanje may considerably increase the demand for iron and steel products as construction materials of the plant itself. This material has to be imported totally.

The market potential of the new plant as the most important producer of primary steel in Tanzania may justify a designed capacity of about 500,000 tpy of steel.

It is not likely that the plant will be in operation before 1990. Therefore, a stepwise implementation may be the best suited way to begin with an installation of a capacity of 500,000 tpy in a first step and go ahead with an expansion up to 1,000,000 tpy later on.

The production programme was agreed upon with NDC as follows:

1. stage: 500,000 tpy, production of slabs

   20 % plates, 30 mm thick,
   80 % hot rolled coils, 2 - 3 mm thick,
   depending on Cr-content,
   max. weight 7 t/coil;

2. stage: 500,000 tpy, production of blooms

10 - 15 % rails, 90 lbs/yard,
10 - 15 % beams, 12 inch max.,
10 - 15 % chanels, 50 mm,
10 - 15 % angles, 120 to 150 mm max.,
60 - 40 % billets, 120 squares max..

The above production programme was taken as the basis of the project design in the present techno-economic study.

SECTION 2.3

Selection Criteria of Technology

2.3 Selection Criteria of Technology

2.3.1 Introduction

In designing the technological route for NDC's steelworks project the following guidelines have been applied:

- maximized utilization of domestic raw material sources and minimized imports for secondary input materials, spares and consumables;

- maximum utilization of coal as low cost energy source;

- reliability of process technologies in terms of already existing commercial references proving the suitability of the process steps selected with raw materials of similar characteristics;

- simple and trustworthy design of the technical facilities rendering sufficient operational reserves;

- high employment potential of the plants by dropping costly automation systems, wherever this can be justified from the safety of operations point of view;

- optimum balance between investment requirements and potential savings in operating costs as could be achieved by installing costly high-tec facilities.

According to this philosophy, the coal-based direct reduction route according to the SL/RN technology was selected to process pellets produced from beneficiated Maganga/Liganga titanomagnetite iron ore and washed Mchuchuma coal into DRI pellets with 92% metallization, which again will be melted to semi-steel in a submerged electric arc furnace especially designed to melt the DRI containing rather high gangue content with Ti, V, Cr as restrictive constituents. The hot metal produced will be converted into finished steel in a separate ladle furnace before being continuously cast and rolled.

The decision to select this route of technology was guided by the following restrictions imposed by the characteristics of the raw materials to be processed:

1. Lack of coking coal and electric power supplies in Tanzania combined with the high TiO_2-content of the raw iron ore prevents its utilization as feed material in any process step yielding liquid pig iron as product due to excessive heat requirement and slag viscosity problems.

Conclusion: The blast furnace route and pig iron production via electric or coal-fired smelting is ruled out, solid state direct reduction is the only applicable option.

2. The high gangue content and especially TiO2-content of the raw iron ore prevents the utilization of the DRI produced therefrom in a conventional electric arc steel furnace due to excessive slag volumes and energy consumption.

Conclusion: The Liganga/Maganga titanomagnetite has to be beneficiated and pelletized before being processed via direct reduction into liquid steel.

3. The Cr-content as it is intergrown with the iron oxide, cannot be sufficiently reduced by beneficiation. As formation of Cr carbides during melting has to be strictly avoided due to steel quality considerations, any melting process for DRI which yields carbon containing pig iron has to be ruled out.

Conclusion: DRI produced from Cr-containing Liganga/Maganga pellets has to be melted under oxidizing slag into semi-steel with a low initial carbon content. This necessarily leads to certain losses of iron units in the slag, however only by this procedure, Cr and V can be eliminated.

4. The public electric grid in the project area - even if newly installed - will not supply the necessary short circuit capacity required by ultra-high power electric arc furnaces; moreover DRI charging rates of above 50% of the furnace charge - as would be required due to lack of domestic scrap - are uneconomical, especially when the DRI shows higher gangue contents.

Conclusion: The DRI should be smelted in an open bath submerged arc electric smelter providing more stable power inputs via Soederberg electrodes combined with continuous tapping of surplus slag. Refining of the semi-steel will be done in the ladle. Further processing of the finished steel follows conventional technical routes. This type of electric smelter is/will be in operation in Kavadarçi, Yugoslavia; New Zealand Steel, New Zealand; Highveld Steel, South Africa as industrial references.

2.3.2 Process Steps

2.3.2.1 Iron Ore Beneficiation

The iron ore of Liganga and Maganga contains magnetite as main iron bearing constituent. The magnetite particles in the ore can be liberated at a size of approx. 0.060 mm. The magnetite is not a pure one, but shows partly ilmenite lamela segregation. For an ore of such composition and intergrowth the most economic way of beneficiation is low intensity magnetic separation.

To get the required liberation of the minerals for a concentrate suitable for direct reduction, two stage comminution will be necessary. The ore of Liganga and Maganga shows the characteristics, which allow the autogenous grinding. The preconcentrate achieved after this step has to be liberated for final upgrading by a second grinding step. This is done by ball mill grinding, since fine grinding by autogenous or semi-autogenous grinding could create too much slimes, which would be lost in the final magnetic separation step.

The particularity of the ores of Liganga and Maganga to be mentioned is the beneficiation behaviour of the ilmenite. Since it shows only partly coarse intergrowth, but partly lamela segregation inside the magnetite crystals, the TiO_2-content of the raw ore can be decreased by magnetic separation from approx. 13 wt.% to approx. 6 - 8 wt.%. Vanadium will even be increased during magnetic separation as it goes parallel to the Fe-units as also does the Cr-content. Therefore, the tailings of the beneficiation step also cannot form a raw material basis for the recovery of these constituents of this iron ore.

2.3.2.2 Pelletizing

The following reasons were decisive for selecting the equipment for pellet induration:

Travelling grate pellets are not only generally accepted for the blast furnace route but have also been employed increasingly during the last few years for direct reduction. Most of the large scale DRI plants at present in operation or under construction are predominantly fed with pellets. The share of straight grate pellets is above 70%.

Due to the fact that during the entire drying and indurating process the pellets are not subjected to any rolling movement their surfaces are not compacted and a high porosity is preserved, which is decisive for ensuring a good reducibility in the DR plant for economic reasons.

The firing technology using burners and recuperated hot air permits the exact adjustment of a specific temperature profile for each ore type and a wide range of operating conditions. Thus overheating and sintering of bed surface are avoided. The close and homogenous size range achieved during balling is maintained during induration and ensures high permeability of the burden, which is an advantage for direct reduction.

As a further consequence optimum oxidation is ensured resulting in a low Fe^{++} content of 5% and less. This favours the direct reduction process as well.

Travelling grate equipment was selected not only because of the superior pellet qualities obtainable but for economical reasons as well. One single unit is required for the entire drying, firing and cooling process, and since this unit is subdivided into various zones, the heat supply to each 20 m can be exactly proportioned to adapt the conditions to the varying requirements imposed by the fluctuation in ore composition as is especially necessary for titanomagnetites.

Another advantage of the compact unit employed is the high availability normally reached in operating industrial plants. 330 and more production days per year are the rule, even in remote areas and with problematic concentrates.

Energy consumption is drastically reduced by thermal insulation and recuperation of hot air from cooling zones and hot exhaust gases from the firing zone.

A magnetite pelletizing plant built by LURGI in Sweden, for instance, requires only 7.5 l oil/t of pellets.

Tests in LURGI's Research Laboratories revealed that fuel oil consumption when using Liganga/Maganga concentrate could be expected in the range between 10 and 11 kg per t pellets.

Though it is technically feasible to replace fuel oil by coal for heat generation - it is not economical to do so. Due to the small size of plant, investment required for coal preparation and handling equipment is not justified and was therefore not taken into consideration.

For the Maganga/Liganga pellet plant a specific rate of production of approx. 21 t/day x m^2 was realized in pilot plant tests at reasonable pressure drops across pellet layer in the different zones of the travelling grate.

Doubling of plant capacity could simply be achieved by installation of an identical second plant next to the existing one.

Due to the fact that the pellets are resting during the entire process on the pallets without being subjected to any movement only low green pellet strength is required. Thus bentonite addition could be restricted to a minimum or avoided at all in many cases. The lower content of acid gangue thus achieved, combined with a correspondingly higher Fe content make for better economics in steelmaking.

Required pellet qualities were obtained in LURGI's Research Laboratories by adding 0.7% bentonite and 1.5% limestone to concentrate sample. This results in a basicity of .71 based on $\frac{CaO + MgO}{SiO_2 + Al_2O_3}$.

In order to comply with the rules and regulations dealing with environmental protection the pellet plant is equipped with a multiclone for the cleaning of waste gas and two washers for the cleaning of air sucked off from the different material transfer points in order to provide plant dedusting.

Above equipment is sufficient for keeping dust emission below those values given as limits in most industrialized countries.

2.3.2.3 Direct Reduction

The Liganga/Maganga pellets will be processed in a 4-strand SL/RN coal-based direct reduction plant to obtain DRI (Direct Reduced Iron) suitable for subsequent melting. The direct reduction process will be 100% coal-fueled, processing washed Mchuchuma coal in a grain size of 0 - 10 mm. A certain portion of this coal in the range of 10 - 20% will be pneumatically injected into the rotary kiln outlet section to provide for the energy necessary for final reduction of the DRI in this zone. This measure is recommendable as Mchuchuma coal belongs to the group of less reactive coals, therefore some additional heat, which is missing in the final reduction zone due to the ongoing burnout of the coal has to be substituted. In the 100 kg pilot tests in the LURGI Research Centre it was found, that Mchuchuma coal shows a slight tendency towards agglomeration when being heated. This effect can be drastically reduced by surface oxidation of the coal particles thus destroying the caking bitumen. This oxidation could be done in a separate unit for thermal treatment, however, losses of volatile matter and fixed carbon contained in the coal cannot be avoided. The utilization of treated coal would result in drastically increased consumptions in the direct reduction process, as part of the volatile matter required for process heating is lost by thermal pre-treatment, with negative impacts on the project economy.

Therefore it is justifiable to use natural weathering by prolonged outdoor storage of the coal to decrease its caking capabilities. The coal storeyard at Mahanje site was dimensioned accordingly.

Although this kind of operation will not eliminate completely the slight caking tendencies of the washed Mchuchuma coal, operation results of the direct reduction plant will not be adversely affected; the screen-away of a certain small amount of coal agglomerates in the product separation system has been provided for.

The coal's sulphur content is quite moderate and can be eliminated in the direct reduction process by simple means. Sulphur levels in the DRI of below 0.02% will be achieved by adding approx. 5 - 7% (based on iron ore) of domestic dolomite (1 - 3 mm) to the feed material. In the process, dolomite will be calcined and thus serves as sulphur scavenging agent.

The limited percentage of DRI fines - generated by decrepitation and abrasion of the pellets during reduction - will be briquetted to allow for easy handling also of this product portion during melting.

The SL/RN DR process today can be regarded as an optimum solution for solid state reduction in those countries, where the iron ore characteristics are prohibitive to conventional pig iron production technologies and where non-metallurgical coal is available as low-cost domestic energy source. Amongst todays coal-based DR processes, SL/RN is clearly pioneering the field in terms of plant references and operating reliability.

The utilization of the rotary kiln waste heat by a subsequent heat recovery system is a future option for the Mahanje steel plant. By installing one boiler unit per kiln operating on a combined turbine set, it is possible to cover a certain portion of the plant's energy demand. However, as this possibility is a rather investment-intensive option for further energy savings, it has not been incorporated in the initial project planning due to increased investment cost both for additional high-tec equipment and corresponding infrastructure requirements. The option of waste heat recovery is described separately for information purposes.

In view of the raw materials planned for processing in the Mahanje direct reduction plant, Liganga pellets and Mchuchuma coal do not represent any operational risks and as such can be regarded commensurate to similar conventional SL/RN operations in India, Brasil and Africa all achieving above average plant availabilities.

2.3.2.4 Steelmaking

The DRI produced in the coal-based DR plant from Maganga/Liganga pellets will be smelted in an electric smelter.

The DRI contains approx. 81% total Fe and is characterized by

- high gangue content of approx. 17%,
- acid to neutral gangue composition,
- high TiO_2-content of approx. 8%,
- 0.8% V_2O_5 and 0.4% Cr_2O_3 as critical constituents,

all these features caused by the chemical and cristalline composition of the iron ore.

To smelt this DRI into steel, a two-step procedure is required:

- Open Bath Submerged Arc Electric Smelter

  Continuously operating under oxidizing slag conditions with a minimum of basic additives to keep low the total slag volume and the smelting energy requirements and at the same time to transfer the unwanted elements in their oxidized form (V_2O_5/Cr_2O_3) into the slag, thus avoiding their solution in the liquid semi-steel. The elimination of Cr and V from the semi-steel already in this smelting stage is imperative to avoid negative impacts on the finished steel quality, such as low weldability of the steel produced, since the transfer rates of the metallic V/Cr into the melt are at approx. 90%. The slag of the open bath submerged arc electric smelter thus contains the major portion of the $Cr/V/TiO_2$ contained in the DRI.

A Cr-spoiled hot metal would have to be blown in a separate oxygen converter (O_2-production!) at extremely high temperatures (+ 1650°C) and low C-contents, which represents a difficult and uneconomic operation.

The open bath submerged arc electric smelter operates with low-cost Soederberg electrodes and is ideally suited to handle large slag volumes in combination with low flickering effects on the electric grid.

In its design, this furnace is comparable to the so-called electric low shaft pig iron furnace applied by Highveld Steel and Vanadium Corporation, South Africa, Skopje Iron and Steel Works and various other medium-scale steel producers in India. The main difference is the operation of this furnace without the burden material filling the furnace vessel but with an open slag into which the feed materials are being charged continuously. This furnace type is in operation in several modern ferro-alloy plants (New Caledonia, Yugoslavia, etc.) and will also be applied by New Zealand Steel Ltd. in their 1 000 000 tpy capacity expansion as well as by Highveld Steel, South Africa in their iron plant II.

- Steel Refining Ladle Furnace

The semi-steel produced from Liganga DRI will be refined in a separate ladle furnace to adjust the carbon content to the required values and to produce finished steel by adding the necessary desulphurizers, carburizers and alloy materials. Before casting, the steel will be purged with inert gases for homogenization.

2.3.2.5 Liquid Steel Processing

The further processing of the liquid steel produced in the refining ladle furnace via continuous casting and rolling does not present non-conventional process features and follows the established practices in the steel industry. Therefore, for detailed description it is referred to the individual sections of Volume III.

SECTION 2.4

Report on Metallurgical Testwork

2.4.1 INTRODUCTION

To establish a technological route for the establishment of an iron and steel industry in the United Republic of Tanzania, UNIDO, Vienna contracted LURGI Chemie und Hüttentechnik GmbH, Frankfurt, West Germany to elaborate a Techno - Economic Study.

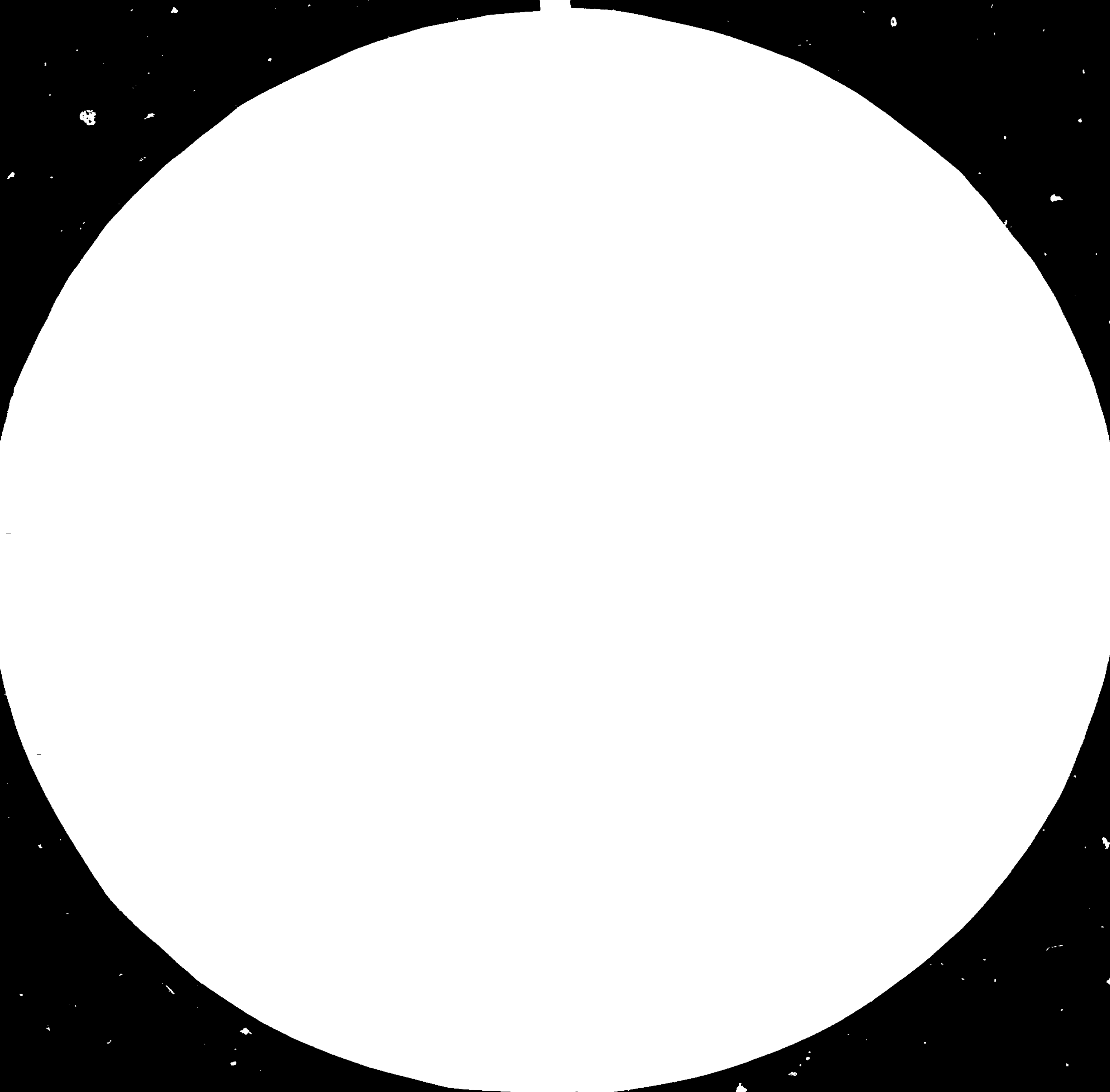
According to the terms of reference for this study, metallurgical testwork had to be carried out in the Lurgi Research Center, Frankfurt with representative samples of raw materials to be collected and sent by National Development Corporation, Dar es Salaam, Tanzania.

The following quantities of sample were to be shipped:

- 6 tons of iron ore
- 1.5 tons of coal
- 250 kg of limestone
- 350 kg of dolomite
- 20 kg of bentonite

all samples in the particle size of minus 50 mm.

The testwork had to include all steps from raw iron ore and raw coal to produce DRI. Based on the analysis of the DRI, the layout of the melting process had to be evaluated by calculation.



1.0 2.8 2.5

3.2 2.2

2.0

1.1

1.8

1.25 1.4 1.6

MICROCOPY RESOLUTION TEST CHART

2.4.1.1 Sample Collection

The collection of the raw material samples had to be carried out by NDC based on a procedure of collection to be agreed upon during the visit of a LURGI field team in Tanzania in January 1983.

To avoid possible delays due to bad weather conditions in the raining season, NDC had collected all samples precocious. When the LURGI team arrived, the raw materials were stored by NDC under roof at the facilities of National Steel Corporation, DarEs Salaam, as shown in the photograph below.

Unfortunately, the coal samples were packed in plastic bags; to prevent further oxidation by air, LURGI recommended to pack the coal samples into air sealed drums filled up with water.

In total, NDC had collected the following samples:

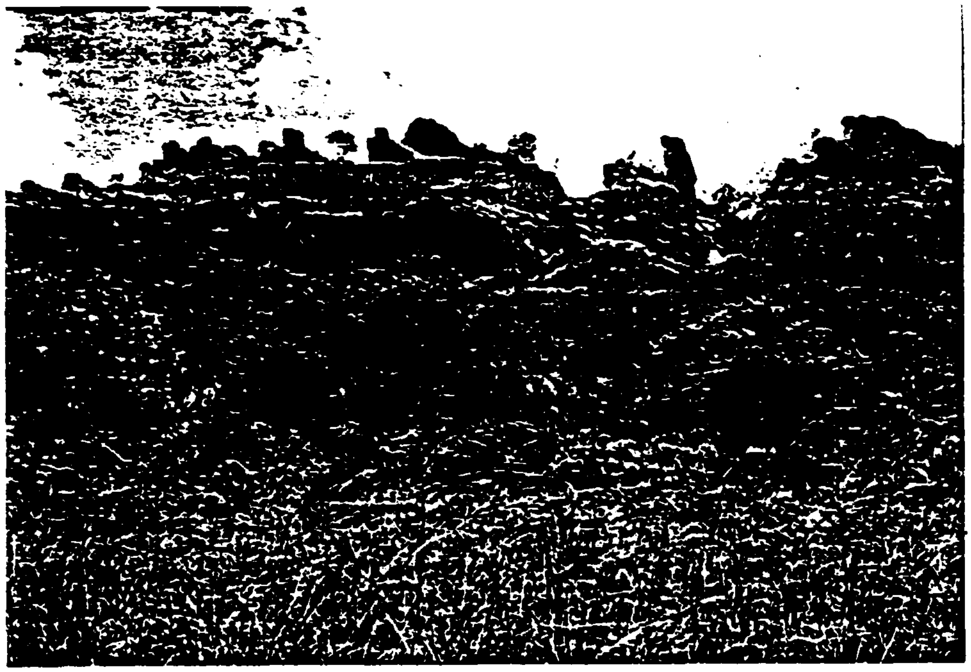
Mchuchuma Coal

Approx. 1.8 tons of samples were extracted from an upper layer of the "lower seam", which represents the superior quality coal of the Mchuchuma deposit.
NDC decided to utilize the existing exploratory shaft installed by Otto Gold GmbH Geologists in 1978 for sampling. Approximately 1 m of wheathered coal was removed in order to exploit fresh coal, which than was collected in lumpy form and packed in 50 kg plastic bags. The photograph below shows the pit of the lower seam flooded with rain water.

Titanomagnetite Iron Ore

Approx. 4 tons of Liganga iron ore and 2.1 tons of Maganga iron ore, both deposits occuring as iron ore lenses in the vicinity of Mundindi village, were taken as samples from the surface of the terrain and packed as lumps into 50 kg plactic bags.

The photograph below shows the sampling point at Manganga Hill.



Collection area of Liganga Hill, near Mundindi village

Other samples:

NDC collected following samples in addition to coal and iron ores:

- 350 kg limestone Wazo Hill
- 20 kg bentonite Arusha
- 350 kg dolomite Chalinze

Macroscopically the limestone could be defined as Coral Limestone, which is unsuitable for conventional lime calcining. LURGI therefore asked NDC to send additional samples of 5 kg limestone/dolomite from deposits closer to the proposed plant site to keep transport requirements for these raw materials within reasonable limits. These samples have not yet been received.

2.4.1.2 Sample Shipment

The raw materials as stored at National Steel Corporation, Dar es Salaam were inspected by the LURGI mission on January 18th, 1983.

The materials left Dar es Salaam port - packed in one container, total weight 8.52 t - aboard of MS Aniello (Mediterranean Shipping Company, Genua) on March 20th, 1983. They arrived at Bremen, West Germany on May 16th, 1983 and were transported by road to Frankfurt LURGI Research Center, where they were received on May 19th, 1983.

The contents of the container was considerably mixed up. Coal, which was packed in textile bags, and additives could easily be sorted out.

However, the plastic bags containing the two iron ore samples of Maganga and Liganga were destroyed and the iron ores were completely mixed. One half bag of each ore type could be carefully recovered and these samples were utilized for initial chemical analyses and laboratory tests. Grain size of the iron ore samples as delivered was below 300 mm.

The mixing of the titanomagnetite iron ores, however, did not impose too many restrictions, since, from a practical point of view, when evaluating a technical process route for processing of this iron ore, the industrial scale facilities had in any way to be designed such, that both ores could be treated in the same units. Therefore, the pilot scale test had be conducted with an iron ore mix.

2.4.2 GENERAL TEST PROGRAMME

The metallurgical testwork carried out in the LURGI Research Center was planned in such a way, that sufficient process and design parameters could be evaluated, which allowed to transfer the results of the laboratory and pilot scale tests into a technical lay out of corresponding industrial scale installations.

Already during 1971/1972 and 1978/1979 LURGI Research Center performed various tests with Tanzanian raw materials as referred hereunder.

29.06.1971 Direct Reduction Tests with Liganga iron ore and Ruhuhu coal for National Development Corp.
LURGI Test Report No. 2818

25.02.1972 Pelletizing and Direct Reduction Tests with Liganga iron ore and Mchuchuma coal for Norconsult.
LURGI Test Report No. 2919

08.08.1978 Test on Beneficiation, Pelletizing and Direct Reduction of Liganga iron ore and Ilima Coal for National Development Corporation.
LURGI Test Report No. 3787

11.02.1979 Tests on Beneficiation and Pelletizing of Liganga iron ore and Direct Reduction of the Pellets with Mchuchuma coal for Dr. Otto Gold.
LURGI Test Report No. 3865

It goes without saying, that the results of these tests were taken as a basis for the new approach to be made under UNIDO contract No. SM/URT/81/004.

Accordingly, during the present test campaign, most emphasis was put on the following subjects, which required further clarifications in order to establish a reliable technical processing route:

- suitability and necessary treatments of Maganga iron ore for Direct Reduction
- suitability of Tanzanian dolomite and bentonite as additives for processing in pelletizing and direct reduction
- suitability of Liganga/Maganga lump ore for Direct Reduction with Mchuchuma coal
- beneficiation, pelletization and direct reduction of a mix of Liganga/Maganga iron ores as alternative to the utilization of lump ores.

The tests were carried out in the period from June, 1st until August 12th, 1983, witnessed by NDC delegates during June 6 - 19th.

The detailed test programme during this period comprised:

1. X-Ray fluorescence chemical analyses of Liganga and Maganga iron ore.
2. Microscopic evaluation of the mineral structure.
3. Davis Tube tests for beneficiation both with Maganga and Liganga iron ore. Determination of Fe-recovery as function of grinding and fineness of concentrates.

4. Grinding, magnetic separation and filtering of a mix of Liganga/Maganga iron ore to determine grinding energy and filter cake moistures and to produce a quantity of concentrate sufficient for pelletizing tests.

5. Pelletizing tests with various types of binders to produce green pellets.

6. Heat hardening tests with green pellets with various firing patterns.

7. Complete chemical, physical and carbo-technical analysis of Mchuchuma coal.

8. Laboratory rotary kiln tests for direct reduction of Liganga lump ore (2 tests).

9. Evaluation of Tanzanian dolomite/limestone for desulphurizing in direct reduction.

10. Laboratory rotary kiln tests with Mchuchuma coal and treated Mchuchuma coal (5 tests) with fired pellets.

11. Confirmatory short rotary kiln test with Liganga lump ore and Mchuchuma coal.

2.4.3 SUMMARY

The results of the metallurgical testwork performed in the LURGI Research Center with Tanzanian raw materials can be summarized as follows:

Beneficiation Tests

Liganga and Maganga iron ores were analyzed and beneficiated to increase the Fe content and at the same time decrease the content of TiO_2 and other gangue elements.

- Liganga iron ore can be beneficiated, increasing the Fe content from 52% Fe tot to 65.6% Fe tot at an iron yield of 86%. The content of TiO_2 is lowered from 13% to 6%.

- Maganga iron ore - due to its higher intergrowth and hematite content - can be beneficiated from 50% Fe tot to 62% Fe tot at an iron yield of only 76%.

- A concentrate from a mix of Liganga/Maganga ores can be produced with 63.3% Fe tot at an iron yield of 83%.

Pelletizing Tests

The concentrates produced from a mix of Liganga/Maganga iron ores were processed into fired DR grade pellets using two types of binders and applying different firing patterns.

- Arusha bentonite (0.7%) and Wazo Hill limestone (1.5%) are suitable binders to produce pellets of high mechanical quality.

- A maximum moisture content of 9% of the filter cake is sufficient to arrive to satisfactory green pellet quality with dry compression strengths of more than 20 N/P.

- A special firing pattern with a prolonged oxidation period of 5 minutes has to be applied to produce thoroughly oxidized pellets with above-average mechanical properties, represented by average compression strengths of more than 2700 N/P in each case.

- Specific rate of production derived from this firing pattern is approx. 21 $t/m^2 \cdot d$.

Direct Reduction Tests

Liganga lump ore and pellets produced from a mix of Liganga/Maganga ores were tested together with Wazo Hill limestone/Chalinze dolomite as alternative desulphurizers and with fresh and charred Mchuchuma coal as alternative reductants.

- Liganga lump ore (52% Fe tot) is not suitable for direct processing in coal-based DR due to low reducibility and excessive decrepitation. Only in the fraction -5 mm, a degree of metallization of above 90% could be achieved; generation of fines -1 mm amounted to more than 6%. The same statement can analogically be transferred to Maganga lump ore.

- Pellets from Liganga/Maganga concentrate mix behaved very well during reduction with an average degree of metallization of more than 92% and a tolerable fines generation of approx. 3% -1 mm. Decrepitation 1 - 6 mm was extremely low.

- Due to superior stability during calcination, Chalinze dolomite is recommended as desulphurizer as compared to Wazo Hill limestone, which strongly decrepitates, thus forming undersized CaO/CaS powder in the process.

- With Chalinze dolomite as desulphurizer, sulphur pick-up of the DRI from Mchuchuma coal could be reduced to below 0.03% in the final product.

- Although Mchuchuma fresh coal shows slight caking tendencies, the resulting formation of coal agglomerates is still within tolerable limits (27.6% +30 mm; 6% 10-30 mm) and does not negatively affect the metallurgical results of the reduction step. Sulphur content, ash melting and reactivity of coal do not impose any restrictions.

- Charring of Mchuchuma coal (30 minutes, 900°C) can suppress the caking characteristics, however, parallel to the devolatilization, the reduction potential of the char deteriorates, resulting in increased specific char requirements for reduction as compared to fresh coal. Therefore charring of Mchuchuma coal is not recommended.

Summarizing, highly metallized (+92 %) DRI with acceptable Fe content (+79 %) and excellent sulphur values (-0.03 %) can be produced from Liganga/Maganga bentonite/limestone bonded pellets using untreated Mchuchuma coal (0 - 10 mm) as reductant at reduction temperatures of around 1800°C.

Lurgi Chemie und Hüttentechnik GmbH LURGI

Forschungslaboratorium

TEST REPORT

VERSUCHSBERICHT

Nr.

HAA 4415 / HSP 4411 / HR 4419

METALLURGICAL TESTWORK WITH TANZANIAN RAW MATERIALS
FOR THE ESTABLISHMENT OF AN IRON AND STEEL INDUSTRY
IN THE UNITED REPUBLIC OF TANZANIA

Bearbeitung: HA: F. Rosenstock / E. Haite
HS: K. Boss
HR: Dr. M. Romberg

Frankfurt am Main,

Gruppenleitung: Dr. F. Cappel

Laborleitung: H. Meiler

Verteiler:

C 1017

2.4.4 BENEFICIATION TESTS

2.4.4.1 Objectives of Testwork and Test Materials

Two titanomagnetite iron ores - Liganga and Maganga - were to be chemically and microscopically analyzed and afterwards beneficiated by low intensity magnetic separation to evaluate the relevant data for designing an industrial scale beneficiation facility especially taking into account the relationship between iron recovery/gangue content of the final concentrate to be further processed into fired pellets.

A sufficient amount of concentrate had to be produced for subsequent pilot scale pelletizing and direct reduction tests.

Both iron ores were tested for their chemical composition by radiofluorescent analyses. Following results were obtained:

Constituents %	Liganga	Maganga
Fe-tot.	51,8	50,1
Fe"	18,1	10,1
TiO_2	12,9	12,9
V_2O_5	0,48	0,50
CaO	0,01	0,01
SiO_2	0,61	2,18
MgO	4,8	4,7
Al_2O_3	8,8	8,9
Mn	0,21	0,20
Ni	0,10	0,09
P	- 0,01	- 0,01
Cr	0,16	0,21

Tab. 1: Chemical composition of the raw ores.

2.4.4.2 Microscopic Structure

In ore - microscopic examination, performed at polished sections and grain preparations of both ore types was found, that the material from the Liganga deposits is essentially composed of magnetite and ilmenite with the latter being present in relatively coarse-grained intergrowths (+ 30 µm) with the former, as well as in the shape of minute lamela of segregation in the magnetite. Beginning on fissures and following along the octaetric structural levels and at the fringes, there were signs for a displacement by hematite (martitization) that in turn is occasionnally changing to limonite Magnetopyrite forming inclusions of a few microns in the magnetite and appearing only in traces. Present as gangue are spinels of aluminate, partly showing aluminate-segregations.

Minute intergrowth (segregations) of magnetite and ilmenite predominate in the ore from the Maganga deposits. The magnetite shows also a very distinctive martitization which at some grains has led to a complete transformation into hematite. The segregated ilmenite lamella remained thus mostly conserved as inclusions in the hematite. To a lesser extent, maghemite (magnetic ferrioxide) has also contributed to the displacement of the magnetite. Limonite plays a lesser role as a displacer of hematite. Magnetopyrite appears, in the same manner as in the Liganga, as traces in the magnetite. Substantially altered aluminate spinels are often forming the gangue. Their original magnetite separations have mostly oxidized to hematite.

The following figures were determined by radiofluorescent analysis in the mixture Liganga / Maganga:

Fe tot.	%	51,4
Fe"	%	16,9
TiO_2	%	12,9
V_2O_5	%	0,49
CaO	%	0,01
SiO_2	%	0,90
MgO	%	4,8
Al_2O_3	%	8,85
Mn	%	0,21
Ni	%	0,10
P	%	- 0,01
Cr	%	0,19

Tab.2: Chemical composition of the raw ore mixture

2.4.4.3 Procedure of Beneficiation Tests

2.4.4.3.1 Davis Tube Tests

A Davis tube was used to determine the magnetic beneficatability. The choice of test conditions was governed by the aspect of reproducibility of the results on industrial - type magnetic separators. In previous test series with titano-magnetites had been ascertained that the metallurgical results, obtained under the conditions described below, are reproducible on industrial permanent magnetic separators.

In the first phase, the Davis tube was run for 2 minutes with 90 strokes per minute, in the second phase for 3 minutes with 120 strokes per minute. The scrubbing water throughout per phase amounted to approx. 5.5 litres. The feed per test amounted to 10 g of ore.

2.4.4.3.2 Grinding

The ore delivered with edge lengths of up to 300 mm was precrushed to 6 mm in a jaw crusher and a cone crusher before grinding. The physical data of the precrushed raw ore are stated in Annex 1. The grinding test was carried out in an open circuit wet grinding process in an overflow ball mill with 1.4 m grinding chamber diameter an 1.4 m grinding chamber length. The ball filling was 35 % vol and consisted of 16 % vol balls with 30 mm and 19 % vol ball with 20 - 25 mm diameter.

The mill speed is in its critical range at 70 %. The mill was fed with ore over a dosing belt scale, the water was added via a flow meter. The total energy conumption was measured by means of an effective output recorder at the mill motor with idle run power requirement being subtracted from this total energy consumption prior to the commencement of the test. The resulting figure was used in the calculation for the net energy requirement per ton of feed.

2.4.4.3.3 Magnetic separation

The ground ore was concentrated by wet LIMS on a three-stage drum separator. The drums of the magnetic separator have a diameter of 600 mm and are 300 mm wide. Each of them contains 3 permanent magnetic poles. At a distance of 50 mm from the drum surface, the magnetic field has an intensity of approx. 600 Gauss. The drums are circuited such that the succeeding drum will reclean the concentrate from the preceding drum. The separator is fitted with counter-curr basins.

2.4.4.3.4 Filtration

The filtration of the concentrate obtained by magnetic separation was performed on a disc filter with 2 m^2 suction surface area. The 12 segments of the disc were fitted with a cloth of multi-filament polyethylen fabric. The vacuum was produced by a water ring pump with a maximum intake capacity of 1000 m^3/h which, by false-air intake, can be decreased to the intake air volume ($m^3/h \times m^2$) needed for the test material. The disc speed is infinitely variable. The flowsheet of the pilot scale beneficiation tests is shown in Annex 2.

2.4.4.4 Results of Beneficiation Tests

2.4.4.4.1 Davis Tube Tests (Laboratory Tests)

Both ore types were subjected to laboratory tests for wet LIMS in the Davis tube at three different grain sizes. The raw ores had in each instance been ground to 100 % wt - 1 mm, 100 % wt -0,5 mm and 82,7 % wt -0,045 mm.

The metallurgical results of the Davis tube tests are compiled in the following tables.

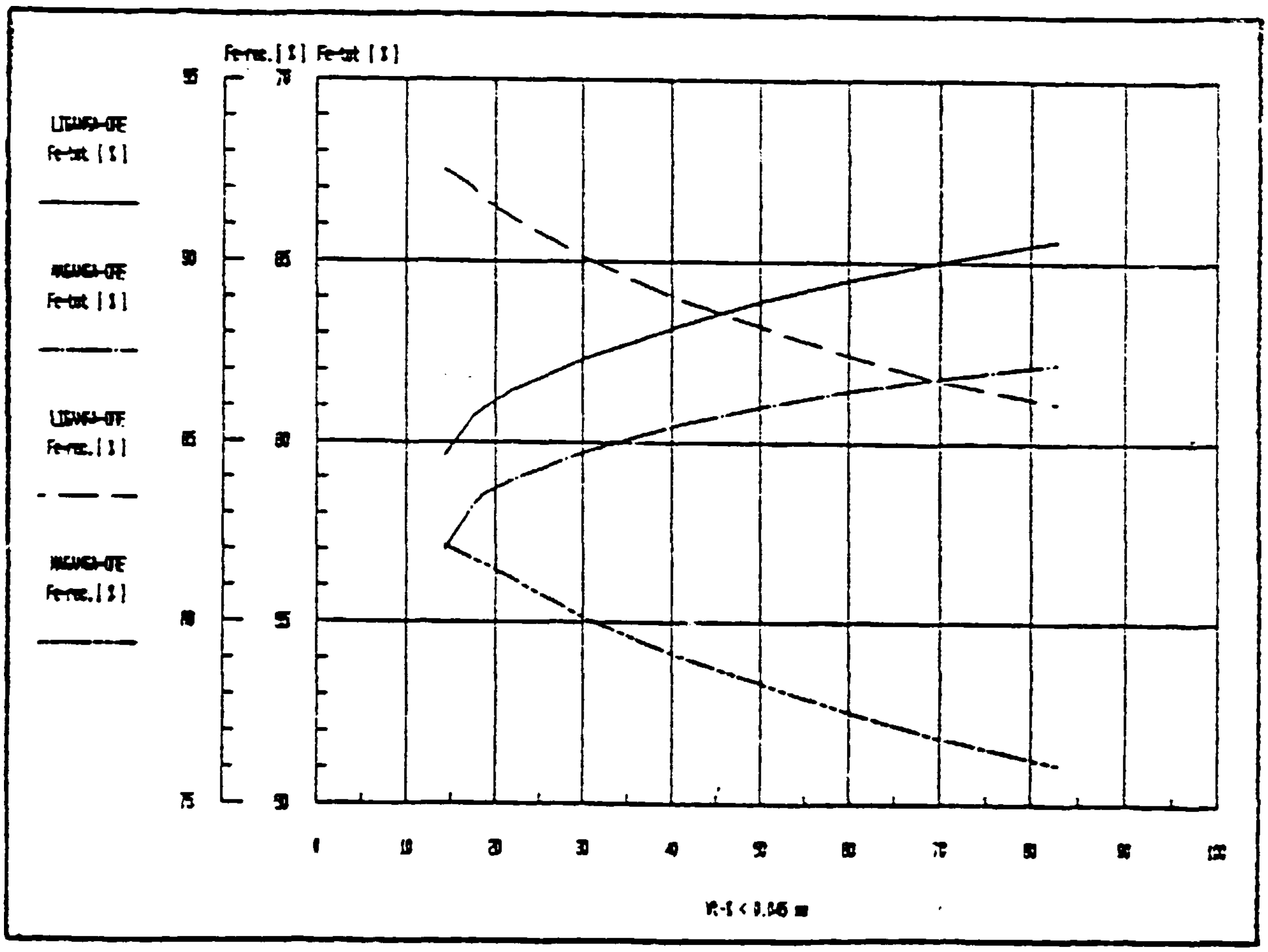
Benefic.	Prod.	Wt %	Contents %			Recovery %		
			Fetot	TiO_2	V_2O_5	Fetot	TiO_2	V_2O_5
100 wt % -1 mm	K	80,4	59,6	11,4	0,59	92,5	71,1	95,8
14,3 wt %	B	19,6	19,9	19,1	0,14	7,5	28,9	4,2
-0,045 mm	A	100,0	51,8	12,9	0,48	100,0	100,0	100,0
100 wt % -0,5 mm	K	78,0	60,9	10,5	0,61	91,7	63,5	95,8
18,5 wt %	B	22,0	19,6	21,4	0,13	8,3	36,5	4,2
-0,045 mm	A	100,0	51,8	12,9	0,48	100,0	100,0	100,0
82,7 wt %	K	68,0	65,6	6,0	0,62	86,1	32,1	88,9
	B	32,0	22,5	26,8	0,18	13,9	67,9	11,1
-0,045 mm	A	100,0	51,8	12,9	0,48	100,0	100,0	100,0

Tab. 3: Balance of Davis tube tests with Liganga raw ore.

Benefic.	Prod.	Wt %	Contents %			Recovery %		
			Fetot	TiO_2	V_2O_5	Fetot	TiO_2	V_2O_5
100 wt % -1 mm	K	70,3	58,2	10,7	0,62	81,7	58,3	87,2
17,4 wt %	B	29,7	30,9	18,1	0,22	18,3	41,7	12,8
-0,045 mm	A	100,0	50,1	12,9	0,50	100,0	100,0	100,0
100 wt % -0,5 mm	K	69,0	58,9	10,2	0,63	81,1	54,6	86,0
21,6 wt %	B	31,0	30,5	18,9	0,25	18,9	45,4	14,0
-0,045 mm	A	100,0	50,1	12,9	0,50	100,0	100,0	100,0
82,7 wt %	K	61,3	62,2	8,2	0,66	76,1	39,8	82,1
	B	38,7	30,9	19,7	0,25	23,9	60,2	17,9
-0,045 mm	A	100,0	50,1	12,9	0,50	100,0	100,0	100,0

Tab. 4: Balance of Davis tube tests with Maganga raw ore.

Iron beneficiation and recovery depending on grain size are plotted in the following graph:



As indicated by the available data, the Liganga raw ore can be concentrated from approx. 52 % Fe_{tot} to 65.6 % Fe_{tot} at an iron recovery of 86 %. The TiO_2 content is thus reduced from approx. 13 % to 6.0 %. This result coincides with the results of previous test series with Liganga ore.

A less satisfactory result was obtained in the laboratory tests with Maganga ore. At the same grain size the Maganga raw ore can be concentrated to approx. 62 % Fe_{tot} at an iron recovery of only 76 %.

The mineralogical examination shows Maganga to be of significantly higher complexity than the Liganga ore. Very minute patterns of intergrowth lead to a dilution of the magnetite by ilmenite in the ferromagnetic concentrate. The distinct oxidative influences result also in the loss of a certain portion of the iron in the hematite.

2.4.4.4.2 Grinding and Magnetic Separation (Mix Liganga/Maganga)

In order to obtain a highest possible iron concentration, it was necessary to choose a smaller grain size than in the laboratory grinding. A net energy requirement of 31 kW/t was specified for the grinding. The screen analysis and chemical analysis of the mill discharge are shown in Annex 3.

An iron concentration of 51.5 % Fe_{tot} in the raw ore mixture to 63.3 % Fe_{tot} in the concentrate at an 83% Fe recovery was achieved in the 3-stage magnetic separation. The TiO_2 content could thus be decreased from 12.9% in the raw ore to 6.5% in the concentrate.

Prod.	wt %	Contents %			Recovery %		
		Fe tot	TiO_2	V_2O_5	Fe tot	TiO_2	V_2O_5
K	67,5	63,3	6,5	0,64	83,0	34,0	88,2
B	32,5	27,0	26,2	0,18	17,0	66,0	11,8
A	100,0	51,5	12,9	0,49	100,0	100,0	100,0

Tab. 5: Balance of pilot test with Liganga/Maganga mixture

For screen analysis of the magnetic separator tailings see Annex 4.

2.4.4.4.3 Filtration

Two filter tests were carried out in total. The tests indicate that the titanomagnetite displays a typical magnetite behaviour.

The test conditions and results of the first test are tabulated below.

Sample No.		1	2	3
bulk density	(kg/l)	1,86	1,86	1,88
solids portion	(%)	57,8	57,8	58,5
filter speed	(rpm)	41	60	77
vacuum	(%)	90	90	90
filter capacity	(t/h.m²)	0,49	0,55	0,56
residual moisture	(%)	10,2	10,1	10,2
specific surface	(cm²/g)	2350	2350	2350

Tab. 6: Test conditions and results - Filter Test No. 1

As the 10.1 - 10.2% residual moisture in the filter cake had a negative effect on the green pelletizing, a filtration aid was added into the filter feed pulp before the second test. This filtration aid is HOE-F-2597. The dosing quantity was 150 ppm. The residual moisture content could thus be reduced to 8.8 - 8.9% as can be seen in the following table.

Sample No.		1	2	3
bulk density	(kg/l)	1,94	1,94	1,94
solids portion	(%)	60,6	60,6	60,6
filter speed	(rpm)	41	60	77
vacuum	(%)	87	87	87
filter capacity	(t/h.m²)	0,64	0,68	0,71
residual moisture	(%)	8,9	8,9	8,8
specific surface	(cm²/g)	2350	2350	2350

Tab. 7: Test conditions and results - Filter Test No. 2

2.4.4.4.4 Final Concentrate

The chemical analysis of the filter cake consisting of the final concentrate is as follows:

Fe tot	%	63.3
Fe^{++}	%	20.7
TiO_2	%	6.5
V_2O_5	%	0.64
CaO	%	-0.01
SiO_2	%	0.1
MgO	%	1.75
Al_2O_3	%	2.8
Mn	%	0.13
Ni	%	0.10
P	%	-
Cr	%	0.21

Tab. 8: Chemical analysis of final concentrate (filter cake)

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Account-No: HAA-50-2771

Annex 1

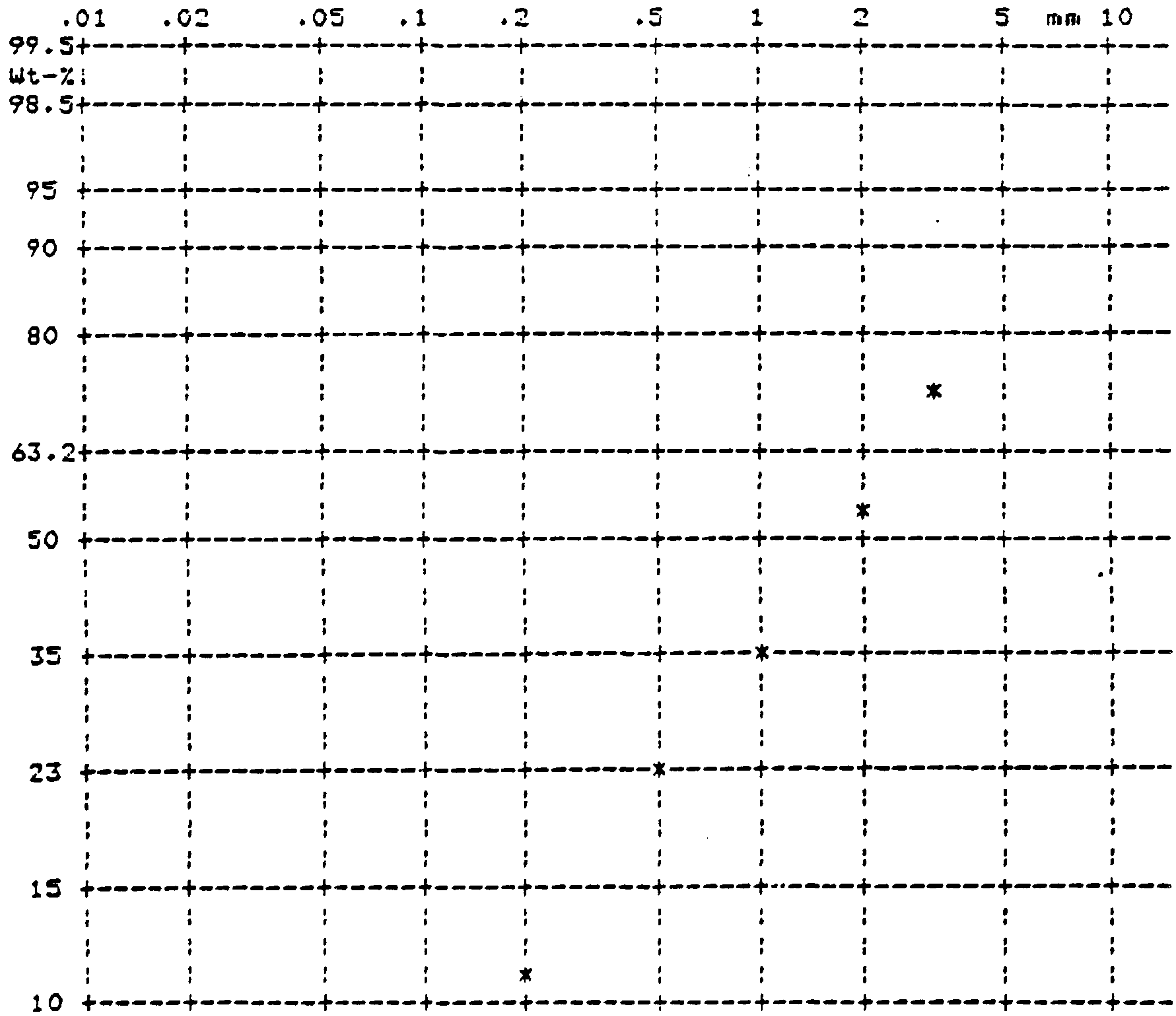
PHYSICAL DATAS

Material: Unido-Tanzania / L:M
Date: 8.6.83
Product: Millfeed < 6.0 mm

Screenanalysis:

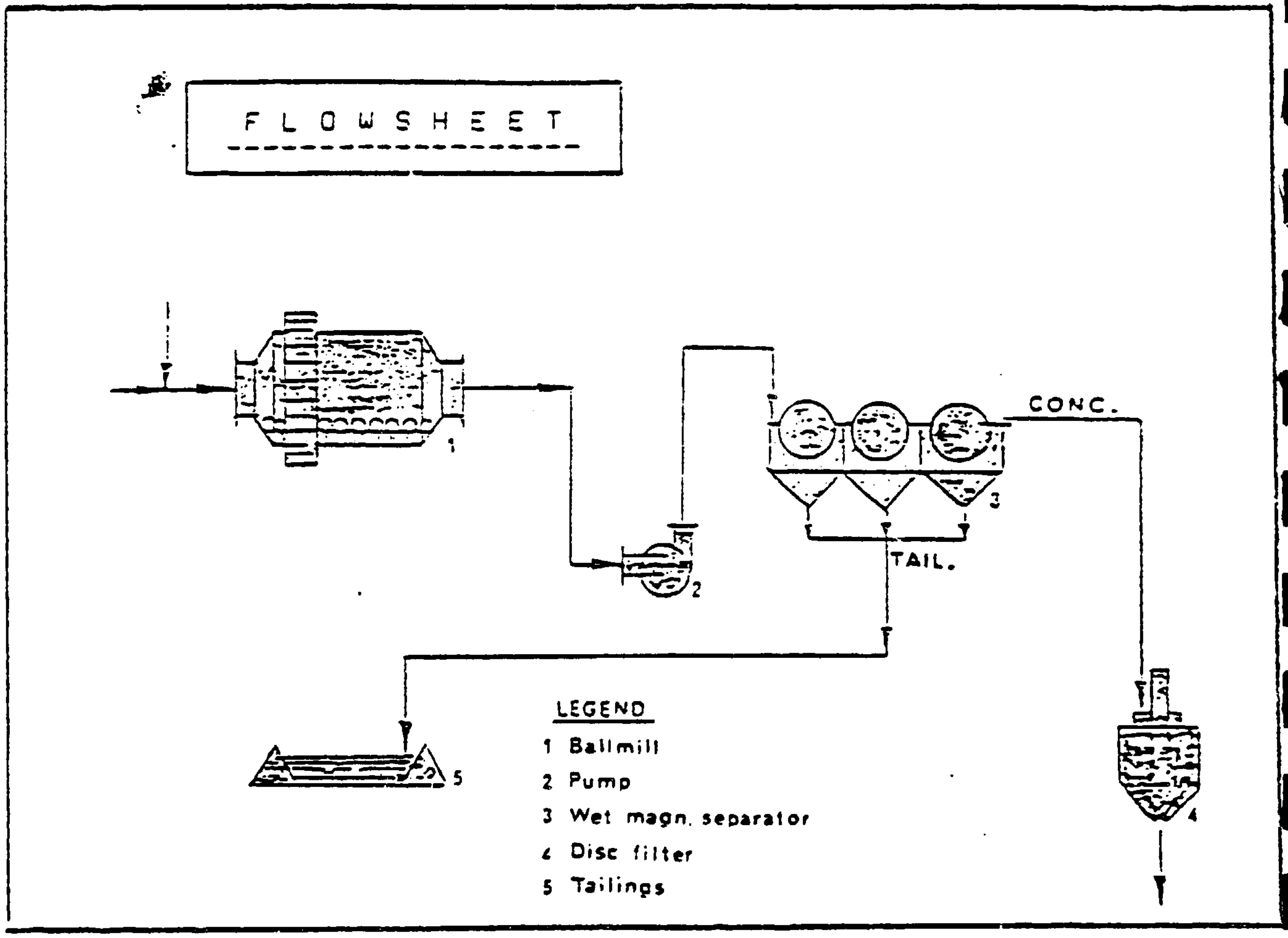
Fraction [mm]	Weight [%]	Fraction [mm]	Compil. [%]	Fraction [mm]	Compil. [%]
> 6.000	.0		100.0	> 6.000	.0
6.000 to 3.000	26.6	< 6.000	100.0	> 3.000	26.6
3.000 to 2.000	17.0	< 3.000	73.4	> 2.000	43.6
2.000 to 1.000	20.1	< 2.000	56.4	> 1.000	63.7
1.000 to .500	13.3	< 1.000	36.3	> .500	77.0
.500 to .200	12.0	< .500	23.0	> .200	89.0
.200 to .125	3.2	< .200	11.0	> .125	92.2
.125 to .090	2.2	< .125	7.8	> .090	94.4
.090 to .063	2.0	< .090	5.6	> .063	96.4
.063 to .045	1.2	< .063	3.6	> .045	97.6
.045 to .032	1.0	< .045	2.4	> .032	98.6
< .032	1.4	< .032	1.4		100.0

Spec. gravity [g/cm3]: 4.66   d50 - size [mm]: 1.630
Bulk-weight loose [kg/l]: 2.75
Bulk-weight stamp. [kg/l]: 3.04
Moisture [%]: .1



LURGI

ANNEX 2



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Account-No: HAA-50-2771

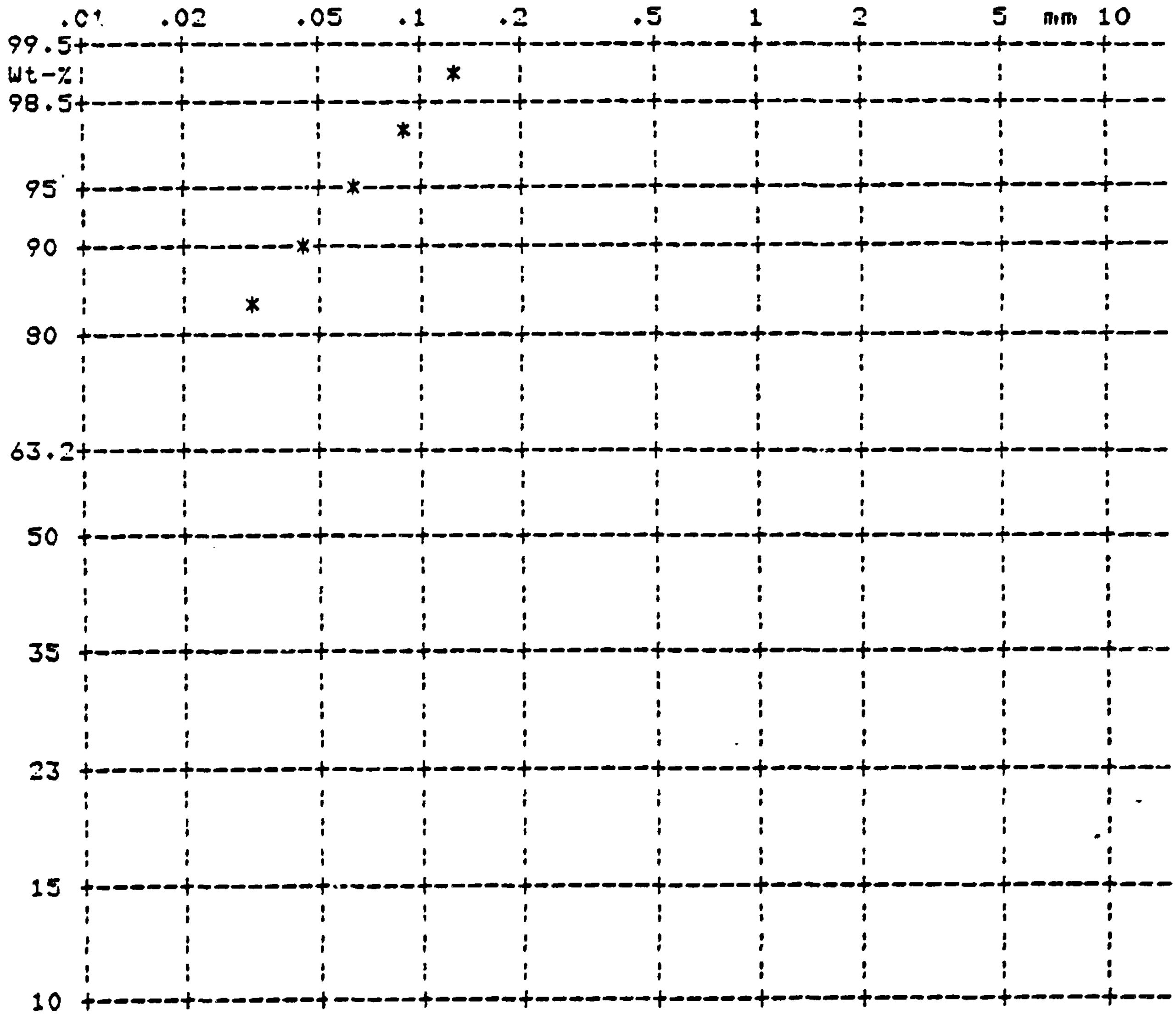
P H Y S I C A L   D A T A S

Material: Unido-Tanzania / L:M
Date: 15.6.83
Product: Milldischarge

Screenanalysis:

Fraction [mm]			Weight [%]	Fraction Compil. [mm]		[%]	Fraction Compil. [mm]		[%]
	>	.125	.7			100.0	>	.125	.7
.125	to	.090	1.3	<	.125	99.3	>	.090	2.0
.090	to	.063	3.6	<	.090	98.0	>	.063	5.6
.063	to	.045	3.7	<	.063	94.4	>	.045	9.3
.045	to	.032	8.1	<	.045	90.7	>	.032	17.4
	<	.032	82.6	<	.032	82.6			100.0

Spec. gravity [g/cm3]: 4.97 Spec. surface [cm2/g]: 2780.
Spec. surface [cm2/cm3]: 13817.



L U R G I - C H E M I E
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Beneficiation-Dep.

Receiving-No: 87/93
Account-No: HAA-50-2771

Annex 4

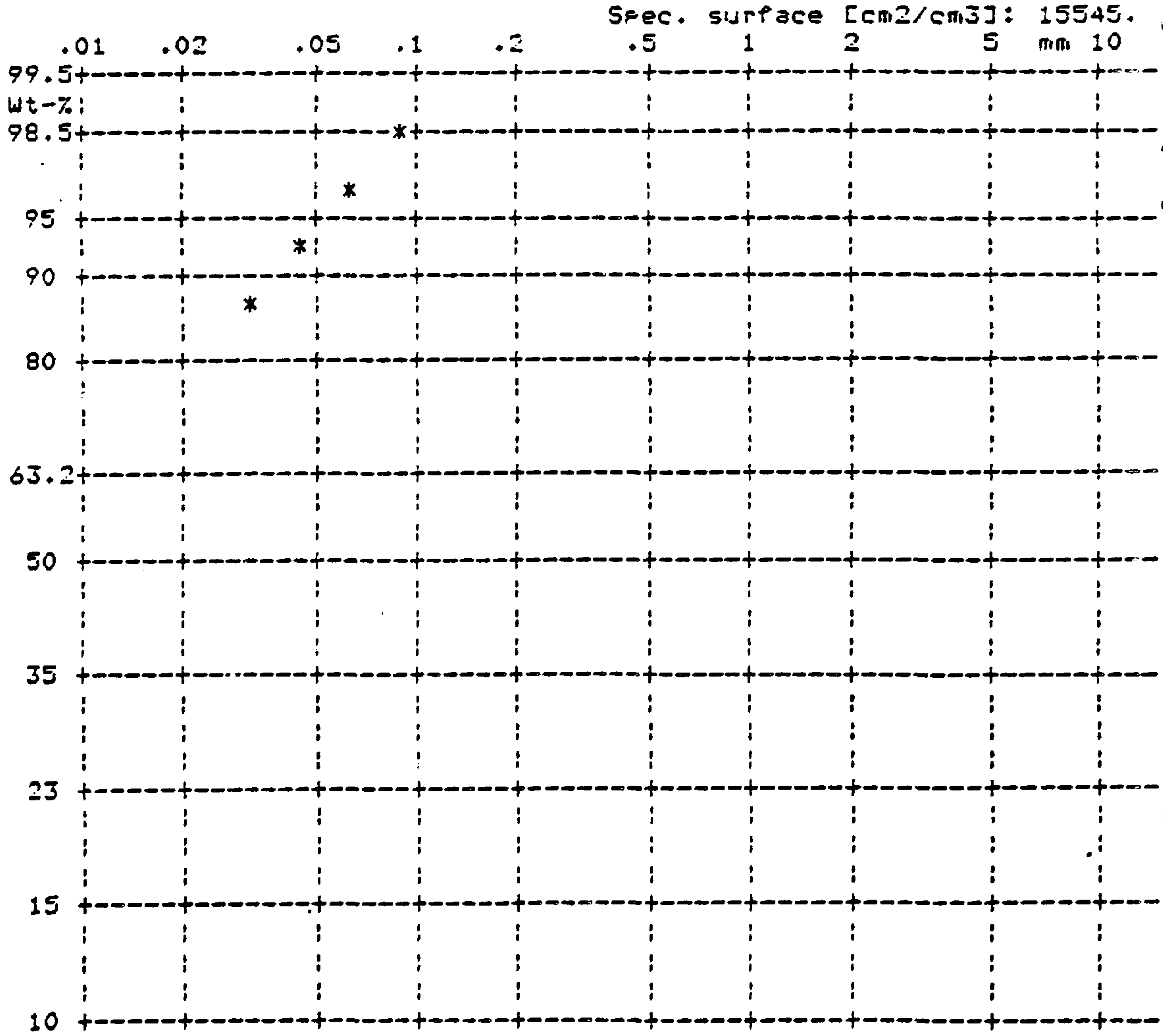
P H Y S I C A L D A T A S

Material: Unido-Tanzania / L:M
Date: 15.6.83
Product: Tailings

Screenanalysis:

Fraction [mm]			Weight [%]	Fraction [mm]		Compil. [%]	Fraction [mm]		Compil. [%]
	>	.125	.3			100.0	>	.125	.3
.125	to	.090	.9	<	.125	99.7	>	.090	1.2
.090	to	.063	2.6	<	.090	98.8	>	.063	3.8
.063	to	.045	3.2	<	.063	96.2	>	.045	7.0
.045	to	.032	6.6	<	.045	93.0	>	.032	13.6
	<	.032	86.4	<	.032	86.4			100.0

Spec. gravity [g/cm3]: 4.19
Spec. surface [cm2/g]: 3710.
Spec. surface [cm2/cm3]: 15545.



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Beneficiation-Dep.

Receiving-No: 87/83
Account-No: HAA-50-2771

Annex 5

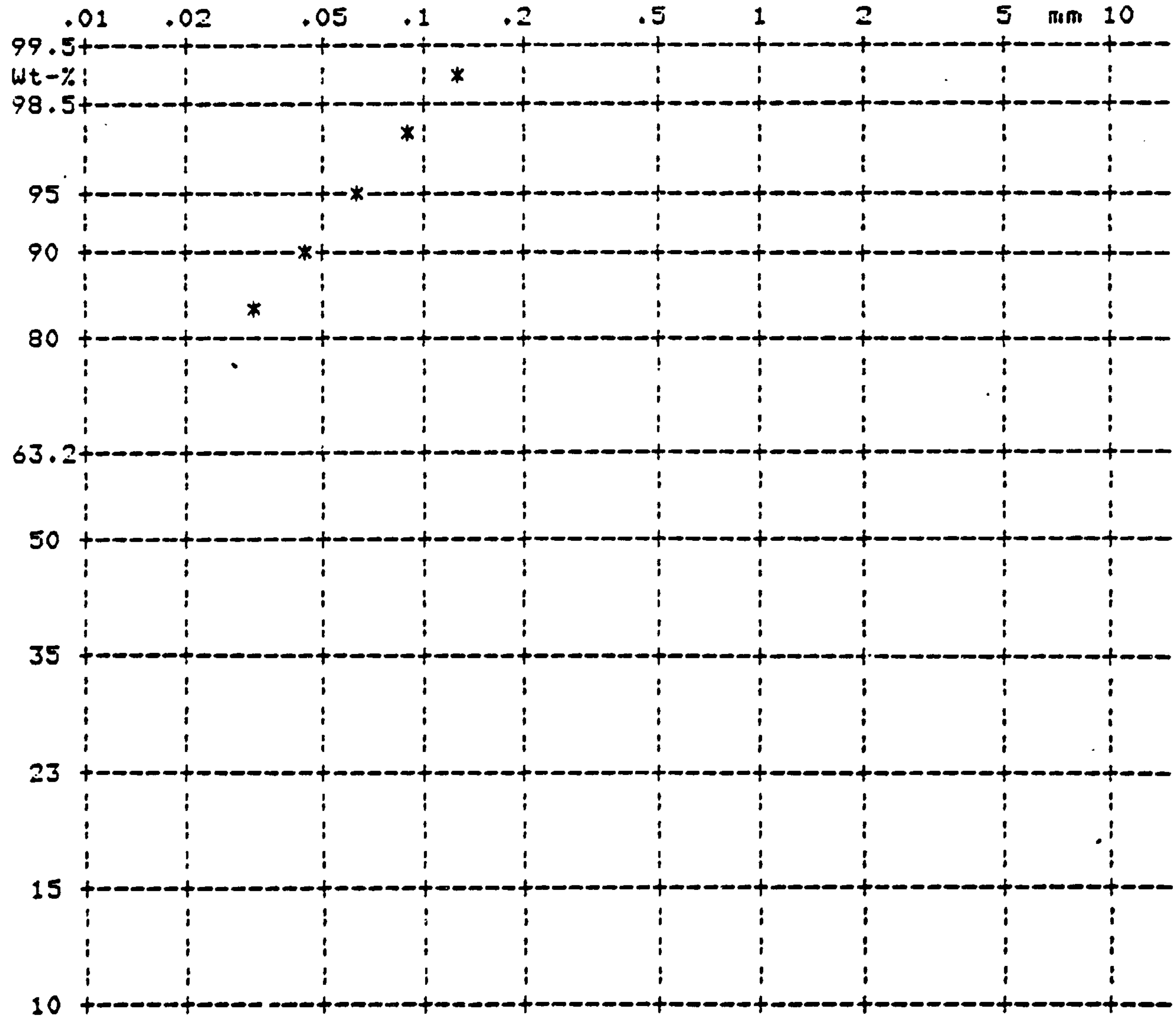
PHYSICAL DATAS

Material: Unido-Tanzania / L:M
Date: 15.6.83
Product: Final concentrate (Filtercake)

Screenanalysis:

Fraction [mm]			Weight [%]	Fraction [mm]	Compil. [%]	Fraction [mm]	Compil. [%]
	>	.125	.7		100.0	> .125	.7
.125	to	.090	1.3	< .125	99.3	> .090	2.0
.090	to	.063	3.6	< .090	98.0	> .063	5.6
.063	to	.045	4.1	< .063	94.4	> .045	9.7
.045	to	.032	7.8	< .045	90.3	> .032	17.5
	<	.032	82.5	< .032	82.5		100.0

Spec. gravity [g/cm3]: 5.00 Spec. surface [cm2/g]: 2350.
Moisture [%]: 9.8 Spec. surface [cm2/cm3]: 11750.



2.4.5 PELLETIZING TESTS

2.4.5.1 Objectives of Testwork and Test Materials

The characteristics of the upgraded Liganga/Maganga concentrate mix had to be evaluated for the purpose of forming green pellets. Fired pellets of a quality and quantity for coal-based direct reduction had to be produced, applying various combinations of binders and an optimum firing pattern.

A concentrate of Liganga/Maganga with a specific surface area of 2350 cm^2/g and a grain size of 90.3 % - 0.005 m - the optimum characteristics in view of the beneficiation results - was used in combination with two combinations of additives:

I Hydrated Lime plus Quarz (German Origin)
II Limestone plus Bentonite (Tanzanian Origin)

All additives were ground to a fineness suitable for pelletizing. The chemical and physical characteristics of all test materials are compiled in the table Annex 1.

2.4.5.2 Procedure of Pelletizing Tests

The pelletizing mix of concentrate and additives was composed in such a way, that the resulting basicity of the pellets amounted to approx:

$$CaO + MgO/SiO_2 + Al_2O_3 = 0.75$$

This range of basicity proved optimum in past coal-based direct reduction test work with respect to decrepitation and reduction characteristics of the fired pellets.

The test schedule is shown in the following table:

Test	No.	1	2	3	4
Raw Material					
Fines - 45 µm	%	90.3	90.3	90.3	90.3
Spec. surface area	cm^2/g	2350	2350	2350	2350
Additives:					
$Ca(OH)_2$	%	1.0	1.0		
SiO_2	%	0.5	0.5		
$CaCO_3$	%			1.5	1.5
Bentonite	%			0.7	0.7
Basicity $\frac{CaO+MgO}{SiO_2+Al_2O_3}$		0.73	0.73	0.75	0.75

2.4.5.2.1 Balling (formation of green pellets)

Before balling, each material sample is uniformly mixed. For each test, about 70 - 80 kg of material are charged into a batchwise-operated Eirich mixer in order to admix the additives and to prewet the mixture to the optimum moisture content for balling, aiming at conditions similar to those of an industrial plant. The Eirich mixer is operated according to the countercurrent principle.

The moist feed mixture is fed into the pelletizing disc via a vibrating trough.

The green pellets are produced in a disc of 80 cm dia. at an inclination of 47 - 48 ^{0} and a rotation speed of 14 rpm. The final amount of water is added while the material turns on the disc. During balling, at first micro-pellets are obtained which grow gradually at increasing residence time until they have attained the desired size.

Due to the classifying effect of the disc, the size of the pellets discharged is within a close range of about 80 % between 9 and 15 mm. For each test, a pellet sample of uniform size between 9 and 15 mm dia. is taken for determining the green pellet quality.

2.4.5.2.2 Firing of Pellets

The Lurgi pot furnace equipment consists of a stationary frame with three windboxes and three hoods, a recuperator and an oil/gas burner (see scheme, Annex 2)

The three windbox and hood positions serve for the following process steps:

Pos. 1: updraught drying
Pos. 2: downdraught drying, preheating and firing
Pos. 3: updraught cooling

For indurating the green pellets, a metallic circular pot of 36 cm dia. is used. The useful grate area on the bottom has an inner diameter of 26.5 cm and is thus 0.0551 sq.m. At first, the grate is fed with 10 cm of hearth layer material which consists of fired pellets. On top of this layer, 30 - 31 cm of green pellets are charged by means of a circular insert of 26.5 cm diameter which is gradually lifted during the filling operation. Between the green pellets and the wall of the pot structure, side layer material is filled in which consists of broken pellets of 3 - 8 mm in size to reduce the so-called side wall effect, acting at the same time as thermal protection for the metal insert. In an industrial plant, pellets separated from the product are used as hearth and side layer material.

The scheme in Annex 3 shows the arrangement of Pt-Pt/Rh couples which are located above the pellet charge, in the charge, in the grate bars and in the windbox. They are provided for controlling and checking the drying and firing process. The temperatures measured are recorded at short intervals by a twelve-colour instrument and also checked manually. For determining the gas volumes sucked or forced through the charge, orifice plates are provided. The volumes are indicated and recorded in cu.m (NTP). The values measured can be converted into figures indicating the volumes per square metre of grate area or per kg of product for establishing a heat balance. The pressure or suction values in the windbox are recorded by hand.

In the first windbox position, the pellets are dried in updraught. The pot with the green pellet charge is moved into this position and pressed by pneumatic cylinders together with the windbox towards the hood.

Hot air, produced by a recuperator, is used for the drying process. The temperature of this air is held constant in the range of 250 - 300 °C. By admitting cold air, the desired temperature for the drying process is established. This cold air admission as well as the pressure control is performed automatically.

During the updraught drying period, the firing hood (Pos. 2) is preheated by hot combustion gases. A second pot with inert material is used for closing the hood against the windbox. The hot waste gas is not sucked through the pot and through the windbox, but forced to the bypass stack. A valve in this stack is used for establishing a slight gas pressure in the hood to enable a better control of the preheating procedure.

After finishing the updraught drying period, the pot with the inert material is moved away and the pot with the pellet charge is put into the second windbox position. At first, hot air from the recuperator (for downdraught drying) and later hot combustion gases produced in the firing chamber of the furnace are sucked through the pellet charge. The suction is established automatically by a speed-controlled fan according to preset values.

For producing the hot gases, a special burner device is used. Fuel oil or gas and atomising air are introduced into the burner. Hot air from the recuperator at 300 - 400 °C is used as primary air in a preset and controlled ratio to the oil consumption. Cold air is introduced into the firing chamber as dilution air. The admission of this cold air is automatically controlled by the hot gas temperature measured above the pellet charge. Additionally, oxygen is blown into the hot air in order to adjust to plant conditions. That means that during the firing step the oxygen content has to be maintained at around 15 - 17 %.

In the third windbox position, the fired pellets are cooled with cold air in updraught. A separate fan is used for supplying the cooling air. The pressure in the windbox is maintained constant according to a preset value by using a motor-operated valve.

2.4.5.2.3 Sampling and Quality Testing

Sampling

After termination of each test, the charge contained in the pot is discharged by hand. It is separated into samples representing the upper, the central and the lower layers. These samples are screened individually at 8 mm in order to separate side layer material. An average sample of approx. 2 kg is taken from each of the 3 samples in order to determine the average compression strength and the chemical analysis, if required. The remainder of the 3 layer samples is put together and mixed. A new sample is taken from the mixture in order to determine the tumble index.

2.4.5.2.4 Methods of Evaluating the Green Pellets Quality

Compression strength

The average compression strength of the green pellets and of the pellets dried at 110 ^{o}C is established by compressing 10 pellets individually on an inclination balance until they crumble. The position of the indicator is marked. The mean value of the 10 tested pellets is considered to be the measure of the compression strength.

Drop number

Besides the compression strength, the drop number of the green pellets is also determined. Ten green pellets are individually dropped onto a steel plate from a height of 46 cm (18") as often as necessary until they disintegrate or crack. The number of drops is marked for each pellet. The arithmetic mean value calculated from the ten tests gives the drop number.

2.4.5.2.5 Method for Establishing the Mechanical Strength of Fired Pellets

Compression strength

To establish the average cold compression strength of the fired pellets, usually 30 pellets of 12 ± 1 mm dia. (10 pellets each at the top, middle and bottom layers) are taken from each pot test and then individually crushed between two parallel steel plates on a special hydraulic press until they break. The indicator position at the breaking of each of the pellets is noted and the arithmetic mean value of the 30 individual tests is calculated.

Abrasion resistance

According to the 1/5 ISO tumble method, 3 kg of pellets of plus 8 mm from the well-mixed representative sample are fed into a drum of 10 cm length and 100 cm diameter, which contains 2 lifters of 5 cm height. The pellets are tumbled during 200 rotations at a rotation speed of 25 rpm.

Subsequently, the pellets are screened to remove - 6.3 mm and - 0.5 mm particles, respectively. The percentage of the screened-off fines in relation to the input of 3 kg of pellets is the measure of the abrasion resistance of the pellets.

2.4.5.3 Results of Pelletizing Tests

2.4.5.3.1 Balling Results (Green Pellets)

The concentrates with a grain size of 90,3 % minus 0.045 mm and with an specific surface of 2350 cm^2/g were suitable to form green pellets of sufficient strength for further handling to the firing grate. However, the moisture content of the concentrate had to remain below 9 % as maximum value. In test No. 1, this moisture content of 9 % resulted in the relatively high drop number of + 10. With decreasing moisture content, the drop number also decreased to normal values of approx. 5. The results of wet and dry compression strength were slightly higher when using hydrated lime and quartz as additives as compared to bentonite/limestone as binder components. However, the minimum nominal values were exceeded in each case.

The results of the balling tests are compiled in the following table.

Greenpellets	No.	1	2	3	4
Compression strength	N/P	22	24	16	13
Dropnumber 18"		+10	5.4	5.9	5.0
Moisture content	%	9.0	8.0	8.2	7.8
Dry compr. strength	N/P	27	26	24	20

2.4.5.3.2 Firing results

For the indurating tests on the pellet indurating installation, a firing pattern elaborated during earlier tests for titano-magnetite concentrate was used. It was possible by means of the same to harden the green pellets as per the updraught drying downdraught firing process. Optimum mechanical qualities resulted upon adding 1 % of $Ca(OH)_2$ and 0,5 of SiO_2.

After drying and heating of the green pellets, first an oxidation period of 4 minutes with a temperature of 900 - 1000 °C was applied. Quality testing however showed, that this time was not yet sufficient, as the lower layer of the pellets in the pot still was slightly magnetic. Complete oxidation could be achieved by applying an oxidizing period of 5 minutes (test No. 3). However, the pellets of this test showed several small surface cracks as a result of excessive heat-up rates during firing with corresponding deterioration of the abrasion values. Therefore in test No. 4 after oxidation of 5 minutes, the heat-up for pellet firing was slightly reduced, resulting in excellent compression strength and acceptable indices of the fired pellets.

The average compression strength of $Ca(OH)_2/SiO_2$-bonded pellets exceeded the values achieved with bentonite/limestone. Test No. 4 showed slightly lower compression strengths of the pellets, as compared to test No. 3, however, the quality deviation of the entire burden (top/middle/bottom) was superior. The abrasion values according to 1/5 ISO tumbling were still acceptable with between 95.7 %/93.3 % + 6.3 mm and between 4.1 %/6 % - 5 mm.

When increasing oxidation time, abrasion values can be improved at the expense of specific rate of production as was demonstrated by Test No. 4.

The quality characteristics of the fired pellets are compiled in the table below:

Fired Pellets	No.	1	2	3	4
Compression Strength					
Toplayer	N/P	3393	4227	3070	2775
Middle	N/P	3472	3315	2599	2609
Bottom	N/P	2501	2579	2775	2766
Average	N/P	3122	3373	2814	2716
ISO-Tumble-Test		1/5	1/5	1/5	1/1
+ 6,3 mm	%	94.8	94.0	93.3	95.7
- 0.5 mm	%	4.6	5.7	6.0	4.1
Specific rate of production	t/m^2d	23.6	26.1	25.3	21.2

Summarizing, excellent compression strength values of the fired pellets can easily be achieved, whereby the abrasion values depend on the time applied for the oxidation period, consequently reflecting the specific rate of production and a given grate.

The final optimum firing pattern was found to be:

	Time	Temperature (°C)	Pressure or negative pressure (mbar)
Updraught drying	3	250 - 270	+ 40
Downdraught drying	2	350	- 20
Heating up	3	350 - 900	- 20
Oxidizing	5	900 - 1000	- 20
Heating up	3	1000 - 1300	- 40
Firing	10.5	1300	- 40
Afterfiring	2.5	abt. 1000	- 40
Cooling	11.8	abt. 20	+ 45
Total	40.8		

A graphical representation of the firing pattern (computer record) of Test No. 4 is enclosed as Annex 4.

According to this firing pattern, the specific rate of production per surface area of an industrial scale installation amounts to 21.2 t/m^2 x 24 h; safety margins are not considered in this figure.

2.4.5.3.3 Fired Pellet Quality

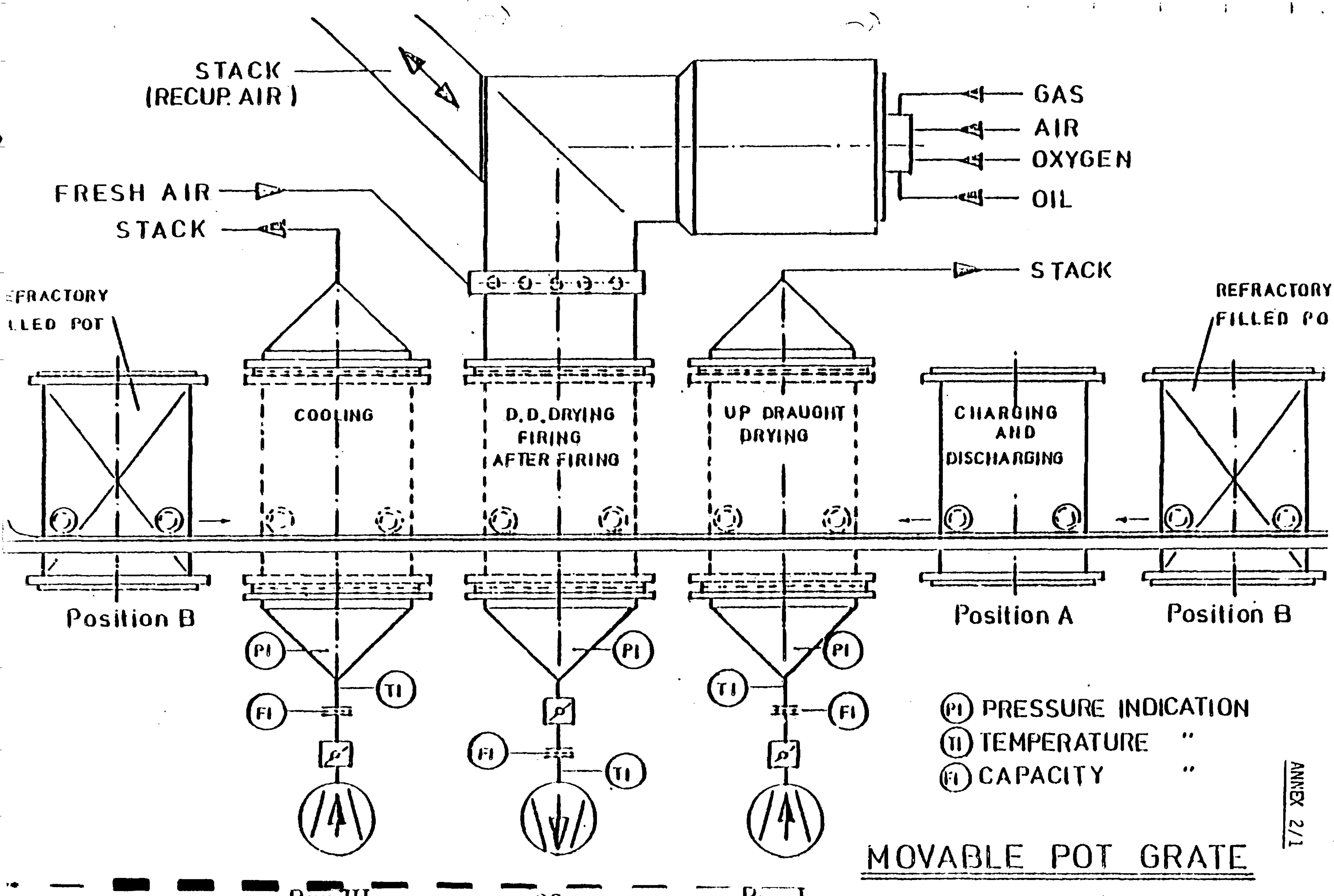
The pellets produced with the addition of 1 % hydrated lime and 0,5 % quartz showed normal values with compression strengths of more than 3.000 N/P. The values of the bottom layer still exceeded a nominal minimum of 2.500 N/P. To homogenize the pellet quality throughout the burden, the heating and oxidizing periods were changed (Test No. 2).

LURGI

ANNEX 1

CHARACTERISTICS OF RAW MATERIALS

Material		Liganga conc.	Limestone	Bentonite	Quartz	Hydrated Lime
Screen analysis						
mm						
+0.315	%	-	0	-	-	-
0.315-0.200	%	-	1.3	-	-	-
0.200-0.125	%	0.7	2.3	1.2	0.2	0.5
0.125-0.090	%	1.3	0.5	1.6	0.8	1.4
0.090-0.063	%	3.6	2.3	5.8	3.3	4.4
0.063-0.045	%	4.1	3.7	12.0	6.7	4.1
0.045-0.032	%	7.8	6.0	12.8	12.7	12.0
-0.032	%	82.5	87.5	66.6	76.3	77.6
Spec. surface area (Fisher Subsieve-Sizer)	cm^2/g	2350	6440	19300	4440	19500
Chem. Analysis						
Fe tot	%	63.3	n.d.	n.d.	n.d.	
Fe^{II}	%	20.7	n.d.	"	"	
SiO_2	%	0.1	3.0	"	90.0	
Al_2O_3	%	2.8	0.7	"	4.91	
CaO	%	0.01	53.6	"	0.08	72.2
MgO	%	1.75	0.8	"	0.04	
TiO_2	%	6.5	n.d.	"	n.d.	
P	%		"			
L.O.I. (1050°C)	%	0	42.2		n.d.	26.5
Bulk densities						
Material loose	kg/l	1.49	0.84	0.66	0.96	0.53
" compacted	kg/l	1.74	1.00	0.74	1.1	0.60
Moisture	%	8	0	0	0	0
Greenpellets	kg/l	2.21	-	-	-	-
Fired pellets	kg/l	2.05	-	-	-	-
From test	No.	4	-	-	-	-



MOVABLE POT GRATE

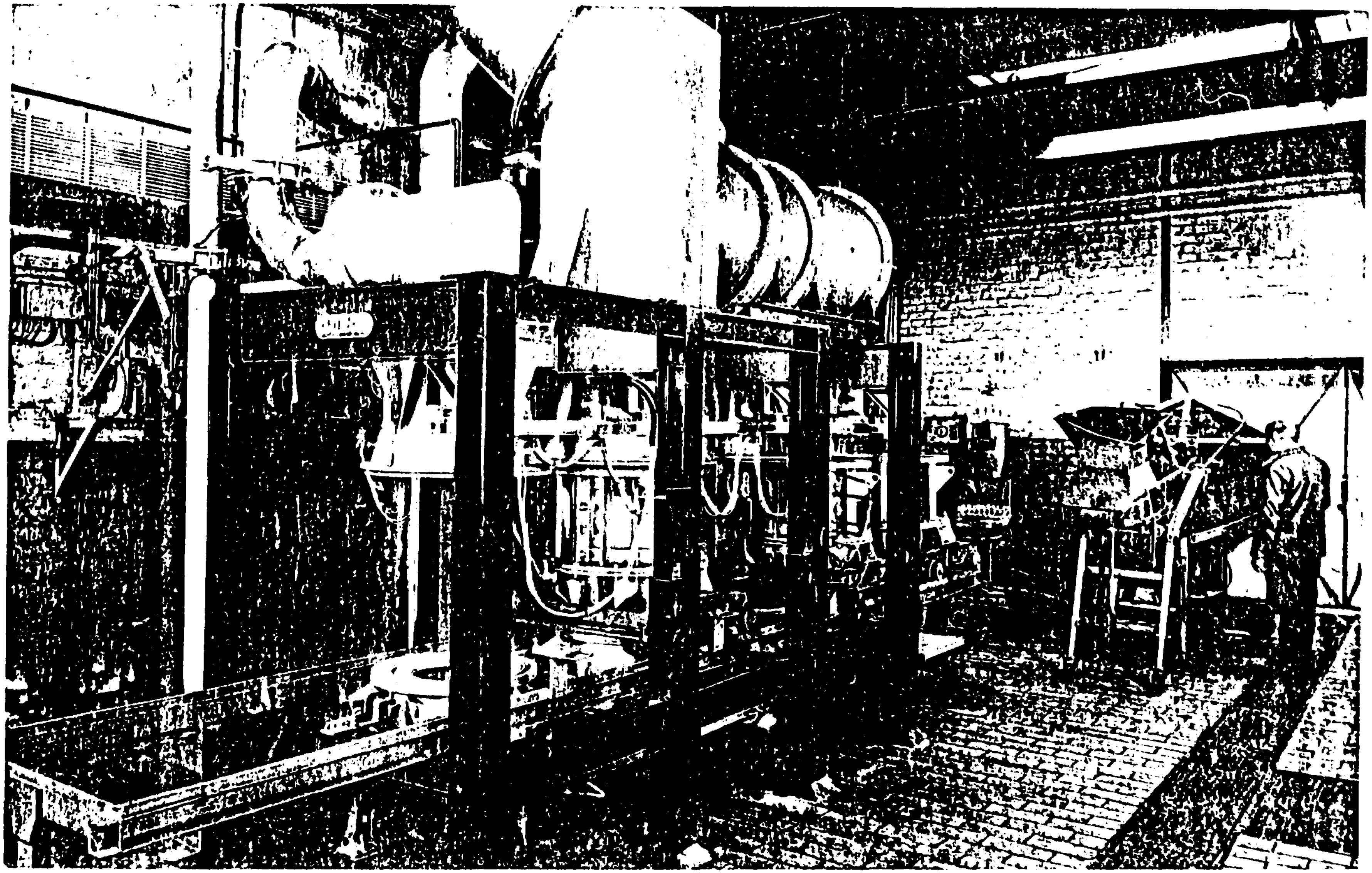
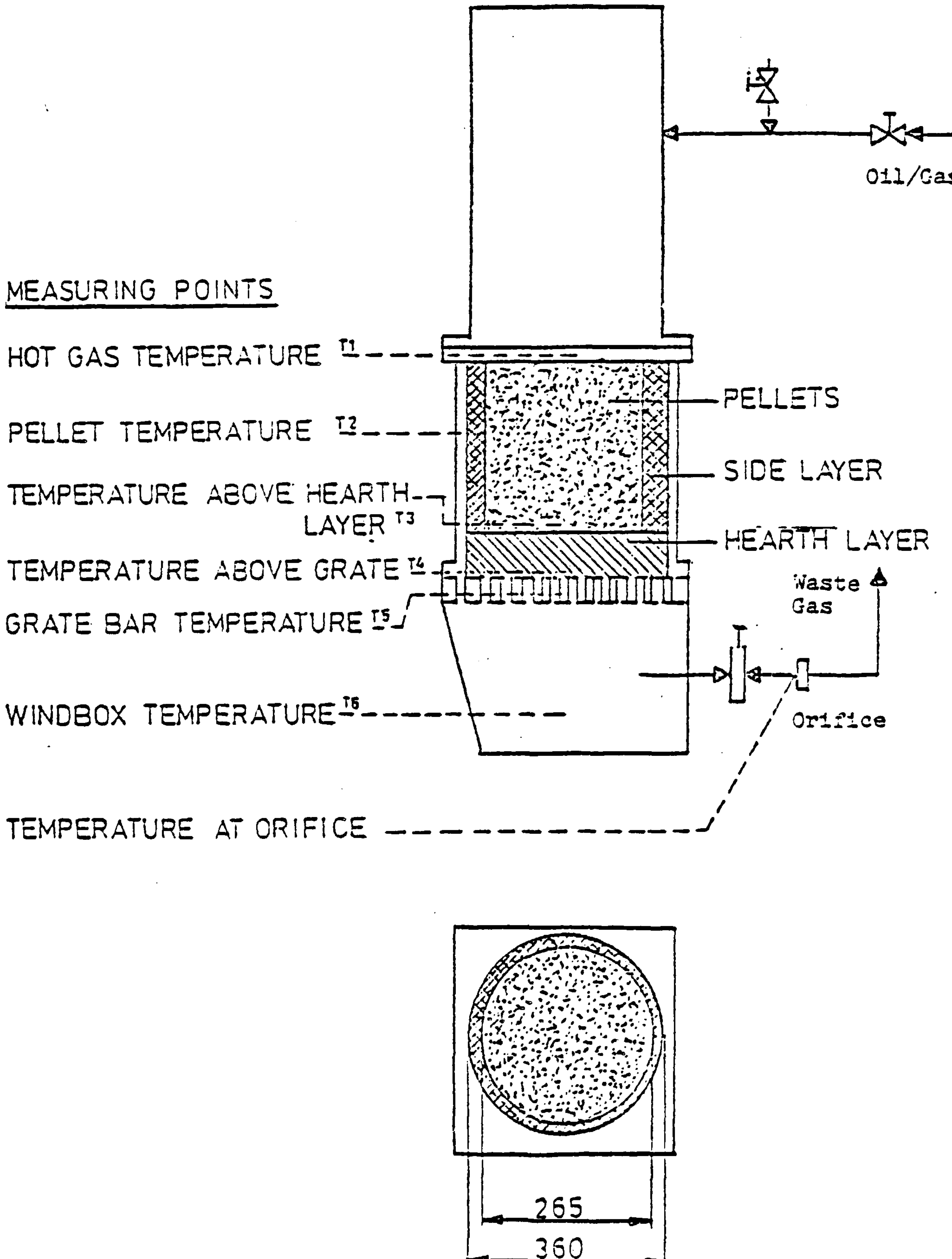


BILD NR. LURGI VERSUCHSANLAGE ZUM PELLETBRENNEN

FIGURE NR. LURGI PELLETIZING POT FURN`CE

ANNEX 3

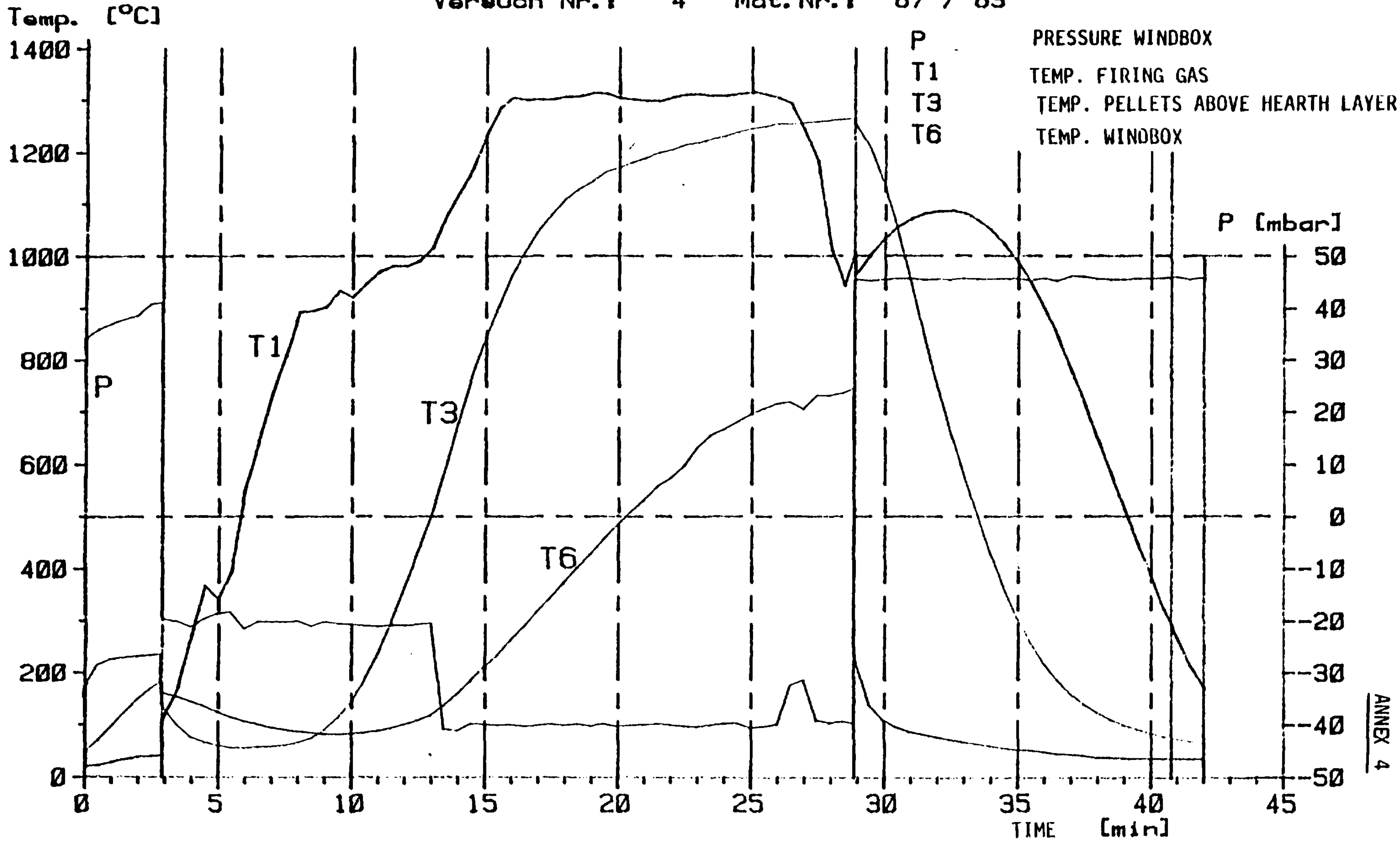


Oil/Gas
MEASURING POINTS
HOT GAS TEMPERATURE T1
PELLET TEMPERATURE T2
TEMPERATURE ABOVE HEARTH LAYER T3
TEMPERATURE ABOVE GRATE T4
GRATE BAR TEMPERATURE T5
WINDBOX TEMPERATURE T6
TEMPERATURE AT ORIFICE
PELLETS
SIDE LAYER
HEARTH LAYER
Waste Gas
Orifice
265
360

LURGI-Chemie, Pellet-Technikum Ffm, 8.08.1983

Material : TANZANIA NDI

Versuch Nr.: 4 Mat.Nr.: 87 / 83



ANNEX 4

2.4.6 DIRECT REDUCTION TESTS

2.4.6.1 Objectives of Testwork and Test Materials

Direct reduction tests were carried out to establish the suitability for coal-based direct reduction according to the SL/RN process of Tanzanian iron ores in the form of

- lump ore
- pellets produced from beneficiated iron ore concentrates using Tanzanian binder materials

in combination with Tanzanian dolomite and limestone as desulphurizers and Mchuchuma coal as reductant. The results of these tests served to evaluate the key design parameters of an industrial scale SL/RN plant in terms of chemical and physical properties of raw materials required and product quality to be expected with special emphasis on the subsequent processing steps of the DRI.

For the direct reduction tests, the following chemical analyses of the Liganga lump ore and of the pellets produced from a mix of Liganga/Maganga concentrates apply:

Mat. No.	87/83		
Contents, dry	lump ore "LIGANGA" 5-30 mm	Pellets # 2	Pellets # 3
	%	%	%
Fe tot	52.4	61.0	60.7
Fe^{2+}	20.7	0.4	0.3
CaO	-0.01	0.77	0.86
MgO	4.76	1.76	1.8
SiO_2	0.29	0.54	0.53
Al_2O_3	8.46	2.67	2.7
TiO_2	13.05	6.14	6.2
V_2O_5	0.52	0.62	0.6
Cr_2O_3	0.26	0.31	0.31
S	0.008	0.004	0.002
L.O.I. 1050°C, air	+2.3	0.05	0.04

Tab. 1: Chemical Analyses of iron bearing materials for DRI tests.

The lump ore was charged into the laboratory kiln after crushing in a grain size range of 5 - 15 mm and into the short rotary kiln because of the higher material bed in the range of 5 - 30 mm. Pellets were charged 8 - 15 mm.

As desulphurizers, Wazo Hill limestone and Chalinze dolomite were added to the charge mix. Their chemical analyses are as follows:

Mat. No.	87/83	
Contents, dry	Limestone	Dolomite
	%	%
CaO	53.6	31.8
MgO	0.8	20.9
SiO_2	3.0	15.3
Al_2O_3	0.7	0.1
S	0.033	0.03
L.O.I.	42.2	32.6

Tab. 2: Chemical Analyses of Additives

As Mchuchuma coal contains 0.48% of sulfur out of which 0.4% is in form of organic sulfur and thus responsible for sulfurization of the sponge iron a desulfurizing agent should be used in direct reduction to obtain reasonable sulfur values in the sponge iron. The added amount in the tests was always 5% of the iron bearer in a grain size range of 1 - 3 mm.

Mchuchuma coal from the upper part of "Lower Seam" was processed together with Liganga lump ore and Liganga/ Maganga pellets. The characteristics of coal and coal ash are given in Table 3.

Mat. No.		87/83	
Type of reductant		Mchuchuma coal	
Proximate analysis			
Ash	%	20.8	
Volatiles	%	25.0	
Cfix	%	54.2	
	Σ	100.0	
S tot	%	0.48	
S organic	%	0.40	
Ultimate analysis		air dry	waf
H_2O	%	2.4	-
Ash	%	20.6	-
C	%	65.5	85.1
H	%	3.79	4.92
N_2	%	1.75	2.27
S	%	0.46	0.6
Cl	%	0.02	0.03
O_2(Diff.)	%	5.48	7.08
Calorific value		air dry	waf
Net	kJ/kg	25280	32910
Gross	"	26170	33990
Ash analysis			
CaO	%	0.3	
MgO	%	0.2	
Al_2O_3	%	26.5	
SiO_2	%	69	
Fe_2O_3	%	1.5	
SO_3	%	0.09	
Melting behaviour of coal ash, CO/CO_2=1/1			
Softening point	°C	1350	
Hemispherical point	°C	+1570	
Melting point	°C	+1570	
Reactivity	cm^3 CO/gC.sec	0.71	
Caking number		12	
Swelling index		1	

Tab. 3: Analysis of Mchuchuma "Lower Seam" coal and coal ash.

Because of comparison reasons the screen analysis of the reductants used in the test was always constant. Based on experience, the reactivity of the reductant requires a reduction temperature of 1080°C to 1100°C. The softening point of the coal ash is high enough to allow these reduction temperatures (1350°C).

2.4.6.2 Procedure of Direct Reduction Tests

2.4.6.2.1 Laboratory Rotary Kiln

The Laboratory Rotary Kiln shown in Annex 1 permits testing material quantities of 1 - 2 kg. The tests were performed under standard conditions, which means that after preheating the kiln to 400°C, a feed of 1 kg lump ore or pellets is charged together with the corresponding quantity of coal or coke (Cfix/Fe ratio always = 0.5). After charging, the material is heated to reaction temperature, which is roughly prescribed by the reactivity of the coal; at this point, the temperature is held constant for a 2 hour reaction period. After that, the temperature is increased by approximately 20°C and the kiln charge is retained for a further one hour at this temperature level. Commercial kiln operation is simulated under these conditions.

2.4.6.2.2 Short Rotary Furnace

The Short Rotary Furnace shown in Annex 2 permits test runs with material quantities of 100 - 150 kg and is heated by direct oil firing. The test procedure is similar to that of the laboratory rotary kiln, with a preheating temperature of 400°C before feeding the raw material samples. The Cfix/Fe ratio was set at 0.6 for these tests. Intermediate samples were taken hourly after heating up to establish chemical and physical reduction profiles.

2.4.6.3 Results of Direct Reduction Tests

In total, 7 laboratory rotary kiln tests and 1 short rotary furnace test were carried out to evaluate the:

- suitability of lumpy iron ore as feed,
- suitability of Wazo Hill limestone and Chalinze dolomite as desulphurizers,
- necessity of Mchuchuma coal treatment and behaviour of charred Mchuchuma coal,
- suitability of pellets produced from a concentrate mix Liganga/Maganga

for SL/RN coal-based direct reduction.

2.4.6.3.1 Results of Laboratory Rotary Kiln Tests

The test conditions and results of the laboratory rotary furnace tests are compiled in tables 4 and 5.

2.4.6.3.2 Direct Reduction of Liganga Lump Ore

Liganga lump ore in the grain size range 5 - 15 mm was tested in combination with Mchuchuma coal (grain size 0 - 10 mm) to evaluate the reduction and decrepitation behaviour of the titanomagnetite iron ore in its lumpy form. As demonstrated in table 4 , tests No. 1 and 2, due to the very compact mineral structure and the low hematite content of Liganga lump ore only pre-reduction degrees of less than 90% metallization are obtained in the reduction tests in the laboratory rotary kiln especially when the lumps become bigger in size.

Especially in the fraction +5 -15 mm, metallization degree was poor with below 80%, which is not acceptable for further processing to steel in the melting vessel. The lump ore furthermore showed a considerable tendency towards decrepitation, generating approx. 20% of fines below 5 mm. As the fines of grain size -1 mm are of major concern for trouble-free operation of industrial scale DR units, the utilization of this lump ore - generating between 6.8 - 7.3% of fines -1 mm - cannot be recommended from this point of view, too.

2.4.6.3.3 Selection of Desulphurizers

As the content of organic sulfur in Mchuchuma coal - which is responsible for sulphurizing the DRI - is slightly high, it is necessary for low sulfur contents in the product of less than 0.02% to add a desulphurizing agent.

Wazo Hill limestone and Chalinze dolomite were tested as desulphurizing agents under same reduction conditions in the laboratory rotary kiln, test No. 1 and 2, table 4. For this purpose 5% per weight of the iron ore charge (grain size 1 - 3 mm) were added to the test charge.

The Wazo Hill is a coral type limestone and disintegrates partly in the kiln when being heated. Consequently a fine powder of CaS is sticking to the surface of the sponge iron after reduction. Therefore it is not possible to achieve a proper magnetic separation of sponge iron and desulphurizing agent in the product separation system. Chalinze dolomite particles, however, behave stable and should thus be preferred to obtain low sulfur values in the sponge iron.

Test Equipment		Laboratory kiln	
Test	No.	1	2
Kiln feed			
Lump ore		Liganga	Liganga
weight	kg	1	1
grain size	mm	5-15	5-15
Reductant, Mchuchuma		coal	coal
weight	kg	0.489	0.489
grain size	mm	0-10	0-10
Desulfurizing agent		Limestone	Dolomite
weight	kg	0.05	0.05
grain size	mm	1-3	1-3
Cfix/Fe-ratio		0.5	0.5
Temp. of kiln upon feeding	°C	400	400
Heat up time	min	90	90
Reduction temperature	°C	1080/1100	1080/1100
Reduction time	min	120/ 60	120/ 60
Results			
Magnetic fraction +5 mm	%	82.6	78.8
Metallization	%	78.9	69.8
Fe tot	%	63.4	62.5
C	%	0.13	0.05
S	%	0.017	0.007
Magnetic fraction 1-5 mm	%	10.6	13.9
Metallization	%	86.9	85.0
Fe tot	%	60.2	61.5
C	%	0.3	0.14
S	%	0.017	0.009
Magnetic fraction -1 mm	%	6.8	7.3
Metallization	%	92.3	94.5
Fe tot	%	59.7	65.4
C	%	4.11	2.2
S	%	0.23	0.075
Nonmagnetics			
weight	g	0.278	0.3
Fe tot	%	0.9	1.4
C	%	53.4	52.4
S	%	1.16	0.61
Nonmagnetic fraction +10mm	%	6.0	11.4

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Tab. 4: Metallurgical results with Liganga lump ore

2.4.6.3.4 Reduction of Liganga/Maganga Pellets

The results of reduction tests with pellets produced from a Liganga/Maganga concentrate mix are compiled in table 5, tests No. 3 - 7. As desulphurizer, dolomite from Chalinze (5%, 1-3mm) was used. Both types of pellets, bentonite/limestone and hydrated lime/quartz bonded, showed excellent reduction behaviour (tests No. 4, 7). The metallization values in the fractions +1 mm exceeded 92% with very satisfying sulphur contents of 0.01%/0.015% in more than 95% of the DRI produced.

Decrepitation of the pellets was low with a fines generation -6 mm of only between 2.8 - 4.8%.

The fines fraction -1 mm which derives mostly from pellet abrasion is - with a maximum value of 3.9 % (Test No. 4) - still within the tolerable range for industrial plant operation. The influence of the reductant, whether coal or coke, is such that reduction tests with coke always lead to slightly lower values than coal. This is due to the fact that the coal volatiles owing to their reduction potential are causing low temperature disintegration (comparison Test No. 3, 4).

The particle fraction between 1 - 6 mm can be neglected with a maximum value in all tests of 1.2%.

The compression strength of the reduced pellets is generally more than 40 kg/pellets and thus sufficiently high for product handling.

2.4.6.3.5 Reduction Tests with Charred Mchuchuma Coal

The carbotechnical analysis of Mchuchuma coal indicates a slight caking behaviour with an index of 12, which is close to the tolerable maximum. Caking coal particles can agglomerate by bitumen formation during heating up in the rotary kiln andthus lead to dismixing of ore and reductant. As can be seen from the screen analysis of the nonmagnetic discharge of the laboratory as well as from the short rotary kiln, there is always a certain portion +10 mm even though the coal has been charged in a size range of -10 mm. In industrial plants unsatisfactory plant operation could be the consequence.

As an alternative to coal, a charred coal sample was prepared for laboratory kiln tests No. 3, 5 and 6 by a thermal treatment of Mchuchuma coal at 900°C for 30 minutes. As can be seen from the proximate analysis the coal is nearly completely devolatilized. With the use of Mchuchuma coke, there was no agglomeration of the reductant during heat up and reduction period.

Ash	%	30.5
Volatiles	%	1.7
Cfix	%	67.8
Caking Number		0
Swelling Index		0
Reactivity	cm^3 CO/g C sec	0.71

Tab. 6: Proximate Analysis of charred Mchuchuma coal as used in tests 3, 5, 6.

The charred Mchuchuma coal ("coke") was tested with regard to its reduction potential in tests No. 3, 5, 6, table 5.

When applying the nominal Cfix/Fe ratio in the kiln charge with charred coal, no sufficient metallization degrees could be reached even if the reduction time is extended for one hour (Tests No. 3/6). This is due to the lack of reduction potential generated by the volatile matter of the coal. This effect can be compensated by a higher Cfix/Fe ratio of for example 0.8 in the laboratory kiln (Test No. 5). The Cfix/Fe ratio of 0.8 was not optimized as, in general, as a result of this comparison, the negative influences of coal charring on the performance results - not considered the economical aspects of this process step - clearly surpass the benefits of entirely avoiding coal agglomeration.

Thus, for an industrial plant, it is recommended tc lower the caking tendency of Mchuchuma coal by natural oxidation rather than by a thermal treatment. For such oxidation, exposure of the coal to wheathering by a scheduled stockholding scheme for readily sized Mchuchuma coal (0 - 10 mm) with planned stacking/reclaiming at the steel plant site would be sufficient.

According to this procedure, the loss of the volatile matter required in the DR process is irrelevantly low and the need to compensate for the missing reduction potential by charging excess carbon can be avoided.

Test Equipment						
Test	No.	3	4	5	6	7
Kiln feed						
Pellets, Test	No.	# 2	# 2	# 2	# 2	# 3
weight	kg	1	1	1	1	1
grain size	mm	8-15	8-15	8-15	8-15	8-15
Reductant, Mchuchuma		coke	coal	coke	coke	coal
weight	kg	0.452	0.579	0.723	0.452	0.573
grain size	mm	0-10	0-10	0-10	0-10	0-10
Desulfurizing Agent		Dolomite	Dolomite	Dolomite	Dolomite	Dolomite
weight	kg	0.05	0.05	0.05	0.05	0.05
grain size	mm	1-3	1-3	1-3	1-3	1-3
Cfix/Fe-ratio		0.5	0.5	0.8	0.5	0.5
Temp. of kiln upon feeding	°C	400	400	400	400	400
Heat up time	min	100	100	100	100	100
Reduction temp.	°C	1080/1100	1080/1100	1080/1100	1080/1100	1080/1100
Reduction time	min	120/ 60	120/ 60	120/ 60	120/120	120/ 60
Results						
Magnetic fraction +6 mm	%	97.0	95.2	96.4	97.2	95.9
Metallization	%	78.7	92.2	92.8	84.0	93.1
Fe tot	%	79.0	81.2	81.9	79.8	81.0
C	%	0.03	0.05	0.05	0.04	0.06
S	%	0.01	0.015	0.007	0.012	0.01
Magnetic fraction 1-6 mm	%	1.2	0.9	1.5	0.9	0.9
Metallization	%	90.4	92.6	98.4	92.9	96.9
Fe tot	%	78.8	79.8	79.5	75.6	77.5
C	%	0.36	0.74	0.61	2.38	0.89
S	%	0.026	0.029	0.039	0.071	0.034
Magnetic fraction -1 mm	%	1,8	3.9	2.1	1.9	3.2
Metallization	%	78.9	94.4	87.8	80.4	90.7
Fe tot	%	39.3	54.0	40.7	35.2	45.0
C	%	15.6	11.3	19.8	17.0	10.7
S	%	1.0	0.72	0.65	0.84	0.32
Compression strength of reduced pellets	kg/P	79.8	46.0	64.5	53.4	42.0
Nonmagnetics						
weight	kg	0.304	0.302	0.539	0.29	0.3
Fe tot	%	0.8	1.0	0.5	0.7	1.0
C	%	47.4	52.1	55.3	43.8	52.3
S	%	0.47	0.62	0.41	0.48	0.64
Nonmagnetic fraction +10 mm	%	0	5.5	0	0	7.8

Tab. 5: Metallurgical results with Liganga/Maganga pellets

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2.4.6.3.6 Results of Short Rotary Furnace Test

A confirmatory short rotary furnace test using 70 kg of iron ore and 46 kg of untreated Mchuchuma coal was carried out to affirm to above statements with regard to

- ruling out the utilization of lump ore as iron oxide feed in terms of reducibility and desintegration,
- allowing for a certain agglomeration of Mchuchuma coal without affecting the reduction result.

For this purpose, also intermediate samples were taken during the test to follow up the reduction progress. Test conditions and metallurgical results are compiled in table 7.

According to these results, the influence of the lump ore's grain size is predominant with regard to the metallization degrees achieved. Only the fraction -5 mm is satisfactorily metallized (+90 %), sulphur contents at the same time being acceptable with below 0.03%. Decrepitation with 17.3% fines -5 mm again exceeds the tolerable value, table 8.

Grain size mm	as charged %	as discharged %
25-30	23	21.4
20-25	24	16.1
18-20	10	8.0
15-18	10	9.4
12-15	10	6.7
10-12	6	6 8
8-10	7	6.0
5- 8	10	8.3
3- 5	-	5.9
1- 3	-	5.0
0- 1	-	6.4
Σ	100	100.0

Tab.8 : Screen Analyses of Liganga lump ore and DRI

Test Equipment		Short Rotary kiln
Test	No.	1
Kiln feed		
Lump ore		Liganga
weight	kg	70
grain size	mm	5-30
Reductant, Mchuchuma		coal
weight	kg	46.1
grain size	mm	0-10
Desulfurizing Agent		Dolomite
weight	kg	3.5
grain size	mm	1-3
Cfix/Fe-ratio		0.6
Temp. of kiln upon feeding	°C	400
Heat up time	min	240
Reduction temp.	°C	1080/1100
Reduction time	min	120/ 60
Results, kiln discharge		
Magnetic fraction 20-30 mm	%	37.5
Metallization	%	63.3
Fe tot	%	62.2
C	%	0.03
S	%	0.008
Magnetic fraction 10-20 mm	%	31.9
Metallization	%	75.2
Fe tot	%	62.9
C	%	0.03
S	%	0.007
Magnetic fraction 5-10 mm	%	16.3
Metallization	%	84.4
Fe tot	%	62.9
C	%	0.04
S	%	0.01
Magnetic fraction 1-5 mm	%	10.9
Metallization	%	90.1
Fe tot	%	62.8
C	%	0.08
S	%	0.023
Magnetic fraction -1 mm	%	6.4
Metallization	%	93.6
Fe tot	%	67.0
C	%	0.33
S	%	0.076
Nonmagnetics		
weight	kg	12.62
Fe tot	%	2.3
C	%	39.0
S	%	0.67

Table 7: Metallurgical results of short rotary furnace test

The detailed screen analysis of the metallized product clearly shows, that a major portion of the fines is generated by abrasion in combination with low temperature degradation as a result of the reducing effect of the coal's volatiles set free during the heating period.

As can be seen in table 9 , the reduction progress nearly stops after a reduction time of approx. 1 hour.

Time	after heating up		after 1 hour		after 2 hours		discharge	
grain size	5-10	10-20	5-10	10-20	5-10	10-20	5-10	10-20
Contents	%	%	%	%	%	%	%	%
Fe tot	62.4	60.8	66.3	60.5	62.5	53.1	62.9	62.9
Met.	64.1	43.9	80.2	63.8	80.0	69.3	84.4	75.2
C	0.04	0.02	0.04	0.05	0.04	0.05	0.04	0.03
S	0.01	0.007	0.01	0.008	0.008	0.008	0.01	0.007

Tab. 9 : Chemical Analysis of intermediate samples.

From this effect, which is due to the extremely dense mineralogical structure of the lump ore, it can be derived, that even by further prolonging retention times in the furnace, the required average metallization of +92 % in the DRI fraction -15 mm cannot be achieved under economical conditions and without drastically reducing the specific throughput of a given DR unit.

The screen analysis of Mchuchuma coal used as reductant, indicates that the agglomeration tendency of this coal sample due to caking effects still is in the tolerable limits, table 9.

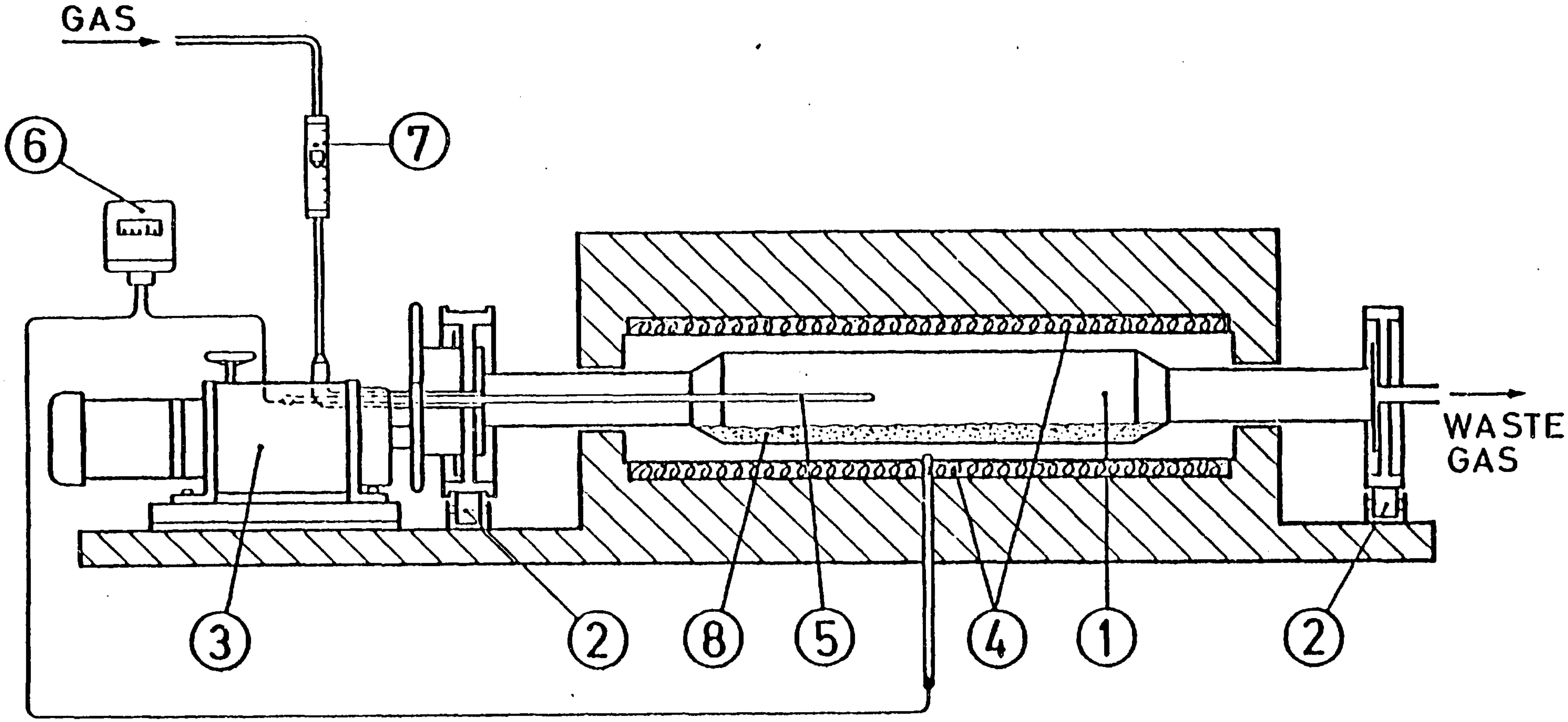
Grain size mm	as charged %	as discharged %
+30		27.6
25-30		1.7
20-25		1.5
18-20		0.6
15-18		0.6
12-15		0.6
10-12		1.0
8-10	8	1.2
5- 8	13	4.5
3- 5	26	16.6
1- 3	25	27.2
0- 1	28	16.9
Σ	100	100.0

Tab. 10 : Screen Analysis of Mchuchuma coal and nonmagnetic kiln discharge material.

The agglomerates formed are mostly coarse (+30 mm) and tend to remain at the surface of the kiln charge. This effect is not yet critical and can be drastically decreased by oxidizing the coal's surface for which, based on experience with similar coal types, LURGI recommends extended wheatering of the readily sized coal through prolonged outdoor storage, rather than providing additional thermal treatment.

For the further evaluations in this study, the following reference analysis of DRI applies:

Fe met	74.5 %	SiO_2	0.7 %
FeO	8.3 %	Al_2O_3	3.5 %
C	0.06%	TiO_2	8.1 %
S	0.02%	V_2O_5	0.8 %
CaO	1.1 %	Cr_2O_3	0.4 %
MgO	2.4 %		



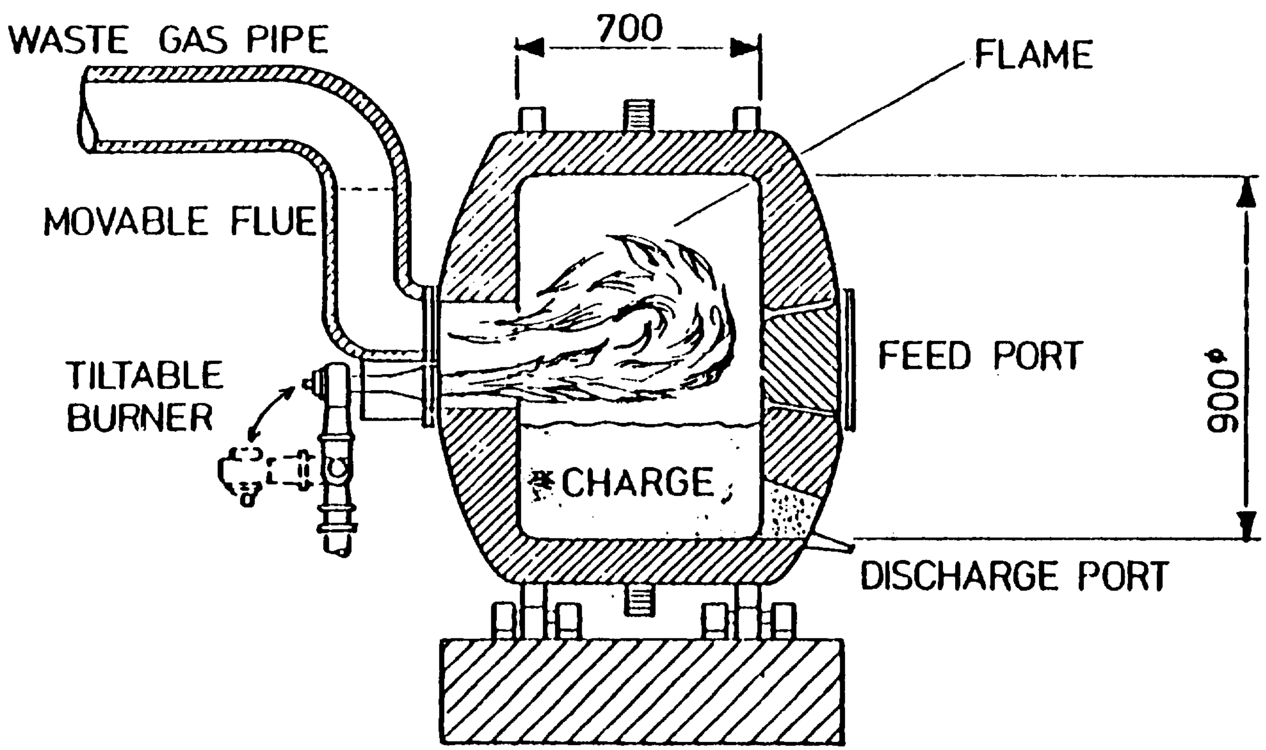
1 ROTARY KILN, 150 mm DIA
2 ROLLER BEARING
3 ADJUSTABLE DRIVE
4 HEATING COILS
5 THERMOCOUPLE
6 TEMPERATURE RECORDER
7 FLOW METER
8 CHARGE

LURGI

LABORATORY ROTARY KILN FOR BENCH SCALE TESTWORK

C76-1012 E

ANNEX 2



LURGI	EXPERIMENTAL SHORT ROTARY KILN	C74-1105E

SECTION 2.5

Recovery of TiO_2 and V

2.5 Recovery of TiO_2 and V

2.5.1 Recovery of Vanadium

Vanadium can be recovered to a large extent from low V-containing iron ores (titanomagnetites) according to the following method:

- the iron oxide is reduced to pig iron in a SAF;
- under such reducing conditions, V is mainly collected in the iron;
- V can be recovered in form of a V_2O_5 rich slag prior to steelmaking, e.g. in a shaking ladle by oxygen blowing of the V-containing pig iron;

This process is successfully applied by Highveld Steel and Vanadium Corp. in South Africa.

	% V	% TiO_2
Iron ore	0.92	13.6
Pig iron	1.32	0.23
SAF slag	0.35	32.0
V slag	approx. 20	n.d.

Due to the limitations imposed by the Cr-contents of the iron ore pellets, production of V-containing pig iron has to be ruled out for the NDC integrated steel project, as previously explained. Therefore an adaptation of the Highveld technology is not possible.

As in the case with Tanzanian raw materials, if steel or semi-steel is directly produced with prereduced material in the electric smelter, V is transferred at a rate of 90% in the slag, as demonstrated by the operations of New Zealand Steel Ltd. in New Zealand.

	% V_2O_5	% TiO_2
Iron ore	0.6	8.0
Melt slag	1.9	27.6
Tapping slag	1.2	12.6

Recovery of this V_2O_5 from the slag is technically feasible by forming water soluable sodium vanadate by treating a slag/soda mix at high temperature in a rotary kiln or multihearth furnace. By subsequent leaching, V_2O_5 can be recovered by precipitation from its solution. We, however, doubt that such a process would be economic under actually prevailing conditions. Another option to treat the $TiO_2/V_2O_5/$ gangue containing slag would be smelting/reduction in a separate electric furnace yielding Cr/V-rich pig iron formed by the $FeO/V_2O_5/Cr_2O_3$ contained in the slag. This, however, would mean reduction of the slag's Cr_2O_3-content as well, thus incurring the need to blow the pig iron under the severe parameters for Cr-slagging in an oxygen converter. There is no industrial operation of this kind known; in view of the adverse techno-economic factors it is not recommended to further process the slag for V_2O_5 recovery.

2.5.2 Recovery of TiO_2

In the cases known of integrated steelworks processing titanomagnetites, i.e. Highveld and New Zealand Steel, the slags produced are too low in TiO_2 contents for further processing and are, therefore, dumped. As a comparison, the TiO_2 contents of slags commonly used in the Ti pigment industry are as follows:

	QIT/Canada	Richards Bay/SA
% TiO_2	approx. 70	approx. 85

For the NDC integrated steel project, the smelting slag will contain less than 25% TiO_2, this rather low level rules out economic operations for TiO_2 recovery at all.

LURGI

A ADDENDUM

Comments derived from the Tripartite

Report Meeting, Dar es Salaam, 23.03.84

1. Selection of DRI Smelting Process

To smelt the DRI, produced in a coal-based SL/RN DR rotary kiln, the Consultant proposes to utilize an open bath submerged arc furnace (SAF).

This type of smelter is ideally suited to process high percentages of gangue-rich DRI in the charge due to the following reasons:

- In contrast to an UHP electric arc furnace (EAF), heat input into the SAF is via resistance heating of the slag, whereas the EAF operates with an arc between electrode and metal surface. With high gangue containing DRI and correspondingly high slag levels, the EAF mode of operation cannot be maintained, as slag quantities of approx. 200 kg/t liquid material are the established maximum for this technology. Due to the necessary slag basicity of 1.7 for EAF smelting, the slag/metal ratio would clearly surpass even 360 kg slag/t liquid metal as applicable for the SAF concept.

- The UHP electric arc furnace requires a high capacity electric grid to avoid flickering effects, whereas - due to nearly constant power input - the SAF operates with minimum short circuit capacities of the electric power supply systems.

- The SAF operates with self-baking electrodes (cost approx. 0.5 US$ per kg) as compared to the EAF, which requires high cost imported graphite electrodes (cost approx. 2 US$ per kg).
  At a capacity of 500,000 tpy finished steel, this results in electrode cost savings as below:

  SAF: 4,750 t x 0.5 $/kg = 2,375,000.- US$
  EAF: 3,560 t x 2.0 $/kg = 7,120,000.- US$

  Savings per year 5,745,000.- US$

  Additional savings are achieved by lower consumption of refractory material with the SAF concept.

The type of SAF proposed for the NDC integrated steel plant is in successful operation since 1981 in Kavadarcy, Yugoslavia, where it proves its reliability in ferro-nickel production with a liquid metal of the following approximate analysis: 81% Fe, 18% Ni, - 0.01% S, C; temperature + 1,650° C (55 MW, 6 electrodes). The same type of SAF will be operated by New Zealand Steel Ltd. beginning 1985 in their 1,000,000 tpy expansion programme.

The SAF represents today's state of the art of smelting high-gangue DRI at DRI/scrap ratio of + 50/50%.

Processing of Liganga/Maganga DRI in the EAF of ALAF, Dar es Salaam, is technically possible. Due to the restrictions mentioned above and depending on the quality of scrap as well as on the steel grades to be produced, the maximum DRI input may be limited to approx. 20 - 25% of the total iron units charged. Higher DRI ratios will result in prolonged tap-to-tap times and higher specific consumptions of electrodes, electric power, refractory and additives. In any case, facilities for continuous charging (bins, conveyors, belt scales, feeding pipes) of the DRI should be installed.

2. Utilization of By-Products

Officials of Ministry of Industries and NDC, Tanzania, pointed out the desirability to recover Vanadium, Titanium, Aluminium and/or ferro-alloys as by-products from processing of the Liganga titano-magnetite iron ore to possibly improve the foreign exchange standing of the iron and steel project.

2.1 Recovery of Vanadium

Beneficiation tests showed that - due to crystalline intergrowth - approx. 90% of the Vanadium were recovered in the iron ore concentrate and only about 10% went into the tailings. Therefore, the tailings cannot be regarded as a source of Vanadium.

As already explained (Volume I, Chapter 2.5.1), the commercially applied routes (Highveld/South Africa, New Zealand Steel) to recover Vanadium via pig iron production in a submerged arc furnace, followed by selective oxygen blowing of the V-rich pig iron in a ladle, has to be ruled out for the Tanzanian Liganga/Maganga ores, because of its chromium content. The reason for this is, that the chromium would be reduced together with the Vanadium and form Cr carbides in the hot metal, which cannot be removed from the metal bath during steel making. Cr carbides would deteriorate rolling properties and weldability.

A source of V could be the slag from the submerged arc furnace with approx. 2.4% V_2O_5. As already explained (Volume I, Chapter 2.5.1), two technical ways are possible:

a) Heat treatment of the ground slag under the addition of soda in a rotary kiln or multi-hearth furnace followed by leaching. A similar process is applied at Highveld/South Africa for the treatment of ore fines, but the plant was shut down a year ago because of the high production costs.

b) Smelting/reduction of the slag in an additional electric furnace. This would, however, mean the development of a new process route, as no industrial operation of this kind is known, implying all the risks of such an undertaking.

Generally, it has to be stated that upgrading of metal contents like V, Ti, Al, Cr of slags is not possible.

Summarizing, it is not recommended to further investigate the recovery of V_2O_5 under the prevailing market conditions and technical possibilites.

2.2 Recovery of TiO_2

The basic raw materials for Ti/TiO2 production are rutiles (+ 90% TiO2) and ilmenites FeTiO3 (after beneficiation approx. 37 - 65% TiO2).

QIT, Canada, uses ilmenite with 37% TiO2 to produce a slag with 70 - 72% TiO2 ("Sorel Slag") together with a low residual pig iron, to be sold on the world market. In Richards Bay/South Africa, a slag with approx. 85% TiO2 is produced and sold.

The main deposits of ilmenite are represented by heavy beach sands, which usually are easy to upgrade.

The following table indicates some of the exploited ilmenite deposits:

Deposit	% TiO_2 in raw ore	% TiO_2 in conc.	known raw ore resources Mill. t
St. Urbain (Canada)	35	37	200
Allard Lake (Canada)	32-40	43	20
N.Y. State (USA)	17	45	100
Virginia (USA)	18.5	44	5
Florida (USA)	0.5-3.0	63	180
Norway	17	43	250
Finland	13.5	44	50
Kerala (India)	20-40	59	100
Umgabuba (South Africa)	5	49	20
Australia	30	50-65	15

The TiO_2 containing slag produced from titano-magnetite iron ores in the submerged arc furnaces at Highveld/South Africa contains approx. 32% TiO_2 and is dumped because of this low TiO_2 content.

The slag from the submerged arc furnace proposed for the Tanzania project would contain approx. 25% TiO_2. This low level does not allow economic recovery of TiO_2. The same applies to the tailings produced during ore beneficiation with a TiO_2 content of approx. 26%.

2.3 Production of Ferro-alloys

The basis for ferro vanadium production is V_2O_5 with little impurities to produce FeV with 60 or 80% V. Silicothermic and aluminothermic processes are known. As high-grade V_2O_5 - the production of which has to be ruled out according to 2.1 above - would be the raw material for the production of ferro vanadium, this option is not viable.

The production of ferro chrome is mainly done in electro reduction furnaces using chromites with 40 - 50% Cr_2O_3 as raw materials. As the slag from the proposed submerged arc furnace contains only 0.9% Cr_2O_3, an economical production of ferro chrome is not possible.

2.4 Recovery of Alumina

Almost all alumina plants in America, Western Europe, Africa and Asia are based on bauxite as raw material, which is in adequate supply. The average Al_2O_3 content of bauxite ranges between 50 - 60%. Mainly in the USSR, non-bauxite raw materials, such as alumite (20 - 35% Al_2O_3) and nephelin (20 - 35% Al_2O_3) have been used. Modern alumina plants constructed recently in the USSR base on imported bauxite.

Other non-bauxite raw materials, such as clay, shale or coal ashes have been processed up to now in pilot plants. Industrial plants have been shut down after World War II.

In recent years, LURGI was engaged in several studies concerning the extraction of Al_2O_3 from non-bauxite raw materials.
The results of those studies have shown that, in general, the processing of alumite and nephelin has the advantage of cheap raw material costs. On the other hand, these processes require extensive thermal treatment of the raw ore as well as various investment-intensive process steps.

It has been found that the energy consumption of these processes is 2 - 3 times that of the conventional Bayer-process. Also the investment cost is higher by a factor of 2.0 compared with the Bayer-process.

In the light of these results from industrial as well as pilot plants, it has to be stated that the extraction of alumina from tailings (20% Al_2O_3) or slags (11 - 12% Al_2O_3) of the treatment of Liganga iron ore will be far more expensive than the processing of nephelin and alumite. We, therefore, cannot recommend the extraction of Al_2O_3 from these materials.

3. Coal-Fired Pelletizing

Within the study, Lurgi recommended to select oil as fuel for pellet induration due to the fact that the use of coal, although technically feasible - will not be economical taking all facts into account.

After the second oil price escalation, a number of different methods for utilizing coal in pellet induration were evaluated, of which only the following three methods proved to be technically feasible:

- Adding of coal dust to the pellet feed before balling. This is possible without major changes to conventional travelling grate equipment and leads to considerable savings in oil and even energy consumption. The original plant outfit with oil heating is being maintained although the level of consumption is lower.
  The method of coal dust/iron ore pellets - due to thermal control - is only feasible with hematite concentrate. For Liganga/Maganga titano-magnetites, this option has to be ruled out.

- Installation of separate combustion chambers on one side of the travelling grate equipped with coal dust injection burners. Of two plants, thus commissioned in the USA, only one was operated successfully for two or three years in intervals using coal dust as fuel.
  Though it was possible to overcome all problems involved, the client decided finally to change to natural gas for economical reasons.

- Installation of a special design hood with facilities for coal injection after the plant has been heated up to operating temperature with fuel oil burning equipment. This method will be applied in the LURGI-designed Mangalore India Pellet Plant which presently is under construction. Though calculations and laboratory tests revealed that this method of coal firing will be successfully commissioned in an industrial plant, actual operating data and practical experience will only be available early 1986.

Due to the fact that the use of coal in pellet plants requires the installation of storage and handling facilities for coal, coal injection equipment and besides this, of course, the complete outfit for plant start-up with fuel oil, substantial savings can only be achieved in large industrial plants (+3 million tpy) processing hematite concentrates which by their nature require higher energy inputs for pellet induration.

Summarizing all considerations, one will have to keep in mind, that whenever magnetite is used as raw material, the low rate of energy consumption does not justify even the additional investment required for coal application based on the latest method described above.

Last but not least, the Consultant cannot recommend entering this "virgin territory" at the present stage of project development.

4. Product Mix

4.1 Production of Blooms

Representatives of the Ministry of Industry as well as of NDC have pointed out, that the production of steel sections in the first step would be under certain circumstances more favourable than the production of flat products as envisaged in the study. The order of magnitude of changes in investment as well as in operating cost associated with the new product mix should be evaluated.
The production of steel sections was already envisaged in the expansion step from 500,000 tpy to 1,000,000 tpy. The total production rate for sections shall be 500,000 tpy. Therefore, it could be assumed that the production of blooms rather than slabs already in the first step is viable. The product mix has already been defined and can be obtained from Table 1. In the following, the changes in investment capital requirement as well as in operating cost are investigated.

4.2 Investment Requirement

The smelting shop, the ladle and the civil work will remain unaffected. Some differences may occur in the continuous casting and the rolling mill. These process steps may require about 72,315,000 TSh more capital investment, which corresponds to an increase of 1% of total plant investment and 1.3% of plant investment of the steel plant at Mahanje.

4.3 Operating Cost

According to the material flow schemes already given in the annex of Volume III, the operating cost for the bloom production turns out to be lower. The cost difference between bloom and slab production is 82,632,400 TSh annually or 165.30 TSh per ton of finished product.

The total operating cost of bloom production thus amounts to:

1,989,692,000 TSh/year
3979.35 TSh/t steel

4.4 Revenues

The price list of steel products of the National Steel Corporation which is enclosed in Annex Volume V, does not contain the prices for the adequate types of steel products. Mainly the large portion of billets allocated for rolling to finished products in existing facilities (Tanga) will result in much lower specific prices and revenues.

The same difficulty arises with respect to a comparison with international steel prices, since billets are mostly processed in integrated steel plants and are not subject to international trade in large scale.

International market prices for IPE-, U- and L-profiles range between 225 to 235 $ per ton FOB German seaport, about 35 $/t less than flat products.

5. Plant Capacity 300,000 tpy Final Product

In order to evaluate the influence of a reduced steel production upon the economics of the Mahanje integrated steel plant, one can assume two main alternatives:

1. Reduced design capacity to 300,000 tpy
2. Reduced availability (60%) of the nominal capacity of 500,000 tpy

5.1 Reduced Design Capacity

At the reduced design capacity of 300,000 tpy of steel, the specific investment cost will rise. This is due to the fact, that the investment capital requirement of a smaller plant does not decrease proportionally to nominal plant capacity but with a power factor:

- The total plant investment therefore will amount to approximately 85% of the original plant investment requirement.

- In the steel plant, 3 instead of 4 kilns are necessary for DRI-production. Each kiln produces only 130,000 tpy of DRI instead of 165,000 tpy. Thus, the kiln specific productivity is lower, smaller kilns are specifically more expensive.

- In the smelting shop, two submerged arc furnaces already have to be installed for safety reasons even with reduced capacity.

- All plant related infrastructure and civil work will require about 90% of the investment of the 500,000 tpy plant. The rolling mill, which already has an average utilization of 4,700 h/a, corresponding to 54% availability, may reach an average utilization of only 2,820 h/a and an availability of 32%.

- All external infrastructure such as roads, railway, communication etc. will have to be provided to nearly the same extent as for 500,000 tpy capacity.

The plant investment thus may amount to 6,019,110,000 TSh (instead of 6,973,071,000 TSh) and specific plant investment per ton of steel will climb from 13,946 TSh/annual ton of steel to 20,064 TSh/t.

We therefore recommend a nominal capacity of 500,000 tpy to be installed in the first step. The plant availability may be lower in the years immediately after start-up before the workforce reaches adequate experience with plant operation.

5.2 Reduced Plant Availability

The effects of a reduced availability could be obtained from the sensitivity analysis. An availability of 60% of nominal capacity corresponds to a steel production of 300,000 tpy. At this capacity utilization rate the DCFRR will be 8.12%. Since a reduced availability will be maintained over only a few years, this approach could be justified rather than the installation of a plant with lower nominal capacity but high specific investment.

6. Revised Parameters for the Economic Analysis

The economic evaluations in Vol. V have been revised. The main aspects of this revision are explained below.

6.1 Tax Allowance

The tax allowance calculation procedure has been revised according to the information given by NDC during the Tripartite Meeting on 23th of March, 1984. The loss generalized in year 3 has now also been taken into account and the figures for profit after tax have been replaced.

6.2 Interest Rate

The interest rate has been changed from 13.5% to 10%. The ratio will be applied upon the total capital requirement.

6.3 Other Revisions

In the light of the discussions of the Tripartite Meeting, some additional explanations have been given in Chapter 6.6. A Table V/63 has been added, showing the cash flows of the base case for the total period.
In the annex, the steel price list of NSC and the determination of the product mix have been added.

6.4 Impact of Changed Parameters

The lower interest rate of 10% does not affect the internal rate of return (DCFRR) directly. Indirect influence is caused by tax and by lower expenses for interest during construction which reduces the investment capital requirement.

As a consequence of lower interest expenses, the profit before tax will rise resulting in higher tax. Since both effects work counter-currently, the cash flow after tax has been held constant.

6.5 Price and Cost Escalation

The economic analysis bases upon fixed prices and cost of December 1983. No escalation of costs and prices, due to inflation over the evaluation period has been taken into account. There are mainly four reasons for this procedure.

1.) The evaluation model should be consistent with respect to revenues, investment and operating costs. The plant investment has been estimated as a budget price on the price basis of December 1983 according to the terms of reference. In order to combine equivalent parameters, prices and costs also have to be based upon a fixed price basis.

2.) The moment of implementation of the project cannot yet be determined. Therefore, the exact basis for escalation schedules cannot be established.

3.) Escalation of prices and cost normally will be taken into consideration at the final stage of the project, when the project is approved and a detailed economic evaluation may be elaborated.

4.) In general, escalation of prices and cost may efface the direct influence of techno-economic parameters. Mainly in the early stages of a project an economic feasibility could not be achieved by outstanding operating parameters of a selected process but by proper assumption of escalation rates.

LURGI 13848 (2 of 7)

Final Report

Volume II

Techno-Economic Evaluation and Project Report

for the

Establishment of an Iron and Steel Industry

in

The United Republic of Tanzania

Unido Project SM/URT/81/004

for

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

April 1984

LURGI

TECHNO-ECONOMIC EVALUATION AND PROJECT REPORT

FOR THE

ESTABLISHMENT OF AN IRON AND STEEL INDUSTRY

IN

THE UNITED REPUBLIC OF TANZANIA

GENERAL LIST OF CONTENTS

UNIDO Project No. SM/URT/81/004

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TECHNO-ECONOMIC EVALUATION AND PROJECT REPORT

FOR THE

ESTABLISHMENT OF AN IRON AND STEEL INDUSTRY

IN

THE UNITED REPUBLIC OF TANZANIA

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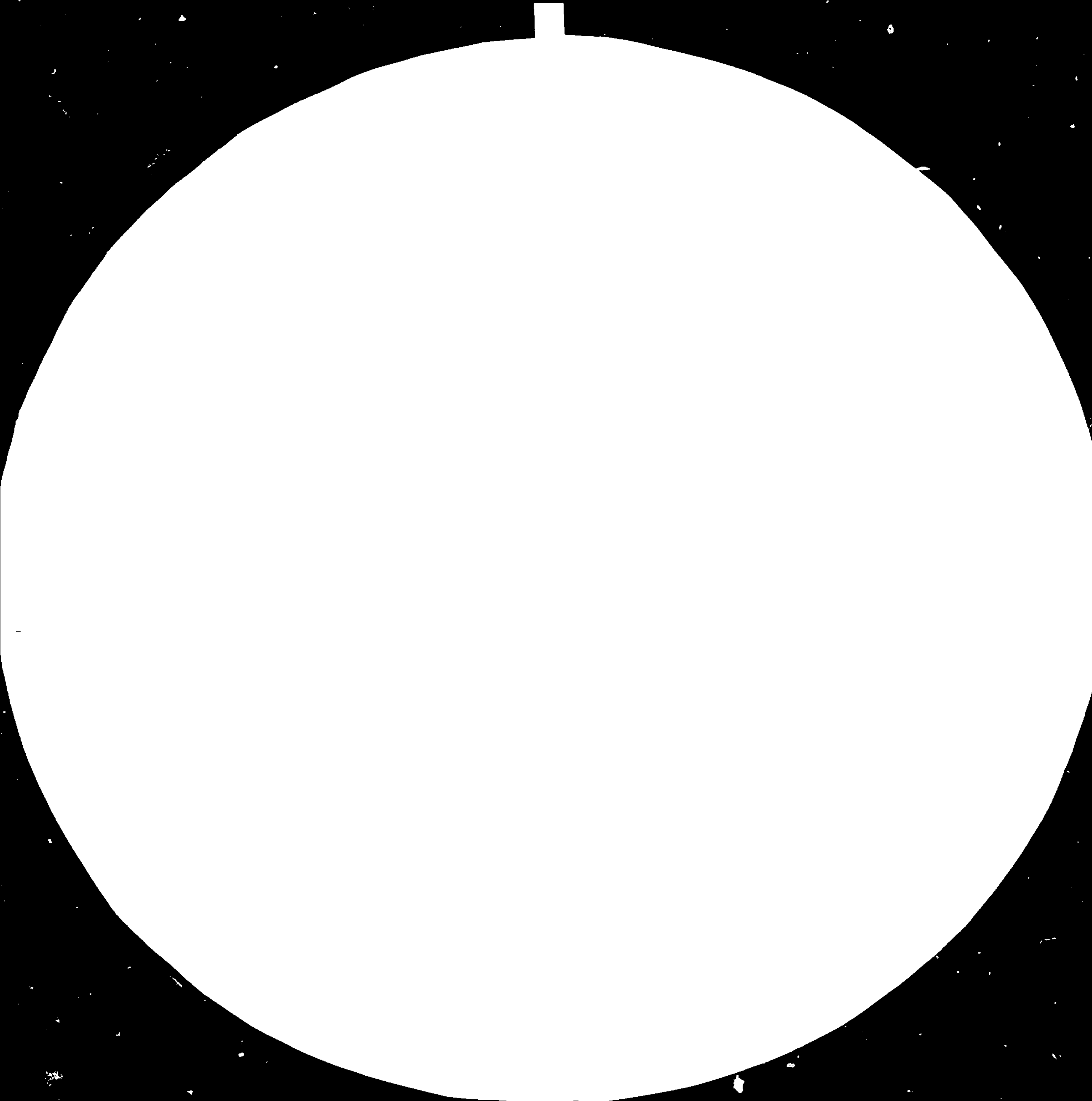
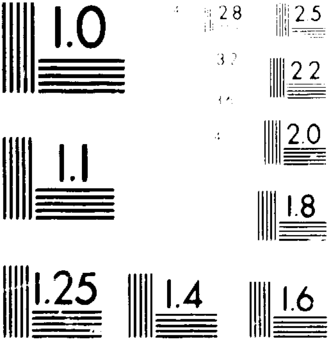
VOLUME II Plant Design Raw Materials





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

Section 1

Mchuchuma Coal

1.1 General Aspects

1.2 Coal Mine

1.3 Coal Washing Plant

1.4 Offsites and Auxiliaries "Mchuchuma"

Section 1.1

General Aspects

1.1 General aspects

1.1.1 Geographical Position

The coal deposit of Mchuchuma represents the western part of the so-called KETEWAKA-MCHUCHUMA coal field. It is situated in southwest Tanzania, about 15 km east of the Lake Nyassa (geographical coordinates 10° 20'S and 34° 40'E (see also general situation map).
The infrastructure with respect to road connections is not developed. During heavy rainfalls the road from Ludewa mission to Manda is not passable for motor cars.

1.1.2 History and previous investigations

Coal is known in Karroo sediments near the Lake Nyassa since 1896 (Bornhardt) and 1899 (Dantz) The first detailed studies including a geological classification of the Karroo sediments were carried out by Stockley (1930 - 1936).

McKinley mapped the Ketewaka-Mchuchuma coal fields topographical and geologically in a scale of 1 : 25 000 between 1947 - 1949 on behalf of the geological survey of Tanganyica.

In 1950 - 1952 the Colonial Development Corporation (CDC) conducted an exploration programme. 30 core drillings, totalling 7246 m were sunk, covering an area of about 20 km^2 west of the Mchuchuma river.

Taking into consideration only coal seams of more than 1 m thickness coal reserves of 186 million tons were indicated.

In addition to the drilling work, a geological map (scale 1 : 10 000) was established by CDC. A nearly 70 m long gallery was drifted in the Nyamaramba section of the Mchuchuma coal field. Also a 25 m deep exploration shaft was sunk in the same section. A 15 t bulk sample was taken from the lower and from the middle seam for boiler heating tests.

In November 1971 three drillholes were sunk to a depth of about 20 m in the vicinity of the old exploration shaft. Samples were taken for laboratory tests of Lurgi Frankfurt, Elkem Norway and the Universitiy of Dar-es Salaam.

In 1972 Norconsult took another coal sample of 440 kg from a surface trench near an outcrop of the lower seam. This sample was regarded as representative for the lower seam in this section of the Mchuchuma coal field.

During the GTZ prefeasibility study carried out by Dr. Otto Gold / Rodeco / Saarberg - Interplan consortium during 1977/1978 additional sampling was undertaken. A gallery was drifted within the lower seam. Two addits were opened up in the upper seam and one addit of 24 m length was opened up in the middle seam. Channel samples and bulk samples were taken. Bulk samples of 1 to 3 tons were mixed and sent to Germany for coal classification, upgrading and for direct reduction tests.

In December 1982 about 1,8 tons of coal were sampled by the National Development Corporation, Dar-es Salaam for further direct reduction test work with in the scope of this report. The sample represents the upper part of the lower seam. Oxidation of this coal cannot be excluded, as the sample was taken from the surface. Only 1 m of weathered coal was removed to obtain the channel sample (see also Volume I, 2.4).

1.1.3 Geology of the Mchuchuma coal field

Type and Age

The MCHUCHUMA-KETEWAKA coal field is a part of the so-called RUHUHU-Depression, which is filled with Karroo sediments. It is delimited in the north and south by morpholigically overlapping cristalline basement and extends over a 30 km wide and 160 km long belt from the Nyassa Lake in eastern direction.

The Karroo formation which STOCKLEY devided into various sequences, viz. K_1 to K_8, contains in its older part (K_2) corresponding to the lower Ecca, respectively the basal lower Permian several recoverable hard coal seams which, in part, show great differences in their structure. Being of limnic origin in an intermontane basin, this coal shows, in part, very great vertical and lateral changes in facies.

Stratigraphy

At the border of the basin, west of the middle MCHUCHUMA-River the coal formation is divided into two distinctive different horizons of facies (K_{2e1} and K_{2e2}) which occur - concordantly bedded - between the basal Camp Sandstone (K_{2d}) and the hanging Scarp Sandstone (K_{2f}). The lower one of the facies (K_{2e1}) is sandy with light medium to coarse grained arkose sandstones in the hanging wall and dark fine-grained and micaceous sandstone at the basis of the coal seams. Three of these coal seams proved to have a minable thickness of 3 1/2 ft and more.

The thickness of these coal series at the western border of the basin ranges from 20 m to 50 m.

The upper facies (K_{2e2}) are slaty with light and dark-up to heavily bituminous - clays and shales which are intercalated by a regionally differing number of coal seams occurring in an alternation with thin clayey and slaty layers, that differ in structure and thickness.

The clayey-bituminous horizons which, in lateral direction, are often overlapping, thus preventing a sharp delimitation towards the hanging wall and foot wall, contains one group of recoverable seams - in parts also two groups - consi[illegible]ing of several split-up single seams separated by clayey intercalations.

The thickness of the upper coal series ranges at the western border of the basin from 15 m to 40 m.

STRATIGRAFIC SECTION / MCHUCHUMA COALFIELD

(schematic)

Karroo-Series K_2

K_{2f} Scarp Sandstone

K_{2e2} mostly clays, shales
± bituminous, coaly schists
schistose coal and
pure coal
with some minor sandstone intercalations

- 7. Upper Seam (not minable) up to appr. 0,5 m
- 4-6 m
- 6. "Coking" Seam
  Group of seams splitted into 1 to 5 seams
  (only partly minable 2 - 3 m)
- 2-5 m
- 5. Top Economic Seam
  Group of seams splitted into 1 to 7 seams up to 4.50 m
- 6-9 m
- 4. Intermediate Seam
  (only partly developed and locally minable up to appr. 2 m)
- 4-6 m
- 3. Middle Economic Seam 4 m
  (15-20 m between 5. Top Economic Seam and 3. Middle Economic Seam)
  2. + 3. = Thick Seam
  (in the East Field up to 4 m)
- 2-5 m
- 2. Lower Economic Seam appr. 2.70 m
- 4-8 m
- 1. Bottom Seam up to 0.9 m (not minable)

K_{2e1} Arkose sandstone
and micaceous
sandy schists with
coal seams

For further details please refer to Mc Kinlay (1954) (1965).

Tectonics

The coal field MCHUCHUMA is part of a trough which dips at a degree of 0 - 15° toward SE. At the northern and western border of this trough, the coal seams occur in circular strikes, and inside the basin they were proved by drillings sunk through K3 down to a depth of 300 m.

Toward SE the the coalfield is separated by pronounced downthrow fault - running NE - of the LIKURUKURU-Ridge from the more recent Karroo sediments (K_5 to K_7).

At the northern and in particular northwestern border of the basin, several striking faults - running NNE and NE - sometimes displace the coal seams in a steplike manner causing downthrow faults of some tens of meters toward SE.

Coal Quality

In accordance with the findings of the C.D.C., the seams exposed by the driven galleries through GTZ belong to the upper cycle of the coking seam and also to the top seam. These seams must be classified as of inferior quality because the close intergrowth of coal and shaly-clayey material is prevailing, which according to the macroscopic evaluation alone permits the conclusion that the ash content is high and the calorific value correspondingly low. This refers in particular to the coking seam which, despite the fact that its seam thickness ranges from sufficient to good, is to be considered minable in some parts only, due to its excessive content of ash and intercalations. The qualitative disadvantages are also pointed out by the density determinations effected on selected coal lumps. In the coking seam where coal with bad coking properties occurs in some horizons only, concretionary marcasite-pyrite lentils, reaching a size of up to several centimeters, are frequently encountered.

Besides, coking seam and top seam are split up in several individual seams which means that the coal is hardly applicable without undergoing a washing procedure.

On the other hand, the coal from the lower coal series, i.e. from the middle and lower seam, appears to be of good quality. Most of the coal is clean and nearly without shaly inclusions, the specific weight is comparatively low, and the combustibility seems to be much better than that of the upper seams.

With regard to the ash content (< 20 %), the coal samples originating from the two lower seams are suitable for the direct reduction of iron ore.

Analytical results of the sample taken in December 1982 and tested by Lurgi are given in the following table:

LURGI

Mat. No.		87/83	
Type of reductant		Mchuchuma coal	
Proximate analysis			
Ash	%	20.8	
Volatiles	%	25.0	
Cfix	%	54.2	
	Σ	100.0	
S tot	%	0.48	
S organic	%	0.40	
Ultimate analysis		air dry	waf
H_2O	%	2.4	-
Ash	%	20.6	-
C	%	65.5	85.1
H	%	3.79	4.92
N_2	%	1.75	2.27
S	%	0.46	0.6
Cl	%	0.02	0.03
O_2(Diff.)	%	5.48	7.08
Calorific value		air dry	waf
Net	kJ/kg	25280	32910
Gross	"	26170	33990
Ash analysis			
CaO	%	0.3	
MgO	%	0.2	
Al_2O_3	%	26.5	
SiO_2	%	69	
Fe_2O_3	%	1.5	
SO_3	%	0.09	
Melting behaviour of coal ash, CO/CO_2=1/1			
Softening point	°C	1350	
Hemispherical point	°C	+1570	
Melting point	°C	+1570	
Reactivity	cm^3 CO/gC.sec	0.71	
Caking number		12	
Swelling index		1	

Analysis of Mchuchuma "Lower Seam" coal and coal ash.

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1.1.4 Determinations of Density

For controlling a qualitative macroscopic evaluation of coal seams and seam parts, density determinations were carried out.
The coal was weighed first in air and than in water.

From the quotient of weight in the air (G_L) and the difference consisting of G_L less weight in water (G_W) the density (D) is computed according to the following formula:

$$D = \frac{G_L}{G_L - G_W}$$

Example:

Weight of a coal sample in air: 1 000 g
in water: 320 g

$$\text{consequently } D = \frac{1\,000}{1\,000 - 320} = \frac{1\,000}{680} = 1.47$$

Only coal with a density of D < 1.50 were considered minable by C.D.C. as according to theoretical calculation coal with D < 1.50 has an ash content exceeding 25 %.

Coal	D = 1.50
bituminous shale	D = 1.51 - 1.75
carbonaceous shale or bituminous clayey shale	D = 1.76 - 2.00
clayey shale - argillaceous shale	D = 2.00

4303

As usual it is very difficult to evaluate the coal macroscopically, the density values were employed for determining the petrographic characteristics of individual seam horizons.

The densities of the "Coking Seam" fluctuate between 1.48 and 2.00, but for the majority of the seam horizons they are between 1.55 and 1.75.

In the top seam the densities fluctuate between 1.40 and 1.82 with a tendency at 1.46 to 1.53.

The densities of the coal from the middle seam fluctuate between 1.36 and 1.45.

In the lower seam there are again very differing densities between 1.37 and 2.80.

1.1.5 Coal Reserves

Final figures of coal reserves in the Mchuchuma coal field are given by C.D.C. in the annual report for 1955.

These reserve calculations are based on the following facts:

Quality:

The specific gravity of the coal is less than 1.5 and/or ash-content is less than 25 %.

Thickness:

The minimum overall thickness for a workable coal seam was taken at 1.07 m.

Depth:

The coal seams in the Mchuchuma field were calculated to a depth of 335 m.

Extent:

In the Mchuchuma field drilling investigations outline workable coal for at least 18 km^2. 26 boreholes penetrated the coal-bearing beds and gave economic results. The maximum distance between adjacent economic boreholes is 2 000 m.

The following reserves were assessed by C.D.C., 1956 for Mchuchuma coal field:

proved	186.6 mio tons
indicated	12.o mio tons.

According to the C.D.C. about 62 mio tons of coal will be mining and other losses, so 124 mio tons of coal net can be mined out of the Mchuchuma coal field.

1.1.6 Recommendations for further exploration work

Two main reasons recommend further exploration work, first the lateral change in charakter and thickness of the coal seams. Correlation of outcropping coal seams and drilling results is uncertain. The workable persistence of seams is estimated and consequently the reserves of coal are not proven.

The irregular grid pattern of boreholes results in distances between adjacent drillholes of more than 2 000 m.
At least four new boreholes of about 300 m depth each have to be drilled to fill in the gaps between hole MC 32 and hole MC 17.

In addition investigations have to be carried out to determine the expected methan gas amounts, parameters of rock mechanics and hydrogeological data. For the following mine planning only assumption figures for gas, water and rock mechanics are taken into consideration.

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Section 1.2

Coal Mine

1.2.1 Mine Layout (Description)

1.2.2 Raw Materials and Products

1.2.3 Consumption Figures incl. Workforce Schedule

1.2.4 Auxiliaries

1.2.5 Equipment Outline Specifications incl. Buildings inside Battery Limits

1.2.6 Investment Cost Estimate

S E C T I O N 1.2.1

Mine Layout Description

1.2 Coal Mine

1.2.1 Mine Layout Description

1.2.1.1 Mineable Reserves

Derived from the C.D.C. drilling results for the Mchuchuma Coal Field, the mineable coal reserves were calculated. The calculation is based on the polygonal method and the isopach method.

Only the Middle Seam and the Lower Seam were taken into consideration. The coal seams of the upper coal series partly overlying the lower coal series are not mineable due to poor development in thickness and inferior quality (shale-clay intercalations), high ash content, low calorific value, coking properties which are not suitable for the direct reduction process and higher sulphur contents.

In the western part of the coal field, both seams occur: the Middle and the Lower Seam. These seams combine to one thick seam in the eastern part of the Mchuchuma Field.

The following table for mineable reserve calculations have to be seen in conjunction with Drawing No. 2, Mineable Reserves.

Differences in the areas for the Middle Seam and the Lower Seam, Mchuchuma West result from different reserve calculation methods.

Reserve calculation Middle Seam Mchuchuma West

Section	Drill hole no. and no. of thickness fluence	Area m²	Thickness m	Volume m³	Coal mass (t)
I	outcrops	419,000	2.5	1,047,500	1,518,875
II	27	353,000	2.87	1,013,110	1,469,010
	30	165,000	3.08	508,200	736,890
	33	160,000	3.83	612,800	888,560
	28	268,000	4.01	1,074,680	1,558,286
III	2 - 3	191,000	2.5	477,500	692,375
	3 - 4	217,000	3.35	726,950	1,054,078
	3 - 4	290,000	3.15	913,500	1,324,575
	4 - 5	345,000	4.52	1,559,400	2,261,130
IV	2 - 3	2,220,000	2.5	5,550,000	8,047,500
	3 - 4	2,647,000	3.5	9,264,500	13,433,525
V	2 - 3	344,000	2.5	860,000	1,247,000
Total					34,231,804
rounded					34,000,000

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Reserve Calculation Lower Seam Mchuchuma West

Section	Drill hole no	Area m²	Thick-ness m	Volume m³	Coal mass (t)
I	outcrops	348,000	2.5	960,000	1,392,000
II	30	538,000	2.21	1,188,980	1,724,021
	33	62,000	2.49	154,380	223,851
	28	402,000	2.59	1,041,180	1,509,711
III	3	397,000	2.44	968,680	1,404,586
	32	269,000	2.64	710,160	1,029,732
	4+32	384,000	2.00	768,000	1,113,600
IV	8	1,085,000	2.54	2,755,900	3,996,055
	7	2,185,000	2.08	4,544,800	6,589,960
	18	1,638,000	2.49	4,078,620	5,913,999
	9	2,370,000	2.46	5,830,200	8,453,790
	15	2,199,000	2.72	5,981,280	8,672,856
V		350,000	2.5	875,000	1,268,750
Total					43,292,911
rounded					43,000,000

Reserve Calculation Middle + Lower (Thick) Seam Mchuchuma East

Section	No. of thickness influences	Area m²	Thickness m	Volume m³	Coal mass (t)
I	2 - 3	680,000	2.5	1,700,000	2,465,000
	3 - 4	945,000	3.5	3,307,500	4,795,875
	4 - 5	545,000	4.5	2,452,500	3,556,125
	5 - 6	281,000	5.4	1,517,400	2,200,230
II	2 - 3	157,000	2.5	392,500	569,125
	3 - 4	468,000	3.5	1,638,000	2,375,100
	4 - 5	569,000	4.5	2,560,500	3,712,725
	5 - 6	550,000	5.5	3,025,000	4,386,250
	6 - 7	2,531,000	6.5	16,451,500	23,854,675
	7 - 7.5	2,498,000	7.25	18,110,500	26,260,225
	7.5 - 7.7	443,000	7.63	3,380,090	4,901,130
Total					79,076,000
rounded					79,000,000

The total mineable reserves for Mchuchuma Coal Field amount to 156,000,000 tons of coal.

Taking into account losses of about 30 % due to tectonic difficulties and safety reasons, 109,000,000 tons of coal will be exploitable.

For a yearly production of 2,4 Mill. tons the mine has a lifetime of 45 years.

1.2.1.2 Mine Capacity and Production

Within the mineable reserve calculations, a volume of coal has been established which does not restrict capacity and lifetime of the project considerations for the integrated steelplant and the necessary thermal power station. Mine capacity and production therefore will depend on the demand of coal only.

In this study, a distinction between two alternatives has been elaborated. The base case = Alternative I deals with a production of 950.000 t/a r.o.m. coal. At 300 working days per year, the daily production will be approx. 3,200 t. This production is needed in order to secure an alimentation of 500,000 t/a of washed coal as per the specification requested for the SL/RN-Plant. An amount of some 200,000 t/a of middlings will be available in addition for the local market.

Alternative II deals with a higher capacity for the alimentation of the direct reduction plant plus a power plant and sales to the local market

Steelworks	950,000	t/a	r.o.m.
Power Plant	1,200,000	t/a	"
Local Market	250,000	t/a	"
Capacity Alternative II	2.4 Mill	t/a	"
at 300 d/a	8,000	t/d	

With a volume of 1.2 Mill t/a of coal, a power plant of 300 MW can be sufficiently supplied.

In the calculations, the r.o.m. production is estimated at a calorific value of 3,810 kcal/kg, allowing a dilution of approx. 30 %.

In addition to the coal output of the mine, some development waste from the double entry system, connecting ramps, ventilation shafts etc. have to be transported to the surface.

The following technical description is related to the base case (Alternative I).

For Alternative II, the investment figures and consumables are derived from Alternative I by up-scaling estimation.

1.2.1.3 Mine Layout

The mine layout for Mchuchuma takes into account the favourable deposit conditions. The flat dipping of less than 15 ° in the north-western part of the deposit turns into nearly horizontal formation in the south-eastern part.

A series of four faults with South-West to North-East striking plus another main fault with West-Northwest to East-Southeast striking cuts the deposit into eight separate blocks.

With regard to the natural conditions, the mine layout will consist of a main double entry system parallel to the West-Northwest to East-Southeast striking fault. The main entry system will be the adit to the various mining blocks which will be developed by stope gates in Northeast and Southwest directions (see Drawings no. 3 + 4).

The natural blocks, separated from each other by faults, will be further subdivided into mining blocks with a width of 180 - 200 m corresponding to the length of the stopes.

The general mine layout has been prepared for coal extraction by longwall mining.

While the main entry is located some 10 - 30 m underneath the lower seam in order to serve for both mineable seams, the stope gates for the development of the mining blocks will be driven within each seam, that means that the development in the north-western part of the deposit with two separate seams (Middle and Lower) will take place in both seam levels.

The connection between the main entry system and the stope gates will be achieved by ramps, respectively concerning the coal transportation by short coal passes.

Another component of the initial mine layout will be a ventilation shaft beyond the second cross fault. In later years, two more ventilation shafts will have to be in operation in a greater distance from the mine portal.

1.2.1.3.1 Exploitation Sequence

Exploitation will start from Block 1 in the Middle Seam after driving 3 gates of 700 m each to the Southwest. The exploitation procedure will be by retreat method.

Two armoured face conveyors transport the coal to the middle gate of the block and from here, the coal is hauled by a conveyor belt.

After one year, 950,000 t of Block 1, Middle Seam, are exploited.
During this first year, simultaneously for exploitation of Block 1, Block 2, Middle Seam, will be opened up.

Block 1 will be exhausted after two months of the second year. Exploitation is then concentrated only on Block 2, Middle Seam.

During exploitation of Block 2, Middle Seam, Block 1, Lower Seam, will be opened up.

The detailed sequence of exploitation for the first 20 years is shown in the following table and in Drawing No. 3, General Mining Layout.

Face heights will change during the years according to different seam thicknesses.

Exploitation Sequence (Mchuchuma)

Block	m + l seam	middle seam	lower seam	face hight (m)	calc. hight (m)	face length (m)	Volume mill.t	Block lenght (m)	year (mill. t) 1	2	3	4	5	6	7	8	9
1		X		2 - 3	2.9	180+180	1.06	700	0.95	0.11							
			X	2 - 3	2.1	170+170	0.724	700			0.189	0.535					
2			X	3 - 5	4	110+180	1.601	920		0.84	0.761						
			X	2 - 3	2.4	100+170	0.867	920				0.415	0.452				
3		X		2 - 3	2.8	180+180	1.461	1000					0.498	0.95	0.013		
			X	2 - 3	2.2	170+170	1.067	1000								0.591	0.476
4		X		3 - 5	4.5	180+180	1.296	800							0.937	0.359	
			X	- 2	1.7	170+170	0.65	800									0.474

Block	m + l seam	middle seam	lower seam	face hight (m)	calc. hight (m)	face length (m)	Volume mill.t	Block lenght (m)	year (mill. t) 10	11	12	13	14	15
4			X	- 2	1.7	170+170	0.65	800	0.176					
5		X		2 - 3	2.5	180+180	1.305	1000	0.774	0.531				
			X	2 - 3	2.2	170+170	1.067	1000			0.69	0.377		
6		X		3 - 5	4.5	180+180	0.679	520		0.419	0.26			
			X	2 - 3	2.2	170+170	0.603	560					0.603	
	X			3 - 5	3.7	170+170	0.698	380				0.573	0.125	

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Block	m + l seam	middle seam	lower seam	face hight (m)	calc. hight (m)	face length (m)	Volume mill.t	Block lenght (m)	year (mill. t) 13	14	15	16	17	18	19	20
6	X			3 - 5	3.7	170+170	0.698	380	0.573	0.125						
7		X		3 - 5	3.1	180+180	1.618	1000		0.222	0.95	0.446				
			X	2 - 3	2.2	170+170	1.067	1000						0.725	0.342	
8	X			3 - 5	3.8	170+170	1.540	830				0.504	0.95	0.086		
			X	2 - 3	2.4	170+170	0.139	120						0.139		
9		X		3 - 5	3.3	180+180	1.723	1000							0.608	0.95

1.2.1.3.2 Mine Development

The mine will be developed for exploitation by the main entry system in order to provide the adit to the various mining blocks and the gates into the blocks.

During the preproduction phase, the gate development has to be performed for the first block (1). The main entry will be drifted to the ventilation shaft. For start-up of production, the ventilation shaft has to be operational as well.

The cross section of the main entry system - twin drifts with a distance of some 10 m - will be 20 - 25 m^2 for each drift. The cross section for the stope gates will be 15 - 20 m^2, the gate height, depending on the seam thickness, however not less than 2.5 m.

Final specification of cross sections will be subject of further investigations on rock mechanics, methan degassing etc.

In coal and in softer host rock, drifting will be done by a tunneling machine with an installed power capacity in the cutting head of 300 - 350 KW.

The tunneling machine will be combined with a moveable bin of 10 - 15 m^3 contents which is the buffer for the discontinuous transport. For transport, 30 t payload articulated dump trucks will be applied.

Development Plan (drifting in m)

Year	Main entry system incl. connecting ramps (m)	Gates	Total
- 2	2050	1000	3050
- 1		3110	3110
1		3460	3460
2		3460	3460
3	990	2450	3440
4		3400	3400
5		3240	3240
6		3250	3250
7	1290	2060	3350
8		3330	3350
9		3380	3380
10		3390	3390
11		3420	3420
12	790	2640	3430
13		2650	2650
14		1880	1880
15		1820	1820
16		2280	2280
17	1030	1500	2530
18		2780	2780
19			
20			
Total	6150	54500	60650

The average drifting per year will be approx. 3000 m. With a working time of 300 d/a, 10 m drifting per day has to be executed. The maximum performance has to take place in year 1 and 2 with
3460 m/a = 11,54 m/d.

The drifting capacity, which will be installed, will be well in the position to achieve 10 m per day respectively 11.54 m per day.

With the conventional equipment in hard rock conditions, theoretically the following performance can be achieved.

1 round a 2 m per shift	=	2 m
3 rounds a 2 m per day	=	6 m
in 2 drifts (twin system) per day	=	12 m

The development by the tunneling machine will have the capacity of 15 - 20 m per day.

The actual capacity, necessary for 10 m (11.54 m) drifting, thus ranges at approx. 40 % of the theoretical capacity.

The transport capacity for the drifting operation (30 t payload truck) depends on the distance to the dumping point. In accordance with volumes of waste and coal, a truck fleet consisting of 4 units is required.

The ventilation shaft will be prepared either by boring or by conventional raising from the bottom to surface. The ventilation shaft has to be built with a diameter of approx. 4 m.

During the development work, the ventilators of the drifts will be arranged by using ventilation pipes.

1.2.1.4 Coal Exploitation

1.2.1.4.1 Stoping method

With regard to the seam thickness of 2 - 3 m and 3 - 5 m and with regard to the horizontal bedding of the deposit, longwall mining system will be applied. This method is characterized by a high productivity, the extraction rate is more than 80 % (see Drawing No. 5).

For safe operation and safe ventilation, longwall retreating will be applied, i.e. direction of mining towards the main entry system.

Two faces are connected to one main gate for coal transportation. Each face has one head gate for circulation of air and supply of consumables.

Backfill is not necessary because longwall caving will be the stoping method. If the hanging wall does not cave by gravity, blasting has to be used.

The exploitation will start with the upper seam. The face width of the faces in the lower seam is reduced by 10 m in order to avoid supplementary pressure at the face ends.

1.2.1.4.1 Design Parameters for Longwall Faces

There are two groups of seam-thicknesses which have to be distinguished with regard to the specification of the equipment:

Group I	2 - 3 m seam thickness,
Group II	3 - 5 m seam thickness.

There are also different face lengths in the direction of the full dip between the faults, (see Drawing No. 3).

Special parameter of each working panel are given in the following table. It shows the seam thickness, the face lengths, the block lengths, the daily face advance and the life time of each panel.

With regard to the production rate of 3,200 t/day r.o.m., two faces will be in operation and one face will be in stand-by.

working area (No.)	Ø seam thick-ness (m)	Ø face length (m)	block length (m)	face advance (m/d)	life time (a)
1_M	2.9	180	700	2.09	1.11
2_M	4.0	145	920	1.82	1.67
1_L	2.1	170	700	3.05	0.76
2_L	2.4	135	920	3.39	0.90
3_M	2.8	180	1,000	2.14	1.53
4_M	4.5	180	800	1.97	1.35
3_L	2.2	170	1,000	2.95	1.11
4_L	1.7	170	800	3.91	0.67
5_M	2.5	180	1,000	2.42	1.36
6_M	4.5	180	520	2.43	0.70
5_L	2.2	170	1,000	2.97	1.11
6_{L+M}	3.7	170	380	1.72	0.72
6_L	2.2	170	560	2.95	0.62
7_M	3.1	180	1,000	1.96	1.70
8_{L+M}	3.8	170	830	1.71	1.61
8_L	2.4	170	170	2.73	0.15
7_L	2.2	170	1,000	2.97	1.12
9_M	3.3	180	1,000	1.84	1.81
					20.00

1.2.1.5 Coal Transportation

Transportation is one of the most determinant factors in actual mining operations. The following factors are taken into account for transportation of Mchuchuma coal:

- adoption of a continuous flow system,
- constant load for each equipment,
- flexibility of transportation capacity,
- safety,
- easy exchange of equipment units.

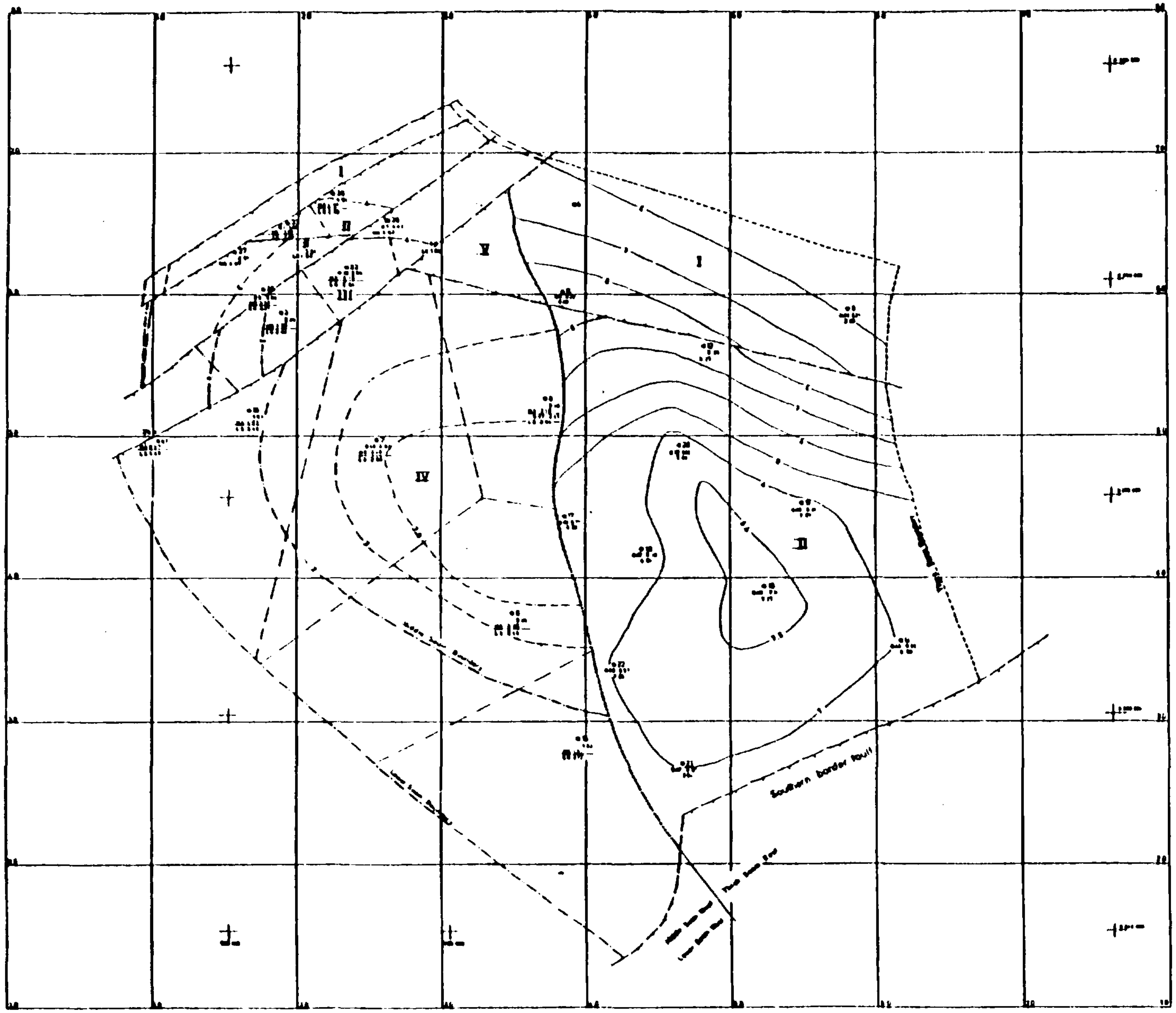
The transport of coal from the faces to the surface will be done by belt conveyors.

Using a factor of unconformability of 2, the maximum load will be 450 t/h. Using a conveyor speed of 2 m/sec., a belt width of 800 mm is sufficient. The

The maximum employment of belt conveyors in different stages is shown in the following table. The conveyor calculation including drives is given in the following tables.

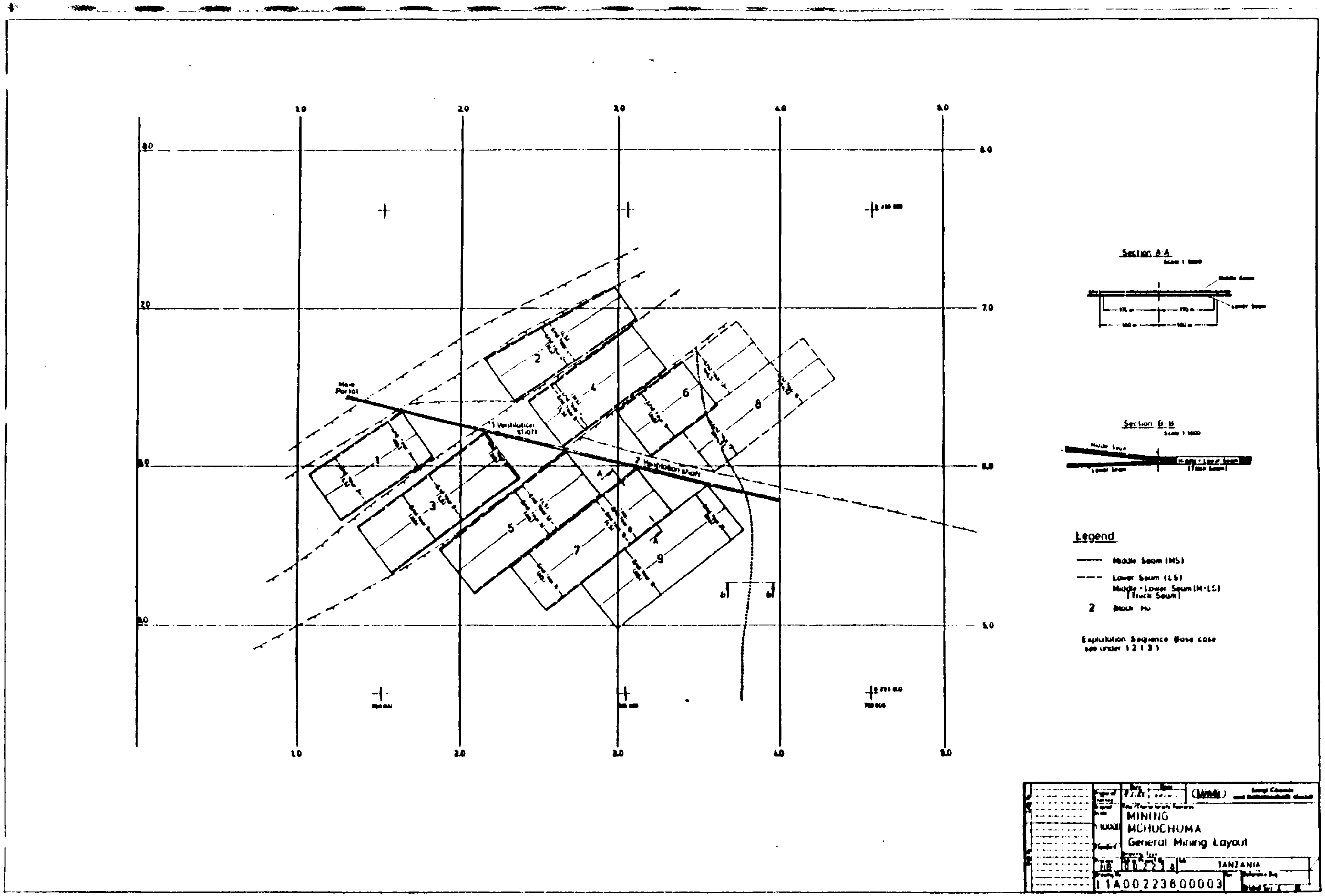
One belt conveyor is always in stand-by (see investment schedule).

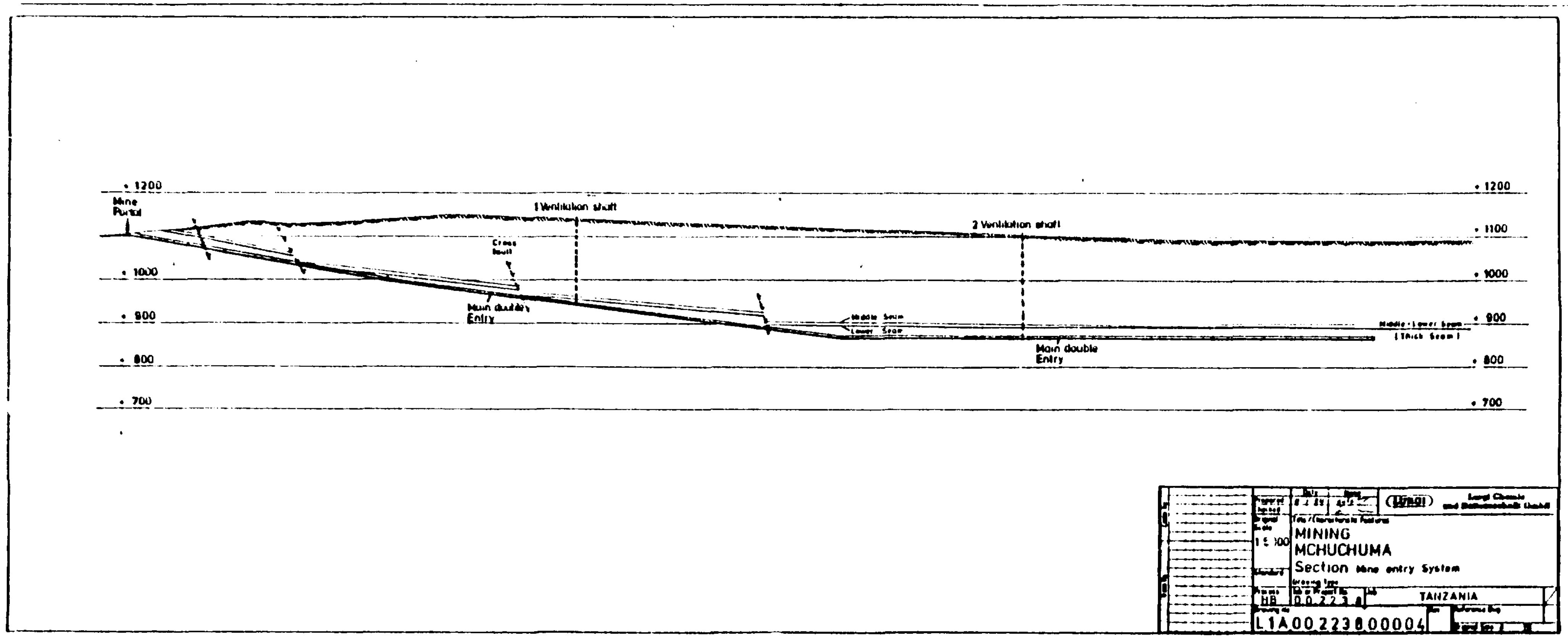
	Year	Length (m)	Lift (m)
Main entry	- 1	650	120
	5	1250	180
	10	1750	230
	14	2200	230
	19	2650	230
Main gate for coal transportation	- 1	850	- 75
	2	1400	- 60
	5	1150	- 20
	8	950	- 90
	10	1150	± 0
	13	1200	- 125
	14	1150	± 0
	17	1200	- 180
	19	1150	+ 25



Legend

MINING
MCHUCHUMA
Reserves


Main Portal
1 Ventilation shaft
2 Ventilation shaft
1
2
3
4
5
6
7
8
9
Section A-A
Section B-B
Middle Seam
Lower Seam
Legend
Middle Seam (MS)
Lower Seam (LS)
Middle + Lower Seam (M+LS)
(Thick Seam)
2 Block No
MINING
MCHUCHUMA
General Mining Layout
TANZANIA
11A00223800003


1200
Mine Portal
1 Ventilation shaft
2 Ventilation shaft
1100
1000
Main double Entry
Middle Seam
Lower Seam
Middle-Lower Seam
(Thick Seam)
900
800
700
MINING
MCHUCHUMA
Section Mine entry System
HB
0 0 2 2 3 8
TANZANIA
L1A00223800004

SECTION 1.2.2

Raw Materials and Products

1.2.2 Raw Materials and Products

1.2.2.1 Raw Materials

The raw material is to be mined in the Mchuchuma Field in two coal seams of different thicknesses.

The Middle Seam has an average thickness of 3.10 m and the Lower Seam has an average thickness of 2.45 m. Both seams combine in the eastern part of the field to one seam of average thickness of 5.70 m.

According to the C.D.C. report the seams have the following composition:

Seam	Av. S.G.	Moist.	Fix Carbon	Volat.	Ash
middle	1.40	1.7	60.3	24.0	14.0
lower	1.39	1.6	62.4	24.4	11.5
thick	1.42	1.5	61.3	23.4	13.8

The hanging wall of the coal seams consist of massive coarse sandstone. The footwall is not as sharp in its boundary to coal and consists of dark coaly and carbonaceous siltstone or shale which gradationally passes to fine micaceous sandstone. The intercalations in the coal are coaly and carbonaceous shales and siltstones.

1.2.2.2 Products

The raw coal produced from the Middle and Lower Seam of Mchuchuma Coal Field consists of about 67 % coal and about 33 % waste.

Maximum lump size
of ROM-Coal : 300 x 300 x 300 mm.

Total production
for Alternative II: 2,400,000 t/a

which meets the requirements of the Mchuchuma 300 MW Thermal Power Plant, of Mahanje Steelworks and some local customers.

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S E C T I O N 1.2.3

Consumption Figures

incl. Workforce Schedule

1.2.3 Consumption Figures and Workforce Schedule

1.2.3.1 Consumption Figures

The consumption of energy, spare parts, ware parts and consumable is estimated in the following tables.

The difference in consumption of electricity in several years depends on different lengths of belt conveyors and different lifts. The consumption of electricity in Alternative I varies from 16.4 Mill. KWh in the first year to 20.1 Mill. KWh in the year no. 20.

Consumption Figures, Alternative I
(0.95 Mill. tons r.o.m.)

Year	1	2	3	4	5	6	7
Electricity Mill. KWh	16.5-------------------				18.2----------		
Explosives t	24-----------------------------------						
Fuel 1000 l	650-----------------------------------						
Consumables for main double entry etc. Mill. US $	1.5----------------------------------						
Spare Parts Mill. US $	5.7----------------------------------						
Ware Parts Tunneling and Shearer Mill. US $	0.3----------------------------------						

Consumption Figures, Alternative I
(0.95 Mill. tons r.o.m.)

Year	8	9	10	11	12	13	14
Electricity Mill. KWh	18.2	-------	18.8	-------	-------	-------	19.4
Explosives t	24	-------	-------	-------	-------	-------	-------
Fuel 1000 l	650	-------	-------	-------	-------	-------	-------
Consumables for main double entry etc. Mill. US $	1.5	-------	-------	-------	-------	-------	-------
Spare Parts Mill. US $	5.7	-------	-------	-------	-------	-------	-------
Ware Parts Tunneling and Shearer Mill. US $	0.3	-------	-------	-------	-------	-------	-------

Consumption Figures, Alternative I
(0.95 Mill. tons r.o.m.)

Year	15	16	17	18	19	20
Electricity Mill. KWh	19.4	----------	----------	19.5	20.1	------
Explosives t	24	----------	----------	----------	----------	----------
Fuel 1000 l	650	----------	----------	----------	----------	----------
Consumables for main double entry etc. Mill. US $	1.5	----------	----------	----------	----------	----------
Spare Parts Mill. US $	5.7	----------	----------	----------	----------	----------
Ware Parts Tunneling and Shearer Mill US $	0.3	----------	----------	----------	----------	----------

Consumption Figures, Alternative II
(2.4 Mill. tons r.o.m.)

Year	1	2	3	4	5	6	7
Electricity Mill. KWh	26.2	----------	----------	----------	29.2	----------	----------
Explosives t	38.5	----------	----------	----------	----------	----------	----------
Fuel 1000 l	1050	----------	----------	----------	----------	----------	----------
Consumables for main double entry etc. Mill. US $	2.8	----------	----------	----------	----------	----------	----------
Spare Parts Mill. US $	14.2	----------	----------	----------	----------	----------	----------
Ware Parts Tunneling and Shearer Mill. US $	0.6	----------	----------	----------	----------	----------	----------

Consumption Figures, Alternative II
(2.4 Mill. tons r.o.m.)

Year	8	9	10	11	12	13	14
Electricity Mill. KWh	29.2		30.2				31.2
Explosives t	38.5						
Fuel 1000 l	1050						
Consumables for main double entry etc. Mill. US $	2.8						
Spare Parts Mill. US $	14.2						
Ware Parts Tunneling and Shearer Mill. US $	0.6						

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Consumption Figures, Alternative II
(0.95 Mill. tons r.o.m.)

Year	15	16	17	18	19	20
Electricity Mill. KWh	31.2	---	---	---	32.2	---
Explosives t	38.5	---	---	---	---	---
Fuel 1000 l	1050	---	---	---	---	---
Consumables for main double entry etc. Mill. US $	2.8	---	---	---	---	---
Spare Parts Mill. US $	14.2	---	---	---	---	---
Ware Parts Tunneling and Shearer Mill. US $	0.6	---	---	---	---	---

1.2.3.2 Workforce Schedule

Workforce schedules are listed-up in detail on page 1 and 2. The compiled workforce requirements are:

Grade of education	Alternative I (persons)	Alternative II (persons)
Graduated personnel	10	20
High skilled "	84	133
Semi skilled "	391	625
Unskilled "	60	96
Subtotal	545	874
Absentees (15 %)	83	131
Total	628	1005

The estimation for the workforce is on the conservative side taking into account that the mine will create employment and that at least at the start-up the performance will be restricted.

The output per manshift (including absentees) will be:

	output per manshift
Alternative I	approx. 5 t
Alternative II	approx. 8 t

LURGI-CHEMIE LC-HB   CONVEYOR CALCULATION
15.12.83 - 15/42/11   PROJECT :MCHUCHUMA CONNECTING BELT YEAR -1

CONVEYOR NO. 1

I N P U T - D A T A

THEOR.CAPACITY	(T/H)	:	450.0
LENGTH OF CONVEYOR	(M)	:	850.0
LIFT	(M)	:	-75.0
SPEED	(M/SEC)	:	2.00
BULK DENSITY	(T/M3)	:	1.25
HAULAGE CONDITIONS		:	UNFAVOURABLE
GRAIN CONDITIONS		:	GRAINSIZE 150-400 MM SLIGHT FINE GRAIN CONTENT
EXCHANGE RATE	(DM/US$)	:	2.70

R E S U L T S

BELT WIDTH	(MM)	:	800.0
WEIGHT OF ROTAT.PARTS	(KG/M)	:	100.0
FACTOR FOR MINOR RESISTANCE	(-)	:	1.15000
FACTOR FOR MAYOR RESISTANCE	(-)	:	0.02300
TROUGHING ANGLE	(DEG)	:	25.0
SURCHARGE ANGLE	(DEG)	:	0.0
THICKNESS OF BELT COVER	(MM)	:	8.0
THICKNESS OF BELT UNDER SIDE	(MM)	:	6.0
LIFE TIME OF BELT	(YEARS)	:	9.4
DRIVE CAPACITY	(KW)	:	-22.0
BELT TENSION	(KP/CM)	:	-17.5
BELT QUALITY			ST 800 X
PRE-SELECTED MOTOR CONFIGURATION			1 * 130 KW
TOTAL INVESTMENT	(DM)	:	2.033
TOTAL INVESTMENT	(US $)		0.753
INVESTMENT FOR BELT ONLY	(DM)	:	0.509
INVESTMENT FOR BELT ONLY	(US $)	:	0.188

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LURGI-CHEMIE LC-HB   CONVEYOR CALCULATION
15.12.83 - 15/45/52   PROJECT :MCHUCHUMA CONNECTING BELT YEAR 5

CONVEYOR NO. 1
I N P U T - D A T A

THEOR.CAPACITY	(T/H)	:	450.0
LENGTH OF CONVEYOR	(M)	:	300.0
LIFT	(M)	:	-20.0
SPEED	(M/SEC)	:	2.00
BULK DENSITY	(T/M3)	:	1.25
HAULAGE CONDITIONS		:	UNFAVOURABLE
GRAIN CONDITIONS		:	GRAINSIZE 150-400 MM SLIGHT FINE GRAIN CONTENT
EXCHANGE RATE	(DM/US$)	:	2.70

R E S U L T S (ONLY CONVEYOR EXTENSION)

BELT WIDTH	(MM)	:	800.0
WEIGHT OF ROTAT.PARTS	(KG/M)	:	100.0
FACTOR FOR MINOR RESISTANCE	(-)	:	1.43000
FACTOR FOR MAYOR RESISTANCE	(-)	:	0.02300
TROUGHING ANGLE	(DEG)	:	25.0
SURCHARGE ANGLE	(DEG)	:	0.0
THICKNESS OF BELT COVER	(MM)	:	8.0
THICKNESS OF BELT UNDER SIDE	(MM)	:	6.0
LIFE TIME OF BELT	(YEARS)	:	3.3
DRIVE CAPACITY	(KW)	:	8.2
BELT TENSION	(KP/CM)	:	6.6
BELT QUALITY			ST 800 X
PRE-SELECTED MOTOR CONFIGURATION			1 * 130 KW
TOTAL INVESTMENT	(DM)	:	0.474
TOTAL INVESTMENT	(US $)		0.176
INVESTMENT FOR BELT ONLY	(DM)	:	0.187
INVESTMENT FOR BELT ONLY	(US $)	:	0.069

PRICE FOB

LURGI-CHEMIE LC-HB CONVEYOR CALCULATION
15.12.83 - 15/48/26 PROJECT :MCHLCHUMA CONNECTING BELT YEAR 17

CONVEYOR NO. 1

I N P U T - D A T A

THEOR.CAPACITY	(T/H) :	450.0
LENGTH OF CONVEYOR	(M) :	1200.0
LIFT	(M) :	-180.0
SPEED	(M/SEC) :	2.00
BULK DENSITY	(T/M3) :	1.25
HAULAGE CONDITIONS	:	UNFAVOURABLE
GRAIN CONDITIONS	:	GRAINSIZE 150-400 MM SLIGHT FINE GRAIN CONTENT
EXCHANGE RATE	(DM/US$):	2.70

R E S U L T S

BELT WIDTH	(MM) :	800.0
WEIGHT OF ROTAT.PARTS	(KG/M) :	100.0
FACTOR FOR MINOR RESISTANCE	(-) :	1.08000
FACTOR FOR MAYOR RESISTANCE	(-) :	0.02300
TROUGHING ANGLE	(DEG) :	25.0
SURCHARGE ANGLE	(DEG) :	0.0
THICKNESS OF BELT COVER	(MM) :	8.0
THICKNESS OF BELT UNDER SIDE	(MM) :	6.0
LIFE TIME OF BELT	(YEARS) :	13.3
DRIVE CAPACITY	(KW) :	-139.1
BELT TENSION	(KP/CM) :	-110.9
BELT QUALITY		ST 800 X
PRE-SELECTED MOTOR CONFIGURATION		1 * 130 KW
TOTAL INVESTMENT	(DM) :	2.572
TOTAL INVESTMENT	(US $)	0.953
INVESTMENT FOR BELT ONLY	(DM) :	0.714
INVESTMENT FOR BELT ONLY	(US $) :	0.264

PRICE FOB

LURGI-CHEMIE LC-HB   CONVEYOR CALCULATION
15.12.83 - 15/50/ 5   PROJECT :MCHUCHUMA CONNECTING BELT YEAR 19

CONVEYOR NO. 1

I N P U T - D A T A

THEOR.CAPACITY	(T/H)	:	450.0
LENGTH OF CONVEYOR	(M)	:	1200.0
LIFT	(M)	:	25.0
SPEED	(M/SEC)	:	2.00
BULK DENSITY	(T/M3)	:	1.25
HAULAGE CONDITIONS		:	UNFAVOURABLE
GRAIN CONDITIONS		:	GRAINSIZE 150-400 MM SLIGHT FINE GRAIN CONTENT
EXCHANGE RATE	(DM/US$)	:	2.70

R E S U L T S

BELT WIDTH	(MM)	:	800.0
WEIGHT OF ROTAT.PARTS	(KG/M)	:	100.0
FACTOR FOR MINOR RESISTANCE	(-)	:	1.08000
FACTOR FOR MAYOR RESISTANCE	(-)	:	0.02300
TROUGHING ANGLE	(DEG)	:	25.0
SURCHARGE ANGLE	(DEG)	:	0.0
THICKNESS OF BELT COVER	(MM)	:	8.0
THICKNESS OF BELT UNDER SIDE	(MM)	:	6.0
LIFE TIME OF BELT	(YEARS)	:	13.3
DRIVE CAPACITY	(KW)	:	140.2
BELT TENSION	(KP/CM)	:	111.7
BELT QUALITY			ST 1250 X
PRE-SELECTED MOTOR CONFIGURATION			2 * 130 KW
TOTAL INVESTMENT	(DM)	:	2.659
TOTAL INVESTMENT	(US $)		0.985
INVESTMENT FOR BELT ONLY	(DM)	:	0.714
INVESTMENT FOR BELT ONLY	(US $)	:	0.264

PRICE FOB

LURGI-CHEMIE LC-FB   CONVEYOR CALCULATION
15.12.83 - 15/33/27   PROJECT :MCHUCHUMA MAIN BELT YEAR -1 (FLIGHT 1)

CONVEYOR NO. 1

I N P U T - D A T A

THEOR.CAPACITY	(T/H)	:	450.0
LENGTH OF CONVEYOR	(M)	:	650.0
LIFT	(M)	:	120.0
SPEED	(M/SEC)	:	2.00
BULK DENSITY	(T/M3)	:	1.25
HAULAGE CONDITIONS		:	UNFAVOURABLE
GRAIN CONDITIONS		:	GRAINSIZE 150-400 MM SLIGHT FINE GRAIN CONTENT
EXCHANGE RATE	(DM/US$)	:	2.70

R E S U L T S

BELT WIDTH	(MM)	:	800.0
WEIGHT OF ROTAT.PARTS	(KG/M)	:	100.0
FACTOR FOR MINOR RESISTANCE	(-)	:	1.19000
FACTOR FOR MAYOR RESISTANCE	(-)	:	0.02300
TROUGHING ANGLE	(DEG)	:	25.0
SURCHARGE ANGLE	(DEG)	:	0.0
THICKNESS OF BELT COVER	(MM)	:	8.0
THICKNESS OF BELT UNDER SIDE	(MM)	:	6.0
LIFE TIME OF BELT	(YEARS)	:	7.2
DRIVE CAPACITY	(KW)	:	227.0
BELT TENSION	(KP/CM)	:	180.9
BELT QUALITY			ST 2000 X
PRE-SELECTED MOTOR CONFIGURATION			2 * 130 KW
TOTAL INVESTMENT	(DM)	:	1.811
TOTAL INVESTMENT	(US $)		0.671
INVESTMENT FOR BELT ONLY	(DM)	:	0.392
INVESTMENT FOR BELT ONLY	(US $)	:	0.145

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LURGI-CHEMIE LC-HB — CONVEYOR CALCULATION
15.12.83 - 15/35/56 — PROJECT :MCHUCHUMA MAIN BELT YEAR 5 (FLIGHT 2)

CONVEYOR NO. 1

I N P U T - D A T A

THEOR.CAPACITY	(T/H)	:	450.0
LENGTH OF CONVEYOR	(M)	:	600.0
LIFT	(M)	:	60.0
SPEED	(M/SEC)	:	2.00
BULK DENSITY	(T/M3)	:	1.25
HAULAGE CONDITIONS		:	UNFAVOURABLE
GRAIN CONDITIONS		:	GRAINSIZE 150-400 MM SLIGHT FINE GRAIN CONTENT
EXCHANGE RATE	(DM/US$)	:	2.70

R E S U L T S

BELT WIDTH	(MM)	:	800.0
WEIGHT OF ROTAT.PARTS	(KG/M)	:	100.0
FACTOR FOR MINOR RESISTANCE	(-)	:	1.20000
FACTOR FOR MAYOR RESISTANCE	(-)	:	0.02300
TROUGHING ANGLE	(DEG)	:	25.0
SURCHARGE ANGLE	(DEG)	:	0.0
THICKNESS OF BELT COVER	(MM)	:	8.0
THICKNESS OF BELT UNDER SIDE	(MM)	:	6.0
LIFE TIME OF BELT	(YEARS)	:	6.7
DRIVE CAPACITY	(KW)	:	140.9
BELT TENSION	(KP/CM)	:	112.3
BELT QUALITY			ST 1250 X
PRE-SELECTED MOTOR CONFIGURATION			2 * 130 KW
TOTAL INVESTMENT	(DM)	:	1.734
TOTAL INVESTMENT	(US $)		0.642
INVESTMENT FOR BELT ONLY	(DM)	:	0.363
INVESTMENT FOR BELT ONLY	(US $)	:	0.134

PRICE FOB

LURGI-CHEMIE LC-HB CONVEYOR CALCULATION
15.12.83 - 15/37/57 PROJECT :MCHUCHUMA MAIN BELT YEAR 10 (FLIGHT 3)

CONVEYOR NO. 1

I N P U T - D A T A

THEOR.CAPACITY	(T/H)	:	450.0
LENGTH OF CONVEYOR	(M)	:	500.0
LIFT	(M)	:	50.0
SPEED	(M/SEC)	:	2.00
BULK DENSITY	(T/M3)	:	1.25
HAULAGE CONDITIONS		:	UNFAVOURABLE
GRAIN CONDITIONS		:	GRAINSIZE 150-400 MM SLIGHT FINE GRAIN CONTENT
EXCHANGE RATE	(DM/US$)	:	2.70

R E S U L T S

BELT WIDTH	(MM)	:	800.0
WEIGHT OF ROTAT.PARTS	(KG/M)	:	100.0
FACTOR FOR MINOR RESISTANCE	(-)	:	1.28333
FACTOR FOR MAYOR RESISTANCE	(-)	:	0.02300
TROUGHING ANGLE	(DEG)	:	25.0
SURCHARGE ANGLE	(DEG)	:	0.0
THICKNESS OF BELT COVER	(MM)	:	8.0
THICKNESS OF BELT UNDER SIDE	(MM)	:	6.0
LIFE TIME OF BELT	(YEARS)	:	5.6
DRIVE CAPACITY	(KW)	:	120.9
BELT TENSION	(KP/CM)	:	96.4
BELT QUALITY			ST 1000 X
PRE-SELECTED MOTOR CONFIGURATION			1 * 130 KW
TOTAL INVESTMENT	(DM)	:	1.493
TOTAL INVESTMENT	(US $)		0.553
INVESTMENT FOR BELT ONLY	(DM)	:	0.304
INVESTMENT FOR BELT ONLY	(US $)	:	0.113

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LURGI-CHEMIE LC-HB — CONVEYOR CALCULATION
15.12.83 - 15/39/29 — PROJECT :MCHUCHUMA MAIN BELT YEAR 14 (FLIGHT 4)

CONVEYOR NO. 1

I N P U T - D A T A

THEOR.CAPACITY	(T/H)	:	450.0
LENGTH OF CONVEYOR	(M)	:	450.0
LIFT	(M)	:	0.0
SPEED	(M/SEC)	:	2.00
BULK DENSITY	(T/M3)	:	1.25
HAULAGE CONDITIONS		:	UNFAVOURABLE
GRAIN CONDITIONS		:	GRAINSIZE 150-400 MM SLIGHT FINE GRAIN CONTENT
EXCHANGE RATE	(DM/US$)	:	2.70

R E S U L T S

BELT WIDTH	(MM)	:	800.0
WEIGHT OF ROTAT.PARTS	(KG/M)	:	100.0
FACTOR FOR MINOR RESISTANCE	(-)	:	1.32000
FACTOR FOR MAYOR RESISTANCE	(-)	:	0.02300
TROUGHING ANGLE	(DEG)	:	25.0
SURCHARGE ANGLE	(DEG)	:	0.0
THICKNESS OF BELT COVER	(MM)	:	8.0
THICKNESS OF BELT UNDER SIDE	(MM)	:	6.0
LIFE TIME OF BELT	(YEARS)	:	5.0
DRIVE CAPACITY	(KW)	:	48.9
BELT TENSION	(KP/CM)	:	39.0
BELT QUALITY			ST 800 X
PRE-SELECTED MOTOR CONFIGURATION			1 * 130 KW
TOTAL INVESTMENT	(DM)	:	1.416
TOTAL INVESTMENT	(US $)		0.524
INVESTMENT FOR BELT ONLY	(DM)	:	0.275
INVESTMENT FOR BELT ONLY	(US $)	:	0.102

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LURGI-CHEMIE LC-HB   CONVEYOR CALCULATION
15.12.83 - 15/40/51   PROJECT :MCHUCHUMA MAIN BELT YEAR 19 (FLIGHT 5)

CONVEYOR NO. 1

I N P U T - D A T A

THEOR.CAPACITY	(T/H)	:	450.0
LENGTH OF CONVEYOR	(M)	:	450.0
LIFT	(M)	:	0.0
SPEED	(M/SEC)	:	2.00
BULK DENSITY	(T/M3)	:	1.25
HAULAGE CONDITIONS		:	UNFAVOURABLE
GRAIN CONDITIONS		:	GRAINSIZE 150-400 MM SLIGHT FINE GRAIN CONTENT
EXCHANGE RATE	(DM/US$)	:	2.70

R E S U L T S

BELT WIDTH	(MM)	:	800.0
WEIGHT OF ROTAT.PARTS	(KG/M)	:	100.0
FACTOR FOR MINOR RESISTANCE	(-)	:	1.32000
FACTOR FOR MAYOR RESISTANCE	(-)	:	0.02300
TROUGHING ANGLE	(DEG)	:	25.0
SURCHARGE ANGLE	(DEG)	:	0.0
THICKNESS OF BELT COVER	(MM)	:	8.0
THICKNESS OF BELT UNDER SIDE	(MM)	:	6.0
LIFE TIME OF BELT	(YEARS)	:	5.0
DRIVE CAPACITY	(KW)	:	48.9
BELT TENSION	(KP/CM)	:	39.0
BELT QUALITY			ST 800 X
PRE-SELECTED MOTOR CONFIGURATION			1 * 130 KW
TOTAL INVESTMENT	(DM)	:	1.416
TOTAL INVESTMENT	(US $)		0.524
INVESTMENT FOR BELT ONLY	(DM)	:	0.275
INVESTMENT FOR BELT ONLY	(US $)	:	0.102

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SECTION 1.2.4

Auxiliaries

1.2.4 Auxiliaries

1.2.4.1 Service trucks

Service trucks are used to provide the supply of consumables (dynamite, wearparts, spare parts, support etc.). Special trucks will be provided to transport the support shields from one face to a new one.

All handling equipment is trackless and of flameproof construction. The necessary truck capacity and the investment schedule are compiled in the investment cost estimate.

1.2.4.2 Fresh water system

Fresh water is required for drilling, dust control and for cooling of motors of high capacity. Therefore, a fresh water pipeline has to be installed in each working face.

The final consumption will have to be calculated in accordance with the results of detailed planning. The investment cost estimate includes the investment for the fresh water system.

1.2.4.3 Compressed air system

For drifting into hard sandstone formation, drilling and blasting is envisaged. The drilling will be performed by pneumatic drills supplied by a central compressed air system.

In case the hanging wall will not cave in by gravity, the roof has to be blasted. For drilling, a compressed air pipeline has to be installed in each working face.

Compressed air is also used for auxiliary ventilation and for pneumatic tools.

The investment cost estimate includes the investment for the compressed air system.

1.2.4.4 Electricity distribution

Power supply to the underground and surface facilities has to be transmitted through a branch line from the main power line with a capacity of 6,000 V located near the mine entrance.

Power for the surface facilities, the main mine fan and for the compressor station has to be supplied after transforming it down to 3000 V.

A line for the ventilation fans is independently distributed in order to prevent it from power failure.

The underground works have to be supplied with a power line of 6,000 V in order to prevent the voltage-drop-down.

In the mine, the voltage has to be transformed to 1,000 V (shearer) and 500 V.

All electrical equipment has to be of flameproof and explosion-proof construction.

The investment cost estimate includes the investment for the electrical supply system.

1.2.4.5 Ventilation

The main entry system consists of 2 adits. During development one of these adits will be the return airway. Exhaust ventilation is used.
The main fan will stay on the surface. Intake airway will be a ventilation shaft. The required negative pressure is subject to exact ventilation planning.
A rough estimation results in a capacity of 300 kW for the main fan.
With the advance of the mine to the East an additional ventilation shaft has to be drilled.
Final specifications are subject to further investigations.
The investment for ventilation is included in the investment cost estimate.

1.2.4.6 Drainage

Up to now there is only little information about the hydrogeological situation in the Mchuchuma deposit. The hydro-geology has to be investigated for final specification of the corresponding systems.
In general, the drainage system includes the draining of the main entry system and of the exploitation areas. A central pump sump and the main water pump station have to be installed in the deepest point of the main entry system.
Natural drain from the northern part of the exploitation area is possible. In contrast, in the southern part, natural drain will be difficult.
Therefore, additional piping might be necessary from the mining panels to the main entry system.
Pumps of same specification should be used to allow for simple replacement and exchange.
The investment cost estimate includes the investment for the drainage system.

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SECTION 1.2.5

Outline Specifications

Mining Equipment

1.2.5 Exploitation Equipment

.1 - double end drum shearer

motor power	:	300	kW
seam thickness	:	2.5 - 4.5	m
drum diameter	:	1600/2000	mm
cutting depth	:	600 - 800	mm
length of ranging arms	:	2.2	m
travelling speed	:	350 - 700	m
Haulage pull	:	200	kN
total weight	:	30	t

.2 - armoured face conveyor

pan width	:	732	mm
pan height	:	222	mm
pan length	:	1.5	m
weight per pan	:	370	kg
chain type	:	22 x 86	mm
power requirement	:	260	kW

.3 - stop loader

equipped with an impact-roll crusher.

.4 - hydraulic shields

support will be done with hydraulic shields, with regard to the seam thickness, two types of self-advancing shield supports have to be used:

	Seam thickness 2 - 3 m	Seam thickness 3 - 5 m
legs per shield	2	4
height, closed	1500 mm	2500 mm
height, extended	3300 mm	4500 mm
adjusting range, hydraulic	1800 mm	2000 mm
yield load per leg	2000 kN	1320 kN

The hydraulic supply-system will stay in the main to supply two faces.

All electric equipment has to be of flameproof construction.

SECTION 1.2.6

Investment Cost Estimate

1.2.6 Investment Cost Estimate

The investment cost estimate is given in the following tables.

Initial investment for start-up of the mine is:

57,040 Mill. US $ for Alternative I
and 96,398 Mill. US $ for Alternative II

The specific investment for Alternative I is

$$\frac{57{,}040{,}000\ \$}{950{,}000\ t/a} = 60\ US\ \$/t \times a$$

for Alternative II 40 US $/t x a

All investment cost of Alternative I are calculated separately for all main components. The investment costs of Alternative II are derived from Alternative 1 by specific extrapolation.

Investment Schedule Mchuchuma, Alternative I
(950,000 t/a, (in Mill. US $, c.i.f. prices)

	Description	Life-time	Price/ item	Init. No. of items	- 2	- 1	1	2
I	Drifting Equipment							
1	tunneling machine	6	1.3	1	1.3			
2	moveable bin install.	6	0.2	1	0.2			
3	articul. dump truck	4	0.2	2	0.4			0.4
4	convention. drill equipment	4	0.1	1	0.1			
5	front end loader	4	0.16	2	0.32			
6	service truck	4	0.05	2	0.1		0.1	
7	ventilation equipment	4	0.2	1	0.2		0.2	
8	pick-up	4	0.015	2	0.03		0.03	
II	Development Work							
9	main double entry				2.74			
10	ventilation shaft					0.36		
11	stope develop. drifts				1.4	4.07		
12	main belt conveyor	6				0.67		
13	ventilation fan					0.3		
III	Exploitation Equipm.							
14	double end drum shearer	6	1.7	3		3.4	1.7	
15	armoured face conveyor	6	0.42	3		0.84	0.42	
16	2 leg-shield set	6	6.0	3		12.0	6.0	
17	hydraulic supply system	6	0.12	3		0.24	0.12	
18	stage loader	6	0.33	3		0.66	0.33	
19	electr. install. set	6	0.7	3		1.4	0.7	
20	service trucks	4	0.1	3		0.2	0.1	
21	main connecting belt incl. reinversement	6				0.75	1.07	
22	service trucks	4	0.05	8		0.2	0.2	
IV	Auxiliary							
23	workshop				1.5			
24	warehouses				0.4			
25	power supply				0.3			
26	compressed air supply				0.3	0.3		
27	buildings				0.2			
28	engineering				2.0			
29	miscellaneous				2.0	2.0		
30	contingency (10 %)				1.35	2.74	1.1	0.04
	Total				14.84	30.13	12.07	0.44

Initial investment for start-up (year - 2, -1, 1) = 57.04

Grandtotal 149.13

Investment Schedule Mchuchuma, Alternative I
(950,000 t/a, (in Mill. US $, c.i.f. prices)

Description	Life-time	Price/item	Init. No. of items	3	4	5	6
I Drifting Equipment							
1 tunneling machine	6	1.3	1			1.3	
2 moveable bin install.	6	0.2	1			0.2	
3 articul. dump truck	4	0.2	2	0.4			0.4
4 convention. drill equipment	4	0.1	1	0.1			
5 front end loader	4	0.16	2	0.32			
6 service truck	4	0.05	2	0.1		0.1	
7 ventilation equipment	4	0.2	1	0.2		0.2	
8 pick-up	4	0.015	2	0.03		0.03	
II Development Work							
9 main double entry							
10 ventilation shaft							
11 stope develop. drifts							
12 main belt conveyor	6					0.64	0.67
13 ventilation fan							
III Exploitation Equipm.							
14 double end drum shea-rer	6	1.7	3				3.4
15 armoured face convey-or	6	0.42	3				0.84
16 2 leg-shield set	6	6.0	3				12.0
17 hydraulic supply sy-system	6	0.12	3				0.24
18 stage loader	6	0.33	3				0.66
19 electr. install. set	6	0.7	3				1.4
20 service trucks	4	0.1	3		0.2	0.1	
21 main connecting belt incl. reinversement	6			0.19		0.13	0.75
22 service trucks	4	0.05	8		0.2	0.2	
IV Auxiliary							
23 workshop							
24 warehouses							
25 power supply							
26 compressed air supply							
27 buildings							
28 engineering							
29 miscellaneous							
30 contingency (10 %)				0.13	0.04	0.30	2.0
Total				1.47	0.44	3.25	22.36

Initial investment for start-up (year - 2, -1, 1) = 57.04

Grandtotal 149.13

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Investment Schedule Mchuchuma, Alternative I
(950,000 t/a, in (Mill. US $, c.i.f. prices)

Description	Life-time	Price/item	Init. No. of items	7	8	9	10
I Drifting Equipment							
1 tunneling machine	6	1.3	1				
2 moveable bin install.	6	0.2	1				
3 articul. dump truck	4	0.2	2	0.4			0.4
4 convention. drill equipment	4	0.1	1	0.1			
5 front end loader	4	0.16	2	0.32			
6 service truck	4	0.05	2	0.1		0.1	
7 ventilation equipment	4	0.2	1	0.2		0.2	
8 pick-up	4	0.015	2	0.03		0.03	
II Development Work							
9 main double entry							
10 ventilation shaft						0.44	
11 stope develop. drifts							
12 main belt conveyor	6						0.55
13 ventilation fan						0.4	
III Exploitation Equipm.							
14 double end drum shea-rer	6	1.7	3	1.7			
15 armoured face convey-or	6	0.42	3	0.42			
16 2 leg-shield set	6	6.0	3	6.0			
17 hydraulic supply sy-system	6	0.12	3	0.12			
18 stage loader	6	0.33	3	0.33			
19 electr. install. set	6	0.7	3	0.7			
20 service trucks	4	0.1	3		0.2	0.1	
21 main connecting belt incl. reinversement	6				0.07	0.19	
22 service trucks	4	0.05	8		0.2	0.2	
IV Auxiliary							
23 workshop							
24 warehouses							
25 power supply							
26 compressed air supply							0.3
27 buildings							
28 engineering							
29 miscellaneous							
30 contingency (10 %)				1.04	0.05	0.17	0.13
Total				11.46	0.52	1.83	1.38

Initial investment for start-up (year -2, -1, 1) = 57.04

Grandtotal 149.13

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Investment Schedule Mchuchuma, Alternative I
(950,000 t/a, (in Mill. US $, c.i.f. prices)

	Description	Life-time	Price/item	Init. No. of items	11	12	13	14
I	Drifting Equipment							
1	tunneling machine	6	1.3	1	1.3			
2	moveable bin install.	6	0.2	1	0.2			
3	articul. dump truck	4	0.2	2	0.4			0.4
4	convention. drill equipment	4	0.1	1	0.1			
5	front end loader	4	0.16	2	0.32			
6	service truck	4	0.05	2	0.1		0.1	
7	ventilation equipment	4	0.2	1	0.2		0.2	
8	pick-up	4	0.015	2	0.03		0.03	
II	Development Work							
9	main double entry							
10	ventilation shaft							
11	stope develop. drifts							
12	main belt conveyor	6			0.64	0.67		0.52
13	ventilation fan							
III	Exploitation Equipm.							
14	double end drum shea-rer	6	1.7	3		3.6	1.8	
15	armoured face convey-or	6	0.42	3		0.9	0.45	
16	2 leg-shield set	6	6.0	3		13.0	6.5	
17	hydraulic supply sy-system	6	0.12	3		0.24	0.12	
18	stage loader	6	0.33	3		0.66	0.33	
19	electr. install. set	6	0.7	3	0.18	1.4	0.7	
20	service trucks	4	0.1	3		0.2	0.1	
21	main connecting belt incl. reinversement	6				0.75		0.07
22	service trucks	4	0.05	8		0.2	0.2	
IV	Auxiliary							
23	workshop							
24	warehouses							
25	power supply							
26	compressed air supply				0.3			
27	buildings							
28	engineering							
29	miscellaneous							
30	contingency (10 %)				0.38	2.16	1.05	0.10
	Total				4.15	23.78	11.58	1.09

Initial investment for start-up (year -2, -1, 1) = 57.04
Grandtotal 149.13
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Investment Schedule Mchuchuma, Alternative I
(950,000 t/a, (in Mill. US $, c.i.f. prices)

Description	Life-time	Price/item	Init. No. of items	15	16	17	18
I Drifting Equipment							
1 tunneling machine	6	1.3	1			1.3	
2 moveable bin install.	6	0.2	1			0.2	
3 articul. dump truck	4	0.2	2	0.4			0.4
4 convention. drill equipment	4	0.1	1	0.1			
5 front end loader	4	0.16	2	0.32			
6 service truck	4	0.05	2	0.1		0.1	
7 ventilation equipment	4	0.2	1	0.2		0.2	
8 pick-up	4	0.015	2	0.03		0.03	
II Development Work							
9 main double entry							
10 ventilation shaft							
11 stope develop. drifts							
12 main belt conveyor	6				0.55	0.64	0.67
13 ventilation fan							
III Exploitation Equipm.							
14 double end drum shearer	6	1.7	3				
15 armoured face conveyor	6	0.42	3				
16 2 leg-shield set	6	6.0	3				
17 hydraulic supply system	6	0.12	3				
18 stage loader	6	0.33	3				
19 electr. install. set	6	0.7	3				
20 service trucks	4	0.1	3		0.2	0.1	
21 main connecting belt	6			0.19		0.18	0.75
incl. reinversement					0.2	0.2	
22 service trucks	4	0.05	8				
IV Auxiliary							
23 workshop							
24 warehouses							
25 power supply							
26 compressed air supply							
27 buildings							
28 engineering							
29 miscellaneous							
30 contingency (10 %)				0.13	0.10	0.30	0.18
Total				1.47	1.05	3.25	2.0

Initial investment for start-up (year -2, -1, 1) = 57.04
Grandtotal 149.13

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Investment Schedule Mchuchuma, Alternative I
(950,000 t/a, (in Mill. US $, c.i.f. prices)

Description	Life-time	Price/item	Init. No. of items	19	20
I Drifting Equipment					
1 tunneling machine	6	1.3	1		
2 moveable bin install.	6	0.2	1		
3 articul. dump truck	4	0.2	2		
4 convention. drill equipment	4	0.1	1		
5 front end loader	4	0.16	2		
6 service truck	4	0.05	2		
7 ventilation equipment	4	0.2	1		
8 pick-up	4	0.015	2		
II Development Work					
9 main double entry					
10 ventilation shaft					
11 stope develop. drifts					
12 main belt conveyor	6			0.52	
13 ventilation fan					
III Exploitation Equipm.					
14 double end drum shea-rer	6	1.7	3		
15 armoured face convey-or	6	0.42	3		
16 2 leg-shield set	6	6.0	3		
17 hydraulic supply sy-system	6	0.12	3		
18 stage loader	6	0.33	3		
19 electr. install. set	6	0.7	3		
20 service trucks	4	0.1	3		
21 main connecting belt incl. reinversement	6				
22 service trucks	4	0.05	8		
IV Auxiliary					
23 workshop					
24 warehouses					
25 power supply					
26 compressed air supply					
27 buildings					
28 engineering					
29 miscellaneous					
30 contingency (10 %)				0.05	
Total				0.57	

Initial investment for start-up (year -2, -1, 1) = 57.04
Grandtotal 149.13
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Investment Schedule Mchuchuma, Alternative II
(2.4 Mill t/a), (in Mill. US $, c.i.f. prices)

Description	Life-time	Price/item	Init. No. of items	- 2	- 1	1	2
I Drifting Equipment							
1 tunneling machine	6	1.3	2	2.6			
2 moveable bin install.	6	0.2	2	0.4			
3 articul. dump truck	4	0.2	4	0.8			0.8
4 convention. drill equipment	4	0.1	2	0.2			
5 front end loader	4	0.16	3	0.48			
6 service truck	4	0.05	3	0.15		0.15	
7 ventilation equipment	4	0.2	1	0.2		0.2	
8 pick-up	4	0.015	3	0.045		0.045	
II Development Work							
9 main double entry				2.74			
10 ventilation shaft					0.36		
11 stope develop. drifts				2.0	6.15		
12 main belt conveyor					0.67		
13 ventilation fan					0.3		
III Exploitation Equipm.							
14 double end drum shearer	6	1.7	6		6.8	3.4	
15 armoured face conveyor	6	0.42	6		1.68	0.84	
16 2 leg-shield set	6	6.0	6		24.0	12.0	
17 hydraulic supply system	6	0.12	4		0.24	0.24	
18 stage loader	6	0.33	4		0.66	0.66	
19 electr. install. set	6	0.7	4		1.4	1.4	
20 service trucks	4	0.1	5		0.3	0.2	
21 main connecting belt incl. reinversement	6				1.5	1.07	
22 service trucks	4	0.05	10		0.25	0.25	
IV Auxiliary							
23 workshop				2.5			
24 warehouses				0.6			
25 power supply				0.45			
26 compressed air supply				0.45	0.45		
27 buildings				0.3			
28 engineering				2.5			
29 miscellaneous				3.0	3.0		
30 contingency (10 %)				1.942	4.78	2.046	0.08
Total				21.357	52.54	22.501	0.88

Initial investment for start-up (year -2, -1, 1) 96.398
Grandtotal 271.696

Investment Schedule Mchuchuma, Alternative II
(2.4 Mill t/a), (in Mill. US $, c.i.f. prices)

Description	Life-time	Price/item	Init. No. of items	3	4	5	6
I Drifting Equipment							
1 tunneling machine	6	1.3	2			2.6	
2 moveable bin install.	6	0.2	2			0.4	
3 articul. dump truck	4	0.2	4	0.8			0.8
4 convention. drill equipment	4	0.1	2	0.2			
5 front end loader	4	0.16	3	0.48			
6 service truck	4	0.05	3	0.15		0.15	
7 ventilation equipment	4	0.2	1	0.2		0.2	
8 pick-up	4	0.015	3	0.045		0.045	
II Development Work							
9 main double entry							
10 ventilation shaft					0.44		
11 stope develop. drifts							
12 main belt conveyor				0.64		0.55	0.67
13 ventilation fan					0.4		
III Exploitation Equipm.							
14 double end drum shearer	6	1.7	6				7.2
15 armoured face conveyor	6	0.42	6				1.8
16 2 leg-shield set	6	6.0	6				26.0
17 hydraulic supply system	6	0.12	4				0.24
18 stage loader	6	0.33	4				0.66
19 electr. install. set	6	0.7	4				1.4
20 service trucks	4	0.1	5		0.3	0.2	
21 main connecting belt incl. reinversement	6			0.38		0.36	1.5
22 service trucks	4	0.05	10		0.25	0.25	
IV Auxiliary							
23 workshop							
24 warehouses							
25 power supply							
26 compressed air supply							
27 buildings							
28 engineering							
29 miscellaneous							
30 contingency (10 %)				0.290	0.139	0.476	4.027
Total				3.185	1.529	5.231	44.297

Initial investment for start-up (year -2, -1, 1) 96.398
Grandtotal 271.696

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Investment Schedule Mchuchuma, Alternative II (2.4 Mill t/a), (in Mill. US $, c.i.f. prices)

Description	Life-time	Price/item	Init. No. of items	7	8	9	10
I Drifting Equipment							
1 tunneling machine	6	1.3	2				
2 moveable bin install.	6	0.2	2				
3 articul. dump truck	4	0.2	4	0.8			0.8
4 convention. drill equipment	4	0.1	2	0.2			
5 front end loader	4	0.16	3	0.48			
6 service truck	4	0.05	3	0.15		0.15	
7 ventilation equipment	4	0.2	1	0.2		0.2	
8 pick-up	4	0.015	3	0.045		0.045	
II Development Work							
9 main double entry							
10 ventilation shaft						0.44	
11 stope develop. drifts							
12 main belt conveyor				0.52		0.64	0.51
13 ventilation fan						0.4	
III Exploitation Equipm.							
14 double end drum shea-rer	6	1.7	6	3.6			
15 armoured face convey-or	6	0.42	6	0.9			
16 2 leg-shield set	6	6.0	6	13.0			
17 hydraulic supply sy-system	6	0.12	4	0.24			
18 stage loader	6	0.33	4	0.66			
19 electr. install. set	6	0.7	4	1.4			
20 service trucks	4	0.1	5		0.3	0.2	
21 main connecting belt incl. reinversement	6				0.14	0.38	
22 service trucks	4	0.05	10		0.25	0.25	
IV Auxiliary							
23 workshop							
24 warehouses							
25 power supply							
26 compressed air supply							0.45
27 buildings							
28 engineering							
29 miscellaneous							
30 contingency (10 %)				2.220	0.069	0.271	0.176
Total				24.415	0.759	2.976	1.936

Initial investment for start-up (year -2, -1, 1) 96.398
Grandtotal 271.656

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Investment Schedule Mchuchuma, Alternative II (2.4 Mill t/a), (in Mill. US $, c.i.f. prices)

Description	Life-time	Price/item	Init. No. of items	11	12	13	14
I Drifting Equipment							
1 tunneling machine	6	1.3	2	2.6			
2 moveable bin install.	6	0.2	2	0.4			
3 articul. dump truck	4	0.2	4	0.8			0.8
4 convention. drill equipment	4	0.1	2	0.2			
5 front end loader	4	0.16	3	0.48			
6 service truck	4	0.05	3	0.15		0.15	
7 ventilation equipment	4	0.2	1	0.2		0.2	
8 pick-up	4	0.015	3	0.045		0.045	
II Development Work							
9 main double entry							
10 ventilation shaft							0.44
11 stope develop. drifts							
12 main belt conveyor				0.55	0.67	0.52	0.50
13 ventilation fan							0.4
III Exploitation Equipm.							
14 double end drum shea-rer	6	1.7	6		7.2	3.6	
15 armoured face convey-or	6	0.42	6		1.8	0.9	
16 2 leg-shield set	6	6.0	6		26.0	13.0	
17 hydraulic supply sy-system	6	0.12	4		0.24	0.24	
18 stage loader	6	0.33	4		0.66	0.66	
19 electr. install. set	6	0.7	4		1.4	1.4	
20 service trucks	4	0.1	5		0.3	0.2	
21 main connecting belt incl. reinversement	6			0.36	1.5		0.14
22 service trucks	4	0.05	10		0.25	0.25	
IV Auxiliary							
23 workshop							
24 warehouses							
25 power supply							
26 compressed air supply				0.45			
27 buildings							
28 engineering							
29 miscellaneous							
30 contingency (10 %)				0.624	4.00	2.117	0.228
Total				6.859	44.02	23.282	2.508

Initial investment for start-up (year -2, -1, 1) 96.398

Grandtotal 271.696

Investment Schedule Mchuchuma, Alternative II
(2.4 Mill t/a), (in Mill. US $, c.i.f. prices)

Description	Life-time	Price/item	Init. No. of items	15	16	17	18
I Drifting Equipment							
1 tunneling machine	6	1.3	2			2.6	
2 moveable bin install.	6	0.2	2			0.4	
3 articul. dump truck	4	0.2	4	0.8			0.8
4 convention. drill equipment	4	0.1	2	0.2			
5 front end loader	4	0.16	3	0.48			
6 service truck	4	0.05	3	0.15		0.15	
7 ventilation equipment	4	0.2	1	0.2		0.2	
8 pick-up	4	0.015	3	0.045		0.045	
II Development Work							
9 main double entry							
10 ventilation shaft							
11 stope develop. drifts							
12 main belt conveyor				0.64	0.51	0.55	0.67
13 ventilation fan							
III Exploitation Equipm.							
14 double end drum shea-rer	6	1.7	6				
15 armoured face convey-or	6	0.42	6				
16 2 leg-shield set	6	6.0	6				
17 hydraulic supply sy-system	6	0.12	4				
18 stage loader	6	0.33	4				
19 electr. install. set	6	0.7	4				
20 service trucks	4	0.1	5		0.3	0.2	
21 main connecting belt incl. reinversement	6			0.38		0.36	1.5
22 service trucks	4	0.05	10		0.25	0.25	
IV Auxiliary							
23 workshop							
24 warehouses							
25 power supply							
26 compressed air supply							
27 buildings							
28 engineering							
29 miscellaneous							
30 contingency (10 %)				0.290	0.106	0.476	0.29
Total				3.185	1.166	5.231	3.26

Initial investment for start-up (year -2, -1, 1) 96.398
Grandtotal 271.096

Investment Schedule Mchuchuma, Alternative II
(2.4 Mill t/a), (in Mill. US $, c.i.f. prices)

Description	Life-time	Price/item	Init. No. of items	19	20
I Drifting Equipment					
1 tunneling machine	6	1.3	2		
2 moveable bin install.	6	0.2	2		
3 articul. dump truck	4	0.2	4		
4 convention. drill equipment	4	0.1	2		
5 front end loader	4	0.16	3		
6 service truck	4	0.05	3		
7 ventilation equipment	4	0.2	1		
8 pick-up	4	0.015	3		
II Development Work					
9 main double entry					
10 ventilation shaft					
11 stope develop. drifts					
12 main belt conveyor				0.52	
13 ventilation fan					
III Exploitation Equipm.					
14 double end drum shea-rer	6	1.7	6		
15 armoured face convey-or	6	0.42	6		
16 2 leg-shield set	6	6.0	6		
17 hydraulic supply system	6	0.12	4		
18 stage loader	6	0.33	4		
19 electr. install. set	6	0.7	4		
20 service trucks	4	0.1	5		
21 main connecting belt incl. reinversement	6				
22 service trucks	4	0.05	10		
IV Auxiliary					
23 workshop					
24 warehouses					
25 power supply					
26 compressed air supply					
27 buildings					
28 engineering					
29 miscellaneous					
30 contingency (10 %)				0.052	
Total				0.572	

Initial investment for start-up (year -2, -1, 1) 96.398
Grandtotal 271.696

LURGI

Section 1.3

Coal Washing Plant

A 1080

S E C T I O N 1.3.1

Process Description

Coal Washing Plant

1.3.1 Process Description

The process for washing of the Mchuchuma coal was developed on the basis of former laboratory tests, carried out with different samples at the laboratories of Saarberg Interplan. For the purpose as reductant for the Liganga ore, only raw coal of the middle and lower seam will be processed.

1.3.1.1 Crushing and Screening

The raw coal will be delivered from the mine with a maximum lump size of approx. 300 mm.
To separate the coal from the included benches of waste material and to achieve the desired grain size for the use as reductant, a comminution to approx. 10 mm grain size is required.
On the other side, the portion of minus 1 mm material in the final product should be as small as possible. For this reason, the raw coal will be crushed in two stages with intermediate screening.

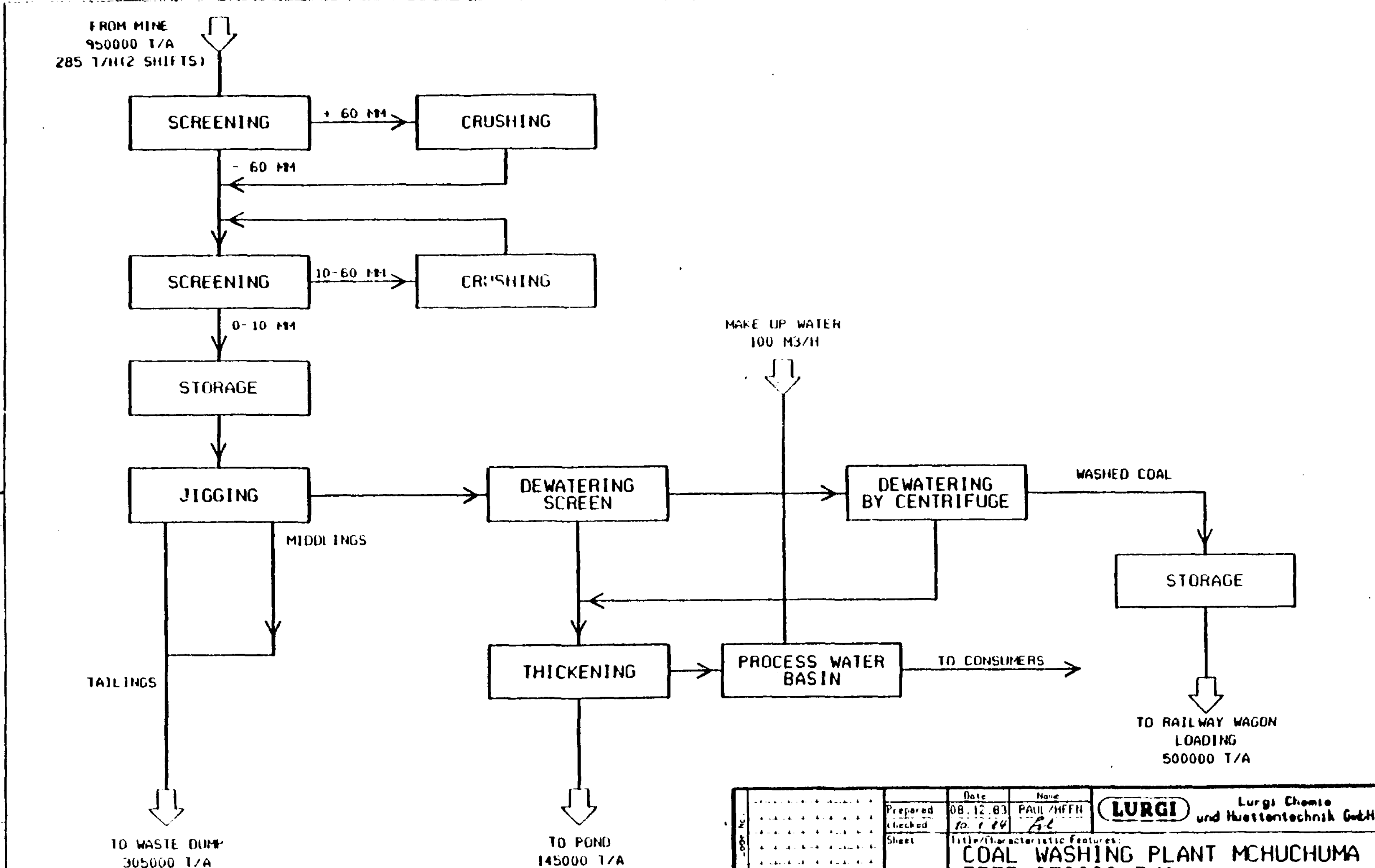
The raw coal passes at first a screening of appr. 75 mm. The screen oversize undergoes crushing in a roll crusher. The crushed product will be screened at 10 mm together with the undersize of the first screen and the product of the second stage crusher. Oversize of this screen is subject to second stage crushing in an impact crusher. The crusher product is recirculated to the screening at 10 mm.

The crushed coal of 0 - 10 mm will be transported for storage to a circular blending bed. This blending bed is able to store the production of approx. 2 days. The special method for stacking and reclaiming of the material has homogenizing effect on it. By this way, a smoother operation of the following washing plant will be achieved.

1.3.1.2 Washing Plant

As a method for the separation of coal and gangue material, jigging was chosen. For the grain size of the product required, this method is well proven. Jigging is easier to handle than a heavy media process and not sensitive to interruptions. For start-up, only a short time is necessary to get steady operation.

From the blending bed, the crushed coal will be discharged at a controlled rate and transported to the feeding point of the jigging machine. There, water is added to wet the material. Thus, a material layer is built up in the jigging machine. By air pulsing of this layer, it will separate according to the specific gravity of the material. Through a layer of feldspar, the tailings and a middlings product will be discharged. Together with a certain amount of water, the washed coal will be discharged at the end of the machine. For dewatering, the coal passes a stationary and a vibrating screen and will be further treated in a vibrating screen centrifuge. After processing, it is transported to the storage prior to shipping to the Mahanje Steelworks.



	Date	Name	
Prepared	08.12.83	PAUL/HFFN	LURGI Lurgi Chemie und Huettentechnik GmbH
Checked			

Title/Characteristic Features:
COAL WASHING PLANT MCHUCHUMA
FEED 950000 T/A

Drawing Type: 202 BLOCK DIAGRAM

Process: HAA | Job or Project No.: 0.12238 | Job: TANZANIA

Drawing No.: 3A0.12238.00004

Rev. | Date | Changed | Checked | Kind of Revision

[202.01]]42236.007.DGN/06.01.84 HFFN

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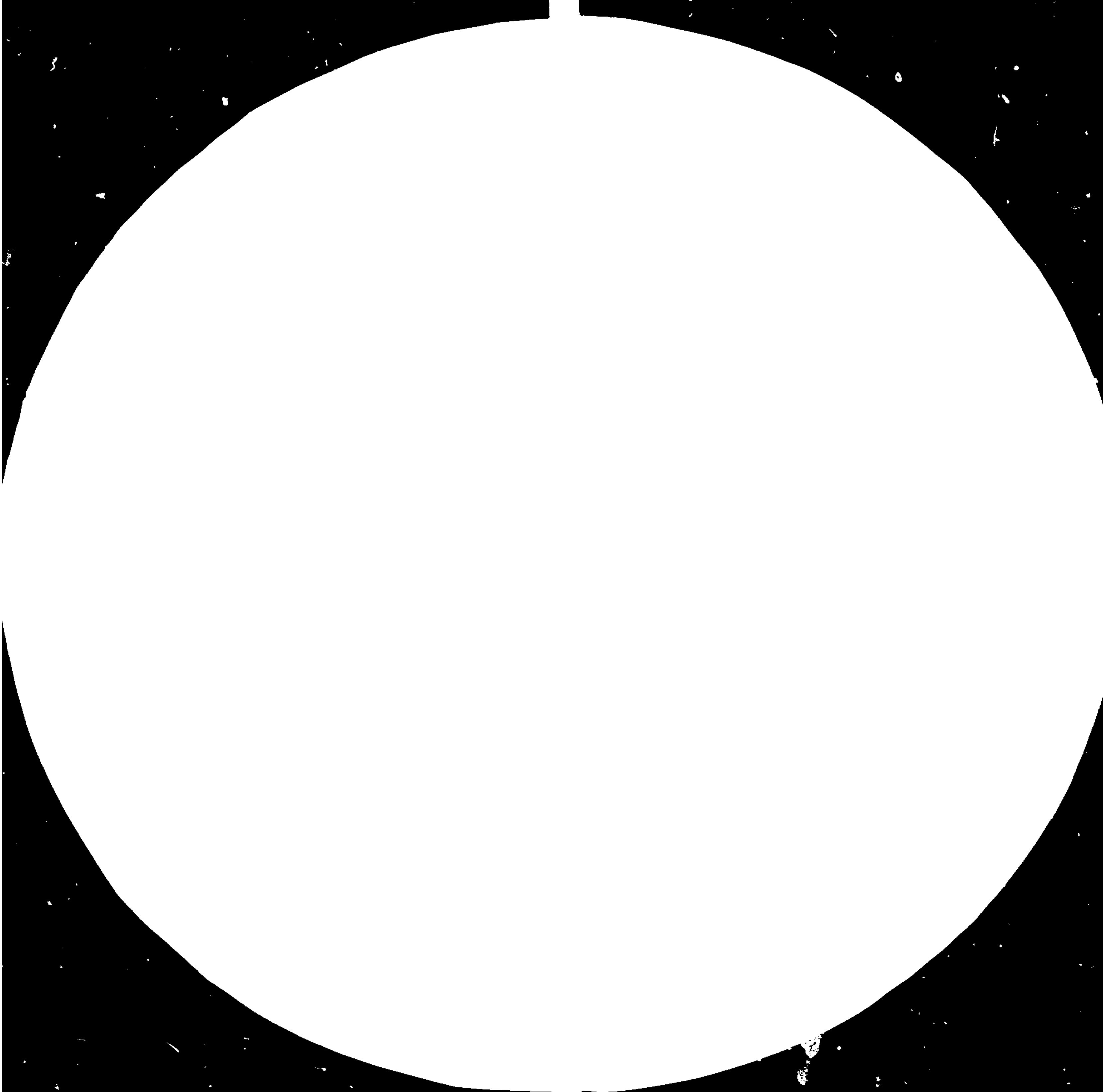
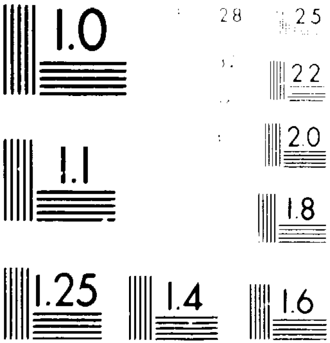
Tanzania/Volume II

S E C T I O N 1.3.2

Plant Description

Coal Washing Plant




1.0
2.8
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

1.3.2 Plant Description

Since coal, as it will be hauled from the mine, will not be suitable for the purpose of serving as reductant for Liganga pellets, it must undergo a beneficiation process in the washing plant. The washing plant will be designed to treat the raw coal of the middle and lower seam of the Mchuchuma deposit. The plant will be operating two shifts per day with a throughput of approx. 285 t/h.

1.3.2.1 Storage and Preparation of Raw Coal

On a belt conveyor, the coal will be transported from the mine with a maximum lump size of approx. 300 mm. It is fed directly to a vibratory screen for screening at 60 mm.

Screen oversize is directed to a roll crusher where the lumps are crushed to below approx. 60 mm. Screen underflow and crusher discharge are joined and transported by two belt conveyors to the feeding point of the fine screens.

The total flow of material is diverted by vibrating conduits to two screens. The screening will be performed at 10 mm grain size. Screen underflow will be directed to the storage for crushed raw coal. Screen oversize is collected in vibrating conduits and fed to an impact crusher. The impact crusher discharge joins the products of the first screening and crushing and is recirculated to the fine screening.

The belt conveyor which transports the coal to the circular storage area is equipped with a belt scale. The material is dumped in a circular pile by the stacker conveyor. By a special automatic program, the stockpiling will be controlled in a way that maximum use of the stockpile volume is made and a blending of the crushed coal takes place.

1.3.2.2 Coal Washing Unit

The coal from the stockpile is reloaded by combined action of the travelling portal frame and the chain scraper. It is transferred via the feed hopper to a belt conveyor. This belt conveyor is equipped with a belt scale and will feed the jig directly.

In front of the jigging machine, a scalping screen is installed. The purpose of this screen is to eliminate all material below 1 mm from the feed to the jigging machine. Furthermore, the material will be wetted by addition of a certain amount of water.

The jigging machine, with an area of approx. 27 m², has two compartments. In the jigging beds, in vertical direction, layers of material will be generated according to their specific gravity. The discharge of material is controlled automatically by a device which is set at a predetermined specific gravity. The two compartments of the machine allow to discharge three products: tailings and middlings in the underflow, clean coal in the overflow. In this case, it is expected, that the middlings are too high in ash content and therefore are joined with the tailings.

Tailings from the jigging machine are discharged by two dewatering bucket elevators, transferred to a conveyor belt and dumped onto a stockpile.
From there, they have to be transported to a final dumping area.

The clean coal passes a dewatering screen after leaving the jigging machine and is then fed to a dewatering screen centrifuge where the moisture content will be diminished to approx. 8 - 10 %. After dewatering, the coal will be transported by a belt conveyor to a circular stockpile to which it is dumped by a stacker.

Reloading from the stockpile is provided by a chain scraper which discharges to a hopper. From there, it is transferred by belt conveyors to the railway wagon loading station.

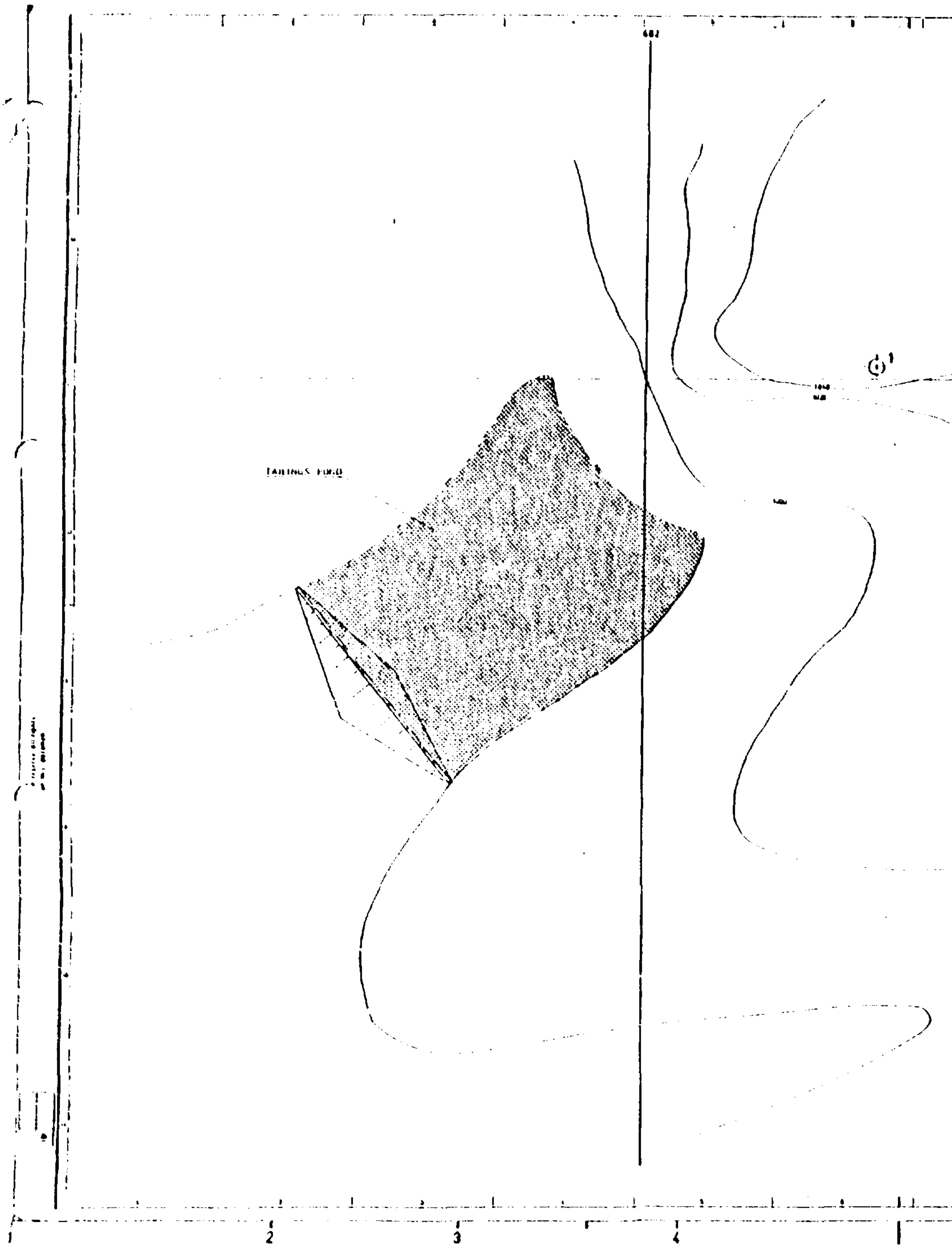
1.3.2.3 Process Water Treatment

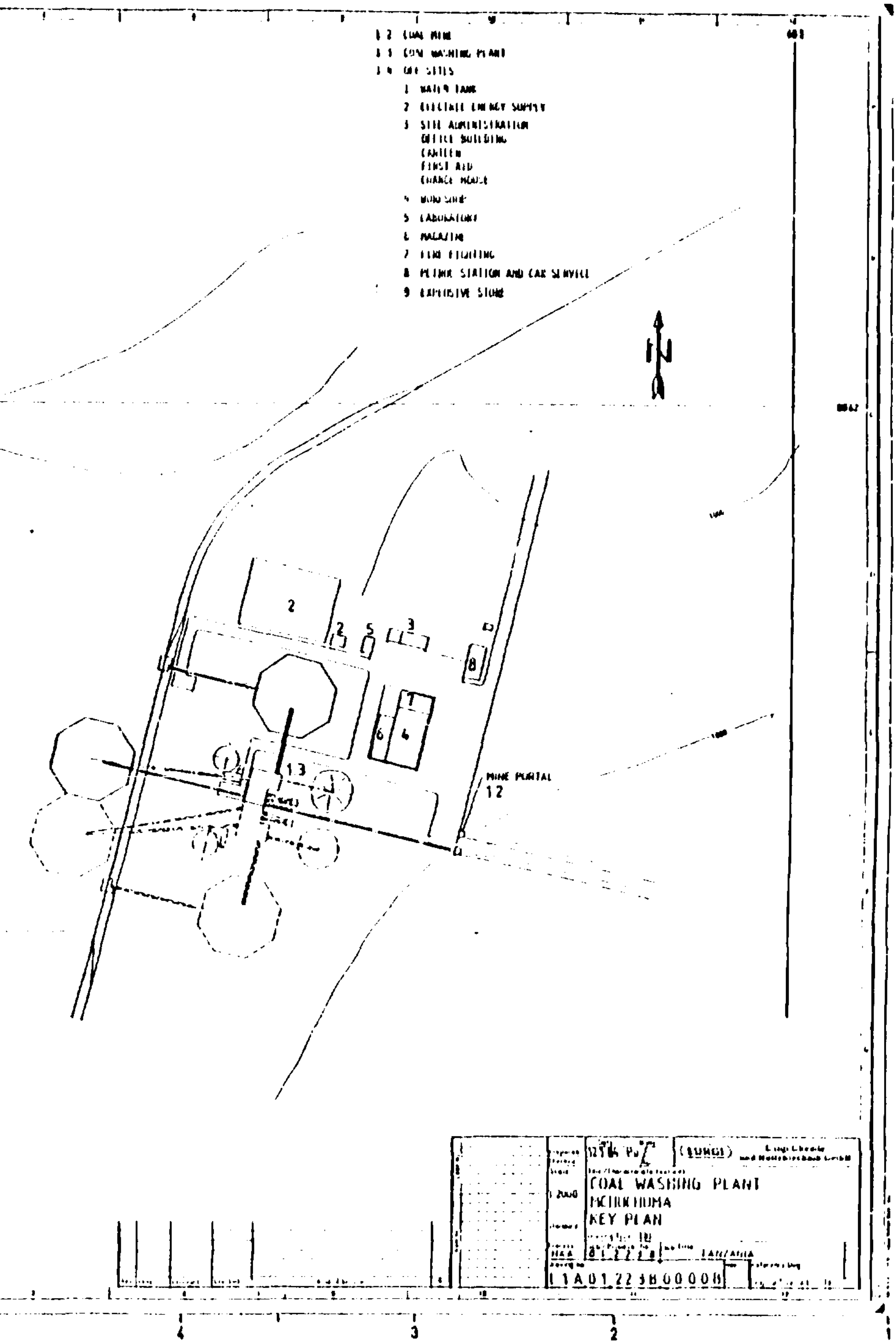
The jigging machine needs a certain amount of water, approx. 300 m³/h as wetting water at the scalping screen and approx. 1000 m³/h as underflow water at the jigging machine. This water is separated from the products mainly during screening and centrifuging after jigging. This water contains solids (coal and tailings) with a grain size up to 1 mm.

The slurry will be fed to a thickener where it is thickened to a solids content of approx. 500 g solids/l slurry. This slurry is pumped to a tailings pond.

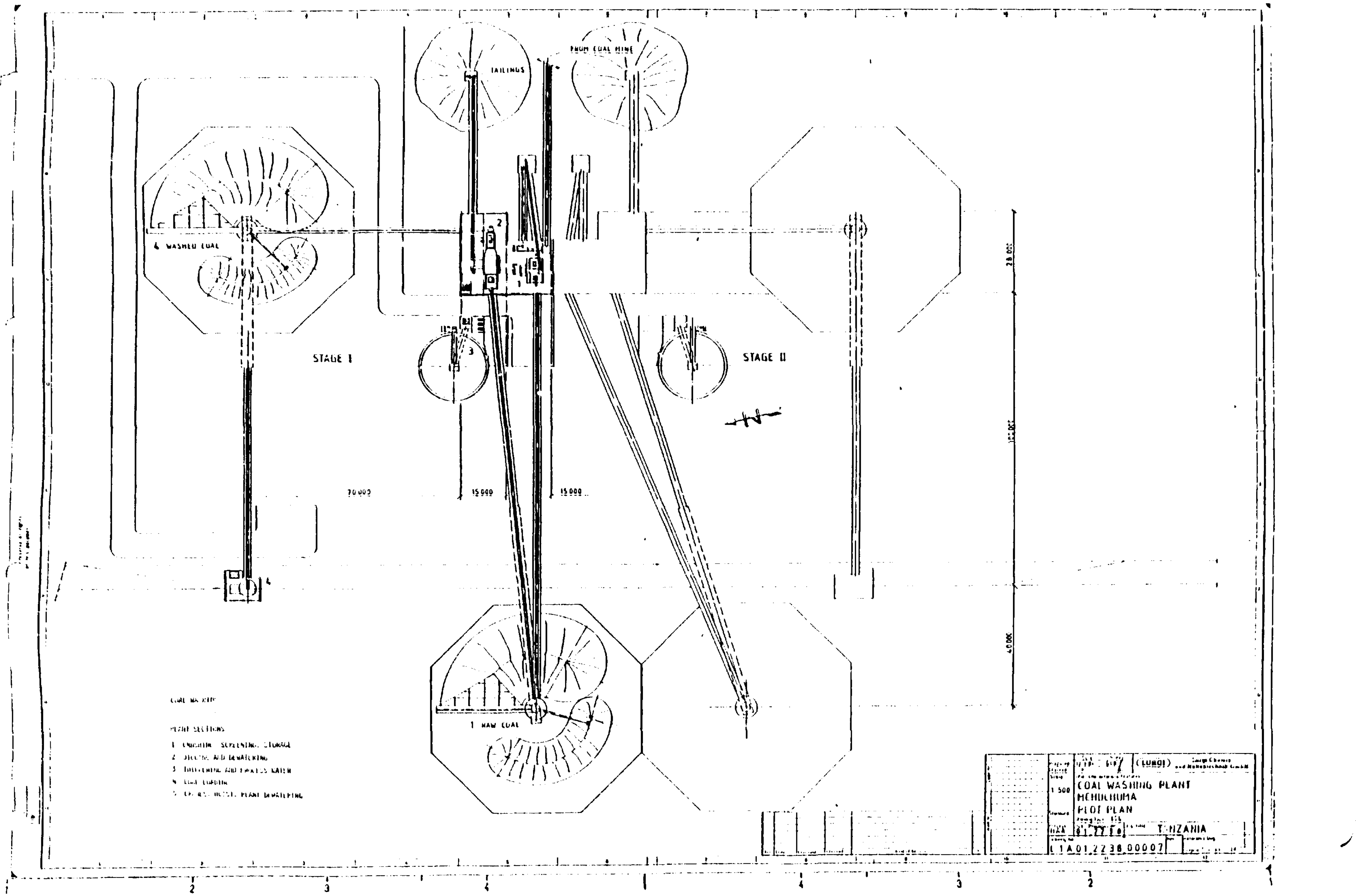
Thickener overflow flows to the process water basin from where it is recirculated to the steady head tank inside the plant and distributed to the different water consumers.

Addition of fresh water, to compensate the water losses, will occur to the process water basin.


TAILINGS POND
2
3
4



MINE PORTAL
12
13
COAL WASHING PLANT
KEY PLAN
TANZANIA


FROM COAL MINE
TAILINGS
4 WASHED COAL
STAGE I
STAGE II
1 RAW COAL
20 000
15 000
15 000
28 000
40 000
PLANT SECTIONS
(LURGI)
COAL WASHING PLANT
PLOT PLAN
1 500
TANZANIA
L 1 A 01 22 38 00007

S E C T I O N 1.3.3

Raw Materials and Products

1.3.3 Raw Materials and Products

1.3.3.1 Raw material

As raw material for the production of washed coal, the raw coal of the middle and lower seam of the Mchuchuma deposit will be used.

Max. lump size of
run-of-mine coal : 300 x 300 x 300 mm,

Ash content : 45 wt. %,

(the run-of-mine coal contains approx. 33 % of dead material from intermediate layers, foot wall and hanging wall).

1.3.3.2 Products

Washed coal:

Size distribution:

100 wt. %	:	below 10 mm
5 wt. %	:	below 1 mm

Residual moisture : 9 % water

Chemical composition:

C_{fix}	:	54.2 %
Volatiles	:	25 %
Ash	:	20.8 %
S	:	0.6 %

Total amount : approx. 545,000 tpy.

Tailings

In the plant, two different types of tailings will be generated:

coarse tailings at the jigging machine and fine tailings at dewatering screens, centrifuges etc. which are discharged from the plant as thickened slurry. Their properties will be as follows:

Coarse tailings:

Size	:	95 wt. %, 10 - 1 mm
Ash content	:	96 %
Moisture	:	approx. 15 % H_2O

Fine tailings:

Size	:	100 wt. %, below 1 mm
Ash content	:	52 %
Density of slurry	:	approx. 40 % solids

Total amount of tailings	:	450,000 tpy

S E C T I O N 1.3.4

Consumption Figures

and

Workforce Schedule

1.3.4 Consumption Figures and Workforce Schedule

1.3.4.1 Consumption Figures

For the production of 500,000 tpy coal as reductant in the Mahanje DR-plant from raw coal of the Mchuchuma mine, the following specific consumption figures apply:

	per ton washed coal		per year		
Raw coal	1.9	t	950,000		t
Electric power	9	KWh	4,500		MWh
Process water	0.7	m^3	0.35	Mio.	m^3
Cooling water	0.2	m^3	0.1	Mio.	m^3
Spares and repair	0.4	US$	0.2	Mio.	US$
Other consumables	0.1	US$	0.05	Mio.	US$
Workforce	0.15	mhrs	30		men

Remark: All material flow figures contain approx. 5 % margin for handling losses.

1.3.4.2 Workforce Schedule, Coal Washing Plant Mchuchuma

(G = Graduated; S = Skilled; SS = Semi-Skilled; US = Unskilled)

Based on four shifts, the following personnel will be required inside plant section:

	Shift 1	Shift 2	Shift 3	Shift 4	Day Shift	Total	Qualification Level
Manager/Coal Washing Plant					1	1	G
Assistant manager					1	1	G
Shift foreman	1	1	1			3	S
Laboratory					1	1	S
Mech. Maintenance					2	2	S
Operators							
Crushing, storage	2	2	2			6	SS
Jigging	3	3	3			9	SS
Helpers							
Mech. Maintenance					2	2	US
El. Maintenance					1	1	US
Subtotal	6	6	6		8	26	
15 % Absentees	1	1	1		1	4	
Total	7	7	7		9	30	

1.3.4 Consumption Figures and Workforce Schedule

1.3.4.1 Consumption Figures

For the production of 500,000 tpy coal as reductant in the Mahanje DR-plant from raw coal of the Mchuchuma mine, the following specific consumption figures apply:

	per ton washed coal		per year		
Raw coal	1.9	t	950,000		t
Electric power	9	KWh	4,500		MWh
Process water	0.7	m^3	0.35	Mio.	m^3
Cooling water	0.2	m^3	0.1	Mio.	m^3
Spares and repair	0.4	US$	0.2	Mio.	US$
Other consumables	0.1	US$	0.05	Mio.	US$
Workforce	0.15	mhrs	30		men

Remark: All material flow figures contain approx. 5 % margin for handling losses.

S E C T I O N 1.3.5

Auxiliaries

1.3.5 Auxiliaries

All media and energy required inside plant section will be supplied by the corresponding central generating, storing and distributing system.

This mainly applies for

- electric energy,
- industrial water,
- cooling water,
- drinking water,

The corresponding systems are described and outlined - as applicable - under section 1.4.

SECTION 1.3.6

Outline Specification

Coal Washing Plant

1.3.6.1 Mechanical Equipment

Plant Sections

.1 Crushing, Screening and Storage

.2 Jigging and Dewatering

.3 Thickening and Process Water

.4 Coal Loading

.5 Cranes, Hoists, Plant Dewatering

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.1 Crushing, Screening and Storage

Plant section 1.3.6.1.1 mainly comprises the following items:

1 vibrating screen

for raw coal from mine,

design capacity	:	340	t/h
feed size	:	300 - 0	mm
scalping size	:	60	mm
screen size	:	1.4 x 4.5	m

1 two roll crusher

for raw coal,

crusher roll dia.	:	1,000	mm
crusher roll length	:	1,500	mm
design capacity	:	170	t/h
size of feed material	:	300 - 60	mm
size of discharge material	:	60 - 0	mm

3 belt conveyors
feeding the second screening stage,

design capacity	:	550	t/h

2 vibrating distributors

feeding the vibrating screens.

2 vibrating screens, second stage

design capacity	:	280	t/h
feed size	:	60 - 0	mm
scalping size	:	10	mm
screen size	:	3.0 x 4.5	m

2 vibrating feeders

feeding the impact mill.

1 impact mill

rotor dia.	:	1,600	mm
rotor length	:	2,100	mm
design capacity	:	220	t/h
feed size	:	60 - 10	mm
wanted size	:	10 - 0	mm

1 belt conveyor

with belt scale installed,
feeding the stock pile,

design capacity	:	340	t/h

1 stacker

for round stock pile,

pile foot width	:	27.5	m approx.
pile height	:	9.6	m approx.
outside dia. of stock pile	:	64	m approx.
design capacity	:	340	t/h

1 reclaimer

for round stock pile,

consisting of chain scraper, travelling portal frame, travelling rails, feed hopper.

1 belt conveyor

with belt scale installed, feeding the jigging section,

design capacity : 340 t/h

.2 Jigging and Dewatering

Plant section 1.3.6.1.2 mainly comprises the following items:

1 vibrating screen

for crushed raw coal,

design capacity	:	340	t/h
feed size	:	10 - 0	mm
scalping size	:	1	mm
screen size	:	3.6 x 5.25	m

1 jig

width	:	4.5	m
length	:	6.2	m

consisting of:

- water trough,
- jigging bed screens,
- outlets for tailings and middlings,
- end draw-off for coal,

- air vessels,
- pulsation valves and control,
- air pulsation chambers,
- dewatering bucket elevator for tailings and middlings,
- air compressor.

1 dewatering screen

for washed coal,

design capacity	:	170	t/h

1 centrifuge

for dewatering of washed coal,

design capacity	:	170	t/h

1 belt conveyor

for tailings and middling to the stockpile,

design capacity	:	170	t/h

1 belt conveyor

for washed coal to the stock pile,

design capacity	:	130	t/h

1 stacker

for round stock pile,

pile foot width	:	27.5	m approx.
pile height	:	9.6	m approx.
outside diameter of stock pile		64	m approx.
design capacity	:	130	t/h

1 reclaimer

for round stock pile,

consisting of chain scraper, travelling portal frame, travelling rails, feed hopper,

design capacity	:	360	t/h

.3 Thickening and Process Water

Plant section 1.3.6.1.3 mainly comprises the following items:

1 thickener

for fine coal slurry,

consisting of:

- thickener mechanism with rake arms,
- steel structure of thickener bridge,
- feed launder and feed wall,
- slurry discharge pipes,
- underflow collecting box,
- process water overflow weir,
- thickener drive and lifting device,

thickener dia. : 22 m

2 slurry pumps, (1 as stand-by), wear protected

for thickener underflow to the pond,

design capacity : 70 m³/h

1 process water basin

live volume : 300 m³ approx.

3 process water pumps, (1 as stand-by)

to supply the jigging plant,

design capacity : 700 m³/h

1 steady head tank

for process water,

life volume : 30 m^3 approx.

.4 Coal Loading

Plant section 1.3.6.1.4 mainly comprises the following items:

1 belt conveyor with belt scale installed

conveying washed coal from the stockpile to the loading station.

design capacity : 360 t/h

2 bins

for wagon loading,

life capacity : 1 of 150 t
1 of 40 t

.5 Cranes, Hoists, Plant Dewatering

Plant section 1.3.6.1.5 mainly comprises the following items.

2 cranes

for crushing and jigging section,

lifting capacity : 7.5 t

2 hoists

for maintenance,

lifting capacity : 2 t

5 dewatering pumps

for plant dewatering, vertical pumps.

1.3.6.2 Electrical Equipment

Plant equipment

.1 6.0 kV Medium High-Voltage Board

.2 380 V Low-Voltage Switchgear Boards

.3 Programmable Logic Control System

.4 Local Switchgear

.5 Power Transformers

.6 6000 V Medium High-Voltage Motors

.7 380 V Low-Voltage Motors

.8 Plant Lighting

.9 Cables

.10 Installation Material

.11 Intercommunication System

.12 Airconditioning Installation

.13 Ventilation System

.14 Grounding

A detailed description of the electric equipment listed above is given in section 2.3.6 of this volume.

1.3.6.3 Instrumentation Equipment

The instrumentation equipment for the coal washing plant mainly comprises:

- field instruments,
- local indicating measuring instruments,
- local measuring detectors,
- transmitters,
- panel instruments incl. indicating instruments and recorders,
- control room panels,
- auxiliary racks and cubicles,
- interfaces and power supply systems,
- all installation material like cables, wiring, fuses, etc.

A detailed description of the lay-out of this equipment is given in section 2.3.6 of this volume.

1.3.6.4 Structural and Civil Works

Main quantities for structural steel and civil works related to the Coal Washing Plant are as follows:

Structural Steel	1585	t
Bins	15	t
Roof and Wall Cladding	18265	m^2
Concrete	3850	m^3
Formwork	9395	m^2
Reinforcement	338	t
Excavation	20895	m^3

Price estimations for these works are based on information obtained from Mowlem International Ltd., London, based on the experiences gained with the Mufindi Pulp and Paper Mill.

SECTION 1.3.7

Investment Cost Estimate

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1.3.7 Investment Cost Estimate

- Coal Washing Plant -

The budgetary investment cost for the Coal Washing Plant, capable to produce 500,000 tpy of washed coal, are estimated as follows (based on the exchange rates: 1 US $ = 2.7 DM = 12.2 T.Sh.).

	approx. Mio. US $	approx. Mio. T.Sh.
- Plant Equipment delivered free site	4.1	50.0
- Erection, Supervision, Commissioning	1.1	13.4
- Civil Work and Steel Stucture, erected and painted	1.2	14.6
- Related Plant Infrastructure	0.7	8.5
Total Investment Cost	7.1	86.5
- Spare Parts for 2 years plant operation	0.4	4.9

This budget estimate is based on German prices and conditions and on cost factors ruling end of December 1983 for the equipment. It does not include any customs duty, taxes, dues or other levies which may arise outside the Federal Republic of Germany.

The estimation of the civil work and structural steel portion is derived from price information supplied by Mowlem International Ltd., London.

The estimation for plant equipment includes the cost for packing and the freight charges delivered free on site. Our budget prices are estimated on the assumption that all work can be performed continuously and in accordance with the time schedules contained in section IV/5.

This budget estimate is furthermore based on usual cash terms of payment, allowing an adequate down payment upon signing of contract and progress payments according to the progress of work in the engineering, manufacturing and erection.

All further terms and conditions will have to be agreed upon during the progress of contract negotiations.

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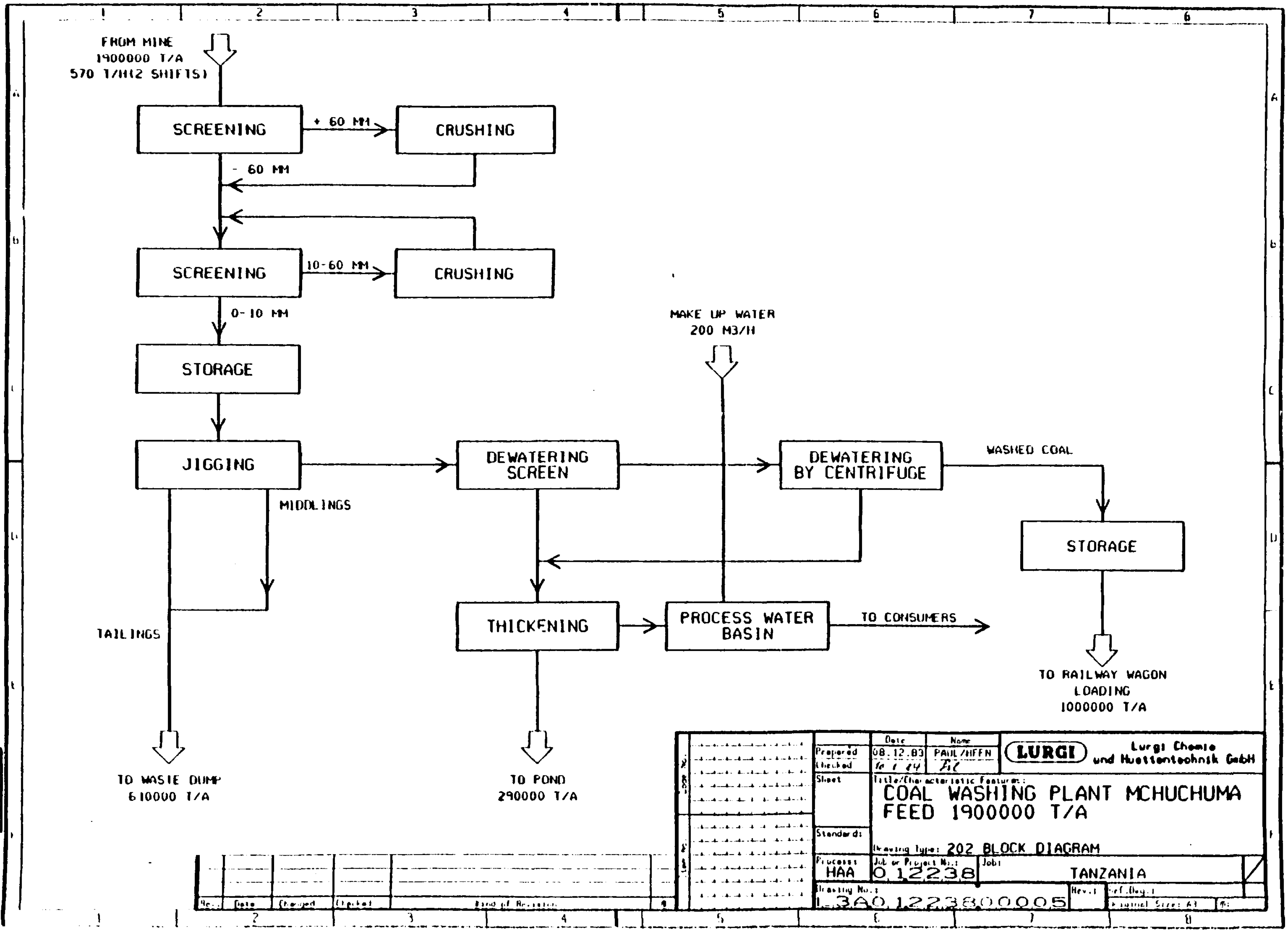
A N N E X

Expansion Step

1 Million tpy Steel


FROM MINE
1900000 T/A
570 T/H(2 SHIFTS)
SCREENING
+ 60 MM
CRUSHING
- 60 MM
SCREENING
10-60 MM
CRUSHING
0-10 MM
STORAGE
JIGGING
MIDDLINGS
TAILINGS
TO WASTE DUMP
610000 T/A
DEWATERING SCREEN
THICKENING
TO POND
290000 T/A
MAKE UP WATER
200 M3/H
PROCESS WATER BASIN
TO CONSUMERS
DEWATERING BY CENTRIFUGE
WASHED COAL
STORAGE
TO RAILWAY WAGON LOADING
1000000 T/A
Prepared
Checked
Date
Name
08.12.83
PAUL/HFFN
LURGI
Lurgi Chemie und Huettentechnik GmbH
Title/Characteristic Features:
COAL WASHING PLANT MCHUCHUMA
FEED 1900000 T/A
Drawing Type: 202 BLOCK DIAGRAM
Process: HAA
Job or Project No.: 0 12238
Job: TANZANIA
Drawing No.: 1 3A0 12238 00005
Rev.
Date
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Checked
Kind of Revision

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Section 1.4

Off-sites and Auxiliaries "Mchuchuma"

S E C T I O N 1.4.1

Description of Facilities

1.4 Off-Sites and Auxiliaries

The Mchuchuma-complex comprises the following plants:

- underground coal mine,
- coal washing plant.

The plants have for full functioning their own infrastructure facilities which are described below.

1.4.1.1 Water Supply and Waste Water Treatment

Raw water will be taken from the river approx. 2.5 km west of the plant. The water will be pumped via a pipe-line to the Mchuchuma-complex where it is stored and treated for the use as:

- industrial water,
- drinking water.

For supply and treatment of water, the following described equipment will be used:

1 river water intake station
concrete design,

2 vertical water pumps (1 as stand-by)
installed in river water intake station,
capacity : 350 m³/h

1 river water basin
concrete design,
volume : approx. 350 m³

2 vertical water pumps (1 as stand-by)
pumping the water to the plant,
capacity : 350 m³/h

1 drainage pump
submersible pump, wear protected

1 pipeline
from river water basin to the water tank,

1 water tank
for fresh water, installed near the plant,
volume : 2000 m³
material : mild steel

1 <u>water treatment station</u>
to prepare potable water,
max. capacity : 60 m³/h

1 <u>water treatment station</u>
for sewage water.

1.4.1.2 Electric Energy Distribution System

The electric energy supplied by the 220 kV overhead transmission line, will be distributed on a 220 kV switchyard with a double busbar system for the Mchuchuma area. The complete switchyard is formed by two incoming overhead line bays, two outgoing overhead line bays and two distribution bays for transformers. Two 220/6 kV step-down transformers will be provided. The busbar system will consist of stranded aluminium conducts for rated current complete with strain and midspan busbar steelstructure as well as insulators and clamps, suitable to accommodate the required number of bays. The individual overhead line bays will consist of SF6 circuit breaker, motor operated line isolators, current transformers.

A 6 kV-switchgear-plant, supplied by the step-down transformers, will distribute the electric energy to the individual plants and off-sites.

1.4.1.3 Site Administration

All the site administration clerical services for the plant will be performed like

- personnel administration,
- offices for salaries and wages,
- bookkeeping of production figures,
- bookkeeping of consumption figures for utilities, wear and spare parts, consumables etc.
- ordering of material.

The office building will be outfitted with room for conferences, furniture, lavatories etc.

Adjacent to the office building, a building for canteen, first aid and change house will be erected for the personnel of the mine and coal washing plant. It will be outfitted with furniture, lavatories and with all kitchen accessories. The canteen will be air-conditioned.

1.4.1.4 Central Workshop

The central workshop has to perform repair and maintenance work for the underground mine and coal washing plant.
The overall measures of the building will be 50 x 30 m, 11 m high. It consists of the following departments:

- mechanical workshop, equipped with necessary workbenches, machine tools and lifting facilities,
- electrical workshop, equipped with the necessary work benches, machines and tools,
- sanitary room for workshop personnel.

1.4.1.5 <u>Central Laboratory</u>

The central laboratory will perform for the mine and coal washing plant all physical and chemical analysis for operation control and product quality control.

The physical analyses comprise mainly determination of grain sizes, moisture etc. The chemical analyses comprise determination of ash content, volatile matter, moisture, heating value, caking indices and elementary analyses.

The central laboratory will be outfitted with the necessary instruments, equipment and materials.

The overall measures for the building of laboratory and drill core storage will be 10 x 15 m², 3 m high.

As far as necessary, the rooms will be equipped with air-conditioners.

1.4.1.6 <u>Central Magazine</u>

The central magazine is provided for consumables, spare and wear parts for the mine and coal washing plant. Shelving and cabinets of various types are provided to allow clear storage of all parts.

The building dimensions will be 40 m x 15 m, 4.2 m high.

1.4.1.7 Fire Fighting and Ambulance

A fire fighting station will be equipped with one fire engine and the necessary fire fighting accessories.

Some rooms will be provided as ambulance with the necessary equipment for first aid.

1.4.1.8 Petrol Station and Car Service

At the car service station, the company cars will be maintained. The workshop is outfitted with hydraulic lifting device, work benches, tools and necessary equipment.

The petrol station has tanks and pumps for diesel oil and petrol.

The following vehicles belong to the fleet:

1 fork lift truck

capacity: 2 t

1 front-end loader

capacity: 2 m^3

1 flat bed truck

capacity: 3 t

1 pick-up truck

capacity: 1.5 t

3 land cruiser jeeps

1 truck

capacity: 20 t

1.4.1.9 Explosive Store

Overall dimensions 10 x 5 m, 3.5 m high, located separately from main social buildings for safety reasons.

1.4.1.10 Structural and Civil Works - Summary

Main quantities for structural steel and civil works related to Off-sites "Mchuchuma" are as follows:

Concrete	6600	m^3
Formwork	20145	m^2
Reinforcement	560	t
Excavation	33260	m^3

Price estimation for these works are based on information obtained from Mowlem International Ltd., Londond, based on the experiences gained with the Mufindi Pulp and Paper Mill.

S E C T I O N 1.4.2

Workforce Schedule

1.4.2 Workforce Schedule

For the various facilities, described in this section, the following workforce requirements can be estimated.

(G = Graduated; S = Skilled; SS = Semi-Skilled; US = Unskilled)

Item	G	S	SS	US	Total
Water supply and treatment	1	4	8	8	21
Electric energy supply		1	2	1	4
Site administration	1	1	4	1	7
Canteen change house		1	6	6	13
Central workshop	incl. in personnel of plants				
Central laboratory	incl. in personnel of plants				
Central magazine	-	1	5	4	10
Fire fighting and ambulance	-	2	5	2	9
Petrol and service station	-	3	5	2	10
Guard	-	-	2	10	12
Explosive Store	-	-	4	4	8
Subtotal	2	13	41	38	94
15 % Absentees	-	2	6	5	13
Total	2	15	47	43	107

S E C T I O N 1.4.3

Investment Cost Estimate

1.4.3 Investment Cost Estimate

- Off-sites and Auxiliaries "Mchuchuma" -

The budgetary investment cost for the Off-sites and Auxiliaries "Mchuchuma" are estimated as follows (based on the exchange rates: 1 US $ = 2.7 DM = 12.2 T.Sh.).

	approx. Mio. US $	approx. Mio. T.Sh.
- Plant Equipment delivered free site	11.8	144.0
- Erection, Supervision, Commissioning	3.6	43.9
- Civil Work and Steel Stucture, erected and painted	3.9	47.6
- Related Plant Infrastructure	0.8	9.8
Total Investment Cost	20.1	245.3
- Spare Parts for 2 years plant operation	0.6	7.3

This budget estimate is based on German prices and conditions and on cost factors ruling end of December 1983 for the equipment. It does not include any customs duty, taxes, dues or other levies which may arise outside the Federal Republic of Germany.

The estimation of the civil work and structural steel portion is derived from price information supplied by Mowlem International Ltd., London.

The estimation for plant equipment includes the cost for packing and the freight charges delivered free on site. Our budget prices are estimated on the assumption that all work can be performed continuously and in accordance with the time schedules contained in section IV/5.

This budget estimate is furthermore based on usual cash terms of payment, allowing an adequate down payment upon signing of contract and progress payments according to the progress of work in the engineering, manufacturing and erection.

All further terms and conditions will have to be agreed upon during the progress of contract negotiations.

Section 2

Liganga Iron Ore

LURGI

Section 2.1

General Aspects

2.1 General Aspects

2.1.1 History of developments and investigations

The titano-magnetite deposit of Liganga is known since 1903 by the German geologist Dantz. Later on, in 1929, a brief reference to the Liganga occurrences was made by C. Gillman. Geological surveys were carried out in the following years. The results of this work are published in Bulletin No. 18 (Stockley 1948) of the Tanganyika Geological Survey.
From 1949 onwards, regional geological mapping has been carried out by Harpum and Haldermann of G.S.T.

In 1952, Ventures Ltd. of Canada became interested in the iron ore occurences. In 1952, the Liganga deposit was visited by Dr. W. Gross and Dr. C. Hitschen. The reserves of iron ore, mined by open-cut methods, was estimated to be 8 to 9.5 mio short tons at that time.

In the years 1952 - 1956, additional geological work was carried out. A new reserve estimate was given by Handley (1952) of the G.S.T. ending up with 24 mio. tons of ore. Magnetometer surveys were carried out by Union Corporation Ltd. The Liganga Iron Ore occurences were verified but no further important magnetic occurences were found.

From 1956 -1957, a more detailed exploration programme was carried out by the G.S.T including trenching, pitting and drilling. Four individual deposits, Maganga Matitu, Central area and Liganga were investigated. Altogether, 28 holes, totalling 9,460 feet (2,883 m) were drilled and cored. Drill indicated tonnage of 44.6 mio. tons averaging 48.4 % Fe, 12.8 % TiO_2 and 0.67 % V_2O_5 were determined.

Feasibility studies on Liganga iron ore started way back in 1971. Norad of Norway appointed Norconsults A.S. for the execution of the study on various technical possibilities of making pig iron and steel with Liganga iron ore and Mchuchuma Coal. Samples of 700 kg and 150 tons were taken from Liganga Hill and metallurgically tested in Sweden (Gränges Steel), Norway (Elkem) and Germany (Lurgi). It was concluded that the Elkem process can be adopted. The Elkem process is high electric power consuming. No exact suggestions regarding Lurgi's SL/RN-process were made.

A second feasibility study of the possibility of establishing an iron and steel industry on the basis of Liganga Iron Ore and Mchuchuma Coal was carried out by a consortium of the German companies Dr. Otto Gold, RODECO and Saarberg-Interplan in the years 1977 -1979. Investigations in the field of concentration, pelletizing and reduction of the respective raw materials were carried out by Lurgi and Krupp. Overall, the study confirmed the possibility of using the solid reduction method. A thorough market survey was not included within this study.

In October 1982, UNIDO authorized Lurgi Chemie und Hüttentechnik GmbH under the project No. SM/URT/81/004 to carry out a Techno-Economic Evaluation and Project Report for the Establishment of an Iron and Steel Industry in The United Republic of Tanzania. According to the terms of reference for this study, metallurgical testwork had to be carried out in the Lurgi Research Centre, Frankfurt, with representative samples of raw materials to be collected and sent by the National Development Corporation, Dar es Salaam, Tanzania.

About 4 tons of iron ore were sampled from Liganga and about 1.2 tons from Maganga. The samples were taken from big lumps near the solid iron ore outcrops.

2.1.2 Geological setting

Iron ore is outcropping with a cristalline series of Precambrian age in four main areas in the Njombe district:

- Liganga Hill,
- Central Hill,
- Maganga Hill,
- Maganga Matitu Hill

All iron ore outcrops are situated within a few kilometres and related to a small NNW-SSE striking geological structure of about 20 km length. The rock series consists of medium basic meta- to ortho-rocks such as norites, gabbros and anortosites. Magnetites and in particular titano-magnetites are locally concentrated in lenses and/or seamlike segregations during the first stage of cristallization. The centre of the cristalline rock complex is occupied by a morphologically remarkable ridge with individually superimposed hilltops and steeply protruding cliffs of massive iron ore.

The deposit represents overthrusted ore blocks which are dipping between 60 ° and 80 °.

LURGI

2.1.3 Mineralogical and chemical composition of the iron ore

The titaniferrous magnetite deposits of Liganga have been formed by differentiation processes in a parent basic magma. It is a hard dense type of iron ore, strongly magnetic.
The ore bodies are sharply delimited from the country rock anothosite and minor occurrences of chlorite shists.

By microscopic examination of the ore, the following mineral constituents were identified:

53 % Vol.	Magnetite	ore minerals
22 % Vol.	Ilmenite	
10 % Vol.	Spinel	gangue
13 % Vol.	Chlorite	
2 % Vol.	Garnet, Pyrite, Sec. Hematite, Dolomite,	

Magnetite-Fe3O4 (72.4 % Fe) is the most abundant mineral present. It occurs in the steel grey masses with metallic lustre and cleavage. In general, there are no crystal boundaries. Inclusions of other minerals are usually present in the magnetite.

Ilmenite-Fe TiO_3 (47.3 % FeO, 52.6 % TiO_2) occurs in three textural habits. Etched polished sections show large anhedral ilmenite grains, about 4 x 12 mm. Within the magnetite, ilmenite forms grains and lamellae. Typical lamellae twinning of ilmenite can be observed.

Spinel (FeAl Cr_2O_4) occurs in the variety of chromite hercanite with an iron content of up to 15 %. The mineral builds up large, black, subhedral crystals, up to 5 mm in diameter.

Chlorite is the principal gangue mineral. It forms a complex hydrous silicate of aluminium, magnesium or ferrous iron. It is present in the magnetite groundmass as high-green wisps and stringers. Chlorite bands, up to several centimeters in width, often associated with porphyroblastic garnets, occupy fracture-planes in the magnetite.
The formation of chlorite is a late phase of mineralization. Intense chloritization of the country rock near the magnetite bodies is obvious at Liganga.

The chemical composition of the ore was determined several times. The analyses, on which the processes of this study are based, are as follows:

Constituents %	Liganga	Maganga	Mixture 1 : 1 Liganga/Maganga
Fe-tot. %	51.8	50.1	51.4
Fe" %	18.1	10.1	16.9
TiO_2 %	12.9	12.9	12.9
V_2O_5 %	0.48	0.50	0.49
CaO %	0.01	0.01	0.01
SiO_2 %	0.61	2.18	0.90
MgO %	4.8	4.7	4.8
Al_2O_3 %	8.8	8.9	8.85
Mn %	0.21	0.20	0.21
Ni %	0.10	0.09	0.10
P %	- 0.01	- 0.01	- 0.01
Cr %	0.16	0.21	0.19

2.1.4 Ore reserves

The only available data to determine the iron ore reserves are from the drilling investigations of the geological Survey of Tanganyika dated back to 1958. No further exploration work was carried out in Liganga.

It has to be clearly stated that the "drill indicated reserves" are not-proved reserves which should be the only base for further mine planning.

Anyhow, a new calculation of minable reserves was done as a base for this study.

Level m	Area m²	Ore Volume m³	Ore Volume t	Waste Volume m³	Waste Volume t
1775	2,297	19,130	86,850	-	-
1762.5	9,060	75,480	342,670	3,080	8,600
1750	11,960	99,620	452,280	27,000	75,890
1737.5	15.972	133,040	604,000	118,120	330,740
1725	19,820	165,080	749,450	274,100	767,480
1712.5	22,800	189,940	862,340	419,340	1,174,150
1700	25,480	212,270	963,690	600,300	1,680,840
1687.5	27,041	225,250	1,022,640	854,130	2,391,610
1675	32,010	266,610	1,210,410	1,107,830	3,101,920
1662.5	39,040	325,180	1,476,300	1,134,070	3,175,380
1650	45,470	378,760	1,719,570	1,102,000	3,085,490
1637.5	51,980	432,980	1,965,720	1,076,800	3,015,050
1625	56,160	467,800	2,123,800	1,091,540	3,059,130
1612.5	58,190	484,700	2,200,550	1,037,980	2,906,350
1600	58,000	483,120	2,193,370	967,450	2,709,850
1587.5	57,650	480,200	2,180,120	916,240	2,565,480
1575	57,520	479,120	2,175,190	781,650	2,188,620
1562.5	57,710	480,730	2,182,500	619,930	1,735,800
1550	57,180	476,370	2,162,720	462,046	1,293,730
1537.5	56,690	472,210	2,143,850	311,660	872,630
1525	56,640	471,840	2,142,140	182,020	509,660
Total:		6,819,430	30,960,160	13,087,290	36,648,400

Following the drilling results, the geological mapping of the surface and taking into consideration the general geology of similar types of ore deposits, new 15-cross-sections were drawn for the Liganga ore block.

The ore reserves were calculated to a depth of 1,525 m per 12.5 m level using the rule of Simpson:

$$I = \frac{h}{6} \quad (F_1 + 4\ F_2 + F_3)\ (m^3)$$

I = Volume;
h = width between F1 and F3
F1 = crossection 1 (upper)
F2 = crossection 2 (middle)
F3 = crossection 3 (lower)

To calculate the minable ore reserves of the other occurences, not sufficient data are available.

For the density of the ore, an amount of 4.54 t/m^3 was determined. Total ore reserves calculated for Liganga, are 30,960,000 metric tons.

For the planned steel production of 500,000 tons/year, the yearly ore production is 1,550,000 tons/year.

Minable ore reserves amount to 29,400,000 tons. This means a lifetime of the Liganga deposit of 19 years.

2.1.5 Further exploration

In order to prove the ore reserve situation for all four localities Maganga, Liganga, Central hill and Maganga Matitu, further exploration work is strongly recommended. The relatively best investigated ore body is Liganga but also, to confirm this reserve situation, several new drillings have to be done.

All drillings should be done under different angles, to cut the ore body in different levels. For instance, from the point of the old drilling G.S.X 10/57 a new drilling of about 150 m length and under 30 ° should be done in order to prove the continuation of the ore body. The old drilling G.S.X.9/57 was drilled horizontally, cutting only a small perhaps isolated ore block. By driling under an angle of 30 ° from the same surface position, the continuation of this ore block can be checked and by drilling 150 m instead of 54 m, as done previously, the main ore block can be perforated in the level of about 1,550 m.

Tanzania/Volume II

S E C T I O N 2.2

Iron Ore Mine

S E C T I O N 2.2.1

Description

Mine Layout

2.2.1 Mine Layout

The ore body of Liganga and the necessary waste will be mined conventionally, that means ore and waste will be broken into pieces by drilling and blasting to be capable for loading. The ore and waste will be loaded by diesel powered hydraulic excavators (226 kW respt. 496 kW) into trucks (35 t respt. 50 t) and transported to the ore crusher and to the outside dump respectively.

Drawing 2.2/15 shows an overall map of the planned open pit, the travelling roads for the trucks, the location of the beneficiation plant and the outside dump.

The mining shall proceed by means of 12.5 m high benches from the top to the bottom. Drawings 2.2/16-2.2/19 show the open pit configurations in five years steps until reaching the deepest level at +1525 m with approach ramp.

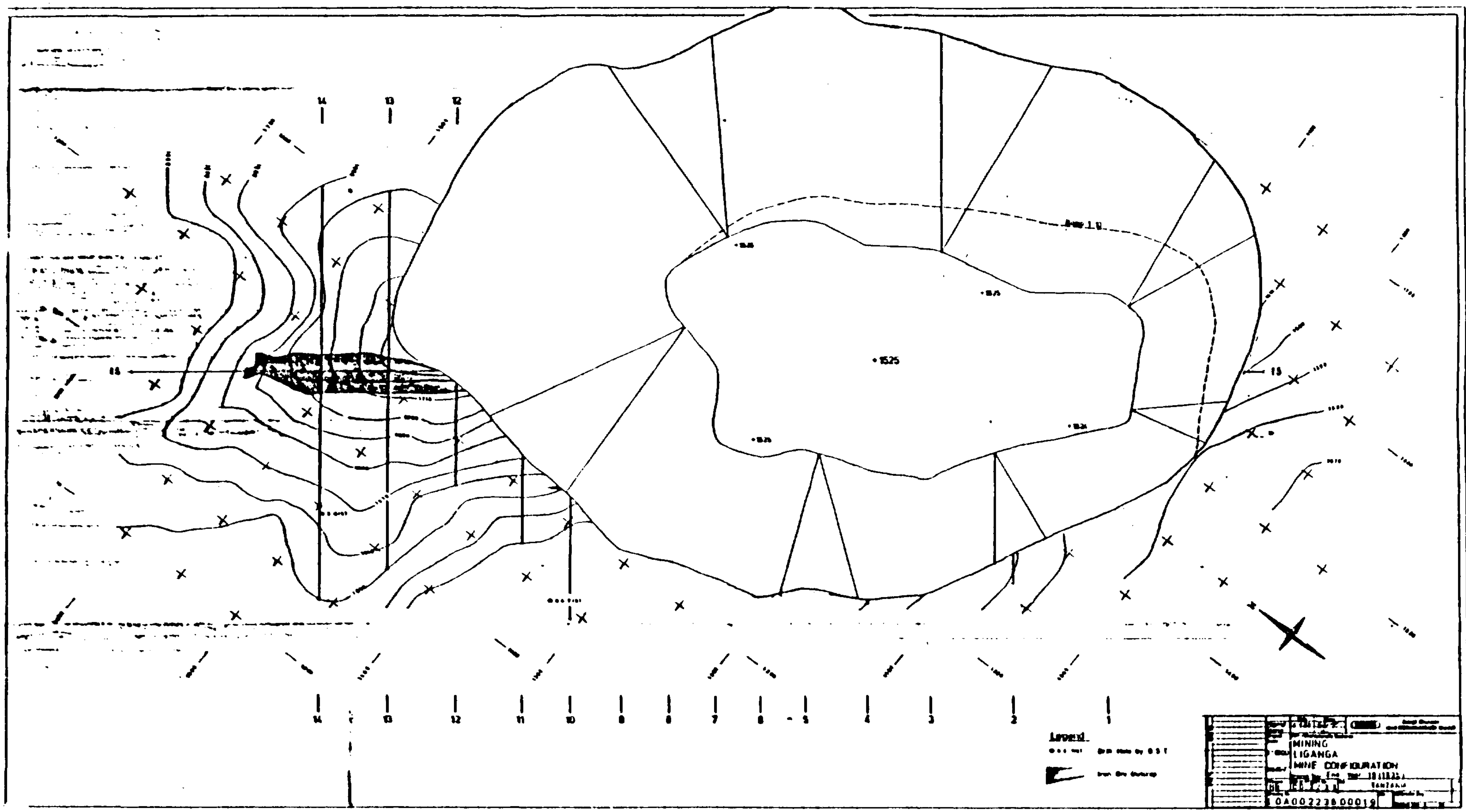
The calculation of the ore reserves and the related waste was done due to the mining face advance, the crossections and the longitudiual section.
Drawings 2.1/6-14 show the ore body and the general indication of the slope. The results of the calculation of the masses are shown under chapter 2.1.4. 5 % of mining losses are taken into consideration.

Before starting the regular mining operation roads have to be built from the ore body to the beneficiation plant to the surface installations and to the outside dump. Because this has to be done by the mining company with their own equipment, the necessary machines have to be bought one year in advance (investment schedule year - 1). At the same time the peaks above level +1750 of the ore body must be capped by daywork.

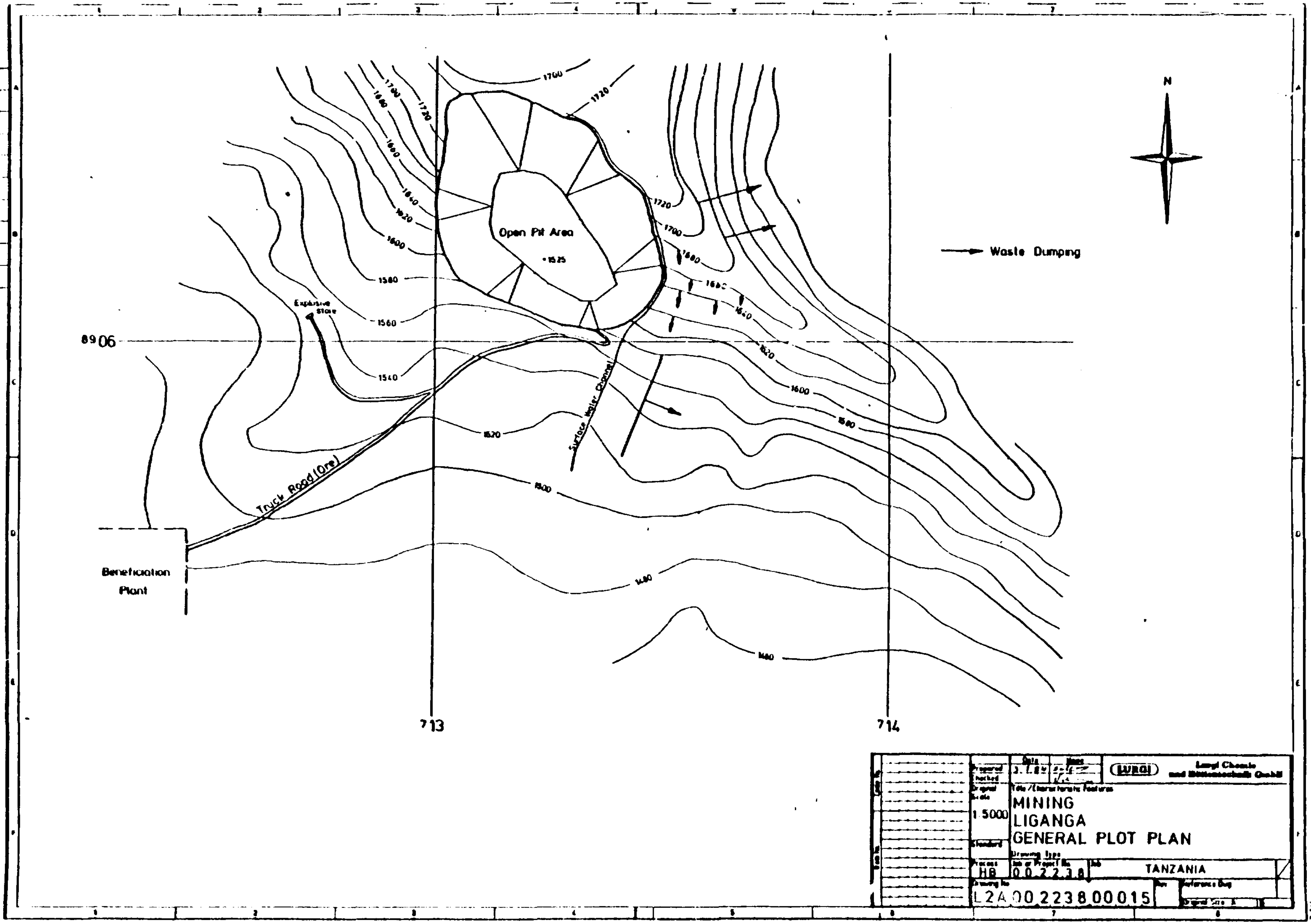
In the first year the scheduled drillingwork will start from level +1750 m down to level +1737,5 m. From here the trucks will be loaded by hydraulic excavators.

The outside dump will be operated during the whole lifetime of the Liganga open pit. An inside dump cannot be established due to shortage of space.

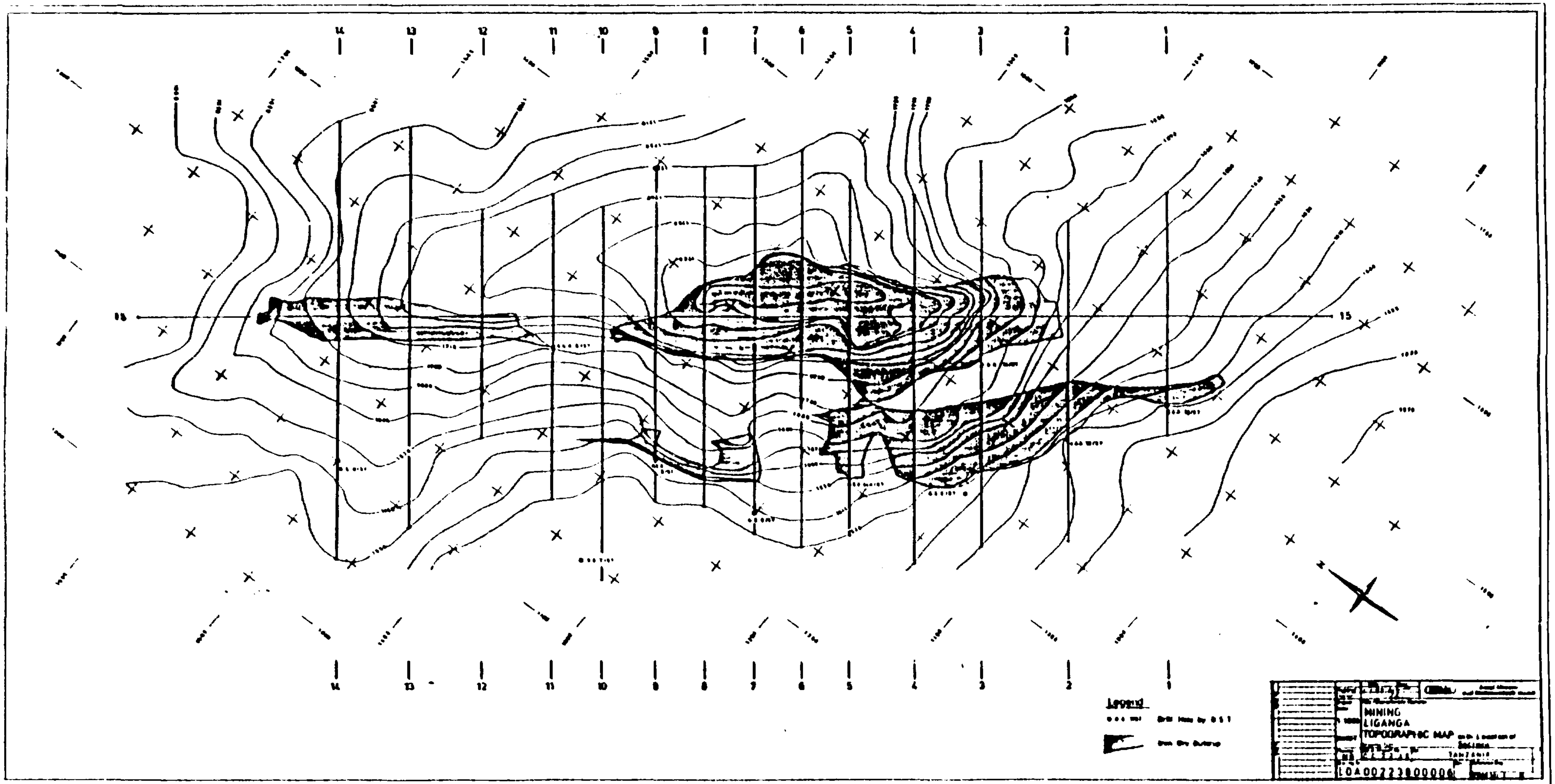
The reserves of the ore block Liganga down to the level of +1525 m are sufficent for a lifetime of the mine of 19 years (alternative 1) and for 9 years (alternative 2). Further explorationwork should investigate the lower part of the Liganga ore block and the other ore blocks of Maganga, Central Hill and Maganga Matitu in the near surrounding. The necessary planning, prestripping and road construction for these ore reserve blocks should be done simultanously to the Liganga mining operation.



+1525
MINING
LIGANGA
MINE CONFIGURATION
10A00223800019



N
Waste Dumping
Open Pit Area
+1525
Explosive Store
Truck Road (Ore)
Surface Water Channel
Beneficiation Plant
8906
713
714
1700
1720
1680
1660
1640
1620
1600
1580
1560
1540
1520
1500
1480
1460
Lurgi Chemie und Hüttentechnik GmbH
LURGI
Original Scale 1:5000
MINING
LIGANGA
GENERAL PLOT PLAN
HB
0 0 2 2 3 8
TANZANIA
L2A 00 2238 00015


Legend
MINING
LIGANGA
TOPOGRAPHIC MAP
TANZANIA
LOA00223800006

S E C T I O N 2.2.2

Raw Materials and Products

2.2.2 Raw Materials and Products

2.2.2.1 Raw Materials

Raw material for the iron ore mining is the Liganga-Maganga- and Central Hill iron ore.

$Fe_{tot.}$	:	50.1 - 51.8 %
Fe"	:	10.1 - 18.1 %
TiO_2	:	12.9 %
V_2O_5	:	0.48 - 0.50 %
SiO_2	:	0.61 - 2.18 %
CaO	:	0.01 %
MgO	:	4.7 %
Al_2O_3	:	8.8 - 8.9 %
Mn	:	0.20 - 0.21 %
Ni	:	0.09 - 0.1 %
P	:	0.01 %
Cr	:	0.16 - 0.21 %
Moisture	:	5 %
Density	:	4.54 t/m^3

2.2.2.2 Products

Iron Ore

Size : 400 x 400 x 400 mm min.
800 x 800 x 800 mm max.

Bulk Density : 3 t/m^3

Chemical analysis as above.

Quantity : 1,560,000 tpy

Waste

During mining operation, waste of different amounts is produced in a range of 250,000 m^3/a in the beginning of the operation and 3,000,000 m^3/a at the end of mining activities.

Size : 600 x 600 x 600 mm max.

Moisture : 8 % approx.

S E C T I O N 2.2.3

Consumption Figures

and

Workforce Schedule

2.2.3 Consumption Figures and Workforce Schedule

2.2.3.1 Consumption Figures

Basis for the consumption figures of diesel fuel, drilling bits, explosives (ANFO), tires, power and spare parts are the number of drilling rigs, excavators, trucks and other auxiliary equipment, which will be shown in the following chapters.

The following basic data are assumed:

- two shifts per day open pit operation
- 4200 operating hours, per year
  (300 working days with 2 shifts, 7 hours each)
- crown life per bit 200 m
- explosive consumption 500 g/m3
  (for blasting accessories 20 % are added)
- lifetime of truck tires 4000 h
- electricity consumption about 1500 kW
  application of load 66 %
  during 2100 operational hours per year

The diesel fuel consumption was computed for average travel roads.

The spare part supply was estimated as a percentage of the investment costs related to the work load. The first procurement of spare parts was calculated with about 10 % of the initial investment and drawn up under the position "various" within the investment lists.

List of Consumption Figures

Year	Drill Sites (Pieces)	Explosives (Slurry) (t)	Fuel incl.Lubr. (1000 l)	Tires 18.00-33(28PR) (Sets)	Power 10^5 kWh	Spare Parts 10^6 TSh
-1	220	227.9	750.0	2	-	1.384
1	247	244.6	1 992.0	5	2.1	2.245
2	382	378.7	2 373.1	6	2.1	2.522
3	512	506.7	2 770.2	8	2.1	2.332
4	543	538.0	2 847.5	8	2.1	2.332
5	544	538.6	2 719.7	7	2.1	3.088
6	544	538.9	2 685.7	7	2.1	3.088
7	552	546.7	2 767.0	7	2.1	3.088
8	537	531.3	2 660.0	7	2.1	3.088
9	549	543.7	2 798.2	8	2.1	3.088
10	568	562.7	2 796.8	9	2.1	3.088
11	595	589.7	2 378.3	9	2.1	3.088
12	631	625.3	3 178.1	8	2.1	3.088
13	647	640.3	3 326.6	9	2.1	3.088
14	669	662.5	3 429.3	9	2.1	3.088
15	697	690.1	3 575.0	10	2.1	3.088
16	728	721.0	3 792.6	11	2.1	3.088
17	752	744.6	3 935.7	11	2.1	3.088
18	780	772.3	4 016.8	12	2.1	3.088
19	798	790.2	4 296.3	13	2.1	3.088
20	798	790.2	4 296.3	13	2.1	3.088

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2.2.3.2 Workforce Schedule

In the following the workforce schedules for 19 years of operation have been computed. With mining activities proceeding over the years, workforce requirements increase as do consumption figures listed before, due to longer transport distances, transporting times with correspondingly increased number of trucks in order to maintain a constant material flow.

The personnel necessary for the two shift operation of the open pit is listed in the following tables.

For the absence of personnel due to holiday and illness a reduction of 15 % was taken into account.

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STAFF REQUIREMENT

Liganga Iron Ore Mine - Year -1

Production personnel	Shift 1	Shift 2	Education G/HS	Education SS	Education US
Managing director	1		x		
Deputy managing director	1		x		
Mining engineer	1		x		
Secretary	1			x	
Technician	1			x	
Typist	1			x	
Foreman drilling	1			x	
Foreman blasting	1			x	
Foreman loading	1			x	
Foreman haulage	1			x	
Accountant	1		x		
Clerks	1				x
Operator blasthole drill	1			x	
Helper blasthole drill	2				x
Blaster	1			x	
Helper blasting	3				x
Operator excavator	2			x	
Truck driver	8			x	
Operator aux. equipment	11			x	
Helper aux. equipment	5				x
Maintenance personnel					
Mechanical engineer	1		x		
Foreman trucks, vehicles	1			x	
Foreman excavator	1			x	
Mechanics	8			x	
Mechanics, Helpers	12				x
Electricians	2			x	
Electricians, Helpers	4				x
Subtotal	74				
+ 15 % Absentees	11				
Total	85				

STAFF REQUIREMENT

Liganga Iron Ore Mine - Year 1

Production personnel	Shift 1	Shift 2	Education G/HS	Education SS	Education US
Managing director	1		x		
Deputy managing director	1		x		
Mining engineer	1		x		
Secretary	1			x	
Technician	1			x	
Typist	1			x	
Foreman drilling	1			x	
Foreman blasting	1			x	
Foreman loading	1	1		x	
Foreman haulage	1	1		x	
Accountant	1		x		
Clerks	3				x
Operator blasthole drill	2	2		x	
Helper blasthole drill	4	4			x
Blaster	2			x	
Helper blasting	4				x
Operator excavator	3	3		x	
Truck driver	8	8		x	
Operator aux. equipment	11	5		x	
Helper aux. equipment	5	2			x
Maintenance personnel					
Mechanical engineer	1		x		
Foreman trucks, vehicles	1	1		x	
Foreman excavator	1			x	
Mechanics	7	4		x	
Mechanics, Helpers	14	8			x
Electricians	2	1		x	
Electricians, Helpers	4	2			x
Subtotal	83	42			
+ 15 % Absentees	13	7			
Total	96	49			

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STAFF REQUIREMENT

Liganga Iron Ore Mine - Year 2

Production personnel	Shift 1	Shift 2	Education G/HS	Education SS	Education US
Managing director	1		x		
Deputy managing director	1		x		
Mining engineer	1		x		
Secretary	1			x	
Technician	1			x	
Typist	1			x	
Foreman drilling	1			x	
Foreman blasting	1			x	
Foreman loading	1	1		x	
Foreman haulage	1	1		x	
Accountant	1		x		
Clerks	3				x
Operator blasthole drill	2	2		x	
Helper blasthole drill	4	4			x
Blaster	3			x	
Helper blasting	5				x
Operator excavator	3	3		x	
Truck driver	10	10		x	
Operator aux. equipment	11	5		x	
Helper aux. equipment	5	2			x
Maintenance personnel					
Mechanical engineer	1		x		
Foreman trucks, vehicles	1	1		x	
Foreman excavator	1			x	
Mechanics	8	5		x	
Mechanics, Helpers	18	10			x
Electricians	2	1		x	
Electricians, Helpers	4	2			x
Subtotal	92	47			
+ 15 % Absentees	14	7			
Total	106	54			

STAFF REQUIREMENT

Liganga Iron Ore Mine - Year 3

Production personnel	Shift 1	Shift 2	Education G/HS	Education SS	Education US
Managing director	1		x		
Deputy managing director	1		x		
Mining engineer	1		x		
Secretary	1			x	
Technician	1			x	
Typist	1			x	
Foreman drilling	1			x	
Foreman blasting	1			x	
Foreman loading	1	1		x	
Foreman haulage	1	1		x	
Accountant	1		x		
Clerks	3				x
Operator blasthole drill	3	3		x	
Helper blasthole drill	6	6			x
Blaster	3			x	
Helper blasting	5				x
Operator excavator	3	3		x	
Truck driver	12	12		x	
Operator aux. equipment	11	5		x	
Helper aux. equipment	5	2			x
Maintenance personnel					
Mechanical engineer	1		x		
Foreman trucks, vehicles	1	1		x	
Foreman excavator	1			x	
Mechanics	10	6		x	
Mechanics, Helpers	21	12			x
Electricians	2	1		x	
Electricians, Helpers	4	2			x
Subtotal	102	55			
+ 15 % Absentees	15	8			
Total	113	63			

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STAFF REQUIREMENT

Liganga Iron Ore Mine - Year 4

Production personnel	Shift 1	Shift 2	Education G/HS	Education SS	Education US
Managing director	1		x		
Deputy managing director	1		x		
Mining engineer	1		x		
Secretary	1			x	
Technician	1			x	
Typist	1			x	
Foreman drilling	1			x	
Foreman blasting	1			x	
Foreman loading	1	1		x	
Foreman haulage	1	1		x	
Accountant	1		x		
Clerks	3				x
Operator blasthole drill	3	3		x	
Helper blasthole drill	6	6			x
Blaster	3			x	
Helper blasting	5				x
Operator excavator	3	3		x	
Truck driver	12	12		x	
Operator aux. equipment	11	5		x	
Helper aux. equipment	5	2			x
Maintenance personnel					
Mechanical engineer	1		x		
Foreman trucks, vehicles	1	1		x	
Foreman excavator	1			x	
Mechanics	10	6		x	
Mechanics, Helpers	21	12			x
Electricians	2	1		x	
Electricians, Helpers	4	2			x
Subtotal	102	55			
+ 15 % Absentees	16	8			
Total	113	63			

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STAFF REQUIREMENT

Liganga Iron Ore Mine - Year 5 - 11

Production personnel	Shift 1	Shift 2	Education G/HS	Education SS	Education US
Managing director	1		x		
Deputy managing director	1		x		
Mining engineer	1		x		
Secretary	1			x	
Technician	1			x	
Typist	1			x	
Foreman drilling	1			x	
Foreman blasting	1			x	
Foreman loading	1	1		x	
Foreman haulage	1	1		x	
Accountant	1		x		
Clerks	3				x
Operator blasthole drill	3	3		x	
Helper blasthole drill	6	6			x
Blaster	3			x	
Helper blasting	5				x
Operator excavator	3	3		x	
Truck driver	12	12		x	
Operator aux. equipment	11	5		x	
Helper aux. equipment	5	2			x
Maintenance personnel					
Mechanical engineer	1		x		
Foreman trucks, vehicles	1	1		x	
Foreman excavator	1			x	
Mechanics	10	6		x	
Mechanics, Helpers	21	12			x
Electricians	2	1		x	
Electricians, Helpers	4	2			x
Subtotal	102	55			
+ 15 % Absentees	16	8			
Total	118	63			

STAFF REQUIREMENT

Liganga Iron Ore Mine - Year 12

Production personnel	Shift 1	Shift 2	Education G/HS	Education SS	Education US
Managing director	1		x		
Deputy managing director	1		x		
Mining engineer	1		x		
Secretary	1			x	
Technician	1			x	
Typist	1			x	
Foreman drilling	1			x	
Foreman blasting	1			x	
Foreman loading	1	1		x	
Foreman haulage	1	1		x	
Accountant	1		x		
Clerks	3				x
Operator blasthole drill	3	3		x	
Helper blasthole drill	6	6			x
Blaster	3			x	
Helper blasting	5				x
Operator excavator	3	3		x	
Truck driver	13	13		x	
Operator aux. equipment	11	5		x	
Helper aux. equipment	5	2			x
Maintenance personnel					
Mechanical engineer	1		x		
Foreman trucks, vehicles	1	1		x	
Foreman excavator	1			x	
Mechanics	10	7		x	
Mechanics, Helpers	21	15			x
Electricians	2	1		x	
Electricians, Helpers	4	2			x
Subtotal	103	60			
+ 15 % Absentees	16	9			
Total	119	69			

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STAFF REQUIREMENT

Liganga Iron Ore Mine - Year 13

Production personnel	Shift 1	Shift 2	Education G/HS	Education SS	Education US
Managing director	1		x		
Deputy managing director	1		x		
Mining engineer	1		x		
Secretary	1			x	
Technician	1			x	
Typist	1			x	
Foreman drilling	1			x	
Foreman blasting	1			x	
Foreman loading	1	1		x	
Foreman haulage	1	1		x	
Accountant	1		x		
Clerks	3				x
Operator blasthole drill	3	3		x	
Helper blasthole drill	6	6			x
Blaster	3			x	
Helper blasting	5				x
Operator excavator	3	3		x	
Truck driver	14	14		x	
Operator aux. equipment	11	5		x	
Helper aux. equipment	5	2			x
Maintenance personnel					
Mechanical engineer	1		x		
Foreman trucks, vehicles	1	1		x	
Foreman excavator	1			x	
Mechanics	10	8		x	
Mechanics, Helpers	21	18			x
Electricians	2	1		x	
Electricians, Helpers	4	2			x
Subtotal	104	65			
+ 15 % Absentees	16	10			
Total	120	75			

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STAFF REQUIREMENT

Liganga Iron Ore Mine - Year 14

Production personnel	Shift 1	Shift 2	Education G/HS	Education SS	Education US
Managing director	1		x		
Deputy managing director	1		x		
Mining engineer	1		x		
Secretary	1			x	
Technician	1			x	
Typist	1			x	
Foreman drilling	1			x	
Foreman blasting	1			x	
Foreman loading	1	1		x	
Foreman haulage	1	1		x	
Accountant	1		x		
Clerks	3				x
Operator blasthole drill	3	3		x	
Helper blasthole drill	6	6			x
Blaster	3			x	
Helper blasting	5				x
Operator excavator	3	3		x	
Truck driver	15	15		x	
Operator aux. equipment	11	5		x	
Helper aux. equipment	5	2			x
Maintenance personnel					
Mechanical engineer	1		x		
Foreman trucks, vehicles	1	1		x	
Foreman excavator	1			x	
Mechanics	11	8		x	
Mechanics, Helpers	24	18			x
Electricians	2	1		x	
Electricians, Helpers	4	2			x
Subtotal	1o9	66			
+ 15 % Absentees	17	10			
Total	126	76			

STAFF REQUIREMENT

Liganga Iron Ore Mine - Year 15

Production personnel	Shift 1	Shift 2	Education G/HS	Education SS	Education US
Managing director	1		x		
Deputy managing director	1		x		
Mining engineer	1		x		
Secretary	1			x	
Technician	1			x	
Typist	1			x	
Foreman drilling	1			x	
Foreman blasting	1			x	
Foreman loading	1	1		x	
Foreman haulage	1	1		x	
Accountant	1		x		
Clerks	3				x
Operator blasthole drill	3	3		x	
Helper blasthole drill	6	6			x
Blaster	3			x	
Helper blasting	5				x
Operator excavator	3	3		x	
Truck driver	16	16		x	
Operator aux. equipment	11	5		x	
Helper aux. equipment	5	2			x
Maintenance personnel					
Mechanical engineer	1		x		
Foreman trucks, vehicles	1	1		x	
Foreman excavator	1			x	
Mechanics	11	9		x	
Mechanics, Helpers	24	21			x
Electricians	2	1		x	
Electricians, Helpers	4	2			x
Subtotal	110	71			
+ 15 % Absentees	17	11			
Total	127	82			

STAFF REQUIREMENT

Liganga Iron Ore Mine - Year 16

Production personnel	Shift 1	Shift 2	Education G/HS	Education SS	Education US
Managing director	1		x		
Deputy managing director	1		x		
Mining engineer	1		x		
Secretary	1			x	
Technician	1			x	
Typist	1			x	
Foreman drilling	1			x	
Foreman blasting	1			x	
Foreman loading	1	1		x	
Foreman haulage	1	1		x	
Accountant	1		x		
Clerks	3				x
Operator blasthole drill	3	3		x	
Helper blasthole drill	6	6			x
Blaster	3			x	
Helper blasting	5				x
Operator excavator	3	3		x	
Truck driver	17	17		x	
Operator aux. equipment	11	5		x	
Helper aux. equipment	5	2			x
Maintenance personnel					
Mechanical engineer	1		x		
Foreman trucks, vehicles	1	1		x	
Foreman excavator	1			x	
Mechanics	12	9		x	
Mechanics, Helpers	27	21			x
Electricians	2	1		x	
Electricians, Helpers	4	2			x
Subtotal	115	72			
+ 15 % Absentees	18	11			
Total	133	83			

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STAFF REQUIREMENT
Liganga Iron Ore Mine - Year 17/18

Production personnel	Shift 1	Shift 2	Education G/HS	Education SS	Education US
Managing director	1		x		
Deputy managing director	1		x		
Mining engineer	1		x		
Secretary	1			x	
Technician	1			x	
Typist	1			x	
Foreman drilling	1			x	
Foreman blasting	1			x	
Foreman loading	1	1		x	
Foreman haulage	1	1		x	
Accountant	1		x		
Clerks	3				x
Operator blasthole drill	3	3		x	
Helper blasthole drill	6	6			x
Blaster	3			x	
Helper blasting	5				x
Operator excavator	3	3		x	
Truck driver	18	18		x	
Operator aux. equipment	11	5		x	
Helper aux. equipment	5	2			x
Maintenance personnel					
Mechanical engineer	1		x		
Foreman trucks, vehicles	1	1		x	
Foreman excavator	1			x	
Mechanics	12	10		x	
Mechanics, Helpers	27	24			x
Electricians	2	1		x	
Electricians, Helpers	4	2			x
Subtotal	116	77			
+ 15 % Absentees	18	12			
Total	134	89			

STAFF REQUIREMENT

Liganga Iron Ore Mine - Year 19/20

Production personnel	Shift 1	Shift 2	Education G/HS	Education SS	Education US
Managing director	1		x		
Deputy managing director	1		x		
Mining engineer	1		x		
Secretary	1			x	
Technician	1			x	
Typist	1			x	
Foreman drilling	1			x	
Foreman blasting	1			x	
Foreman loading	1	1		x	
Foreman haulage	1	1		x	
Accountant	1		x		
Clerks	3				x
Operator blasthole drill	3	3		x	
Helper blasthole drill	6	6			x
Blaster	3			x	
Helper blasting	5				x
Operator excavator	3	3		x	
Truck driver	20	20		x	
Operator aux. equipment	11	5		x	
Helper aux. equipment	5	2			x
Maintenance personnel					
Mechanical engineer	1		x		
Foreman trucks, vehicles	1	1		x	
Foreman excavator	1			x	
Mechanics	13	11		x	
Mechanics, Helpers	30	27			x
Electricians	2	1		x	
Electricians, Helpers	4	2			x
Subtotal	122	83			
+ 15 % Absentees	19	13			
Total	141	96			

S E C T I O N 2.2.4

Auxiliaries

2.2.4 Auxiliaries

For the openpit mining operation the following auxiliary equipment and installations are necessary:

- workshop for excavators, trucks, auxiliary machines, drilling rigs (1000 m2)
- store for spare parts (300 m2)
- administration building and social services (these are included within the buildings for the beneficiation plant)
- open cut drainage
- explosive store (50 m2)

The calculation of the peak amount of water to be pumped is based on the records for rain, precipitation, temperature of the Luglawa mission (50 mm rainfall per day) and the biggest open cut configuration of about 200 000 m2. From these figures the peak amount of water to be pumped results as 400 m3/h. Because the peak rainfall mentioned above seldom occures, an additional pump capacity should not be taken into consideration.

Tanzania/Volume II

SECTION 2.2.5

Outline Specification

Mining Equipment

2.2.5 Equipment Outline Specifications

2.2.5.1 Drilling rigs

Carriage drilling machines of the following capacity are invisaged for the open cut:

hole size: 75 mm
compressor capacity: 20 m3/min
drilling performance: 20 m/h

Drilling in a gridpattern of 3 x 3 m about 9 m3 of ore or waste per drilled meter can be blasted. For two rigs working one rig was calculated in reserve.

2.2.5.2 Hydraulic excavators

The calculation of the required shovel dimension and the necessary number of excavators in connection with the envisaged truck size is shown in the next tables. To avoid outage time one additional excavator is assigned. In case of accidental simultanously and longer lasting breakdowns of two mashines there is allways one mashine available at the minimum, which can be used for ore production.

2.2.5.2.1 Ore Loading Equipment

(1)	Capacity of truck (t)	35
(2)	Swell factor (-)	1.5
(3)	Capacity of truck (three) (m3)	11.6
(4)	Filling degree of bucket (-)	0.9
(5)	Max. number of loading cycles	4
(6)	Bucket capacity (m3)	3.5
(7)	Time per cycle (min)	0.5
(8)	Load time (min)	2.0
(9)	Spot time (min)	0.5
(10)	Total load time per truck (min)	2.5
(11)	Trucks per 50-min-hour	20
(12)	Excavator capacity (m3/hour)	232.0
(13)	Excavator capacity (t/hour)	700.0
(14)	Capacity required (t/hour)	369.0
(15)	Utilization of excavator (%)	52.1

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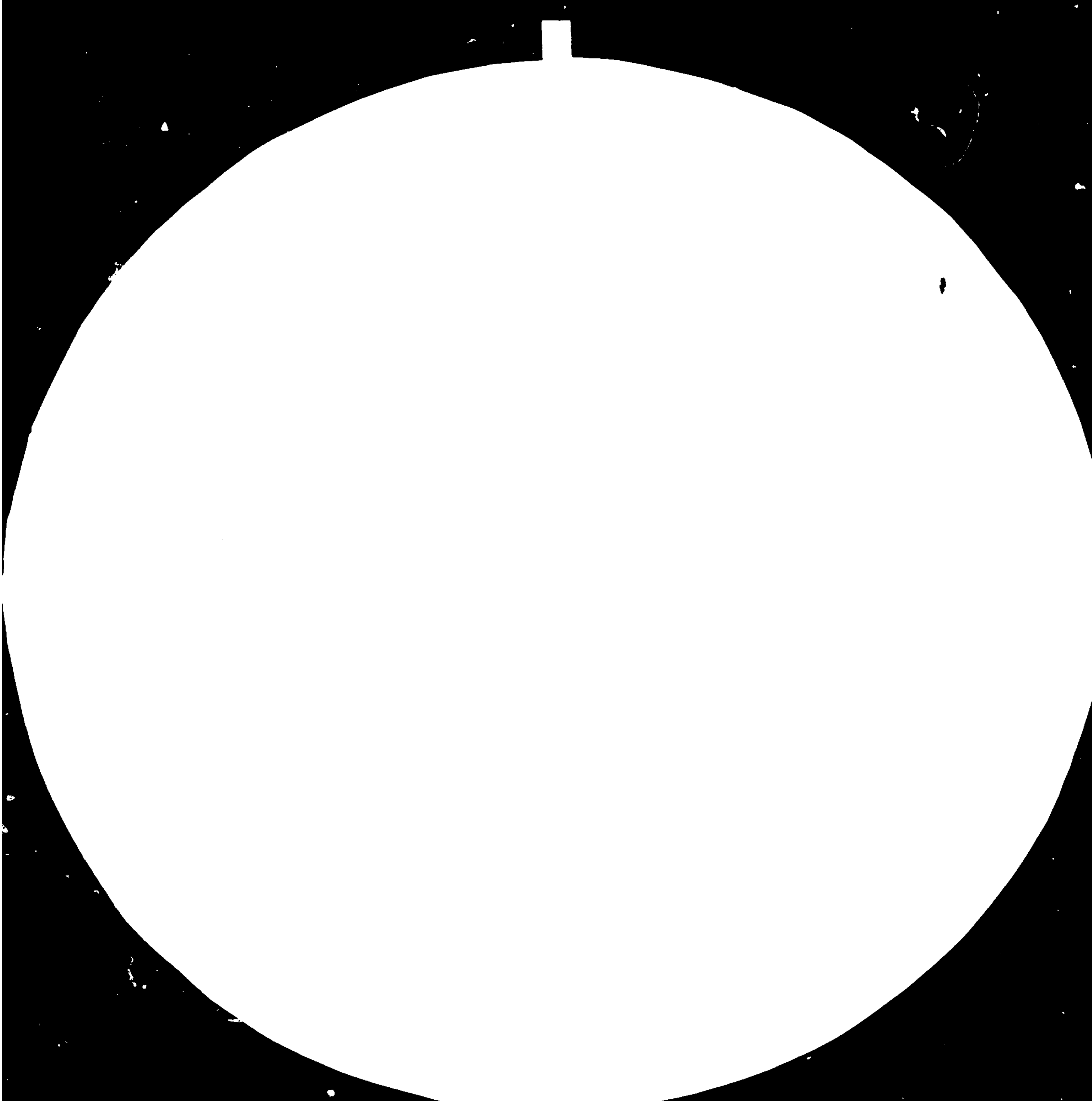
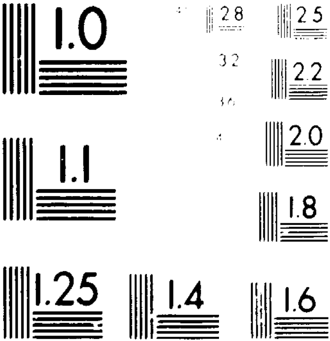
84.10.12





MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS

STANDARD REFERENCE MATERIAL 1010a

ANSI and ISO TEST CHART No. 2

2.2.5.2.2 Waste Loading Equipment

(1)	Capacity of truck (t)	35.0
(2)	Swell factor (-)	1.4
(3)	Capacity of truck (theo.) (m3)	17.5
(4)	Filling degree of bucket (-)	0.9
(5)	Max. number of loading cycles (-)	6
(6)	Bucket capacity (m3)	3.5
(7)	Time per cycle (min)	0.5
(8)	Load time (min)	3.0
(9)	Spot time (min)	0.5
(10)	Total load time per truck (min)	3.5
(11)	Trucks per 50-min-hour	14.3
(12)	Excavator capacity (m3/h)	250.3
(13)	Excavator capacity (t/h)	500.5
(14)	Number of excavators:	

Max. capacity at year:	11	19
t/hour required:	500.3	763.3
No. of excavators:	1	2
Utilization	100 %	65,5 %

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2.2.5.3 Trucks

The calculation of the truck demand was done on the basis of the maximum road distances during the respective years.

The following velocities were assumed:

- empty trip plane road	25 km/h
- loaded trip plane road	20 km/h
- empty trip 10 % slope gradient down	15 km/h
- empty trip 10 % slope gradient up	15 km/h
- loaded trip 10 % slope gradient down	10 km/h
- loaded trip 10 % slope gradient up	10 km/h

The tables below shows the truck demand per year seperate for ore and for waste. For the investment-list first the actual needed trucks were counted together for both activities and afterwards the diminution factors for efficiency and availability were included.

By approximation the real demand of trucks was calculated with diminution factors for

- cune efficiency	83 %
- operator efficiency	90 %
- mechanical availability	30 %

For phase 1 (500 000 tpy steel) trucks with 35 tons loading capacity, 313 kW power and a tire size of 18.00 - 33 (32 PR) E-4 are envisaged. For a possible extension trucks will be used of 50 t loading capacity, 453 kW power and a tire size of 21 - 35 (PR) E-3.

TRUCK MODEL: EUCLID
PAYLOAD (T): 35.0

ALTERNATIVE: 1
ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	110.0	1025.0	100.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.33	6.10	0.46

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	100.0	1025.0	110.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	0.30	4.07	0.51
HAUL AND RET.TIME	(MIN)	11.77		
AVERAGE SPEED	(KM/H)	12.59		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	6.90		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	4.88		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	18.77		

CYCLES PER HOUR	(-)	3.20
PRODUCTIVITY	(T/H)	111.85
TRANSPORT VOLUME	(T/H)	369.00
REQUIRED TRUCKS	(-)	3.30
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00

TOTAL NO. OF TRUCKS (-) 6.0

LURGI-CHEMIE MINING EQUIPMENT

9.11.83 - 10/15/ 1

TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY
LIGANGA YEAR 2 (ORE)

TRUCK MODEL: EUCLID
PAYLOAD (T): 35.0

ALTERNATIVE: 1
ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	180.0	650.0	350.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.54	3.85	1.21

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	350.0	650.0	180.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	0.90	2.57	0.68
HAUL AND RET.TIME	(MIN)	9.[illegible]5		
AVERAGE SPEED	(KM/H)	14.52		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	5.61		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	4.15		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	16.75		

CYCLES PER HOUR	(-)	3.58
PRODUCTIVITY	(T/H)	125.35
TRANSPORT VOLUME	(T/H)	369.00
REQUIRED TRUCKS	(-)	2.94
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00

TOTAL NO. OF TRUCKS (-) 5.0

LURGI-CHEMIE MINING ECUIPMENT TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1

9.11.83 - 10/15/16 LIGANGA YEAR 3 (ORE)

TRUCK MODEL: EUCLID ALTERNATIVE: 1
PAYLOAD (T): 35.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	180.0	400.0	600.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.54	2.35	1.96

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	600.0	400.0	180.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.50	1.57	0.68
HAUL AND RET.TIME	(MIN)	8.60		
AVERAGE SPEED	(KM/H)	16.46		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	4.86		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	3.75		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	15.60		
CYCLES PER HOUR	(-)	3.85		
PRODUCTIVITY	(T/H)	134.59		
TRANSPORT VOLUME	(T/H)	369.00		
REQUIRED TRUCKS	(-)	2.74		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	5.0		

LURGI-CHEMIE MINING EQUIPMENT TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1
9.11.83 - 10/15/34 LIGANGA YEAR 4 (ORE)

TRUCK MODEL: EUCLID ALTERNATIVE: 1
PAYLOAD (T): 35.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	180.0	80.0	920.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.54	0.43	2.92

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	920.0	80.0	180.0
GRADE	(%)	0.0	0.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	4.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	2.26	0.29	0.68
HAUL AND RET.TIME	(MIN)	7.13		
AVERAGE SPEED	(KM/H)	19.86		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	3.90		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	3.23		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	14.13		

CYCLES PER HOUR	(-)	4.25
PRODUCTIVITY	(T/H)	148.62
TRANSPORT VOLUME	(T/H)	369.00
REQUIRED TRUCKS	(-)	2.48
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00

TOTAL NO. OF TRUCKS (-) 5.0

LURGI-CHEMIE MINING ECUIPMENT TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1
9.11.83 - 10/15/59 LIGANGA YEAR 5 (ORE)

TRUCK MODEL: EUCLID ALTERNATIVE: 1
PAYLOAD (T): 35.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	190.0	175.0	825.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.57	1.00	2.64

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	825.0	175.0	190.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	2.04	0.67	0.71
HAUL AND RET.TIME	(MIN)	7.62		
AVERAGE SPEED	(KM/H)	18.74		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	4.21		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	3.41		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	14.62		
CYCLES PER HOUR	(-)	4.10		
PRODUCTIVITY	(T/H)	143.62		
TRANSPORT VOLUME	(T/H)	369.00		
REQUIRED TRUCKS	(-)	2.57		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	5.0		

LURGI-CHEMIE MINING EQUIPMENT

TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1

9.11.83 - 10/16/19

LIGANGA YEAR 6 (ORE)

TRUCK MODEL: EUCLID
PAYLOAD (T): 35.0

ALTERNATIVE: 1
ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	170.0	300.0	700.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.51	1.75	2.26

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	700.0	300.0	170.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.74	1.17	0.66
HAUL AND RET.TIME	(MIN)	8.09		
AVERAGE SPEED	(KM/H)	17.36		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	4.53		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	3.56		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	15.09		
CYCLES PER HOUR	(-)	3.98		
PRODUCTIVITY	(T/H)	139.18		
TRANSPORT VOLUME	(T/H)	369.00		
REQUIRED TRUCKS	(-)	2.65		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	5.0		

LURGI-CHEMIE MINING EQUIPMENT — TRUCK HAULAGE SIMULATION — TRUCK REQUIREMENT AND PRODUCTIVITY — CZHBRE2 PAGE 1

9.11.83 - 10/16/32 — LIGANGA YEAR 7 (ORE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 1
PAYLOAD (T): 35.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	170.0	425.0	875.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.51	2.50	2.79

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	875.0	425.0	170.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	2.16	1.67	0.66
HAUL AND RET.TIME	(MIN)	10.28		
AVERAGE SPEED	(KM/H)	17.15		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	5.80		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	4.48		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	17.28		

CYCLES PER HOUR	(-)	3.47
PRODUCTIVITY	(T/H)	121.50
TRANSPORT VOLUME	(T/H)	369.00
REQUIRED TRUCKS	(-)	3.04
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00
TOTAL NO. OF TRUCKS	(-)	6.0

LURGI-CHEMIE MINING EQUIPMENT

TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY
LIGANGA YEAR 8 (ORE)

CZHBRE2 PAGE 1

9.11.83 - 10/16/47

TRUCK MODEL: EUCLID
PAYLOAD (T): 35.0

ALTERNATIVE: 1
ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	120.0	550.0	750.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.36	3.25	2.41

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	750.0	550.0	120.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.86	2.17	0.54
HAUL AND RET.TIME	(MIN)	10.59		
AVERAGE SPEED	(KM/H)	16.09		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	6.03		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	4.56		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	17.59		
CYCLES PER HOUR	(-)	3.41		
PRODUCTIVITY	(T/H)	119.40		
TRANSPORT VOLUME	(T/H)	369.00		
REQUIRED TRUCKS	(-)	3.09		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	6.0		

LURGI-CHEMIE MINING EQUIPMENT | TRUCK HAULAGE SIMULATION

TRUCK REQUIREMENT AND PRODUCTIVITY | CZHBRE2 PAGE 1

9.11.83 - 10/17/ 3 | LIGANGA YEAR 9 (ORE)

TRUCK MODEL: EUCLID | ALTERNATIVE: 1

PAYLOAD (T): 35.0 | ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	320.0	550.0	750.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.96	3.25	2.41

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	750.0	550.0	320.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.86	2.17	1.02
HAUL AND ET.TIME	(MIN)	11.67		
AVERAGE SPEED	(KM/H)	16.66		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	6.63		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	5.04		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	18.67		
CYCLES PER HOUR	(-)	3.21		
PRODUCTIVITY	(T/H)	112.49		
TRANSPORT VOLUME	(T/H)	369.00		
REQUIRED TRUCKS	(-)	3.28		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	6.0		

9.11.83 - 10/17/29 LIGANGA YEAR 10 (ORE)

TRUCK MODEL: EUCLID ALTERNATIVE: 1
PAYLOAD (T): 35.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	250.0	675.0	625.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.75	4.00	2.04

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	625.0	675.0	250.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.56	2.67	0.85
HAUL AND RET.TIME	(MIN)	11.87		
AVERAGE SPEED	(KM/H)	15.68		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	6.79		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	5.07		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	18.87		

CYCLES PER HOUR	(-)	3.18
PRODUCTIVITY	(T/H)	111.31
TRANSPORT VOLUME	(T/H)	369.00
REQUIRED TRUCKS	(-)	3.31
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00

TOTAL NO. OF TRUCKS (-) 6.0

LURGI-CHEMIE MINING EQUIPMENT   TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY   CZHBRE2   PAGE 1
9.11.83 - 10/17/48   LIGANGA YEAR 11 (ORE)

TRUCK MODEL: EUCLID   ALTERNATIVE: 1
PAYLOAD (T): 35.0   ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	200.0	800.0	500.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.60	4.75	1.66

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	500.0	800.0	200.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.26	3.17	0.73
HAUL AND RET.TIME	(MIN)	12.17		
AVERAGE SPEED	(KM/H)	14.79		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	7.02		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	5.15		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	19.17		
CYCLES PER HOUR	(-)	3.13		
PRODUCTIVITY	(T/H)	109.54		
TRANSPORT VOLUME	(T/H)	369.00		
REQUIRED TRUCKS	(-)	3.37		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	6.0		

LURGI-CHEMIE MINING EQUIPMENT — TRUCK HAULAGE SIMULATION — TRUCK REQUIREMENT AND PRODUCTIVITY — CZHBRE2 PAGE 1

9.11.83 - 10/17/59 — LIGANGA YEAR 12 (ORE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 1

PAYLOAD (T): 35.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	110.0	950.0	450.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.33	5.65	1.5[illegible]

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	450.0	950.0	110.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.14	3.77	0.51
HAUL AND RET.TIME	(MIN)	12.91		
AVERAGE SPEED	(KM/H)	14.03		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	7.50		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	5.42		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	19.91		
CYCLES PER HOUR	(-)	3.01		
PRODUCTIVITY	(T/H)	105.45		
TRANSPORT VOLUME	(T/H)	369.00		
REQUIRED TRUCKS	(-)	3.50		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	6.0		

LURGI-CHEMIE MINING EQUIPMENT TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY CZHURE2 PAGE 1
9.11.83 - 10/18/15 LIGANGA YEAR 13 (ORE)

TRUCK MODEL: EUCLID ALTERNATIVE: 1
PAYLOAD (T): 35.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	280.0	950.0	450.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.84	5.65	1.51

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	450.0	950.0	280.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.14	3.77	0.92
HAUL AND RET.TIME	(MIN)	13.83		
AVERAGE SPEED	(KM/H)	14.57		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	8.01		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	5.83		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	20.83		
CYCLES PER HOUR	(-)	2.88		
PRODUCTIVITY	(T/H)	100.80		
TRANSPORT VOLUME	(T/H)	369.00		
REQUIRED TRUCKS	(-)	3.66		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	7.0		

LURGI-CHEMIE MINING EQUIPMENT TRUCK HAULAGE SIMULATION

TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1

9.'1.83 - 10/18/34 LIGANGA YEAR 14 (ORE)

TRUCK MODEL: EUCLID ALTERNATIVE: 1

PAYLOAD (T): 35.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	180.0	1050.0	425.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.54	6.25	1.44

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	425.0	1050.0	180.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.08	4.17	0.68
HAUL AND RET.TIME	(MIN)	14.16		
AVERAGE SPEED	(KM/H)	14.03		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	8.23		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	5.93		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	21.16		
CYCLES PER HOUR	(-)	2.84		
PRODUCTIVITY	(T/H)	99.26		
TRANSPORT VOLUME	(T/H)	369.00		
REQUIRED TRUCKS	(-)	3.72		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	7.0		

LURGI-CHEMIE MINING EQUIPMENT TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1

9.11.83 - 10/18/54 LIGANGA YEAR 15 (ORE)

TRUCK MODEL: EUCLID ALTERNATIVE: 1
PAYLOAD (T): 35.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	170.0	1175.0	400.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.51	7.00	1.36
RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	400.0	1175.0	170.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.02	4.67	0.66
HAUL AND RET.TIME	(MIN)	15.22		
AVERAGE SPEED	(KM/H)	13.76		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	8.88		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	6.34		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	22.22		
CYCLES PER HOUR	(-)	2.70		
PRODUCTIVITY	(T/H)	94.52		
TRANSPORT VOLUME	(T/H)	369.00		
REQUIRED TRUCKS	(-)	3.90		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	7.0		

LURGI-CHEMIE MINING EQUIPMENT — TRUCK HAULAGE SIMULATION — TRUCK REQUIREMENT AND PRODUCTIVITY — CZHBRE2 PAGE 1

9.11.83 - 10/19/13 — LIGANGA YEAR 16 (ORE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 1

PAYLOAD (T): 35.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	100.0	1300.0	375.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.30	7.75	1.29

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	375.0	1300.0	100.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	0.96	5.17	0.49
HAUL AND RET.TIME	(MIN)	15.96		
AVERAGE SPEED	(KM/H)	13.35		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	9.34		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	6.61		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	22.96		
CYCLES PER HOUR	(-)	2.61		
PRODUCTIVITY	(T/H)	91.48		
TRANSPORT VOLUME	(T/H)	369.00		
REQUIRED TRUCKS	(-)	4.03		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	7.0		

LURGI-CHEMIE MINING EQUIPMENT TRUCK HAULAGE SIMULATION

TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1

9.11.83 - 10/19/27 LIGANGA YEAR 17 (ORE)

TRUCK MODEL: EUCLID ALTERNATIVE: 1

PAYLOAD (T): 35.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	170.0	1300.0	375.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.51	7.75	1.29

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	375.0	1300.0	170.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	0.96	5.17	0.66
HAUL AND RET.TIME	(MIN)	16.33		
AVERAGE SPEED	(KM/H)	13.56		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	9.55		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	6.78		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	23.33		
CYCLES PER HOUR	(-)	2.57		
PRODUCTIVITY	(T/H)	90.00		
TRANSPORT VOLUME	(T/H)	369.00		
REQUIRED TRUCKS	(-)	4.10		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	7.0		

LURGI-CHEMIE MINING EQUIPMENT TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1
9.11.83 - 10/19/42 LIGANGA YEAR 18 (ORE)

TRUCK MODEL: EUCLID ALTERNATIVE: 1
PAYLOAD (T): 35.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	200.0	575.0	980.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.60	3.40	3.10

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	980.0	575.0	200.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	2.41	2.27	0.73
HAUL AND RET.TIME	(MIN)	12.51		
AVERAGE SPEED	(KM/H)	16.83		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	7.11		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	5.41		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	19.51		
CYCLES PER HOUR	(-)	3.07		
PRODUCTIVITY	(T/H)	107.62		
TRANSPORT VOLUME	(T/H)	369.00		
REQUIRED TRUCKS	(-)	3.43		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	6.0		

LURGI-CHEMIE MINING EQUIPMENT   TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY   CZHBRE2 PAGE 1

9.11.83 - 10/19/53   LIGANGA YEAR 19 (ORE)

TRUCK MODEL: EUCLID   ALTERNATIVE: 1
PAYLOAD (T): 35.0   ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	200.0	700.0	980.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.60	4.15	3.10

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	980.0	700.0	200.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	2.41	2.77	0.73
HAUL AND RET.TIME	(MIN)	13.76		
AVERAGE SPEED	(KM/H)	16.39		
LOAD TIME	(MIN)	2.00		
TOTAL HAUL TIME	(MIN)	7.86		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	5.91		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	20.76		

CYCLES PER HOUR	(-)	2.89
PRODUCTIVITY	(T/H)	101.14
TRANSPORT VOLUME	(T/H)	369.00
REQUIRED TRUCKS	(-)	3.65
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00
TOTAL NO. OF TRUCKS	(-)	7.0

LURGI-CHEMIE MINING EQUIPMENT

TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY

CZHBRE2 PAGE 1

9.11.83 - 10/20/12

LIGANGA YEAR 1 (WASTE)

TRUCK MODEL: EUCLID
PAYLOAD (T): 35.0

ALTERNATIVE: 1
ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	110.0	1700.0	50.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.33	10.15	0.31

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	50.0	1700.0	110.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	0.18	6.77	0.51
HAUL AND RET.TIME	(MIN)	18.25		
AVERAGE SPEED	(KM/H)	12.23		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	10.80		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	7.46		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	26.25		
CYCLES PER HOUR	(-)	2.29		
PRODUCTIVITY	(T/H)	79.99		
TRANSPORT VOLUME	(T/H)	78.60		
REQUIRED TRUCKS	(-)	0.98		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	2.0		

LURGI-CHEMIE MINING EQUIPMENT TRUCK HAULAGE SIMULATION

TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1

9.11.83 - 10/20/27 LIGANGA YEAR 2 (WASTE)

TRUCK MODEL: EUCLID ALTERNATIVE: 1

PAYLOAD (T): 35.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	180.0	1450.0	150.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.54	8.65	0.61

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	150.0	1450.0	18C.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	0.42	5.77	0.68
HAUL AND RET.TIME	(MIN)	16.67		
AVERAGE SPEED	(KM/H)	12.81		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	9.81		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	6.87		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	24.67		
CYCLES PER HOUR	(-)	2.43		
PRODUCTIVITY	(T/H)	85.12		
TRANSPORT VOLUME	(T/H)	242.80		
REQUIRED TRUCKS	(-)	2.85		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	5.0		

LURGI-CHEMIE MINING EQUIPMENT　TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY　CZHBRE2　PAGE 1
9.11.83 - 10/20/38　LIGANGA YEAR 3 (WASTE)

TRUCK MODEL: EUCLID　ALTERNATIVE: 1
PAYLOAD (T): 35.0　ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	180.0	1200.0	150.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.54	7.15	0.61

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	150.0	1200.0	180.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	0.42	4.77	0.68
HAUL AND RET.TIME	(MIN)	14.17		
AVERAGE SPEED	(KM/H)	12.95		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	8.31		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	5.87		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	22.17		

CYCLES PER HOUR	(-)	2.71
PRODUCTIVITY	(T/H)	94.71
TRANSPORT VOLUME	(T/H)	399.30
REQUIRED TRUCKS	(-)	4.22
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00

TOTAL NO. OF TRUCKS (-) 8.0

LURGI-CHEMIE MINING EQUIPMENT TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1
9.11.83 - 10/20/51 LIGANGA YEAR 4 (WASTE)

TRUCK MODEL: EUCLID ALTERNATIVE: 1
PAYLOAD (T): 35.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	180.0	1200.0	200.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.54	7.15	0.76

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	200.0	1200.0	180.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	0.54	4.77	0.68
HAUL AND RET.TIME	(MIN)	14.44		
AVERAGE SPEED	(KM/H)	13.13		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	8.46		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	5.99		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	22.44		
CYCLES PER HOUR	(-)	2.67		
PRODUCTIVITY	(T/H)	93.57		
TRANSPORT VOLUME	(T/H)	437.50		
REQUIRED TRUCKS	(-)	4.68		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	8.0		

LURGI-CHEMIE MINING EQUIPMENT | TRUCK HAULAGE SIMULATION | TRUCK REQUIREMENT AND PRODUCTIVITY | CZHURE2 PAGE 1

9.11.83 - 10/21/20 | LIGANGA YEAR 5 (WASTE)

TRUCK MODEL: EUCLID | ALTERNATIVE: 1
PAYLOAD (T): 35.0 | ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	190.0	825.0	300.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.57	4.90	1.06
RETURN SECTION		**R 1**	**R 2**	**R 3**
SECTION LENGTH	(M)	300.0	825.0	190.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	0.78	3.27	0.71
HAUL AND RET.TIME	(MIN)	11.29		
AVERAGE SPEED	(KM/H)	13.98		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	6.54		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	4.75		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	19.29		
CYCLES PER HOUR	(-)	3.11		
PRODUCTIVITY	(T/H)	108.88		
TRANSPORT VOLUME	(T/H)	438.40		
REQUIRED TRUCKS	(-)	4.03		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	7.0		

LURGI-CHEMIE MINING EQUIPMENT TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1
9.11.83 - 10/21/36 LIGANGA YEAR 6 (WASTE)

TRUCK MODEL: EUCLID ALTERNATIVE: 1
PAYLOAD (T): 35.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	170.0	700.0	350.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.51	4.15	1.21

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	350.0	700.0	170.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	0.90	2.77	0.66
HAUL AND RET.TIME	(MIN)	10.20		
AVERAGE SPEED	(KM/H)	14.36		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	5.88		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	4.32		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	18.20		
CYCLES PER HOUR	(-)	3.30		
PRODUCTIVITY	(T/H)	115.39		
TRANSPORT VOLUME	(T/H)	438.70		
REQUIRED TRUCKS	(-)	3.80		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	7.0		

LURGI-CHEMIE MINING ECUIPMENT

TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY

CZHBRE2 PAG. 1

9.11.83 - 10/21/46

LIGANGA YEAR 7 (WASTE)

TRUCK MODEL: EUCLID
PAYLOAD (T): 35.0

ALTERNATIVE: 1
ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	170.0	575.0	450.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.51	3.40	1.51
RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	450.0	575.0	170.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.14	2.27	0.66
HAUL AND RET.TIME	(MIN)	9.49		
AVERAGE SPEED	(KM/H)	15.11		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	5.43		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	4.06		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	17.49		
CYCLES PER HOUR	(-)	3.43		
PRODUCTIVITY	(T/H)	120.08		
TRANSPORT VOLUME	(T/H)	448.20		
REQUIRED TRUCKS	(-)	3.73		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	7.0		

LURGI-CHEMIE MINING EQUIPMENT | TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY | CZHURE2 PAGE 1
9.11.83 - 10/21/59 | LIGANGA YEAR 8 (WASTE)

TRUCK MODEL: EUCLID | ALTERNATIVE: 1
PAYLOAD (T): 35.0 | ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	120.0	450.0	460.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.36	2.65	1.54

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	460.0	450.0	120.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.16	1.77	0.54
HAUL AND RET.TIME	(MIN)	8.02		
AVERAGE SPEED	(KM/H)	15.41		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	4.56		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	3.47		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	16.02		

CYCLES PER HOUR	(-)	3.74
PRODUCTIVITY	(T/H)	131.07
TRANSPORT VOLUME	(T/H)	430.00
REQUIRED TRUCKS	(-)	3.28
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00

TOTAL NO. OF TRUCKS	(-)	6.0

LURGI-CHEMIE MINING EQUIPMENT — TRUCK HAULAGE SIMULATION — CZHBRE2 PAGE 1

TRUCK REQUIREMENT AND PRODUCTIVITY

9.11.83 - 10/22/11 — LIGANGA YEAR 9 (WASTE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 1

PAYLOAD (T): 35.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	320.0	450.0	480.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.96	2.65	1.60

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	480.0	450.0	320.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.21	1.77	1.02
HAUL AND RET.TIME	(MIN)	9.21		
AVERAGE SPEED	(KM/H)	16.29		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	5.22		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	3.99		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	17.21		

CYCLES PER HOUR	(-)	3.49
PRODUCTIVITY	(T/H)	122.02
TRANSPORT VOLUME	(T/H)	444.60
REQUIRED TRUCKS	(-)	3.64
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00

TOTAL NO. OF TRUCKS (-) 7.0

LURGI-CHEMIE MINING EQUIPMENT — TRUCK HAULAGE SIMULATION — TRUCK REQUIREMENT AND PRODUCTIVITY — CZHBRE2 PAGE 1

9.11.83 - 10/22/25 — LIGANGA YEAR 10 (WASTE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 1

PAYLOAD (T): 35.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	220.0	325.0	550.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.66	1.90	1.81

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	550.0	325.0	220.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.38	1.27	0.78
HAUL AND RET.TIME	(MIN)	7.80		
AVERAGE SPEED	(KM/H)	16.85		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	4.38		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	3.42		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	15.80		

CYCLES PER HOUR	(-)	3.80
PRODUCTIVITY	(T/H)	132.92
TRANSPORT VOLUME	(T/H)	467.80
REQUIRED TRUCKS	(-)	3.52
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00
TOTAL NO. OF TRUCKS	(-)	6.0

LURGI-CHEMIE MINING EQUIPMENT — TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY — CZHBRE2 PAGE 1

9.11.83 - 10/22/38 — LIGANGA YEAR 11 (WASTE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 1
PAYLOAD (T): 35.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	200.0	200.0	750.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.60	1.15	2.41

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	750.0	200.0	200.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.86	0.77	0.73
HAUL AND RET.TIME	(MIN)	7.52		
AVERAGE SPEED	(KM/H)	18.35		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	4.17		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	3.35		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	15.52		
CYCLES PER HOUR	(-)	3.87		
PRODUCTIVITY	(T/H)	135.31		
TRANSPORT VOLUME	(T/H)	500.80		
REQUIRED TRUCKS	(-)	3.70		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	7.0		

LURGI-CHEMIE MINING EQUIPMENT TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY CZHURE2 PAGE 1
9.11.83 - 10/22/48 LIGANGA YEAR 12 (WASTE)

TRUCK MODEL: EUCLID ALTERNATIVE: 1
PAYLOAD (T): 35.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3	H 4
SECTION LENGTH	(M)	110.0	100.0	175.0	780.0
GRADE	(%)	0.0	4.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	14.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	10.0	20.0
HAUL TIME	(MIN)	0.33	0.55	1.05	2.50

RETURN SECTION		R 1	R 2	R 3	R 4
SECTION LENGTH	(M)	780.0	175.0	100.0	110.0
GRADE	(%)	0.0	10.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	15.0	25.0
RETURN TIME	(MIN)	1.93	0.67	0.40	0.51
HAUL AND RET.TIME	(MIN)	7.95			
AVERAGE SPEED	(KM/H)	17.59			
LOAD TIME	(MIN)	3.00			
TOTAL HAUL TIME	(MIN)	4.44			
TURN AND DUMP TIME	(MIN)	2.00			
TOTAL RETURN TIME	(MIN)	3.51			
SPOT TIME	(MIN)	3.00			
TOTAL CYCLE TIME	(MIN)	15.95			
CYCLES PER HOUR	(-)	3.76			
PRODUCTIVITY	(T/H)	131.69			
TRANSPORT VOLUME	(T/H)	544.30			
REQUIRED TRUCKS	(-)	4.13			
TIME EFFICIENCY	(%)	83.00			
OPERATOR EFFICIENCY	(%)	90.00			
MECH. AVAILABILITY	(%)	80.00			
TOTAL NO. OF TRUCKS	(-)	7.0			

LURGI-CHEMIE MINING EQUIPMENT — TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY — CZHBRE2 PAGE 1
9.11.83 - 10/22/59 — LIGANGA YEAR 13 (WASTE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 1
PAYLOAD (T): 35.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3	H 4
SECTION LENGTH	(M)	280.0	100.0	175.0	800.0
GRADE	(%)	0.0	4.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	14.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	10.0	20.0
HAUL TIME	(MIN)	0.84	0.55	1.05	2.56

RETURN SECTION		R 1	R 2	R 3	R 4
SECTION LENGTH	(M)	800.0	175.0	100.0	280.0
GRADE	(%)	0.0	10.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	15.0	25.0
RETURN TIME	(MIN)	1.98	0.67	0.40	0.92
HAUL AND RET.TIME	(MIN)	8.97			
AVERAGE SPEED	(KM/H)	18.12			
LOAD TIME	(MIN)	3.00			
TOTAL HAUL TIME	(MIN)	5.01			
TURN AND DUMP TIME	(MIN)	2.00			
TOTAL RETURN TIME	(MIN)	3.97			
SPOT TIME	(MIN)	3.00			
TOTAL CYCLE TIME	(MIN)	16.97			
CYCLES PER HOUR	(-)	3.54			
PRODUCTIVITY	(T/H)	123.73			
TRANSPORT VOLUME	(T/H)	563.40			
REQUIRED TRUCKS	(-)	4.55			
TIME EFFICIENCY	(%)	83.00			
OPERATOR EFFICIENCY	(%)	90.00			
MECH. AVAILABILITY	(%)	80.00			
TOTAL NO. OF TRUCKS	(-)	8.0			

LURGI-CHEMIE MINING EQUIPMENT — TRUCK HAULAGE SIMULATION

TRUCK REQUIREMENT AND PRODUCTIVITY — CZHBRE2 PAGE 1

9.11.83 - 10/23/ 8 — LIGANGA YEAR 14 (WASTE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 1

PAYLOAD (T): 35.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3	H 4
SECTION LENGTH	(M)	180.0	175.0	125.0	900.0
GRADE	(%)	0.0	4.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	14.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	10.0	20.0
HAUL TIME	(MIN)	0.54	1.00	0.75	2.86

RETURN SECTION		R 1	R 2	R 3	R 4
SECTION LENGTH	(M)	900.0	125.0	175.0	180.0
GRADE	(%)	0.0	10.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	15.0	25.0
RETURN TIME	(MIN)	2.22	0.47	0.70	0.68
HAUL AND RET.TIME	(MIN)	9.22			
AVERAGE SPEED	(KM/H)	17.96			
LOAD TIME	(MIN)	3.00			
TOTAL HAUL TIME	(MIN)	5.16			
TURN AND DUMP TIME	(MIN)	2.00			
TOTAL RETURN TIME	(MIN)	4.07			
SPOT TIME	(MIN)	3.00			
TOTAL CYCLE TIME	(MIN)	17.22			
CYCLES PER HOUR	(-)	3.48			
PRODUCTIVITY	(T/H)	121.93			
TRANSPORT VOLUME	(T/H)	589.90			
REQUIRED TRUCKS	(-)	4.84			
TIME EFFICIENCY	(%)	83.00			
OPERATOR EFFICIENCY	(%)	90.00			
MECH. AVAILABILITY	(%)	80.00			
TOTAL NO. OF TRUCKS	(-)	9.0			

LURGI-CHEMIE MINING ECUIPMENT — TRUCK HAULAGE SIMULATION

TRUCK REQUIREMENT AND PRODUCTIVITY — CZHBRE2 PAGE 1

9.11.83 - 10/23/18 — LIGANGA YEAR 15 (WASTE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 1

PAYLOAD (T): 35.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3	H 4
SECTION LENGTH	(M)	170.0	275.0	100.0	960.0
GRADE	(%)	0.0	4.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	14.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	10.0	20.0
HAUL TIME	(MIN)	0.51	1.60	0.60	3.04

RETURN SECTION		R 1	R 2	R 3	R 4
SECTION LENGTH	(M)	960.0	100.0	275.0	170.0
GRADE	(%)	0.0	10.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	15.0	25.0
RETURN TIME	(MIN)	2.36	0.37	1.10	0.66
HAUL AND RET.TIME	(MIN)	10.24			
AVERAGE SPEED	(KM/H)	17.63			
LOAD TIME	(MIN)	3.00			
TOTAL HAUL TIME	(MIN)	5.76			
TURN AND DUMP TIME	(MIN)	2.00			
TOTAL RETURN TIME	(MIN)	4.49			
SPOT TIME	(MIN)	3.00			
TOTAL CYCLE TIME	(MIN)	18.24			
CYCLES PER HOUR	(-)	3.29			
PRODUCTIVITY	(T/H)	115.12			
TRANSPORT VOLUME	(T/H)	599.90			
REQUIRED TRUCKS	(-)	5.21			
TIME EFFICIENCY	(%)	83.00			
OPERATOR EFFICIENCY	(%)	90.00			
MECH. AVAILABILITY	(%)	80.00			
TOTAL NO. OF TRUCKS	(-)	9.0			

LURGI-CHEMIE MINING EQUIPMENT — TRUCK HAULAGE SIMULATION

TRUCK REQUIREMENT AND PRODUCTIVITY — CZHBRE2 PAGE 1

9.11.83 - 10/23/28 — LIGANGA YEAR 16 (WASTE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 1

PAYLOAD (T): 35.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3	H 4
SECTION LENGTH	(M)	100.0	375.0	75.0	960.0
GRADE	(%)	0.0	4.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	14.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	10.0	20.0
HAUL TIME	(MIN)	0.30	2.20	0.45	3.04

RETURN SECTION		R 1	R 2	R 3	R 4
SECTION LENGTH	(M)	960.0	75.0	375.0	100.0
GRADE	(%)	0.0	10.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	15.0	25.0
RETURN TIME	(MIN)	2.36	0.27	1.50	0.49
HAUL AND RET.TIME	(MIN)	10.61			
AVERAGE SPEED	(KM/H)	17.07			
LOAD TIME	(MIN)	3.00			
TOTAL HAUL TIME	(MIN)	6.00			
TURN AND DUMP TIME	(MIN)	2.00			
TOTAL RETURN TIME	(MIN)	4.62			
SPOT TIME	(MIN)	3.00			
TOTAL CYCLE TIME	(MIN)	18.61			

CYCLES PER HOUR	(-)	3.22
PRODUCTIVITY	(T/H)	112.82
TRANSPORT VOLUME	(T/H)	661.40
REQUIRED TRUCKS	(-)	5.86
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00
TOTAL NO. OF TRUCKS	(-)	10.0

LURGI-CHEMIE MINING ECUIPMENT TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1
9.11.83 - 10/23/40 LIGANGA YEAR 17 (WASTE)

TRUCK MODEL: EUCLID ALTERNATIVE: 1
PAYLOAD (T): 35.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3	H 4
SECTION LENGTH	(M)	170.0	375.0	75.0	1000.0
GRADE	(%)	0.0	4.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	14.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	10.0	20.0
HAUL TIME	(MIN)	0.51	2.20	0.45	3.16

RETURN SECTION		R 1	R 2	R 3	R 4
SECTION LENGTH	(M)	1000.0	75.0	375.0	170.0
GRADE	(%)	0.0	10.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	15.0	25.0
RETURN TIME	(MIN)	2.46	0.27	1.50	0.66
HAUL AND RET.TIME	(MIN)	11.21			
AVERAGE SPEED	(KM/H)	17.34			
LOAD TIME	(MIN)	3.00			
TOTAL HAUL TIME	(MIN)	6.33			
TURN AND DUMP TIME	(MIN)	2.00			
TOTAL RETURN TIME	(MIN)	4.88			
SPOT TIME	(MIN)	3.00			
TOTAL CYCLE TIME	(MIN)	19.21			
CYCLES PER HOUR	(-)	3.12			
PRODUCTIVITY	(T/H)	109.33			
TRANSPORT VOLUME	(T/H)	690.40			
REQUIRED TRUCKS	(-)	6.31			
TIME EFFICIENCY	(%)	83.00			
OPERATOR EFFICIENCY	(%)	90.00			
MECH. AVAILABILITY	(%)	80.00			
TOTAL NO. OF TRUCKS	(-)	11.0			

LURGI-CHEMIE MINING EQUIPMENT — TRUCK HAULAGE SIMULATION

TRUCK REQUIREMENT AND PRODUCTIVITY — CZHBRE2 PAGE 1

9.11.83 - 10/24/ 6 — LIGANGA YEAR 18 (WASTE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 1

PAYLOAD (T): 35.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3	H 4
SECTION LENGTH	(M)	200.0	500.0	75.0	1050.0
GRADE	(%)	0.0	4.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	14.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	10.0	20.0
HAUL TIME	(MIN)	0.60	2.95	0.45	3.31

RETURN SECTION		R 1	R 2	R 3	R 4
SECTION LENGTH	(M)	1050.0	75.0	500.0	200.0
GRADE	(%)	0.0	10.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	15.0	25.0
RETURN TIME	(MIN)	2.58	0.27	2.00	0.73
HAUL AND RET.TIME	(MIN)	12.89			
AVERAGE SPEED	(KM/H)	16.99			
LOAD TIME	(MIN)	3.00			
TOTAL HAUL TIME	(MIN)	7.32			
TURN AND DUMP TIME	(MIN)	2.00			
TOTAL RETURN TIME	(MIN)	5.57			
SPOT TIME	(MIN)	3.00			
TOTAL CYCLE TIME	(MIN)	20.89			
CYCLES PER HOUR	(-)	2.87			
PRODUCTIVITY	(T/H)	100.52			
TRANSPORT VOLUME	(T/H)	724.70			
REQUIRED TRUCKS	(-)	7.21			
TIME EFFICIENCY	(%)	83.00			
OPERATOR EFFICIENCY	(%)	90.00			
MECH. AVAILABILITY	(%)	80.00			
TOTAL NO. OF TRUCKS	(-)	13.0			

LURGI-CHEMIE MINING EQUIPMENT TRUCK HAULAGE SIMULATION

TRUCK REQUIREMENT AND PRODUCTIVITY CZHDRE2 PAGE 1

9.11.83 - 10/24/19 LIGANGA YEAR 19 (WASTE)

TRUCK MODEL: EUCLID ALTERNATIVE: 1

PAYLOAD (T): 35.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3	H 4
SECTION LENGTH	(M)	200.0	625.0	75.0	1080.0
GRADE	(%)	0.0	4.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	14.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	10.0	20.0
HAUL TIME	(MIN)	0.60	3.70	0.45	3.40

RETURN SECTION		R 1	R 2	R 3	R 4
SECTION LENGTH	(M)	1080.0	75.0	625.0	200.0
GRADE	(%)	0.0	10.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	15.0	25.0
RETURN TIME	(MIN)	2.65	0.27	2.50	0.73
HAUL AND RET.TIME	(MIN)	14.30			
AVERAGE SPEED	(KM/H)	16.61			
LOAD TIME	(MIN)	3.00			
TOTAL HAUL TIME	(MIN)	8.16			
TURN AND DUMP TIME	(MIN)	2.00			
TOTAL RETURN TIME	(MIN)	6.15			
SPOT TIME	(MIN)	3.00			
TOTAL CYCLE TIME	(MIN)	22.30			
CYCLES PER HOUR	(-)	2.69			
PRODUCTIVITY	(T/H)	94.16			
TRANSPORT VOLUME	(T/H)	763.30			
REQUIRED TRUCKS	(-)	8.11			
TIME EFFICIENCY	(%)	83.00			
OPERATOR EFFICIENCY	(%)	90.00			
MECH. AVAILABILITY	(%)	80.00			
TOTAL NO. OF TRUCKS	(-)	14.0			

S E C T I O N 2.2.6

Investment Cost Estimate

2.2.6 Investment Cost Estimate

The calculated costs shown in the tables below are of an accuracy of ± 25 % (Base 1983). The necessary reinvestment respective to the different lifetimes of the mine are also included within the 1983 costs. For contigency 10 % were taken into account.

The costs for opening up, which are usually capitalized as operation costs for the years before actual production (shown as prestripping in the investment list), are not included.

LURGI-CHEMIE LC-HB
20.12.83 - 9/10/37

I N V E S T M E N T - S C H E D U L E

PROJECT : L I G A N G A (ALTERNATIVE 1)
PRODUCTION: 1.56 MILL.T/A ROM

PAGE 1

DATE 11/15/1983

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	YEAR -1	1	2	3	4	5
1	EXCAVATOR (3.5 M3)	6	0.400	4	0.400	0.800	0.0	0.0	0.0	0.0
2	TRUCK (35 T)	5	0.255	20	1.020	1.020	0.510	0.510	0.0	1.020
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
8	TRIPPER CAR	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
11	BLASTHOLE DRILL	6	0.270	3	0.270	0.270	0.0	0.270	0.0	0.0
12	DOZER	5	0.385	3	0.385	0.385	0.0	0.0	0.0	0.385
13	WHEEL DOZER	5	0.365	1	0.365	0.0	0.0	0.0	0.0	0.365
14	GRADER	5	0.305	1	0.305	0.0	0.0	0.0	0.0	0.305
15	SERVICE TRUCK	5	0.020	2	0.020	0.020	0.0	0.0	0.0	0.020
16	WAREHOUSE TRUCK	5	0.025	1	0.0	0.025	0.0	0.0	0.0	0.0
17	FUELTRUCK	5	0.077	1	0.077	0.0	0.0	0.0	0.0	0.077
18	WATERTRUCK	5	0.075	1	0.075	0.0	0.0	0.0	0.0	0.075
19	TRACTOR	10	0.030	1	0.030	0.0	0.0	0.0	0.0	0.0
20	TRAILER	10	0.010	1	0.010	0.0	0.0	0.0	0.0	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
22	CRANE-LIGHT	10	0.058	1	0.058	0.0	0.0	0.0	0.0	0.0
23	PICK-UP	5	0.013	4	0.026	0.026	0.0	0.0	0.0	0.026
24	WATER CONTROL	20	0.250	1	0.0	0.0	0.250	0.0	0.0	0.0
25	WORKSHOPS	20	0.580	1	0.200	0.380	0.0	0.0	0.0	0.0
26	WAREHOUSES	20	0.120	1	0.120	0.0	0.0	0.0	0.0	0.0
27	POWER SUPPLY	20	0.040	1	0.040	0.0	0.0	0.0	0.0	0.0
28	BUILDINGS	20	0.080	1	0.040	0.040	0.0	0.0	0.0	0.0
29	RELOCATIONS	20	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
31	EXPLORATION/STUDIES	20	0.750	0	0.250	0.0	0.0	0.0	0.0	0.0
32	MISCELLANEOUS	0	1.500	0	0.500	1.000	0.0	0.0	0.0	0.0
33	CONTINGENCY (10 %)	0	0.0	0	0.419	0.397	0.076	0.078	0.0	0.227
34	TOTAL				4.610	4.363	0.836	0.158	0.0	2.500
35	INITIAL INVESTMENT F.START-UP(YEAR -1,1)				8.973					
36	GRANDTOTAL (20 YEARS)				39.374					

ALL FIGURES IN MILLION US$

LURGI-CHEMIE LC-HB
20.12.83 - 9/18/37

I N V E S T M E N T - S C H E D U L E

PROJECT : L I G A N G A (ALTERNATIVE 1)
PRODUCTION: 1.56 MILL.T/A ROM

DATE 11/15/1983

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	YEAR 6	7	8	9	10	11
1	EXCAVATOR (3.5 M3)	6	0.400	4	0.800	0.0	0.0	0.0	0.0	0.0
2	TRUCK (35 T)	5	0.255	20	1.020	0.510	0.510	0.0	1.020	1.020
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
8	TRIPPER CAR	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
11	BLASTHOLE DRILL	6	0.270	3	0.270	0.270	0.0	0.270	0.0	0.0
12	DOZER	5	0.385	3	0.385	0.0	0.0	0.0	0.385	0.385
13	WHEEL DOZER	5	0.365	1	0.0	0.0	0.0	0.0	0.365	0.0
14	GRADER	5	0.305	1	0.0	0.0	0.0	0.0	0.305	0.0
15	SERVICE TRUCK	5	0.020	2	0.020	0.0	0.0	0.0	0.020	0.020
16	WAREHOUSE TRUCK	5	0.025	1	0.025	0.0	0.0	0.0	0.0	0.025
17	FUELTRUCK	5	0.077	1	0.0	0.0	0.0	0.0	0.077	0.0
18	WATERTRUCK	5	0.075	1	0.0	0.0	0.0	0.0	0.075	0.0
19	TRACTOR	10	0.030	1	0.0	0.0	0.0	0.0	0.030	0.0
20	TRAILER	10	0.010	1	0.0	0.0	0.0	0.0	0.010	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
22	CRANE-LIGHT	10	0.058	1	0.0	0.0	0.0	0.0	0.058	0.0
23	PICK-UP	5	0.013	4	0.026	0.0	0.0	0.0	0.026	0.026
24	WATER CONTROL	20	0.250	1	0.0	0.0	0.0	0.0	0.0	0.0
25	WORKSHOPS	20	0.580	1	0.0	0.0	0.0	0.0	0.0	0.0
26	WAREHOUSES	20	0.120	1	0.0	0.0	0.0	0.0	0.0	0.0
27	POWER SUPPLY	20	0.040	1	0.0	0.0	0.0	0.0	0.0	0.0
28	BUILDINGS	20	0.080	1	0.0	0.0	0.0	0.0	0.0	0.0
29	RELOCATIONS	20	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
31	EXPLORATION/STUDIES	20	0.750	0	0.0	0.250	0.0	0.0	0.0	0.0
32	MISCELLANEOUS	0	1.500	0	0.0	0.0	0.0	0.0	0.0	0.0
33	CONTINGENCY (10 %)	0	0.0	0	0.255	0.103	0.051	0.027	0.237	0.148
34	TOTAL				2.801	1.133	0.561	0.297	2.608	1.624

ALL FIGURES IN MILLION US$

LURGI-CHEMIE LC-HB
20.12.83 - 9/18/37

I N V E S T M E N T - S C H E D U L E
PROJECT : L I G A N G A (ALTERNATIVE 1)
PRODUCTION: 1.56 MILL.T/A RCM

DATE 11/15/1983

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	YEAR 12	13	14	15	16	17
1	EXCAVATOR (3.5 M3)	6	0.400	4	1.200	0.0	0.0	0.0	0.0	0.0
2	TRUCK (35 T)	5	0.255	20	0.765	0.765	0.255	1.275	1.275	1.020
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
8	TRIPPER CAR	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
11	BLASTHOLE DRILL	6	0.270	3	0.270	0.270	0.0	0.270	0.0	0.0
12	DOZER	5	0.385	3	0.385	0.0	0.0	0.385	0.385	0.385
13	WHEEL DOZER	5	0.365	1	0.0	0.0	0.0	0.365	0.0	0.0
14	GRADER	5	0.305	1	0.0	0.0	0.0	0.305	0.0	0.0
15	SERVICE TRUCK	5	0.020	2	0.0	0.0	0.0	0.020	0.020	0.0
16	WAREHOUSE TRUCK	5	0.025	1	0.0	0.0	0.0	0.0	0.025	0.0
17	FUELTRUCK	5	0.077	1	0.0	0.0	0.0	0.077	0.0	0.0
18	WATERTRUCK	5	0.075	1	0.0	0.0	0.0	0.075	0.0	0.0
19	TRACTOR	10	0.030	1	0.0	0.0	0.0	0.0	0.0	0.0
20	TRAILER	10	0.010	1	0.0	0.0	0.0	0.0	0.0	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
22	CRANE-LIGHT	10	0.058	1	0.0	0.0	0.0	0.0	0.0	0.0
23	PICK-UP	5	0.013	4	0.0	0.0	0.0	0.026	0.026	0.0
24	WATER CONTROL	20	0.250	1	0.0	0.0	0.0	0.0	0.0	0.0
25	WORKSHOPS	20	0.580	1	0.0	0.0	0.0	0.0	0.0	0.0
26	WAREHOUSES	20	0.120	1	0.0	0.0	0.0	0.0	0.0	0.0
27	POWER SUPPLY	20	0.040	1	0.0	0.0	0.0	0.0	0.0	0.0
28	BUILDINGS	20	0.080	1	0.0	0.0	0.0	0.0	0.0	0.0
29	RELOCATIONS	20	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
31	EXPLORATION/STUDIES	20	0.750	0	0.0	0.0	0.250	0.0	0.0	0.0
32	MISCELLANEOUS	0	1.500	0	0.0	0.0	0.0	0.0	0.0	0.0
33	CONTINGENCY (10 %)	0	0.0	0	0.262	0.104	0.051	0.280	0.173	0.140
34	TOTAL				2.832	1.138	0.555	3.078	1.904	1.545

ALL FIGURES IN MILLION US$

LURGI-CHEMIE LC-HB
20.12.83 - 9/18/37

INVESTMENT-SCHEDULE
PROJECT : L I G A N G A (ALTERNATIVE 1)
PRODUCTION: 1.56 MILL.T/A ROM

DATE 11/15/1983

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	YEAR 18	19	20
1	EXCAVATOR (3.5 M3)	6	0.400	4	1.200	0.0	0.0
2	TRUCK (35 T)	5	0.255	20	0.765	0.765	1.275
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0	0.0
8	TRIPPER CAR	25	0.0	0	0.0	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0	0.0
11	BLASTHOLE DRILL	6	0.270	3	0.270	0.0	0.0
12	DOZER	5	0.385	3	0.0	0.0	0.385
13	WHEEL DOZER	5	0.365	1	0.0	0.0	0.365
14	GRADER	5	0.305	1	0.0	0.0	0.305
15	SERVICE TRUCK	5	0.020	2	0.0	0.0	0.020
16	WAREHOUSE TRUCK	5	0.025	1	0.0	0.0	0.0
17	FUELTRUCK	5	0.077	1	0.0	0.0	0.077
18	WATERTRUCK	5	0.075	1	0.0	0.0	0.075
19	TRACTOR	10	0.030	1	0.0	0.0	0.0
20	TRAILER	10	0.010	1	0.0	0.0	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0	0.0
22	CRANE-LIGHT	10	0.058	1	0.0	0.0	0.0
23	PICK-UP	5	0.013	4	0.0	0.0	0.026
24	WATER CONTROL	20	0.250	1	0.0	0.0	0.0
25	WORKSHOPS	20	0.580	1	0.0	0.0	0.0
26	WAREHOUSES	20	0.120	1	0.0	0.0	0.0
27	POWER SUPPLY	20	0.040	1	0.0	0.0	0.0
28	BUILDINGS	20	0.080	1	0.0	0.0	0.0
29	RELOCATIONS	20	0.0	0	0.0	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0	0.0
31	EXPLORATION/STUDIES	20	0.750	0	0.0	0.0	0.0
32	MISCELLANEOUS	0	1.500	0	0.0	0.0	0.0
33	CONTINGENCY (10 %)	0	0.0	0	0.223	0.076	0.253
34	TOTAL				2.458	0.841	2.781

ALL FIGURES IN MILLION US$

LURGI-CHEMIE LC-HB
20.12.83 - 9/16/19

I N V E S T M E N T - S C H E D U L E
PROJECT : L I G A N G A (ALTERNATIVE
PRODUCTION: 1.56 MILL.T/A ROM

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	-1	1
1	EXCAVATOR (3.5 M3)	6	4.880	4	4.880	9.760
2	TRUCK (35 T)	5	3.111	20	12.444	12.444
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0
8	TRIPPER CAR	25	0.0	0	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0
11	BLASTHOLE DRILL	6	3.294	3	3.294	3.294
12	DOZER	5	4.697	3	4.697	4.697
13	WHEEL DOZER	5	4.453	1	4.453	0.0
14	GRADER	5	3.721	1	3.721	0.0
15	SERVICE TRUCK	5	0.244	2	0.244	0.244
16	WAREHOUSE TRUCK	5	0.305	1	0.0	0.305
17	FUELTRUCK	5	0.939	1	0.939	0.0
18	WATERTRUCK	5	0.915	1	0.915	0.0
19	TRACTOR	10	0.366	1	0.366	0.0
20	TRAILER	10	0 122	1	0.122	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0
22	CRANE-LIGHT	10	0.708	1	0.708	0.0
23	PICK-UP	5	0.159	4	0.317	0.317
24	WATER CONTROL	20	3.050	1	0.0	0.0
25	WORKSHOPS	20	7.076	1	2.440	4.636
26	WAREHOUSES	20	1.464	1	1.464	0.0
27	POWER SUPPLY	20	0.488	1	0.488	0.0
28	BUILDINGS	20	6.976	1	0.488	0.488
29	RELOCATIONS	20	0.0	0	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0
31	EXPLORATION/STUDIES	20	9.150	0	3.050	0.0
32	MISCELLANEOUS	0	18.300	0	6.100	12.200
33	CONTINGENCY (10 %)	0	0.0	0	5.113	4.839
34	TOTAL				56.243	53.224
35	INITIAL INVESTMENT F.START-UP(YEAR -1,1)				109.467	
36	GRANDTOTAL (20 YEARS)				480.367	

ALL FIGURES IN MILLION TANZANIAN SHILLINGS

1)

DATE 11/15/1983

YEAR			
2	3	4	5
0.0	0.(	0.0	0.0
6.222	6.222	0.0	12.444
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	3.294	0.0	0.0
0.0	0.(	0.0	4.697
0.0	0.(	0.0	4.453
0.0	0.(	0.0	3.721
0.0	0.(	0.0	0.244
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.939
0.0	0.(	0.0	0.915
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.317
3.050	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.0	0.(	0.0	0.0
0.927	0.552	0.0	2.773
10.199	10.468	0.0	30.504

LURGI-CHEMIE LC-HB
20.12.83 - 9/16/19

I N V E S T M E N T - S C H E D U L E
PROJECT : L I G A N G A (ALTERNATIVE 1)
PRODUCTION: 1.56 MILL.T/A ROM

DATE 11/15/1983

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	YEAR 6	7	8	9	10	11
1	EXCAVATOR (3.5 M3)	6	4.880	4	9.760	0.0	0.0	0.(	0.0	0.0
2	TRUCK (35 T)	5	3.111	20	12.444	6.222	6.222	0.(	12.444	12.444
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0	0.0	0.(	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0	0.0	0.(	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0	0.0	0.(	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0	0.0	0.(	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0	0.0	0.(	0.0	0.0
8	TRIPPER CAR	25	0.0	0	0.0	0.0	0.0	0.(	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0	0.0	0.(	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0	0.0	0.(	0.0	0.0
11	BLASTHOLE DRILL	6	3.294	3	3.294	3.294	0.0	3.294	0.0	0.0
12	DOZER	5	4.697	3	4.697	0.0	0.0	0.(	4.697	4.697
13	WHEEL DOZER	5	4.453	1	0.0	0.0	0.0	0.(	4.453	0.0
14	GRADER	5	3.721	1	0.0	0.0	0.0	0.(	3.721	0.0
15	SERVICE TRUCK	5	0.244	2	0.244	0.0	0.0	0.(	0.244	0.244
16	WAREHOUSE TRUCK	5	0.305	1	0.305	0.0	0.0	0.(	0.0	0.305
17	FUELTRUCK	5	0.939	1	0.0	0.0	0.0	0.(	0.939	0.0
18	WATERTRUCK	5	0.915	1	0.0	0.0	0.0	0.(	0.915	0.0
19	TRACTOR	10	0.366	1	0.0	0.0	0.0	0.(	0.366	0.0
20	TRAILER	10	0.122	1	0.0	0.0	0.0	0.(	0.122	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0	0.0	0.(	0.0	0.0
22	CRANE-LIGHT	10	0.708	1	0.0	0.0	0.0	0.(	0.708	0.0
23	PICK-UP	5	0.159	4	0.317	0.0	0.0	0.(	0.317	0.317
24	WATER CONTROL	20	3.050	1	0.0	0.0	0.0	0.(	0.0	0.0
25	WORKSHOPS	20	7.076	1	0.0	0.0	0.0	0.(	0.0	0.0
26	WAREHOUSES	20	1.464	1	0.0	0.0	0.0	0.(	0.0	0.0
27	POWER SUPPLY	20	0.488	1	0.0	0.0	0.0	0.(	0.0	0.0
28	BUILDINGS	20	0.976	1	0.0	0.0	0.0	0.(	0.0	0.0
29	RELOCATIONS	20	0.0	0	0.0	0.0	0.0	0.(	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0	0.0	0.(	0.0	0.0
31	EXPLORATION/STUDIES	20	9.150	0	0.0	3.050	0.0	0.(	0.0	0.0
32	MISCELLANEOUS	0	18.300	0	0.0	0.0	0.0	0.(	0.0	0.0
33	CONTINGENCY (10 %)	0	0.0	0	3.106	1.257	0.622	0.329	2.893	1.801
34	TOTAL				34.167	13.823	6.844	3.623	31.819	19.808

ALL FIGURES IN MILLION TANZANIAN SHILLINGS

LURGI-CHEMIE LC-HB
20.12.83 - 9/16/19

INVESTMENT-SCHEDULE
PROJECT : L I G A N G A (ALTERNATIVE I
PRODUCTION: 1.56 MILL.T/A ROM

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	12	13
1	EXCAVATOR (3.5 M3)	6	4.880	4	14.640	0.0
2	TRUCK (35 T)	5	3.111	20	9.333	9.333
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0
8	TRIPPER CAR	25	0.0	0	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0
11	BLASTHOLE DRILL	6	3.294	3	3.294	3.294
12	DOZER	5	4.697	3	4.697	0.0
13	WHEEL DOZER	5	4.453	1	0.0	0.0
14	GRADER	5	3.721	1	0.0	0.0
15	SERVICE TRUCK	5	0.244	2	0.0	0.0
16	WAREHOUSE TRUCK	5	0.305	1	0.0	0.0
17	FUELTRUCK	5	0.939	1	0.0	0.0
18	WATERTRUCK	5	0.915	1	0.0	0.0
19	TRACTOR	10	0.366	1	0.0	0.0
20	TRAILER	10	0.122	1	0.0	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0
22	CRANE-LIGHT	10	0.708	1	0.0	0.0
23	PICK-UP	5	0.159	4	0.0	0.0
24	WATER CONTROL	20	3.050	1	0.0	0.0
25	WORKSHOPS	20	7.076	1	0.0	0.0
26	WAREHOUSES	20	1.464	1	0.0	0.0
27	POWER SUPPLY	20	0.488	1	0.0	0.0
28	BUILDINGS	20	0.976	1	0.0	0.0
29	RELOCATIONS	20	0.0	0	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0
31	EXPLORATION/STUDIES	20	9.150	0	0.0	0.0
32	MISCELLANEOUS	0	18.300	0	0.0	0.0
33	CONTINGENCY (10 %)	0	0.0	0	3.196	1.263
34	TOTAL				35.160	13.890

ALL FIGURES IN MILLION TANZANIAN SHILLINGS

DATE 11/15/1983

YEAR 14	15	16	17
0.0	0.0	0.0	0.0
3.111	15.555	15.555	12.444
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	3.294	0.0	0.0
0.0	4.697	4.697	4.697
0.0	4.453	0.0	0.0
0.0	3.721	0.0	0.0
0.0	0.244	0.244	0.0
0.0	0.0	0.305	0.0
0.0	0.539	0.0	0.0
0.0	0.515	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.317	0.317	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
3.050	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.616	3.414	2.112	1.714
6.777	37.549	23.230	18.855

INVESTMENT-SCHEDULE
PROJECT : L I G A N G A (ALTERNATIVE 1)
PRODUCTION: 1.56 MILL.T/A RUM

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	YEAR 18	19	20
1	EXCAVATOR (3.5 M3)	6	4.880	4	14.640	0.0	0.0
2	TRUCK (35 T)	5	3.111	20	9.333	9.333	15.555
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0	0.0
8	TRIPPER CAR	25	0.0	0	0.0	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0	0.0
11	BLASTHOLE DRILL	6	3.294	3	3.294	0.0	0.0
12	DOZER	5	4.697	3	0.0	0.0	4.697
13	WHEEL DOZER	5	4.453	1	0.0	0.0	4.453
14	GRADER	5	3.721	1	0.0	0.0	3.721
15	SERVICE TRUCK	5	0.244	2	0.0	0.0	0.244
16	WAREHOUSE TRUCK	5	0.305	1	0.0	0.0	0.0
17	FUELTRUCK	5	0.939	1	0.0	0.0	0.939
18	WATERTRUCK	5	0.915	1	0.0	0.0	0.915
19	TRACTOR	10	0.366	1	0.0	0.0	0.0
20	TRAILER	10	0.122	1	0.0	0.0	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0	0.0
22	CRANE-LIGHT	10	0.708	1	0.0	0.0	0.0
23	PICK-UP	5	0.159	4	0.0	0.0	0.317
24	WATER CONTROL	20	3.050	1	0.0	0.0	0.0
25	WORKSHOPS	20	7.076	1	0.0	0.0	0.0
26	WAREHOUSES	20	1.464	1	0.0	0.0	0.0
27	POWER SUPPLY	20	0.488	1	0.0	0.0	0.0
28	BUILDINGS	20	0.976	1	0.0	0.0	0.0
29	RELOCATIONS	20	0.0	0	0.0	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0	0.0
31	EXPLORATION/STUDIES	20	9.150	0	0.0	0.0	0.0
32	MISCELLANEOUS	0	18.300	0	0.0	0.0	0.0
33	CONTINGENCY (10 %)	0	0.0	0	2.727	0.933	3.084
34	TOTAL				29.994	10.266	33.926

ALL FIGURES IN MILLION TANZANIAN SHILLINGS

Tanzania/Volume II

A N N E X

Expansion Step

1 Million tpy Steel

LURGI-CHEMIE MINING ECUIPMENT TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1
9.11.83 - 12/ 5/25 LIGANGA YEAR 1 (ORE)

TRUCK MODEL: EUCLID ALTERNATIVE: 2
PAYLOAD (T): 50.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	180.0	650.0	350.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.54	3.85	1.21

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	350.0	650.0	180.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	0.90	2.57	0.68
HAUL AND RET.TIME	(MIN)	9.75		
AVERAGE SPEED	(KM/H)	14.52		
LOAD TIME	(MIN)	2.50		
TOTAL HAUL TIME	(MIN)	5.61		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	4.15		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	17.25		
CYCLES PER HOUR	(-)	3.48		
PRODUCTIVITY	(T/H)	173.89		
TRANSPORT VOLUME	(T/H)	738.10		
REQUIRED TRUCKS	(-)	4.24		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	8.0		

LURGI-CHEMIE MINING EQUIPMENT TRUCK HAULAGE SIMULATION

TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1

9.11.83 - 12/ 5/38 LIGANGA YEAR 2 (ORE)

TRUCK MODEL: EUCLID ALTERNATIVE: 2

PAYLOAD (T): 50.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	180.0	80.0	920.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.54	0.43	2.92

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	920.0	80.0	180.0
GRADE	(%)	0.0	0.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	4.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	2.26	0.29	0.68
HAUL AND RET.TIME	(MIN)	7.13		
AVERAGE SPEED	(KM/H)	19.86		
LOAD TIME	(MIN)	2.50		
TOTAL HAUL TIME	(MIN)	3.90		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	3.23		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	14.63		
CYCLES PER HOUR	(-)	4.10		
PRODUCTIVITY	(T/H)	205.05		
TRANSPORT VOLUME	(T/H)	738.10		
REQUIRED TRUCKS	(-)	3.60		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	7.0		

9.11.83 - 12/ 5/52   LIGANGA YEAR 3 (ORE)

TRUCK MODEL: EUCLID   ALTERNATIVE: 2
PAYLOAD (T): 50.0   ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	170.0	300.0	700.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.51	1.75	2.26

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	700.0	300.0	170.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.74	1.17	0.66
HAUL AND RET.TIME	(MIN)	8.09		
AVERAGE SPEED	(KM/H)	17.36		
LOAD TIME	(MIN)	2.50		
TOTAL HAUL TIME	(MIN)	4.53		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	3.56		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	15.59		
CYCLES PER HOUR	(-)	3.85		
PRODUCTIVITY	(T/H)	192.45		
TRANSPORT VOLUME	(T/H)	738.10		
REQUIRED TRUCKS	(-)	3.84		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	7.0		

LURGI-CHEMIE MINING EQUIPMENT   TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY   CZHBRE2   PAGE 1
9.11.83 - 12/ 6/ 3   LIGANGA YEAR 4 (ORE)

TRUCK MODEL: EUCLID   ALTERNATIVE: 2
PAYLOAD (T): 50.0   ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	120.0	550.0	750.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.36	3.25	2.41

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	750.0	550.0	120.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.86	2.17	0.54
HAUL AND RET.TIME	(MIN)	10.59		
AVERAGE SPEED	(KM/H)	16.09		
LOAD TIME	(MIN)	2.50		
TOTAL HAUL TIME	(MIN)	6.03		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	4.56		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	18.09		
CYCLES PER HOUR	(-)	3.32		
PRODUCTIVITY	(T/H)	165.85		
TRANSPORT VOLUME	(T/H)	738.10		
REQUIRED TRUCKS	(-)	4.45		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	8.0		

LURGI-CHEMIE MINING EQUIPMENT | TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY | CZHBRE2 PAGE 1

9.11.83 - 12/ 6/16 | LIGANGA YEAR 5 (ORE)

TRUCK MODEL: EUCLID | ALTERNATIVE: 2
PAYLOAD (T): 50.0 | ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	250.0	675.0	625.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.75	4.00	2.04
RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	625.0	675.0	250.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.56	2.67	0.85
HAUL AND RET.TIME	(MIN)	11.87		
AVERAGE SPEED	(KM/H)	15.68		
LOAD TIME	(MIN)	2.50		
TOTAL HAUL TIME	(MIN)	6.79		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	5.07		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	19.37		
CYCLES PER HOUR	(-)	3.10		
PRODUCTIVITY	(T/H)	154.92		
TRANSPORT VOLUME	(T/H)	738.10		
REQUIRED TRUCKS	(-)	4.76		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	8.0		

LURGI-CHEMIE MINING EQUIPMENT — TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY — CZHBRE2 PAGE 1
9.11.83 - 12/ 6/26 — LIGANGA YEAR 6 (ORE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 2
PAYLOAD (T): 50.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	110.0	950.0	450.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.33	5.65	1.51

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	450.0	950.0	110.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.14	3.77	0.51
HAUL AND RET.TIME	(MIN)	12.91		
AVERAGE SPEED	(KM/H)	14.05		
LOAD TIME	(MIN)	2.50		
TOTAL HAUL TIME	(MIN)	7.50		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	5.42		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	20.41		
CYCLES PER HOUR	(-)	2.94		
PRODUCTIVITY	(T/H)	146.95		
TRANSPORT VOLUME	(T/H)	738.10		
REQUIRED TRUCKS	(-)	5.02		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	9.0		

LURGI-CHEMIE MINING EQUIPMENT | TRUCK HAULAGE SIMULATION | CZHBREZ PAGE 1

TRUCK REQUIREMENT AND PRODUCTIVITY

9.11.83 - 12/ 6/37

LIGANGA YEAR 7 (ORE)

TRUCK MODEL: EUCLID
PAYLOAD (T): 50.0

ALTERNATIVE: 2
ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	180.0	1050.0	425.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.54	6.25	1.44
RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	425.0	1050.0	180.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.08	4.17	0.68
HAUL AND RET.TIME	(MIN)	14.16		
AVERAGE SPEED	(KM/H)	14.03		
LOAD TIME	(MIN)	2.50		
TOTAL HAUL TIME	(MIN)	8.23		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	5.93		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	21.66		
CYCLES PER HOUR	(-)	2.77		
PRODUCTIVITY	(T/H)	138.52		
TRANSPORT VOLUME	(T/H)	738.10		
REQUIRED TRUCKS	(-)	5.33		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	9.0		

LURGI-CHEMIE MINING EQUIPMENT — TRUCK HAULAGE SIMULATION — TRUCK REQUIREMENT AND PRODUCTIVITY — CZHBRE2 PAGE 1

9.11.83 - 12/ 6/49 — LIGANGA YEAR 8 (ORE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 2

PAYLOAD (T): 50.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	100.0	1300.0	375.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.30	7.75	1.29

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	375.0	1300.0	100.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	0.96	5.17	0.49
HAUL AND RET.TIME	(MIN)	15.96		
AVERAGE SPEED	(KM/H)	13.35		
LOAD TIME	(MIN)	2.50		
TOTAL HAUL TIME	(MIN)	9.34		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	6.61		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	23.46		
CYCLES PER HOUR	(-)	2.56		
PRODUCTIVITY	(T/H)	127.90		
TRANSPORT VOLUME	(T/H)	738.10		
REQUIRED TRUCKS	(-)	5.77		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	10.0		

LURGI-CHEMIE MINING EQUIPMENT   TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY   CZHBRE2   PAGE 1

9.11.83 - 12/ 7/ 0   LIGANGA YEAR 9 (ORE)

TRUCK MODEL: EUCLID   ALTERNATIVE: 2
PAYLOAD (T): 50.0   ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	200.0	575.0	980.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.60	3.40	3.10

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	980.0	575.0	200.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	2.41	2.27	0.73
HAUL AND RET.TIME	(MIN)	12.51		
AVERAGE SPEED	(KM/H)	16.83		
LOAD TIME	(MIN)	2.50		
TOTAL HAUL TIME	(MIN)	7.11		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	5.41		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	20.01		
CYCLES PER HOUR	(-)	3.00		
PRODUCTIVITY	(T/H)	149.91		
TRANSPORT VOLUME	(T/H)	738.10		
REQUIRED TRUCKS	(-)	4.92		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	9.0		

LURGI-CHEMIE MINING EQUIPMENT TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1

9.11.83 - 12/ 7/12 LIGANGA YEAR 1 (WASTE)

TRUCK MODEL: EUCLID ALTERNATIVE: 2
PAYLOAD (T): 50.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	180.0	1450.0	150.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.54	8.65	0.61

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	150.0	1450.0	180.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	0.42	5.77	0.68
HAUL AND RET.TIME	(MIN)	16.67		
AVERAGE SPEED	(KM/H)	12.81		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	9.81		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	6.87		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	24.67		

CYCLES PER HOUR	(-)	2.43
PRODUCTIVITY	(T/H)	121.59
TRANSPORT VOLUME	(T/H)	321.40
REQUIRED TRUCKS	(-)	2.64
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00

TOTAL NO. OF TRUCKS	(-)	5.0

LURGI-CHEMIE MINING ECUIPMENT — TRUCK HAULAGE SIMULATION — TRUCK REQUIREMENT AND PRODUCTIVITY — CZHBREZ PAGE 1

9.11.83 - 12/ 7/23 — LIGANGA YEAR 2 (WASTE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 2
PAYLOAD (T): 50.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	180.0	1200.0	200.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.54	7.15	0.76

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	200.0	1200.0	180.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	0.54	4.77	0.68
HAUL AND RET.TIME	(MIN)	14.44		
AVERAGE SPEED	(KM/H)	13.13		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	8.46		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	5.99		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	22.44		
CYCLES PER HOUR	(-)	2.67		
PRODUCTIVITY	(T/H)	133.68		
TRANSPORT VOLUME	(T/H)	836.90		
REQUIRED TRUCKS	(-)	6.26		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	11.0		

LURGI-CHEMIE MINING EQUIPMENT — TRUCK HAULAGE SIMULATION

TRUCK REQUIREMENT AND PRODUCTIVITY — CZHBRE2 — PAGE 1

9.11.83 - 12/ 7/49 — LIGANGA YEAR 3 (WASTE).

TRUCK MODEL: EUCLID — ALTERNATIVE: 2

PAYLOAD (T): 50.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	170.0	700.0	350.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.51	4.15	1.21

RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	350.0	700.0	170.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	0.90	2.77	0.66
HAUL AND RET.TIME	(MIN)	10.20		
AVERAGE SPEED	(KM/H)	14.36		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	5.88		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	4.32		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	18.20		

CYCLES PER HOUR	(-)	3.30
PRODUCTIVITY	(T/H)	164.85
TRANSPORT VOLUME	(T/H)	877.00
REQUIRED TRUCKS	(-)	5.32
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00

TOTAL NO. OF TRUCKS (-) 9.0

LURGI-CHEMIE MINING EQUIPMENT　　TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY　　CZHBRE2　PAGE 1
9.11.83 - 12/ 7/59　　LIGANGA YEAR 4 (WASTE)

TRUCK MODEL: EUCLID　　ALTERNATIVE: 2
PAYLOAD (T): 50.0　　ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	120.0	450.0	460.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.36	2.65	1.54
RETURN SECTION		R 1	R 2	R 3
SECTION LENGTH	(M)	460.0	450.0	120.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.16	1.77	0.54
HAUL AND RET.TIME	(MIN)	8.02		
AVERAGE SPEED	(KM/H)	15.41		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	4.56		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	3.47		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	16.02		
CYCLES PER HOUR	(-)	3.74		
PRODUCTIVITY	(T/H)	187.24		
TRANSPORT VOLUME	(T/H)	878.20		
REQUIRED TRUCKS	(-)	4.69		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	8.0		

LURGI-CHEMIE MINING EQUIPMENT — TRUCK HAULAGE SIMULATION

TRUCK RECUIREMENT AND PRODUCTIVITY — CZHBRE2 PAGE 1

9.11.83 - 12/ 8/ 8 — LIGANGA YEAR 5 (WASTE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 2

PAYLOAD (T): 50.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3
SECTION LENGTH	(M)	220.0	325.0	550.0
GRADE	(%)	0.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	20.0
HAUL TIME	(MIN)	0.66	1.90	1.81
RETURN SECTION		**R 1**	**R 2**	**R 3**
SECTION LENGTH	(M)	550.0	325.0	220.0
GRADE	(%)	0.0	10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	4.0
SPEED	(KM/H)	25.0	15.0	25.0
RETURN TIME	(MIN)	1.38	1.27	0.78
HAUL AND RET.TIME	(MIN)	7.80		
AVERAGE SPEED	(KM/H)	16.85		
LOAD TIME	(MIN)	3.00		
TOTAL HAUL TIME	(MIN)	4.38		
TURN AND DUMP TIME	(MIN)	2.00		
TOTAL RETURN TIME	(MIN)	3.42		
SPOT TIME	(MIN)	3.00		
TOTAL CYCLE TIME	(MIN)	15.80		
CYCLES PER HOUR	(-)	3.80		
PRODUCTIVITY	(T/H)	189.89		
TRANSPORT VOLUME	(T/H)	912.40		
RECUIRED TRUCKS	(-)	4.80		
TIME EFFICIENCY	(%)	83.00		
OPERATOR EFFICIENCY	(%)	90.00		
MECH. AVAILABILITY	(%)	80.00		
TOTAL NO. OF TRUCKS	(-)	9.0		

LURGI-CHEMIE MINING EQUIPMENT

TRUCK HAULAGE SIMULATION

TRUCK REQUIREMENT AND PRODUCTIVITY

9.11.83 - 12/ 8/25

LIGANGA YEAR 6 (WASTE)

TRUCK MODEL: EUCLID

PAYLOAD (T): 50.0

ALTERNATIVE: 2

ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3	H 4
SECTION LENGTH	(M)	110.0	100.0	175.0	780.0
GRADE	(%)	0.0	4.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	14.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	10.0	20.0
HAUL TIME	(MIN)	0.33	0.55	1.05	2.50

RETURN SECTION		R 1	R 2	R 3	R 4
SECTION LENGTH	(M)	780.0	175.0	100.0	110.0
GRADE	(%)	0.0	10.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	15.0	25.0
RETURN TIME	(MIN)	1.93	0.67	0.40	0.51
HAUL AND RET.TIME	(MIN)	7.95			
AVERAGE SPEED	(KM/H)	17.59			
LOAD TIME	(MIN)	3.00			
TOTAL HAUL TIME	(MIN)	4.44			
TURN AND DUMP TIME	(MIN)	2.00			
TOTAL RETURN TIME	(MIN)	3.51			
SPOT TIME	(MIN)	3.00			
TOTAL CYCLE TIME	(MIN)	15.95			

CYCLES PER HOUR	(-)	3.76
PRODUCTIVITY	(T/H)	[illegible]
TRANSPORT VOLUME	(T/H)	1045.10
REQUIRED TRUCKS	(-)	5.56
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00
TOTAL NO. OF TRUCKS	(-)	10.0

LURGI-CHEMIE MINING EQUIPMENT TRUCK HAULAGE SIMULATION
TRUCK REQUIREMENT AND PRODUCTIVITY CZHBRE2 PAGE 1
9.11.83 - 12/ 8/36 LIGANGA YEAR 7 (WASTE)

TRUCK MODEL: EUCLID ALTERNATIVE: 2
PAYLOAD (T): 50.0 ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3	H 4
SECTION LENGTH	(M)	180.0	175.0	125.0	900.0
GRADE	(%)	0.0	4.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	14.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	10.0	20.0
HAUL TIME	(MIN)	0.54	1.00	0.75	2.86

RETURN SECTION		R 1	R 2	R 3	R 4
SECTION LENGTH	(M)	900.0	125.0	175.0	180.0
GRADE	(%)	0.0	10.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	15.0	25.0
RETURN TIME	(MIN)	2.22	0.47	0.70	0.68
HAUL AND RET.TIME	(MIN)	9.22			
AVERAGE SPEED	(KM/H)	17.96			
LOAD TIME	(MIN)	3.00			
TOTAL HAUL TIME	(MIN)	5.16			
TURN AND DUMP TIME	(MIN)	2.00			
TOTAL RETURN TIME	(MIN)	4.07			
SPOT TIME	(MIN)	3.00			
TOTAL CYCLE TIME	(MIN)	17.22			

CYCLES PER HOUR	(-)	3.48
PRODUCTIVITY	(T/H)	174.19
TRANSPORT VOLUME	(T/H)	1153.20
REQUIRED TRUCKS	(-)	6.62
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00
TOTAL NO. OF TRUCKS	(-)	12.0

TRUCK MODEL: EUCLID
PAYLOAD (T): 50.0

ALTERNATIVE: 2
ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3	H 4
SECTION LENGTH	(M)	100.0	375.0	75.0	960.0
GRADE	(%)	0.0	4.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	14.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	10.0	20.0
HAUL TIME	(MIN)	0.30	2.20	0.45	3.04

RETURN SECTION		R 1	R 2	R 3	R 4
SECTION LENGTH	(M)	960.0	75.0	375.0	100.0
GRADE	(%)	0.0	10.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	15.0	25.0
RETURN TIME	(MIN)	2.36	0.27	1.50	0.49
HAUL AND RET.TIME	(MIN)	10.61			
AVERAGE SPEED	(KM/H)	17.07			
LOAD TIME	(MIN)	3.00			
TOTAL HAUL TIME	(MIN)	6.00			
TURN AND DUMP TIME	(MIN)	2.00			
TOTAL RETURN TIME	(MIN)	4.62			
SPOT TIME	(MIN)	3.00			
TOTAL CYCLE TIME	(MIN)	18.61			

CYCLES PER HOUR	(-)	3.22
PRODUCTIVITY	(T/H)	161.17
TRANSPORT VOLUME	(T/H)	1261.20
REQUIRED TRUCKS	(-)	7.83
TIME EFFICIENCY	(%)	83.00
CPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00
TOTAL NO. OF TRUCKS	(-)	14.0

LURGI-CHEMIE MINING EQUIPMENT — TRUCK HAULAGE SIMULATION

TRUCK REQUIREMENT AND PRODUCTIVITY — CZHBRE2 PAGE 1

9.11.83 - 12/ 9/ 1 — LIGANGA YEAR 9 (WASTE)

TRUCK MODEL: EUCLID — ALTERNATIVE: 2

PAYLOAD (T): 50.0 — ACCELERATION : 0.50 M/S**2 / RETARDATION: 0.50 M/S**2

HAUL SECTION		H 1	H 2	H 3	H 4
SECTION LENGTH	(M)	200.0	500.0	75.0	1050.0
GRADE	(%)	0.0	4.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	14.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	-6.0	-6.0	4.0
SPEED	(KM/H)	20.0	10.0	10.0	20.0
HAUL TIME	(MIN)	0.60	2.95	0.45	3.31

RETURN SECTION		R 1	R 2	R 3	R 4
SECTION LENGTH	(M)	1050.0	75.0	500.0	200.0
GRADE	(%)	0.0	10.0	-10.0	0.0
ROLLING RESISTANCE	(%)	4.0	4.0	4.0	4.0
TOTAL RESISTANCE	(%)	4.0	14.0	-6.0	4.0
SPEED	(KM/H)	25.0	15.0	15.0	25.0
RETURN TIME	(MIN)	2.58	0.27	2.00	0.73
HAUL AND RET.TIME	(MIN)	12.89			
AVERAGE SPEED	(KM/H)	16.99			
LOAD TIME	(MIN)	3.00			
TOTAL HAUL TIME	(MIN)	7.32			
TURN AND DUMP TIME	(MIN)	2.00			
TOTAL RETURN TIME	(MIN)	5.57			
SPOT TIME	(MIN)	3.00			
TOTAL CYCLE TIME	(MIN)	20.89			

CYCLES PER HOUR	(-)	2.87
PRODUCTIVITY	(T/H)	143.61
TRANSPORT VOLUME	(T/H)	1415.10
REQUIRED TRUCKS	(-)	9.85
TIME EFFICIENCY	(%)	83.00
OPERATOR EFFICIENCY	(%)	90.00
MECH. AVAILABILITY	(%)	80.00
TOTAL NO. OF TRUCKS	(-)	17.0

LURGI-CHEMIE LC-HB
20.12.83 - 13/47/ 1

I N V E S T M E N T - S C H E D U L E
PROJECT : L I G A N G A (ALTERNATIVE 2)
PRODUCTION: 3.12 MILL.T/A ROM

DATE 11/15/1983

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	YEAR -1	1	2	3	4	5
1	EXCAVATOR (4.6 M3)	6	0.475	4	0.950	0.475	0.475	0.0	0.0	0.0
2	TRUCK (50 T)	5	0.400	25	2.400	2.400	2.000	0.0	0.0	2.400
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
8	TRIPPER CAR	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
11	BLASTHOLE DRILL	6	0.270	6	0.270	0.540	0.540	0.270	0.0	0.0
12	DOZER	5	0.385	4	0.385	0.770	0.385	0.0	0.0	0.385
13	WHEEL DOZER	5	0.365	2	0.365	0.365	0.0	0.0	0.0	0.365
14	GRADER	5	0.305	2	0.305	0.0	0.305	0.0	0.0	0.305
15	SERVICE TRUCK	5	0.020	3	0.020	0.020	0.020	0.0	0.0	0.020
16	WAREHOUSE TRUCK	5	0.025	2	0.025	0.025	0.0	0.0	0.0	0.025
17	FUELTRUCK	5	0.077	2	0.077	0.0	0.077	0.0	0.0	0.077
18	WATERTRUCK	5	0.075	1	0.075	0.0	0.0	0.0	0.0	0.075
19	TRACTOR	10	0.030	1	0.030	0.0	0.0	0.0	0.0	0.0
20	TRAILER	10	0.010	1	0.010	0.0	0.0	0.0	0.0	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
22	CRANE-LIGHT	10	0.058	1	0.058	0.058	0.0	0.0	0.0	0.0
23	PICK-UP	5	0.013	6	0.039	0.039	0.0	0.0	0.0	0.039
24	WATER CONTROL	20	0.250	1	0.0	0.0	0.250	0.0	0.0	0.0
25	WORKSHOPS	20	1.000	1	0.400	0.600	0.0	0.0	0.0	0.0
26	WAREHOUSES	20	0.200	1	0.120	0.080	0.0	0.0	0.0	0.0
27	POWER SUPPLY	20	0.050	1	0.050	0.0	0.0	0.0	0.0	0.0
28	BUILDINGS	20	0.120	1	0.060	0.060	0.0	0.0	0.0	0.0
29	RELOCATIONS	20	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
31	EXPLORATION/STUDIES	20	1.500	0	0.500	0.0	0.0	0.0	0.0	0.0
32	MISCELLANEOUS	0	2.500	0	0.820	1.680	0.0	0.0	0.0	0.0
33	CONTINGENCY (10 %)	0	0.0	0	0.695	0.711	0.405	0.027	0.0	0.369
34	TOTAL				7.555	7.823	4.457	0.297	0.0	4.060
35	INITIAL INVESTMENT +START-UP(YEAR -1,1)				15.378					
36	GRANDTOTAL (20 YEARS)				77.875					

ALL [illegible] IN MILLION [illegible]

LURGI-CHEMIE LC-HB
20.12.83 - 13/47/ 1

I N V E S T M E N T - S C H E D U L E
PROJECT : L I G A N G A (ALTERNATIVE 2)
PRODUCTION: 3.12 MILL.T/A ROM

DATE 11/15/1983

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	YEAR 6	7	8	9	10	11
1	EXCAVATOR (4.6 M3)	6	0.475	4	0.950	0.475	0.0	0.0	0.0	0.0
2	TRUCK (50 T)	5	0.400	25	2.800	2.400	0.800	0.800	2.400	2.800
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
8	TRIPPER CAR	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
11	BLASTHOLE DRILL	6	0.270	6	0.270	0.540	0.540	0.270	0.0	0.0
12	DOZER	5	0.385	4	0.770	0.385	0.0	0.0	0.385	0.770
13	WHEEL DOZER	5	0.365	2	0.365	0.0	0.0	0.0	0.365	0.365
14	GRADER	5	0.305	2	0.0	0.305	0.0	0.0	0.305	0.0
15	SERVICE TRUCK	5	0.020	3	0.020	0.020	0.0	0.0	0.020	0.020
16	WAREHOUSE TRUCK	5	0.025	2	0.025	0.0	0.0	0.0	0.025	0.025
17	FUELTRUCK	5	0.077	2	0.0	0.077	0.0	0.0	0.077	0.0
18	WATERTRUCK	5	0.075	1	0.0	0.0	0.0	0.0	0.075	0.0
19	TRACTOR	10	0.030	1	0.0	0.0	0.0	0.0	0.030	0.0
20	TRAILER	10	0.010	1	0.0	0.0	0.0	0.0	0.010	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
22	CRANE-LIGHT	10	0.058	1	0.0	0.0	0.0	0.0	0.058	0.058
23	PICK-UP	5	0.013	6	0.039	0.0	0.0	0.0	0.039	0.039
24	WATER CONTROL	20	0.250	1	0.0	0.0	0.0	0.0	0.0	0.0
25	WORKSHOPS	20	1.000	1	0.0	0.0	0.0	0.0	0.0	0.0
26	WAREHOUSES	20	0.200	1	0.0	0.0	0.0	0.0	0.0	0.0
27	POWER SUPPLY	20	0.050	1	0.0	0.0	0.0	0.0	0.0	0.0
28	BUILDINGS	20	0.120	1	0.0	0.0	0.0	0.0	0.0	0.0
29	RELOCATIONS	20	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
31	EXPLORATION/STUDIES	20	1.500	0	0.500	0.0	0.0	0.0	0.0	0.0
32	MISCELLANEOUS	0	2.500	0	0.0	0.0	0.0	0.0	0.0	0.0
33	CONTINGENCY (10 %)	0	0.0	0	0.574	0.460	0.134	0.107	0.379	0.408
34	TOTAL				6.313	5.062	1.474	1.177	4.168	4.485

ALL FIGURES IN MILLION US$

LURGI-CHEMIE LC-HB
20.12.83 - 13/47/ 1

I N V E S T M E N T - S C H E D U L E
PROJECT : L I G A N G A (ALTERNATIVE 2)
PRODUCTION: 3.12 MILL.T/A ROM

DATE 11/15/1983

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	YEAR 12	13	14	15	16	17
1	EXCAVATOR (4.6 M3)	6	0.475	4	0.950	0.475	0.0	0.0	0.0	0.0
2	TRUCK (50 T)	5	0.400	25	2.800	0.800	0.800	2.400	2.800	2.800
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
8	TRIPPER CAR	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
11	BLASTHOLE DRILL	6	0.270	6	0.270	0.540	0.540	0.270	0.0	0.0
12	DOZER	5	0.385	4	0.385	0.0	0.0	0.385	0.770	0.385
13	WHEEL DOZER	5	0.365	2	0.0	0.0	0.0	0.365	0.365	0.0
14	GRADER	5	0.305	2	0.305	0.0	0.0	0.305	0.0	0.305
15	SERVICE TRUCK	5	0.020	3	0.020	0.0	0.0	0.020	0.020	0.020
16	WAREHOUSE TRUCK	5	0.025	2	0.0	0.0	0.0	0.025	0.025	0.0
17	FUELTRUCK	5	0.077	2	0.077	0.0	0.0	0.077	0.0	0.077
18	WATERTRUCK	5	0.075	1	0.0	0.0	0.0	0.075	0.0	0.0
19	TRACTOR	10	0.030	1	0.0	0.0	0.0	0.0	0.0	0.0
20	TRAILER	10	0.010	1	0.0	0.0	0.0	0.0	0.0	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
22	CRANE-LIGHT	10	0.058	1	0.0	0.0	0.0	0.0	0.0	0.0
23	PICK-UP	5	0.013	6	0.0	0.0	0.0	0.039	0.039	0.0
24	WATER CONTROL	20	0.250	1	0.0	0.0	0.0	0.0	0.0	0.0
25	WORKSHOPS	20	1.000	1	0.0	0.0	0.0	0.0	0.0	0.0
26	WAREHOUSES	20	0.200	1	0.0	0.0	0.0	0.0	0.0	0.0
27	POWER SUPPLY	20	0.050	1	0.0	0.0	0.0	0.0	0.0	0.0
28	BUILDINGS	20	0.120	1	0.0	0.0	0.0	0.0	0.0	0.0
29	RELOCATIONS	20	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
31	EXPLORATION/STUDIES	20	1.500	0	0.500	0.0	0.0	0.0	0.0	0.0
32	MISCELLANEOUS	0	2.500	0	0.0	0.0	0.0	0.0	0.0	0.0
33	CONTINGENCY (10 %)	0	0.0	0	0.531	0.101	0.134	0.396	0.402	0.359
34	TOTAL				5.838	1.996	1.474	4.357	4.421	3.946

ALL FIGURES IN MILLION US$

LURGI-CHEMIE LC-HB
20.12.83 - 13/47/ 1

I N V E S T M E N T - S C H E D U L E
PROJECT : L I G A N G A (ALTERNATIVE 2)
PRODUCTION: 3.12 MILL.T/A RCM

DATE 11/15/1983

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	YEAR 18	19	20
1	EXCAVATOR (4.6 M3)	6	0.475	4	0.950	0.475	0.0
2	TRUCK (50 T)	5	0.400	25	0.800	0.800	2.400
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0	0.0
8	TRIPPER CAR	25	0.0	0	0.0	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0	0.0
11	BLASTHOLE DRILL	6	0.270	6	0.270	0.540	0.540
12	DOZER	5	0.385	4	0.0	0.0	0.385
13	WHEEL DOZER	5	0.365	2	0.0	0.0	0.365
14	GRADER	5	0.305	2	0.0	0.0	0.305
15	SERVICE TRUCK	5	0.020	3	0.0	0.0	0.020
16	WAREHOUSE TRUCK	5	0.025	2	0.0	0.0	0.025
17	FUEL TRUCK	5	0.077	2	0.0	0.0	0.077
18	WATERTRUCK	5	0.075	1	0.0	0.0	0.075
19	TRACTOR	10	0.030	1	0.0	0.0	0.0
20	TRAILER	10	0.010	1	0.0	0.0	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0	0.0
22	CRANE-LIGHT	10	0.058	1	0.0	0.0	0.0
23	PICK-UP	5	0.013	6	0.0	0.0	0.039
24	WATER CONTROL	20	0.250	1	0.0	0.0	0.0
25	WORKSHOPS	20	1.000	1	0.0	0.0	0.0
26	WAREHOUSES	20	0.200	1	0.0	0.0	0.0
27	POWER SUPPLY	20	0.050	1	0.0	0.0	0.0
28	BUILDINGS	20	0.120	1	0.0	0.0	0.0
29	RELOCATIONS	20	0.0	0	0.0	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0	0.0
31	EXPLORATION/STUDIES	20	1.500	0	0.0	0.0	0.0
32	MISCELLANEOUS	0	2.500	0	0.0	0.0	0.0
33	CONTINGENCY (10 %)	0	0.0	0	0.202	0.181	0.423
34	TOTAL				2.222	1.996	4.654

ALL FIGURES IN MILLION US$

LURGI-CHEMIE LC-HB
20.12.83 - 12/31/54

I N V E S T M E N T - S C H E D U L E

PROJECT : L I G A N G A (ALTERNATIVE 2)
PRODUCTION: 3.12 MILL.T/A ROM

DATE 11/15/1983

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	YEAR -1	1	2	3	4	5
1	EXCAVATOR (4.6 M3)	6	5.795	4	11.590	5.795	5.795	0.0	0.0	0.0
2	TRUCK (50 T)	5	4.880	25	29.280	29.280	24.400	0.0	0.0	29.280
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
8	TRIPPER CAR	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
11	BLASTHOLE DRILL	6	3.294	6	3.294	6.588	6.588	3.294	0.0	0.0
12	DOZER	5	4.697	4	4.697	9.394	4.697	0.0	0.0	4.697
13	WHEEL DOZER	5	4.453	2	4.453	4.453	0.0	0.0	0.0	4.453
14	GRADER	5	3.721	2	3.721	0.0	3.721	0.0	0.0	3.721
15	SERVICE TRUCK	5	0.244	3	0.244	0.244	0.244	0.0	0.0	0.244
16	WAREHOUSE TRUCK	5	0.305	2	0.305	0.305	0.0	0.0	0.0	0.305
17	FUELTRUCK	5	0.939	2	0.939	0.0	0.939	0.0	0.0	0.939
18	WATERTRUCK	5	0.915	1	0.915	0.0	0.0	0.0	0.0	0.915
19	TRACTOR	10	0.366	1	0.366	0.0	0.0	0.0	0.0	0.0
20	TRAILER	10	0.122	1	0.122	0.0	0.0	0.0	0.0	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
22	CRANE-LIGHT	10	0.708	1	0.708	0.708	0.0	0.0	0.0	0.0
23	PICK-UP	5	0.159	6	0.476	0.476	0.0	0.0	0.0	0.476
24	WATER CONTROL	20	3.050	1	0.0	0.0	3.050	0.0	0.0	0.0
25	WORKSHOPS	20	12.200	1	4.880	7.320	0.0	0.0	0.0	0.0
26	WAREHOUSES	20	2.440	1	1.464	0.976	0.0	0.0	0.0	0.0
27	POWER SUPPLY	20	0.610	1	0.610	0.0	0.0	0.0	0.0	0.0
28	BUILDINGS	20	1.464	1	0.732	0.732	0.0	0.0	0.0	0.0
29	RELOCATIONS	20	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
31	EXPLORATION/STUDIES	20	18.300	0	6.100	0.0	0.0	0.0	0.0	0.0
32	MISCELLANEOUS	0	30.500	0	10.004	20.496	0.0	0.0	0.0	0.0
33	CONTINGENCY (10 %)	0	0.0	0	8.490	8.677	4.943	0.329	0.0	4.503
34	TOTAL				93.390	95.443	54.378	3.623	0.0	49.533
35	INITIAL INVESTMENT F.START-UP(YEAR -1,1)				188.833					
36	GRANDTOTAL (20 YEARS)				950.079					

ALL FIGURES IN MILLION TANZANIAN SHILLINGS

LURGI-CHEMIE LC-H8
20.12.83 - 12/31/54

INVESTMENT-SCHEDULE
PROJECT : L I G A N G A (ALTERNATIVE
PRODUCTION: 3.12 MILL.T/A ROM

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	6	7
1	EXCAVATOR (4.6 M3)	6	5.795	4	11.590	5.795
2	TRUCK (50 T)	5	4.880	25	34.160	34.160
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0
8	TRIPPER CAR	25	0.0	0	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0
11	BLASTHOLE DRILL	6	3.294	6	3.294	6.588
12	DOZER	5	4.697	4	9.394	4.697
13	WHEEL DOZER	5	4.453	2	4.453	0.0
14	GRADER	5	3.721	2	0.0	3.721
15	SERVICE TRUCK	5	0.244	3	0.244	0.244
16	WAREHOUSE TRUCK	5	0.305	2	0.305	0.0
17	FUELTRUCK	5	0.939	2	0.0	0.939
18	WATERTRUCK	5	0.915	1	0.0	0.0
19	TRACTOR	10	0.366	1	0.0	0.0
20	TRAILER	10	0.122	1	0.0	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0
22	CRANE-LIGHT	10	0.708	1	0.0	0.0
23	PICK-UP	5	0.159	6	0.476	0.0
24	WATER CONTROL	20	3.050	1	0.0	0.0
25	WORKSHOPS	20	12.200	1	0.0	0.0
26	WAREHOUSES	20	2.440	1	0.0	0.0
27	POWER SUPPLY	20	0.610	1	0.0	0.0
28	BUILDINGS	20	1.464	1	0.0	0.0
29	RELOCATIONS	20	0.0	0	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0
31	EXPLORATION/STUDIES	20	18.300	0	6.100	0.0
32	MISCELLANEOUS	0	30.500	0	0.0	0.0
33	CONTINGENCY (10 %)	0	0.0	0	7.002	5.614
34	TOTAL				77.017	61.759

ALL FIGURES IN MILLION TANZANIAN SHILLINGS

2)

DATE 11/15/1983

YEAR

8	9	10	11
0.0	0.0	0.0	0.0
9.760	9.760	29.280	34.160
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
6.588	3.294	0.0	0.0
0.0	0.0	4.697	9.394
0.0	0.0	4.453	4.453
0.0	0.0	3.721	0.0
0.0	0.0	0.244	0.244
0.0	0.0	0.305	0.305
0.0	0.0	0.939	0.0
0.0	0.0	0.915	0.0
0.0	0.0	0.366	0.0
0.0	0.0	0.122	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.708	0.708
0.0	0.0	0.476	0.476
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
1.635	1.205	4.623	4.974
17.983	14.359	50.848	54.713

LURGI-CHEMIE LC-HB
20.12.83 - 12/31/54

I N V E S T M E N T - S C H E D U L E
PROJECT : L I G A N G A (ALTERNATIVE
PRODUCTION: 3.12 MILL.T/A ROM

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	12	13
1	EXCAVATOR (4.6 M3)	6	5.795	4	11.590	5.795
2	TRUCK (50 T)	5	4.880	25	34.160	9.760
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0
8	TRIPPER CAR	25	0.0	0	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0
11	BLASTHOLE DRILL	6	3.294	6	3.294	6.588
12	DOZER	5	4.697	4	4.697	0.0
13	WHEEL DOZER	5	4.453	2	0.0	0.0
14	GRADER	5	3.721	2	3.721	0.0
15	SERVICE TRUCK	5	0.244	3	0.244	0.0
16	WAREHOUSE TRUCK	5	0.305	2	0.0	0.0
17	FUELTRUCK	5	0.939	2	0.939	0.0
18	WATERTRUCK	5	0.915	1	0.0	0.0
19	TRACTOR	10	0.366	1	0.0	0.0
20	TRAILER	10	0.122	1	0.0	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0
22	CRANE-LIGHT	10	0.708	1	0.0	0.0
23	PICK-UP	5	0.159	6	0.0	0.0
24	WATER CONTROL	20	3.050	1	0.0	0.0
25	WORKSHOPS	20	12.200	1	0.0	0.0
26	WAREHOUSES	20	2.440	1	0.0	0.0
27	POWER SUPPLY	20	0.610	1	0.0	0.0
28	BUILDINGS	20	1.464	1	0.0	0.0
29	RELOCATIONS	20	0.0	0	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0
31	EXPLORATION/STUDIES	20	18.300	0	6.100	0.0
32	MISCELLANEOUS	0	30.500	0	0.0	0.0
33	CONTINGENCY (10 %)	0	0.0	0	6.475	2.214
34	TOTAL				71.220	24.357

ALL FIGURES IN MILLION TANZANIAN SHILLINGS

2)

DATE 11/15/1983

YEAR 14	15	16	17
0.0	0.0	0.0	0.0
9.760	29.280	34.160	34.160
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
6.588	3.294	0.0	0.0
0.0	4.697	9.394	4.697
0.0	4.453	4.453	0.0
0.0	3.721	0.0	3.721
0.0	0.244	0.244	0.244
0.0	0.305	0.305	0.0
0.0	0.939	0.0	0.939
0.0	0.915	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.476	0.476	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
1.635	4.832	4.903	4.376
17.983	53.157	53.935	48.137

LURGI-CHEMIE LC-BB
20.12.83 - 12/31/54

I N V E S T M E N T - S C H E D U L E
PROJECT : L I G A N G A (ALTERNATIVE 2)
PRODUCTION: 3.12 MILL.T/A ROM

DATE 11/15/1983

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS	18	19	YEAR 20
1	EXCAVATOR (4.6 M3)	6	5.795	4	11.590	5.795	0.0
2	TRUCK (50 T)	5	4.880	25	9.760	9.760	29.280
3	IN-PIT CRUSHER	25	0.0	0	0.0	0.0	0.0
4	CONVEYOR-STRUCTURE	25	0.0	0	0.0	0.0	0.0
5	CONVEYOR-BELTING	8	0.0	0	0.0	0.0	0.0
6	REINV.OF BELTING	8	0.0	0	0.0	0.0	0.0
7	HOPPER CAR	25	0.0	0	0.0	0.0	0.0
8	TRIPPER CAR	25	0.C	0	0.0	0.0	0.0
9	SPREADER	25	0.0	0	0.0	0.0	0.0
10	FRONTENDLOADER	5	0.0	0	0.0	0.0	0.0
11	BLASTHOLE DRILL	6	3.294	6	3.294	6.588	6.588
12	DOZER	5	4.697	4	0.0	0.0	4.697
13	WHEEL DOZER	5	4.453	2	0.0	0.0	4.453
14	GRADER	5	3.721	2	0.0	0.0	3.721
15	SERVICE TRUCK	5	0.244	3	0.0	0.0	0.244
16	WAREHOUSE TRUCK	5	0.305	2	0.0	0.0	0.305
17	FUELTRUCK	5	0.939	2	0.0	0.0	0.939
18	WATERTRUCK	5	0.915	1	0.0	0.0	0.915
19	TRACTOR	10	0.366	1	0.0	0.0	0.0
20	TRAILER	10	0.122	1	0.0	0.0	0.0
21	CRANE-HEAVY	10	0.0	0	0.0	0.0	0.0
22	CRANE-LIGHT	10	0.708	1	0.0	0.0	0.0
23	PICK-UP	5	0.159	6	0.0	0.0	0.476
24	WATER CONTROL	20	3.050	1	0.0	0.0	0.0
25	WORKSHOPS	20	12.200	1	0.0	0.0	0.0
26	WAREHOUSES	20	2.440	1	0.0	0.0	0.0
27	POWER SUPPLY	20	0.610	1	0.0	0.0	0.0
28	BUILDINGS	20	1.464	1	0.0	0.0	0.0
29	RELOCATIONS	20	0.0	0	0.0	0.0	0.0
30	PRESTRIPPING	20	0.0	0	0.0	0.0	0.0
31	EXPLORATION/STUDIES	20	18.300	0	0.0	0.0	0.0
32	MISCELLANEOUS	0	30.500	0	0.0	0.0	0.0
33	CONTINGENCY (10 %)	0	0.0	0	2.464	2.214	5.162
34	TOTAL				27.108	24.357	56.780

ALL FIGURES IN MILLION TANZANIAN SHILLINGS

LURGI-CHEMIE LC-H8
15.11.83 - 7/38/10

I N V E S T M E N T
PROJECT : L I G A N
PRODUCTION: 3.10 MIL

NO.	DESCRIPTION	LIFE TIME	PRICE /ITEM	NO OF ITEMS
1	EXCAVATOR (4.6 M3)	6	4.560	4
2	TRUCK (50 T)	5	3.840	25
3	IN-PIT CRUSHER	25	0.0	0
4	CONVEYOR-STRUCTURE	25	0.0	0
5	CONVEYOR-BELTING	8	0.0	0
6	REINV.OF BELTING	8	0.0	0
7	HOPPER CAR	25	0.0	0
8	TRIPPER CAR	25	0.0	0
9	SPREADER	25	0.0	0
10	FRONTENDLOADER	5	0.0	0
11	BLASTHOLE DRILL	6	2.592	6
12	DOZER	5	3.696	4
13	WHEEL DOZER	5	3.504	2
14	GRADER	5	2.928	2
15	SERVICE TRUCK	5	0.192	3
16	WAREHOUSE TRUCK	5	0.240	2
17	FUELTRUCK	5	0.739	2
18	WATERTRUCK	5	0.720	1
19	TRACTOR	10	0.288	1
20	TRAILER	10	0.096	1
21	CRANE-HEAVY	10	0.0	0
22	CRANE-LIGHT	10	0.557	1
23	PICK-UP	5	0.125	6
24	WATER CONTROL	20	2.400	1
25	WORKSHOPS	20	9.600	1
26	WAREHOUSES	20	1.920	1
27	POWER SUPPLY	20	0.480	1
28	BUILDINGS	20	1.152	1
29	RELOCATIONS	20	0.0	0
30	PRESTRIPPING	20	0.0	0
31	EXPLORATION/STUDIES	20	14.400	0
32	MISCELLANEOUS	0	24.000	0
33	CONTINGENCY (10 %)	0	0.0	0
34	TOTAL			
35	INITIAL INVESTMENT F.START-UP(YEAR -1,1)			
36	GRANDTOTAL (20 YEARS)			

[redacted] ALL [redacted] GUR [redacted] N [redacted] IO [redacted] N7 [redacted] N [redacted] alt (9.6)

- S C H E D U L E
G A (ALTERNATIVE 2)
L.T/A ROM

PAGE 1

DATE 11/15/1983

YEAR					
-1	1	2	3	4	5
9.120	4.560	4.560	0.0	0.0	0.0
23.040	23.040	19.200	0.0	0.0	23.040
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
2.592	5.184	5.184	2.592	0.0	0.0
3.696	7.392	3.696	0.0	0.0	3.696
3.504	3.504	0.0	0.0	0.0	3.504
2.928	0.0	2.928	0.0	0.0	2.928
0.192	0.192	0.192	0.0	0.0	0.192
0.240	0.240	0.0	0.0	0.0	0.240
0.739	0.0	0.739	0.0	0.0	0.739
0.720	0.0	0.0	0.0	0.0	0.720
0.288	0.0	0.0	0.0	0.0	0.0
0.096	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.557	0.557	0.0	0.0	0.0	0.0
0.374	0.374	0.0	0.0	0.0	0.374
0.0	0.0	2.400	0.0	0.0	0.0
3.840	5.760	0.0	0.0	0.0	0.0
1.152	0.768	0.0	0.0	0.0	0.0
0.480	0.0	0.0	0.0	0.0	0.0
0.576	0.576	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
4.800	0.0	0.0	0.0	0.0	0.0
4.800	9.600	0.0	0.0	0.0	0.0
6.373	6.175	3.890	0.259	0.0	3.543
70.108	67.922	42.789	2.651	0.0	38.977
138.029					
739.683					

SECTION 2.3

Iron Ore Beneficiation

S E C T I O N 2.3.1

Process Description

Iron Ore Beneficiation

2.3.1 Process description

The process for upgrading of the iron ore from the Liganga and Maganga iron ore deposits was developed on the basis of tests carried out in the laboratories of Lurgi Chemie und Hüttentechnik GmbH.
The investigations consisted of laboratory and pilot scale tests. The main figures for design of process and beneficiation plant can be derived from these investigations.

As a further source of process development, Lurgi reviewed reports of former investigations.

2.3.1.1 Crushing

The ore will be delivered from the mine by trucks. The lump size is expected to be up to 800 mm. Liberation of the different mineralogical constituents of the ore makes comminution to liberation size necessary. The first step is the crushing. The run-of-mine ore will be dumped directly into the gyratory crusher. By action of the cone, the feed material is crushed to a grain size below 300 mm. This material is suitable for the next process step of autogenous grinding. As a buffer, the crushed material will be stored at an open stockpile. A certain blending of the crushed crude ore takes place at this stockpile. Since Liganga ore is homogeneous in its composition, no special measures in regard of blending are taken.

Since autogenous grinding is applied, only one stage of crushing will be sufficient.

2.3.1.2 Autogenous Grinding

By autogenous grinding, the crushed ore will be further comminuted near to liberation size. This kind of grinding takes place in a tube mill without the usual grinding media like rods or balls. The bigger lumps of the ore are acting as grinding media. To get equilibrium over longer periods of operation, the ratio of coarse to fine material has to be maintained more or less constant.

From the stockpile, the crushed ore is discharged at controlled rate to the screening on top of the bins. There, at approx. 80 mm, the crude ore is classified in coarse and fine fractions and stored in respective bins. From there. the two fractions will be fed in a predetermined ratio to the autogenous mill. Water is added to the crude ore in order to get a slurry of approx. 65 % solids inside the mill. The slurry, with material up to approx. 6 mm, is discharged from the mill and undergoes screening. The fraction minus 1 mm is separated for further processing, the coarser product is recirculated to the feed of the mill.

2.3.1.3 Magnetic Separation and Regrinding

The iron bearing minerals of the Liganga ore are mainly magnetite. The easiest and most economic way to recover this mineral is by wet low intensity magnetic separation.

This separation is performed in two stages:

The minus 1 mm product of the autogenous grinding is fed to a first magnetic separation step. There, approx. 75 weight % of the feed are recovered as a preconcentrate. The remaining 25 weight % are tailings. The preconcentrate will also consist, besides of free magnetite particles, of intergrown magnetite/gangue material. This makes further liberation by grinding necessary.

The preconcentrate is fed to hydrocyclones, where separation between coarse and fine particles is carried out. The coarse underflow is fed to a ball mill for further grinding, the fine overflow is directed to a second magnetic separation step.

The feed of the second magnetic separation will be upgraded to a final concentrate, the remaining tailings join the tailings from the first magnetic separation stage.

2.3.1.4 Concentrate Dewatering and Mixing

The process of pelletizing, which follows the upgrading of the iron ore, will utilize a filter cake with a moisture content of appr. 9 %. Therefore, thickening and filtration steps are necessary to treat the concentrate of the second magnetic separation step which occurs in form of slurry. This slurry is directed to the concentrate thickener, where thickening of the slurry to appr. 65 % solids takes place. The clear overflow goes to the process water tank for further reuse as process water.

The thickened slurry will be stored in a slurry tank. This slurry tank acts also as buffer between beneficiation plant and filtration. From the slurry tank, the filters are fed by a pump at controlled amount and density. By action of vacuum, the water is sucked off from the slurry and the filter cake with appr. 9 % moisture discharged onto a belt conveyor.

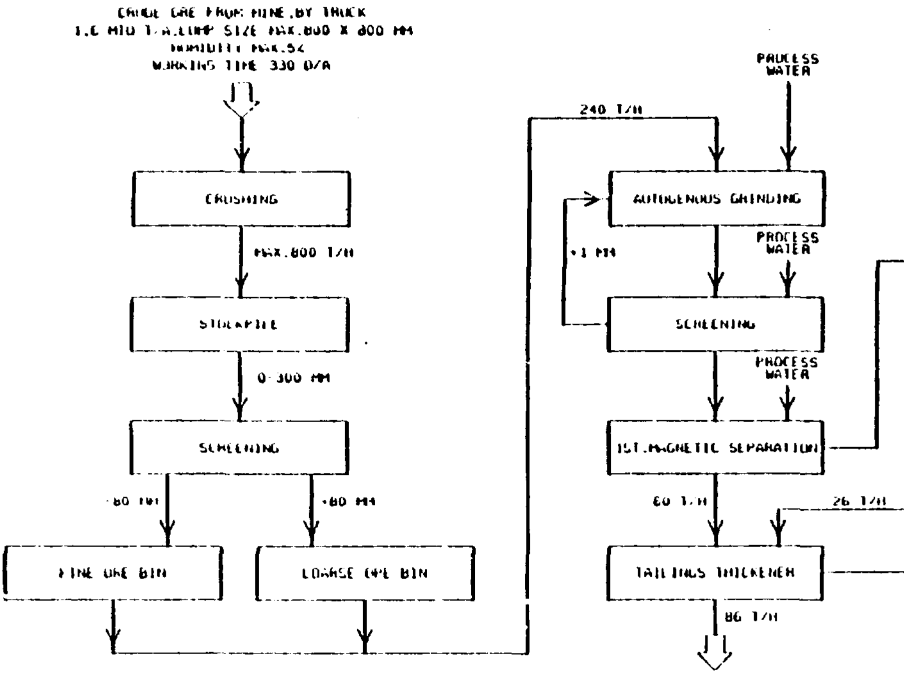
This belt conveyor discharges into a mixer where also additives are added at a controlled ratio. After mixing, this material is transferred by a belt conveyor to the bins of the pellet plant.

2.3.1.5 Water treatment

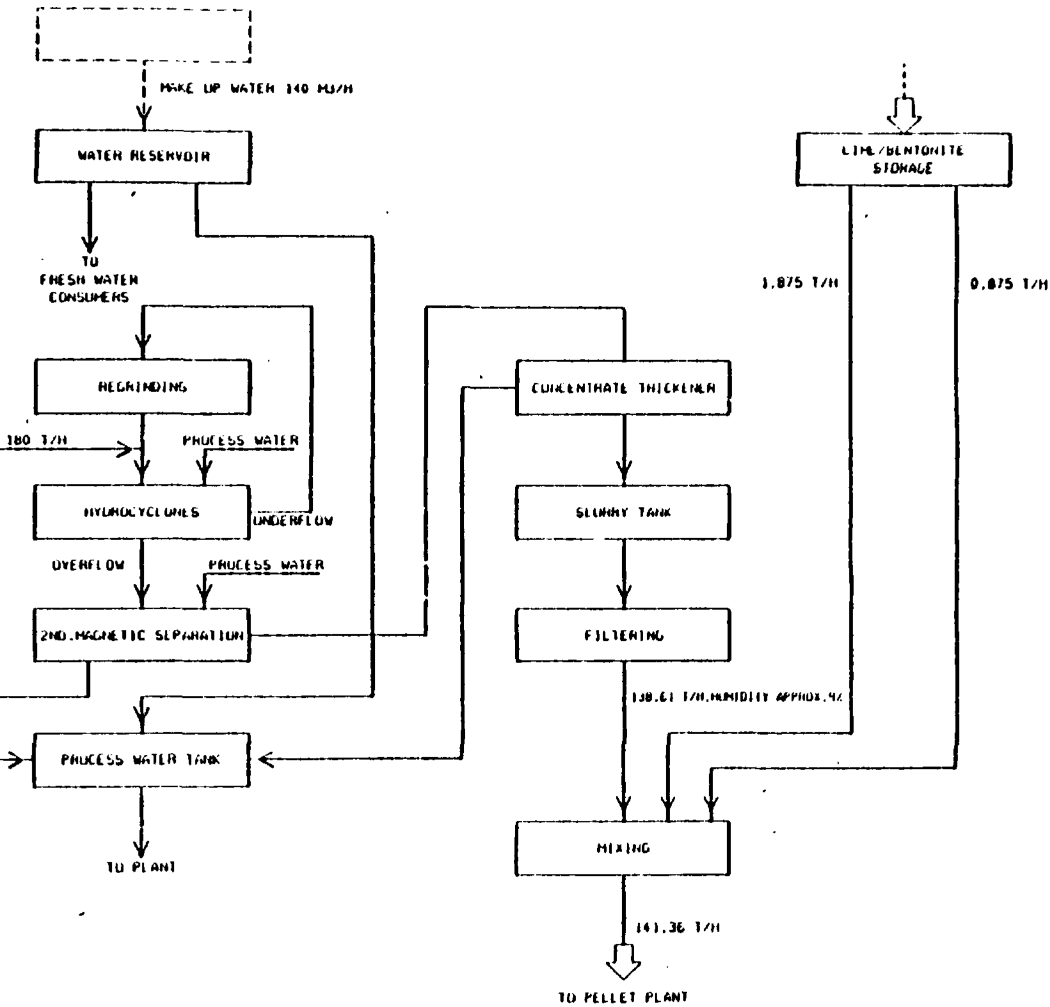
Grinding, classification and magnetic separation are wet processes which need a certain amount of water. From a fresh water source, clean water will be pumped to the fresh water reservoir near the plant. From here, it will be distributed to the fresh water consumers (cooling etc.) and as make-up water to the process water tank.

From the process water tank, all consumers of process water like autogenous mill, pump sumps, magnetic separators etc. will be delivered. The major part of the water is recirculated after thickening of the products (concentrate, tailings).

Water losses, which have to be replaced, occur with the underflow of the tailings, thickener and as remaining moisture in the concentrate filter cake.



CRUDE ORE FROM MINE, BY TRUCK
1.6 MIO T/A, LUMP SIZE MAX. 800 X 800 MM
HUMIDITY MAX. 5%
WORKING TIME 330 D/A
CRUSHING
MAX. 800 T/H
STOCKPILE
0-300 MM
SCREENING
-80 MM
+80 MM
FINE ORE BIN
COARSE ORE BIN
240 T/H
PROCESS WATER
AUTOGENOUS GRINDING
+1 MM
PROCESS WATER
SCREENING
PROCESS WATER
1ST MAGNETIC SEPARATION
60 T/H
26 T/H
TAILINGS THICKENER
86 T/H



LURGI — Lurgi Chemie und Huettentechnik GmbH

IRON ORE BENEFICIATION PLANT
LIGANGA
1.6 MIO T/A ORE FEED

202 BLOCK DIAGRAM

HAA 112238 TANZANIA

L2A0 122380000 1

S E C T I O N 2.3.2

Plant Description

Iron Ore Beneficiation

2.3.2 Plant Description

2.3.2.1 General Remarks

Based on the results of the laboratory and pilot plant tests with the Liganga/Maganga iron ore, the beneficiation plant was designed.

As layout basis in regard of the working time, the following figures were defined:

Working days per year :	330
Working hours per day :	20.2
Working hours per year:	6,600

The mean planned working time of 20.2 hrs/day allows an idle time of the plant of 3.8 hrs/day for breakdown or planned stops (maintenance, repairs). The design figures result in an hourly throughput for the plant of 240 t/h. For an iron ore beneficiation plant with the proposed flowsheet, this capacity can be handled in one line with machine sizes of proved design.

2.3.2.2 Precrushing and Crushed Ore Storage

Dump trucks, delivering the ore from the mine, will dump the ore with max. 800 mm lump size directly into the crusher. From a bin below the crusher, the crushed ore (0 - 300 mm) is discharged by an apron feeder and transferred to a conveyor belt. This conveyor belt drops the material onto an ore storage pile which acts as a buffer stock between mine and concentrator.

At the bottom of the stockpile, the ore can be taken away through three openings by means of vibro-feeders and discharged onto a conveyor belt for transport to the bins.

2.3.2.3 Autogenous Grinding

Ahead of the grinding, two ore bins are arranged for coarse ore (300 - 80 mm) and fine ore (80 - 0 mm) respectively. On top of the bins, the ore from the stockpile is classified into the two different size fractions and stored in the corresponding bins. Discharging from the bins will be performed at a predetermined ratio of coarse to fine ore. It is effected by a rotating table feeder for the fine ore and by a vibrating feeder for the coarse ore. Both feeders discharge onto the feeding belt of the autogenous mill. This belt conveyor is equipped with two belt scales, which deliver the signals for controlling the feed rate and water addition to the mill. The autogenous mill, with 6 m dia. x 5 m length, has a discharge grate with pebble ports. Discharge from the mill is screened at approx. 1 mm on a vibrating screen. Underflow is collected in a pump sump and goes to the first magnetic separation, whereas the overflow is recirculated to the mill. Coarse gangue material can be separated as coarse tailings by a magnetic drum separator on this way.

First magnetic separation:

This separation step consists of two separators, each with two drums with concurrent trough type. The feed slurry to the separators is pumped to a distributor, from where it is uniformly distributed to the separators. Tailings from the separators will be directed to the tailings thickener, the preconcentrate goes to the grinding circuit.

2.3.2.4 Grinding Circuit

To get upgrading of the magnetite to an iron content, suitable for direct reduction, further grinding is required. This is done in a closed grinding circuit. Preconcentrate together with the ball mill discharge are pumped for classification to two hydrocyclone groups, each with four hydrocyclones. The cyclones separate the fine fraction of the cyclone overflow and the coarse section in the underflow. The underflow is fed to the regrinding mill which is operated with steel balls as grinding media. Besides further liberation of the ore constituents, this grinding creates the specific surface of the material necessary for pelletizing.

Second magnetic separation

The cyclone overflow is fed by gravity to the second magnetic separation step. This step is equipped with three separators with three drums each. The drums are of countercurrent trough type with permanent magnet systems. At the third drum, the final concentrate is achieved and flows by gravity to the concentrate thickener. The tailings are directed together with that of the first magnetic separation step to the tailings thickener.

2.3.2.5 Concentrate Dewatering

The concentrate will be thickened inside the thickener to approx. 65 % solids. The overflow flows to the process water basin, from where it is recycled for further use to the plant. Underflow is pumped with a variable speed pump to the slurry tank for intermediate storage. From the tank, the slurry is pumped at controlled rate to the distributor ahead of the four disc filters, with 100 m² filter area each.
Under normal conditions, three filters are working and one acts as stand-by unit. Each filter has its own vacuum system consisting of vacuum pump (water-ring type) and three filtrate separators. Filtrate discharge from this system is by barometric leg type to a joint filtrate collecting tank.
The discharged filter cake is collected on the filter cake conveyor.

2.3.2.6 Additive Addition and Mixing

The weight of the filter cake is measured with a belt scale installed at the filter cake conveyor. By a signal from this belt scale and a predetermined ratio of addition, the discharge of additives (limestone and bentonite) from the day bins is controlled.

The material enters a special mixer for intense mixing of the different components. From the mixer, it is discharged onto a conveyor belt for transport to the bins of the pelletizing plant.

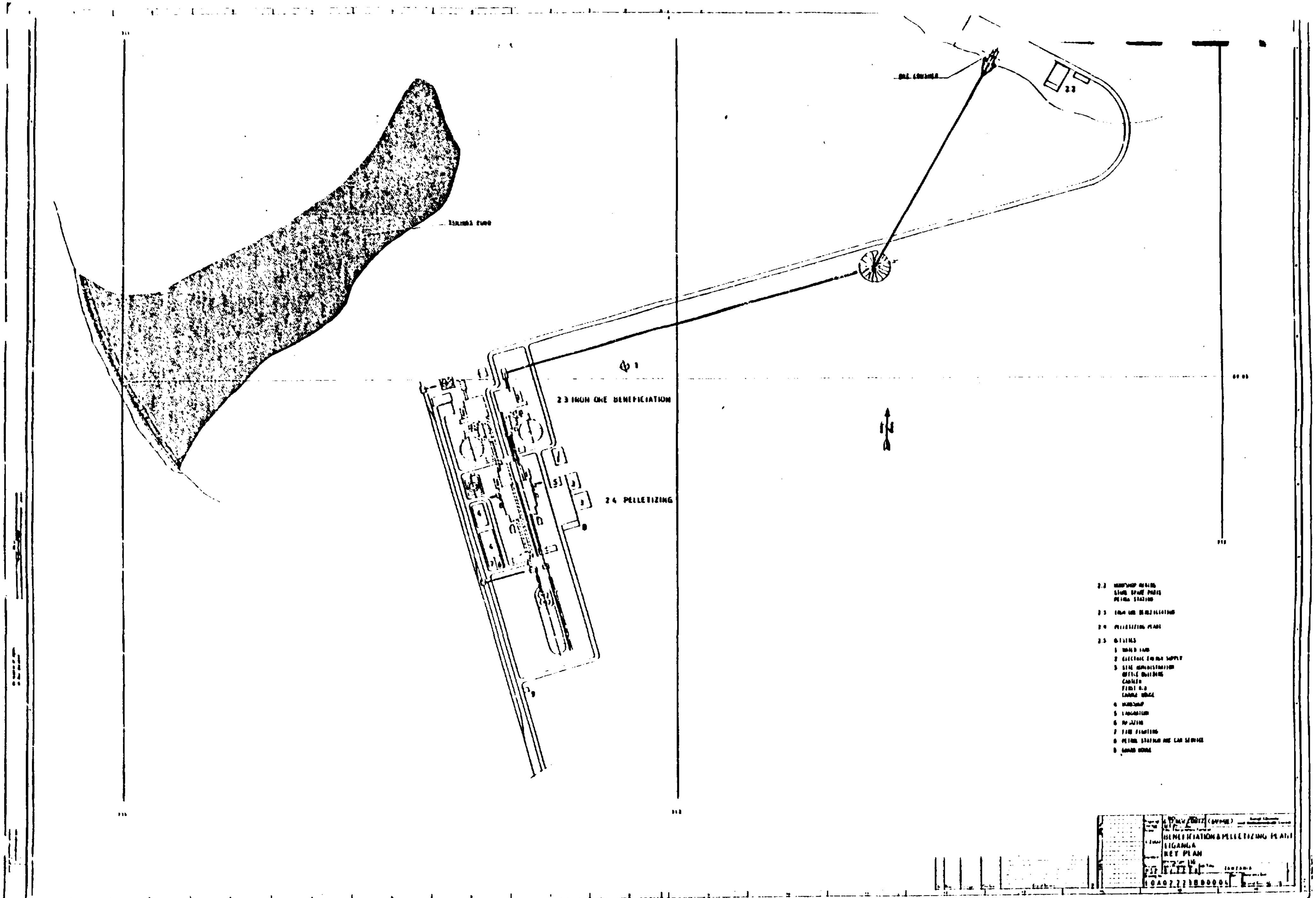
2.3.2.7 Emergency Stockpile for Mixed Filtercake

To transport the mixed filter cake to the pelletizing plant, a plough-type scraper is installed at the conveyor. In the lower position, it will push the mix off the belt and drop it to a stockpile. This procedure can be necessary if the filter cake is too wet during start-up of the filtration. For feeding this material back to the plant, a mixing tank with agitator is provided. The material will be loaded by a shovel loader from the stockpile to the mixing tank. Inside the tank, water is added to the filter cake. The slurry is then pumped to the concentrate thickener.

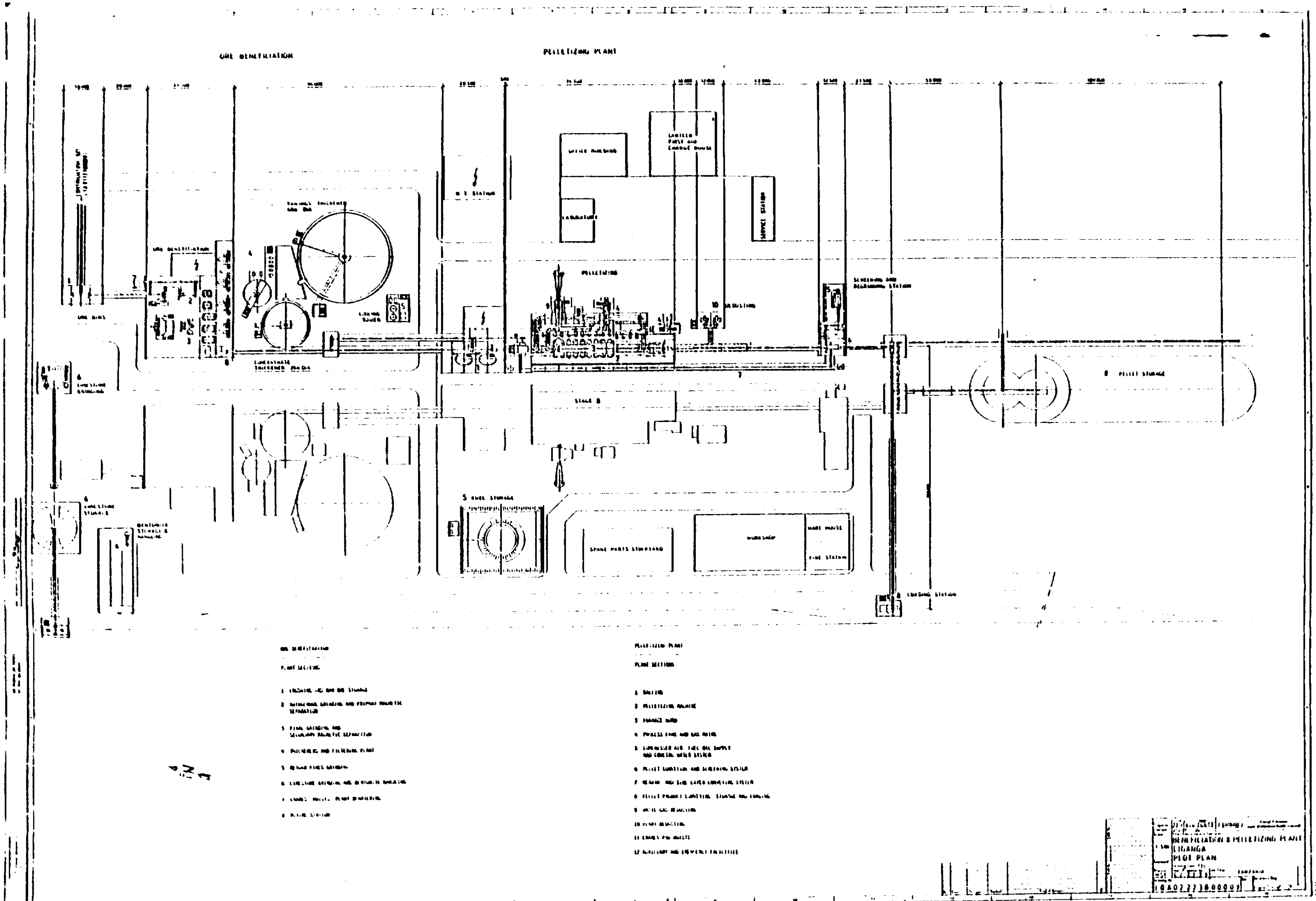
2.3.2.8 Water Usage at the Beneficiation Plant

The upgrading of the ore to a final concentrate is performed in this plant by a wet process. Different process steps require the addition of process or the use of cooling water.
Process water is stored in the process water basin adjacent to the tailings and concentrate thickener, from where it collects the overflows. From a steady head tank inside the concentrator building, all consumers will be delivered with process water. Losses of process water will be compensated by addition of fresh water from the fresh water basin to the process water basin.

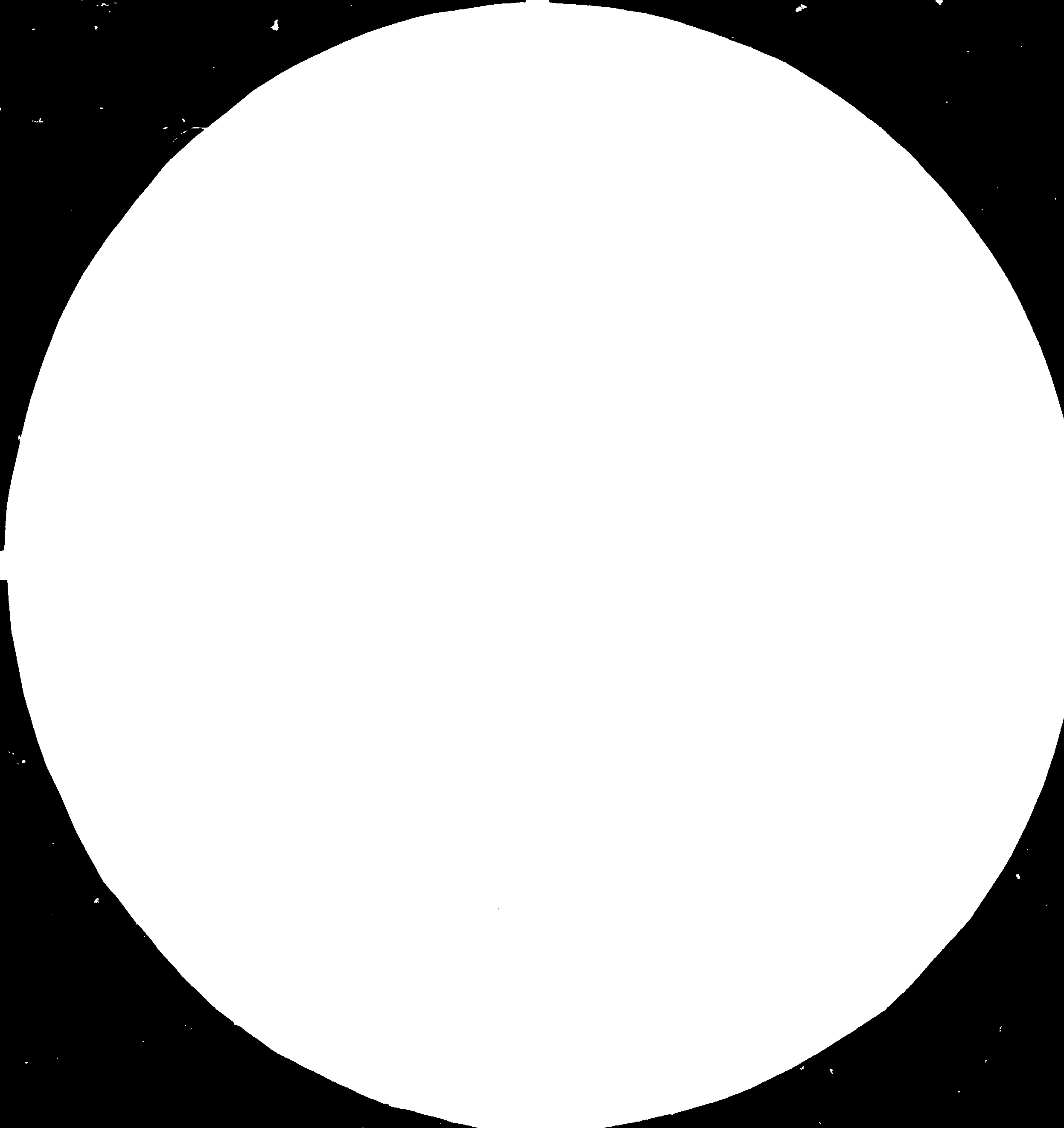
Fresh water will be required for cooling of large drives and gear boxes and as sealing water for the vacuum pumps and as gland water for slurry pumps.

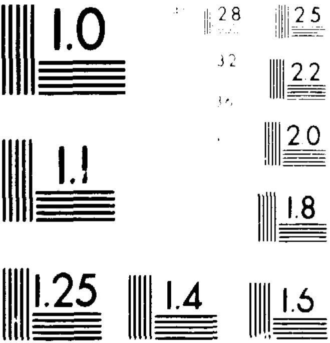


2.3 IRON ORE BENEFICIATION
2.4 PELLETIZING
BENEFICIATION & PELLETIZING PLANT
LIGANGA
KEY PLAN


ORE BENEFICIATION
PELLETIZING PLANT
OFFICE BUILDING
LABORATORY
SERVICE STATION
PELLETIZING
PELLET STORAGE
5 FUEL STORAGE
SPARE PARTS STORAGE
WORKSHOP
WARE HOUSE
FIRE STATION
LOADING STATION
PLANT SECTIONS
BENEFICIATION & PELLETIZING PLANT
LIGANGA
PLOT PLAN

B-535



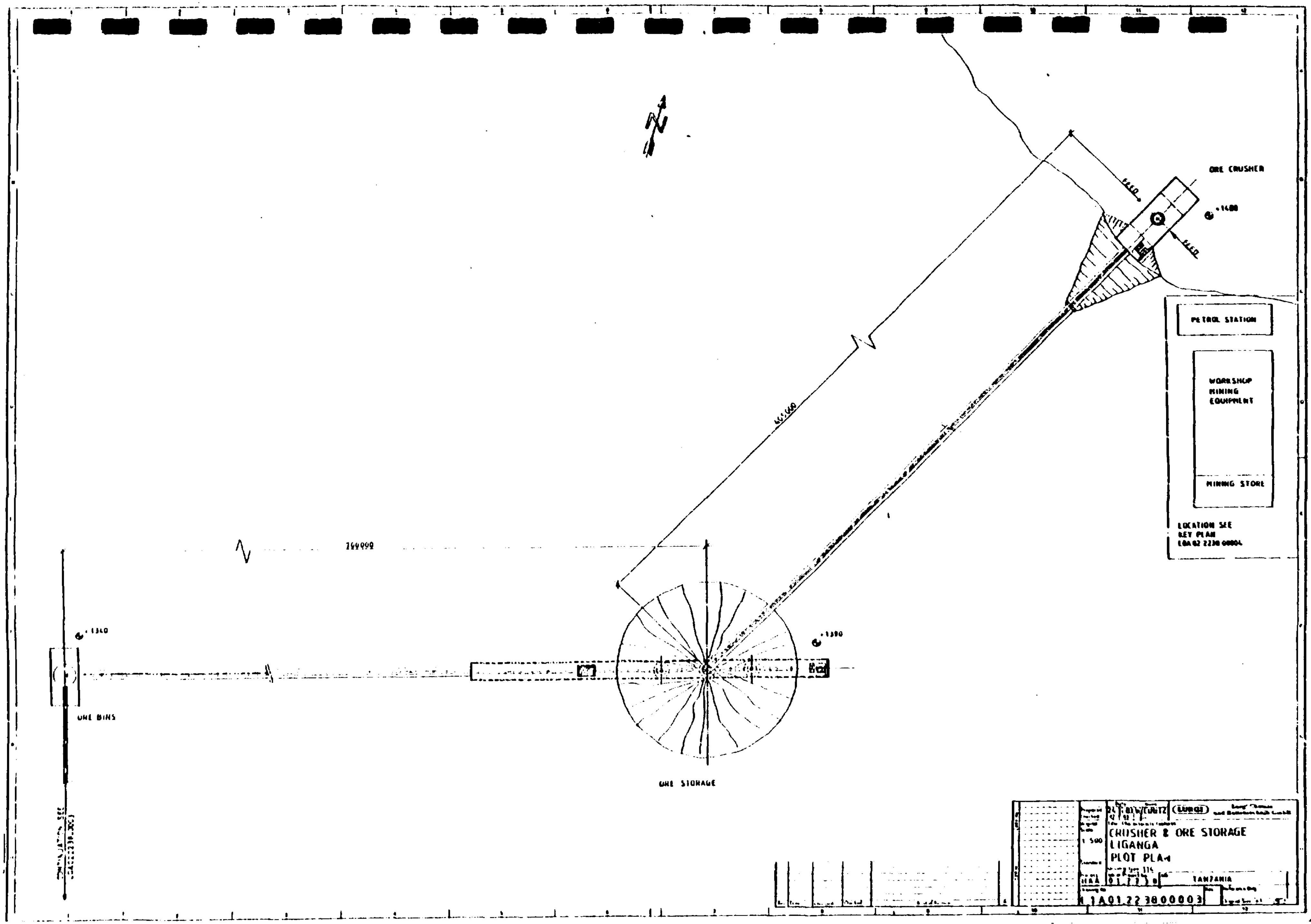


MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS

STANDARD REFERENCE MATERIAL 1010a

(ANSI and ISO TEST CHART No. 2)


ORE CRUSHER
FEED
FEED
PETROL STATION
WORKSHOP
MINING
EQUIPMENT
MINING STORE
LOCATION SEE
KEY PLAN
ORE BINS
ORE STORAGE
CRUSHER & ORE STORAGE
LIGANGA
PLOT PLAN
1:500
TANZANIA
1A01 22 38 00003

S E C T I O N 2.3.3

Raw Materials and Products

2.3.3 Raw Materials and Products

2.3.3.1 Raw Materials

The only raw material for the Iron Ore Beneficiation Plant will be the raw ore from the Liganga and Maganga deposits. In the following, the physical and chemical properties are listed:

Max. lump size	:	800 x 800 x 800 mm
Moisture	:	max. 5 %
$Fe_{tot.}$	:	51.4 %
Fe"	:	16.9 %
TiO_2	:	12.9 %
V_2O_5	:	0.49 %
SiO_2	:	0.90 %
MgO	:	4.8 %
Al_2O_3	:	8.85 %

Feed rate : 1,560,000 tpy

2.3.3.2 Products

Iron Ore Concentrate

During beneficiation, the raw ore is upgraded to a concentrate, suitable for pelletizing prior to direct reduction.

The properties will be as follows:

Grain size: 99.3 % minus 0.125 mm,
90.3 % minus 0.045 mm,
82.5 % minus 0.032 mm.

Specific surface (Fisher method): 2,350 cm^2/g
Residual moisture : 9 %.

Chemical composition:

$Fe_{tot.}$	:	63.3 %
Fe"	:	20.7 %
TiO_2	:	6.5 %
V_2O_5	:	0.64 %
SiO_2	:	0.1 %
MgO	:	1.75 %
Al_2O_3	:	2.8 %

Discharge rate: 999,000 tpy

Tailings

The tailings as by-product of the concentrate will have the following properties.

Grain size: 99.7 % minus 0.125 mm,
Grain size: 86.4 % minus 0.032 mm.

Density of thickener underflow : approx. 40 % solids.

Chemical composition:

$Fe_{tot.}$	:	17.0 %
TiO_2	:	26.2 %
V_2O_5	:	0.18 %
Gangue	:	46.6 %

Discharge rate: 481,000 tpy

S E C T I O N 2.3.4

Consumption Figures

and

Workforce Schedule

2.3.4 Consumption Figures and Workforce Schedule

2.3.4.1 Consumption Figures

For the production of 999,000 tpy of iron ore concentrate as filter cake with approx. 9 % residual moisture, using raw ore from the Liganga/Maganga deposits, the following consumption figures apply.

	per ton dry concentrate		per year	
Raw ore	1.56	t	1,560,000	t
Electric energy	45	KWh	45,000	MWh
Industrial water	0.9	m³	0.9 Mio.	m³
Fuel oil (for limestone drying)	-		20	t
Autog. mill liners (Ni-hard steel)	0.125	kg	125	t
Grinding balls	1.8	kg	1,800	t
Spares and repairs	0.9	US$	0.9 Mio.	US$
Other consumables	0.2	US$	0.2 Mio.	US$
Workforce	0.2	mhrs	99	men

Remark: All material flow figures contain approx. 5 % margin for handling losses.

2.3.4.2 Workforce Schedule, Iron Ore Beneficiation Plant

(G = Graduated; S = Skilled; SS = Semi-Skilled; US = Unskilled)

Based on four shifts, the following personnel will be required inside plant section:

	Shift 1	2	3	4	Day Shift	Total	Qualification Level
Manager/Beneficiation Plant					1	1	G
Plant engineer					1	1	G
Maint. engineer					1	1	G
Shift foremen	1	1	1	1		4	S
Operator control-room	1	1	1	1		4	S
Laboratory					2	[illegible]	[illegible]
Operators							
Crushing, storage	2	2	2	2		8	S/SS
Grinding	1	1	1	1		4	S
Magnetic separation	1	1	1	1		4	S
Filtering, mixing	2	2	2	2		8	S/SS
Water, tailings	1	1	1	1		4	SS
Sampler	1	1	1	1		4	S
Helpers	2	2	2	2		8	US
Maintenance							
Mechanics	2	2	2	2		8	S
Electricians	1	1	1	1		4	S
Measuring, control	1	1	1	1		4	S
Fitters					8	8	SS
Helper electricians					6	6	SS
Helper					5	5	US
Subtotal	16	16	16	16	24	88	
15 % Absentees	2	3	3	2	3	13	
Total	18	19	19	18	27	101	

SECTION 2.3.5

Auxiliaries

2.3.5 Auxiliaries

All media and energy required inside plant section will be supplied by the corresponding central generating, storing and distributing system.

This mainly applies for:

- drinking water,
- cooling water,
- fuel oil for limestone grinding.

The corresponding systems are described and outlined - as applicable - under section 2.5.

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S E C T I O N 2.3.6

Outline Specification

Iron Ore Beneficiation Plant

2.3.6.1 Mechanical Equipment

Plant Sections

.1 Crushing and Raw Ore Storage

.2 Autogenous Grinding and Primary Magnetic Separation

.3 Final Grinding and Secondary Magnetic Separation

.4 Thickeners and Filtering Plant

.5 Return Fines Grinding

.6 Limestone Grinding and Bentonite Handling

.7 Cranes, Hoists, Plant Dewatering

.8 Mixing Station

.1 Crushing and Raw Ore Storage

Plant section 2.3.6.1.1 mainly comprises the following items:

1 giratory crusher for raw ore

size: 42",

crusher consisting of:

- crusher cone and mantle,
- drive,
- lubricating system;

size of feed material	:	800 - 0	mm
size of discharged material	:	300 - 0	mm
design capacity	:	842	t/h

1 apron feeder, for crusher discharge

design capacity	:	842	t/h

1 belt conveyor,

feeding the storage pile,
with belt scale installed,

design capacity	:	842	t/h

3 vibrating feeders

discharging the storage pile,

design capacity	:	316	t/h ea.

1 belt conveyor, with belt scale installed

design capacity	:	632	t/h

1 vibrating screen for iron ore

feed design capacity	:	632	t/h
feed size	:	300 - 0	mm
scalping size	:	80	mm

1 bin for fine ore, 80 - 0 mm

storage volume	:	300	m^3
materials of construction	:	mild steel, concrete	

1 bin for coarse ore, 300 - 80 mm

storage volume	:	300	m^3
material of construction	:	concrete	

.2 Autogenous Grinding and Primary Magnetic Separation

Plant section 2.3.6.1.2 mainly comprises the following items:

1 table feeder

for fine ore discharge and dosing,

design capacity	:	200	t/h
table dia.	:	3	m

2 vibrating feeders

for coarse ore discharge and dosing,

design capacity	:	100	t/h

1 belt conveyor, with 2 belt scales installed

feeding the autogenous mill,

design capacity	:	288	t/h

1 autogenous mill

for wet grinding,

mill length 5 m, dia. 6 m approx.,

mill consisting of:

- shell and heads,
- trunnions and trunnion bearings,
- feed chute,
- main and inching drive,
- lubricating system,
- complete liner;

size of feed material	:	300 - 0	mm,
rated feed	:	240	t/h, dry
circulating load	:	31.2	t/h,

1 vibrating screen with pump sump

for wet screening of autogenous mill discharge,

solids feed	:	276	t/h
slurry feed	:	258	m³/h
size of solids	:	75 - 0	mm
scalping size	:	1	mm

3 belt conveyors

for returning the oversize material from vibrating screen,

design capacity	:	40	t/h

1 permanent magnetic pulley, as drive pulley

of one belt conveyor,

for separation of ore and tailings,

2 compressors, (1 as stand-by),

producing compressed air for the grease spray system of the mill gears,

design capacity	:	50	m³/each
working pressure	:	7	bar

1 slurry pump, wear protected

delivering slurry to the magnetic separators,

design capacity	:	504 m^3/h
slurry density	:	1.33 kg/dm^3

1 process water dosing valve

motorized valve for dosing the waterflow to the mill.

1 slurry distributor

distributing slurry to the magnetic separators,

material	:	mild steel,

2 wet magnetic separators

each equipped with 2 drums,

complete with steel structure, separation boxes, concentrate collecting boxes, drive,

feed solids	:	235.2 t/h
slurry	:	504 m^3/h
solids size	:	1 - 0 mm

.3 Final Grinding and Secondary Magnetic Separation

Plant section 2.3.6.1.3 mainly comprises the following items:

1 ball_mill

for wet grinding,

mill length 10 m, dia. 5 m approx.,

mill consisting of:

- shell and heads,
- trunnions and trunnion bearings,
- feed chute,
- discharge trommel screen,
- main and inching drive,
- lubrication system,
- complete liner,
- ball container,
- ball charge,
- lifting craddle;

size of feed material	:	1 - 0	mm
rated feed	:	360	t/h
wanted size	:	0.044	mm

1 pump_sump

behind the mill.

2 slurry_pumps, wear protected

delivering slurrry to the hydrocyclone groups,

design capacity	:	600	m^3/h ea.
slurry density	:	1.54	kg/dm^3

2 hydrocyclone groups

each consisting of 4 cyclones, 500 mm dia.,

cyclone group consisting of:

- feed pipe,
- overflow and underflow launder,
- complete cyclones with inlet, apex and vortex nozzle,
- steel structure;

slurry feed per group	:	600	m^3/h
separation size	:	0.044	mm

1 slurry distributor

distributing slurry to the magnetic separators,

material : mild steel,

3 secondary magnetic separators

each equipped with 3 drums,

complete with steel structure, separation boxes, concentrate collecting boxes, drive,

slurry feed	:	229	m^3/h ea.

.4 Thickeners and Filtering Plant

Plant section 2.6.3.1.4 mainly comprises the following items:

1 thickener for tailings

consisting of:

- thickener mechanism with rake arms, installed in a concrete basin,
- steel structure of thickener bridge,
- feed launder and feed well,
- exchangeable discharge pipe,
- underflow collecting box,
- process water overflow weir,
- thickener drive and lifting device;.

thickener dia.	:	40	m
feed	:	1,123	m^3/h
underflow	:	157	m^3/h

2 slurry pumps (1 as stand-by), wear protected

for thickener underflow to the tailings pond,

design capacity	:	157	m^3/h
slurry density	:	1.37	kg/dm^3

1 thickener for concentrated ore

description see tailings thickener,

thickener dia.	:	20	m
feed	:	273	m^3/h
underflow	:	115	m^3/h

2 slurry pumps (1 as stand-by), wear protected

for thickener underflow to the slurry tank,

design capacity	:	115	m^3/h
slurry density	:	2.07	kg/dm^3

2 demagnetizing coils (electromagnetic)

installed in the pipe lines to the slurry tank.

1 slurry tank with agitator

for slurry storage,

volume	:	1,000	m^3 approx.
tank material	:	mild steel.	

2 slurry pumps, (1 as stand-by), wear protected

delivering slurry to the filter plant,

design capacity	:	135	m^3/h
slurry density	:	1.91	kg/dm^3

1 slurry distributor

distributing slurry to the filters,

material	:	mild steel,

4 vacuum disc filters, (1 as stand-by)

consisting of:

- filter tank with agitator,
- filter shaft with filtrate pipes, filter discs and sectors,
- control heads and snap blow systems,
- lubricating system,
- filtrate receivers,
- drive;

filter area	:	100	m^2 each
capacity	:	51.4	t/h dry solids

1 filtrate water tank, with agitator

material	:	mild steel

2 filtrate water pumps, (1 as stand by)

delivering filtrate water to the concentrate thickener,

design capacity	:	88	m^3/h

4 vacuum pumps, (1 as stand-by)

water-ring type,

consisting of:

- rotor,
- casing,
- suction manifold,
- suction and discharge port,
- water separator,
- drive;

sucked air volume	:	17,000	m³/h
absolute suction pressure	:	110	mbar

1 collecting vessel, for seal water

material	:	mild steel

2 seal water pumps, (1 as stand by)

pumping vacuum pumps seal water to the cooling tower,

design capacity	:	180	m³/h

2 gland water pumps, (1 as stand-by)

pumping gland water to the stuffing boxes of the slurry pumps,

design capacity	:	45	m³/h

2 compressors, (1 as stand-by),

for generation of compressed air for filter snap blow system,

volume flow	:	2,150	m³/h
pressure	:	3.5	bar

1 compressed air vessel

volume	:	10	m³
material	:	mild steel	

1 process water basin

for process water from the thickeners overflow, concrete design,

volume	:	approx. 250	m³

3 process water pumps, (1 as stand-by)

to supply the beneficiation plant,

design capacity	:	600	m³/h each

2 process water pumps, (1 as stand-by)

to supply the pelletizing plant,

design capacity	:	200	m³/h

1 steady head tank

for process water,

material	: mild steel,
volume	:approx. 10 m^3

2 cooling water pumps, (1 as stand-by)

pumping cooling water from the cooling tower to the beneficiation plant,

design capacity	: 285 m^3/h

.5 Return Fines Grinding

Plant section 2.6.3.1.5 mainly comprises the following items:

1 bin for pellet return fines

storage volume	:	30	m^3
material	:	mild steel	

1 belt conveyor with belt scale installed

feeding the regrinding mill,

design capacity	:	4	t/h

1 regrinding mill

for wet grinding,

mill length 5 m, dia. 2.2 m approx.,

mill consisting of:

- shell and heads,
- trunnions and trunnion bearings,
- feed chute,
- discharge trommel screen,
- main and inching drive,
- lubricating system,
- complete liner,
- ball container,
- ball charge,
- lifting craddle;

size of feed material	:	5 - 0	mm
rated feed	:	4	t/h
wanted size	:	0.044	mm

1 pump sump

behind the mill,

1 slurry pump, wear protected

delivering slurry to the hydro-cyclone group,

design capacity	:	28.4	m³/h

1 process water dosing valve

motorized valve for dosing the waterflow to the mill,

1 hydro-cyclone group

consisting of 2 cyclones of 200 mm dia.,

1 pump sump

behind the hydro-cyclone group,

1 slurry pump, wear protected

delivering slurry to the thickener,

design capacity	:	22.6	m³/h

.6 Limestone Grinding and Bentonite Handling

Plant section 2.3.6.1.6 mainly comprises the following items:

1 ground hopper

for unloading limestone from the railway waggons, concrete design.

1 chain conveyor

for discharging the hopper.

1 belt conveyor

feeding the limestone to the stockpile,

design capacity	:	100	t/h

1 feed hopper and belt conveyor

feeding the limestone grinding plant,

design capacity	:	100	t/h

1 bin, for limestone

storage volume	:	25	m^3
material	:	mild steel	

1 dosing belt scale

feeding the pendulum roller mill,

design capacity : 6 t/h

1 pendulum roller mill

for limestone grinding,

consisting of:

- mill,
- air sifter,
- inlet star feeder,
- gear and drive,
- hot gas generator with fan;

design capacity : 6 t/h

1 cyclone, with discharge star feeder

for ground limestone.

1 bag filter, with discharge screw conveyor

for ground limestone.

1 fan

behind the bag filter.

1 pneumatic conveyor, with compressor

for limestone,
feeding the bin in the mixing station,

design capacity : 6 t/h

1 bag emptying machine

for bentonite,

consisting of:

- feeder belt,
- bag cutter and beater,
- dedusting filter and fan,
- discharge screw conveyor;

design capacity : 150 bags/h

1 pneumatic conveyor, with compressor

for bentonite,

feeding the bin in the mixing station,

design capacity : 8 t/h

.7 Cranes, Hoists, Plant Dewatering

Plant section 2.3.6.1.7 mainly comprises the following items:

1 crane

for the crusher station,

lifting capacity	:	30	t

1 crane

for grinding mills,

lifting capacity	:	20	t

1 crane

for magnetic separators,

lifting capacity	:	7.5	t

1 hoist

for bin building,

lifting capacity	:	3	t

1 hoist

for vacuum filters,

lifting capacity	:	7.5	t

1 hoist

for limestone grinding station,

lifting capacity : 1.5 t

3 hoists

for maintenance,

lifting capacity : 2 t

4 dewatering pumps

for plant dewatering, vertical pump,

.8 Mixing Station

Plant section 2.3.6.1.8 mainly comprises the following items:

1 belt_conveyor,_with belt scale installed,

for filter cake from the vacuum filter, feeding the mixer, with installed plug scraper for emergency discharge to repulper,

design capacity	:	200	t/h

1 repulper_

for filter cake,

consisting of tank, agitator and pump sump.

1 slurry_pum, wear protected

pumping slurry from the repulper to the thickener.

2 bins_for_limestone_and_bentonite

storage volume	:	75	m³ ea.

2 weigh feeders

for limestone and bentonite.

2 bag filters, with fans

for dedusting of limestone and bentonite bins,

1 belt conveyor

for limestone and bentonite,
feeding the mixer,

1 mixer

for filtercake, limestone and bentonite,

consisting of:

- mixing drum,
- shaft,
- drive;

1 belt conveyor

for mixed material,

feeding the bins in the balling area,
with 1 installed plug scraper.

2.3.6.2 Electrical Equipment

Plant equipment

.0 General Prerequisite

.1 6.0 kV Medium High-Voltage Board

.2 380 V Low-Voltage Switchgear Boards

.3 Programmable Logic Control System

.4 Local Switchgear

.5 Power Transformers

.6 6000 V Medium High-Voltage Motors

.7 380 V Low-Voltage Motors

.8 Plant Lighting

.9 Cables

.10 Installation Material

.11 Intercommunication System

.12 Airconditioning Installation

.13 Ventilation System

.14 Grounding

.15 Emergency Power Supply

.0 General Prerequisites

Main Data

Medium high-voltage:	6.0	kV, 50 cps
Low-voltage :	380	V, 50 cps
Lighting system :	380/220	V, 50 cps
Control voltage for power portion :	220	V, 50 cps
Control voltage for Control system :	48	V, DC
Signal voltage :	24	V, DC

Protective Measures for:

Medium High-Voltage System:	Grounding via resistance
Low Voltage System :	Transformer starpoint solid grounding

Regulations and Standards

DIN, VDE, IEC, LURGI Standards

Supply Limit

Connection terminals on the circuit breaker of the incoming feeder in the 6.0 kV switchgear.

.1 6.0 kV - Medium High-Voltage Board

The switchgear installation will be of indoor design with sheet steel clad panels with drawout circuit breakers. The single bus bar system will have a continuous current rating of 1,600 A and will be braced for a fault level of 100 MVA. Circuit breakers will have motor operated closing mechanism (110 V, DC-supply) and will be of the 3-pole low oil volume type.

Technical Data

Operating voltage	:	6.0	kV
Frequency	:	50	Hz
Rated bus bar current	:	1,600	A
System short circuit capacity	:	100	MVA
Enclosure	:	IP 40	

The board mainly consists of the following panels:

Incoming feeder panel, equipped with minimum oil circuit breaker,

Measuring panel,

Motor out-feed panels, each equipped with vacuum contactors and fuses,

Transformer panels, equipped with minimum oil circuit breaker.

Battery system

A battery system of 110 V has been envisaged for the control and monitoring of the medium high-voltage switchgear board.

The system consists of:

1 level storage battery, 110 V,
1 constant voltage rectifier in a sheet steel casing for automatic charging of the battery system.

.2 Low Voltage Switchgear Boards

The distribution board will be provided to be supplied by 6.0/0.38 kV transformers.

Separate 380 V motor control centres (MCC) will be provided for different sections of the plant. The MCC will be of sheet steel, dust-tight, enclosed cubicles of compartmental construction having 3-phase bus bars and being provided with plug-in, draw-out modular type incoming and outgoing feeder compartment.

.3 Programmable Logic Control (PLC)

for process controlling.

The programmable logic control mainly consists of:

- the central controller including program memory module, processsor module, function check module,
- power supply unit, counter, timer units,
- extension units including input and output modules to match the number of inputs and outputs to the particular control problem. The bus system transfers the data between the central funtion units and the peripheral modules (inputs, outputs).
- Interface to central computer;

The required control functions ar: implemented by program stored in memories.

.4 Local Switchgear

The following equipment is provided for the local control of the consumers:

Local Control Box

consisting of:

1 operation selector switch, lockable in the O-position

Switch Positions

1 - Local Control
0 - Blocked (connection for drive impossible)
2 - Remote Control (group operation from the central control panel)

1 momentary contact push-button for 'Start',

1 selector switch in case of a reversible drive with 'left' and 'right' position,

1 terminal strip with series terminals,

1 stay-put push-button for 'Stop'.

Limit Switches

Pull Rope Emergency Switches

arranged at a distance of approx. 50 m.

Belt Speed Monitors

Emergency Stop Switches

Crane Switches

.5 Power Transformers

three-phase oil transformers of outdoor performance, type of cooling: ONAN,

each equipped with:

- oil temperature indicator with alarm and trip contacts,
- buchholz relay, with alarm and trip contacts,
- pressure relief device;

The following transformers are provided:

Power Distribution Transformers

Rated output	:	1,600	kVA, respt. 1,250 kVA,
High-side voltage	:	6.0	kVA,
Low-side voltage	:	380	V.

Lighting Transformer

Rated output	:	250	kVA,
High-side voltage	:	6.0	kV,
Low-side voltage	:	380	V.

.6 6.000 V High-Voltage Motors

Electrical drives 200 kW and above will be provided as 6.000 V squirrel cage motors. The motors will be designed for direct on line starting.

Rated voltage	:	6,000	V
Rated frequency	:	50	cps
Enclosure	:	IP 55	
Insulation class	:	F	
Temperature utilization according to	:	B	
Type of construction	:	B3	

.7 Low Voltage Motors

The motors will be totally enclosed, fan cooled squirrel cage/slipring induction type, the former being suitable for direct-on-line starting. Motor dimensions will comply with relevant IEC standards. Slipring motors will be supplied complete with starting resistors.

Rated voltage	:	380	V
Rated frequency	:	50	cps
Enclosure	:	IP 54	
Insulation class	:	B	
Temperature utilization according to	:	B	

.8 Plant Lighting Installation

The plant lighting will operate on a 380/220 V supply. The light fittings in all the sections of the plant will be controlled from local switch-fuse/lighting distribution boards.

Outdoor lighting will be provided for the plant entry gates and equipment.

.9 Cables

All power and control cablings for the complete plant will be included. The main cable runs will be carried on trays, or ladder racks. All cables and core terminations will be number ferruled for identification purposes.

.10 Installation Material

The installation material comprises:

- cable racks for horizontal and vertical installation of the main cable routes, including accessories such as bracket columns and fastening irons, without covering, steel-armoured tubes with clamps etc.,
- cable clamps,
- small items such as bolts, nuts etc.,
- installation auxiliaries, cable and sealing boxes, cable lugs, cable clamps, marking material etc.

.12 Air-Conditioning Installation

An air-conditioning installation has been envisaged for the central control stand.

.13 Ventilation System

An over-pressure ventilation system has been envisaged for the switchgear installation rooms with a view to maintaining these rooms free of dust and to dissipate the heat of the losses.

.14 Grounding

The entire grounding system will be provided complete with earthing rods in order to achieve the specified total earthing resistance not exceeding 2 Ohm. The earthing ring main will consist of galvanized band iron.

.15 Emergency Power Supply

1 Diesel generating set will be envisaged for the supply of the required consumers including approx. 10 % of the lighting system in the case of a mains failure. It will start automatically and feed the emergency service board.

The Diesel generating set is designed for:

Rated output	:	250	kVA
Rated voltage	:	380	V
Rated frequency	:	50	cps

and mainly consists of:

Three-phase constant voltage generator with constant voltage unit,

Base frame for the accommodation of the engine and the generator.

1 battery installation with battery charger,
1 cabinet for automatic system,
1 exhaust system, complete,
1 day tank for oil.

2.6.3.3 Instrumentation Equipment

.01 General Design

- The overall plant will be monitored and controlled in clearly arranged manner from a central control stand, to be suitably accommodated in a building.

- Generally, all transmission and control functions will be electronic, utilizing a 4...20 mA DC-signal.

- In exceptional cases, such as for current measurements, indicators are connected directly to the secondary side of the current transformer with 1 ampere output.

- No pneumatic transmission systems will be applied.

- Potential free contacts will be used for binary signal transfer from instrumentation system onto the control system.

- Alarm and interlock contacts will be normally closed. "Normally" refers to normal conditions of process or device and bears no relation to "shelf" contact position and/or manufacturer's switch or terminal markings.

- For connection to resistance thermometers, a 3-wire-lead-system will be applied.

- The instrumentation will be based on a conventional analogue control system.

- The system design and procurement procedures will be executed in such a manner that a minimum number of types and manufacture of components are considered for both field and control panel equipment.

- Special precautions will be taken in order to protect field mounted electronic equipment in tropical and semi-tropical environments.

- Electronic circuit boards for converters and transmitters will be tropicalized with humidity and fungus-resistant coatings.

- All electronic equipment (electronic temperature converters, etc.) will be located in a controlled climate area.

- The control room will be designed as an entity, i.e. all control panels mounted therein, irrespective of the section of plant or the source of supply, are to be of similar design.

  The control room should be maintained at a temperature of 20 °C + 5 °C and should be suitably ventilated and if necessary pressurized to ensure that dust, flammable or noxious gases cannot enter.

.02 Design Components

Field instruments

All locally mounted instrumentation hardware will be designed and protected to withstand a high humidity tropical environment and an industrial plant atmosphere loaden with coal/ore dust.

Local indicating measuring instruments

the following will be used:

- pressure gauges,
- flow meters,
- level indicators,
- contact manometers and contact thermometers, normally of dial 160 mm type with inductive slots.

The pressure gauges to be of stainless steel, furnished with filling liquid and/or pulsation dampeners for pulsating services.

Local temperature indication should be made by bimetallic thermometer.

Local measuring detectors

- resistance thermometers,
- thermo-couplles,
- pressure tapping branches for connection to pressure measuring units,
- measuring orifices for flow measurements, annubars, venturi tubes, flow meters, level measuring probes working on a capacitive or conductivity basis, load cells.

Where necessary, protective tubes are built into pipelines and containers for the incorporation of temperature sensors. Stop flanges and counter flanges at the thermo-sensors are included in the supply volume.

As far as the level measuring probes are concerned, the electronic components will preferably be mounted in the vicinity of the probes.
Special cables will be used for connecting the level measuring probes and the load cells to the electronic components.

Transmitters

Electronic transmitters are provided for transforming the physical quantities measured into a uniform signal. Wherever possible, the transmitter will be mounted in a protection box in the vicinity of the measuring point.
Their accuracy should be 0.5 % or less of the calibrated range. Electronic transmitters will generally be of two-wire type for operation with a 24 V DC loop power supply.
Output signal will be 4...20 mA, load capability will be 0...6000 mA minimum.

Pressure transmitters

- measuring elements of min. stainless steel,
- measuring cell of steel or stainless steel, depending on medium, with output indicator, output signal 4...20 mA D.C.

Electronic temperature transmitters

Temperature transmitters will have a down-scale or up-scale burnout protection.
If using thermocouples, cold junction compensation circuits will be provided.

Final control elements

Electric drives will be used for the actuators on control valves and dampers.
The actuators will be equipped with R/I-transmitter (4...20 mA D.C.-output) for detection of the actuator position.
Displacement and torque dependent limit switches will be built in.

Panel instruments in general (144 x 72 mm)

Instruments of standard dimensions will be provided for the control panel. The instruments will be built into the panel in accordance with the course of production to allow a coordination with the flow diagram.

Indicating instruments (144 x 36 mm, 72 x 72 mm, 48 x 48 mm)

Indicators with moving coil elements, moving iron elements or potentiometric elements are proposed. Indicators may be equipped with adjustable potential free limit contacts.

Recorders, (144 x 144 mm, 288 x 144 mm)

For important measured values single-line recorders or double or triple recorders with compensating measuring system have been envisaged.
Temperatures and slowly varying quantites may be represented on single or multiple dotted-line recorders.

Input signal : 4...20 mA D.C.

The recorders may be equipped with a uniform chart (0-100 %). A reading ruler is to be added for evaluation purposes, the respective scale showing physical units.
The paper feed speed is normally 20 mm/h.

Controller

Controllers to be designed as analogue controllers, with an actual value and set-point indicator, with hand-automatic change-over switch, a reference value adjuster and a more-less adjusting device for hand operation.

The controller will provide indication of controllers output or true position of final control element.

The input and output side of the controller will be designed for the uniform signal used in the plant. Depending on the requirements, the controller is to be either designed with continuous output or as step controller.

Controller will be equipped with "anti-reset-wind-up" feature and output limiting.

Weighing system

The weighing equipment will emit a uniform signal of 4 - 20 mA which is available at the respective transfer terminal strip. This signal is used in the system of the entire measuring, control and regulating equipment for indication and recording or as reference for subordinate regulating circuits.

The essential instruments for the weighing and proportioning equipment which have to be monitored and newly adjusted in dependence on the process are also to be accommodated on the control panel.

Control Room Equipment

Conventional panels will be with switch console in the front. The panels to be open on the rear and on the top. Panel height to be 2,000 mm. A flow diagram, semigraphic, painted design, of approx. 800 mm height will be installed above the instrument panel, inclined approx. 10 °.

The display area contains the control stations, manual stations, recorders, indicators and the operating units for the weighing equipment.

All required motor control switches are built in the switch console.

The switches and the lamps in the mimics are marked with the associated consumer item number. Critical conditions will be indicated by rear light annunciator windows.

Auxiliary racks, cubicles

All the instruments for the measuring and regulating circuits other than field instruments or panel instruments in the control room will be accomodated on auxiliary racks. These instruments comprise system modules as there are transmitters, devices for square root extraction, isolating transformers for inputs and outputs, limit value units and the like. Since these instruments do not require constant monitoring, needing only occasional adjustment, for instance of the limit values, said auxiliary racks are installed in the control room behind the control panel.

Racks/cubicle will be of the free-standing type and will mainly follow manufacturer's standard design.

Interfaces

All field cables coming from or going to field devices will be connected to terminals in the control marshalling cubicles.

The marshalling cubicles serve as collecting and distribution centre to the instrument cubicles and central control panels.

Power supply and distribution

Power supply and distribution boards for the instrumentation will be provided.

The boards will be equipped with

- incoming circuit breakers,
- isolating transformer 380/220 V; 220/24 V,
- outgoing feeders for the individual consumers.

The instrumentation will be fed from the emergency power bus bar.

Mains supply voltage for all instrumentation will be 380 V A.C., 50 cps.

The mains will be connected to the emergency diesel power generator.

.03 Installation material

Premium quality installation materials will be used throughout. Contractor will employ the maximum amount of prefabricated components which will be corrosion resistant.

All field mounted instruments and device enclosure will be of material adapted to the heavy ambient conditions.
Tray and other materials will be hot dip galvanized.

Site fabricated steel supports, brackets etc. will be sand-blasted and protected with two coats of primer and one coat of finish paint.

included will be:

- all the required junction and protection boxes in the plant, shut-off valves, manifolds, pulse tubes, fittings (316 SS), galvanized cable racks, open conduits with end caps unless the main raceways/routes of the power cables can be used,
- small installation material for fastening and installing, local instruments, transmitters etc.,
- bars of angle iron, flat iron, anchors, bolts, supports.

Cable and wire will be run in rigid steel conduit tube or cable tray.
All wiring in panel and cubicle will be enclosed in slotted plastic wire tray.

Parallel run of A.C.- and D.C.-wiring closer than 300 mm will be avoided.

Cables

Cables will be used in wet and dry location, in underground duct and conduit and on cable trays.
The areas through which cables pass will be subject to water, oils, iron oxide fines, coal dust and other elements normally associated with industrial plants.

Non-armoured cables will normally be applied.
Multicore signal cables will be provided with overall screening.
The isolating material will be flame-retardant and non-hygroscopic.

Electrical control and power cables

3, 4, 5, 7-core cables, solid copper conductors size 1.5 mm^2, with core green/yellow (earth), type: NYY-J, NYCY-J.

Current signal cables

The conductor of each multicore cable, installed in the field, to be 0.8 mm in dia. minimum.
Cable type: 2 Y (St) Y, A-Y (St) YY.
Where multi-pair cables are to be used exclusively for 4...20 mA D.C. signals, individual pairs need not be shielded, however, an overall shield is required.

Thermocouple compensating cables

The solid conductor of each pair will be of 1.38 mm dia. minimum and will be matched and calibrated to DIN 4371 for Standard Limits (for example 1/2 DIN) of errors within the range of 0 - 200 °C.

Cable type: Agl DIN 43714-20 D, Ni Cr-Ni,
Pt Rh-Pt for example

Control room cables

For interconnecting wiring within the control room area (general purpose), flexible single- or multicore cables to be used of following specification:

copper conductor size 0.75 mm², stranded, PVC-insulated with overall sheat.

Ground wires

will be minimum 3.5 mm², stranded, insulated conductor coloured green/yellos.

All cables for (Ex) i circuits will be provided with the overall jacket coloured blue (RAL 5015).

Shields will be grounded at one point only to prevent ground loops.

Tubing and Fittings

The process connection lines for remote instruments will be stainless steel (316 SS) seamless tubing, for example: 12 x 1.5 mm.
Piping is only used for connection nipples and local instruments mounted directly on process lines or vessels.

2.3.6.4 Structural and Civil Works

Main quantities for structural steel and civil works related to the Beneficiation Plant are as follows:

Structural Steel	1915	t
Bins	60	t
Roof and Wall Cladding	13245	m^2
Concrete	11353	m^3
Formwork	25240	m^2
Reinforcement	1021	t
Excavation	32280	m^3

Price estimation for these works are based on information obtained from Mowlem International Ltd., London, based on the experiences gained with the Mufindi Pulp and Paper Mill.

S E C T I O N 2.3.7

Investment Cost Estimate

2.3.7 Investment Cost Estimate

- Iron Ore Beneficiation Plant -

The budgetary investment cost for the Iron Ore Beneficiation Plant, capable to produce 999,000 tpy of iron ore concentrate for pelletizing, are estimated as follows (based on the exchange rates: 1 US $ = 2.7 DM = 12.2 T.Sh.).

	approx. Mio. US $	approx. Mio. T.Sh.
- Plant Equipment delivered free site	26.7	325.7
- Erection, Supervision, Commissioning	5.0	61.0
- Civil Work and Steel Stucture, erected and painted	8.8	107.4
- Related Plant Infrastructure	3.6	43.9
Total Investment Cost	44.1	538.0
- Spare Parts for 2 years plant operation	0.8	9.9

This budget estimate is based on German prices and conditions and on cost factors ruling end of December 1983 for the equipment. It does not include any customs duty, taxes, dues or other levies which may arise outside the Federal Republic of Germany.

The estimation of the civil work and structural steel portion is derived from price information supplied by Mowlem International Ltd., London.

The estimation for plant equipment includes the cost for packing and the freight charges delivered free on site. Our budget prices are estimated on the assumption that all work can be performed continuously and in accordance with the time schedules contained in section IV/5.

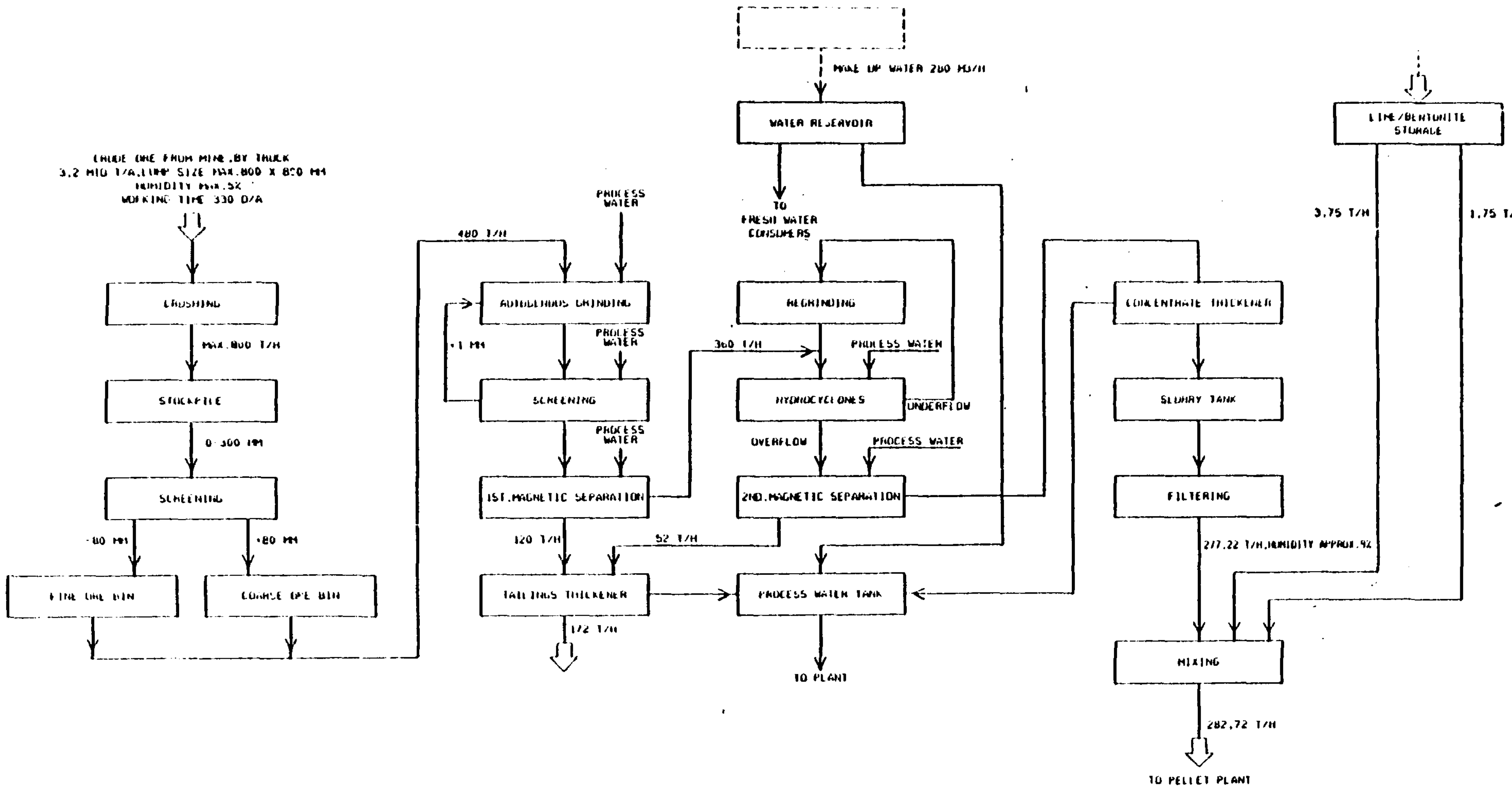
This budget estimate is furthermore based on usual cash terms of payment, allowing an adequate down payment upon signing of contract and progress payments according to the progress of work in the engineering, manufacturing and erection.

All further terms and conditions will have to be agreed upon during the progress of contract negotiations.

A N N E X

Expansion Step

1 Million tpy Steel



LURGI Lurgi Chemie und Huettentechnik GmbH

IRON ORE BENEFICIATION PLANT
LIGANGA
3,2 MIO T/A ORE FEED

202 BLOCK DIAGRAM

HAA 012238

TANZANIA

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Tanzania/Volume II

Section 2.4

PELLETIZING PLANT

LURGI

S E C T I O N 2.4.1

Process Description

Pelletizing Plant

2.4.1 PROCESS DESCRIPTION

2.4.1.1 General Process Features

Pelletizing serves to agglomerate very fine-grained raw materials and yields a spherical product, "pellets", having physical and chemical properties which can be adjusted according to the requirements of subsequent processes and handling conditions.

The pelletizing process can only be utilized if the raw materials to be treated are sufficiently fine-grained to enable the formation of pellets. Materials of - 0.5 mm with 60 - 90 % fines (- 0.04 mm) are generally considered as suitable. If the material to be pelletized does not have the necessary fine grain size, it has to be ground to the required fineness.

As a rule, pelletizing comprises two operational steps:

1. The forming of wet balls (green pellets) and
2. their subsequent hardening.

For the forming of green pellets, the fines are wetted with water (approx. 9 % moisture) and rolled. Under the influence of capillary adhesion forces arising between the individual particles due to liquid bridges, the particles agglomerate to balls by rolling. The green pellets are of low strength and thus have to be hardened.

The hardening process to be applied depends on the required pellet strength which is virtually determined by the stresses occurring during handling, transportation and further processing and on the behaviour of the raw materials and any binders at elevated temperatures.

Therefore, it is necessary to fire the pellets in an oxidizing atmosphere at temperatures below the softening point of the raw materials constituents (1200 -1350 °C). In contrast to sintering, the pellets are hardened during firing by crystallization, grain growth and inside structural changes. When magnetite is used as starting material, the grain growth is accompanied by lattice modification caused by the exothermic oxidation of the magnetite to hematite taking place during pellet firing.
This will be the case with Liganga/Maganga concentrate as feed material for the projected plant.

Pelletizing finds its widest application in the iron and steel industry where it has, besides sintering, developed into a process of ever-increasing importance as a method for the agglomeration of fine-grained iron ores, particularly concentrates. This development is due to a large number of reasons.

- the constant decrease of high-grade ore world reserves calls for the beneficiation of low-grade ores by grinding and separation of gangue and iron oxide. On account of the high portion of very fine particles, the concentrates obtained cannot be sintered economically. Furthermore, the storage and transportation of concentrates is problematic if they are produced by wet methods,

- due to their high strength and suitability for storage, the pellets can be easily transported over long distances with repeated transshipment,

- thanks to their ideal physical and metallurgical properties, pellets are appreciated as valuable feed for sponge iron production in direct reduction plants

- the increasing importance of direction of iron ores (sponge iron = DRI) has opened new markets for pellets,

For economic reasons, the pelletizing process can only be recommended for iron ores with more than 60 % iron, free from loss on ignition. Should the iron content of the ore be at a lower level, beneficiation of the ore is required, as is the case with the quite complexe Liganga/Maganga titanomagnetite iron ore.

2.4.1.2 Forming of Green Pellets

On an industrial scale, pelletizing drums and pelletizing discs have hitherto proved to be most suitable units. With the pelletizing disc, green pellets are formed in a single process stage. Due to the classifying effect of the disc, the pellets are discharged from the disc rim at a close size range. Consequently, green pellet screening directly after the pelletizing disc and recirculation of undersize are normally not necessary.

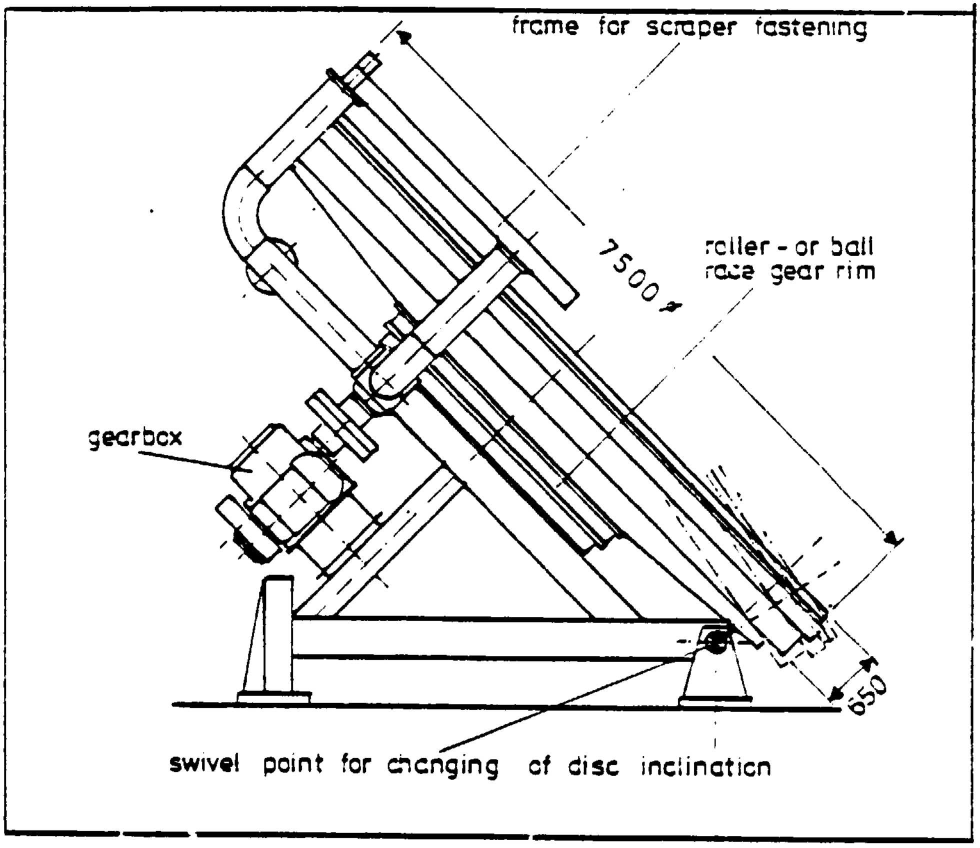

Figure 1 Lurgi pelletizing disc

Figure 1 is a schematic view of the pelletizing disc developed by Lurgi, supplied in a great variety of sizes and which has given excellent service in numerous plants. It is driven through a roller race gear rim which ensures particularly smooth disc rotation. Stationary scrapers are provided for cleaning the bottom and inner rim of the disc. The disc slope and disc speed can be easily varied to obtain the desired green pellet production rate and quality.

2.4.1.3 Pellet Indurating according to the Lurgi Dravo Travelling Grate Process

Nowadays, the following three processes are used in the industry for the induration of iron ore pellets:

1. Shaft furnace process
2. Travelling grate process
3. Grate-kiln process

The shaft furnace process is the oldest process which is rarely used for modern plants. It is limited to magnetite and is inferior to the other processes with respect to production capacity of the individual plant units and the attainable pellet strength.

The travelling grate process (introduced in 1954) is known in several variants of which the variant introduced by Lurgi and developed further in cooperation with Dravo Corporation in Pittsburgh has gained a predominating rank.

The grate-kiln process (preheating grate, rotary kiln, circular cooler) was introduced on an industrial scale in 1960.

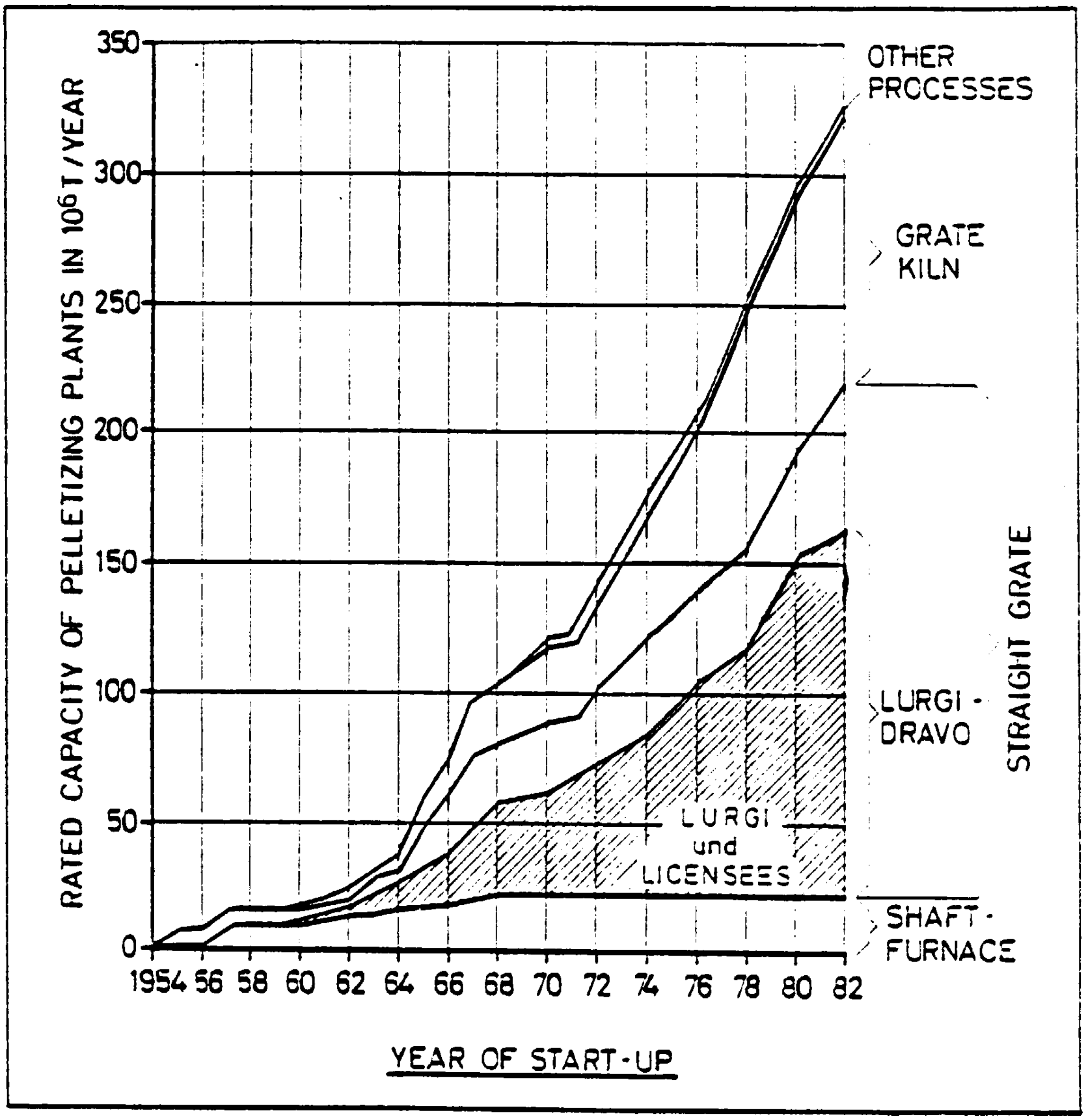

Figure 2 Capacity Distribution

Figure 2 illustrates the development of world iron ore pellet production from the beginning, divided according to the processes utilized. As can be seen, the travelling grate process holds a dominating position. More than 40 % of the world pellet production is obtained in the plants built by Lurgi and its licensees.

The travelling grate - an endless chain of pallets - carries the green pellets in a specific bed height through a furnace where they pass through the four principal zones: drying, preheating, firing and cooling. The individual pellets charged on the travelling grate remain motionless so that the losses caused by abrasion or breakage are insignificant. Underneath the pallet chain, numerous wind boxes are provided for supplying and exhausting the process gases. The furnace is sealed against the pallet chain so that it is possible to adjust specific pressure values above and below the pallet bed according to which important process parameters can be controlled.

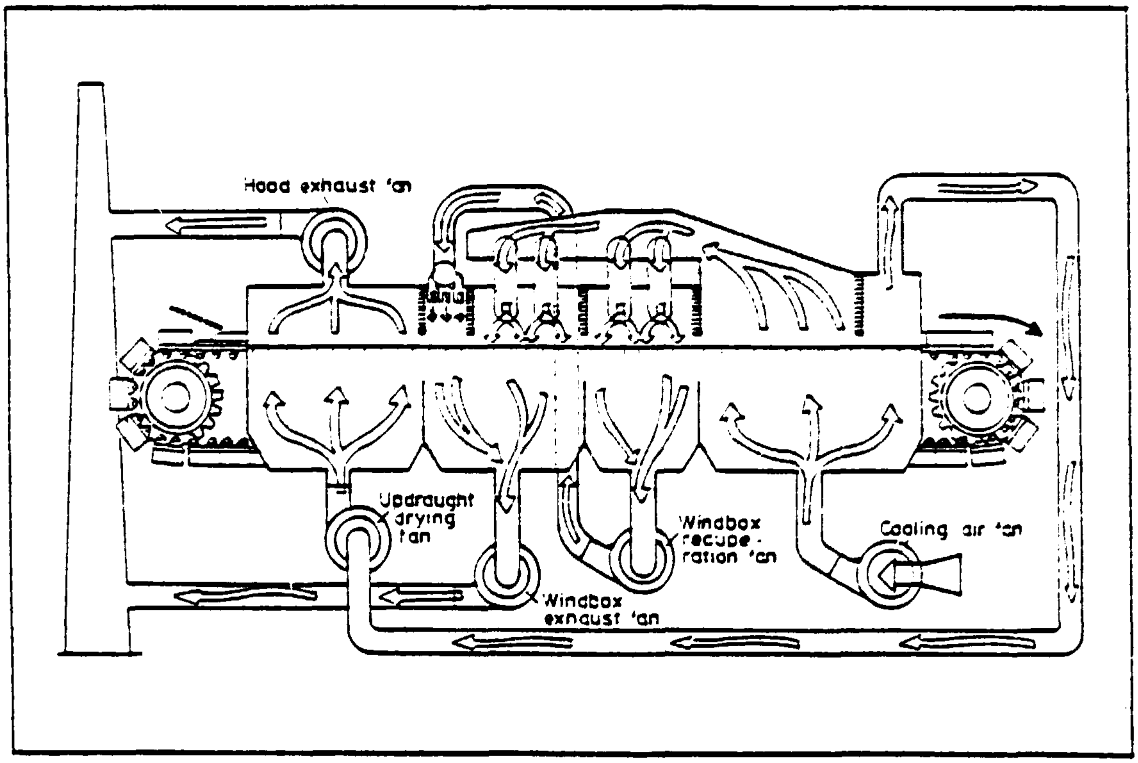

Figure 3 Process gas flow of the Lurgi-Dravo travelling grate process

Figure 3 shows the gas flow as applied in the Liganga/Maganga pellet plant. Cooling air of ambient temperature is forced in upward direction through the pallets and their charge; this air is heated while cooling the pellets to the desired temperature (average temperature mostly 100 - 120 °C). The cooler portion of the air, of approx. 250 - 300 °C (cooling zone II), is delivered by a fan to the first part of the drying zone (updraft drying) where it passes through the pallet bed also in upward direction and leaves the plant after having been cooled to 50 - 60 °C.

Due to the pressure prevailing above the pellet bed, the hot portion of the heated cooling air (cooling zone I) flows into the firing zone and preheating zone (direct recuperation). In these zones, it is mixed with the hot combustion gases which are produced in the heavy fuel oil fired combustion chambers located on both sides of the furnace. Two fans suck the gas/air mixture through the pellet bed and the pallets. The hotter portion of the waste gases is utilized for updraft drying and preheating of pellets, while the cooler portion is discharged to atmosphere.

The green pellets are charged on the travelling grate by means of a roller conveyor ensuring gentle green pellet handling and simultaneous separation of the small amount of fines arriving together with the green pellets. The pellets are fed onto the roller conveyor by a feeding belt which is charged by a reciprocating conveyor arranged at right angles. (Fig. 4). An important feature

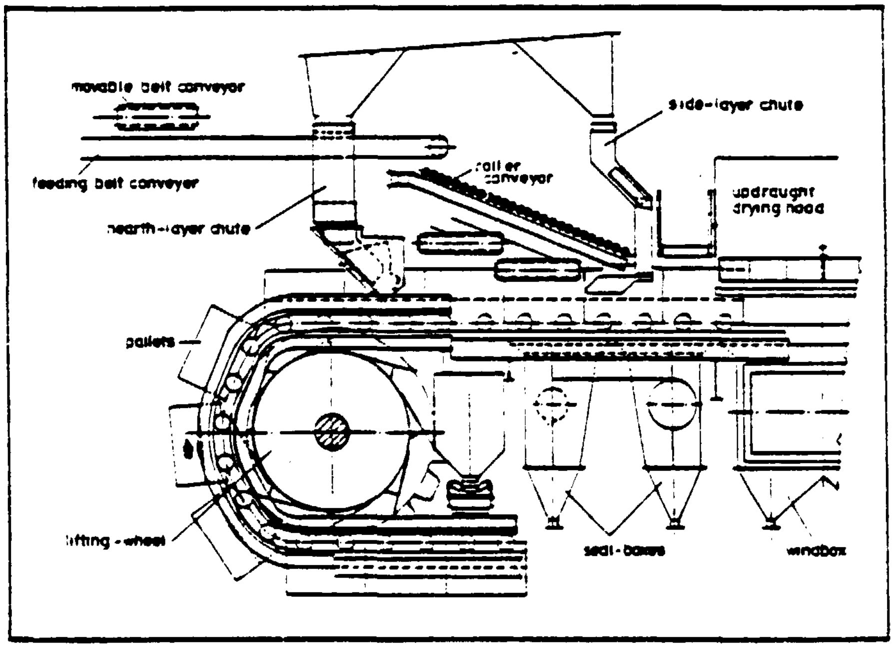

Figure 4 Roller Conveyor

An important feature of the Lurgi-Dravo process is the use of hearth layer and side-wall layer consisting of indurated pellets being withdrawn from production and recirculated to the travelling grate feed end. The use of hearth layer allows for the treatment of the green pellet bottom layer at the same firing temperature as the green pellet top layer; the side wall layer prevents the so-called side wall effect and protects the pallet side walls against overheating. (Figure 5). The bed height of hearth layer is mostly 8 - 10 cm and that of green pellets 30 - 40 cm.

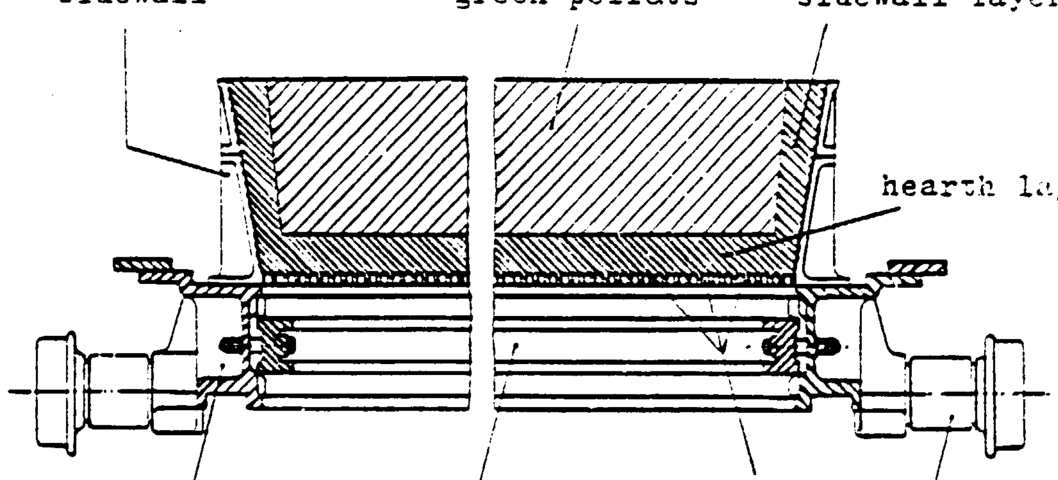

Figure 5 Charging of travelling grate with green pellets, hearth layer and sidewall layer.

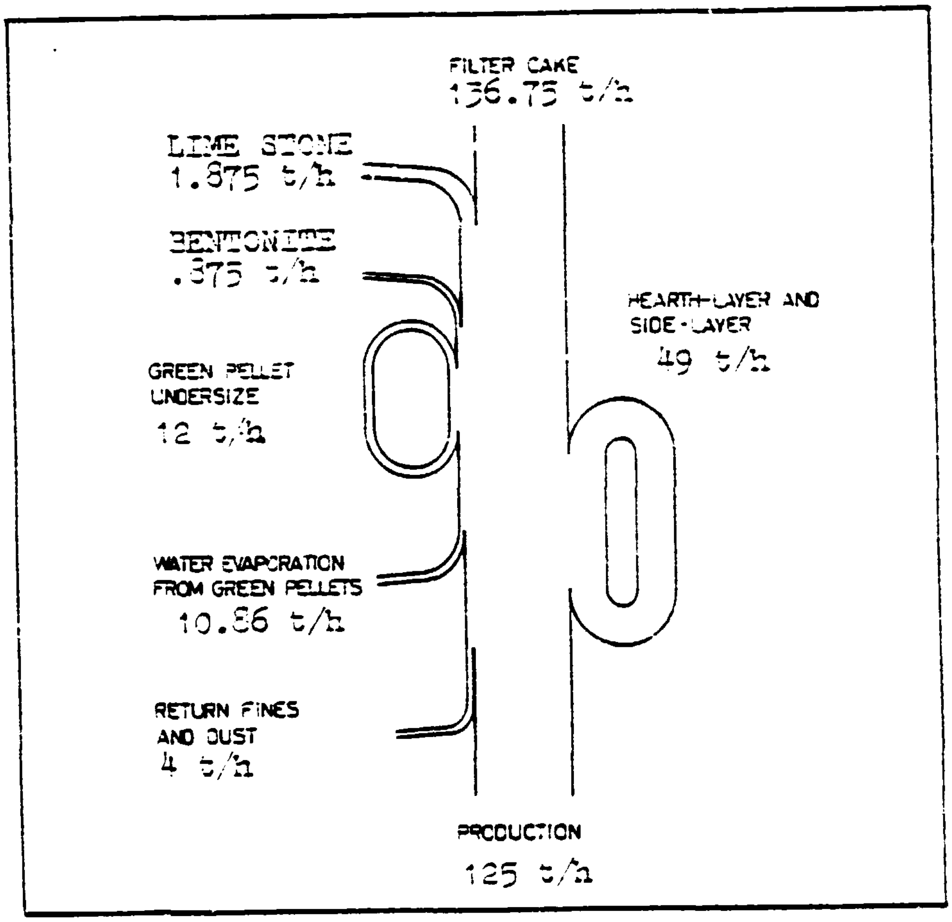

Figure 6 Material Flowsheet

Figure 6 illustrates a simplified material flow sheet of the iron ore pelletizing plant in Liganga/Maganga with an annual production rate of 990.000 tons.

The simplicity of the proposed plant is ensured by the fact that the whole process of drying, firing and cooling is achieved on a single unit - the travelling grate (indurating machine) - which is connected to its auxiliary equipment in such a way that a high degree of automatic process control can be achieved.

Flexibility is obtained by the fact that the whole suction zone is divided into various sections in which the heat supply can be controlled independently through the hot gas temperature and hot gas rate.
In this way, the firing conditions can be easily and quickly adapted in an optimum manner to the behaviour of the raw materials to be treated and the desired indurated pellet properties.

The profitability of the process is primarily ensured by its low heat consumption resulting from the application of the direct recuperation principle and from the fact that only very low percentages of binders, in the case of Liganga/Maganga concentrate 0.7 % bentonite and 1.5 % limestone, have to be added because the pellets remain stationary on the moving grate.

2.4.1.4 Quality of Iron Ore Pellets

Travelling grate plants are suitable for the production of pellets of adequate quality to meet the highest consumer demands provided that the optimum production conditions found in tests for every specific ore type (e.g. ore size, type and percentage of additives, firing pattern) are observed. The corresponding test results for Liganga/Maganga concentrate are listed in Volume I, Section 2.4.

For determining the quality of indurated iron ore pellets, numerous testing methods are known, the performance rules of which are not generally accepted as standards. The following table gives an example of quality characteristics for pellets downstream of the product screen of the pellet plant:

Pellet diameter 10 - 16 mm	min.	85 %
Fines portion, minus 5 mm	max.	1 %
Average cold crushing strength	min.	200 kg/P
ISO-tumble strength, minus 0.5 mm	max.	5 %
Reducibility at 40 % reduction, 950 °C	min.	0.5 %/min.
Swelling according to ISO-test, 1000°C	max.	20 %
Softening under load during reduction (Othfresen Test at 1050 °C) P	max.	20 mm WG

The iron content of the Liganga pellets will be above 60 % and their sulphur content will fall below 0.02 %.

The most important parameter for dimensioning a pellet plant is the specific capacity in tons per day of indurated pellets which can be achieved per m² of grate reaction area. This parameter mainly depends on the following factors:

Iron ore type, gangue content, crystal structure
Percentage and type of additives
Grinding method (dry or wet)
hence, moisture content of green pellets
Average pellet diameter
Desired abrasion resistance of pellets
Pressure conditions prevailing in the wind boxes

The iron ore type influences the specific capacity in several respects. A higher natural magnetite content normally results in a remarkable capacity increase whilst a higher content of combined water or carbonates leads to a lower capacity. High Al_2O_3 contents mostly result in a capacity decrease as do above-average contents of TiO_2 and SiO_2 which is the case with Liganga/Maganga concentrate.

Potgrate tests with Liganga ore in Lurgi's Frankfurt research laboratories revealed that the design of the travelling grate will have to be based on a specific capacity of 19.6 t/m² per 24 h.

The specific capacity decreases with increasing green pellet moisture content, mostly a result of finer ore grain size. This also applies if a major percentage of additives such as limestone is added to the ore. The pellet size also influences the specific capacity: the greater the mean pellet diameter, the lower the specific capacity. The demands on the pellet quality exercise a great influence on specific capacity, e.g. a rising abrasion strength results in a decrease in capacity.

The specific capacity can finally be influenced by the suction or pressure at which the gases are conveyed through the pellets during drying, firing and cooling. The higher these values are, the more will the specific capacity rise. The plant is called "high-power plant" if, at a low electric energy price, high fan pressures are applied which result in an indurating machine of small size and low capital cost, as opposed to the "low-power plant" - high electric energy price, low pressures, low fan capacity, big indurating machine, higher capital costs, but a lower consumption.

The heat and energy consumption of a pellet plant is also highly dependent on the above factors, the influence of the ore type being predominant. The consumption figures for the production of Liganga/Maganga pellets in this travelling grate plant with normal pressure conditions prevailing inside the wind boxes are as follows:

- Heat consumption: 460.000 kJ/t,
- Energy consumption incl. mixing, green pellet forming and pellet stockyard: 30 kWh/t pellets,

Pellet plants are often built in regions where not enough fresh water is available. For this reason, Lurgi plants are generally equipped with a cooling unit in which the warmed cooling water discharged from the various consumers is re-cooled. In this way, it is possible to limit the fresh water consumption to about 0.25 m^3/t pellets. Wet scrubbers are used for the in-plant dedusting system. The dust precipitated in this system is carried as slurry to a thickener, in which the major part of water is recovered as process water.

The start-up period and the plant availability are of great importance for the pellet plant owner. In general, a start-up period of 3 months is considered as normal.

Provided that plant operation conforms to the relevant instructions and a systematic and careful maintenance is ensured, the average annual availability of pellet plants built by Lurgi is above 90 % of the calendar time.

02

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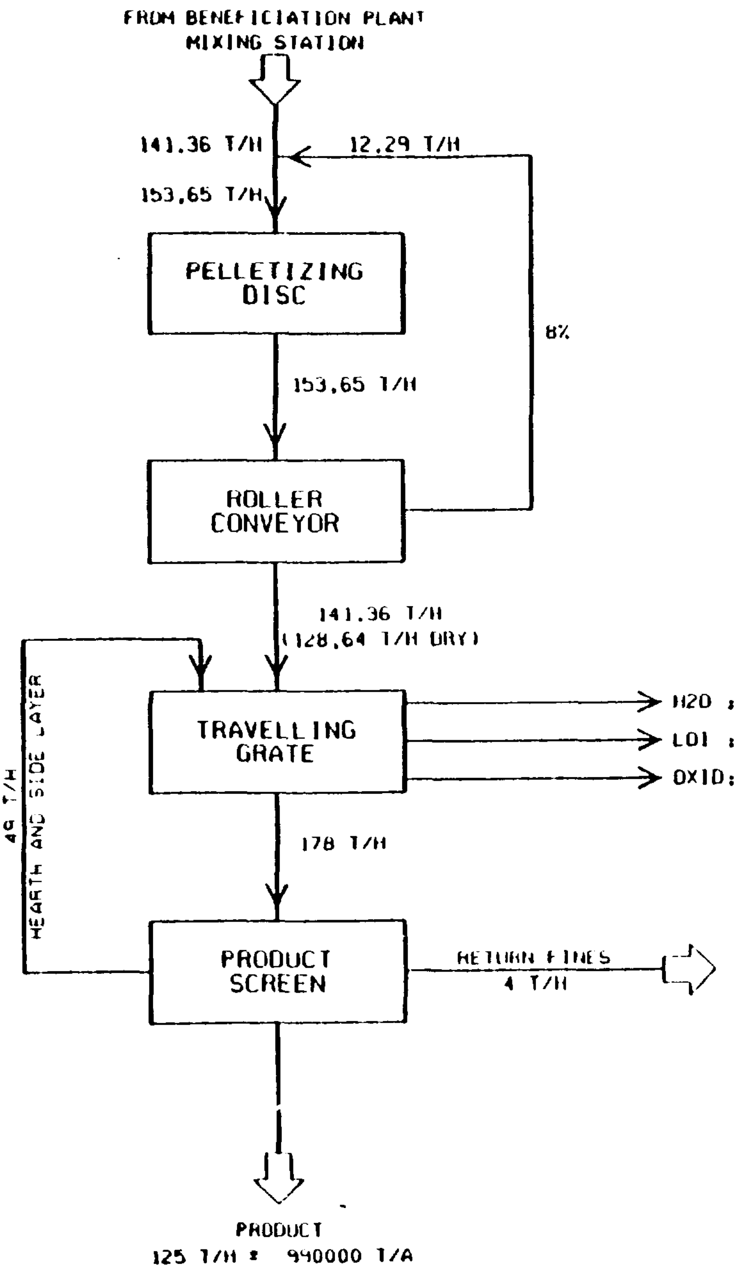

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- 12,72 T/H
- 3,23 T/H
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- 12,36 T/H LOSSES

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	Date	Name	LURGI — Lurgi Chemie und Huettentechnik GmbH
Prepared	01.12.83	PAUL/WH	
Checked			
Sheet	Title/Characteristic Features: IRON ORE PELLETIZING PLANT LIGANGA 0,99 MIO T/A PRODUCT		
Standards:	Drawing Type: 202 BLOCK DIAGRAM		
Process: HSP	Job or Project No.: 022238	Job: TANZANIA	
Drawing No.: L3A0222380000 1	Rev.:	Ref.Dwg.:	Original Size: A1

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S E C T I O N 2.4.2

Plant Description

Pelletizing Plant

2.4.2 Plant Description

This description of the pelletizing plant is based on flow sheet:

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Bentonite and limestone are used as additives for pelletizing.

The plant consists of the following plant sections:

green pelletizing
firing section
screening station

Besides which, wet scrubbers are used for dedusting. Suction dust from the wet scrubbers is added to the pelletizing material by means of a thickener, in the form of slurry. The dedusting units are described separately from the pelletizing process.

2.4.2.1 Green pelletizing

The wetted mixed material is transported to the bins for mixed material by means of belt conveyors.

A plough which is installed directly over the final belt conveyor distributes the transported mixed material into the respective bin.

The fullness of the bins for mixed material is measured and indicated by load cells. The filling cycle of the bins is automatically carried out at pre-arranged intervals and according to the fullness of the bin.

The bins have a holding capacity of 40 m³ each; the conical outlet parts are internally lined with a polyethylene sheeting to prevent sticking and blockages of the mixed material. Green pellets are being produced on 2 balling discs.

The material discharge from each bin is controlled by a weigh feeder which is equipped with a variable speed drive. Both balling discs with 7.5 m diameter are charged by a fluffer. The fluffer has two functions, the disintegration of lumps as well as the distribution of the mixed material over a wider balling disc area. The weigh feeder as well as the fluffer are within certain limits, adjustable (manually) in their location in order to obtain the best feeding point for good green pellet production. The two discs are arranged in line and have a diameter of 7.5 m and reach a production rate of up to 150 t/h with an adjustable speed of between 5.8 and 6.8 rpm.

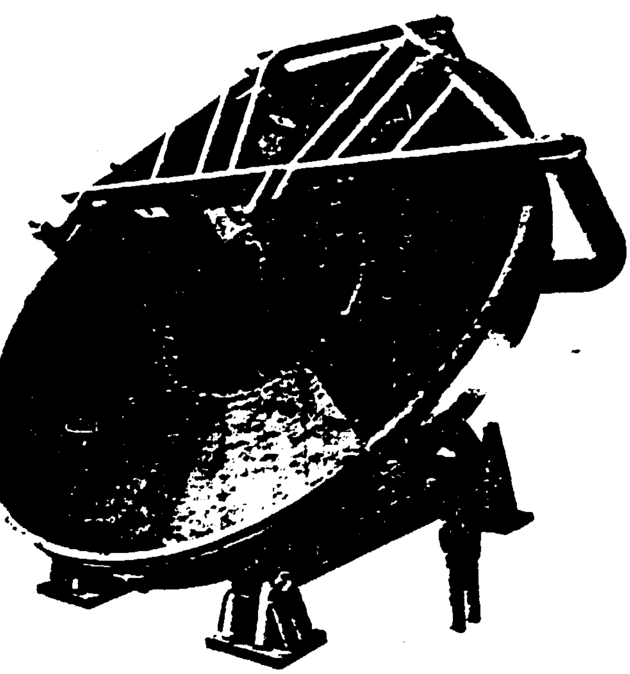

Figure 1 Pelletizing disc of 7.5 m diameter

The green pellets are formed in the disc with addition of little quantities of water. Inclination and rotary speed of the discs are variable and optimum settings are to be determined during start-up according to mixed materials properties, the desired green pellets diameter and the feed rate. The discs are equipped with stationary scrapers. Speed variations are possible by exchange of drive pulleys.

On reaching a certain size, the pellets are carried out of the balling discs on the reversible belt conveyors.

Should the green pellet quality be insufficient, the green pellets can be transported via the reversible belt conveyors to a slurry tank from where slurry is pumped back to the thickener.

During normal operation of the plant, the reversible belt conveyors transfer the green pellets to the collecting belt conveyor. In this conveyor, a single idler belt weigher is installed for weighing the total amount of green pellets fed to the roller conveyor.

The pellets are fed onto the roller conveyor by a feeding belt which is charged by a reciprocating conveyor arranged at right angles. (Fig. 3).

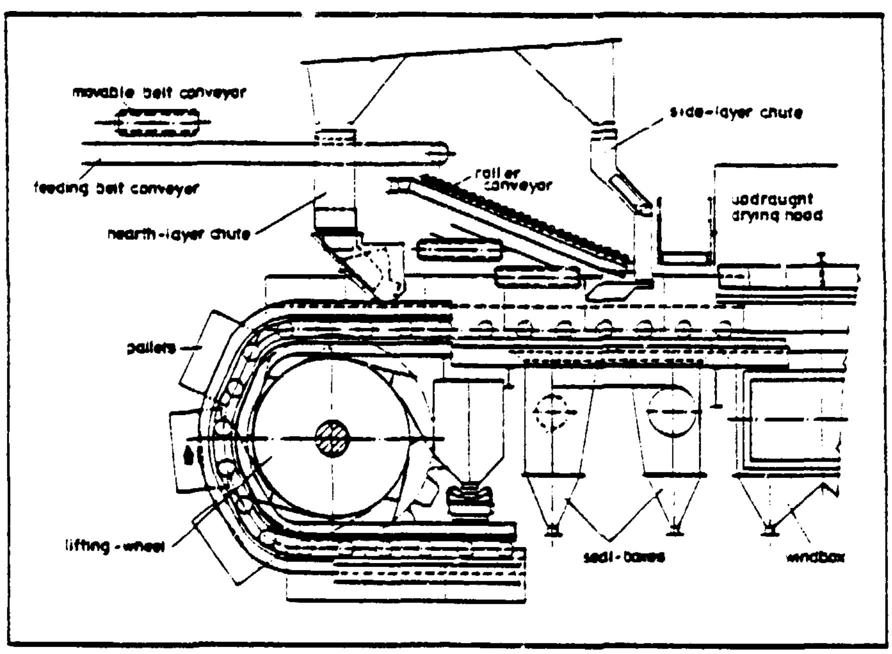

Figure 2 Green pellet feeding system

This ensures uniform distribution of the green pellets over the width of the roller conveyor. The number of strokes and the speed of the reciprocating conveyor as well as the belt speed of the feeding belt are adjustable.

The optimal adjustment of all movements makes a regular and continuous supply of green pellets to the roller conveyor possible.

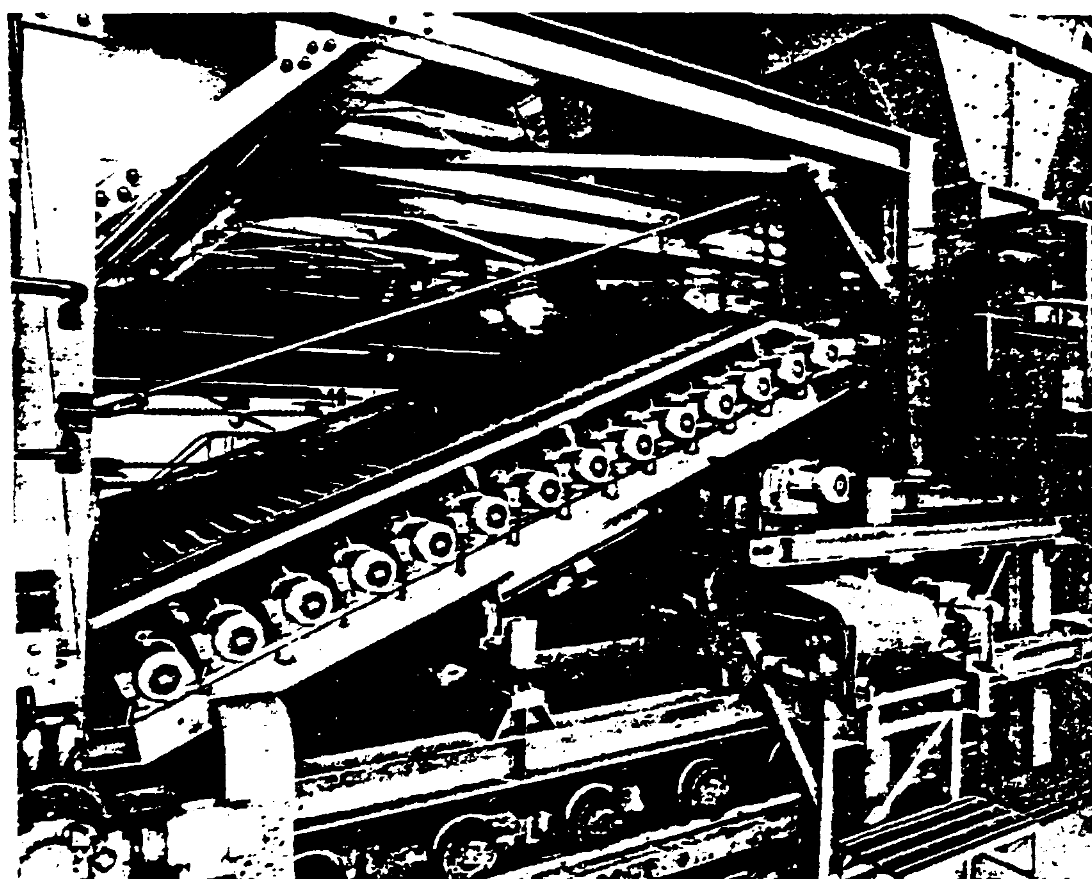

Figure 3 Roller conveyor

An important design feature of the Lurgi-Dravo travelling grate is the roller conveyor acting as green pellet feeding device. This roller conveyor consists of several rollers which are driven individually by gear-motors. The rollers are made of stainless steel.

In its upper part, the roller conveyor has gaps of 6 - 8 mm width for separating the small amount of fines arriving together with the green pellets. In its lower transportation section, the roller conveyor has gaps of 2 - 3 mm width. The roller conveyor slope and number of rollers depend on constructional details in the travelling grate feeding zone. In this case, a 22° slope was selected for a total of 29 rollers.

By transporting the green pellets via the roller conveyor, undersize material is sieved out and a re-tumbling effect and a continuous supply to the travelling grate are achieved.

The sieving out of undersize green pellets (- 6 mm) is achieved on 2/3 of the length of the roller conveyor. This undersize material falls through the sieve fissures of the roller conveyor onto a belt conveyor arranged directly under the roller conveyor and is transported by means of belt conveyors back to mixed material bins.

One belt conveyor is equipped with a single idler belt scale in order to register the quantity of undersize pellets.

The amount of undersize green pellets is subtracted from the overall green pellet amount, thus yielding the effective green pellet amount to be supplied to the indurating machine.

2.4.2.2 Pellet Induration

The green pellets are dried, heated up, indurated and cooled on the travelling grate. The travelling grate has a reaction surface of 153 m² (3 m wide and 51 m long), consisting of an endless chain of pallets which continuously circulate.

One of the technological preconditions for achieving a product of uniform quality is a uniform layer height. This is achieved by automatic regulation of the travelling grate speed, depending on the amount of green pellets and the hearth layer depth.

A thermal strain on the pallets which would lead to premature wear, is avoided by means of hearth layer and side layer (fired pellets of 10 ÷ 25 mm diameter). The side layer also has the task of avoiding the so-called "side edge effect".

The bin for hearth layer and side layer has a capacity of approx. 165 t and is placed at the feed-end of the travelling grate. The hearth layer on the pallets is regulated by means of a motorized mushroom valve. Side layer is discharged by means of 2 side layer gates.

Charging the pallets is achieved in the following sequence:

1. hearth layer
2. side layer
3. green pellets

The bin for hearth and side layer is additionally equipped with an emergency discharge chute, allowing the pallets to be loaded over the overall width with 40 cm of hearth layer in an emergency.

The most important component of the travelling grate is the pallet. It consists of two end castings with running wheels, pressure wheels and side walls as well as the center casting made of alloyed cast steel and divided into several sections supporting the grate bars. The center casting is of symmetrical design

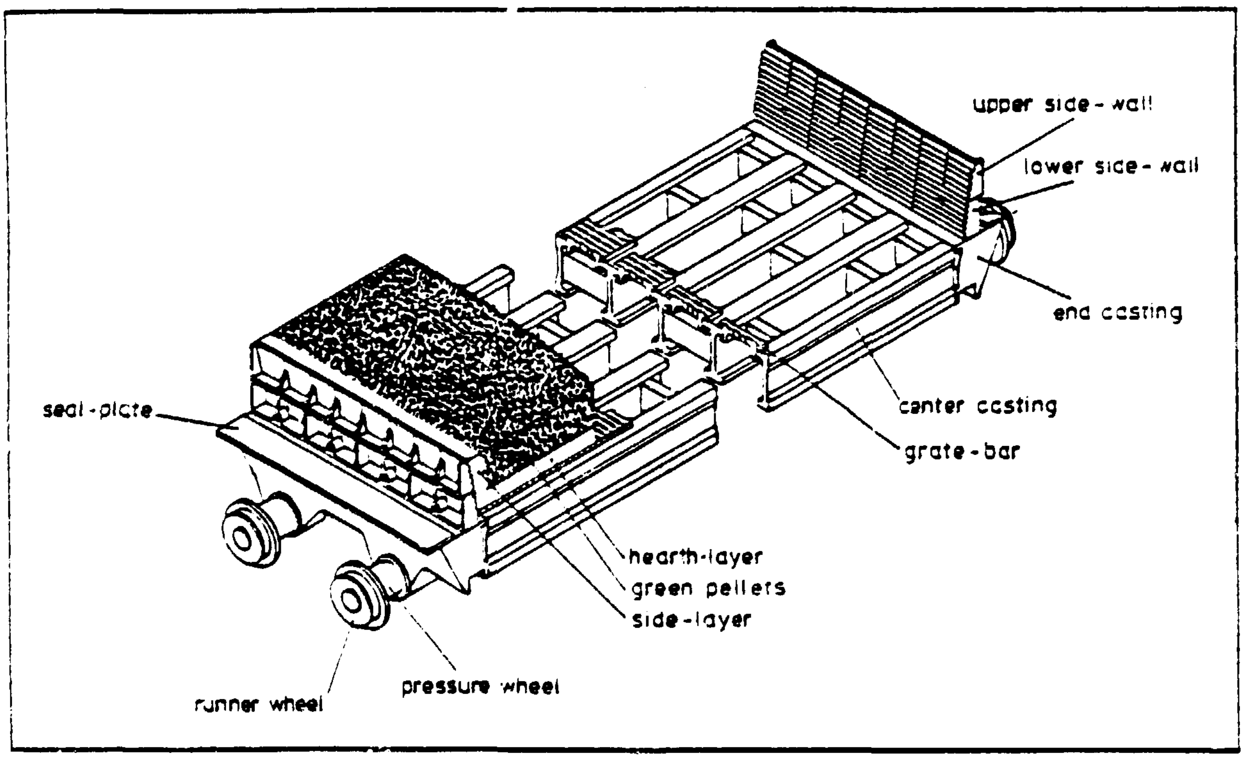

Figure 4 Pallet

and can be easily turned around and reused without any further machining when it has sagged past the maximum permissible tolerance due to thermal and mechanical stresses after a prolonged operating time. The center casting shape and mass are adapted to the expected thermal stresses occurring during pellet firing, which are dependent on the ore type. Based on these design principles, a service life of several years is achieved.

The grate bar shape, weight and material were repeatedly modified by Lurgi and Dravo in the development of the iron ore pelletizing process as a result of many year's experience gained in commercial plants. Nowadays, grate bars of austenitic chrome-nickel steel are used which are designed that they ensure, together with the pallets, the high availability of the Lurgi plants.

The pellets pass through the following zones:

	length of zone
updraught drying	4.5 m
downdraught drying	4.5 m
preheating and firing	25.5 m
afterfiring zone	1.5 m
cooling zones I and II	18 m

The process gas flow takes place as described below:

The hot combustion gases come from the indiviual burner chambers into the preheating zone and the firing zone. A total of 14 burner chambers are paired up opposite each other along the length of the preheating and firing hoods.
The laying out and dimensioning of the burner chambers guarantee a uniform hot gas temperature along the width of the pallet charge and make the adjusting of an optimal preheating and burning scheme possible.

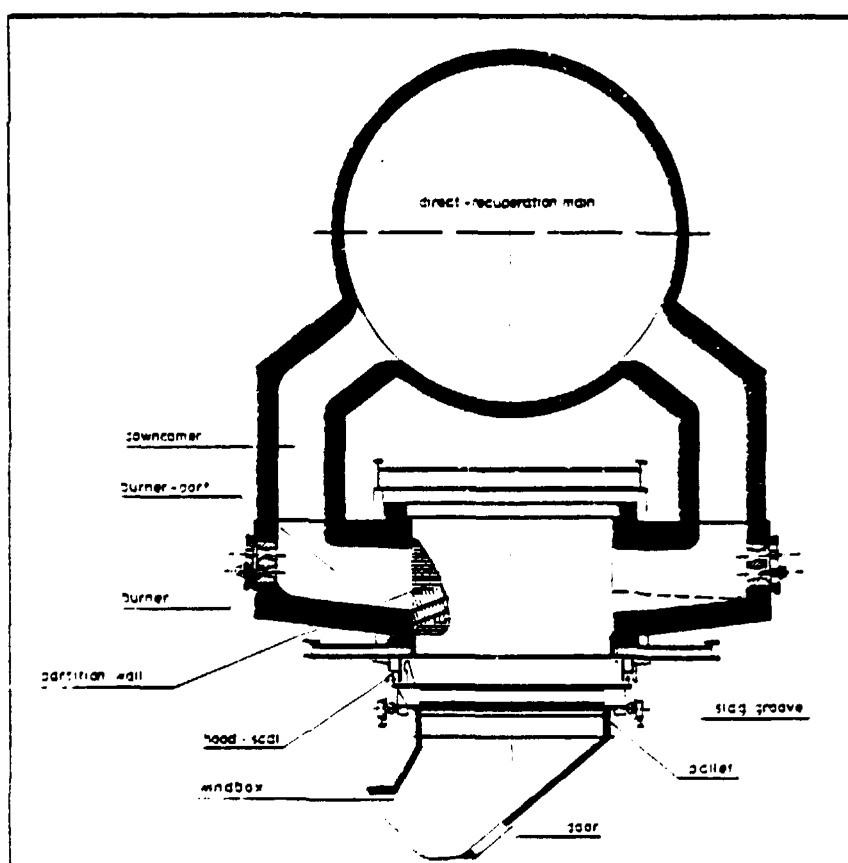

Figure 5 Section of the firing zone of a Lurgi-Dravo travelling grate.

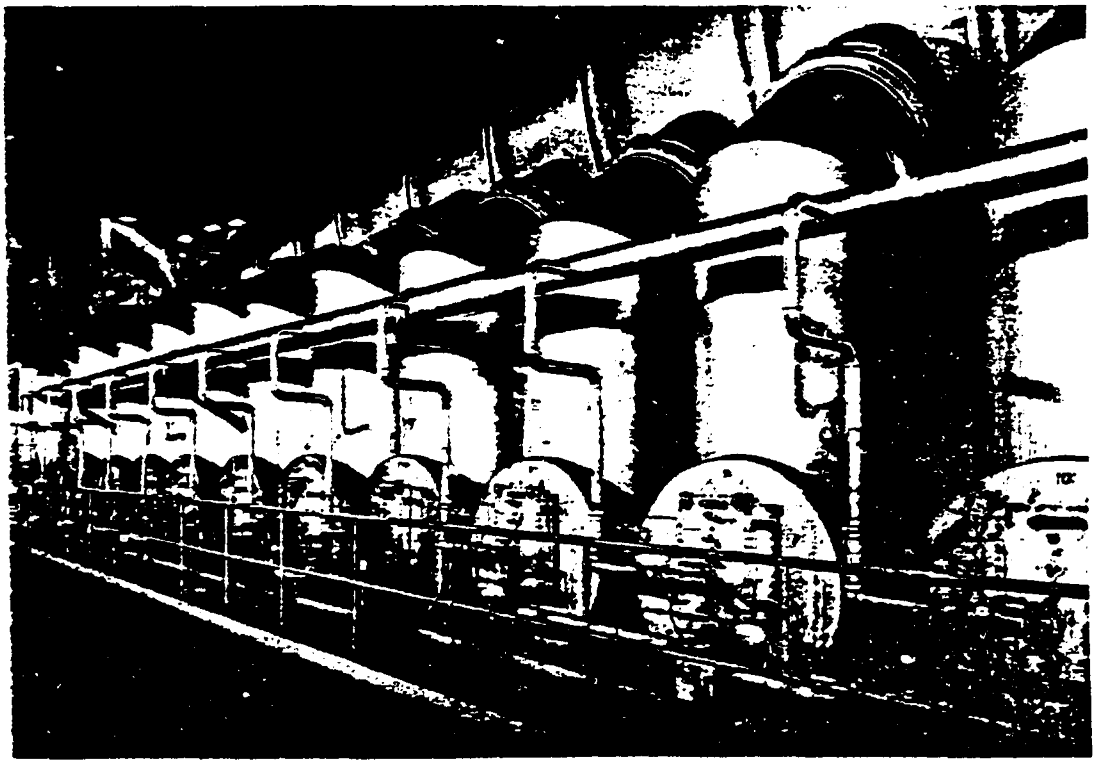

Figure 7 Combustion chambers with heavy oil burners

The whole reaction zone of the Lurgi-Dravo travelling grate is covered with a hood which, according to the process stages updraft drying, downdraft drying, preheating, firing, after-firing and cooling is divided into these zones.

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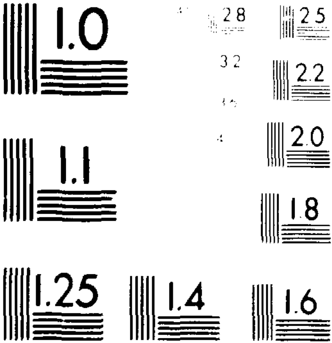


MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS

STANDARD REFERENCE MATERIAL 1010a

ANSI and ISO TEST CHART No. 2

The hood is lined with refractory material so that the radiation losses are limited to a minimum. This is one of the reasons for the well-known low heat consumption of the Lurgi-Dravo process. The use of the most suitable materials and the design based on the experience gained in a great number of commercial plants ensure a long service life.

In the preheating and firing zone, combustion chambers are located at a distance of 3 m on both longitudinal sides of the hood. The burners are of special design with the characteristic feature being that only about 15 % of the stoichiometrical combustion air volume is needed in the form of cold air as atomization agent. Hot air of about 800 - 900 °C from the cooling zone is used as supplementary combustion air and dilution air required for adjusting the flue gas temperature to the desired value. In this way, it is ensured that only the real minimum of cold air is needed for the burner operation which is a further reason for the low heat consumption of the Lurgi-Dravo process.

Each burner chamber is equipped with an oil burner which supplies the required heat for preheating and burning.

The preheating and firing zone is divided up into different control zones. The hot gas temperature over the pellet bed is measured in each of these zones with thermocouples and is indicated in the process control board.

The measured temperature values serve as control limits for oil supply to the individual burners.
The supply and circulation of the air and gas quantities necessary for the process are ensured by means of the process fans. The firing process is characterized by the use of the greatest amount of heat possible which becomes available by cooling of the hot pellets through the use of the direct recuperation principle that is returning the heated air from cooling zone 1 to the firing zone.

The cooling air fan sucks surrounding air in and forces this air via a pipeline system into the wind boxes of the cooling zone. The cooling air, which is warmed in passing through the hot pellet bed, is collected in the 1st and 2nd cooling hoods. These hoods are situated directly over the travelling grate and are sealed against this. Due to this seal, a positive pressure rises in cooling hood 1, which is sufficient to transport the warmed air via the direct recuperation main to the combustion chambers.

A part of the heated air from cooling zone I is directly supplied to the secondary firing zone. The warm air accumulating in cooling zone II is drawn off through the updraught drying fan and transported to the updraught drying zone. To prevent this air from exceeding a certain maximum value, cold air can be sucked in via a suction socket. Excess air which is not necessary in the updraught drying zone can be blown off via a blow-out socket. This blow-out socket is equipped with an adjustable valve in order to be able to adjust constant pressure relations for the updraught drying. A fan serves to generate sealing air for the seal between hood structures and pallets in cooling zone I and II.

The hot combustion gases from the burner chambers and the hot air supplied for down-draught drying, preheating and after firing zones, are drawn by means of fans through the pellet bed. The wind boxes of the down-draught drying zone and of the preheating zone are connected to the waste gas fan.

The waste gases from wind boxes 2 to 6 undergo a dust extraction process in the multi-cyclone and are discharged via the waste gas stack into the atmosphere.

Wind boxes in the down-draught drying and preheating zones are fitted with motorized throttle dampers in order to make the regulation of the vacuum pressures in the wind boxes possible.

The gases coming from the burning zone and from the after firing zone serve as drying gases for the down-draught drying and preheating zones. These gases are fed from the wind box recuperating fan by means of a pipeline into the down-draught drying and preheating zones.

In order to keep the temperature of the drying gases constant and to protect the wind box recuperating fan from excessive temperatures, a suction socket is fitted on the suction side of the fan for ambient air, equipped with a throttle damper.

The hood exhaust air fan is installed above the updraught drying hood. This fan sucks out the damp air from the updraught drying hood.

In front of wind box 1 are the two sealing boxes. From these boxes, the escaping air from the up-draught drying zone is drawn off.
Sealing box 01 is connected to wind box 6. By means of a damper, the amount of air being drawn off can be regulated. The second sealing box is fitted with a ducting leading to the atmosphere.

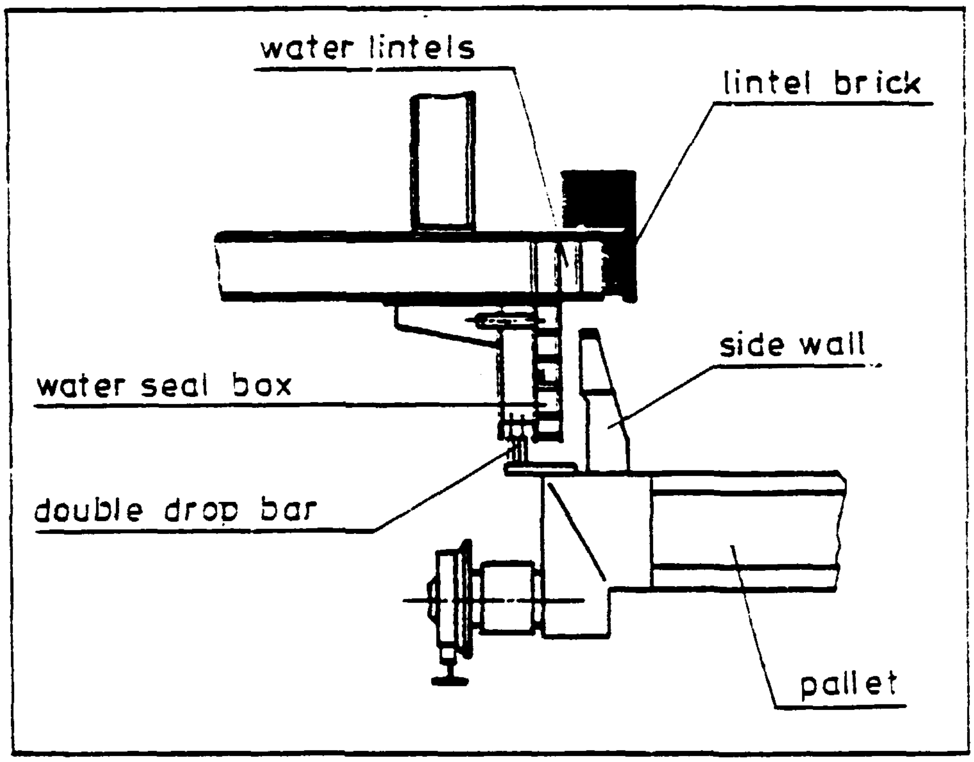


Fig. 7 Principle of longitudinal hood sealing

A typical feature of the Lurgi-Dravo travelling grate is the design of the driving and reversing stations, (Fig. 8). The driving station consists of two lifting sprockets which are connected with each other by a drum in a torsion-proof manner. These lifting sprockets serve to lift the pallets from the lower strand to the upper strand. The lifting sprockets are arranged on a shaft which accomodates the main gear, mounted at one shaft end and driven by means of two pinions.

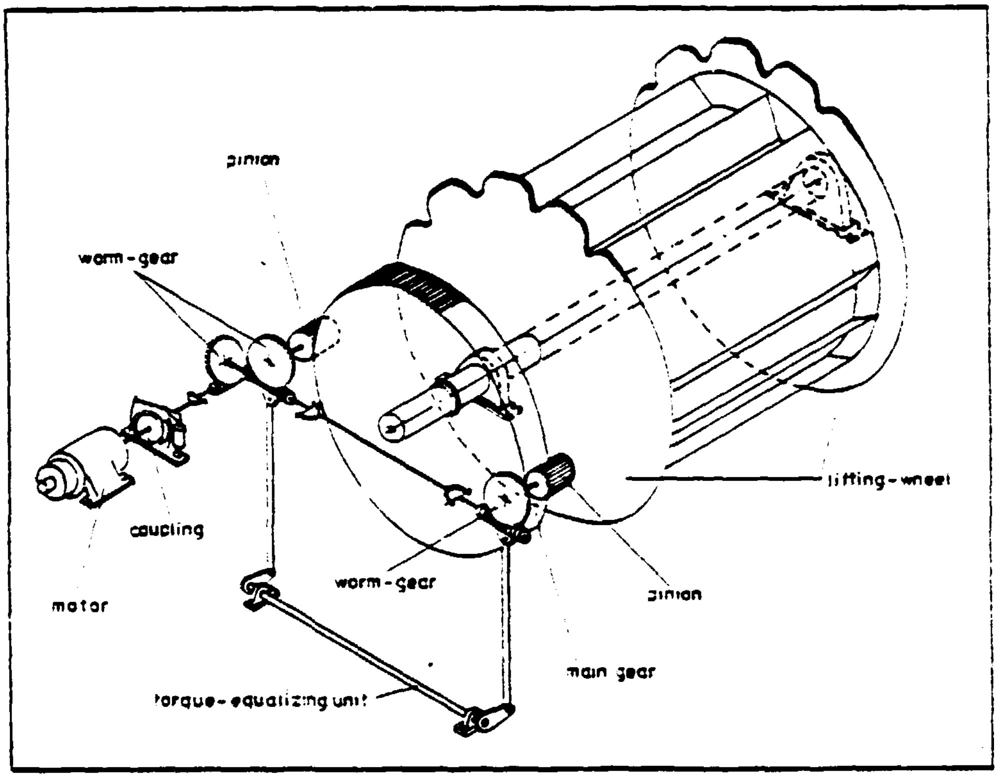


Fig. 8 Driving station of a travelling grate.

The driving motor normally is a D.C. motor to enable the pallet travelling speed to be varied within wide limits.

The reversing station comprises a pair of lowering sprockets which have the same shape and dimensions as the pair of lifting sprockets. As soon as the teeth of the lowering sprockets grasp a pallet, it is separated from the subsequent pallet on the slide track. Subsequently, the pallets are emptied while they are passed to the return track (rotating chute) without the pallets coming into contact with one another.

The heat elongation of the pallet chain due to temperature influence is compensated by a counter-balanced, pendulum-like suspended reversing station. A counterweight ensures an uninterrupted pallet chain, (Fig. 9).

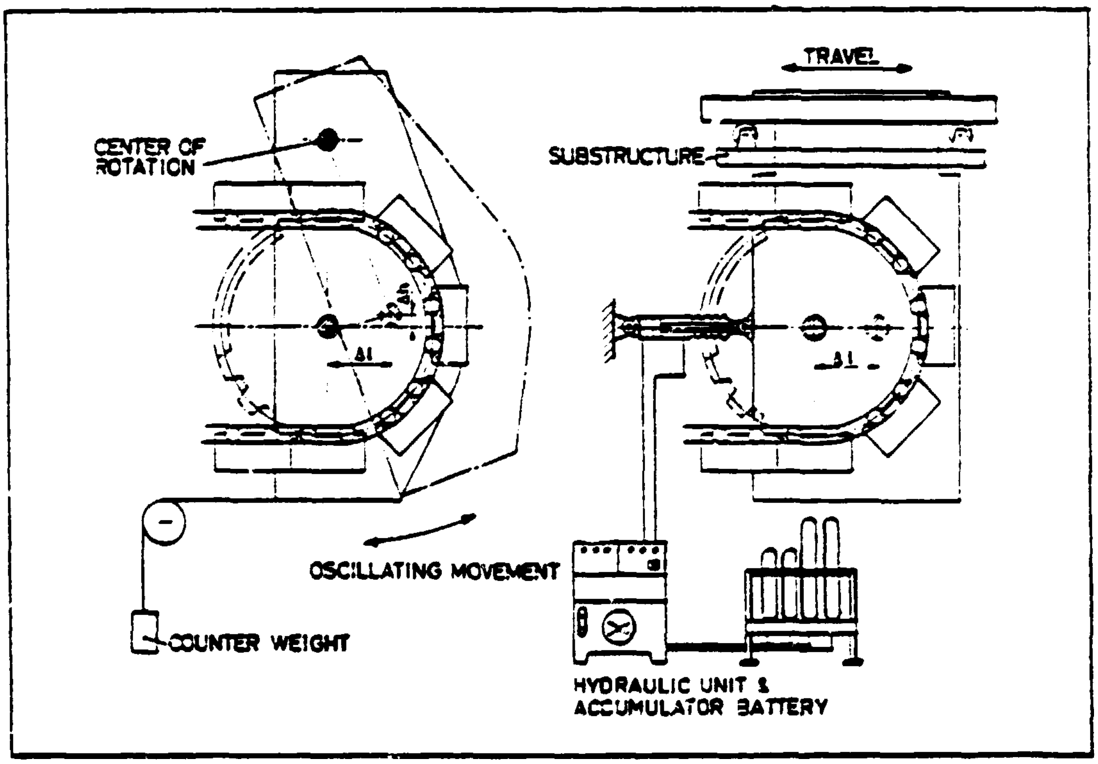


Figure 9 Oscillating reversing station

In the vicinity of the lifting wheel of the grate is a special hoist in order to lift out pallets. It may be necessary to exchange pallets if grate bars are lost, side walls are to be replaced, car midsections sag, etc. In order to identify a pallet with too much sagging, a measuring appliance has been fitted in the lower section of the travelling grate.

A grate bar rapping device is installed in the vicinity of the lowering wheel under the return strand of the travelling grate.

Each pellet plant comprises a central control room from which the operation of the individual equipment items is monitored and controlled with the latest facilities. Furthermore, the interlocked drives are switched on and off from this control room, (Fig. 10).

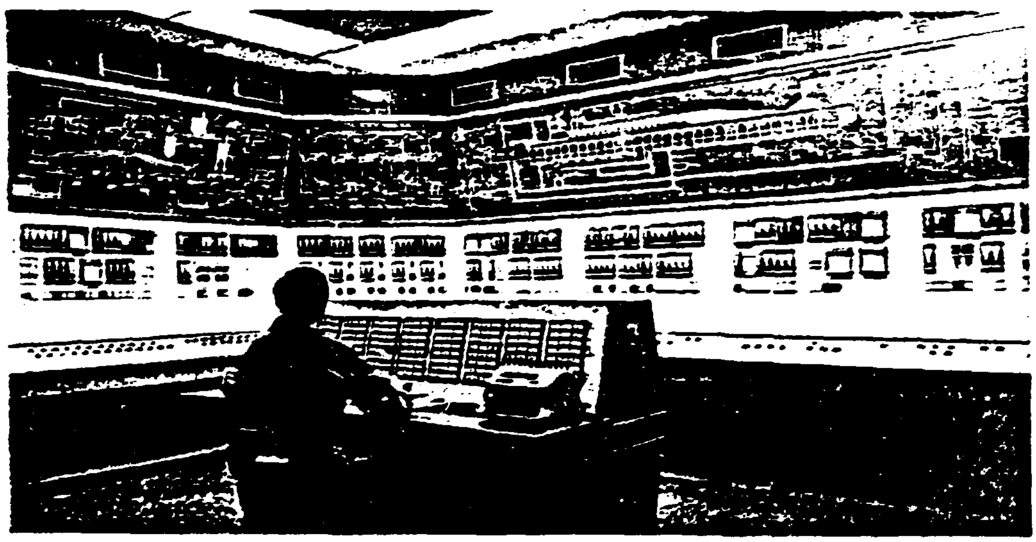


Fig. 10 Central control room

2.4.2.3 Product handling

The indurated and cooled pellets are discharged from the travelling grate to an intermediate hopper, mounted on load cells, with a capacity of approx. 130 t. This hopper is equipped with a manually operated gate. The pellets are discharged from the hopper via this gate by a conveyor to the vibrating screen.

A movable saddle - operated by a gear motor - is installed above the vibrating screen. This moveable saddle acts as a two-way chute and allows that only a certain portion of pellets will be fed via the vibrating screen to cover the demand of hearth and side layer material. According to the filling degree of the hearth and side layer bin, the saddle will be automatically moved in the required position.

The portion which by-passes the vibrating screen is fed directly to the direct reduction plants whilst from the portion fed onto the vibrating screen, the fraction 10 - 25 mm is screened out and returned to the hearth and side layer bin via the belt conveyors.

The product fed to the direct reduction plants will be weighed and registered by a multi-idler belt weigher.

The feed system and the storage facilities of the oxide pellets do not belong to the scope of the Pelletizing Plants. For technical details, please refer to the separate operating manual for this plant area.

2.4.2.4 Dedusting

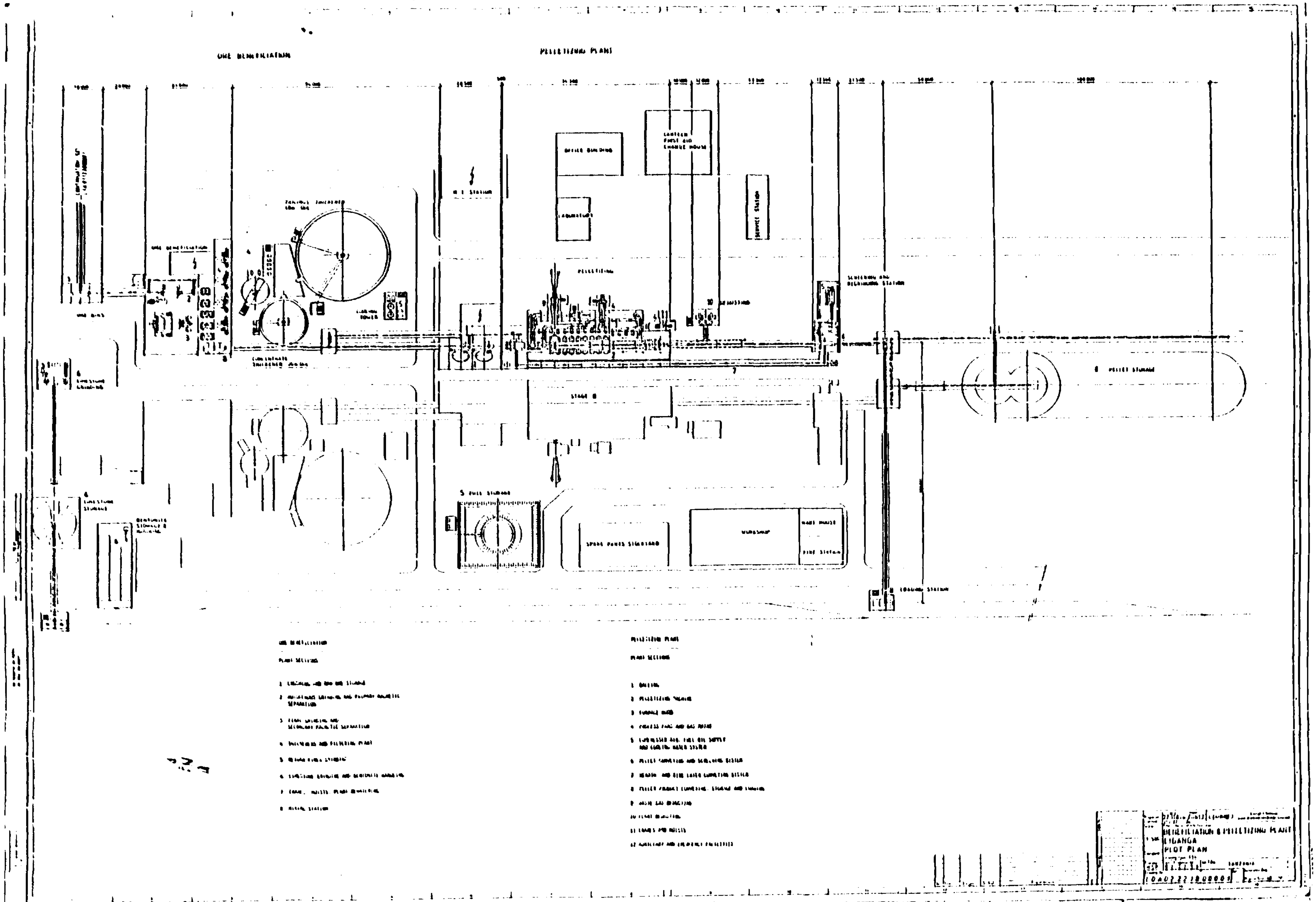
Two Wet dedusting units are installed for dedusting the different delivery points for pellets, hearth layer, product screen etc.. One radial flow washer is installed at the charge end of the travelling grate whilst the other is situated in the discharge area.

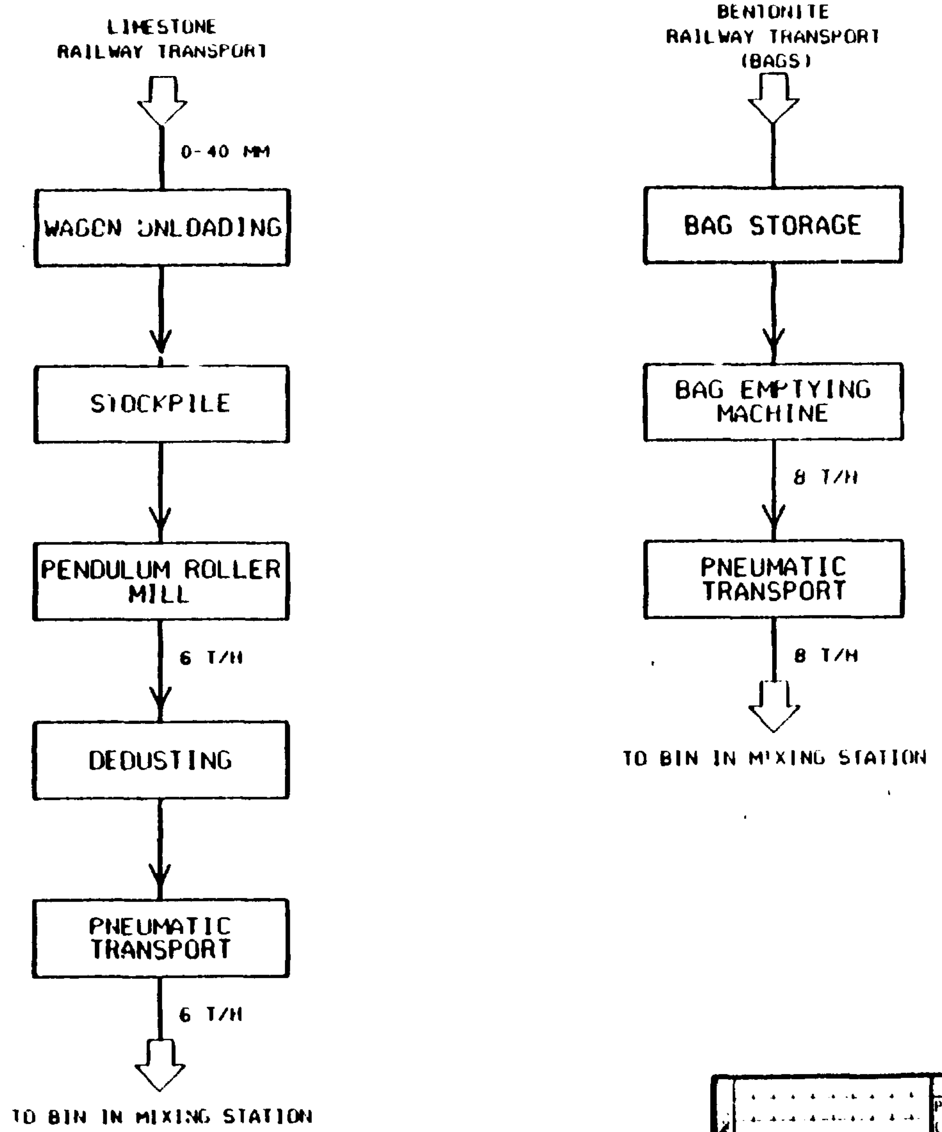
The functioning of both scrubbers is the same. A fan blows the dust-filled air into the scrubbers. The dust particles are moistened by means of a spray system (water) and sink to the lowest part of the scrubber. The clean exhaust comes into the atmosphere through the flue.

The slurry from the scrubber at charge end is collected in a slurry tank and transferred to an agitator tank.

The slurry of the other scrubber is collected in a different slurry tank and transferred to the thickener.

For the extraction of dust from the waste gases from the down-draught drying and preheating zones, a multi-cyclone has been installed. The waste gases are dry cleaned. The fine dust settles in the discharge tips of the multi-cyclone and from there is passed by a double pendulum flap onto a chain conveyor. This transports the dust to an agitator tank where, after the addition of water, a thin, pumpable slurry is produced. A slurry pump conveys the slurry to the thickener.


PELLETIZING PLANT
OFFICE BUILDING
LABORATORY
SERVICE STATION
PELLETIZING
PELLET STORAGE
WORKSHOP
LOADING STATION
PLANT SECTIONS
BENEFICIATION & PELLETIZING PLANT
LIGANGA
PLOT PLAN



1.STAGE: 1 SHIFT OPERATION
2.STAGE: 2 SHIFT OPERATION

	Date	Name
Prepared	06.12.83	PAUL/HFFN
Checked	10.1.84	

LURGI — Lurgi Chemie und Huettentechnik GmbH

Title/Characteristic Features:
LIMESTONE AND BENTONITE HANDLING LIGANGA

Drawing Type: 202 BLOCK DIAGRAM

Process: HAA — Job or Project No.: 0.12238 — Job: TANZANIA

Drawing No.: L3A0.12238.00006

LURGI

S E C T I O N 2.4.3

Raw Materials and Products

2.4.3 Raw Materials and Products

2.4.3.1 Raw Materials

Liganga Concentrate

$Fe_{tot.}$	%	63.3
Fe"	%	20.7
SiO_2	%	0.1
Al_2O_3	%	2.8
CaO	%	0.01
MgO	%	1.75
TiO_2	%	6.5
P	%	-
L.O.I. (1050 °C)	%	0
+ 0.315 mm	%	-
0.315 - 0.200 mm	%	-
0.200 - 0.125 mm	%	0.7
0.125 - 0.090 mm	%	1.3
0.090 - 0.063 mm	%	3.6
0.063 - 0.045 mm	%	4.1
0.045 - 0.032 mm	%	7.8
- 0.032 mm	%	82.5
Spec. surface area (Fisher Subsieve-Sizer)	= cm^2/g	2,350
Bulk density:	kg/l	1.49
Moisture :	%	9
Feed rate :	tph	138.6
	tpy	1,098,000
	t/t	1.11 of fired pellets

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Limestone

SiO_2	%	3.0
Al_2O_3	%	0.7
CaO	%	53.6
MgO	%	0.8
L.O.I. (1050 °C)	%	42.2
+ 0.315 mm	%	0
0.315 - 0.200 mm	%	1.3
0.200 - 0.125 mm	%	2.3
0.125 - 0.090 mm	%	0.5
0.090 - 0.063 mm	%	2.3
0.063 - 0.045 mm	%	3.7
0.045 - 0.032 mm	%	6.0
- 0.032 mm	%	87.5

Spec. surface area (Fisher Subsieve-Sizer)	=	cm^2/g	6,440	
Bulk density	:	kg/l	0.84	
Moisture	:	%	0	
Feed rate	:	tph	1.875	
		tpy	14,850	
		t/t	0.015	of fired pellets

Bentonite

+ 0.315 mm	%	0
0.315 - 0.200 mm	%	0
0.200 - 0.125 mm	%	1.2
0.125 - 0.090 mm	%	1.6
0.090 - 0.063 mm	%	5.8
0.063 - 0.045 mm	%	12.0
0.045 - 0.032 mm	%	12.8
- 0.032 mm	%	66.6

Spec. surface area = cm^2/g 19,300
(Fisher Subsieve-Sizer)

Bulk density	:	kg/l	0.66
Moisture	:	%	0

Feed rate	:	tph	0.875
		tpy	6,930
		t/t	0.007 of fired pellets

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Heavy Fuel Oil

Layout of burners and auxiliary equipment was based on a heavy fuel oil supply according to German Standard DIN 51603, specified as follows:

Calorific value	:	approx.	42,500	kJ/kg	
Cinematic viscosity (c St)	:	max.	450	mm^2/s	at 50 °C
		max.	40	"	at 40 °C
Conradson-test	:	max.	15	%	coke
Sulphur	:	max.	2.8	%	
Water	:	max.	0.5	%	
Sediments	:	max.	0.5	%	
Ash	:	max.	0.15	%	
Specific gravity	:	approx.	0.95	g/cm^3	

Consumption rate	:	tph	1.375
		tpy	10,890
		t/t	0.011 of fired pellets

2.4.3.2 Products

Liganga Fired Pellets

$Fe_{tot.}$	%	61.3
Fe"	%	0
SiO_2	%	0.6
Al_2O_3	%	2.9
CaO	%	0.8
MgO	%	1.7
TiO_2	%	6.3
P	%	0
L.O.I. (1050 °C)	%	0

Bulk density	:	kg/l	2.05
Average compression strength	:	N/P	2,716
ISO Tumble + 6.3 mm	:	%	95.7
- 0.5 mm	:	%	4.1

Production rate	:	125	tph
		990,000	tpy

S E C T I O N 2.4.4

Consumption Figures

and

Workforce Schedule

LURGI

2.4.4 Consumption Figures and Workforce Schedule

2.4.4.1 Consumption Figures

For the production of 990,000 tpy in a pellet plant from Liganga/Maganga concentrate using heavy fuel oil as the only energy source and limestone as well as bentonite as additives, the following specific consumption figures apply:

	per ton product		per year	
Concentrate	975	kg	965,250	t
Limestone	15	kg	14,850	t
Bentonite	7	kg	6,930	t
Heavy fuel oil	11	kg	10,890	t
Light fuel oil (for start-up)			50	
Electric power	31	KWh	30,690	MWh
Cooling water	0.05	m^3	49,500	m^3
Consumables and spares	0.65	US $	643,500	US $
Workforce (operation and maintenance)	0.17	mhrs	100	men

Remark: All material flow figures contain a margin of 5 % for handling losses.

2.4.4.2 Workforce Schedule, Pelletizing Plant

(G = Graduated; S = Skilled; SS = Semi-Skilled; US = Unskilled)

	Shift 1	2	3	4	Day Shift	Total	Qualification Level
Plant Manager					1	1	G
Superintendent Pelletizing					1	1	G
Shift foreman	1	1	1	1		4	S
Operator control rooms	2	2	2	2		8	S
Ass. operator control rooms	2	2	2	2		8	S
Operator green pellets	1	1	1	1		4	S
Ass. operator green pellets	1	1	1	1		4	SS
Operator burning machine	1	1	1	1		4	S
Ass. operator burnning machine	1	1	1	1		4	SS
Operator screening and material handling	1	1	1	1		4	S
Operator fans and burners	1	1	1	1		4	S

	Shift 1	2	3	4	Day Shift	Total	Qualification Level
Operator truck unloading	1	1	1	1		4	S
Operator additives unloading and storage	1	1	1	1		4	S
Operator fuel oil unloading and storage	1	1	1	1		4	S
Operator pellet stockyard	1	1	1	1		4	S
<u>Maintenance personnel</u>							
Maintenance superintendent					1	1	G
Shift foreman	1	1	1	1		4	S
Mechanics	3	3	3	3		12	S
Electricians	2	2	2	2		8	S
Measuring and Control	1	1	1	1		4	S
Cleaners					4	4	US
Lubrication	2	2	2	2		8	US
Sub-total	20	20	20	20	7	87	
15 % Absentees	3	3	3	3	1	13	
Total:	23	23	23	23	8	100	

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S E C T I O N 2.4.5

Auxiliaries

2.4.5 Auxiliaries

All media and energy required inside plant sections will be supplied by the corresponding central generating, storing and distributing system.

This mainly applies for:

- drinking water
- cooling water
- fuel oil for burners
- compressed air for double pendulum flaps, ploughs and lubrication
- instrumentaion for control valve actuation.

The corresponding systems are described and outlined - as applicable - in the Plant Description, Section 2.4.2, Outline Specification Section 2.4.6.1 and Utilities and Off-sites, Section 2.4.7.

SECTION 2.4.6

Outline Specification

Pelletizing Plant

2.4.6.1 MECHANICAL EQUIPMENT

Plant Sections

.1 Balling Section

.2 Feeding System and Travelling Grate

.3 Furnace Hood

.4 Process Fans and Gas Mains

.5 Compressed Air; Fuel Oil Supply and Cooling Water System

.6 Pellet Conveying and Screening System

.7 Hearth and Sidelayer Conveying System

.8 Pellet Product Conveying, Storage and Loading Plant System

.9 Waste Gas Dedusting

.10 Plant Dedusting

.11 Cranes and Hoists

.12 Auxiliary and Emergency Facilities

.1 BALLING SECTION

Plant Section 2.4.6.1.1 mainly comprises the following items:

2 Storage bins, for mixed material

life capacity	:	66.3	t/ea.

incl. level indication by load cells.

2 Weighfeeders, for mixed material

design capacity	:	76	t/h ea.
range of control	:	10 : 1	

2 Fluffers

design capacity	:	95	t/h ea.

incl. chutes.

2 Balling discs, for preparation of green pellets

design capacity	:	76	t/h ea.
disc	:	7.5	m
height of border	:	650	mm

incl. chutes.

2 Ascending reversible belt conveyors for green pellets,

design capacity	:	76	t/h ea.

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1 Horizontal belt conveyor

for collecting of green pellets,

design capacity : 151.5 t/h

1 Single idler belt weigher

for measuring the green pellets production,

design capacity : 151.5 t/h

1 Horizontal belt conveyor,

for green pellets undersize,

design capacity : 12 t/h

1 Single idler belt weigher

for measuring the green pellets undersize,

design capacity : 12 t/h

1 Horizontal belt conveyor,

for green pellets undersize,

design capacity : 95 t/h

1 Ascending belt conveyor,

for green pellets undersize,

design capacity : 12 t/h

1 Desintegrator

for crushing the green pellets undersize.

1 Horizontal belt conveyor

for green pellets undersize,

design capacity : 12 t/h

2 Chutes

with rubber sealing and compensators for weighfeeder.

6 Chutes, for belt conveyors.

1 Centralized grease supply system

for balling disc.

2 Pipes, fittings and fastenings

for water to the balling disc.

.2 FEEDING SYSTEM AND TRAVELLING GRATE

Plant Section 2.4.6.1.2 mainly comprises the following items:

1 Reciprocating conveyor

movable cross to the conveying direction, with hydraulic drive for distribution of green pellets.

design capacity : 151.5 t/h

Conveyor drive and travelling drive with variable speed.

1 Horizontal belt conveyor

for green pellet feeding the roller screen,

design capacity : 151.5 t/h

Conveyor drive with variable speed.

1 Roller conveyor

feeding pelletizing machine with green pellets,

design capacity : 151,5 t/h

1 Feeding station,

for hearth and side layer as well as for emergency hearth layer.

1 Horizontal belt conveyor

for green pellets undersize underneath roller screen,

design capacity : 12 t/h

1 Travelling grate

reaction area	:	153	m^2
width of pallet	:	3	m
centre	:	62.6	m

1 Seal air duct

with manually operated throttle valves.

2 Centralized grease lubrication system

for travelling grate.

1 Discharge upper part and discharge bin

with 2 manually operated gates incl. level indication by load cells.

1 Grate bar rapping device

1 Pallet sagging and indicating device

5 Butterfly damper drives

20 Double pendulum flaps

40 Pneumatic cylinders

for double pendulum flaps.

.3 FURNACE HOOD

Plant Section 2.4.6.1.3 mainly comprises the following items:

1 Furnace hood and recuperation main

width of hood	:	3	m
total length	:	51	m

incl. steel structure and refractory material.

1 Firing equipment, for heavy oil

1 Ignition gas station

2 Atomizing air fan, for burners one as stand-by.

2 Motorized butterfly shut-off flaps

for atomizing air fan.

1 Impulse air production

1 Set of piping

comprising:
pipes, bends, flanges, bolts, fittings, onions, seals, support for air and gas.

2 Jack screw pumps

with electrical foot heating incl. oil heater, oil filter and electrical tracing heating.

1 Complete oil supply equipment

consisting of:
jack screw pumps, tanks, oil heaters, filters, ring mains, pipes, armatures.

.4 PROCESS FANS AND GAS MAINS

Plant Section 2.4.6.1.4 mainly comprises the following items:

1 Intake silencer

before cooling air fan, incl. compensator.

1 Cooling air fan, (axial type)

flow volume : 82.6 m^3/s

incl. starter motor, vane control, stand still heating, accustic insulation.

1 Cooling air main

from cooling fan to the wind boxes, incl. compensator, accoustic insulation.

1 Updraught drying main, (suction side)

between cooling hood and updraught drying fan, incl. bleed-in, compensators, insulation.

1 Updraught drying fan, (radial type)

flow volume : 25.3 m^3/s

incl. starter motor, vane control, oil pump, stand still heating, insulation.

1 Cooling air main

from cooling fan to the wind boxes, incl. compensator, acoustic insulation.

1 Updraught drying main, (suction side)

between cooling hood and updraught drying fan, incl. bleed-in, compensators, insulation.

1 Updraught drying fan, (radial type)

flow volume	:	25.3	m^3/s

incl. starter motor, vane control, oil pump, stand still heating, insulation.

1 Updraught drying main, (pressure side)

from updraught drying fan and wind boxes, incl. bleed-off, compensators, insulation.

1 Motorized throttle damper

installed in bleed-in of updraught drying main (suction side).

1 Motorized throttle damper

installed in bleed-off of updraught drying main (pressure side).

1 Windbox recuperation main,

(suction side) between wind boxes and windbox recuperation fan, incl. bleed-in, compensators, internal lining.

1 Windbox recuperation fan, (radial type)

flow volume: 28.9 m^3/s

incl. starter motor, vane control, oil pump, stand still heating, insulation.

1 Windbox recuperation main

(pressure side), between fan and updraught drying hood, incl. bleed-off, compensators, insulation.

1 Motorized throttle damper

installed in bleed-in of wind box recuperation main

5 Motorized throttle damper

installed in bleed-off windbox recuperation main and updraught drying hood.

1 Connection duct

between windbox recuperation main and updraught drying main, incl. compensator, insulation.

1 Motorized throttle damper

in connection duct.

2 Waste gas mains

to multiclone and from multiclone to waste gas fan, incl. compensator.

1 Waste gas fan, (radial type)

flow volume	:	69.2	m^3/s

incl. starter motor, vane control, oil pump, stand sill heating.

1 Waste gas duct,

designed as stack behind the waste gas fan, incl. compensator.

1 Hood exhaust duct

above updraught drying hood, incl. compensator.

1 Hood exhaust fan (axial type)

flow volume	:	33.9	m^3/s

incl. starter motor, vane control, oil pump, stand still heating.

1 Hood exhaust duct

above the hood exhaust fan, designed as stack.

1 Intake silencer

before hood sealing air fan.

1 Hood sealing air fan (radial type)

flow volume : 5 m^3/s

1 Hood sealing air duct

incl. compensators.

.5 COMPRESSED AIR AND COOLING WATER SYSTEM

Plant section 2.4.6.1.5 mainly comprises the following items:

2 Compressors

for compressed air, incl. silencer and cooler.

2 Compressed air vessels

for double pendulum flaps, plough and balling discs.

1 Set of piping

comprising pipes, bends, flanges, bolts, fittings, seals for compressed air.

1 Cooling tower

2 Cooling water pumps

1 Cooling water collecting tank

2 Cooling water pumps

1 Heat exchanger for cooling water

1 Cooling water high-level tank

3 <u>Set of cooling water ring pipes</u>

incl. armatures for pelletizing machine, fans, cooling water high-level tank and runback to cooling water collecting tank.

1 <u>Set of pipes for additional water</u>

incl. armatures.

.6 PELLET CONVEYING AND SCREENING SYSTEM

Plant Section 2.4.6.1.6 mainly comprises the following items:

1 Spillage collecting trough

under pelletizing machine,

width of trough	:	4.5	m
length of trough	:	62	m

1 Ascending belt conveyor

for burnt pellets,

design capacity : 178 t/h

2 Vibro feeders

under discharge bin, with variable speed,

design capacity : 89 t/h ea.

1 Distribution chute

from conveyor to double deck vibro screen.

1 Double deck vibro screen

design capacity : 178 t/h

- Div. Chutes under screen and supports for motors (vibro feeders and screen).

1 Horizontal belt conveyor, for dust from multiclone,
design capacity : 15 t/h

1 Ascending belt conveyor, for dust from multiclone,
design capacity : 15 t/h

.7 HEARTH- AND SIDELAYER CONVEYING SYSTEM

Plant Section 2.4.6.1.7 mainly comprises the following items:

1 Vibro feeder, under double deck
vibro screen with variable speed,
design capacity : 49 t/h

1 Horizontal belt conveyor, for hearth layer
design capacity : 49 t/h

1 Ascending belt conveyor, for hearth layer
design capacity : 49 t/h

1 Horizontal belt conveyor, for hearth layer
design capacity : 82 m^3
incl. level indication by load cells.

1 Hopper for hearth layer and side layer,
in case of emergency, installed above belt conveyor.

1 Ascending belt conveyor

for return fines,

design capacity : 4 t/h

1 Belt bucket elevator

for return fines,

design capacity : 4 t/h

- Div. Chutes for conveyors and Support for motors

.8 PELLET PRODUCT CONVEYING, STORAGE AND LOADING PLANT SYSTEM

Plant section 2.4.6.1.8 mainly comprises the following items:

1 Ascending belt conveyor

for pellet production,

design capacity : 125 t/h

1 Multi idler belt weigher

for measuring the pellet production,

design capacity : 125 t/h

1 Chute with movable saddle

electrically operated.

1 Stacking belt conveyor

for pellet production,

design capacity : 125 t/h

1 Boom stacker with boom conveyor

for pellet production,

design capacity : 125 t/h

incl. stacker rails.

2 Reclaiming conveyor hopper
with motorized outlet gate.

1 Ascending belt conveyor
for pellet production,
design capacity : 375 t/h

1 Ascending belt conveyor
for pellet production,
design capacity : 375 t/h

1 Buffer bin for pellet production
live capacity : 150 m^3
with motorized outlet gate and level indication by load cells.

1 Loading bin for pellet production
live capacity : 40 m^3
with 2 motorized outlet gates and level indication by load cells.

3 Locking device

for buffer bin and loading bin.

- Div. Chutes for conveyors and Supporting structure for bins

.9 WASTE GAS DEDUSTING

Plant Section 2.4.6.19 mainly comprises the following items:

1 Multiclone

for waste gas dedusting incl. outside isolation and supporting structure.

4 Double pendulum flaps

under the multiclone.

4 Pneumatic cylinders

for double-pendulum flaps.

1 Waste gas duct

above multiclone.

.10 PLANT DEDUSTING

Plant section 2.4.6.1.10 mainly comprises the following items:

1 Dedusting equipment

at feeding station of pelletizing machine, incl. pipelines, encasings, gates, compensators and supports.

1 Wet scrubber

incl. interior equipment and stack.

1 Fan for wet scrubber

1 Supporting structure

for wet scrubber and fan.

1 Pump sump

underneath wet scrubber.

- Water injection for wet scrubber, Piping for process water, slurry

fittings, bends, fixing material.

1 Dedusting equipment

at discharge end of pelletizing machine and screening station incl. pipelines, encasings, gates, compensators and supports.

1 Wet scrubber

incl. interior equipment and stack.

2 Fans for wet scrubber

1 Supporting structure

for wet scrubber and fan.

1 Pump sump

underneath wet scrubber.

1 Slurry pump

delivering to grinding mill for return fines.

- Water Injection for wet scrubber, Pipings for process water, slurry

fittings, bends, fixing material.

1 Slurry pump

delivering to thickener.

.11 CRANES AND HOISTS

Plant section 2.4.6.1.11 mainly comprises the following items:

1 Trolley with rail, hand operated

above hood exhaust fan,

lifting capacity : 7.5 t

1 Suspended crane

electrically operated,
above balling discs,

lifting capacity : 5.0 t

1 Suspended crane

electrically operated,
above double deck vibro screen,

lifting capacity : 7.5 t

1 Suspended crane

electrically operated,
above grinding mill for return fines,

lifting capacity : 7.5 t

.12 AUXILIARY AND EMERGENCY FACILITIES

Plant section 2.4.6.1.12 mainly comprises the following items.

2 Vertical dewatering pumps

installed in conveyor channel underneath pelletizing machine.

2 Vertical dewatering pumps

installed in cable channel.

1 Belt spraying system

above belt conveyors to prevent belt fires.

- all pipes, fittings, fastenings

for dewatering, spraying, water, freshwater, floorwashing system.

- Hand fire extinguishers

2.4.6.2 Electrical Equipment

Plant equipment

.0 General Prerequisite

.1 6.0 kV Medium High-Voltage Board

.2 380 V Low-Voltage Switchgear Boards

.3 Variable Voltage DC-Motor Controls + Power Supply

.4 Programmable Logic Control System

.5 Local Switchgear

.6 Power Transformer

.7 6000 V Medium High-Voltage Motors

.8 380 V Low-Voltage Motors

.9 Variable Voltage DC-Motors

.10 Plant Lighting

.11 Cables

.12 Installation Material

.13 Intercommunication System

.14 Airconditioning Installation

.15 Ventilation System

.16 Grounding

.17 Emergency Power Supply

For further details on lay-out of electrical equipment, see detailed description in section 2.3.6.2.

2.4.6.3 Instrumentation Equipment

The instrumentation equipment for the pelletizing plant mainly comprises:

- field instruments,
- local indication measuring instruments,
- local measuring detectors,
- transmitters,
- panel instruments incl. indicating instruments and recorders,
- control room panels,
- auxiliary racks and cubicles,
- interfaces and power supply systems,
- all instrumentation material like cables, wiring, fuses, etc..

A detailed description of the lay-out of this equipment is given in section 2.3.6.3 of this volume.

2.4.6.4 Structural and Civil Works

Main quantities for structural steel and civil works related to the Pelletizing Plant are as follows:

Structural Steel	1910	t
Bins	35	t
Roof and Wall Cladding	13280	m^2
Concrete	4428	m^3
Farmwork	16890	m^2
Reinforcement	660	t
Excavation	26945	m^3

Price estimations for these works are based on information obtained from Mowlem International Ltd., London, based on the experiences gained with the Mufindi Pulp and Paper Mill.

SECTION 2.4.7

Investment Cost Estimate

2.4.7 Investment Cost Estimate

- Pelletizing Plant -

The budgetary investment cost for the Pelletizing Plant, capable to produce 990,000 tpy of pellets from Liganga/Maganga concentrate, are estimated as follows (based on the exchange rates: 1 US $ = 2.7 DM = 12.2 T.Sh.).

	approx. Mio. US $	approx. Mio. T.Sh.
- Plant Equipment delivered free site	19.1	233.0
- Erection, Supervision, Commissioning	3.2	39.0
- Civil Work and Steel Stucture, erected and painted	10.3	125.7
- Related Plant Infrastructure	2.5	30.5
Total Investment Cost	35.1	428.2
- Spare Parts for 2 years plant operation	0.8	9.8

This budget estimate is based on German prices and conditions and on cost factors ruling end of December 1983 for the equipment. It does not include any customs duty, taxes, dues or other levies which may arise outside the Federal Republic of Germany.

The estimation of the civil work and structural steel portion is derived from price information supplied by Mowlem International Ltd., London.

The estimation for plant equipment includes the cost for packing and the freight charges delivered free on site. Our budget prices are estimated on the assumption that all work can be performed continuously and in accordance with the time schedules contained in section IV/5.

This budget estimate is furthermore based on usual cash terms of payment, allowing an adequate down payment upon signing of contract and progress payments according to the progress of work in the engineering, manufacturing and erection.

All further terms and conditions will have to be agreed upon during the progress of contract negotiations.

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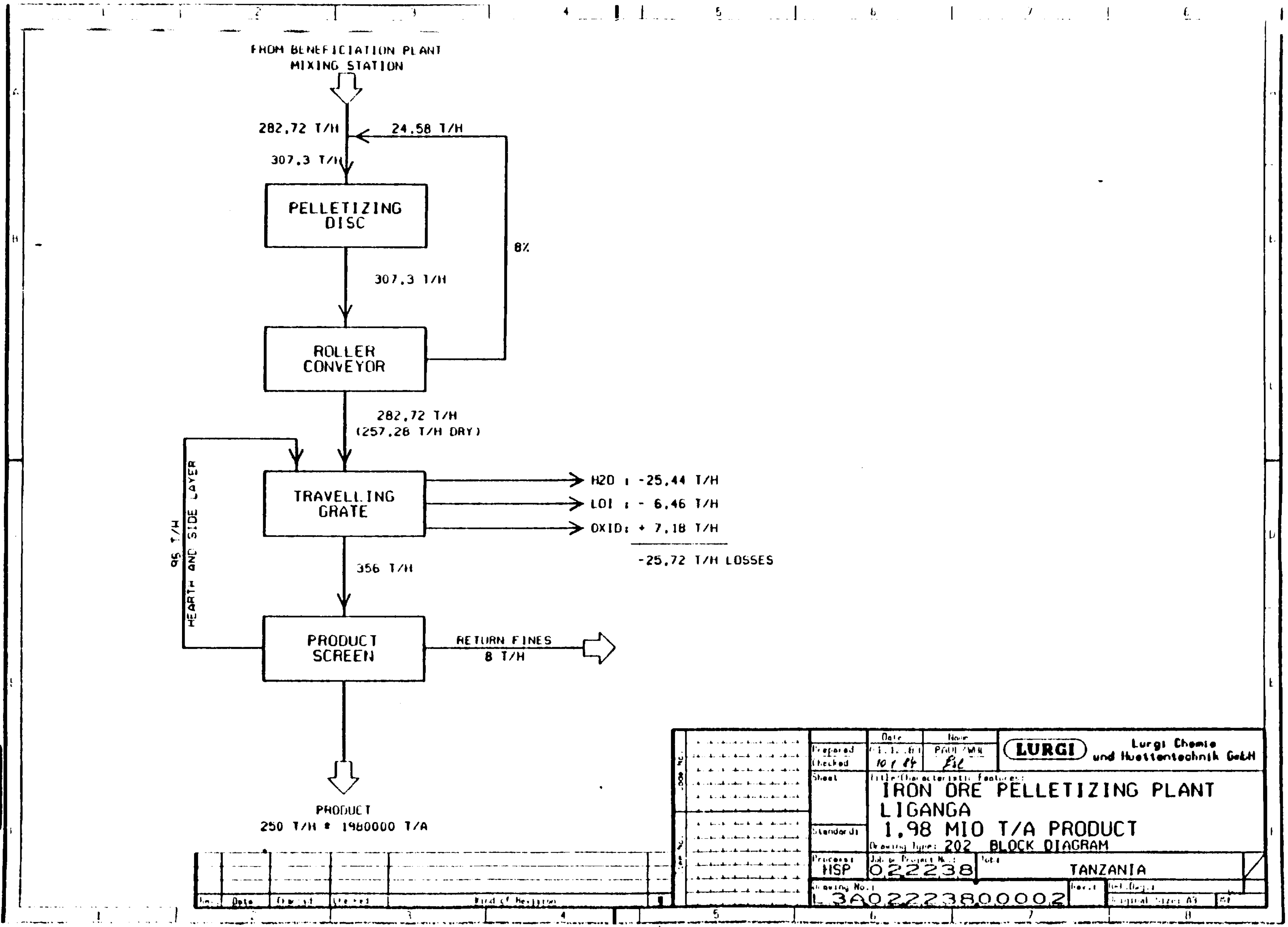
Tanzania/Volume II

A N N E X

Expansion Step

1 Million tpy Steel

4303



FROM BENEFICIATION PLANT
MIXING STATION
282,72 T/H
24,58 T/H
307,3 T/H
PELLETIZING DISC
8%
307,3 T/H
ROLLER CONVEYOR
282,72 T/H
(257,28 T/H DRY)
TRAVELLING GRATE
HEARTH AND SIDE LAYER
95 T/H
H2O : -25,44 T/H
LOI : - 6,46 T/H
OXID: + 7,18 T/H
-25,72 T/H LOSSES
356 T/H
PRODUCT SCREEN
RETURN FINES
8 T/H
PRODUCT
250 T/H ≙ 1980000 T/A
LURGI
Lurgi Chemie und Huettentechnik GmbH
IRON ORE PELLETIZING PLANT
LIGANGA
1,98 MIO T/A PRODUCT
Drawing Type: 202 BLOCK DIAGRAM
HSP
022238
TANZANIA
L 3A022238000002
[202.0117A2238B005.DGN/06.01.84 HFFN
02

Section 2.5

Off-sites and Auxiliaries "Liganga"

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S E C T I O N 2.5.1

Description of Facilities

2.5.1 Description of Facilities

The Liganga complex near the iron ore deposit comprises the following plants:

- iron ore mine,
- iron ore beneficiation plant,
- iron ore pelletizing plant.

These plants are located side by side and have for full functioning their own infrastructure facilities which are described below.

2.5.1.1 Water Supply and Water Treatment

Raw water will be taken from the Lupali river approx. 8 km west of the plant. As records show, the river will have enough water to supply the plants also at minimum flow. The water will be pumped via a pipeline to the Liganga complex, where it is stored and treated for the use as

-	industrial water	150 m^3/h,
-	cooling water	20 m^3/h,
-	drinking water	400 m^3/d,

For supply and treatment of water, the following described equipment will be used.

1 river water intake station

concrete design.

2 vertical water pumps (1 as stand-by)

installed in river water intake station,

capacity : 350 m³/h

1 river water basin

concrete design,
10 x 10 x 4 m,

volume : approx. 350 m³

2 vertical water pumps (1 as stand-by)

pumping the water to the plant,

capacity : 350 m³/h

1 drainage pump

submersible pump, wear protected

1 pipeline

from river water basin to the water tank,

1 water tank

for fresh water, installed near the beneficiation plant,

volume : 2000 m³
material : mild steel

1 <u>water treatment station</u>

to prepare potable water,

max. capacity : 40 m^3/h

1 <u>water treatment station</u>

for sewage water.

2.5.1.2 Electric Energy Distribution System

The electric energy supplied by the 220 kV overhead transmission line, will be distributed on a 220 kV switchyard with a double busbar system for the Liganga area. The complete switchyard is formed by two incoming overhead line bays, two outgoing overhead line bays and two distribution bays for transformers. Two 220/6 kV step-down transformers will be provided. The busbar system will consist of stranded aluminium conducts for rated current complete with strain and midspan busbar steelstructure as well as insulators and clamps, suitable to accommodate the required number of bays. The individual overhead line bays will consist of SF6 circuit breaker, motor operated line isolators, current transformers.

A 6 kV-switchgear-plant, supplied by the step-down transformers, will distribute the electric energy to the individual plants respect. off-sites.

2.5.1.3 Site Administration

All the site administration, clerical services for the plant will be performed like

- personnel administration,
- offices for salaries and wages,
- bookkeeping of production figures,
- bookkeeping of consumption figures for utilities, wear and spare parts, consumables etc.
- ordering of material.

The office building will be outfitted with room for conferences, furniture, lavatories etc.

Adjacent to the office building, a building for canteen, first aid and change house will be erected for the personnel of the mining, beneficiation and pelletizing plant. It will be outfitted with furniture, lavatories and with all kitchen accessories. The canteen will be air-conditioned.

2.5.1.4 Central Workshop

The central workshop has to perform repair and maintenance work for the concentrator and pelletizing plant. For maintenance of the mine vehicles, a special workshop exists which is described under section 2.2.

The overall measures of the building will be 50 x 25 m, 8 m high. It consists of the following departments:

- mechanical workshop, equipped with necessary work-benches, machine tools and crane (8 m span),
- electrical and instrumentation workshop, equipped with the necessary work benches, machines and tools,
- sanitary room for workshop personnel.

2.5.1.5 Central Laboratory

The central laboratory will perform for the beneficiation and pelletizing plant all physical and chemical analysis for operation control and product quality control.

The physical analyses comprise mainly determination of grain sizes, moisture, compression strength of green and burned pellets, abrasion strength of burned pellets etc.

The chemical laboratory will perform analyses of elements and compounds like Fe, Fe++, SiO2, CaO, MgO, Al2O3, P, S by wet methods.

The central laboratory will be outfitted with the necessary instruments, equipment and materials.
As far as necessary, the rooms will be equipped with air conditioners.

2.5.1.6 Central Magazine

The central magazine is provided for consumables, spare and wear parts for the plants. Shelving and cabinets of various types are provided to allow clear storage of all parts.

Bulky and heavy goods, which don't need storage under roof, are stored on an adjacent storeyard area.

Moreover, a special issue area for tools, which are needed in special cases only, is provided in the detail store.

2.5.1.7 Fire Fighting and Ambulance

A fire fighting station will be equipped with one fire engine and the necessary fire fighting accessories.

Some rooms will be provided as ambulance with the necessary equipment for first aid.

2.5.1.8 Petrol Station and Car Service

At the car service station, the company cars will be maintained. The workshop is outfitted with hydraulic lifting device, work benches, tools and necessary equipment.

The petrol station has tanks and pumps for diesel oil and petrol.

The following vehicles belong to the fleet of the beneficiation/pelletizing facilities:

2 fork lift truck

capacity: 2 t

3 front-end loader

capacity: 2 m^3

1 flat bed truck

capacity: 10 t

1 flat bed truck

capacity: 3 t

2 pick-up truck

capacity: 1.5 t

1 boom truck

capacity: max. 10 t

4 land cruiser jeep

All other mobile equipment of operative function for the iron ore mine is listed in the corresponding specifications.

2.5.1.9 Structural and Civil Works - Summary

Main quantities for structural steel and civil works related to Off-sites "Liganga" are as follows:

Structural Steel	560	t
Roof and Wall Cladding	8630	m²
Concrete	4705	m³
Formwork	11670	m²
Reinforcement	390	t
Excavation	42040	m³

Price estimation for these works are based on information obtained from Mowlem International Ltd., London, based on the experiences gained with the Mufindi Pulp and Paper Mill.

SECTION 2.5.2

Workforce Schedule

2.5.2 Workforce Schedule

For the various facilities, described in this section, the following workforce requirements can be estimated.

(G = Graduated; S = Skilled; SS = Semi-Skilled; US = Unskilled)

Item	G	S	SS	US	Total
Water supply and treatment	1	4	8	8	21
Electric energy supply		1	2		3
Site administration	1	1	4	2	8
Canteen change house		1	6	6	13
Central workshop	incl. in personnel of plants				
Central laboratory	incl. in personnel of plants				
Central magazine	–	1	5	4	10
Fire fighting and ambulance	–	2	5	2	9
Petrol and service station	–	2	5	2	9
Guard	–	–	2	10	12
Subtotal	2	12	37	34	85
15 % Absentees	–	2	6	5	13
Total	2	14	43	39	98

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S E C T I O N 2.5.3

Investment Cost Estimate

2.5.3 Investment Cost Estimate

- Off-sites and Auxiliaries "Liganga" -

The budgetary investment cost for the Off-sites and Auxiliaries "Liganga" are estimated as follows (based on the exchange rates: 1 US $ = 2.7 DM = 12.2 T.Sh.).

	approx. Mio. US $	approx. Mio. T.Sh.
- Plant Equipment delivered free site	6.8	83.0
- Erection, Supervision, Commissioning	1.9	23.2
- Civil Work and Steel Stucture, erected and painted	6.4	78.1
- Related Plant Infrastructure	1.1	13.4
Total Investment Cost	16.2	197.7
- Spare Parts for 2 years plant operation	0.3	3.7

This budget estimate is based on German prices and conditions and on cost factors ruling end of December 1983 for the equipment. It does not include any customs duty, taxes, dues or other levies which may arise outside the Federal Republic of Germany.

The estimation of the civil work and structural steel portion is derived from price information supplied by Mowlem International Ltd., London.

The estimation for plant equipment includes the cost for packing and the freight charges delivered free on site. Our budget prices are estimated on the assumption that all work can be performed continuously and in accordance with the time schedules contained in section IV/5.

This budget estimate is furthermore based on usual cash terms of payment, allowing an adequate down payment upon signing of contract and progress payments according to the progress of work in the engineering, manufacturing and erection.

All further terms and conditions will have to be agreed upon during the progress of contract negotiations.

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((3 of 7)

Final Report

Volume III

Techno-Economic Evaluation and Project Report

for the

Establishment of an Iron and Steel Industry

in

The United Republic of Tanzania

Unido Project SM/URT/81/004

for

ORGANIZATION

LURGI

TECHNO-ECONOMIC EVALUATION AND PROJECT REPORT

FOR THE

ESTABLISHMENT OF AN IRON AND STEEL INDUSTRY

IN

THE UNITED REPUBLIC OF TANZANIA

GENERAL LIST OF CONTENTS

UNIDO Project No. SM/URT/81/004

GENERAL LIST OF CONTENTS

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LURGI

VOLUME III Plant Design Steelworks

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2. General Layout and Capacity Expansion Concept

3. Direct Reduction Plant

4. Electric Smelting Plant

5. Ladle Furnace Plant

6. Continuous Casting Plant

7. Rolling Mill and Product Finishing

8. Offsites and Auxiliaries "Mahanje"

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VOLUME IV General Area Infrastructure and Project Implementation

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TECHNO-ECONOMIC EVALUATION AND PROJECT REPORT

FOR THE

ESTABLISHMENT OF AN IRON AND STEEL INDUSTRY

IN

THE UNITED REPUBLIC OF TANZANIA

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VOLUME III

UNIDO Project No. SM/URT/81/004

DETAILED LIST OF CONTENTS

VOLUME III Plant Design Steelworks

S E C T I O N 1

Introductory Remarks

Introductory Remarks

The following Volume III contains the detailed technical descriptions of the individual metallurgical facilities of the integrated steelworks Mahanje.

As a general introduction to the conceptual design of the Mahanje steelworks, in Section 2, the overall arrangement of the various facilities, such as direct reduction plant, steel plant, rolling mill and auxiliary systems is briefly described based on the general plot plan. The material flow considerations for the plant arrangements are explained, as they form the basis for the layout of a future capacity expansion.

The description of each individual plant (Sections 3 - 7) is subdivided as follows:

- process description (including flowsheet);
- plant description (including plot plan);
- raw materials and products specifications;
- consumption figures and workforce schedule;
- auxiliaries related to plant;
- outline specifications of mechanical, electrical and instrumentation equipment, structural and civil works quantities;
- investment cost estimate splitted into equipment, erection, structural and civil works, spare parts.

This structure of description is maintained for all technical installations, for better orientation.

The process description contains a detailed description of the metallurgical processes and reactions involved in the operations of each plant and explains the special design characteristics of the custom-tailored process technology to allow for a clear understanding of the technical route applied. Whereas the process layout up to the stage of DRI production is based on the results of metallurgical testwork, the design of the melting process is based on calculations as per the terms of reference.

The plant description is subdivided by following up the various plant sections parallel to the flow of materials and contains a description of the plant operations, of the main equipment functions involved as well as the arguments for the selection of layout parameters and conceptual design of the plant units.

The raw materials and products specifications form the basis for separating the different processing units, whereby the product of the preceding unit represents the input material for the following one.

Main information contained in this section are the physical and chemical features of the diverse materials entering the processing units as well as the identification of the wastes and by-products generated.

The consumption figures are based on detailed material balances for each process step and also identify the main utility consumptions, such as energy, fuel, water, gases, etc.
They form the basis for the corresponding cost analyses of each process step and contain a 5% safety margin for handling losses, fluctuations, etc. In these consumption figures also the main consumptions of the overall auxiliary and offsite facilities are included.

The workforce schedule shows a detailed manning proposal splitted into the various shifts and determining the degree of skill for the various positions. They are applicable for the individual plant and strictly refer to the labour force required for plant operation. These schedules form the basis of corresponding workforce cost calculations included in the operation cost of each single process step.

The auxiliaries required for plant operations do not much differ between the major steelworks plants and are briefly mentioned in a corresponding section. They have to be seen in connection with the detailed description of the general offsites and auxiliaries systems for the entire steelworks given in Section 8.

The outline specifications are subdivided into a mechanical, electrical and instrumentation portion. Especially the electrical and instrumentation equipment follows in its design the well established international norms and standards, therefore these equipment portions have been explained in extreme detail in the first of the technical sections, i.e. section 3 (items 3.6.2/3.6.3) to be referred to for the other plants as well. It goes without saying, that the portion of electrical and instrumentation equipment, which is not common to all metallurgical units - for instance electric furnace transformers or rotary kiln slip rings - are listed under the corresponding individual sections.

The quantity estimates on the structural and civil works are based on detailed evaluations of the individual buildings like conveyor bridges, junction towers, storeyards, houses, etc. For more transparent information, the various categories, such as concrete, form work, claddings, structural steel, excavation, have been calculated separately.

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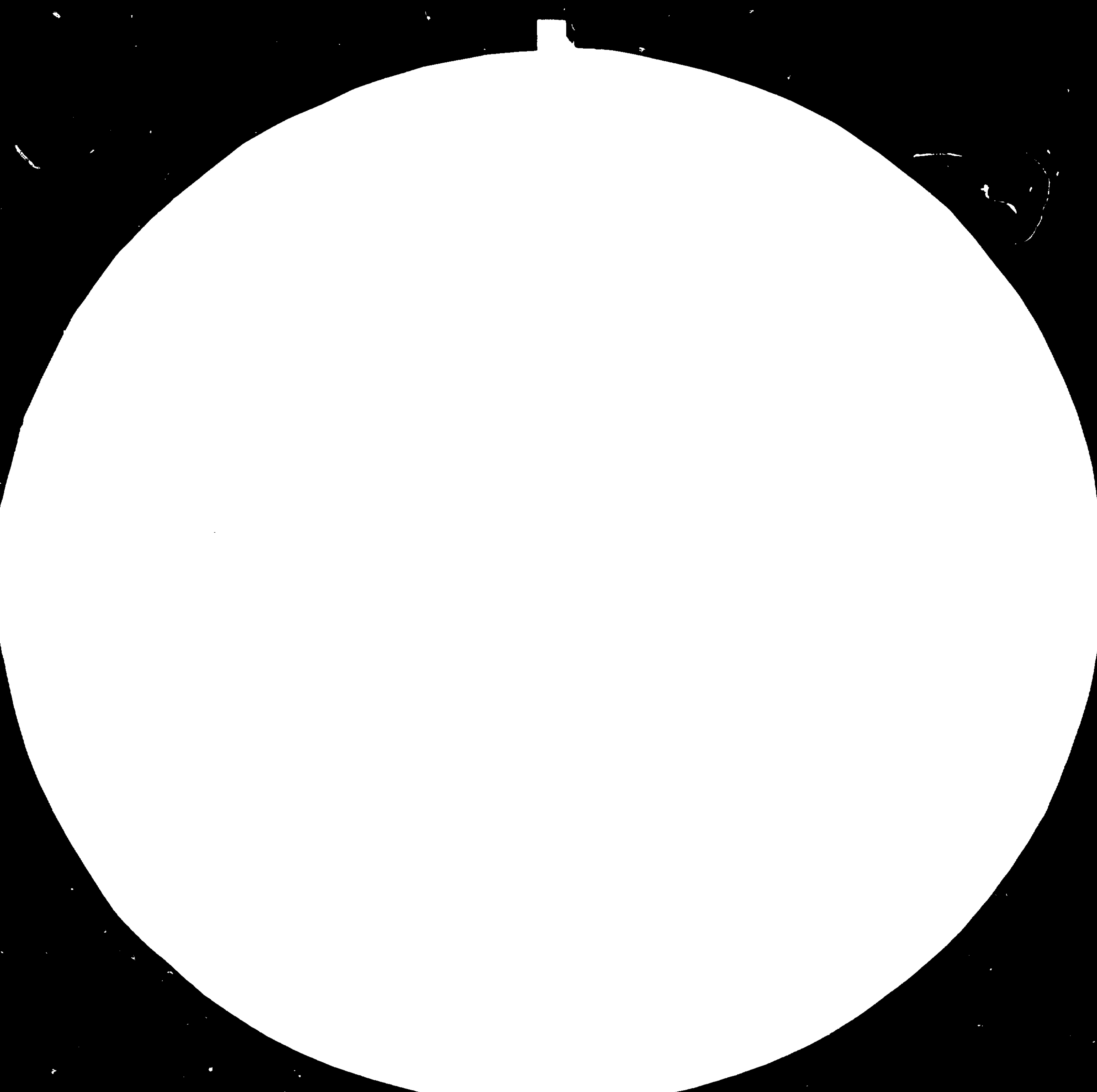

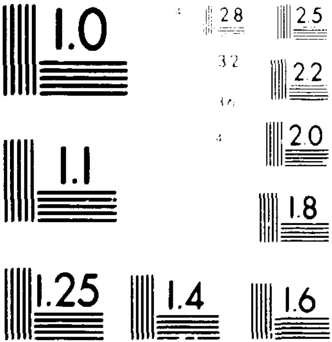

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
ANSI and ISO TEST CHART No. 2

The investment cost estimate is given for every single plant within battery limits and including the special auxiliary systems related to those plants. The estimate is splitted into the cost for equipment, erection and commissioning as well as structural and civil works. The spare part costs for a two years' plant operation are indicated too.

The general auxiliary systems and offsites of the Mahanje steel plant are described in Section 8. This especially refers to the lime calcining facility, raw materials preparation, power and water distribution networks, administration and transport facilities, etc. Section 8 includes all services required for proper functioning of the overall plant according to an island concept and this fact explains the quite considerable number of personnel listed in the related workforce schedule. Investment cost for this offsites sector have been estimated separately too.

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Tanzania/Volume III

SECTION 2

General Layout and Capacity Expansion Concept

2. General Layout and Capacity Expansion Concept

2.1 Site selection criteria

To arrive at a conclusion for the selection of the most suitable plant site, the following main criteria must be considered:

- capacities, locations and accessibility of raw materials deposits;
- location of intermediate- and finished product takeover areas or consumers;
- evaluation of suitable means of transportation, evaluation of transport routing and interlinkage to existing systems;
- capacities, availability and sources of utilities;
- workforce requirements;
- infrastructural facilities;
- site conditions and accessibility;
- climatic conditions.

The presented techno-economic evaluation supports the findings in the respective NDC-Report from January 1983 which clearly outlines, that the Madaba/Mahanje site provides the most suitable conditions under consideration of the selection criteria as outlined above.

2.2 Steel plant arrangement

Based on the "MROMBOJI"-map, series Y 742, sheet 275/3, edition 1-TSD the overall steel plant complex will be located inside the following grid zone.

- 83 04 north
- 89 03 south
- 7 39 west
- 7 41 east

Plant elevation shall be approx. 1 000 m above mean sea level.
Outlines of the various installations for the initial steel plant with an annual capacity of 500.000 t/year of finished steel product as well as outline of additional installations for the final plant capacity of 1 million t/year of finished steel product are indicated in drawing:

LOA 03 2238 00016 Steelworks "MAHANJE"
Key plan

The initial steel plant mainly comprises the following installations:

- Raw materials handling and storage facilities
- SL/RN direct reduction plant
- Limestone and dolomite calcining plant
- Electric smelting plant
- Ladle metallurgy plant
- Continuous casting plant
- Rolling mill and product finishing for production of plates and sheets
- Offsites and auxiliaries.

The interlinking railway facilities between the raw materials deposit areas and the existing TAZARA railway system pass the envisaged steel plant site at the south. Incoming raw matrials arrive from the west side. Consequently the unloading facilities for oxide pellets, coal, limestone, dolomite etc. shall be arranged in the southwest corner of the steelplant site.
The DR-plant facilities shall be located in the adjacent area north of the raw materials storage for minimum handling distances of bulk materials.

Steel making facilities extend to the east of the DR-plant, basically in the sequence of electric smelting, ladle metallurgy, continuous casting and product rolling and finishing.
The finished product leaves the steel plant at the east boundary of the plant site by rail.

Utilities enter the steel plant complex in a service corridor arranged between the direct reduction- and the steel-making facilities.
Distribution of utilities from common installations for both areas shall be in accordance with the individual plant requirements.

For detailed descriptions of the various installations, refer to the respective sections of the report.

2.3 Capacity expansion concept

The overall steelplant arrangement concept considers provisions for a future plant extension.

Final plant capacity will be 1 million t/year of finished steel product, comprising 500.000 t/year of plates and sheets from the first plant stage, plus 500.000 t/year of billets and sections from the plant extension.

The additional facilities for the final steelplant capacity mainly comprise the following:

- additional raw materials handling and storage facilities arranged south of the initial storage area.
- DR-plant extension, basically consisting of four additional rotary kilns, - coolers and associated equipment, arranged north of the initial direct reduction plant.
- additional intermediate storage and handling facilities between DR-plant and steelmaking plant.
- electric smelting plant extension, basically consisting of two additional smelting furances and associated equipment, arranged north of the initial plant.
- additional liquid steel handling and ladle furnaces including their associated equipment, arranged north of the initial installation.

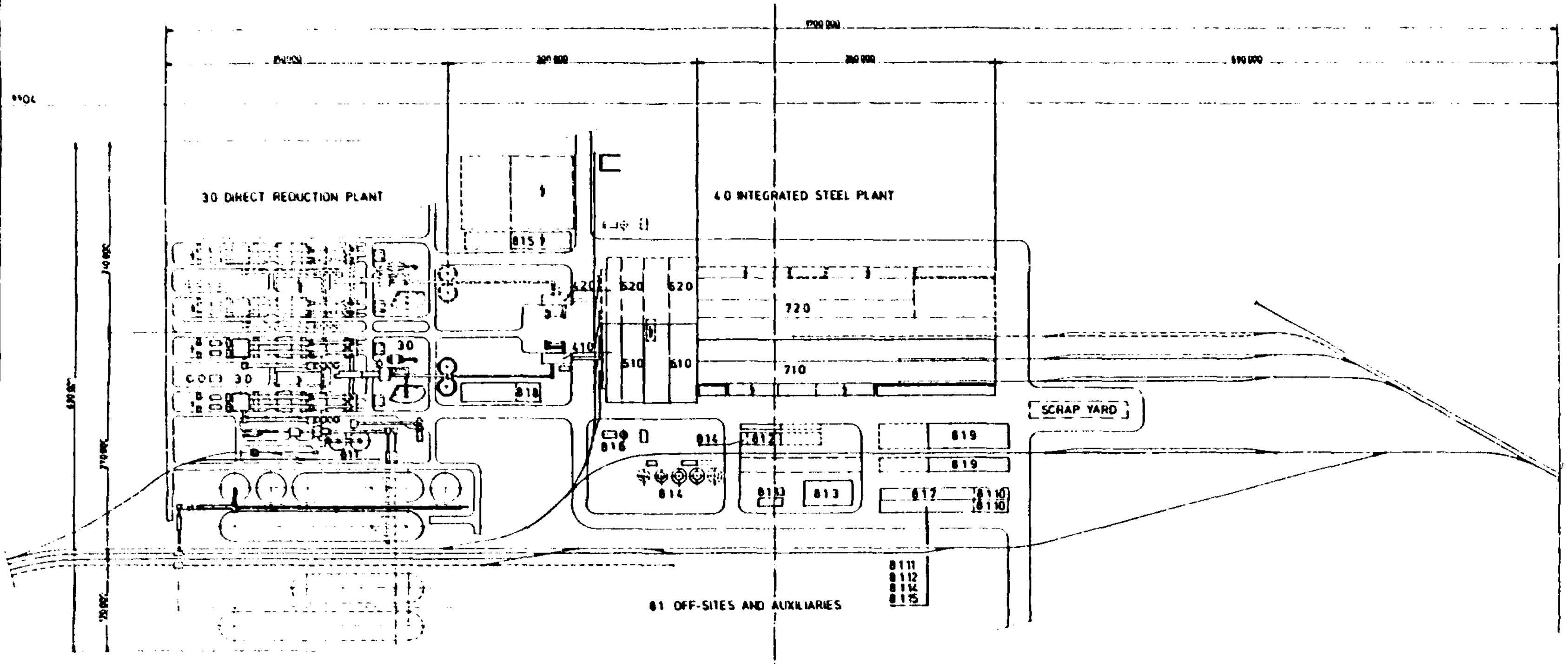
- one additional continuous casting plant, for billets arranged north of the initial installation.
- one billet and section mill for the production of 200.000 t/year of sections and 300.000 t/year of billets.
  The mill shall be arranged north of hot strip and plate mill provided for the initial 500.000 t/year plant.

With regard to the steelplant capacity expansion, the following criteria have been observed:

- location of plants of similar types and with similar modes of operation are arranged adjacent to each other, with the benefits of possible personnel cost savings and economical execution of operational and maintenance functions.
  Advantageous use of common auxiliaries and maintenance equipment, i.e. heating - facilities or overhead travelling cranes.
- possible future changes in the plant expansion concept by avoiding of overlapping arrangement concepts.
- construction and erection activities with minimum interference with the continuing operation of the initial plant.
- construction and erection activities for the various plants can to a large extent be executed in parallel, without interferring with each other, thus decreasing the respective periods in the overall expansion time schedule.

From the above mentioned points, an intermediate expansion step to 750 0000 tpy capacity cannot be recommended due to severe disadvantages with regard to optimum plant site and related specific investment. This is applicable especially for the benefication/ pelletizing facilities in Liganga as well as for the smelting, refining, casting and rolling facilities in Mahanje, these installations having optimum economic capacities in the range of 500 000 tpy and abcve.

A detailed description of the various sections of the Mahanje integrated steelworks is given herehafter in combination with a larger scale plot plan.



30 DIRECT REDUCTION PLANT

40 INTEGRATED STEEL PLANT

410 ELECTRIC SMELTING PLANT FOR SLABS (1st STAGE)
420 ELECTRIC SMELTING PLANT FOR BILLETS (2nd STAGE)
510 LADLE FURNACE PLANT (1st STAGE)
520 LADLE FURNACE PLANT (2nd STAGE)
610 CONTINUOUS CASTING PLANT FOR SLABS (1st STAGE)
620 CONTINUOUS CASTING PLANT FOR BILLETS (2nd STAGE)
710 HOT STRIP AND PLATE MILL (1st STAGE)
720 BILLET AND SECTION MILL (2nd STAGE)

81 OFF-SITES AND AUXILIARIES

811 LIMESTONE / DOLOMITE FACILITIES
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813 AIR FRACTIONING PLANT
814 FUELS AND COMPRESSED AIR
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817 CENTRAL WORKSHOP
818 CENTRAL LABORATORY
819 CENTRAL MAGAZINE
8110 FIRE FIGHTING AND AMBULANCE
8111 COMMUNICATION SYSTEM
8112 MOBILE FACILITIES AND FINISHINGS
8113 PETROL STATION
8114 TRAFFIC FACILITIES
8115 MAIN ADMINISTRATION BUILDING

NOTE
2nd STAGE IS SHOWN IN DOTTED LINES

STEELWORKS MAHANJE
KEY PLAN
TANZANIA
10A0J223B00016

LURGI

S E C T I O N 3

Direct Reduction Plant

SECTION 3.1

Process Description

Direct Reduction Plant

3.1 PROCESS DESCRIPTION

3.1.1 BRIEF HISTORY OF THE SL/RN PROCESS

The SL/RN process originates from two independent processes:

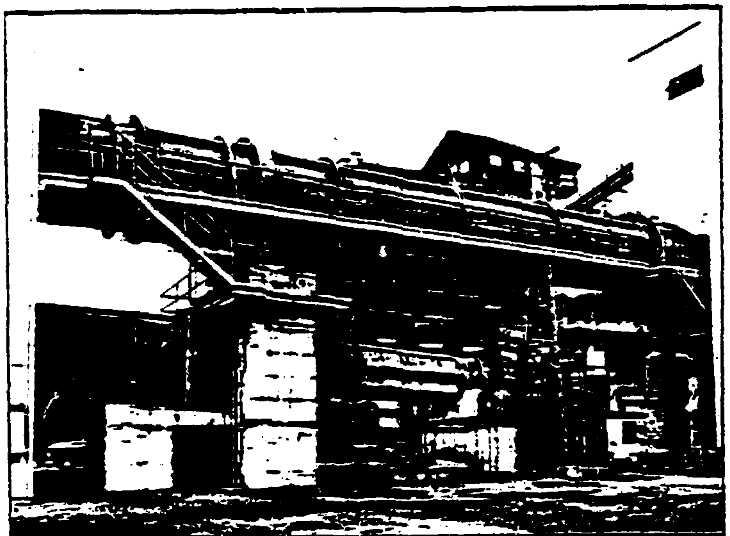
- the RN process, which was basically developed for upgrading of lean ores and which was commercially applied already in the '20s and '30s, using a rotary kiln as reactor, anthracite as reductant and fuel oil or gas as auxiliary fuel;

- the SL process for the production of sponge iron from high-grade iron ores, which was developed in the early '60s when high-grade iron ores and pellets became available.

In order to make the best use of the accumulated experience, it was decided to combine the two processes into one. Thus, in 1964, the SL/RN process was established.

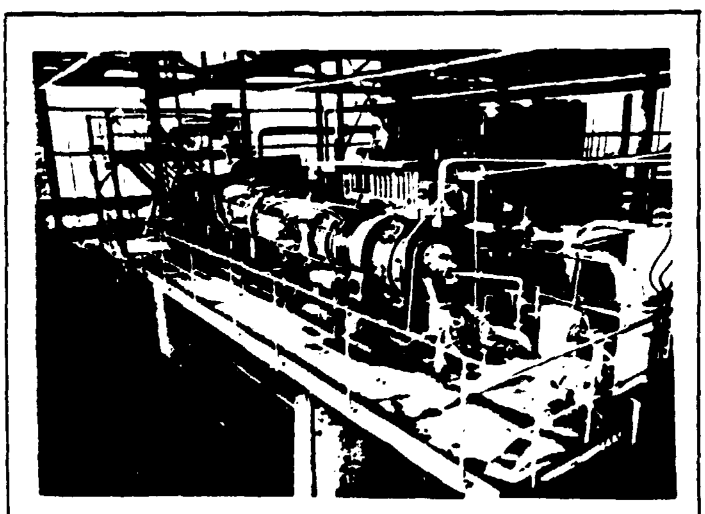
SL/RN means:
(S) Steel Company of Canada (STELCO)
(L) Lurgi Chemie und Huettentechnik GmbH
(R) Republic Steel Corporation
(N) National Lead Corporation
and thus indicates the names of the companies involved in the first process development.

Lurgi was entrusted with the further technical development and the exclusive worldwide marketing of the process. Extensive test work has been carried out in STELCO's pilot plant in Hamilton, Ontario, Canada (kiln dimensions: 2.7 m dia x 35 m long),



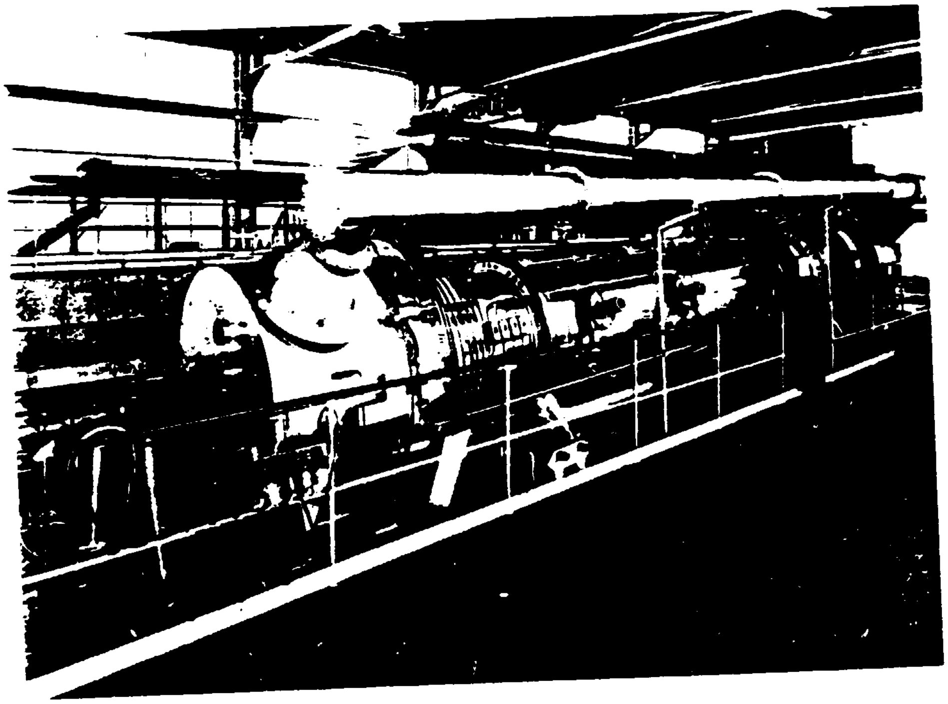
LURGI	SL - PILOT PLANT HAMILTON / KANADA	H 1010

in Lurgi's pilot plants in Frankfurt, Germany
(kiln dimensions: 0.8 m dia x 8.6 m long

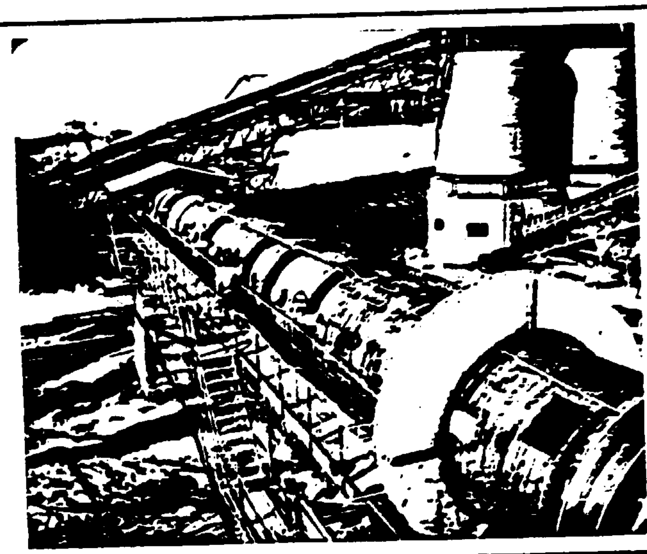


LURGI	Versuchs-Ofen EXPERIMENTAL ROTARY KILN Four rotatif d'essai	H 1131

and 1.3 m dia x 12 m long)



and in the RN pilot plant in Birmingham, Alabama (kiln size 2.8 m dia x 48 m long)



LURGI. RN PILOT PLANT IN BIRMINGHAM/ALABAMA H 1436

In the course of this development it was possible to increase the plant availability to values which are above average for modern metallurgical plants. Today all SL/RN plants in operation produce at 5 - 30 per cent above their nominal capacity.

	Start up Date	Kiln size (m)	Kiln units	Ore	Coal	Capacity (tpy DRI)
WESTERN TITANIUM	[illegible]	2.4 x 30	1	Ilmenite	Subbituminous	15 000
HIGHVELD I	1968/80	4.0 x 60	10	Lump ore	Bituminous	***2 000 000
NEW ZEALAND STEEL I	1969	4.0 x 75	1	Beach sand conc.	Lignite	175 000
ACOS FINOS PIRATINI	1973	3.6 x 50	1	Pellets/Lump ore	Bituminous	60 000
STELCO**	1975	6.0 x 125	1	Pellets	Subbituminous	360 000
NIPPON KOKAN**	1974	6.0 x 70	1	Waste oxide pellets	Bituminous	400 000
SIDERPERU	1980	2.9 x 62	3	Pellets	Coke/Anthracite	120 000
UNIDO/SIIL	1980	3.0 x 40	1 (2)	Lump ore	Bituminous	35 000
HIGHVELD II*	1983	4.0 x 60	3	Lump ore	Bituminous	***600 000
ISCOR*	1984	4.8 x 80	4	Lump ore	Bituminous	720 000
NEW ZEALAND STEEL II*	1984	4.8 x 65	4	Beach sand conc.	Lignite	900 000

*) under construction   **) in operation as required   ***) prereduction

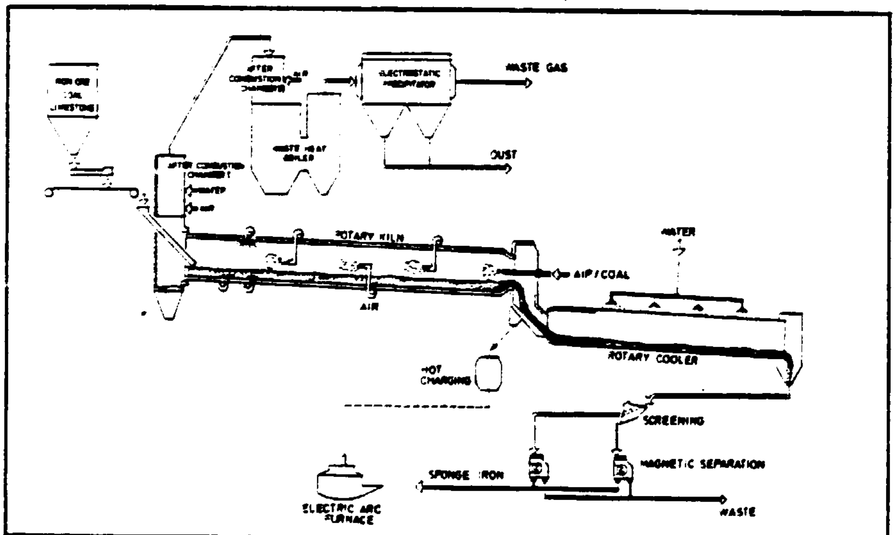
LURGI | Lurgi Coal-Based Direct Reduction Plants In Operation | C 82-1051 E

The long-standing experience and the maturity of process and equipment based on such experience are an essential characteristic of the SL/RN direct reduction process in its present state.

3.1.2 GENERAL PROCESS DESCRIPTION

The SL/RN direct reduction process uses a special design rotary kiln.

The raw materials, iron ore and coal, are dosified in a predetermined quantitative ratio and jointly charged to the reduction unit. After drying and preheating of the charge to the reduction temperature, the iron oxides of the ore are reduced by means of carbon monoxide (CO), an uninterrupted supply of which is ensured by the conversion of the coal used as reductant.



LURGI	SL / RN PROCESS FOR IRON ORE	C82-1049E

The temperatures required by the process are provided and controlled by predetermined rates of combustion air injected through shell blowers arranged along the kiln length.

At temperatures between 1000 and 1100° C, the ore is reduced in the solid state to form sponge iron. After being discharged from the rotary kiln, the sponge iron is cooled to ambient temperature together with the remaining char in a cooler arranged downstream, for the purpose of avoiding reoxidation and conditioning the materials for subsequent handling.

Separation of the sponge iron from the non-magnetic kiln discharge material is effected by screening. Smaller fractions are removed in a magnetic separation system

The hot rotary kiln off-gases are led in countercurrent with the material charge, leaving the kiln at the feed end. After passing through a dust chamber, they are afterburned and then cleaned.

LURGI

3.1.3 Raw Materials

3.1.3.1 Mchuchuma Coal

Up to now, no other coal-based direct reduction process has demonstrated the great flexibility of the SL/RN process with regard to the wide range of solid reductants being used.

The coals commercially used in the various SL/RN plants range from high-volatile lignite (New Zealand Steel) and bituminous coal (Aços Finos Piratini, Brasil and Sponge Iron India Ltd.) to anthracite/coke breeze (Siderperu).

Company	Coal	% Moist	% dry			
			F.C.	V.M.	Ash	S
Acos Finos Piratini	Charqueadas/Brazil	9	40	25	35	0.4
Acos Finos Piratini*)	Leao/Brazil	15	51	34	15	0.6
Acos Finos Piratini*)	Brown Coal Briqu./Germany	17	45	51	4	0.3
Steel Comp. of Canada	Forestburg/Alberta-Canada	20	51	40	9	0.5
Nippon Kokan	Grose Valley/Australia	8	58	26	16	0.5
Highveld South Africa	Greenside/South Africa	3	54	31	15	0.6
Western TI Corp. Australia	Collie/Australia	22	56	40	4	0.5
N. Z. Steel Ltd.	Huntly/New Zealand	16	49	42	9	0.3
Siderperu	Coke Breeze/Peru	1	81	3	18	0.7
Sponge Iron India Ltd.	Singareni/India	8	44	31	25	0.3
Iscor Vanderbijlpark	Van Dyksdrift/South Africa	8	59	26	14	0.6

*) Industrial Test

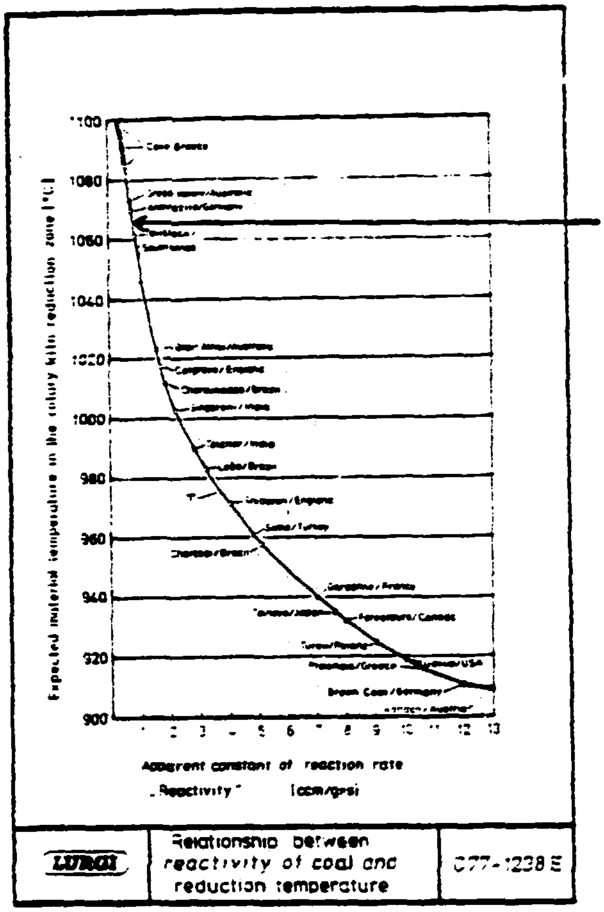
LURGI | Coals processed in LURGI Direct Reduction Plants | C 82-1073 E

In coal-based direct reduction, widely varying coal properties lead to substantial differences in process design. Apart from the chemical composition, factors such as degradation and ash softening behaviour, mixing properties as well as the behaviour of the volatile components and the sulphur play a considerable part in the design of the plant in which the coal is to be used.

Corresponding lay-out data have been evaluated for Mchuchuma coal in a series of metallurgical tests, which are compiled in Volume I, Section 2.4.

Since the reactivity of the coal is the main factor affecting the kinetics of the SL/RN process, it follows that process temperatures directly relate to the type of coal. For the Mchuchuma coal sample, collected by NDC, a reactivity of 0.71 (LURGI Standard) corresponding to an operating temperature of approx. 1060 - 1080 °C has been determined.

The average reduction temperatures of the coals used at the time in the SL/RN plants are shown together with a small selection of coals tested for various projects in Lurgi's Research Centre.



---- Mchuchuma Coal (NDC sample)

The ash content of Mchuchuma coal (20.8 % dry basis) is tolerable and does not impose any process restrictions.

The ash melting behaviour is acceptable as well.

The sulphur level in the coal should not exceed the range of 1.0 - 1.5 % to achieve reasonable sulphur levels in the sponge iron.
Mchuchuma coal (0.48 % S) is well below this limit. However, dolomite will be added to the kiln feed to adsorb sulphur and prevent its pickup by the metallized product.

The slight caking characteristics (S.J.1) of Mchuchuma coal do not justify investment into separate coal pretreatment facilities. Mchuchuma coal can be processed as washed coal accepting a slight agglomeration during processing.

To allow natural wheatering of the coal, the plant's stockyard was designed for a coal reserve of 1 month operation, thus considerably decreasing the caking tendency of the fresh coal.

Decrepitation of the coal during reduction favours the gasification conditions and reduction potential in the rotary kiln; therefore non-decrepitating coals should have a mean size corresponding approximately to half of that of the ore feed, with approx. 10 % -1 mm fines to prevent waste gas dust losses. The ideal grain size for Mchuchuma coal was selected to be 0 - 10 mm, as the stable ash structure prevents this coal from decrepitation.

3.1.3.2 Maganga/Liganga Pellets

The SL/RN process is similarly flexible with regard to the ores that can be treated.

Company	Iron Ore	% dry			
		Fe	SiO_2	CaO	Others
Aços Finos Piratini	Itabira Pellets/Brazil	67	2.4	1.6	
Aços Finos Piratini**	Urucum Lump Ore/Brazil	69.4	0.58	0.03	
Nippon Kokan	Waste Oxide Pellets	55	4.9	3.3	0.7 Zn
Nippon Kokan**	Sishen Lump Ore/South Africa	66	2.5	0.2	
Steel Comp. of Canada	Griffith Pellets/Canada	67	3.4	0.6	
Hecla Mining Corp.	Leach Residue Pellets	47	19.0	2.0	1.5 Cu
Western Ti Corp./Australia	Ilmenite Conc./Australia	30	0.8	-	55 TiO_2
Highveld South Africa	Titaniferous Magnetite Lump Ore	54	2.1	-	13.2 TiO_2 1.7 V_2O_5
Highveld South Africa**	Sishen Lump Ore/South Africa	66	2.5	0.2	
N.Z. Steel Ltd.	Iron Sand Conc./New Zealand	58	1.1	0.2	8 TiO_2
Siderperu	Marcona Pellets/Peru	66	2.2	1.0	
Sponge Iron India Ltd.	Bayaram Lump Ore/India	63	4.5	0.1	
Iscor Vanderbijlpark	Sishen Lump Ore/South Africa	66	2.5	0.2	

** Large Scale Test

LURGI | Iron Ores processed in Lurgi coal-based DR-plants | C 82-1160 E

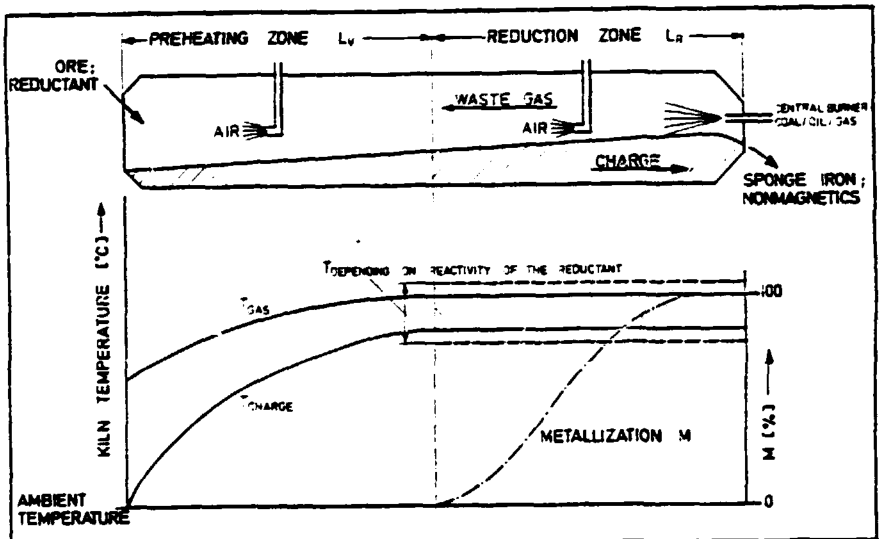
Processing of lump ores and pellets by the rotary kiln reduction method is generally known. This method is applied in the SL/RN plant of Aços Finos Piratini, Siderperu and Sponge Iron India Ltd.

The SL/RN plant of NDC will be fed with pellets produced at the spot in a separate pelletizing plant using Liganga/Maganga iron ore concentrates and local bentonite/limestone as binders. The quality parameters of these pellets correspond to optimum operating conditions of the direct reduction and steelmaking plants.

3.1.4 SPECIAL PROCESS CHARACTERISTICS

3.1.4.1 Countercurrent Kiln Operation

The rotary kiln can be sub-divided into two zones as schematically shown below:



LURGI | COUNTER-CURRENT KILN OPERATION | 076-1300 E

- the preheating zone, where iron ore and coal will be dried, heated up to reduction temperatures and where volatiles of the fresh coal are released,

- the reduction zone, where the iron ore is reduced.

Depending on the amount of heat to be transferred into the material charge, the heat-consuming reactions take place within the charge. Controlled balance of the exothermic and endothermic reactions is of great importance for safe kiln operation. Therefore, controlled combustion and controlled mixing conditions must be ensured at all times.

For this, the rotary kiln filling degree and retention times were adjusted correspondingly, (see chapter 3.1.4.7).

3.1.4.2 Chemistry in the Reduction Zone

In the reduction zone the iron oxides react with carbon monoxide according to the following equation:

$$Fe_xO_y + CO \rightarrow Fe_xO_{y-1} + CO_2$$

The carbon dioxide forming in the process is converted to carbon monoxide by means of the carbon of the reductant in accordance with the Boudouard reaction:

$$C + CO_2 \rightarrow 2\ CO \quad \text{(Boudouard)}$$

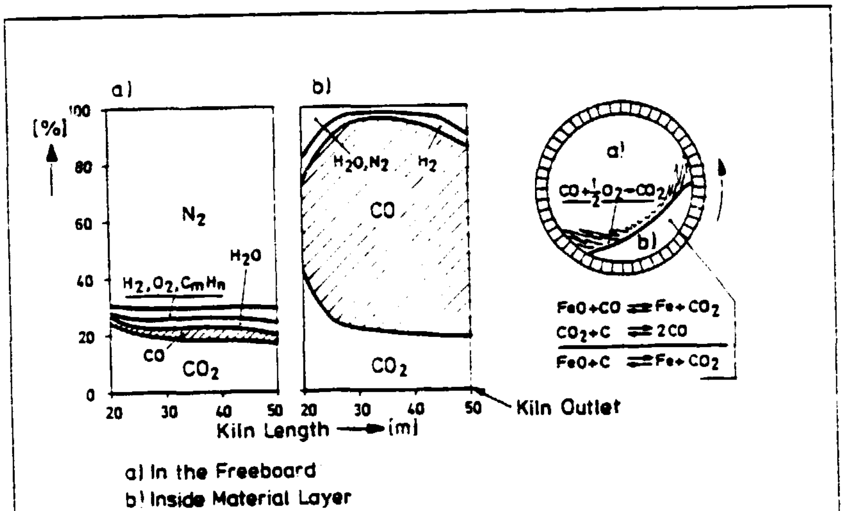
The chemical reactions involved in direct reduction can consequently be summarized as follows:

$$Fe_xO_y + C \rightarrow Fe_xO_{y-1} + CO \quad \text{(endothermic)}$$

In order to cover the heat requirements for the process reactions, excessive carbon monoxide and a small portion of carbon are burned with air supplied from the outside through air tubes:

$$CO + 1/2\ O_2 \rightarrow CO_2 \quad \text{(exothermic)}$$

A schematic cross-section through the rotary kiln will show the following picture:



Gas Composition in the Reduction Zone of the Rotary Kiln

A reducing and an oxidizing atmosphere prevail side by side within the rotary kiln, that is, a reducing atmosphere with endothermic reactions within the material charge (b) and oxidizing conditions with exothermic reactions in the gas space above (a).

Separation of the two atmospheres is ensured by a certain generating pressure of the carbon monoxide emerging from the charge into the kiln freeboard. This will safely avoid reoxidation of the reduced ore particles at the charge surface.

Due to thermodynamic conditions, the Cr-, Ti- and V-oxides contained in the pellets will not be reduced to the metallic state and thus can be separated as oxides in the melting process.

As a general rule, the result of reduction is expressed by the degree of metallization as the relationship between the contents of metallic and total iron contained in the sponge iron:

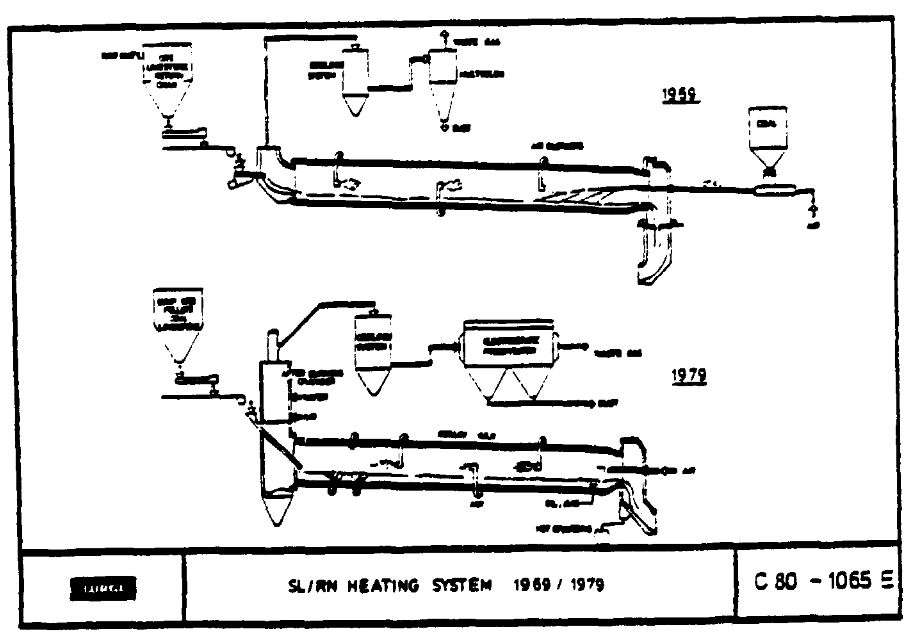
$$= \frac{\%\ Fe\ met}{\%\ Fe\ total} \times 100\ \%$$

metallization degree

The DRI produced from Liganga pellets will posses metallization degrees of up to 92 % in normal operation.

3.1.4.3 SL/RN Heating System

The heating system applied in SL/RN rotary kilns is the result of comprehensive development work. The following picture compares the principle heating systems of 1969 and 1982:



Originally, 100 % of fresh coal was injected into the kiln from the discharge end. With increased kiln diameter, heat accumulation occurred and combustion became uncontrollable. As a result accretions were forming which, in extreme cases, necessitated the stoppage of the plant.

Nowadays, most of the fresh coal is fed in together with the iron ore at the kiln inlet. In the preheating zone, air injection nozzles and air tubes are used, whereas in the reduction zone only air tubes for the control of combustion are installed. At the kiln discharge a central burner is installed, operating with gas for start-up and only with air during normal operation.

3.1.4.4 Coal Injection

With bituminous coal of the Mchuchuma type, a small amount of external energy at the kiln discharge is necessary:

- for covering the required heat demand in the reduction zone and

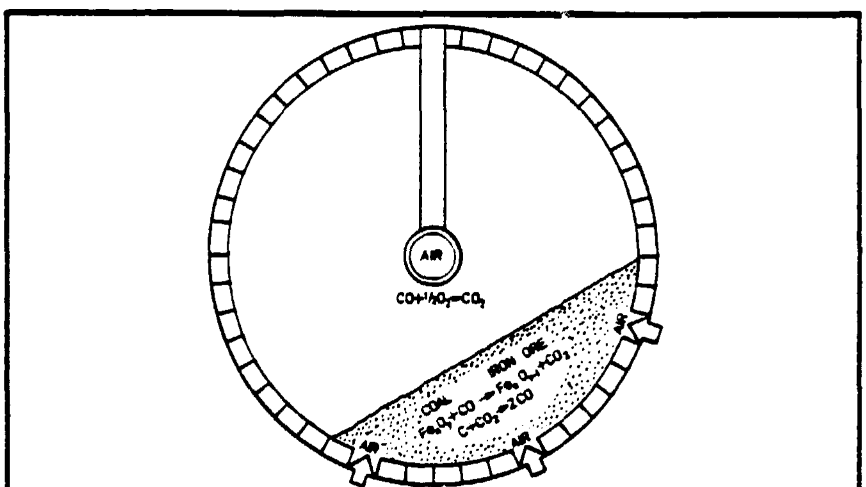
- for creating a reducing atmosphere.

This energy source could be gas, oil or coal. As practised at Aços Finos Piratini and Sponge Iron India Ltd., a certain amount of fine size Mchuchuma coal (10 - 20 % of total coal) will be injected pneumatically at the kiln discharge. The coal will be injected via a separate feeding tube by means of an air blower. During operation, neither gas nor oil are required.

3.1.4.5 Submerged Air Injection

The principle of submerged air injection has been found to be of advantage when utilizing coal types containing more than 15 % volatile components. In this case a certain amount of combustion air is directly injected into the material charge through air nozzles in the preheating zone. The volatile components arising from the coal at temperatures between 300 and 800° C are thus burned directly within the charge and transfer the heat of combustion immediately to the raw materials to be preheated.

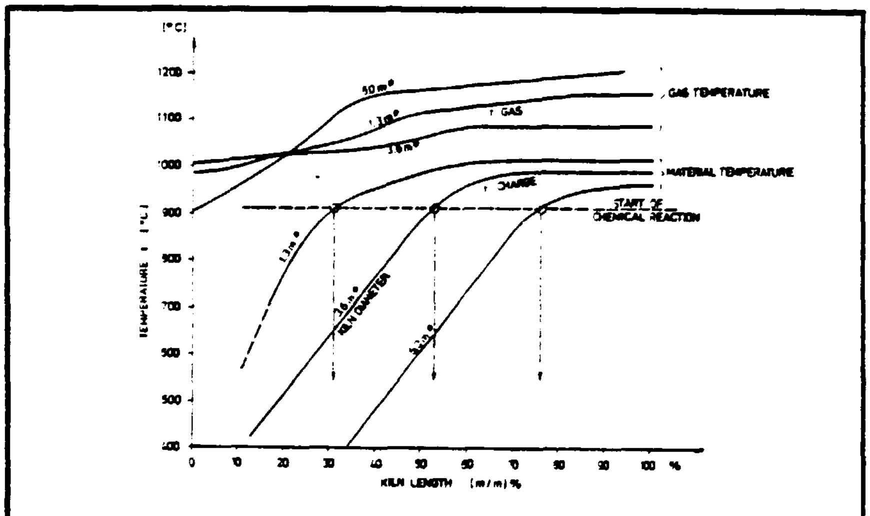
This system is shown in the following figure:



LURGI | SL/RN HEATING SYSTEM (CROSS SECTION) | C81-1117E

Compared to the conventional rotary kiln reduction operation, this method leads to a shortening of the preheating time and positive effects on the output of a given rotary kiln. Moreover, the disadvantages caused by an intermediate dam-ring installed for the same purpose, like overheating and disturbed gas flow as well as charge mixing are avoided.

The following figure shows the development of material and gas temperatures at various kiln diameters without submerged air injection:

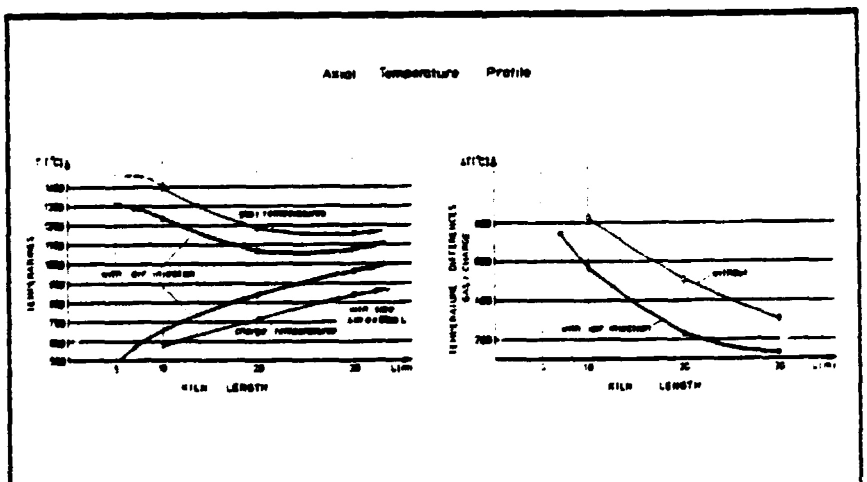


LURGI	AXIAL TEMPERATURE PROFILE FOR VARIOUS ROTARY KILN SIZES	C78- 1006 E

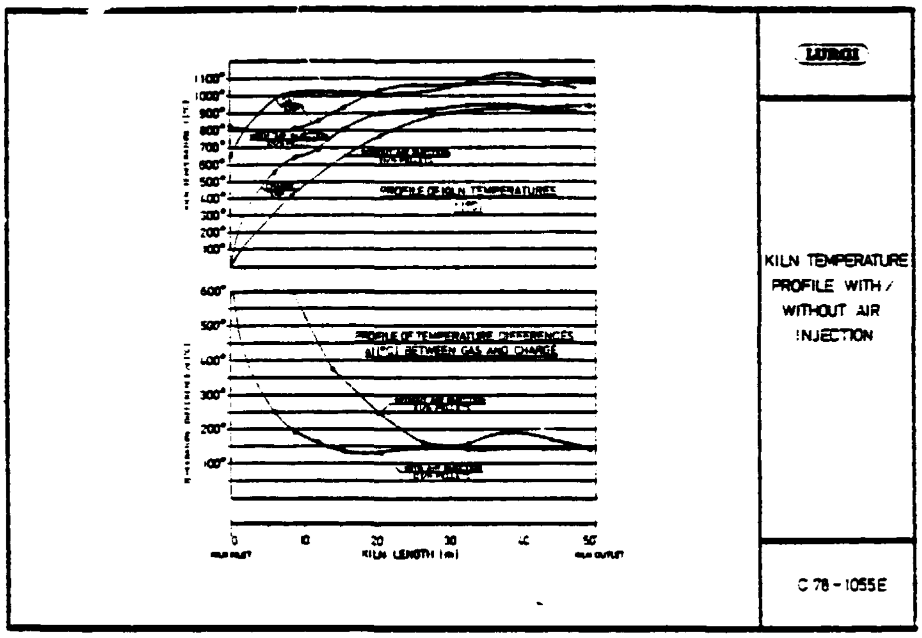
It is evident that at increasing kiln diameter the preheating times for the raw materials rise steeply. The reason is that the ratio of surface to volume of the material charge is becoming smaller at increasing kiln size. In the conventional rotary kiln production process, the heat is transferred by gas radiation to the charge surface and from there into the charge by the mixing effect to which the material is exposed.

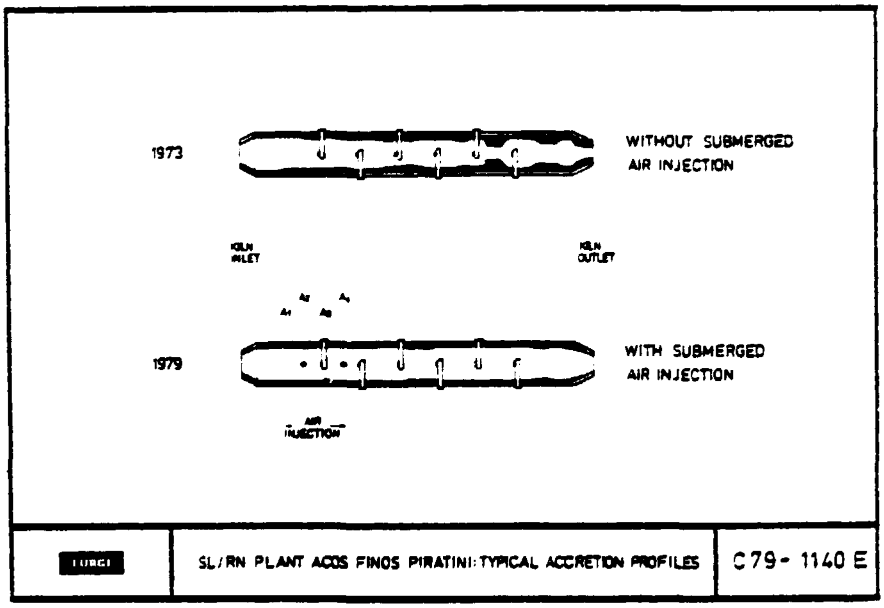
Increasing of the heat transfer through higher gas temperatures may lead to operational problems. That is why in the SL/RN process the heat transfer surface was extended by injecting air into the charge. The result is a considerable increase in output corresponding to about 25 to 30 % for a given kiln at simultaneously improved process control through lower gas temperatures.

In addition, controlled combustion of the coal volatile matters has been achieved by introducing the submerged air injection system, resulting in an accretion-free kiln operation.



LURGI | HIGHVELD No. 9 OPERATION WITH SUBMERGED AIR INJECTION | C80-1105 E

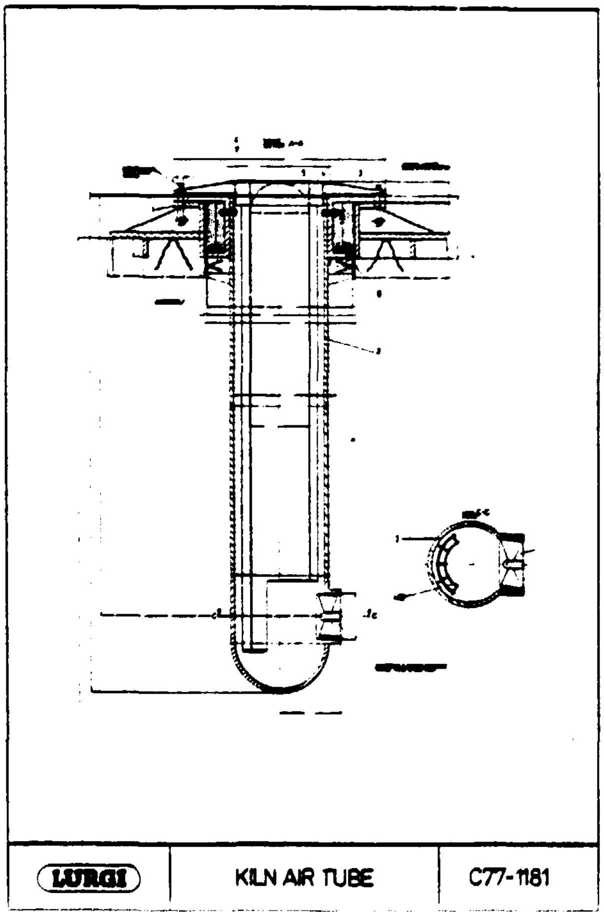

LURGI
KILN TEMPERATURE PROFILE WITH / WITHOUT AIR INJECTION
C 78 - 1055E
1100°
1000°
900°
800°
700°
600°
500°
400°
300°
200°
100°
PROFILE OF KILN TEMPERATURES
600°
500°
400°
300°
200°
100°
PROFILE OF TEMPERATURE DIFFERENCES
BETWEEN GAS AND CHARGE
0
10
20
30
50
KILN LENGTH (m)


1973
WITHOUT SUBMERGED AIR INJECTION
KILN INLET
KILN OUTLET
1979
WITH SUBMERGED AIR INJECTION
AIR INJECTION
LURGI
SL/RN PLANT ACOS FINOS PIRATINI: TYPICAL ACCRETION PROFILES
C79- 1140 E

3.1.4.6 Combustion Control

As a result of the reaction of the coal with air and oxygen from the ore, during rotary kiln reduction surplus carbon monoxide will form, the combustion of which in the kiln freeboard will supply the requisite heat for the process.

Controlled combustion is a prerequisite to avoid overheatings and steep temperature changes which are the main causes for the formation of accretions and fluctuations in product quality. Hence, controlled combustion is decisive for continuity of operation. In the SL/RN process, the requisite air for combustion is injected along the kiln length. For this purpose, several air tubes are installed, each of them equipped with its own blower.



The air tubes are cast from special material. Each air tube outlet opening is equipped with a swirler designed to ensure an optimum, turbulent flow of the emerging air of combustion. By this means, the flame formation can be controlled so that the formation of unburnt gas streaks or direct contact of the burner flame with the kiln wall are safely excluded.

The above described system is complemented by a central burner installed at the kiln outlet end to fulfill several functions:

- kiln preheating after stoppages for maintenance and short interruptions of production. For this purpose the burner may be fired with oil or gas;

- injection of combustion air in normal operation;

- injection of air and fresh coal (separate tube) when using bituminous coals as an additional heat source at high degree of metallization of the sponge iron with low carbon monoxide production.

3.1.4.7 Filling Degree and Mixing Control

Besides the combustion control, the mixing conditions are also of great importance.

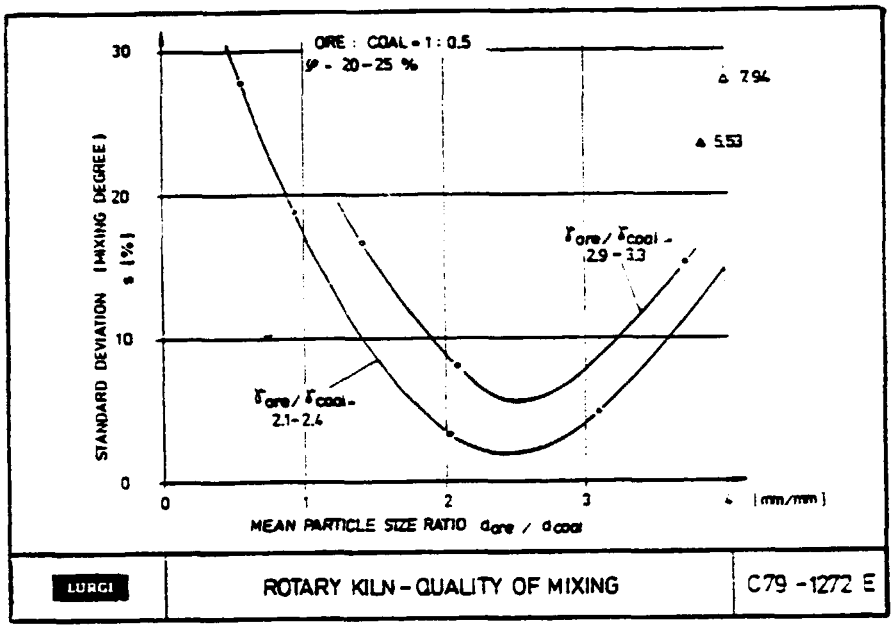
The chemical reactions of iron oxide reduction take place within the material charge. The aim must be to achieve a large charge volume to ensure optimum utilization of the carbon monoxide produced from the coal.

The moving behaviour of the raw material depends significantly on the filling degree, the most favourable case being as high as possible in the reduction zone.

In this special case, an inlet filling degree of 15 % and an outlet filling degree of 25 % were selected in combination with a kiln slope of 2 %, thus allowing for approx. 8 hours retention time of the materials in the kiln.

Besides being controlled by the filling degree, the mixing conditions are controlled by the size and bulk density ratio between iron ore and reductant. All inserts and dam-rings in the kiln will disturb the mixing pattern of the charge and should be avoided.

As the Mchuchuma coal does not decrepitate under thermal stress or during reduction, the size of the coal has to be adjusted correspondingly by a crushing unit to the optimum of 0 - 10 mm.



ROTARY KILN - QUALITY OF MIXING

With the high filling degree mentioned above, any undesirable sliding effect of the charge can be prevented, heat transfer and throughput will be as high as possible and product quality in metallization will be uniformly high.

3.1.4.8 Temperature and Air Flow Measurement

Continuous logging of all important operating parameters is a prerequisite for optimum process control.

This refers especially to the uniform temperature control in the reduction zone, where the charge temperature has to be adapted within extremely close limits to the reactivity of the coal and the ore properties, in this case 1060 °C.

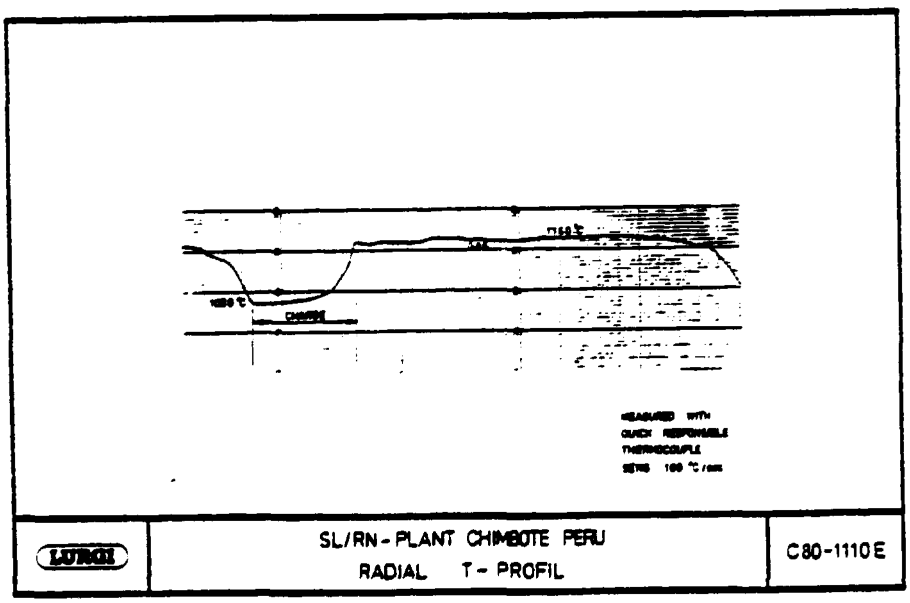
Whilst the above-mentioned heating system with air tubes and central burner fulfills the requirements for correct combustion, it is the direct measuring of the actually injected air air rates at each individual air tube which allows an efficient control of heat supply to be effected.

For this purpose, the SL/RN process uses a specific measuring equipment permitting the air volumes to be determined continously with the kiln in rotation, independently of kiln pressure fluctuations and atmospheric influences, with central logging of the measured variables in the control panel.

This system of direct air volume measurement is supplemented by an improved temperature monitoring method using two independent thermocouple systems.

Continuous temperature measurement is effected by means of the so-called working thermocouples, which thanks to their sturdy design with the respectively retarded response provide a mean value of the charge and gas temperatures prevailing at the various measuring points along the rotary kiln length. The signal transmission from the rotating kiln to the control panel is accomplished by means of slip rings.

The temperature measuring system with quick-response thermocouples developed by Lurgi is used additionally for direct determination of the actual charge and gas temperatures. For this purpose, extremely thin thermocouples are introduced into the kiln via separate measuring nozzles for a period corresponding to a few kiln rotations. The system provides for wireless transmission and gathering of the signals in the control panel.



Based on the diagram, apart from the actual gas and charge temperatures other significant control parameters for kiln operation can be calculated, such as filling degree and angle of slope of the charge within the kiln.

3.1.4.9 Waste Gas System

The waste gases leaving the rotary kiln have to be subjected to a waste gas treatment for conditioning with regard to their

- temperature
- dust content
- combustible constituents
- contaminants

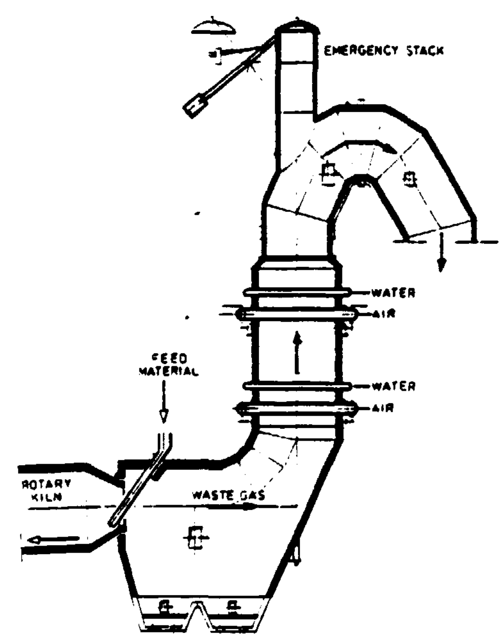
The SL/RN concept considers the cleaning of the waste gases according to the future state of the public health regulations in Tanzania.

The waste gas treatment applied for the SL/RN process can be subdivided into three major groups:

- afterburning system
- gas cooling system
- gas cleaning system

All combustible constituents of the waste gases, such as carbon, soot particles and combustible gases are burnt out in an afterburning chamber - ABC. The hydrocarbons and carbon monoxide are converted into carbon dioxide and water vapour, all sulphur compounds into sulphur dioxide.

The following graph shows the principle of the ABC with the dust settling chamber in the lower part:



LURGI	SL/RN AFTER BURNING CHAMBER	C81-1036E

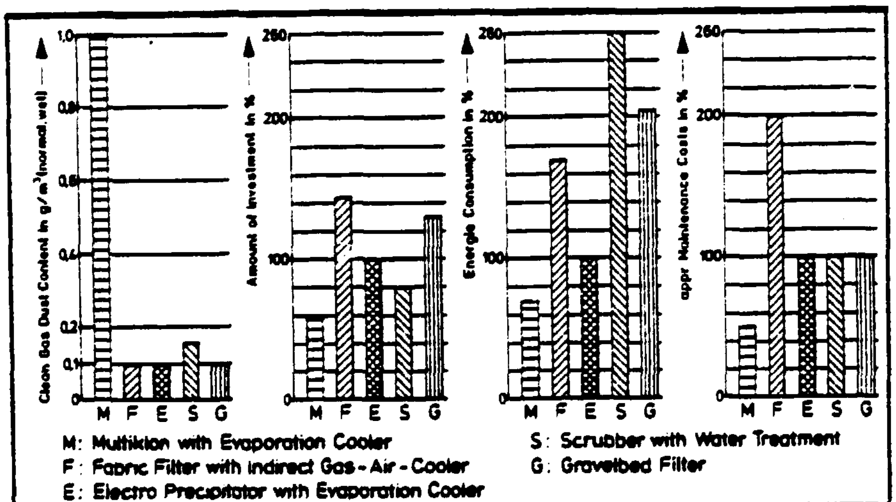
The combustion takes place in two sections of the ABC by air injection in a narrow and controlled temperature range between 950 and 1100 °C.

The temperature of the waste gases leaving this chamber are controlled automatically by a water nozzle. On top of the ABC an emergency flap is arranged, which opens automatically if, for instance, the temperature of the waste gases entering the waste gas cleaning systems is too high.

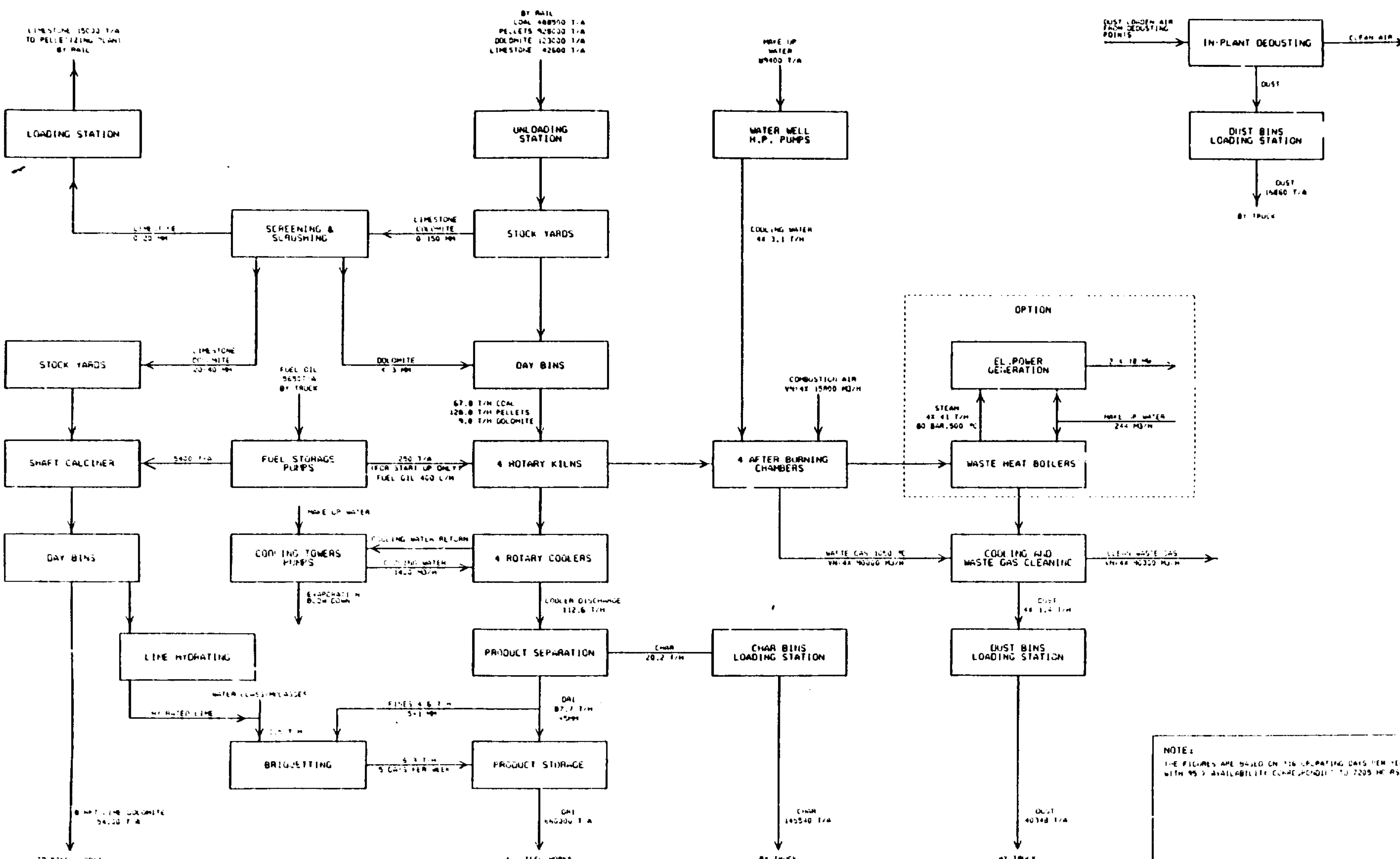
Before entering the cleaning system, the hot gases from the ABC are cooled to the appropriate temperature.

The waste gas cleaning system is designed to meet a dust limit of below 100 mg/Nm3 by LURGI design electrostatic precipitators.

With this system Lurgi has gathered comprehensive experience in existing plants.



LURGI | Gas Cleaning of SL/RN-Plants (200 000 MT/Y Ore Throughput) | C81-1073E



NOTE:
THE FIGURES ARE BASED ON 316 OPERATING DAYS PER YEAR WITH 95 % AVAILABILITY CORRESPONDING TO 7205 HOURS.

LURGI Lurgi Chemie und Huettentechnik GmbH

SL/RN DIRECT REDUCTION PLANT
660000 T/A DRI
BLOCK DIAGRAM

DIN 202
HRE 032238
TANZANIA
L 1A03223800017

SECTION 3.2

Plant Description

Direct Reduction Plant

3.2 Plant description

3.2.1 General remarks

The Direction Reduction Plant, Phase 1, has a nominal production capacity of 660.000 t DRI/year, based on 316 operating days per year at an availability factor of 0.95, corresponding to 7.205 operating hours. Four rotary reduction kilns with a diameter of 4.8 m and a length of 80 m are provided.

The overall plant arrangement allows for a future plant extension of 100 % capacity of the initial plant.

This extension would consist of four further rotary kilns, coolers and associated equipment, arranged north of the initial plant as shown in plot plan LOA 03 2238 00004.

3.2.2 Plant description, mechanical installations

Plant sections:

.1 Raw Materials Unloading, Storage and Handling

.2 open

.3 Raw Materials Bins, Metering and Handling to the Rotary Reduction Kilns

.4 Rotary Reduction Kilns and Auxiliary Equipment

.5 Rotary Coolers and Auxiliary Equipment

.6 Cooling Water Systems for Rotary Coolers

.7 Product Separation Systems and Intermediate Storage Facilities

.8 Product Fines Briquetting

.9 Product Storage

.10 Waste Gas Afterburning Systems

.11 Waste Gas Dedusting Systems

.12 Plant Dedusting System

.13 Compressed Air System

.14 Plant Safety System

For identification of plant sections refer to plot plan LOA 03 2238 00005.

.3 Raw materials bins, metering and handling to the rotary reduction kilns

Oxide pellets, coal and dolomite are discharged from storage bins by weighfeeders at a preset ratio. Storage bins have a life capacity of approx. 20 hours operation. The raw materials are discharged to the rotary kiln feed tubes via belt conveyors.

Dynamic air sealing is provided at the kiln feed tubes by sealing air fan and adjustable butterfly valve.

Coal is discharged from a storage bin at each kiln discharge end by a weighfeeder. The bin has a life capacity of approximately 20 hours operation.

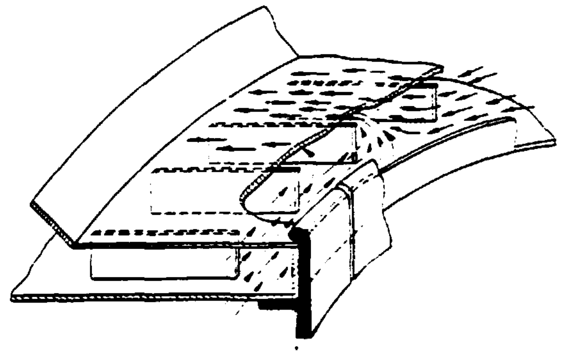
Coal is fed to the pneumatic coal injector which is arranged in front of the rotary kiln discharge head. Separate compressor and cooler are provided for coal injection air.

.4 Rotary reduction kilns and auxiliary equipment

Four rotary kilns will be provided for the Phase I DR-plant. Each rotary kiln has a diameter of 4.8 m and a length of 80 m. The kiln is resting on three supports, each of them having two roller pedestals.

The inlet and the outlet end are conically shaped and provided with additional jacket walls for cooling air which will be supplied by radial fans and introduced by air ducts.

Both ends of the shell are equipped with nose ring casting for wear and heat protection.

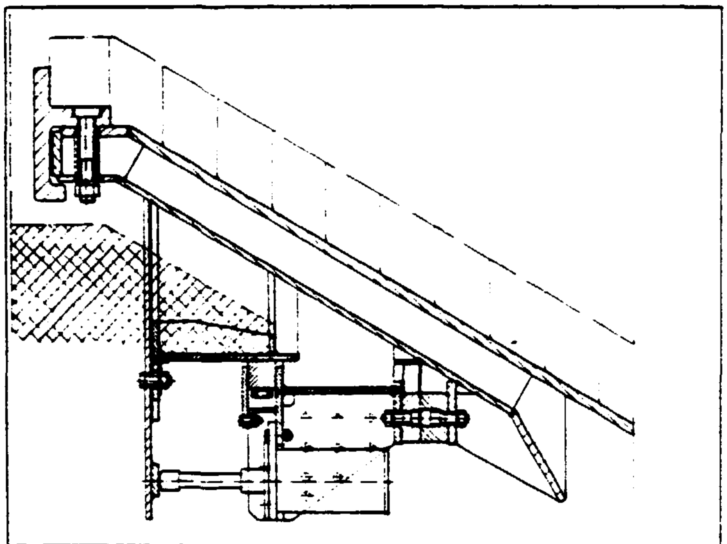


LURGI	END SECTION-AIR COOLED-AIR GUIDE	C74-1081E

Furthermore, manholes, sample ports, sockets for thermocouples, sockets for air tubes and air nozzles are installed. Inside the shell, retaining rings for brickwork are provided.

Sealing devices at the kiln inlet and outlet are provided between the rotating part (kiln shell) and the stationary part. The sealing devices are equipped with pneumatic actuator cylinders for provision of a uniform and adjustable sealing pressure.

To prevent wear at the sealing elements, intermittent grease lubrication is installed.



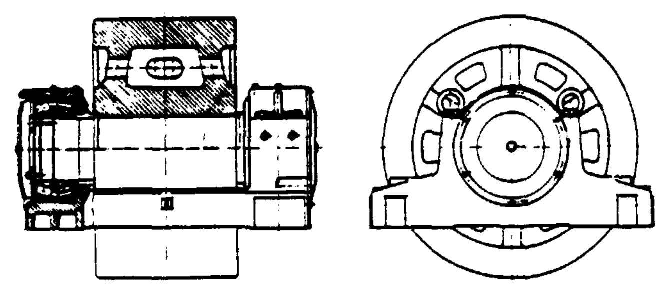
LURGI	ROTARY KILN - SLIPRING SEAL	C74 - 1083E

The gear rim is furnished in two sections and is attached to the shell by spring plates and special shackles facilitating alignment with the shell.

Running tyres will be of the close fitting floating type and made of cast steel with solid cross section.

The rotary kiln is supported on three supporting stations, each of them having two roller pedestals.

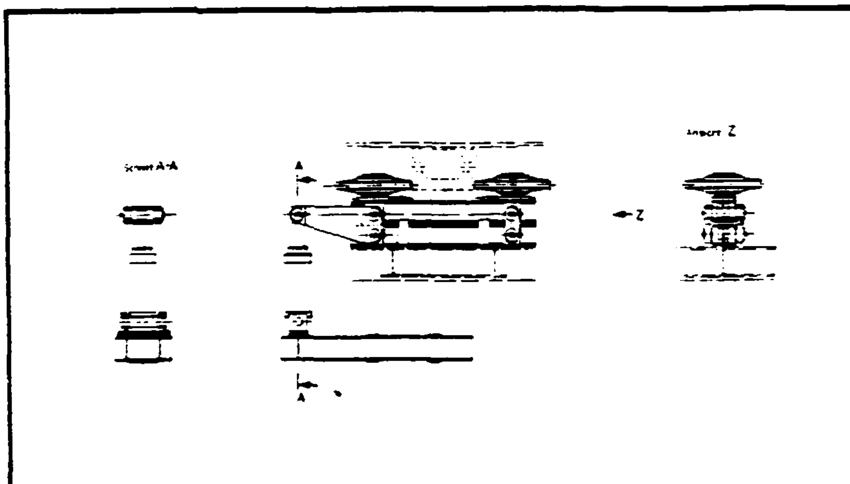
Each bearing is grease lubricated and equipped with a grease lubricated felt ringlabyrinth seal combination which avoids dust and moisture penetration.



LURGI	SUPPORTING ROLLER WITH SPHERICAL ROLLER BEARING	C74-1077E

To guide the rotary kiln in axial direction, a hydraulic thrusting device will be furnished. It consists of two cylindrical thrust rollers which force the kiln backwards and forwards.

They are mounted on a hydro-thrust mechanism which is moved by an hydraulic actuator. The actuator is powered by an hydraulic pump unit.



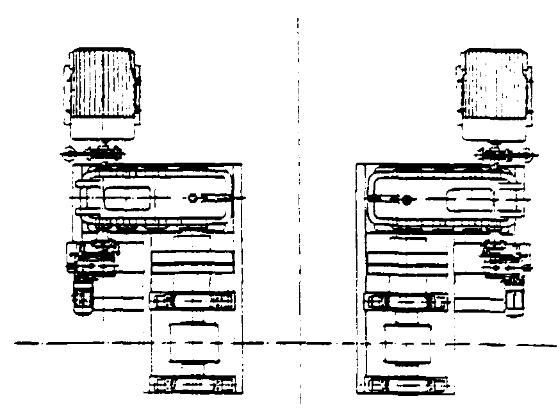
LURGI | HYDRO THRUST | C 78-1256

The kiln is driven by a tandem drive arrangement employing two pinions of forged steel.

The gear rim and pinions are encased in a totally enclosed guard with inspection openings.

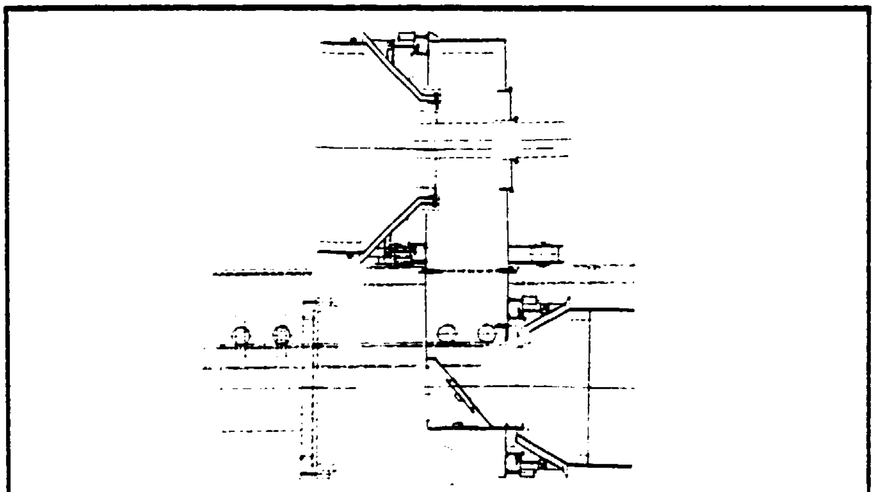
Each drive set consists of main coupling, main gear box, main drive coupling with automatically operated brake, hand operated overriding jaw clutch, auxiliary gear box with built-in brake to limit the roll-back of the kiln and auxiliary drive coupling. The main gear boxes are driven by DC-motors and the auxiliary gear boxes by AC-motors.

All drive components are arranged on common steel bases, welded design, fabricated from structural sections. Heat protection shields are provided for main gear boxes and main motors. All couplings are protected by safety guards.



LURGI | KILN - TANDEM DRIVE | C74-1085E

The kiln outlet head allows free access from the kiln discharge into the indirect cooler. Connection for the central burner is provided as well as sight glasses for process observation and inspection doors for maintenance inspection.



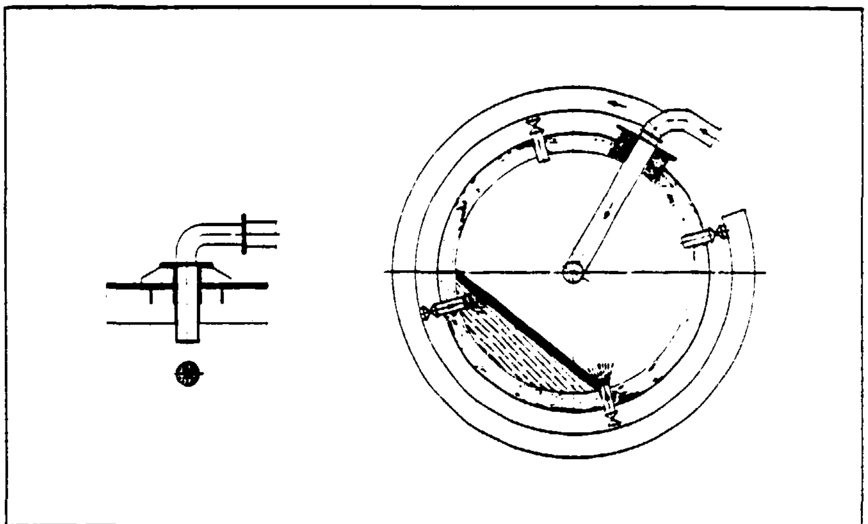
LURGI	TRANSITION ROTARY KILN-COOLER	C81-1094E

A retractable central burner is installed at the rotary kiln outlet head. The burner is designed for combustion of fuel oil. The burner can also be used as air pipe with reduced air volume. The combustion air fan is equipped with pole changing motor to facilitate this type of operation.

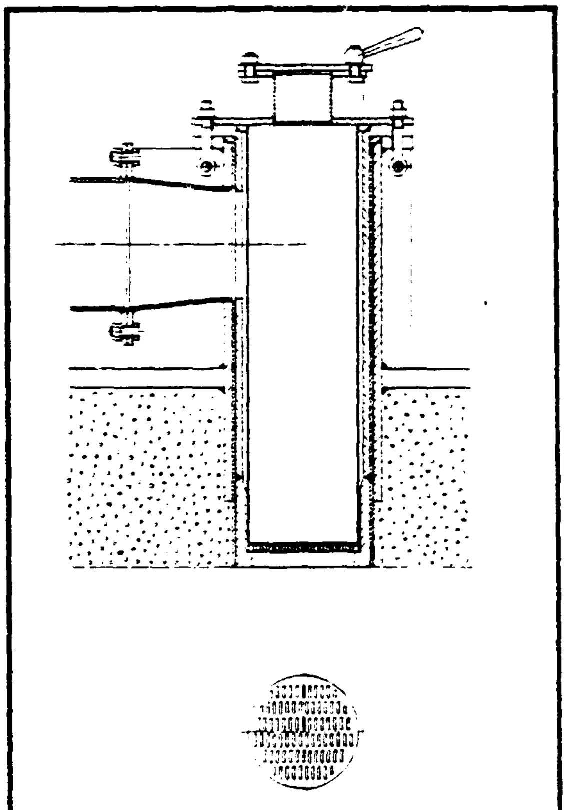
On the kiln shell, radial fans are provided for the supply of combustion air. Air will be introduced partly by centrifugal cast air tubes and in the preheating area of the kiln by air nozzles.

The air tubes are equipped with heat sinks and swirlers.

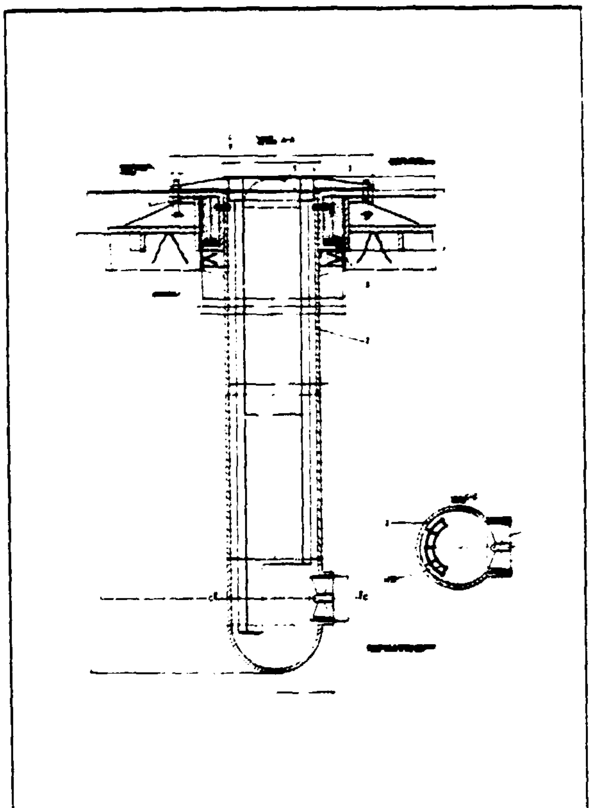
Each shell fan has an inidividual air duct system. the regulation and distribution of combustion air according to process requirements is provided by means of butterfly valves.



LURGI	PREHEATING SYSTEM	C77-1186



LURGI | SUBMERGED AIR NOZZLE | C81-1092E



LURGI | KILN AIR TUBE | C77-1181

The refractory lining of the rotary kiln consists of a high-strength and dense refractory lining of 230 mm thickness.

Corrugated V-anchors will be provided for anchorage of the refractory concrete sections.

To ensure continous operation, automatic lubrication is essential for the gear rim and pinion as well as the sealing device at kiln inlet and outlet. Each system operates independently and automatically. It mainly consists of one pneumatically operated grease pump which is mounted directly on a grease barrel.

The lubrication intervals can be predetermined by automatically operated systems according to plant requirements.

.5 Rotary coolers and auxiliary equipment

Four rotary coolers with a diameter of 3.6 m and length of 50 m will be provided for the initial DR-plant.

The discharged material from the kilns will be fed by a "spoon-shaped" feed chute into the rotary coolers. The chute itself is mounted on a carriage and furnished with segment castings for heat and wear protection. The chute is lined with castable material. the feed chute can be withdrawn by a winch.

Sealing device, pneumatic actuators, including grease lubrication, operate as described for similar equipment at kiln inlet and outlet.

The cooler shell rests on two supports. Two tyres are welded onto the cooler shell. The inlet end of the cooler shell is conical and is provided with an additional jacket wall for cooling air, supplied by a radial fan and introduced by an air duct. At the cylindrical outlet end, a screening section is furnished.

Inside the cooler shell, retaining rings for brickwork and flights to prevent sliding of material and to improve heat exchange between material and cooler shell are installed.

The inlet cone and the first tyre section are lined with ramming mass.

The gear rim is furnished in two sections and is attached to the shell by spring plates and special shackles facilitating alignment with the shell.

The cooler is driven by a single drive arrangement.

The cooler outlet head is of welded mild steel plate construction with adequate stiffening and is stationary mounted. The bottom part of the outlet head is designed as a hopper with two outlet openings. Two needle gates are installed underneath the hopper. For the discharge of oversize material as well as for emergency cases, a chute with pneumatically operated flap is furnished at the cooler outlet.

The water for indirect cooling will be spread onto the cooler shell by means of two pipelines with nozzles and one pipeline with bore holes. The pipelines with nozzles are arranged along the cooler shell and on the circumference in 4 and 8 o'clock positions. The pipeline with bore holes and water guide device in rubber-steel construction is arranged along the cooler shell in 12 o'clock position.

At each end of the spraying zone, water deflector rings on the cooler shell are provided to direct dripping water into the water collecting trough.

To ensure continous operation, automatic lubrication of the gear rim and pinion as well as the sealing device at cooler inlet and outlet is essential. The lubrication systems are designed and installed as described for the rotary kiln.

Cooler inlet chute and cooler inlet section will receive a refractory lining consisting of a high-strength and dense refractory concrete with 230 mm thickness. Corrugated V-anchors are provided for anchorage.

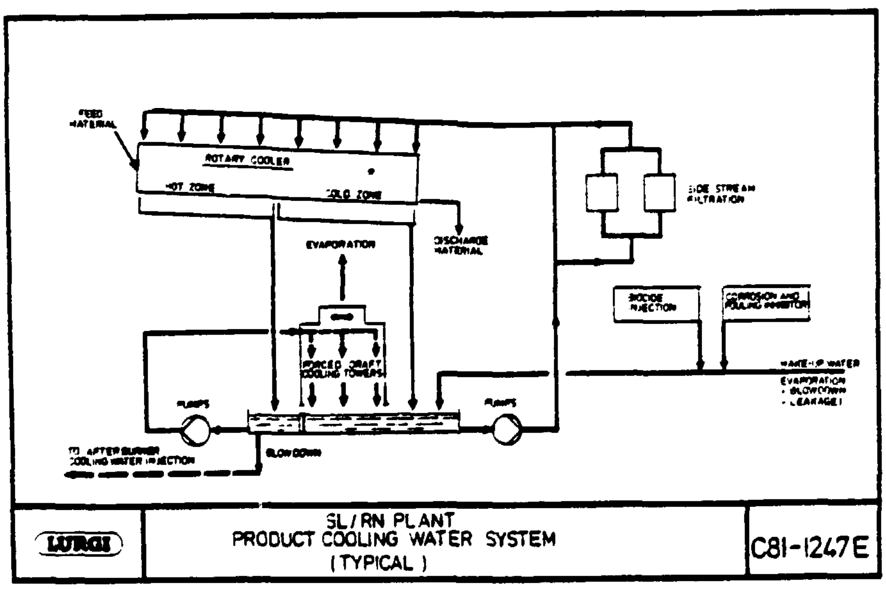
.6 Cooling water systems for rotary coolers

Two cooling water systems will be provided, each system serves two rotary coolers.

Three pumps (one standby), pick up water from a collector basin and feed it via a distributor nozzle system over the length of the rotary cooler shells. Cooling circuit is designed for 100% indirect cooling.

Water from the "hot" section of the cooler is collected separately and distributed to forced draft cooling towers via two pumps (one standby).
Cooling tower ventilators are equipped with pole changing motors.

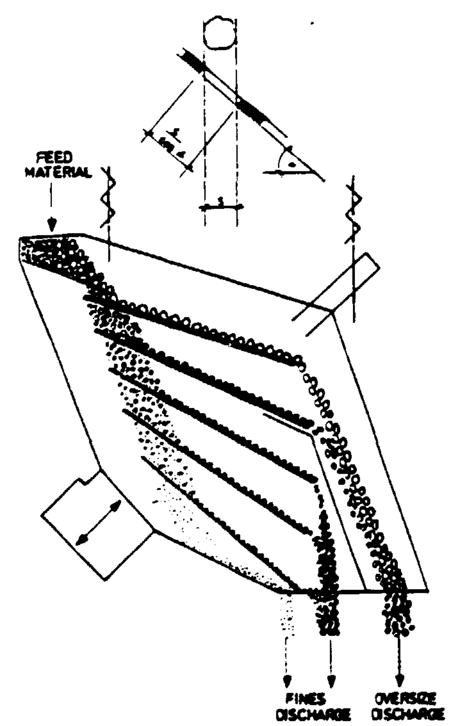
Water from the "cold" section of rotary coolers is fed directly to the collector basin ahead of pumps (see above).



.7 Product separation system and intermediate storage facilities

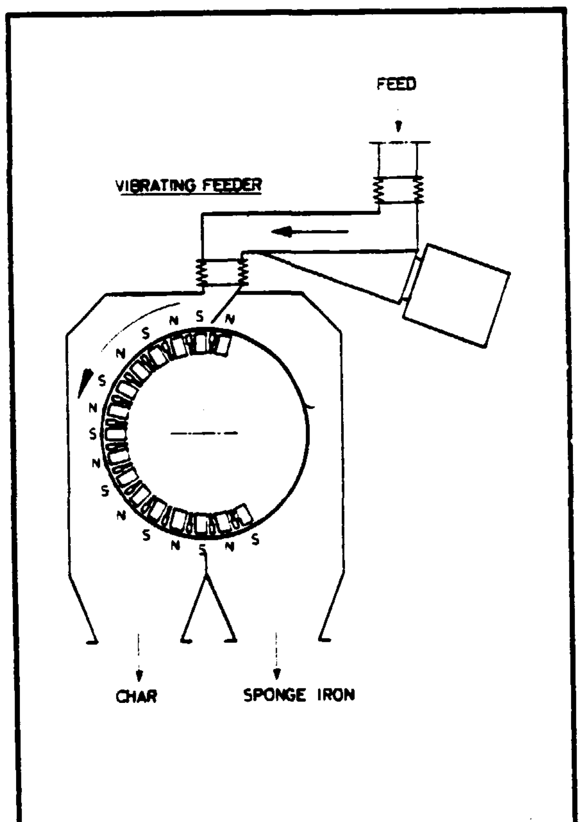
Two product separation systems will be provided, each system serves two rotary coolers.

The material discharged from each rotary cooler is continuously weighed and automatically sampled at preset intervals.
In the product separation, the material is first screened into various fractions.



LURGI	MOGENSEN SIZER	C81-1208E

Each fraction is separated on an individual one- or two-stage magnetic separator.



LURGI | DRY MAGNETIC SEPARATOR PRINCIPLE | C82-1036 E

The magnetic portions plus 5 mm are collected on a common belt conveyor and fed to the DRI-product bins.

The magnetic portion minus 5 mm is fed to the briquetting plant.

The non-magnetic material is collected in a waste materials loadout bin.

During emergency operating conditions, i.e. electr. power supply failure or product separation shutdown, the cooler discharge material is collected in an intermediate storage bin. After re-establishment of normal operating conditions, the material is returned to the main product handling system.

Intermediate storage bin feeding equipment is connected to the emergency electr. power system of the DR-plant.

.8 Product fines briquetting

It is proposed to briquet the product fines minus 5 mm with a binder combination of hydrated lime and waterglass or hydrated lime and molasses.
Product fines and binder components are discharged from storage bins, respectively a liquid binder tank by weighfeeders and dosing pumps in metered proportions.

The feed mix passes a continuous mixer and is directly discharged to a roll briquetter with pre-densifying screw.

The briquettes are screened at the briquetter discharge and then fed via a swivelling belt conveyor to a curing and storage pile. Depending on the liquid binder selection, this pile can be open (waterglass) or covered (molasses).

The undersize material from the briquettes screening is returned to the continuous mixer.

.9 Product storage

Two storage bins with a holding capacity of approx. 7500 t each are provided.

Bins are fed via a belt conveyor system. Rock ladders are installed inside the storage bins to minimize degradation of the product.

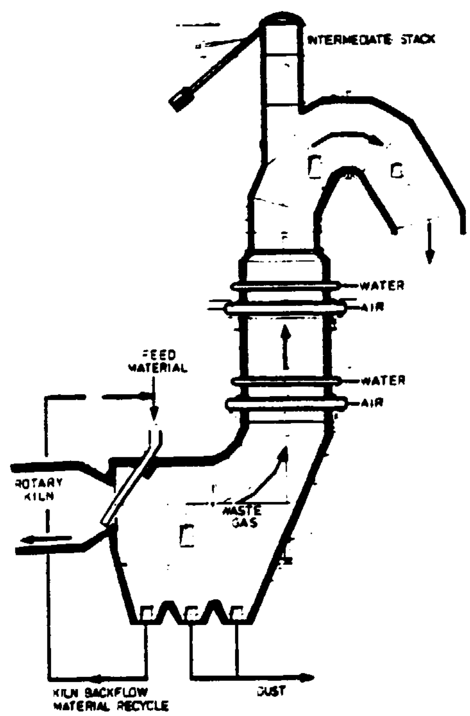
The product will be discharged from bins by vibrating feeders.

.10 Waste gas afterburning system

The waste gas from each kiln passes through a dust chamber. The first part of the chamber is designed to collect the kiln back-flow material separately from the dust. The material is discharged by a motorized double flap valve and fed back to the kiln inlet tube via a bucket elevator. Two further outlets are provided for discharge of settled dust via chain conveyor and double flap valve.

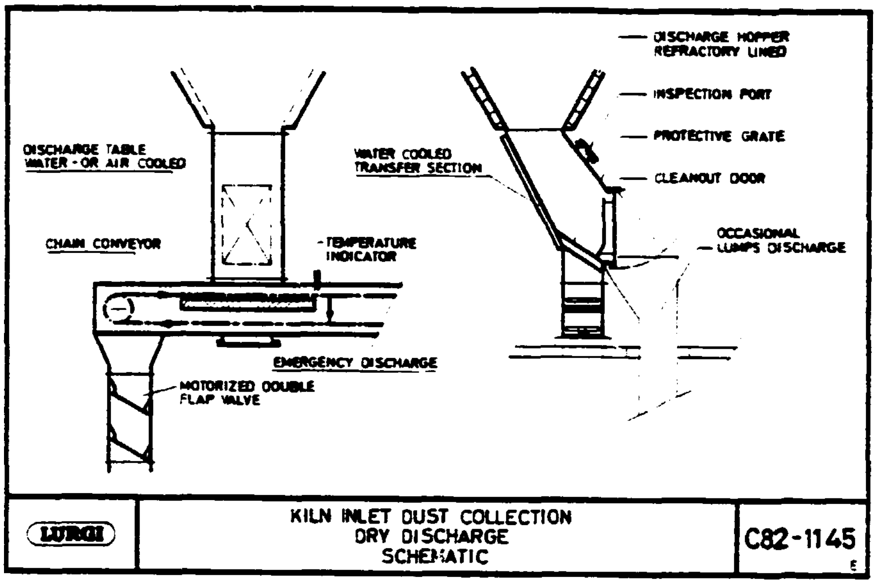
After passing the dust chamber, the waste gas enters the vertical after-combustion chamber where combustion air and high pressure cooling water are introduced at various levels. Combustion air is supplied by a radial fan and distributed by two ring mains, each individually controlled by means of butterfly valves. For water injection, high pressure backlow nozzles and high pressure centrifugal pumps are installed. the water volume at the individual water nozzles is controlled automatically from the control centre.

On top of the after-combustion chamber, an emergency stack with cap, leverage frame etc. will be furnished. The cap is operated by a hydraulic system which opens the cap automatically, i.e. in case of power failure or high temperature. During idling conditions of the rotary kiln, the draft through the stack can be controlled by infinitely variable positioning of the cap.



LURGI	SL/RN AFTER BURNING CHAMBER	C77-1177 E

Dust collected from the dust chamber at kiln inlet and the ESP is discharged via a series of rotary star feeders and Redler-type chain conveyors into a bucket elevator. Dust is stored in a dust bin.
A pug mill discharges moistened dust into trucks.



Refractory lining

- Dust chamber

  The arch of the dust chamber is lined with two layers of 150 mm thick refractory concrete and 100 mm thick insulating concrete.

  The castables will be anchored by corrugated V-anchors.

The walls and hopper section of the dust chamber will receive a two-layer brick lining. A super-duty fireclay brick of 114 mm thickness will be installed for the inside layer, backed by a 114 mm thick layer of insulating bricks. The refractory lining will be designed with the necessary expansion joints, steel supports and anchorage.

- Combustion chamber

  A high temperature-resistant refractory concrete with a thickness of 230 mm is envisaged for the internal refractory lining whereas a 114 mm thick insulating brick lining will be provided as insulation between the concrete and the metal shell. The refractory concrete will be anchored with corrugated V-anchors.

Transition and Emergency Stack

The internal refractory lining of these areas will consist of a refractory concrete together with a ramming clay for insulation.

.11 <u>Waste gas dedusting system</u>

Leaving the after-combustion chamber, the waste gas is pre-cooled directly by water injection and then enters two recuperator-type indirect air coolers arranged in parallel.

Gases pass vertically downwards through the pipes of the first cooler section and after being deflected 180 °C above the dust collection hopper of the cooler, pass vertically upwards through the pipes of the second section. Cooled gases enter the electrostatic precipitator via a collector duct.

Cooling is achieved by a series of axial blowers. Cooling air flow enters the cooler horizontally on the "hot" side (first section) and leaves on the "cold" side. This principle ensures that below dew point conditions are avoided, thus preventing cooler corrosion in the cold section. Individual cooling air ventilators are shut down automatically if the temperatures of the cooler exit gases drop below a pre-set point.

We have provided a horizontal precipitator for each kiln strand with two electrostatic fields. The dust is discharged by way of an extraction chain conveyor and a double-flap valve. The high tension direct current is supplied to the two electrostatic fields by two transformer-rectifier sets of the latest design with thyristor control.

After the electrostatic precipitator, the waste gas passes the radial flow fan and is then discharged into the stack. The waste gas fan is equipped with automatic louvre damper control.

.12 Plant dedusting system

One centralized dedusting system for the DR-plant is provided.

The system mainly consists of:

- dust hoods and suction ducts,
- electrostatic precipitator,
- clean air ducts and stack,
- waste air fan,
- dust conveyors, storage bin and dust loadout pug-mill with truck charging facilities.

.13 Compressed air system

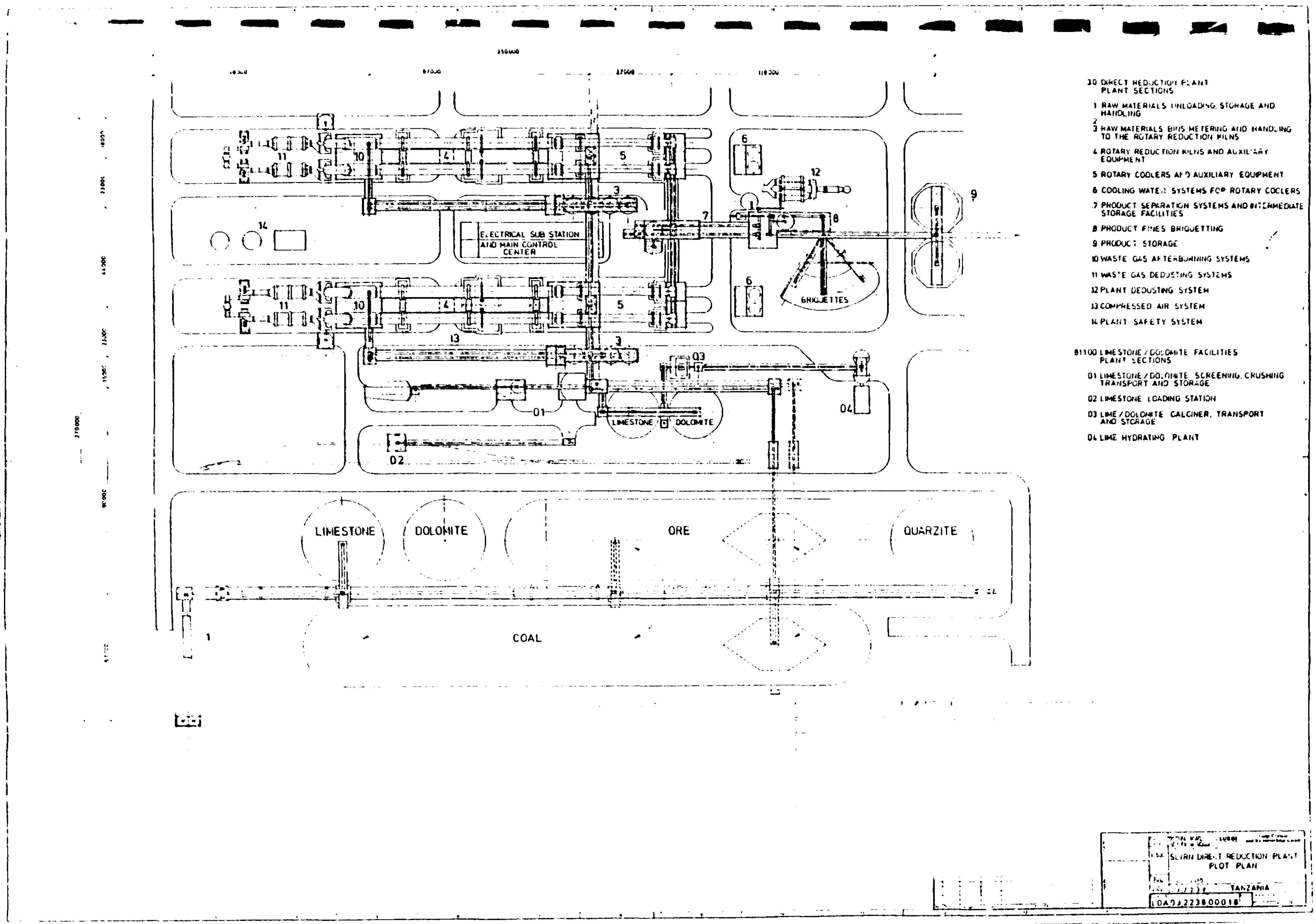
A compressed air station and distribution system for equipment and general purposes is provided.

.14 Plant safety

A fire alarm- and fire fighting system is provided.

The fire fighting system mainly consists .:

- two water storage tanks,
- pump station with main- and jokey pumps,
- ring main, hydrants and hoses,
- various fire extinguishers.



ELECTRICAL SUB STATION
AND MAIN CONTROL CENTER
BRIQUETTES
LIMESTONE
DOLOMITE
LIMESTONE
DOLOMITE
ORE
QUARZITE
COAL
30 DIRECT REDUCTION PLANT
PLANT SECTIONS
1 RAW MATERIALS UNLOADING, STORAGE AND HANDLING
2
3 RAW MATERIALS BINS, METERING AND HANDLING TO THE ROTARY REDUCTION KILNS
4 ROTARY REDUCTION KILNS AND AUXILIARY EQUIPMENT
5 ROTARY COOLERS AND AUXILIARY EQUIPMENT
6 COOLING WATER SYSTEMS FOR ROTARY COOLERS
7 PRODUCT SEPARATION SYSTEMS AND INTERMEDIATE STORAGE FACILITIES
8 PRODUCT FINES BRIQUETTING
9 PRODUCT STORAGE
10 WASTE GAS AFTERBURNING SYSTEMS
11 WASTE GAS DEDUSTING SYSTEMS
12 PLANT DEDUSTING SYSTEM
13 COMPRESSED AIR SYSTEM
14 PLANT SAFETY SYSTEM
81100 LIMESTONE / DOLOMITE FACILITIES
PLANT SECTIONS
01 LIMESTONE / DOLOMITE SCREENING, CRUSHING TRANSPORT AND STORAGE
02 LIMESTONE LOADING STATION
03 LIME / DOLOMITE CALCINER, TRANSPORT AND STORAGE
04 LIME HYDRATING PLANT
SL/RN DIRECT REDUCTION PLANT
PLOT PLAN
TANZANIA

SECTION 3.3

Raw Materials and Products

3.3 Raw Materials and Products

3.3.1 Raw Materials

Liganga/Maganga Pellets

$Fe_{tot.}$	%	60.7
Fe^{2+}	%	0.3
CaO	%	0.86
MgO	%	1.8
SiO_2	%	0.53
Al_2O_3	%	2.7
TiO_2	%	6.2
V_2O_5	%	0.6
Cr_2O_3	%	0.31
S	%	0.002
L.O.J.	%	0.04

Grain size	6 - 10	mm
Bulk density	2.1	t/m^3
Moisture	2	%

Feed Rates (kiln inlet)

- per strand	32.2	tph
- total plant	128.8	tph
- annual	928,000	tpy
- specific	1.41	t/t DRI

Mchuchuma Coal (washed)

C fix	%	54.2
Vol. Matter	%	25.0
Ash	%	20.8
S	%	0.6
S.J.		1

Grain size	0 - 10	mm
Bulk density	- 0.95	t/m³
Moisture	10	%

Feed rates (kiln inlet)

- per strand	16.9	tph
- total plant	67.8	tph
- annual	489,000	tpy
- specific	0.74	t/t DRI

Chalinze Dolomite

$CaCO_3$	%	51.2	
$MgCO_3$	%	33.3	
SiO_2	%	15.3	
Al_2O_3	%	0.2	

Grain size	C - 3	mm
Bulk density	- 1.3	t/m³
Moisture	2	%

Feed Rates (kiln inlet)

- per strand	2.25	tph
- total plant	9.0	tph
- annual	64960	tpy
- specific	0.098	t/t DRI

Air

Air volume to each kiln: 57.100 Nm³/h
Air volume to each after combustion unit : 15.800 Nm³/h

3.3.2 Products

....

DRI

Metallisation	%	92
$Fe_{tot.}$	%	81
FeO	%	8.3
$Fe_{met.}$	%	74.5
C	%	0.06
S	%	0.02
CaO	%	1.1
MgO	%	2.4
SiO_2	%	0.7
Al_2O_3	%	3.5
TiO_2	%	8.1
V_2O_5	%	0.8
Cr_2O_3	%	0.4

Grain size	5 - 10	mm
Bulk density	1.6	t/m^3

Discharge Rates (product separation)

- per strand	21	tph (+ 5 mm)
- total plant	87.7	tph (+ 5 mm)
- annual	633.000	tpy (+ 5 mm)

Fine DRI (1 - 5 mm)

Metallisation	%	92	
C	%	0.5	
S	%	0.03	

Grain size	1 - 5	mm
Bulk density	1.8	t/m^3

Discharge Rates (product separation)

- per strand	1.15	tph
- total plant	4.62	tph
- annual	33,000	tpy
- specific	0.052	t/t DRI (+ 5 mm)

Briquettes (1 - 2")

Briquettes as produced from DRI (1 - 5 mm):

Grain size	1 - 2"	
Bulk density	2.7	t/m^3

Production Rates

- hourly	10	tph
- annual	35,310	tpy

Continuous operation 5 days per week.

Dolochar

C_{fix}	%	18.4	
Ash	%	58.5	
Spent Dolomite	%	23.1	
Bulk density		- 0.65	t/m^3
Grain size		- 5	mm

Discharge rates (product separation)

- per strand	5.06	tph
- total plant	20.25	tph
- annual	146,000	tpy
- specific	0.22	t/t DRI (+ 5 mm)

Waste gas dust

Iron ore	%	65	
Dolomite	%	11	
C fix + Ash	%	24	
Grain size		0 - 1	mm
Bulk density		- 1	t/m^3

Discharge Rates (ESP plus dust chamber)

- per strand	1.4	tph
- total plant	5.6	tph
- annual	40,350	tpy
- specific	0.06	t/t DRI

Clean Waste Gas

CO_2	%	19.6
H_2O	%	16.7
N_2	%	63.2
O_2	%	0.5
SO_2	%	- 0.1

Temperature: + 200 °C
Volume per strand: 90.000 Nm³/h
Volume at stack: 360.000 Nm³/h

V 4303 A 10 80

SECTION 3.4

Consumption Figures and Workforce Schedule

3.4 Consumption Figures and Workforce Schedule

3.4.1 Consumption Figures

For the production of 660,000 tpy DRI in a 4-strand SL/RN plant from Liganga/Maganga pellets using Mchuchuma coal as the only energy source and Chalinze dolomite as desulphurizer, the following specific consumption figures apply:

	per ton DRI		per year	
Pellets (2% moisture)	1.48	t	990,000	t
Coal (10% moisture)	0.76	t	500,000	t
Dolomite (2% moisture)	0.10	t	66,000	t
Electric power	110	KWh	72,600	MWh
Fuel oil (for start-up)	-		300	t
Cooling water	2.2	m³	1.45 Mio.	m³
Consumable and spares	5	US$	3.3 Mio.	US$
Briquetting binders (molasses + hydrated lime)	3.5	kg	2,310	t
Workforce (operation and maintenance)	0.85	mhrs	256	men

Remark: All material flow figures contain approx. 5 % margin for handling losses.

3.4.2 Workforce Schedule , DR Plant Mahanje

(G = Graduated; S = Skilled; SS = Semi-Skilled; US = Unskilled)

	Shift 1	Shift 2	Shift 3	Shift 4	Day Shift	Total	Qualification Level
Manager DR Plant					1	1	G
Assistant Managers					4	4	G
Process Eng.					1	1	G
Shift Formen							
- Raw Mat.	1	1	1	1	1	5	S
- Products	1	1	1	1	1	5	S
- Kilns I-IV	4	4	4	4	2	18	S
- Mech. Maint.	2	2	2	2	1	7	S
- Refractory					1	1	S
- El. Maint.	1	1	1			3	S
- Instrument.	1	1	1			3	S
Controller							
- Raw Mat.	1	1	1	1	1	5	S
- Products	1	1	1	1	1	5	S
- Kilns I-IV	4	4	4	4	2	18	S
Filters							
- Mechanical	2	2	2	2	2	10	S
- Electrical	2	1	1	1	1	6	S
- Instrument.	2	1	1	1	1	6	S
Operators							
- Raw Mat.	2	2	2	2	2	10	SS
- Products	2	2	2	1	1	8	SS
- Kilns I-IV	4	4	4	4	2	18	SS
Helpers							
- Raw Mat.	3	3	3	3	2	14	US
- Products	3	3	3	3	2	14	US
- Kilns I-IV	8	8	8	8	2	34	US
- Mech. Maint.	4	4	4	4	2	18	US
- El. Maint.	2	2	2	2	1	9	US
Sub-total	50	48	48	43	34	223	
15 % absentees	8	7	7	6	5	33	
Total	58	55	55	49	39	256	

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SECTION 3.5

Auxiliaries

3.5 Auxiliaries

The provision of media and electr. energy will cover the requirements for:

- plant normal- and emergency operating conditions
- plant startup- and shutdown conditions
- repair- and maintenance support
- fire fighting installations

In general, this comprises the supply of:

- industrial water
- fuel oil
- instrument air
- electr. energy

The applicable facilities for generation, treatment storage and distribution of above utilities comprise all items which form an operational unit with the respective process equipment they serve.
For description and outline specifications, see section 3.2 and 3.6 of the report.

For auxiliaries which do not form an integrated part of the process plant or which provide services for general requirements, see section 8. of the report.

SECTION 3.6

Outline Specifications

Direct Reduction Plant

3.6.1 Mechanical Equipment

Plant Sections

.01 Raw Materials Unloading, Storage and Handling

.02 -

.03 Raw Material Bins, Metering and Handling to the Rotary Reduction Kilns

.04 Rotary Reduction Kilns and Auxiliary Equipment

.05 Rotary Coolers and Auxiliary Equipment

.06 Cooling Water Systems for Rotary Coolers

.07 Product Separation Systems and Intermediate Storage Facilities

.08 Product Fines Briquetting

.09 Product Storage

.10 Waste Gas Afterburning Systems

.11 Waste Gas Dedusting Systems

.12 Plant Dedusting System

.13 Compressed Air System

.14 Plant Safety System

.1 Raw Material Unloading, Storage and Handling

Plant section 3.6.1.1 mainly comprises the following items:

1 unloading hopper, for raw materials

with two outlets,
material of construction: concrete,
including grate and two manually operated slide gates,

live capacity : 50 t

2 vibrating feeders, for raw materials

discharging the unloading hopper,

design capacity: 600 t/h

2 belt conveyors, for raw materials

design capacity: 1,200 t/h

1 boom stacker, for raw materials

design capacity: 1,200 t/h

1 moveable hopper, for raw materials

including two vibrating feeders,

design capacity: 490 t/h

4 discharge cone

located underneath day piles,
including shut-off gate.

4 vibrating feeder

discharging the raw material day piles,

design capacity: 490 t/h

1 belt conveyor system, for raw material

comprising 8 belt conveyors,

design capacity: 490 t/h

1 belt weigher

design capacity: 490 t/h

4 two way chutes

pneumatically operated.

1 lot transfer chutes

including wear resistant lining.

.3 Raw Material Bins, Metering and Handling to the Rotary Kilns

Plant section 3.6.1.3 mainly comprises the following items:

4 storage bins, for oxide pellets

live capacity : 835 t

material of construction: mild steel.

4 storage bins, for coal

live capacity : 335 t

material of construction : mild steel

4 storage bins, for dolomite

live capacity : 100 t

material of construction : mild steel

4 weighfeeders, for oxide pellets

design capacity : 40 t
range of control: 10 : 1

4 weighfeeders, for coal

design capacity : 20 t
range of control: 10 : 1

4 weighfeeders, for dolomite

design capacity : 10 t
range of control: 10 : 1

1 belt conveyor system

to rotary kiln inlet,
for mixed material, comprising 8 belt conveyors,

design capacity : 60 t/h

4 storage bins, for coal

live capacity : 40 t

material of construction: mild steel.

4 weighfeeders, for coal

design capacity : 5 t/h
range of control: 10 : 1

4 pneumatic coal injection systems

including compressors, coolers and feed piping to rotary kiln outlet head,

design capacity : 6 t/h

1 lot transfer chutes

including wear resistant lining.

.4 Rotary Reduction Kilns and Auxiliary Equipment

Plant section 3.6.1.4 mainly comprises the following items:

4 rotary reduction kilns

with 3 supports,

dia.	:	4.8 m
length	:	80 m

each kiln consisting of:

- kiln shell with welded on board items,
- kiln shell tire-sections,
- cast inlet and outlet segments,
- running tires,
- support- and thrust roller assemblies,
- support frames,
- various guard cases and protection equipment,
- various support structures,
- hydro thruster,
- hydraulic system for hydro thruster,
- fans for air cooling of inlet and outlet sections,
- cooling air ducts,
- kiln feed tube,
- kiln inlet and outlet seals,
- seals lubrication systems,
- gear rim- and pinion assemblies,
- pillow block assemblies,
- lubrication system,
- main gear box,
- emergency gear box,
- couplings,
- brakes,
- clutches,

- kiln outlet head,
- air injection tube assemblies,
- air injection nozzle assemblies,
- shell air fans,
- air duct systems,
- regulating valves,
- compensators,
- inspection glasses,
- refractory bricks for kiln shell,
- refractory castable for kiln shell,
- refractory bricks and castable for kiln outlet head,
- refractory anchors.

4 central burner system

for heavy fuel oil,
including fuel oil storage tanks, pumps, piping and heating facilities, combustion air fans and air ducts.

design capacity : 400 kg/h

4 sealing air fan systems

for rotary kiln inlet feed tubes,
including air ducts and valves,

design capacity : 1,200 m³/h

.5 Rotary Coolers and Auxiliary Equipment

Plant section 3.6.1.5 mainly comprises the following items:

4 rotary coolers

with 2 supports,

dia.	:	3.6 m
length	:	50 m

each cooler consisting of:

- cooler shell with welded on-board items and screening section,
- running tires,
- support- and thrust roller assemblies,
- support frames,
- various guard cases and protection equipment,
- various support structures,
- hydro thruster,
- hydraulic system for hydro thruster,
- fan for air cooling of inlet section,
- cooling air duct,
- cooler inlet- and outlet seals,
- seals lubrication systems,
- gear rim and pinion assemblies,
- pillow block assemblies,
- lubrication system,
- main gear box,
- emergency gear box,
- couplings,
- brakes,
- clutches,
- cooler inlet chute with operating platform,
- cooler outlet head with oversize chute,
- cast segments for cooler inlet chute,

- actuator for oversize chute,
- water spray system for indirect cooling,
- water spray system for direct cooling,
- spray nozzles,
- regulating and control equipment,
- refractory castable for cooler shell,
- refractory bricks and castable for cooler inlet chute,
- refractory anchors,
- special erection equipment,
- cooler incasings, including vapour hoods and vapour stacks.

.6 Cooling Water Systems for Rotary Coolers

Plant section 3.6.1.6 mainly comprises the following items:

4 collecting troughs, for cooling water

from rotary coolers,

material of construction : concrete

2 piping systems, for cooling water

from rotary coolers to basin for warm water.

2 basins, for warm water from rotary coolers

material of construction : concrete.

4 centrifugal pumps, for cooling water

from rotary cooler, feeding the cooling towers,

design capacity : 700 m^3/h

2 pumps as stand-by.

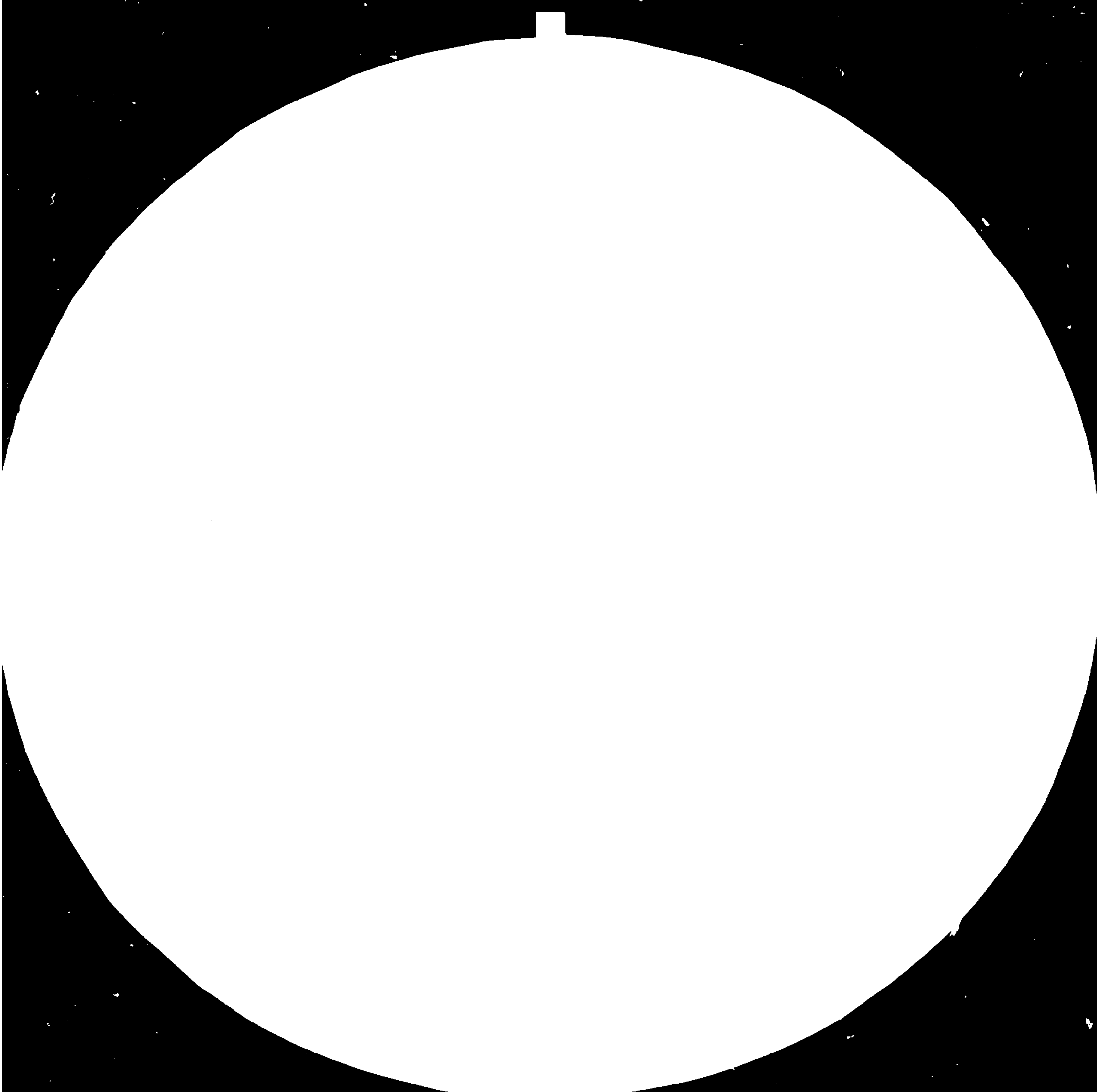
4 cooling towers, for cooling water
including cooler fans,
design capacity : 350 m³/h each

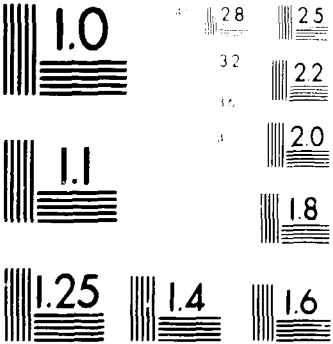
2 basins, for cold water from cooling tower
material of construction : concrete.

6 centrifugal pumps, for water
to rotary coolers,
design capacity : 700 m³/h
2 pumps as stand-by.

4 piping system, for cooling water
to rotary coolers.

2 dosing stations, for biocide
including pumps.





MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS

STANDARD REFERENCE MATERIAL 1010a

(ANSI and ISO TEST CHART No. 2)

2 basins, for direct cooling water

material of construction : concrete

4 high pressure pumps

for supply of direct cooling water to rotary coolers,

design capacity : 3 m³/h

4 piping systems

for direct cooling water.

.7 Product Separation Systems and Intermediate Storage Facilites

Plant section 3.6.1.7 mainly comprises the following items:

8 double pendulum valves

for cooler discharge material,

design capacity : 35 t/h

2 belt conveyor systems

for cooler discharge material, comprising 4 belt conveyors,

design capacity : 70 t/h

2 belt weighers

design capacity : 35 t/h

2 automatic sampler

for cooler discharge material.

4 two way chutes

pneumatically operated.

1 vibrating feeder

for cooler discharge material,

design capacity : 135 t/h

1 intermediate bin

for cooler discharge material,

live capacity : 600 t

material of construction : mild steel

2 vibrating feeders

for cooler discharge material,

design capacity : 70 t/h

2 flexowell conveyors

for cooler discharge material,

design capacity : 70 t/h

2 vibrating screens (double deck)

for cooler discharge material,

design capacity : 70 t/h
feed mat'l size : 0-25 mm
undersize : 0-5/5-25 mm

2 magnetic separators

for cooler discharge material,
comprising integrated vibrating feeders,

feed mat'l size	:	5-25 mm
design capacity	:	70 t/h
drum dia.	:	900 mm

2 two-stage magnetic separators

for coolers discharge material,

comprising integrated vibrating feeders,

feed mat'l size	:	0-05 mm
design capacity	:	14 t/h
drum dia.	:	900 mm

1 belt conveyor

for non-magnetics,

design capacity : 25 t/h

1 bucket elevator

for non-magnetics and dust,

design capacity : 25 t/h

1 storage bin

for non-magnetics and dust,

live capacity : 180 t/h

including slide gate and telescope chute.

2 belt conveyors

for product fines,

design capacity : 10 t/h

1 bucket elevator

for product fines,

design capacity : 10 t/h
centre distance : 23 m

1 conveyor system, for product

feeding the storage bins,

comprising 3 belt conveyors,

design capacity : 110 t/h

1 lot transfer chutes

including wear resistant lining.

.8 Product Fines Briquetting

Plant section 3.6.1.8 mainly comprises the following items:

1 storage bin, for product fines

live capacity	:	150	t
material of construction	:	mild steel	

1 weighfeeder, for product fines

design capacity	:	10	t/h
range of control	:	10:1	

1 feed hopper

for charging recycled material, including grate and manually operated gate,

live capacity	:	6	t

1 vibrating feeder

for charging recycled material,

design capacity	:	3	t/h

1 belt conveyor

for product fines and recycled material,

design capacity : 12 t/h

1 vibrating feeder

for product fines and recycled material,

design capacity : 12 t/h

1 bucket elevator

for product fines and recycled material, feeding the continuous mixer,

design capacity : 12 t/h
centre distance : 19 m

1 storage bin, for hydrated lime

live capacity : 20 t
material of construction : mild steel

including bin filter, aeration equipment and fan.

1 star-wheel feeder

for hydrated lime,

design capacity : 0.5 t/h

1 weighfeeder, for hydrated lime,
feeding the continuous mixer,
design capacity : 0.5 t/h

1 storage tank
for liquid binder (molasses),
live capacity : 30 t
material of construction : mild steel

1 storage tank
for water,
live capacity : 2 m^3
material of construction : mild steel

2 pairs piston dosing pumps,
for liquid binder (molasses),
design capacity : 0.2-0.5 t/h
one pair as stand-by.

1 pump
for liquid binder recirculation,
design capacity : 10 m^3/h

1 piping system, for liquid binder

feeding the continuous mixer.

1 continuous mixer

for product fines, return fines,
dry binder and liquid binder,

design capacity : 12 t/h

1 chain conveyor

for mixed material,
with two outlets,

design capacity : 12 t/h

1 briquetting machine

for mixed material,

feed mat'l size : 0-5 mm
design capacity : 12 t/h

1 vibrating screen, (single deck)
for briquettes or max. 100 % return fines.
design capacity : 12 t/h

1 belt conveyor
for return fines,
design capacity : 12 t/h

1 belt weigher
for return fines conveyor,
design capacity : 12 t/h

1 belt conveyor
for briquettes,
design capacity : 12 t/h

1 belt weigher
for briquettes conveyor,
design capacity : 12 t/h

1 belt conveyor, slewing and lifting,
for briquettes,
design capacity : 12 t/h

1 lot transfer chutes
including wear resistant lining,

1 crane
lifting capacity: 6 t

.9 Product Storage

Plant section 3.6.1.9 mainly comprises the following items:

2 storage bins, for product

including rock ladders,

live capacity : 7,500 t

material of construction : mild steel/concrete

2 vibrating feeders, for product

design capacity : 60 t/h

2 belt conveyors, for product

feeding the transfer system of the electric smelting plant,

design capacity : 60 t/h

1 lot transfer chutes

including wear resistant lining.

.10 Waste Gas Afterburning System

Plant section 3.6.1.10 mainly comprises the following items:

4 dust settling chambers

for waste gas.

4 high pressure water spray nozzles

with return pass,

design capacity : 2 m^3/h

4 double pendulum valves

for kiln back flow,
including wear resistant lining,

design capacity : 2 t/h

4 bucket elevators

for kiln back flow,

design capacity : 2 t/h
elevator length : 25 m

1 lot transfer chutes

including wear resistant lining.

4 chain conveyors

for dust,

design capacity : 0.5 t/m³

4 double pendulum valves

for dust,

design capacity : 0.5 t/m³

4 expansion joints

between dust settling chamber and afterburning chamber.

4 afterburning chambers

for waste gas,

diameter : 4.8 m
height : 12 m

including:

- ring mains for water,
- ring mains for air,
- hign pressure water spray nozzles with return pass,
- combustion air fans,
- duct systems between fan and afterburning chambers.

4 ducts for waste gas

between afterburning chamber and emergency stack, including expansion joints.

4 emergency stacks

for waste gas,

including:

- cape for stack with centre weight,
- hydraulic actuator,
- emergency winch,
- hydraulic pump.

4 ducts for waste gas

between afterburning chamber and indirect coolers, including high pressure water spray nozzles with return pass.

2 water basins

for water to high pressure spray nozzles,

live capacity : 20 m³

material of construction : concrete

including floating valve.

6 high pressure pumps

for water to high pressure spray nozzles,
2 pumps as stand-by,

design capacity : 16 m³/h

2 filters

for water to high pressure spray nozzles.

4 piping systems

for water from and to spray nozzles.

4 lots refractory lining

the refractory lining comprises:

- superduty fireclay bricks,
- insulating bricks,
- insulating castable,
- anchors.

The following items are refractory lined:

- dust settling chambers,
- afterburning chambers,
- ducts,
- emergency stacks.

.11 Waste Gas Dedusting System

Plant section 3.6.1.11 mainly comprises the following items:

8 indirect air coolers

for waste gas,

including axial blower for cooling air.

8 star-wheel feeders

design capacity : 0.2 t/h

2 chain conveyors

for dust,

design capacity : 1 t/h

2 ducts, (Y-type)

between indirect air coolers and electrostatic precipitators, including expansion joints.

4 electrostatic precipitators

for waste gas,
including rapping devices and steel structures.

capacity, Vn	:	105,000	m³/h
temperature	:	250	°C

4 bottom chain conveyors

for dust,

design capacity : 1 t/h

4 double pendulum valves

for dust,

design capacity : 1 t/h

4 ducts

for clean waste gas,
between electrostatic precipitators and
waste gas fans,
including expansion joints.

4 waste gas fans

including motor base frame,

capacity, Vn	:	105,000	m³/h
temperature	:	250	°C

4 vanes

for waste gas fans.

4 ducts

for waste gas,
between waste gas fans and stack,
including expansion joints.

2 waste gas stacks

height : 50 m

2 bucket elevators

for dust,

design capacity : 3 t/h

2 storage bins

for dust,

live capacity : 125 t

material of construction : mild steel

2 pug mills

for dust,

design capacity : 15 t/h

including water spray system.

1 <u>lot transfer chutes</u>

including wear resistant lining.

.12 Plant Dedusting System

Plant section 3.6.1.12 mainly comprises the following items:

1 duct system

between pick-up points and electrostatic precipitator.

1 electrostatic precipitator

with steel structure and rapping device,

capacity, approx.: 468,000 m³/h

2 bottom chain conveyors

for dust,

design capacity : 4 t/h

2 double pendulum valves

for dust,

capacity : 4 t/h

2 chain conveyors

for dust,

design capacity : 8 t/h

1 duct system

from electrostatic precipitator to fan,
including expansion joints.

1 exhaust fan

for electrostatic precipitator,

capacity	:	468,000 m^3/h

1 duct system

from exhaust fan to stack,
including expansion joints.

1 stack

for electrostatic precipitator,

diameter	:	3 m
height	:	30 m

1 lot transfer chutes

including wear resistant lining.

.13 Compressed Air System

Plant section 3.6.1.13 mainly comprises the following items:

2 air compressors, (1 as stand-by)
for compressed air,
design capacity : 950 m³/h

1 pressure vessel, (air receiver)
for compressed air,
capacity : 10 m³

1 air dryer
for compressed air.

1 piping system
for compressed air.

.14 Plant Safety System

Plant section 3.6.1.14 mainly comprises the following items:

2 fire fighting pumps

capacity	:	150	m^3/h
pressure	:	10	bar

2 jockey pumps

capacity	:	15	m^3/h
pressure	:	10	bar

1 fire fighting pump, (stand-by)

capacity	:	300	m^3/h
pressure	:	10	bar

including diesel engine.

2 air compressors

capacity	:	3	m^3/h
pressure	:	16	bar

2 pressure vessels

capacity	:	1	m^3

1 fuel storage tank

for light oil,

live capacity	:	1	m³

2 ventilators

for pump station,

capacity	:	15,000	m³/h

2 water basin

live capacity	:	310	m³ ea.
diameter	:	8	m
height	:	10	m

45 outdoor hydrants

DN	:	100

25 wall hydrants

1 manual and automatic fire alarm system

for the complete plant,

comprising:

- smoke detectors,
- heat detectors,
- manual alarm boxes.

Portable and mobile fire fighting extinguishers

comprising:

50 portable CO_2-extinguishers

capacity : 10 kg

80 portable dry powder extinguishers

capacity : 12 kg

4 wheeled dry powder extinguishers

capacity : 50 kg

4 wheeled dry powder extinguishers

capacity : 100 kg

3.6.2 Electrical Equipment

.00 General Prerequisite

.01 6.0 kV Medium High-Voltage Board

.02 380 V Low-Voltage Switchgear Boards

.03 Variable Voltage DC-Motor Controls + Power Supply

.04 Programmable Logic Control System

.05 Local Switchgear

.06 Power Transformers

.07 6000 V Medium High-Voltage Motors

.08 380 V Low-Voltage Motors

.09 Variable Voltage DC-Motors

.10 Plant Lighting

.11 Cables

.12 Installation Material

.13 Intercommunication System

.14 Airconditioning Installation

.15 Ventilation System

.16 Grounding

.17 Emergency Power Supply

.18 Sliprings for Rotary Kilns

.19 Power Distribution on Rotary Kilns

.00 General Prerequisites

Main Data

medium high-voltage:	6.0	kV, 50 cps
low-voltage :	380	V, 50 cps
lighting system :	380/220	V, 50 cps
control voltage for power portion :	220	V, 50 cps
control voltage for control system :	48	V, DC
signal voltage :	24	V, DC

Protective Measures for:

medium high-voltage system : grounding via resistance

low-voltage system : transformer starpoint solid grounding

Regulations and Standards

DIN, VDE, IEC, LURGI Standards

Supply Limits

Connection terminals on the circuit breaker of the incoming feeder in the 6.0 kV switchgear.

.01 6.0 - Medium High-Voltage Board

The switchgear installation will be of indoor design with sheet steel clad panels with drawout circuit breakers. The single bus bar system will have a continuous current rating of 1,600 A and will be braced for a fault level of 100 MVA. Circuit breakers will have motor operated closing mechanism (110 V, DC-supply) and will be of the 3-pole low oil volume type.

Technical Data

operating voltage	:	6.0 kV
frequency	:	50 Hz
rated bus bar current	:	1,600 A
system short circuit capacity	:	100 MVA
enclosure	:	IP 40

The board mainly consists of the following panels:

- incoming feeder panel, equipped with minimum oil circuit breaker
- measuring panel,
- motor out-feed panels, each equipped with: vacuum contactors and fuses,
- transformer panels, equipped with minimum oil circuit breaker.

Battery System

A battery system of 110 V has been envisaged for the control and monitoring of the medium high-voltage switchgear board.

The system consists of:

1 lead storage battery, 110 V
1 constant voltage rectifier in a sheet steel casing for automatic charging of the battery system.

.02 Low Voltage Switchgear Boards

The distribution board will be provided to be supplied by 6.0/0.38 kV transformers.

Separate 380 V motor control centres (MCC) will be provided for different sections of the plant.
The MCC will be of sheet steel, dust-tight, enclosed cubicles compartmental construction having 3-phase bus bars and being provided with plug-in, draw-out modular type incoming and outgoing feeder compartment.

Special supply transformer for control voltage with primary isolator and HRC fuses on primary and secondary side will be accommodated in the MCCs.

.03 Variable Voltage DC-Motor Controls and Power Supply

The main components of the power supply of the DC-motors for each rotary kiln and cooler are the rectifier-transformers and the thyristor units.
The rectifier transformer to be of cast-resin type with the following data:

1. for motors of the rotary kiln

power output	:	1,000	kVA
vector group	:	Dyn	5
imp. voltage	:	6	%

2. for motors of the cooler

power output	:	400	kVA
vector group	:	Dyn	5
imp. voltage	:	6	%

Each of the transformers will supply two thyristor supply units. The thyristor units will be designed for single quadrant operation.

The switchgear will be located in air-conditioned rooms and rated for an ambient temperature of 45 °C. Max. degree of protection will be IP 20.

.04 Programmable Logic Control (PLC)

for process controlling.

The programmable logic control mainly consists of:

- the central controller including program memory module, processor module, function check module,
- power supply unit, counter, timer units,
- extension units including input and output modules to match the number of inputs and outputs to the particular control problem.
  The bus system transfers the data between the central function units and the peripheral modules (inputs, outputs),
- interface to central computer.

The required control functions are implemented by program stored in memories.

Additional equipment:

1 printer,

1 video-monitor.

Emergency stop-switches are made in relay technique and connected to the motor circuit breaker.
All other interlockings and sequence control are connected to and made in the PLC.

The analysis of interlocking conditions is done in the PLC. When there is a fault, the following indications will be sent from the PLC to the central control panel mimic diagram:

- audible alarm,
- faulty drive,
- type of fault.

The control voltage for the external control portion is 48 V DC. The entire control portion is accommodated in a sheet steel clad control cubicle, located in a pressurized room and rated for an ambient temperature of 45 °C.

The coupling relays for the power portion are located in the MCC's.

.05 Local Switchgear

The following equipment is provided for the local control of the consumers:

- local control box

  consisting of:

  1 operation selector switch, lockable in the O-position,

  switch positions

  1 - local control

  0 - blocked (connection for drive impossible)

  2 - remote control (group operation from the central control panel)

  1 momentary contact push-button for 'start',

  1 selector switch in case of a reversible drive,

  1 terminal strip with series terminals,

  1 stay-put push-button for 'stop'.

- limit switches

- pull rope emergency switches

  arranged at a distance of approx. 50 m.

- belt speed monitors

- emergency stop switches

- crane switches

.06 Power Transformers

three-phase oil transformers of outdoor performance,

each equipped with:

- oil temperature indicator with alarm and trip contacts,
- buchholz relay with alarm and trip contacts,
- pressure relief device.

The following transformers are provided:

- power distribution transformers

rated output	:	1,600	kVA, respt. 1,250 kVA
high-side voltage	:	6.0	kV
low-side voltage	:	380	V

- lighting transformer

rated output	:	250	kVA
high-side voltage	:	6.0	kV
low-side voltage	:	380	V

.07 6,000 V High-Voltage Motors

Electrical drives of 200 kW and above will be provided as 6,000 V squirrel cage motors.
The motors will be designed for direct on line starting.

rated voltage	:	6,000	V
rated frequency	:	50	cps
enclosure	:	IP 55	
insulation class	:	F	
temperature utilization according to	:	B	
type of construction	:	B3	

The motors will be equipped with:

- anti-condensation heater,
- winding temperature detectors,
  (for motors larger than 4,000 kW).

The motors will be designed for three consecutive starts from cold respectively two consecutive starts from hot condition.

.08 Low Voltage Motors

The motors to be of totally enclosed, fan-cooled squirrel cage/slipring induction type, the former being suitable for direct-on-line starting.
Motor dimensions will comply with relevant IEC standards. Slipring motors will be supplied complete with starting resistors.

rated voltage	:	380	V
rated frequency	:	50	cps
enclosure	:	IP 54	
insulation class	:	B	
temperature utilization according to:		B	

.09 Variable Speed DC-Motors

DC-motors to be horizontal foot-mounted, totally enclosed, separately excited, shunt wound machines giving constant output torque over the full speed range. The motors will operate in conjunction with the thyristor converter equipment,

enclosure	:	IP 54
insulation class	:	F

.10 Plant Lighting Installation

The plant lighting will operate on a 380/220 V supply. The light fittings in all the sections of the plant will be controlled from local switch-fuse/lighting distribution boards.

Outdoor lighting will be provided for the plant entry gates and equipment:

The following light fittings have been envisaged:

a) mercury vapour lamps for high bay installation,

b) fluorescent lamps for rooms and offices,

c) incandescent lamps for low bay installation.

The lighting volume will include welding sockets for 380 V/63 A as well as sockets for 220 V/15 A.

.11 Cables

All power and control cabling for the complete plant will be included. The main cable runs will be carried on trays or ladder racks. All cables and core terminations will be number ferruled for identification purposes.

The complete installation will be in accordance with VDE standards and relevant regulations and will comply with good engineering practices.

.12 Installation Material

The installation material comprises:

- cable racks for horizontal and vertical installation of the main cable routes, including accessories such as bracket columns and fastening irons, without covering, steel-armoured tubes with clamps etc.,
- cable clamps,
- small items such as bolts, nuts etc.,
- installation auxiliaries, cable and sealing boxes, cable lugs, cable clamps, marking material etc.

.13 Intercommunication System

An intercommunication system will be envisaged for the internal communication of the staff with the central control stand. The required partner can be contacted directly via loudspeaker by actuating a switch. Furthermore, it is possible to contact, from the exchange in the control stand, all speaking points simultaneously (collective call) or individual speaking point groups (group call).
The individual partners can speak with each other directly without intervention of the exchange.

.14 Air Conditioning Installation

An air-conditioning installation has been envisaged for the central control stand.

.15 Ventilation System

An over-pressure ventilation system has been envisaged for the switchgear installation rooms with a view to maintaining these rooms free of dust and to dissipate the heat of the losses.

.16 Grounding

The entire grounding system will be provided, complete with earthing rods in order to achieve the specified total earthing resistance not exceeding 2 Ohm. The earthing ring main will consist of galvanized band iron.

.17 Emergency Power Supply

1 Diesel generating set will be envisaged for the supply of the required consumers including approx. 10 % of the lighting system in the case of a mains failure. It will start automatically and feed the emergency service board.

The Diesel generating set is designed for:

rated output	:	1,400	kVA
rated voltage	:	380	V
rated frequency	:	50	cps

and mainly consists of:

- three-phase constant voltage generator with constant voltage unit,
- base frame for the accommodation of the engine and the generator,

1 battery installation with battery charger,

1 cabinet for automatic system,

1 exhaust system, complete,

1 day tank for oil.

.18 Sliprings for Rotary Kiln

For transmission of electrical power to the shell air-fans on the rotary kiln, we have provided 4 power sliprings. For supervision of an electrical fault on the kiln, we have provided for a signal-transmission via two control sliprings. 1 slipring continuous and 1 divided slipring for temperature measuring.

.19 Power Distribution on Rotary Kiln

Power distribution on the rotary kiln will be achieved by a distribution unit arranged on the kiln shell. The distribution system consists of bus bars, fused load switches and motor protection switches.

3.6.3 Instrumentation Equipment

.01 General Design

- The overall plant will be monitored and controlled in clearly arranged manner from a central control stand, to be suitably accommodated in a building.
- Generally, all transmission and control functions will be electronic, utilizing a 4...20 mA DC-signal.
- In exceptional cases, such as for current measurements, indicators are connected directly to the secondary side of the current transformer with 1 ampere output.
- No pneumatic transmission systems will be applied.
- Potential free contacts will be used for binary signal transfer from instrumentation system onto the control system.
- Alarm and interlock contacts will be normally closed. "Normally" refers to normal conditions of process or device and bears no relation to "shelf" contact position and/or manufacturer's switch or terminal markings.
- For connection to resistance thermometers, a 3-wire-lead-system will be applied.
- The instrumentation will be based on a conventional analogue control system.
- The system design and procurement procedures will be executed in such a manner that a minimum number of types and manufacture of components are considered for both field and control panel equipment.
- Special precautions will be taken in order to protect field mounted electronic equipment in tropical and semi-tropical environments.

- Electronic circuit boards for converters and transmitters will be tropicalized with humidity and fungus-resistant coatings.

- All electronic equipment (electronic temperature converters, etc.) will be located in a controlled climate area.

- The control room will be designed as an entity, i.e. all control panels mounted therein, irrespective of the section of plant or the source of supply, are to be of similar design.

  The control room should be maintained at a temperature of 20 °C + 5 °C and should be suitably ventilated and if necessary pressurized to ensure that dust, flammable or noxious gases cannot enter.

.2 Design Components

Field instruments

All locally mounted instrumentation hardware will be designed and protected to withstand a high humidity tropical environment and an industrial plant atmosphere loaden with coal/ore dust.

Local indicating measuring instruments

the following will be used:

- pressure gauges,
- flow meters,
- level indicators,
- contact manometers and contact thermometers, normally of dial 160 mm type with inductive slots.

The pressure gauges to be of stainless steel, furnished with filling liquid and/or pulsation dampeners for pulsating services.

Local temperature indication should be made by bimetallic thermometer.

Local measuring detectors

- resistance thermometers,
- thermo-couples,
- pressure tapping branches for connection to pressure measuring units,
- measuring orifices for flow measurements, annubars, venturi tubes, flow meters, level measuring probes working on a capacitive or conductivity basis, load cells.

Where necessary, protective tubes are built into pipelines and containers for the incorporation of temperature sensors. Stop flanges and counter flanges at the thermo-sensors are included in the supply volume.

As far as the level measuring probes are concerned, the electronic components will preferably be mounted in the vicinity of the probes.
Special cables will be used for connecting the level measuring probes and the load cells to the electronic components.

Transmitters

Electronic transmitters are provided for transforming the physical quantities measured into a uniform signal. Wherever possible, the transmitter will be mounted in a protection box in the vicinity of the measuring point.
Their accuracy should be 0.5 % or less of the calibrated range. Electronic transmitters will generally be of two-wire type for operation with a 24 V DC loop power supply.
Output signal will be 4...20 mA, load capability will be 0...6000 mA minimum.

Pressure transmitters

- measuring elements of min. stainless steel,
- measuring cell of steel or stainless steel, depending on medium, with output indicator, output signal 4...20 mA DC.

Electronic temperature transmitters

Temperature transmitters will have a down-scale or up-scale burnout protection.
If using thermocouples, cold junction compensation circuits will be provided.

Final control elements

Electric drives will be used for the actuators on control valves and dampers.
The actuators will be equipped with R/I-transmitter (4...20 mA DC-output) for detection of the actuator position.
Displacement and torque dependent limit switches will be built in.

Panel instruments in general (144 x 72 mm)

Instruments of standard dimensions will be provided for the control panel. The instruments will be built into the panel in accordance with the course of production to allow a coordination with the flow diagram.

Indicating instruments (144 x 36 mm, 72 x 72 mm, 48 x 48 mm)

Indicators with moving coil elements, moving iron elements or potentiometric elements are proposed. Indicators may be equipped with adjustable potential free limit contacts.

Recorders, (144 x 144 mm, 288 x 144 mm)

For important measured values single-line recorders or double or triple recorders with compensating measuring system have been envisaged.
Temperatures and slowly varying quantites may be represented on single or multiple dotted-line recorders.

Input signal : 4...20 mA D.C.

The recorders may be equipped with a uniform chart (0-100 %). A reading ruler is to be added for evaluation purposes, the respective scale showing physical units.
The paper feed speed is normally 20 mm/h.

Controller

Controllers to be designed as analogue controllers, with an actual value and set-point indicator, with hand-automatic change-over switch, a reference value adjuster and a more-less adjusting device for hand operation.

The controller will provide indication of controllers output or true position of final control element.

The input and output side of the controller will be designed for the uniform signal used in the plant. Depending on the requirements, the controller is to be either designed with continuous output or as step controller.

Controller will be equipped with "anti-reset-wind-up" feature and output limiting.

Weighing system

The weighing equipment will emit a uniform signal of 4 - 20 mA which is available at the respective transfer terminal strip. This signal is used in the system of the entire measuring, control and regulating equipment for indication and recording or as reference for subordinate regulating circuits.

The essential instruments for the weighing and proportioning equipment which have to be monitored and newly adjusted in dependence on the process are also to be accommodated on the control panel.

Control Room Equipment

Conventional panels will be with switch console in the front. The panels to be open on the rear and on the top. Panel height to be 2,000 mm. A flow diagram, semigraphic, painted design, of approx. 800 mm height will be installed above the instrument panel, inclined approx. 10 °.

The display area contains the control stations, manual stations, recorders, indicators and the operating units for the weighing equipment.

All required motor control switches are built in the switch console.

The switches and the lamps in the mimics are marked with the associated consumer item number. Critical conditions will be indicated by rear light annunciator windows.

Auxiliary racks, cubicles

All the instruments for the measuring and regulating circuits other than field instruments or panel instruments in the control room will be accomodated on auxiliary racks. These instruments comprise system modules as there are transmitters, devices for square root extraction, isolating transformers for inputs and outputs, limit value units and the like. Since these instruments do not require constant monitoring, needing only occasional adjustment, for instance of the limit values, said auxiliary racks are installed in the control room behind the control panel.

Racks/cubicle will be of the free-standing type and will mainly follow manufacturer's standard design.

Interfaces

All field cables coming from or going to field devices will be connected to terminals in the control marshalling cubicles.

The marshalling cubicles serve as collecting and distribution centre to the instrument cubicles and central control panels.

Power supply and distribution

Power supply and distribution boards for the instrumentation will be provided.

The boards will be equipped with

- incoming circuit breakers,
- isolating transformer 380/220 V; 220/24 V,
- outgoing feeders for the individual consumers.

The instrumentation will be fed from the emergency power bus bar.

Mains supply voltage for all instrumentation will be 380 V A.C., 50 cps.

The mains will be connected to the emergency diesel power generator.

.3 Installation material

Premium quality installation materials will be used throughout. Contractor will employ the maximum amount of prefabricated components which will be corrosion resistant.

All field mounted instruments and device enclosure will be of material adapted to the heavy ambient conditions.
Tray and other materials will be hot dip galvanized.

Site fabricated steel supports, brackets etc. will be sand-blasted and protected with two coats of primer and one coat of finish paint.

included will be:

- all the required junction and protection boxes in the plant, shut-off valves, manifolds, pulse tubes, fittings (316 SS), galvanized cable racks, open conduits with end caps unless the main raceways/routes of the power cables can be used,
- small installation material for fastening and installing, local instruments, transmitters etc.,
- bars of angle iron, flat iron, anchors, bolts, supports.

Cable and wire will be run in rigid steel conduit tube or cable tray.
All wiring in panel and cubicle will be enclosed in slotted plastic wire tray.

Parallel run of A.C.- and D.C.-wiring closer than 300 mm will be avoided.

.4 Cables

Cables will be used in wet and dry location, in underground duct and conduit and on cable trays.
The areas through which cables pass will be subject to water, oils, iron oxide fines, coal dust and other elements normally associated with industrial plants.

Non-armoured cables will normally be applied.
Multicore signal cables will be provided with overall screening.
The isolating material will be flame-retardant and non-hygroscopic.

Electrical control and power cables

3, 4, 5, 7-core cables, solid copper conductors size 1.5 mm², with core green/yellow (earth), type: NYY-J, NYCY-J.

Current signal cables

The conductor of each multicore cable, installed in the field, to be 0.8 mm in dia. minimum.
Cable type: 2 Y (St) Y, A-Y (St) YY.
Where multi-pair cables are to be used exclusively for 4...20 mA D.C. signals, individual pairs need not be shielded, however, an overall shield is required.

Thermocouple compensating cables

The solid conductor of each pair will be of 1.38 mm dia. minimum and will be matched and calibrated to DIN 4371 for Standard Limits (for example 1/2 DIN) of errors within the range of 0 - 200 °C.

Cable type: Agl DIN 43714-20 D, Ni Cr-Ni,
Pt Rh-Pt for example

Control room cables

For interconnecting wiring within the control room area (general purpose), flexible single- or multicore cables to be used of following specification:

copper conductor size 0.75 mm², stranded, PVC-insulated with overall sheat.

Ground wires

will be minimum 3.5 mm², stranded, insulated conductor coloured green/yellos.

All cables for (Ex) i circuits will be provided with the overall jacket coloured blue (RAL 5015).

Shields will be grounded at one point only to prevent ground loops.

Tubing and Fittings

The process connection lines for remote instruments will be stainless steel (316 SS) seamless tubing, for example: 12 x 1.5 mm.
Piping is only used for connection nipples and local instruments mounted directly on process lines or vessels.

.4 Remarks

Kiln temperature measurements

In order to withstand the severe mechanical, chemical and thermal conditions, the kiln thermocouples are enclosed in protective tubes of substantial mass which causes a delayed response. Thus, they indicate a temperature averaging between the bed temperature and the higher one of the gases. These thermocouples are reliable and fully sufficient for routine process control.

For special process measurements, a quick response thermocouple system is used. The thermocouples are of thin special alloy protective tube design and are inserted into the kiln only for a short period of time.

Lurgi have developed a thermocouple protective tube sufficiently sturdy and having a much quicker response. Together with a high speed temperature recorder, it is possible to record the exact temperature curve and consequently determine directly the charge temperature, gas temperature, angle of repose of charge and filling degree along the kiln.

The measurement can be effected without influencing normal kiln operation. Special inserts are provided on the kiln shell to allow easy placing and removing of the thermocouples.

The signals of each measuring point along the kiln shell are recorded subsequently via slip-ring and recorder.

Signal_transmission

Lurgi have taken a number of practical steps in order to obtain a reliable method of transmitting temperature measurements from the rotating kiln.

Our experience shows that the most reliable method applied so far is the transmission via slip rings taking 4...20 mA generated by temperature transmitters to be installed on the kiln. We have chosen this solution for the Corporation as well and offered transmitters which can be exposed to the ambient temperature on the kiln.

Direct_air_volume measurement

Lurgi used the intake of the shell fans to measure the actual amount of air blown into the kiln. The intake will be fitted with a venturi tube or annubars and the differential pressure signal tapped is measured by a dp-cell generating a 4...20 mA signal. With a suitable synchronisation device, the signal is transmitted via slip rings and can be calibrated in conjunction with the venturi tube in Nm^3/h. This measuring device allows exacct determination of the actual amount of air blown into the kiln.

3.6.4 Structural and Civil Works

Main quantities for structural steel and civil works related to the Direct Reduction Plant, are as follows:

Structural Steel	4465	t
Bins	865	t
Roof and Wall Cladding	12640	m^2
Concrete	23316	m^3
Formwork	52911	m^2
Reinforcement	1980	t
Excavation	34764	m^3

Price estimations for these works are based on information obtained from Mowlem International Ltd., London, based on the experiences gained with the Mufindi Pulp and Paper Mill.

S E C T I O N 3.7

Investment Cost Estimate

3.7 Investment Cost Estimate

- Direct reduction plant -

The budgetary investment cost for the direct reduction plant, capable to produce 660,000 tpy of sponge iron, are estimated as follows (based on the exchange rates: 1 US $ = 2.7 DM = 12.2 T.Sh.).

	approx. Mio. US $	approx. Mio. T.Sh.
- Plant Equipment delivered free site	97.8	1,193.2
- Erection, Supervision, Commissioning	19.2	234.2
- Civil Work and Steel Stucture, erected and painted	33.4	407.5
- Related Plant Infrastructure	7.4	90.3
Total Investment Cost	157.8	1,925.2
- Spare Parts for 2 years plant operation	3.9	47.6

This budget estimate is based on German prices and conditions and on cost factors ruling end of December 1983 for the equipment. It does not include any customs duty, taxes, dues or other levies which may arise outside the Federal Republic of Germany.

The estimation of the civil work and structural steel portion is derived from price information supplied by Mowlem International Ltd., London.

The estimation for plant equipment includes the cost for packing and the freight charges delivered free on site. Our budget prices are estimated on the assumption that all work can be performed continuously and in accordance with the time schedules contained in section IV/5.

This budget estimate is furthermore based on usual cash terms of payment, allowing an adequate down payment upon signing of contract and progress payments according to the progress of work in the engineering, manufacturing and erection.

All further terms and conditions will have to be agreed upon during the progress of contract negotiations.

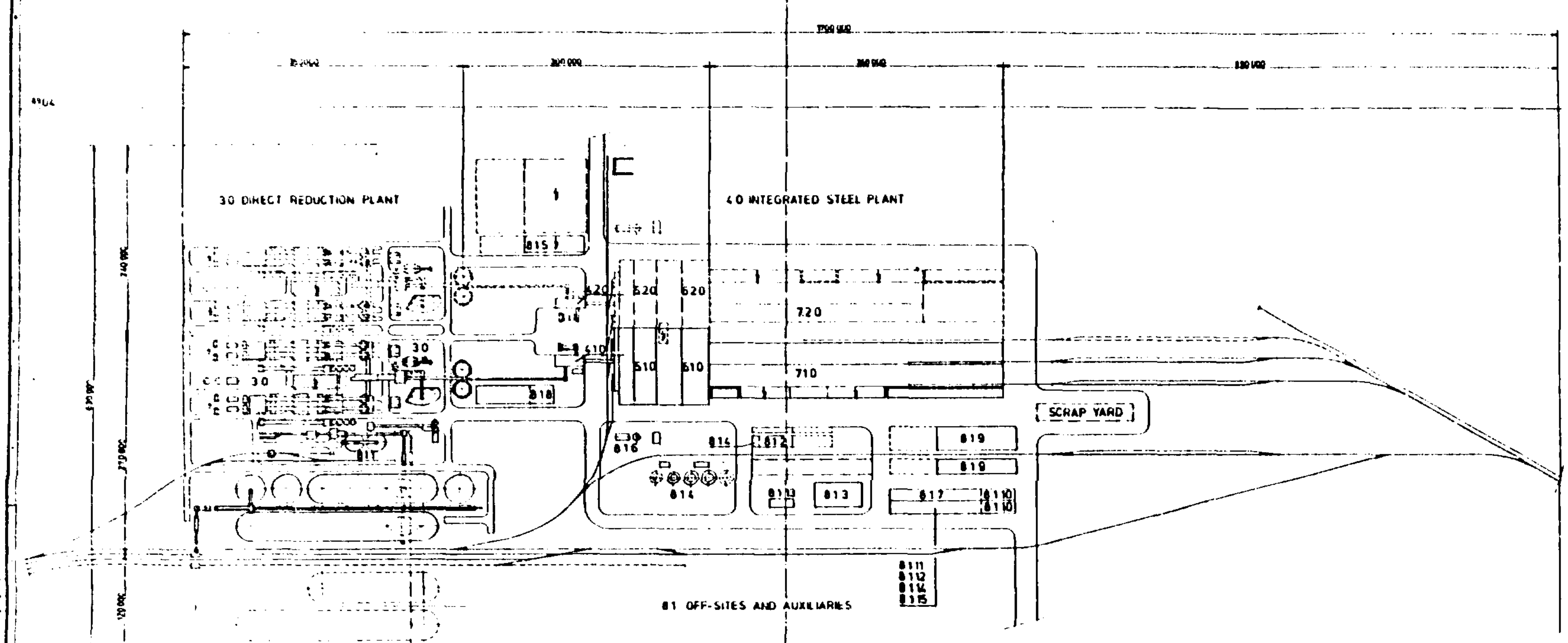
LURGI

Tanzania/Volume III

A N N E X

Expansion Step

1 Million tpy Steel



30 DIRECT REDUCTION PLANT

40 INTEGRATED STEEL PLANT

410 ELECTRIC SMELTING PLANT FOR SLABS (1st STAGE)
420 ELECTRIC SMELTING PLANT FOR BILLETS (2nd STAGE)
510 LADLE FURNACE PLANT (1st STAGE)
520 LADLE FURNACE PLANT (2nd STAGE)
610 CONTINUOUS CASTING PLANT FOR SLABS (1st STAGE)
620 CONTINUOUS CASTING PLANT FOR BILLETS (2nd STAGE)
710 HOT STRIP AND PLATE MILL (1st STAGE)
720 BILLET AND SECTION MILL (2nd STAGE)

81 OFF-SITES AND AUXILIARIES

811 LIMESTONE / DOLOMITE FACILITIES
812 WATER SYSTEMS
813 AIR FRACTIONING PLANT
814 FUELS AND COMPRESSED AIR
815 ELECTRIC ENERGY DISTRIBUTION
816 FUME EXHAUST AND CLEANING
817 CENTRAL WORKSHOP
818 CENTRAL LABORATORY
819 CENTRAL MAGAZINE
8110 FIRE FIGHTING AND AMBULANCE
8111 COMMUNICATION SYSTEM
8112 MOBILE FACILITIES AND FINISHINGS
8113 PETROL STATION
8114 TRAFFIC FACILITIES
8115 MAIN ADMINISTRATION BUILDING

NOTE
2nd STAGE IS SHOWN IN DOTTED LINES

STEELWORKS MAHANJE
KEY PLAN

TANZANIA

0A03223800016

S E C T I O N 4

Electric Smelting Plant

S E C T I O N 4.1

Process Description

Electric Smelting Plant

4.1 Process Description

For the production of steel two steps are provided.
- Smelting of semi steel by the ESH-process and
- Refining the semi steel by a ladle furnace treatment.

ESH-process means Electro Slag Heating process, a new technology for steel production developed recently.

The electric furnaces used for this process are furnaces of the type "submerged arc furnace" modified for the ESH process.

Submerged arc furnaces are used for the production of pig iron, ferroalloys and carbide. Characteristic for the ESH furnace is the operation with an open slag bath and self-baking electrode submerging into the slag. The conversion of the elctrical energy takes place mainly by using the resistance of the slag. In a submerged arc furnace the conversion of the electric energy normally takes place in a vertical and in a horizontal direction. In furnaces, using traditional technology with a slag layer covered by burden, the main portion of the electrical energy is converted to thermal energy in a plasmalike arc in the areas below the tip of the electrode. The portion of conversion in the horizontal direction by resistance heating is low. With regard to the humble height of the slag this fact is understandable. In the case of higher slag levels in connection with a slag surface covered by burden, the slag becomes locally overheated and starts

to boil, i.e. the slag starts to rise into the burden. The hot slag and the "cold" burden start to form crusts.
To avoid this disadvantage the open slag technology has been developed. This smelting technique assures to increase the height of the slag. The conversion of the electric energy in the horizontal direction becomes in this way the dominating portion. For this reason the process is called ESH process.
The slag volume due to the height of the slag represents an important heat accumulator. The raw material charged into the slag immediately starts to melt and the rate of chemical reactions becomes forced.
Furthermore the large slag volume promotes by excellent mixing of the components an approach to the equilibrium values.

This reality is demonstrated in Fig. 1 representing the connection of the contents of carbon of the steel produced by the ESH-process.
Comparable results in respect of the approach to the equilibrium values indicates Fig. 2 presenting a comparison of the distribution of sulphur contained in slag and metal. The left-line presents the ESH process (ESW) and the right side the direct arc furnace process (LIBO).

Fig. 1 Connection of oxygen and carbon content of steel ESH process

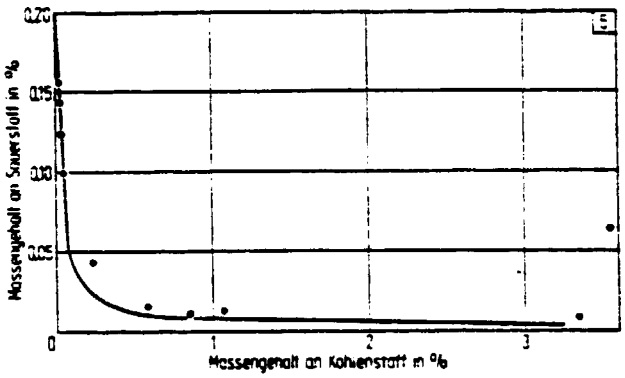
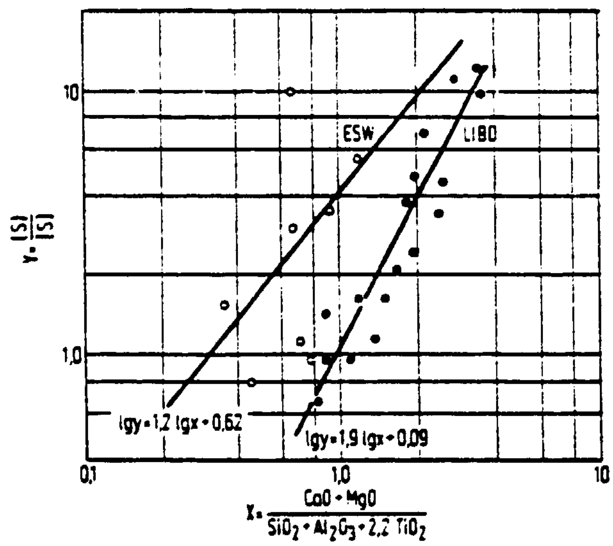


Fig. 2 Comparison of the sulphur distribution between metal and slag for electric arc furnace and EHS process

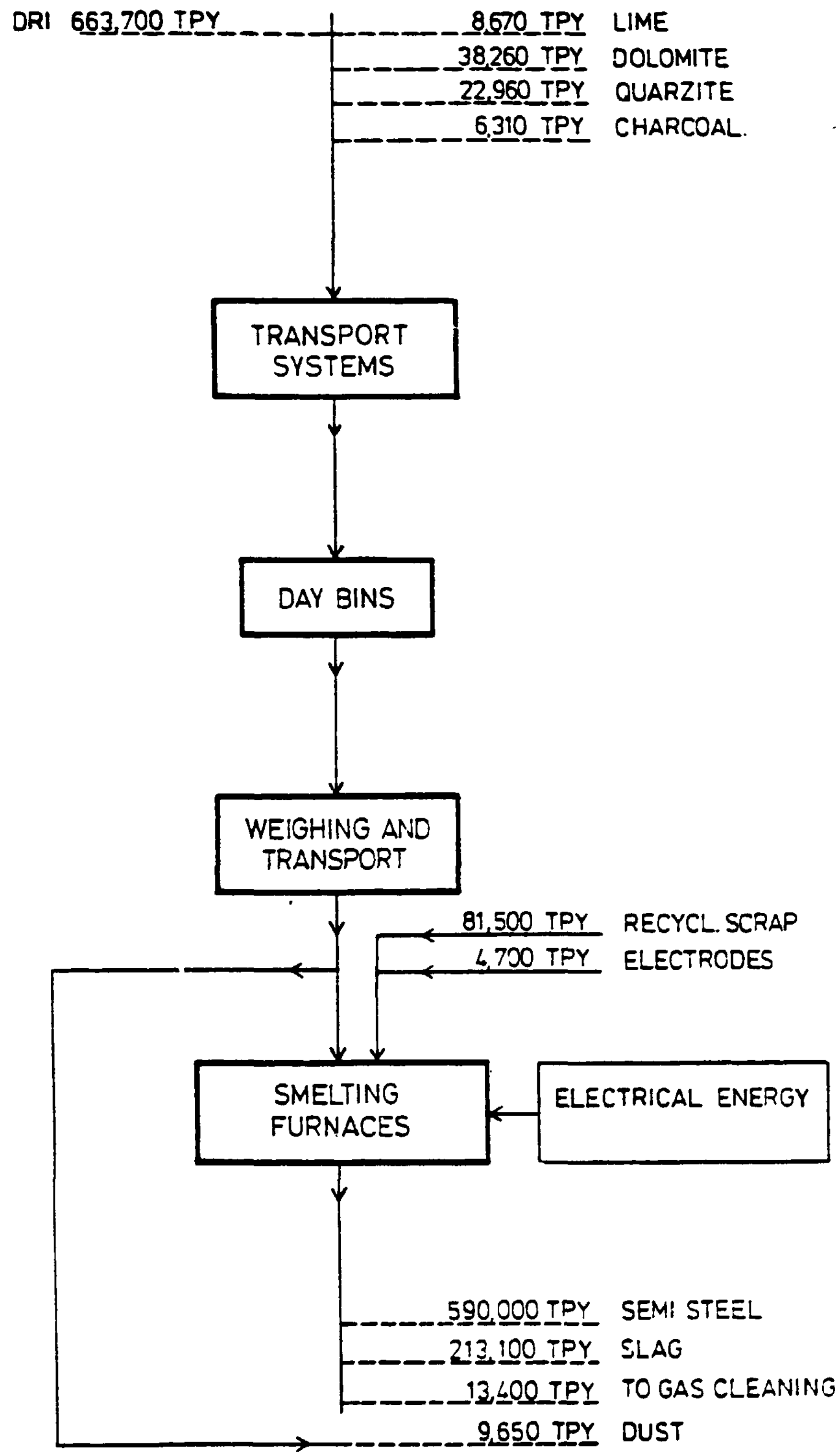


The DRI slag forming additions and reducing agents will be charged in batches into the open slag.

The addition of carbon is proportioned to the required FeO content of the slag to meet the carbon content of the semi steel and/or the acceptable concentration of the tramp elements. In such a way the chromium content of the steel will be adjusted in the tolerance range.

The tapping of slag and semi steel takes place on opposite sides of the furnace. In this way a tapping of the steel free of slag is assured.

The semi steel will be transferred to the ladle furnace.
The slag is tapped into slag pots and transferred to a dumping pit. At the present time there is no process known to charge the slag into another furnace in liquid stage for further reduction. This fact is a result of the low difference of liquidus and solidus temperatures of the slag, mainly conditioned by the TiO_2 content. However the slag composition has been selected in a way that after a reduction of the remaining contents of Fe, Cr and V in the future a slag of sufficient viscosity will be obtained.



ELECTRIC SEMI STEEL SMELTING
MAIN FLOWSHEET
SLABS (1st STAGE)

F 3A03223800020 LURGI

MANNESMANN DEMAG

SECTION 4.2

Plant Description

Electric Smelting Plant

4.2 Plant Description

Drwg. No. F OA 03 223800022

The electric smelting plant consists of two main areas:

- The raw material handling and storage area arranged in front of the steel making building itself.

  This area is separated off from the steel making building by a road and a rail/road system. The road is provided for material transportation by trucks, where the rail/road system is used for slag transportation.

- Within the steel making building between the column rows A, and C, and 1 and 6 the electric smelting furnaces for the production of semi steel are arranged.

4.2.1. Raw material handling and storage area

The transfer of DRI from the SL/RN plant storage bins is provided by a combined belt conveyor-bucket elevator-belt-conveyor-system into the day bins.

Burned lime and dolomite will be transported by trucks from the storage bins of the corresponding calcining units to a receiving hopper and will be transfered via a sieving station and belt conveyor-bucket elevator-belt conveyor system into the day bins.

Quarzite and char coal will be also transported by trucks from the corresponding storage areas to a separate receiving hopper. The transfer into the day bins is provided by a belt conveyor-bucket elevator-belt conveyor system also.

The storage capacity of the day bins amounts to 12 hours for DRI and to 24 h for all the other raw materials.

4.2.2. Burden Weighing and Transfer System into the Furnace Hoppers

DRI, lime, dolomite and quarzite are withdrawn by vibro feeders into weighing bins, where at times two vibro feeder are serving one weighing bin. The The metering of the charcoal is done by volumetric units.

The discharge of the weighing bins is provided by vibro feeders on a belt conveyor. The individual raw materials are forming a so called "sandwich" layer.

That sandwich corresponds to the accurate burden mix. The burden will be transfered via an intermediate hopper-vibro feeder - bucket elevator-belt conveyor-system into the furnace bay of the steelmaking building.

The belt conveyor leads across the road and the rail road system by a belt bridge.

Inside the steel making building the burden will be distributed by a double acting chute to both belt conveyor systems serving the furnace hoppers of the two electric smelting furnace.

All transfer systems and the day bins outside the steel making building are of covered design to protect the raw materials and the burden against rain.

The sieving station and the day bin area will be dedusted.

4.2.3. Smelting Furnaces

The two smelting furnaces are consisting of the type "submerged arc furnace" and are modified to the requirements of the ESH process. They are of totally closed design. The gases generated by the reduction process will be sucket off and dedusted in a gas cleaning system. Due to the insignifacant amount of this gas a further utilization of the cleaned gas is not provided.

4.2.4. Slag Tapping and Dumping

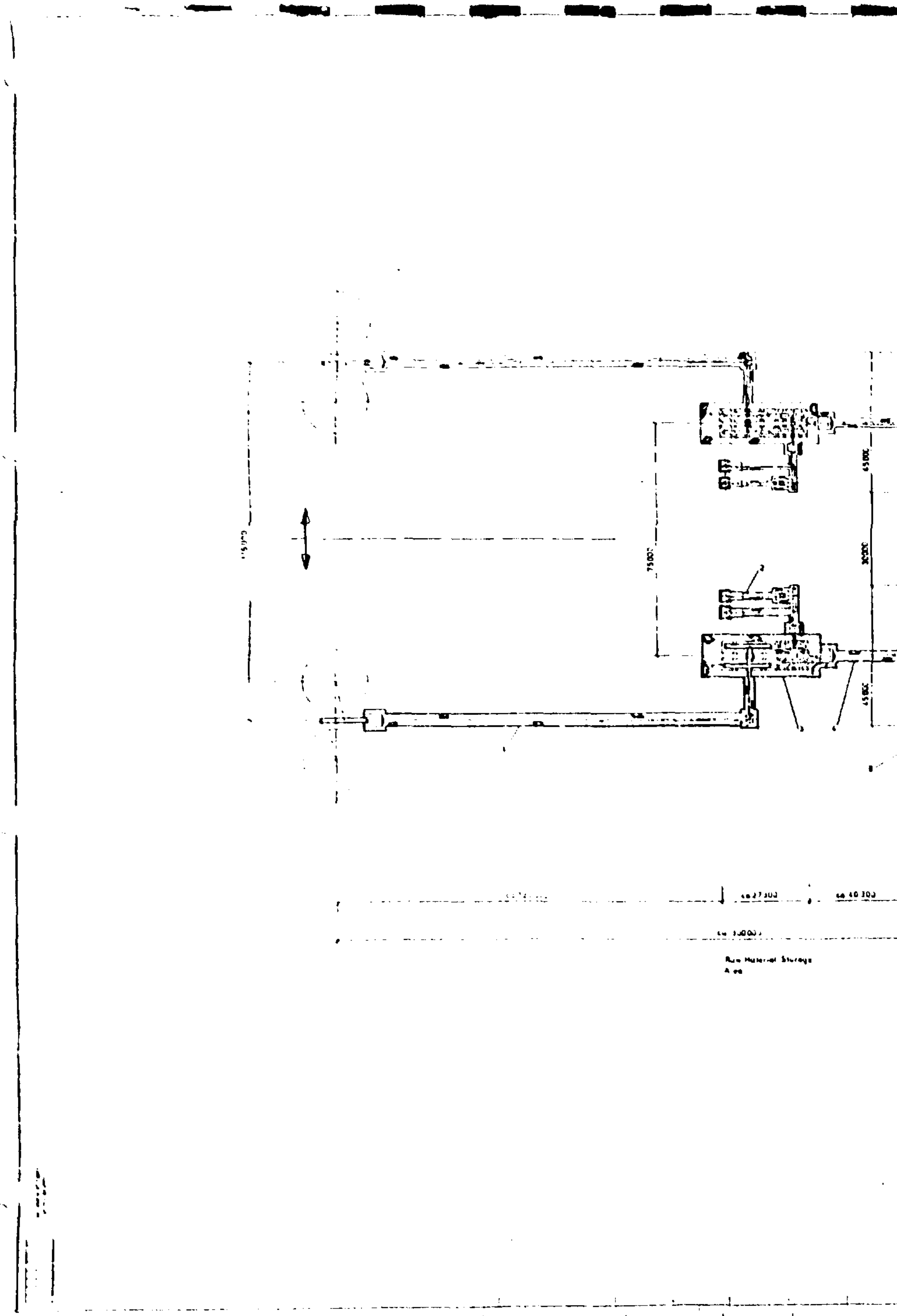
The slag generated during the smelting process will be tapped in intervals into slag pots. The slag pots are arranged on slag pot transfer cars and transported to a slag dumping pit.

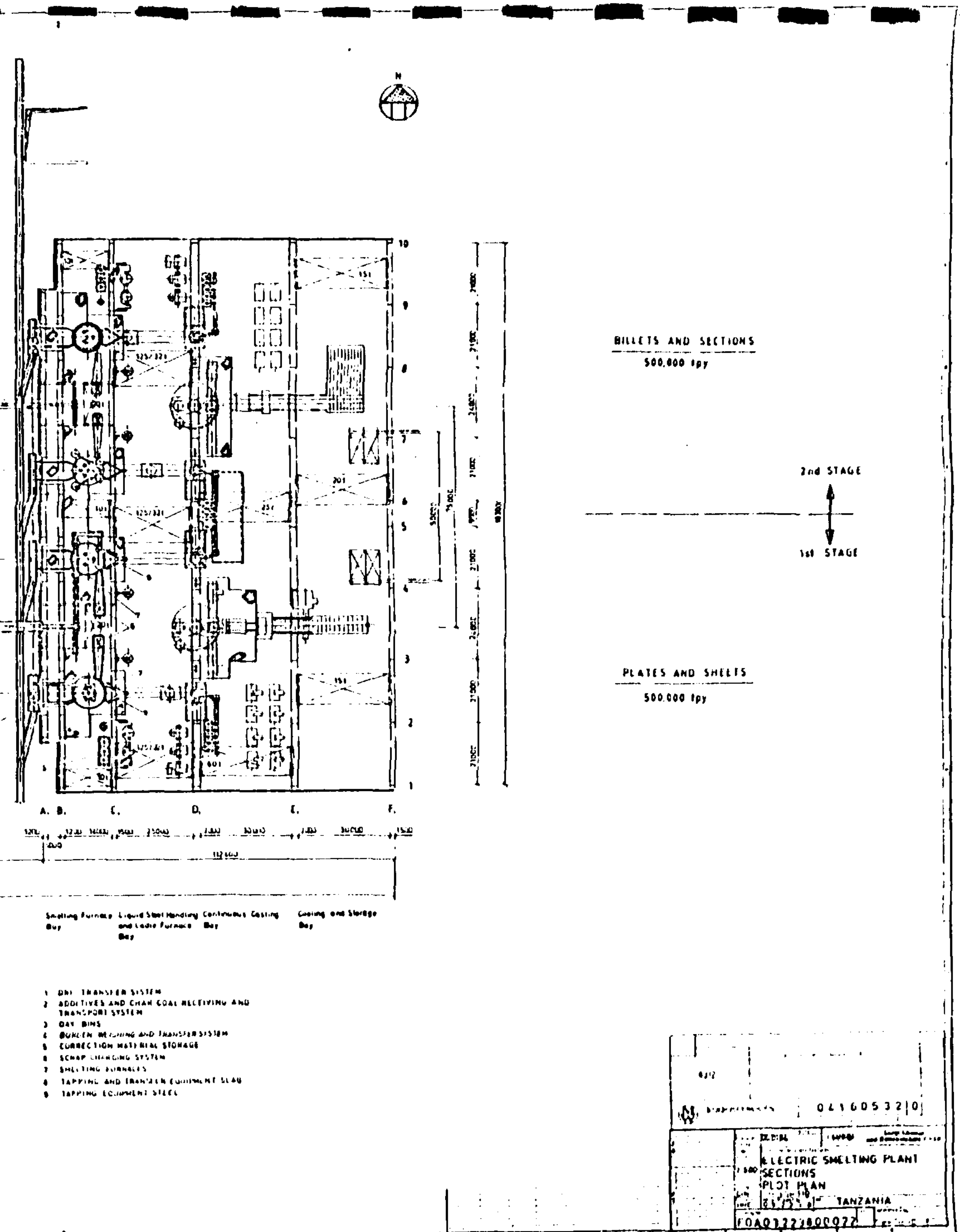
After the cooling down period the slag will be reclaimed by pay-loaders and transported to the slag deposit.

4.2.5. <u>Semi Steel Tapping</u>

The semi steel will be tapped into ladles and transfered to the ladle furnace bay between column rows C, and D.

The tapping intervals are expected in two hours cycles per furnace, i.e. each hour one tapping operation.


Raw Material Storage
Area


N
BILLETS AND SECTIONS
500,000 tpy
2nd STAGE
1st STAGE
PLATES AND SHEETS
500,000 tpy
A. B.
C.
D.
E.
F.
Smelting Furnace Bay
Liquid Steel Handling and Ladle Furnace Bay
Continuous Casting Bay
Cooling and Storage Bay
1 ORE TRANSFER SYSTEM
2 ADDITIVES AND CHAR COAL RECEIVING AND TRANSPORT SYSTEM
3 DAY BINS
5 CORRECTION MATERIAL STORAGE
6 SCRAP CHARGING SYSTEM
0 4 1 6 0 5 3 2 | 0
ELECTRIC SMELTING PLANT
SECTIONS
PLOT PLAN
TANZANIA

S E C T I O N 4.3

Raw Materials and Products

4.3 Raw Materials and Products

4.3.1 Raw Materials

DRI

Fe met.	:	74.5	%
FeO	:	8.3	%
C	:	0.06	%
S	:	0.02	%
CaO	:	1.1	%
MgO	:	2.4	%
SiO2	:	0.7	%
Al2O3	:	3.5	%
TiO2	:	8.1	%
V2O5	:	0.8	%
Cr2O3	:	0.4	%

Grain size	:	5 - 25	mm
Bulk density	:	1.6	t/m^3
Feed rate	:	663,700	tpy

Burnt lime

CaO	:	94.4	%
MgO	:	1.3	%
SiO2	:	5.7	%
Al2O3	:	1.2	%
CO2	:	2	%

Grain size	:	5 - 40	mm
Bulk density	:	1.3	t/m^3
Feed rate	:	8,670	tpy

Burnt dolomite

CaO	:	45.8	%
MgO	:	30.0	%
SiO2	:	22.0	%
Al2O3	:	0.2	%
Grain size	:	5 - 40	mm
Bulk density	:	~ 1.3	t/m^3
Feed rate	:	38,260	tpy

Charcoal

C fix.	:	80	% (dry)
Vol. Mat.	:	17	% (dry)
Ash	:	3	% (dry)
Moisture	:	8	%
Grain size	:	5 - 50	mm
Bulk density	:	0.6	t/m^3
Feed rate	:	6,310	tpy

Quarzite

SiO2	:	95	%
Others	:	5	%
Grain size	:	5 - 30	mm
Bulk density	:	2.4	t/m^3
Feed rate	:	22,960	tpy

Electrode paste

of commercial grade, consisting of a mix of

- anthracite,
- petrolcoke,
- graphite,
- tar, tar oil and pitch,

physical properties of burnt paste:

density	:	1.25 - 1.55	g/cm^3
porosity	:	20 - 22	%
compressive strength	:	250 -300	N/cm^2
bending strength	:	50 -100	N/cm^2
sensible strength	:	30 - 50	N/cm^2
ash content	:	5 - 6	%
spec. resistance	:	75 - 70	x $10^{-6}\Omega$ x cm (20 °C)

Feed rate : 4,700 tpy

Electrode casings

mild steel sheets : approx. 2.4 mm

Returned scrap

generated with the

- continuous casting plant and
- rolling mills.

Feed rate : 81,500 tpy.

4.3.2 **Products** (based on calculations)

Semi-steel

C	:		0.05 - 0.10	%
Cr	:	approx.	0.10	%
S	:	approx.	0.02	%
P, Mn, Si	:		traces	
Temperature	:	approx.	1,600	°C
Production rate	:		590,000	tpy

Slag

FeO	:	approx.	15.0	%
CaO	:	approx.	15.4	%
MgO	:	approx.	12.7	%
SiO_2	:	approx.	16.9	%
Al_2O_3	:	approx.	11.2	%
TiO_2	:	approx.	25.3	%
V_2O_5	:	approx.	2.4	%
Cr_2O_3	:	approx.	0.9	%
Production rate	:		213,100	tpy

Gas

CO	:	80 - 90	Vol.
CO_2	:	3 - 8	Vol.
H_2	:	0 - 6	Vol.
CxHy	:	0 - 3	Vol.
N_2	:	traces	
Production rate	:	13,400	tpy

SECTION 4.4

Consumption Figures

and

Workforce Schedule

4.4 Consumption Figures and Workforce Schedule

4.4.1 Consumption Figures

for the production of 590,000 tpy of semi-steel are as follows:

	per ton semi-steel		per year	
DRI	1,293	kg	660,000	t
Burnt dolomite	75	kg	38,260	t
Burnt lime	17	kg	8,670	t
Quarzite	45	kg	22,960	t
Recycled scrap	134	kg	81,500	t
Char coal (dry)	12	kg	6,130	t
Electrode paste	8	kg	4,750	t
Steel for casings	2	kg	1,180	t
Refractories	1	kg	5,900	t
Electrical energy	860	KWh/t	507,400	MWh
Workforce	0.54	mhrs	161	men
Nitrogen	1,800	Nm^3/h	-	
Oxygen	80	Nm^3/h	-	
Compressed air	100	Nm^3/h	-	
Cooling water				
- open circuit	320	m^3/h	-	
- closed circuit	1,400	m^3/h	-	

Remark: All material flow figures contain approx. 5 % margin for handling losses.

4.4.2 Workforce Schedule, Electric Melting Plant

(G = Graduated; S = Skilled; SS = Semi-Skilled; US = Unskilled)

Based on four shifts, the following personnel will be required inside plant section.

	Shift 1	Shift 2	Shift 3	Shift 4	Day Shift	Total	Qualification Level
Superintendent					1	1	G
Staff					3	3	SS
for plant operation							
foremen	2	2	2	2		8	S
operators	3	3	3	3		12	SS
assistant operators	3	3	3	3		12	SS
unskilled	15	15	15	12		57	US
for plant maintenance:							
foremen	2	2	2	2		8	S
mechanics	2	2	2	2		8	SS
electricians	2	2	2	2		8	S
instr. technicians	1	1	1	1		4	S
for plant cleaning							
plant cleaners					6	6	US
for waste handling							
unskilled					2	2	US
for laboratory							
chemist					1	1	G
technician	2	2	2	2	2	10	SS
Subtotal	32	32	32	29	15	140	
15 % absentees	5	5	5	4	2	21	
Total	37	37	37	33	17	161	

S E C T I O N 4.5

Auxiliaries

4.5 Auxiliaries

All media and energy required inside plant sections will be supplied by the corresponding central generating, storing and distributing systems as outlined in Sections 8 and 4.6.1.

This mainly refers to the corresponding general systems for the supplies of:

- Nitrogen,
- Oxygen,
- Compressed Air,
- Cooling Water,

to the Electrical Melting Plant.

All other input materials, like refractories, additives, electrode paste, are handled by the individual facilities within the plant section.

SECTION 4.6

Outline Specification
for
Electric Smelting Plant

4.6.1 Mechanical Equipment

Plant Sections

.01 DRI Transfer System

.02 Additives and Char Coal Receiving and Transport Systems

.03 Day Bins

.04 Burden Weighing and Transfer System

.05 Correction Material Storage and Transport

.06 Scrap Charging System

.07 Smelting Furnaces and Charging System

.08 Tapping and Transfer Equipment

.09 Tapping Equipment

.10 Cranes and Elevators

.11 Fluids and Gases

.1 Raw Material Handling and Storage

DRI Transfer System

Capacity : 60 t/h = 60 m^3/h

Section 4.6.1.1 mainly comprises the following items:

- belt conveyor,
- intermediate hopper,
- vibro feeder,
- bucket elevator,
- belt conveyor supported by a belt bridge,
- intermediate hopper,
- belt conveyor, reversible,
- belt conveyors, moveable and reversible,
- drives and control equipment.

.2 Additives and Char Coal Receiving and Transport Systems

Lime and Dolomite

Capacity : 10 t/h = 10 m^3/h

Quarzite and Char Coal

Capacity : 10 t/h = 24 m^3/h

Section 4.6.1.2 mainly comprises the following items:

for lime and dolomite:

- receiving bin,
- vibro feeder,
- bag conveyor with supporting structure,
- sieving station,
- unloading equipment fines,
- fines containers,
- discharge chute to belt conveyor, specified with quarzite-char coal system,
- drives and control equipment.

for quarzite and char coal

- receiving bin,
- vibro feeder,
- belt conveyor with supporting structure,
- intermediate hopper,
- vibro feeder.

- belt conveyor,
- bucket elevator,
- belt conveyor,
- intermediate hopper,
- belt conveyor reversible,
- belt conveyors, moveable and reversible,
- drives and control equipment.

-

.3 Day Bins

Capacity

for DRI	:	8 bins, 100 m³ each,
for dolomite	:	3 bins, 50 m³ each,
for quarzite	:	2 bins, 50 m³ each,
for char coal	:	3 bins, 50 m³ each.

Section 4.6.1.3 mainly comprises the following items:

- bins made of steel,
- supporting structure for the bins,
- needle gates,
- frames for vibro feeders,
- upper and lower level indicators,
- indicating instruments.

.4 Burden Weighing and Transfer

Burden weighing and transfer system into the furnace bins.

Capacity : 250 t/h = 150 m³/h

Section 4.6.1.4 mainly comprises the following items:

- vibro feeders for DRI, dolomite, lime and quarzite,
- volumetric metering units for char coal,
- weighing hoppers,
- vibro feeders,
- belt conveyor,
- intermediate hopper,
- vibro feeder,
- bucket elevator,
- belt conveyor supported by a belt bridge,
- double acting transfer chute,
- belt conveyors,
- belt conveyors, moveable and reversible,
- belt conveyors,
- belt conveyors, moveable and reversible,
- drives and control equipment,
- control desks and panels.

.5 Correction Material Storage and Transport

Section 4.6.1.5 mainly comprises the following items:

- material transport containers, capacity 2 m^3 each,
- material storage bins, made of steel arranged in one group,

  number of bin per group: 3,

  capacity : 10 m^3 each bin,
- vibro feeders,
- weighing hopper, moveable,
- vibro feeder, for weighing hopper discharge,
- transport containers for bottom discharge into furnace correction material bins,
- drives and control equipment.

.6 Scrap Charging System

Section 4.6.1.6 mainly comprises the following items:

- cranes (included in section 4.6.1.10),
- scrap transport and charging boxes,
- charging chutes,
- charging sluices, (nitrogen atmosphere),
- drive and control equipment.

.7 Smelting Furnaces and Charging System

Technical Data Smelting Furnace

product	:	semi steel
furnace type	:	totally closed
electrode diameter	:	1,270 mm
type of electrode	:	selfbaking
no. of electrodes	:	three
shell diameter	:	10 m
shell hight	:	6.5 m
transformer capacity	:	42 MVA
active load, max.	:	35 MW

Section 4.6.1.7 mainly comprises the following items:

2 Electric Smelting Furnaces

mainly consisting of:

- furnace shells,
- furnace roofs,
- refractory lining material for furnace shell and roof,
- waste gas stacks and ducts,
- electrode assemblies,
- water cooled flexible current conductors,
- water cooling systems,
- hydraulic pressure generating plant,
- secondary side busbar systems.

2 Furnace Charging Systems

mainly consisting of:

- furnace hoppers for burden,
- furnace hoppers for correction material,
- needle gates,
- vibro feeders,
- charging tubes,
- suspension and isolating material,
- drives and control equipment.

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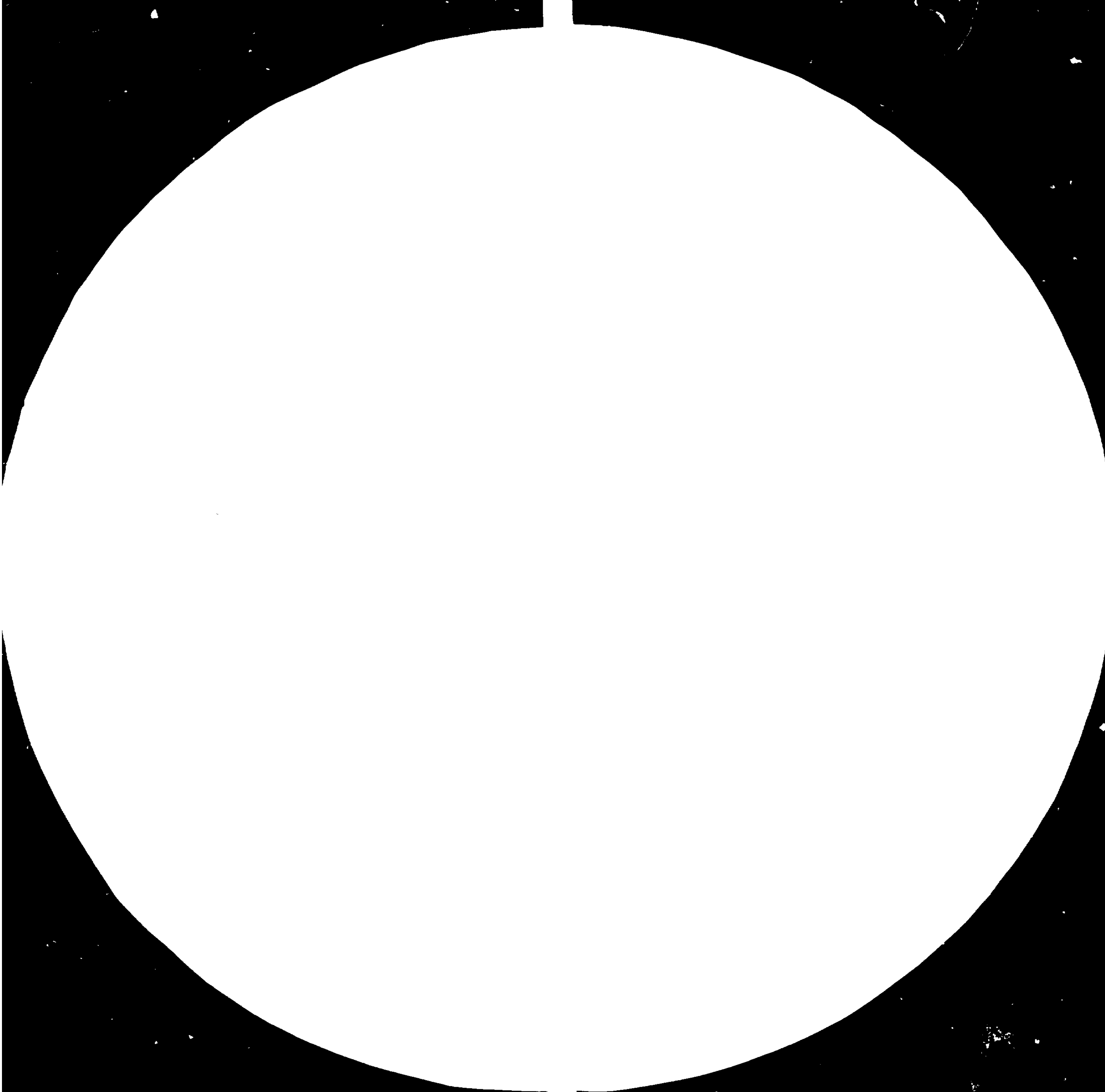

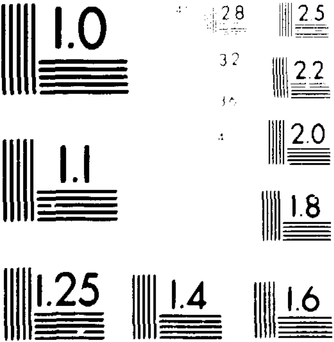

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS

STANDARD REFERENCE MATERIAL 1010a

ANSI and ISO TEST CHART No. 2

.8 Slag Tapping and Transfer System

Section 4.6.1.8 mainly comprises the following items:

2 combined hydraulic tap hole, drilling and mud gun assemblies,

4 tapping launders for slag with refractory lining,

2 slag pot transfer cars,

1 traction engine (diesel),

6 slag pots,

1 rail system.

.9 Semi Steel Tapping Equipment

Section 4.6.1.9 mainly comprises the following items:

- combined hydraulic tap hole drilling and mud gun asserblies,
- tapping launders for semi steel with refractory lining.

.10 Cranes and Elevators

Section 4.6.1.10 mainly comprises the following items:

2 furnace house cranes, capacity 10 t each,

2 crane trackle sets,

1 scrap charging crane, capacity 20 t,

1 furnace house elevator,

- motors and control system,
- crane rails.

.11 Fluids and Gases Distributing Systems

Section 4.6.1.11 mainly comprises the following items:

Distributing Systems for:

- oxygen,
- nitrogen,
- compressed air,
- open and closed cooling water circuits.

mainly consisting of:

- pipes,
- assemblings,
- armatures,
- measuring and control equipment.

4.6.2 Electrical Equipment

Section 4.6.2 mainly comprises the following items:

- low voltage main distribution,
- motor control centres,
- control and measuring devices,
- safety and protection equipment,
- control panels and desks,
- cabling and erection material,
- earthing,
- lighting system,
- communication systems.

For further details on the outline specifications of electrical equipment, please refer to section 3.6.2.

The special equipment related to the electric smelter furnaces mainly consists of:

- furnace transformers,
- high voltage switch gear furnace, circuit breakers,
- power factor compensation equipment,
- furnace control equipment,
- motors and controls,
- cables, cabling accessories,
- earthing material.

4.6.3 Instrumentation Equipment

The instrumentation equipment for the electric smelter plant mainly comprises:

- field instruments,
- local indicating measuring instruments,
- local measuring detectors,
- transmitters,
- panel instruments incl. indicating instruments and recorders,
- control room panels,
- auxiliary racks and cubicles,
- interfaces and power supply systems,
- all installation material like cables, wiring, fuses, etc.

A detailed description of the lay-out of this equipment is given in section 3.6.3 of this volume.

4.6.4 Structural and Civil Works

Main quantities for structural steel and civil works related to the Steel Plant are as follows:

Structural Steel	4900	t
Bins	210	t
Roof and Wall Cladding	20060	m^2
Concrete	9650	m^3
Formwork	24200	m^2
Reinforcement	820	t
Excavation	41000	m^3

Price estimations for these works are based on information obtained from Mowlem International Ltd., London, based on the experiences gained with Mufindi Pulp and Paper Mill.

This section is common to the

- Electric Smelting Plant,
- Ladle Furnace Plant,
- Continuous Casting Plant,

which are located in one common building.

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S E C T I O N 4.7

Investment Cost Estimate

4.7 Investment Cost Estimate

- Electric smelting plant -

The budgetary investment costs for the electric smelting plant, capable to produce 590,000 tpy of semi steel, are estimated as follows (based on the exchange rates: 1 US $ = 2.7 DM = 12.2 T.Sh.).

	approx. Mio. US $	approx. Mio. T.Sh.
- Plant Equipment delivered free site	20.9	255.0
- Erection, Supervision, Commissioning	6.9	84.2
- Civil Work and Steel Stucture, erected and painted	7.4	90.3
- Related Plant Infrastructure	1.2	14.6
Total Investment Cost	36.4	444.1
- Spare Parts for 2 years plant operation	1.2	14.6

This budget estimate is based on German prices and conditions and on cost factors ruling end of December 1983 for the equipment. It does not include any customs duty, taxes, dues or other levies which may arise outside the Federal Republic of Germany.

The estimation of the civil work and structural steel portion is derived from price information supplied by Mowlem International Ltd., London.

The estimation for plant equipment includes the cost for packing and the freight charges delivered free on site. Our budget prices are estimated on the assumption that all work can be performed continuously and in accordance with the time schedules contained in section IV/5.

This budget estimate is furthermore based on usual cash terms of payment, allowing an adequate down payment upon signing of contract and progress payments according to the progress of work in the engineering, manufacturing and erection.

All further terms and conditions will have to be agreed upon during the progress of contract negotiations.

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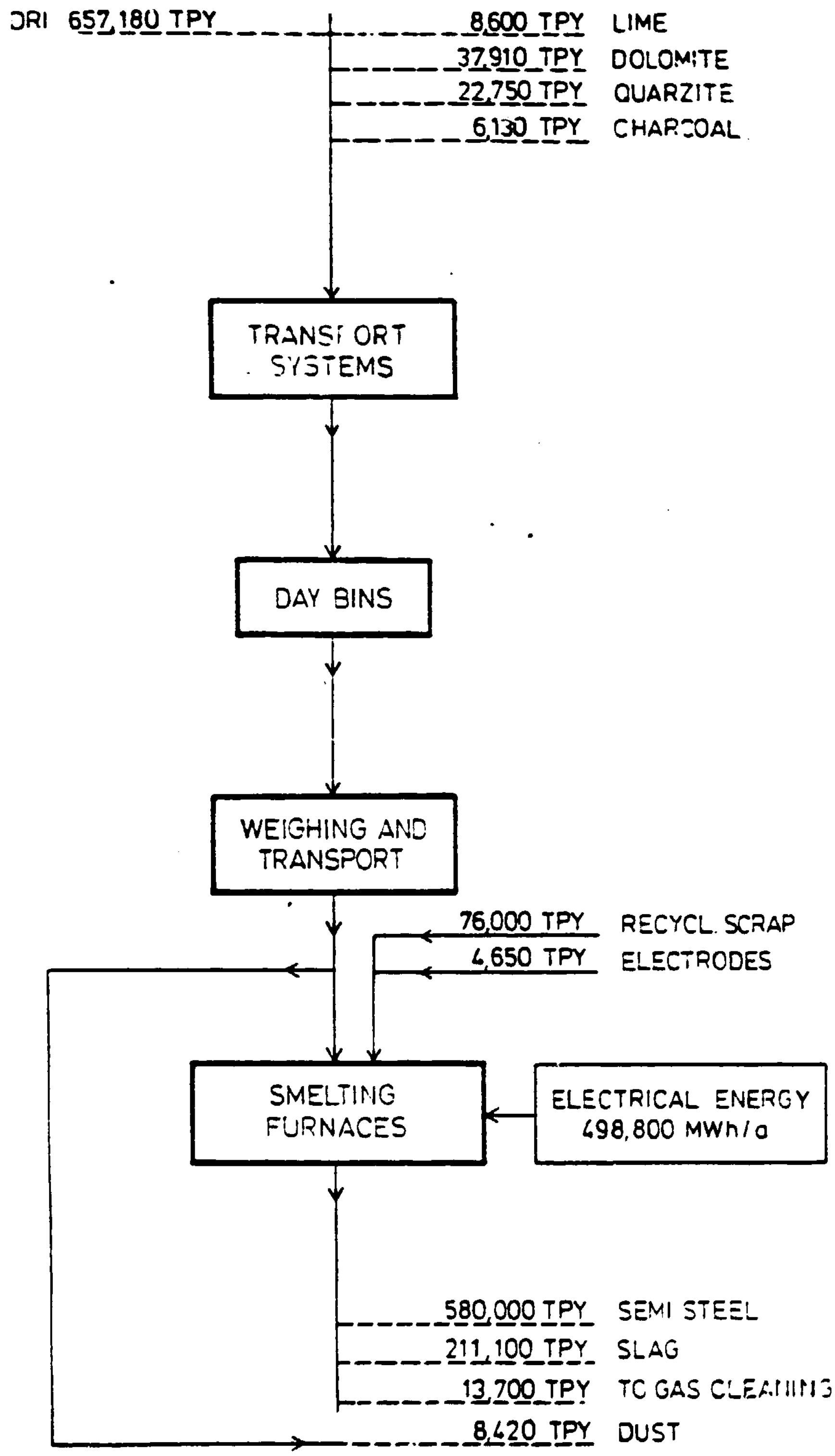
A N N E X

Expansion Step

1 Million tpy Steel



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ELECTRIC SEMI STEEL SMELTING
MAIN FLOWSHEET
BILLETS (2nd STAGE)

SECTION 5

Ladle Furnace Plant

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S E C T I O N 5.1

Process Description

Ladle Furnace Plant

5.1 Process Description

Deoxidation and final preparation of the steel in respect of temperature and the chemical content by carbon or alloying elements (mainly manganese and silicon) is done in the ladle.

During tapping the semi steel from the open bath submerged arc electric smelters, and due to the addition of the required ferroalloys and/or carbon a certain temperature drop takes place. Furthermore to protect the liquid steel against reoxydation it is necessary to form a slag layer on the steel surface, by addition of lime and fluxes.
The carbonization of the liquid semi steel will be carried out by using a carburization agent of high. activity. In this case charcoal is provided.

To solve the carbon in the liquid steel one portion of the charcoal is fed into the ladle before pouring, the other one by charging bags during the tapping operation.

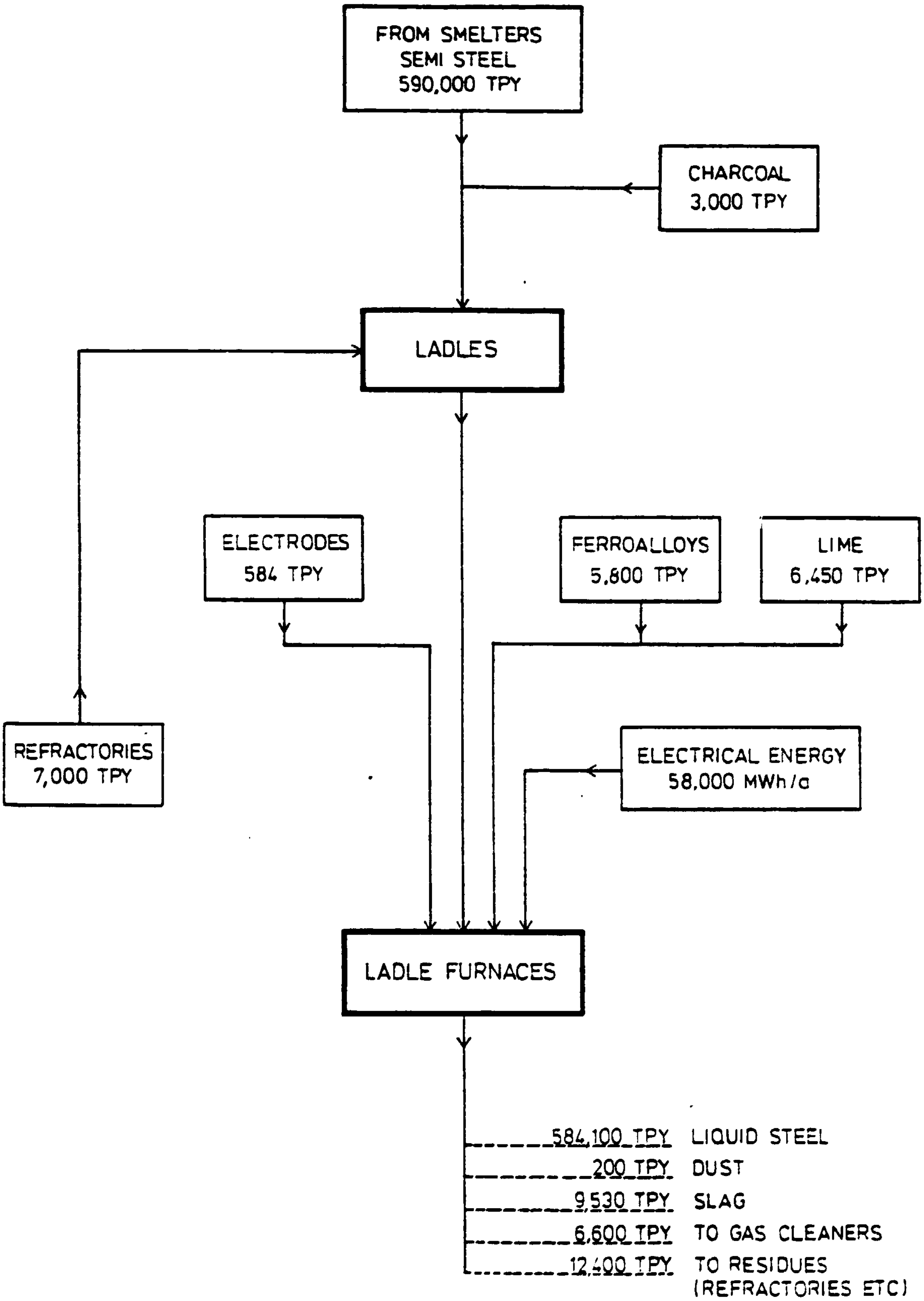
To equalize the temperature drops and to attain the required casting temperature a ladle treatment furnace is provided.

The required energy is supplied by direct arc heating.
A certain superheating below the tips of the electrodes could not be excluded without purging the heat by argon. The argon is supplied from the bottom of the ladle via purging units fabricated of refractory material.

Due to the purging with argon an equalizing of the heat, both in respect of temperature and chemical uniformity is obtained.

In addition the ladles are covered by ladle hoods, equipped with openings for the electrodes.
The main portions of lime and ferroalloys are charged through the ladle hood via a charging pipe system into the ladle itself. These operations being carried out temporarily before and during the time, when the ladle treatment furnace is in operation.

When the required temperature and chemical composition are achieved, the ladle will be transferred by a crane to the turret of the continuous casting plant.



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MANNESMANN DEMAG

LIQUID STEEL HANDLING AND LADLE FURNACES

MAIN FLOWSHEET

SLABS (1st STAGE)

SECTION 5.2

Plant Description

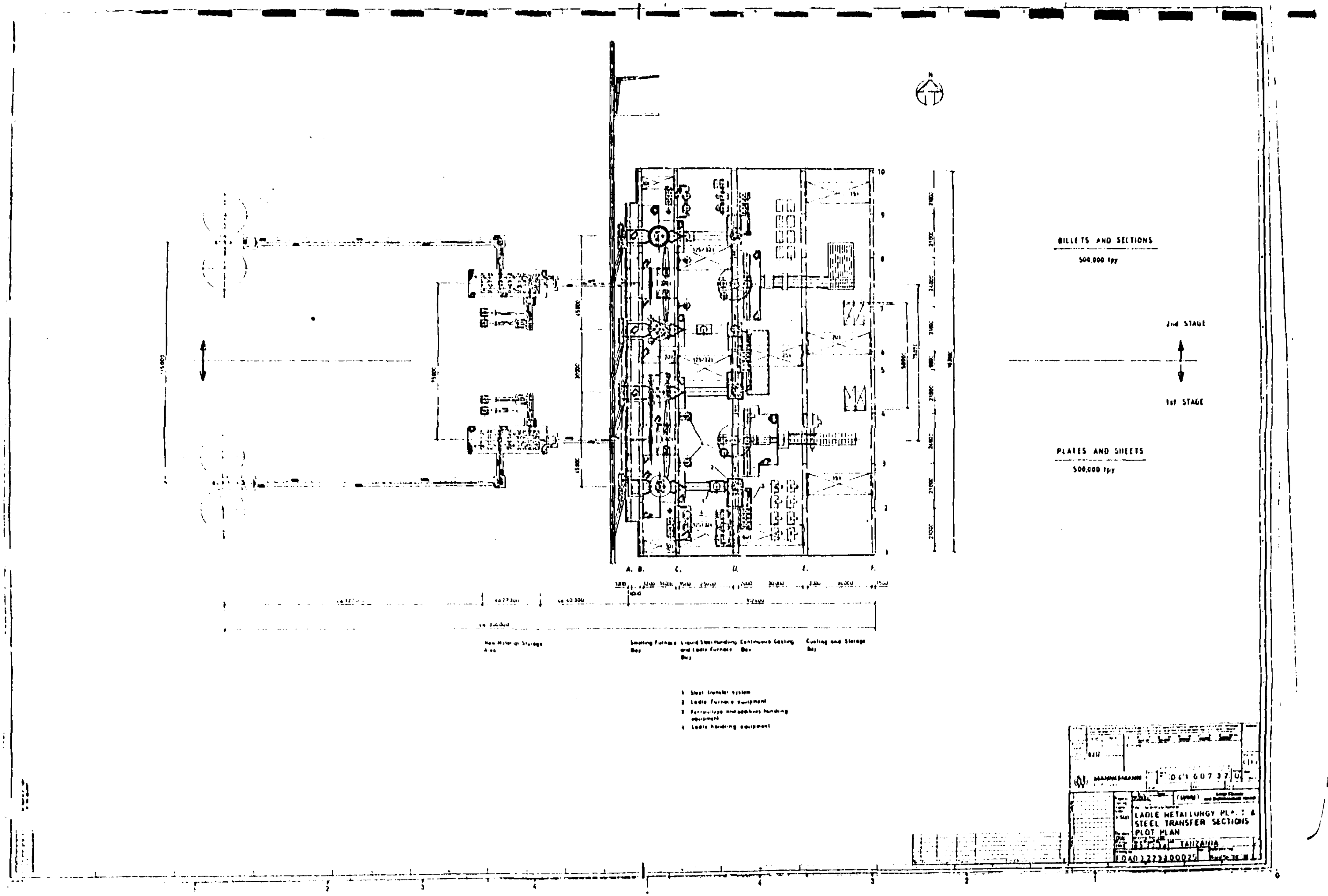
Ladle Furnace Plant

5.2 Plant description

The liquid steel handling and ladle furnace bay is arranged between column rows, C_1 and D_1. The liquid semi steel is tapped into a ladle standing on a ladle transfer car.
Before the ladle is transferred to the ladle treatment furnace the transfer car and the liquid steel is weighed out on a weigh bridge. The conversion of semi steel to finished liquid steel is carried out by ladle furnace treatment operation. The ladle containing the finished liquid steel will be transferred by crane into the ladle turret of the continuous casting machine and turned over into the casting position.
The emptied ladle will be returned after pouring into the liquid steel handling and transfer bay, and taken over by a crane.

After cleaning and raw inspection the ladle has to be transported to the ladle inspection and preparation area. In case that a complete relining will not be necessary, only slide gates and purging units have to be replaced. After this maintenance work the ladle will be preheated inside the same area. For this type of preheating horizontal preheaters are provided. After preheating time the ladle is prepared for the next pouring cycle. In case of fully abrasion of the refractories, the ladle will set down into debricking position and broken-out by debricking machine of self-movable design. Then the ladle will be relined and dried by a vertical drying unit.
After a sufficient period of time the ladle is ready for normal operation.

Inside the plant area a quick laboratory is provided. These quick tests are based on chemo-physical methods. All other tests should be made within the central laboratory.


BILLETS AND SECTIONS
500,000 tpy
2nd STAGE
1st STAGE
PLATES AND SHEETS
500,000 tpy
Raw Material Storage Area
Smelting Furnace Bay
Liquid Steel Handling and Ladle Furnace Bay
Continuous Casting Bay
Cooling and Storage Bay
1 Steel transfer system
2 Ladle Furnace equipment
3 Ferroalloys and additives handling equipment
4 Ladle handling equipment
MANNESMANN
LADLE METALLURGY PLANT &
STEEL TRANSFER SECTIONS
PLOT PLAN
TANZANIA

SECTION 5.3

Raw Materials and Products

5.3 Raw Materials and Products

5.3.1 Raw Materials

Semi steel

as per 4.3,

Feed rate: 590,000 tpy.

Ferrosilicon 75:

Si	:	73 - 79	%
Al. max.	:	2	%
P. max.	:	0.05	%
S. max.	:	0.04	%
C approx.	:	0.5	%
Cr max.	:	0.50	%

Ferromanganese:

Mn	:	75 - 80	%
C	:	6 - 8	%
Si max.	:	1.5	%
P max.	:	0.35	%
S max.	:	0.03	%
As max.	:	0.05	%

Siliconmanganese

Mn	:	58 - 72 %
Si	:	25 - 35 %
C	:	0.1 - 0.50 %
P max.	:	0.20 %
S max.	:	0.10 %

Aluminium

Al	:	99.5 %

Feed rate
Ferroalloys: 5,800 tpy

Charcoal

C fix	:	80	% (dry)
Vol. Mat.t	:	17	% (dry)
Ash	:	3	% (dry)
Grain size	:	5 - 50	mm
Feed rate	:	3,000	tpy

Burnt lime

CaO	:	45.8	%
MgO	:	30.0	%
SiO2	:	22.0	%
Al2O3	:	0.2	%

Grain size	:	5 - 40	mm
Feed rate	:	6,450	tpy

5.3.2 Products (based on calculations)

Liquid steel

Carbon	:	0.08 - 0.12 %
Silicon	:	0.10 - 0.30 %
Manganese	:	0.30 - 0.40 %
Sulphur	:	less 0.05 %
Phosphorus	:	less 0.05 %

Production rate: 584,100 tpy

Slag

CaO + MgO	:	80 %
FeO	:	15 %
S	:	- 0.05 %
P	:	- 0.05 %
SiO_2	:	4.5 %
MnO	:	- 0.5 %

Production rate: 9,530 tpy

Gas

to gas cleaning facilities.

Production rate: 6,600 tpy

LURGI

Tanzania/Volume III

SECTION 5.4

Consumption Figures
and
Workforce Schedule

5.4 Consumption Figures and Workforce Schedule

5.4.1 Consumption Figures

for the production of 584,100 tpy of liquid steel for slabs, the following consumption figures apply:

	per ton liquid steel		per year	
Semi steel	1,010	kg	590,000	t
Char coal	4 - 6	kg	3,000	t
Burnt lime	8 -12	kg	6,450	t
Ferroalloys	10 -12	kg	5,800	t
Electrode (graphite)	1	kg	584	t
Steel for tools	0.5	kg	292	t
Refractories for Ladles	8.0	kg	4,670	t
Slide gates	3.0	kg	1,750	t
Argon purging	1.0	kg	585	t
Fuel oil	3.5	kg	2,050	t
Argon for purging	0.09	Nm^3/t	52,600	Nm^3
Electric Power	100	KWh/t	58,400	MWh
Workforce	0.55	mhrs/t	162	men
Oxygen	20	Nm^3/h	-	
Compressed air	100	Nm^3/h	-	
Cooling water				
- closed circuit	150	m^3/h	-	
- open circuit	150	m^3/h	-	

Remark: All material flow figures contain approx. 5 % margin for handling losses.

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5.4.2 Workforce Schedule, Ladle Metallurgy

(G = Graduated; S = Skilled; SS = Semi-Skilled; US = Unskilled)

Based on four shifts, the following personnel will be required inside plant section:

	Shift 1	Shift 2	Shift 3	Shift 4	Day Shift	Total	Qualification Level
Superintendent					1	1	G
Staff					3	3	S
for plant operation							
foremen	3	3	3	3		12	S
operators	5	5	5	5		20	SS
assistant operators	2	2	2	2		8	SS
unskilled	15	15	15	15		60	US
for plant maintenance:							
foremen	2	2	2	2		8	S
mechanics	3	3	3	3		12	SS
electricians	1	1	1	1		4	SS
instr. technicians	1	1	1	1		4	S
for plant cleaning							
plant cleaners					6	6	US
for waste handling							
unskilled					2	2	US
for laboratory chemist technician	included in section 4						
Subtotal	32	32	32	32	12	140	
15 % Absentees	5	5	5	5	2	22	
Total	37	37	37	37	14	162	

S E C T I O N 5.5

Auxiliaries

5.5 Auxiliaries

All media and energy required inside plant sections will be supplied by the corresponding central generating, storing and distributing systems as outlined under Section 8 as well as in the Outline Specifications hereafter (Section 5.6.1.7).

This mainly refers to the corresponding general systems for the supplies of:

- Argon,
- Fuel Oil,
- Oxygen,
- Compressed Air,
- Cooling Water,

to the Ladle Furnace Plant.

All other input materials, like refractories, slide gates, ferroalloys, lime and char are handled by the individual facilities within the plant section.

SECTION 5.6

Outline Specification

Ladle Furnace Plant

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5.6.1 Mechanical Equipment

Plant Sections

.1 Steel transfer system

.2 Ladle furnace equipment

.3 Ferroalloys and additives handling equipment

.4 Ladles and ladle handling equipment

.5 Laboratory inside plant section

.6 Cranes

.7 Fluids and gases

.1 <u>Steel Transfer System</u>

Capacity of ladles : 80 t each

Section 5.6.1.1 mainly comprises the following items:

2 ladle transfer cars,

2 rail systems for ladle transfer cars,

2 weighing bridges,

2 purging gas units.

.2 <u>Ladle Furnace Equipment</u>

Section 5.6.1.2 mainly comprises the following items:

2 ladle furnaces

product	:	liquid steel
electrode diameter	:	400 mm
type of electrode	:	graphite
pitch circle dia.	:	900 mm
transformer capacity	:	13 MVA

each mainly consisting of:

- guide frame,
- roof lifting devices, including cylinders,
- electrode masts,
- regulator cylinders,
- electrode arms,
- cover hood at furnace,
- fume gas elbow,
- water-cooled pipes and pressure pipes,
- hydraulic pressure generating plant.

.3 Ferroalloys and Additives Handling Equipment

Section 5.6.1.3 mainly comprises the following items:

2 groups of additive bins

each consisting of:

- bins of mild steel including support structure,
- vibro feeder,
- moveable weighing unit, with rails and steel structure,
- transfer chute,
- charging vibro pipe.

- additives transport containers

- downpipes

.4 Ladles and Ladle Handling Equipment

Section 5.6.1.4 mainly comprises the following items:

16 ladles, equipped for slide gate operation and Ar purging,
- ladle hoods,
- ladle stands for debricking and relining,
2 ladle drying plants,
2 ladle preheating plants,
1 ladle debricking machine,
1 slide gate and purging set of inspection and maintenance facilities,
1 set of tools and tackles for ladle relining,
1 set of containers for debricking material.

.5 Laboratory and Sampling Equipment

Section 5.6.1.5 mainly comprises the following items:

2 sets of sample taking and preparation facilities,

- pneumatic tube system
- sample preparation equipment,
- laboratory inside plant, mainly consisting of:
  - quick analyzer,
  - gas analyzer,
  - 1 set of auxiliary equipment,
  - teleprinter.

.6 Cranes

Section 5.6.1.6 mainly comprises the following items:

2 EOT-cranes

capacity : main hoist 125 t,
auxiliary hoist 32 t,

1 maintenance hoist,

3 Jib-cranes, capacity: 3 t,

- contact lines etc.

.7 Fluids and Gases Distributing Systems

Section 5.6.1.7 mainly comprises the following items:

Distributing system for:

- oxygen,
- compressed air,
- open and closed cooling water circuits,
- argon accumulator,

mainly consisting of:

- pipes,
- assemblies,
- armatures,
- measuring and control equipment.

5.6.2 Electrical Equipment

inside section 5.6.2 mainly comprises the following items:

- low voltage main distribution,
- motor control centres,
- control and measuring devices,
- safety and protection equipment,
- control panels and desks,
- cabling and erection material,
- earthing,
- lighting system,
- communication systems.

For further details on the outline specificacion of electrical equipment, please refer to section 3.6.2.

The electrical equipment of the Ladle Furnaces mainly comprises the following items:

- high voltage switchgear,
- disconnecting switch,
- surge arrestors,
- furnace transformer, 13 MVA,
- secondary bus bars and tubes,
- control panels,
- furnace control equipment,
- cables, cabling accessories,
- earthing material,
- tools and tackles.

5.6.3 Instrumentation Equipment

The instrumentation equipment for the ladle furnace plant mainly comprises:

- field instruments,
- local indicating measuring instruments,
- local measuring detectors,
- transmitters,
- panel instruments incl. indicating instruments and recorders,
- control room panels,
- auxiliary racks and cubicles,
- interfaces and power supply systems,
- all installation material like cables, wiring, fuses, etc.

A detailed description of the lay-out of this equipment is given in section 3.6.3 of this volume.

5.6.4 Structural and Civil Works

Main quantities for structural steel and civil works related to the Ladle Furnace Plant are as follows:

Structural Steel	4900	t
Bins	210	t
Roof and Wall Cladding	20060	m^2
Concrete	9650	m^3
Formwork	24200	m^2
Reinforcement	820	t
Excavation	41000	m^3

Price estimations for these works are based on information obtained from Mowlem International Ltd., London, based on the experiences gained with Mufindi Pulp and Paper Mill.

This section is common to the

- Electric Smelting Plant,
- Ladle Furnace Plant,
- Continuous Casting Plant,

which are located in one common building.

S E C T I O N 5.7

Investment Cost Estimate

5.7 Investment Cost Estimate

- Laddle furnace plant -

The bidgetary investment costs for the laddle furnace plant, capable to produce 584,000 tpy of liquid steel, are estimated as follows (based on the exchange rates: 1 US $ = 2.7 DM = 12.2 T.Sh.).

	approx. Mio. US $	approx. Mio. T.Sh.
- Plant Equipment delivered free site	10.3	125.7
- Erection, Supervision, Commissioning	3.5	42.7
- Civil Work and Steel Stucture, erected and painted	3.7	45.1
- Related Plant Infrastructure	0.8	9.8
Total Investment Cost	18.3	223.3
- Spare Parts for 2 years plant operation	0.6	7.3

This budget estimate is based on German prices and conditions and on cost factors ruling end of December 1983 for the equipment. It does not include any customs duty, taxes, dues or other levies which may arise outside the Federal Republic of Germany.

The estimation of the civil work and structural steel portion is derived from price information supplied by Mowlem International Ltd., London.

The estimation for plant equipment includes the cost for packing and the freight charges delivered free on site. Our budget prices are estimated on the assumption that all work can be performed continuously and in accordance with the time schedules containe in section IV/5.

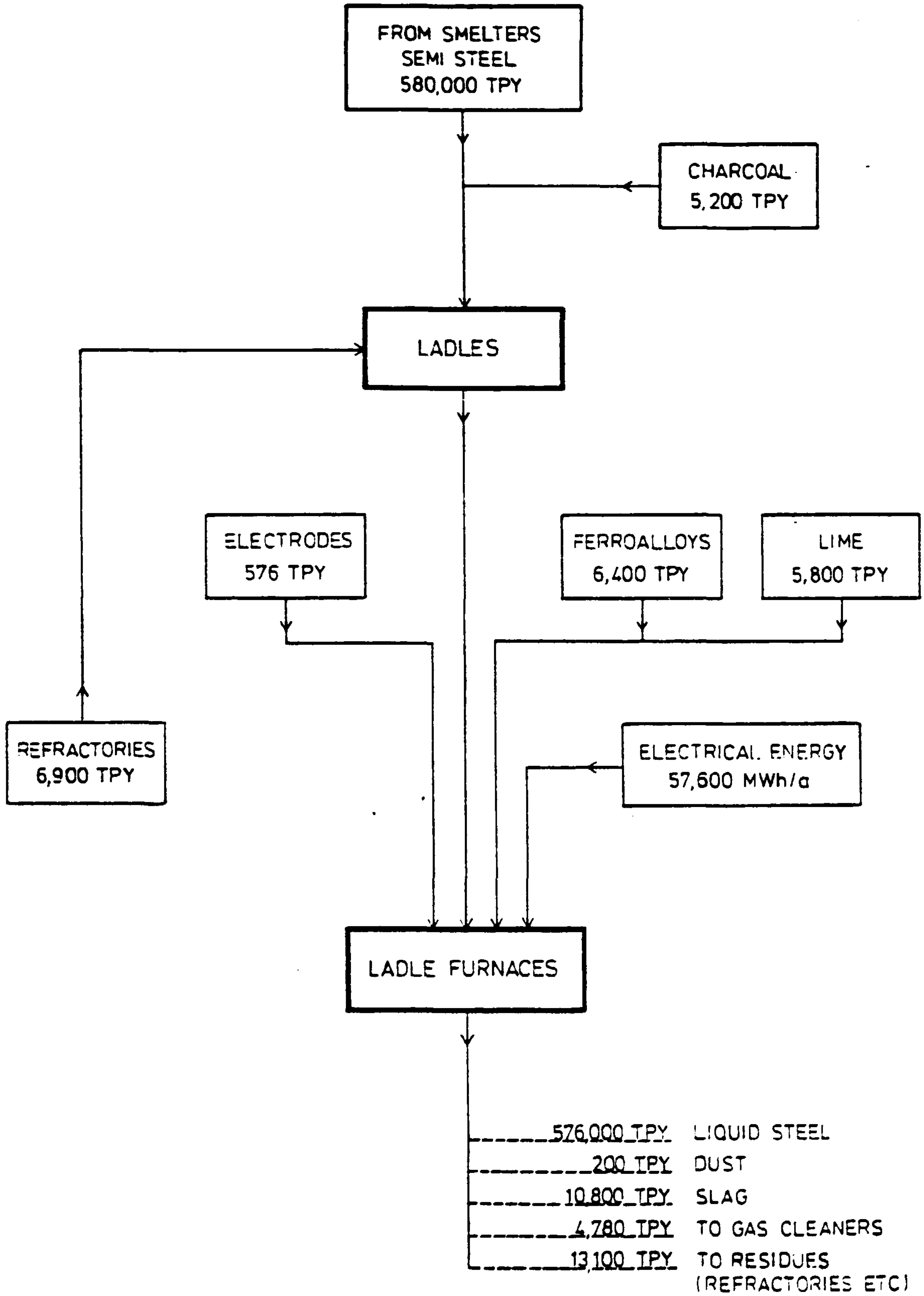
This budget estimate is furthermore based on usual cash terms of payment, allowing an adequate down payment upon signing of contract and progress payments according to the progress of work in the engineering, manufacturing and erection.

All further terms and conditions will have to be agreed upon during the progress of contract negotiations.

A N N E X

Expansion Step

1 Million tpy Steel



LIQUID STEEL HANDLING AND LADLE FURNACES
MAIN FLOWSHEET
BILLETS (2nd STAGE)

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Tanzania/Volume III

S E C T I O N 6

Continuous Casting Plant

S E C T I O N 6.1

Process Description

Continuous Casting Plant

6.1 Process Description

The continuous casting installation is designed for the continuous casting of steel. The plant essentially consists of the following components:

Ladle stand
Tundish
Tundish car
Mould
Mould oscillator
Roller aprons
Spray chamber and steam exhaust
Withdrawal-straightening machine
Cut-off machine
Run-out equipment

When commencing casting operations, the head of the starter bar is tightly sealed in the mould and retained by the driven rollers of the withdrawal and straightening machine.

Molten steel is fed from the steel ladle into a tundish with stopper-controlled nozzles to permit accurate apportioning of the steel running into the mould. The tundish is positioned on a tundish car. The tundish car travels at right angle to the casting direction. Arrangement and construction of the car provide good accessibility to and an unobstructed view into the mould and travelling without hindering the machine operators.

A ladle stand serves as a ladle receiving device. With the aid of the ladle crane the ladle is lowered onto the ladle stand.

The tundish parking position is on right side of the casting position, where a swivel-mounted tundish pre-heat facility is located.

When the cast is terminated, the tundish is transported into the tundish repair shop where the residual slag in the tundish is cooled by means of water sprays and the skull removed with the aid of a crane.

From the tundish in casting position the steel is fed into a water-cooled curved mould.

The design of this mould prevents plastic deformation, it has been developed for long service life.

A lubricant (casting powder) is fed to the mould during casting to obviate wetting of the mould wall by the liquid steel, create a reducing atmosphere above the metal level and reduce friction between strand and mould.

A mould oscillator imparts an oscillating motion to the mould. The frequency is adjustable.

The strand leaving the mould with only a thin shell and guided along the bow through cooling zones arranged below the mould, is further solidified by direct spraying with water. Cooled water flow and spray intensity can be adjusted to suit the steel composition, casting dimensions and casting speed.

Flat jet nozzles are used for spraying the strand.

This system provides for spray water between two apron rollers being applied trough three nozzles to the entire slab width from segment No. 0 on.

This system offers the following advantages:

1. Reduced risk of nozzle clogging since larger nozzles have to be comployed.

2. Reduced number of nozzles and headers.

3. Simplified maintenance.

4. Minimal delay due to nozzle replacement.

The cooling zones are arranged in a spray chamber. The steam produced during cooling is evacuated by exhausters.

The strand is supported and guided by means of rollers. Roller spacing and roller diameter have been selected to ensure little bulging due to ferrostatic pressures. Several pairs of rolls are grouped in segments.

The first segment of the roller apron, segment 0 is arranged below the mould.

The strand guide frame following segment 0 comprises 7 additional segments mounted on supporting frames.

The length of segment 0 and segment 1 - 7 beyond the mould is governed by the maximum solidifaction path of the slab.

The length of the solidification path is determined by the casting speed and the rate of heat transfers from the molten steel to the coolant.

The cast strand is handled into the withdrawal-straightening zone by means of a starter bar which is supported and conveyed by the driven rollers.

The withdrawal-straightening zone, is followed by an approach table and a cutting table.

By means of the torch cutting machine the strand is subdivided into sections. The minimum cut lengths which can be achieved are dependent on the size of the slabs being cast and the casting speed.

Starter bar feeding is from the bottom.

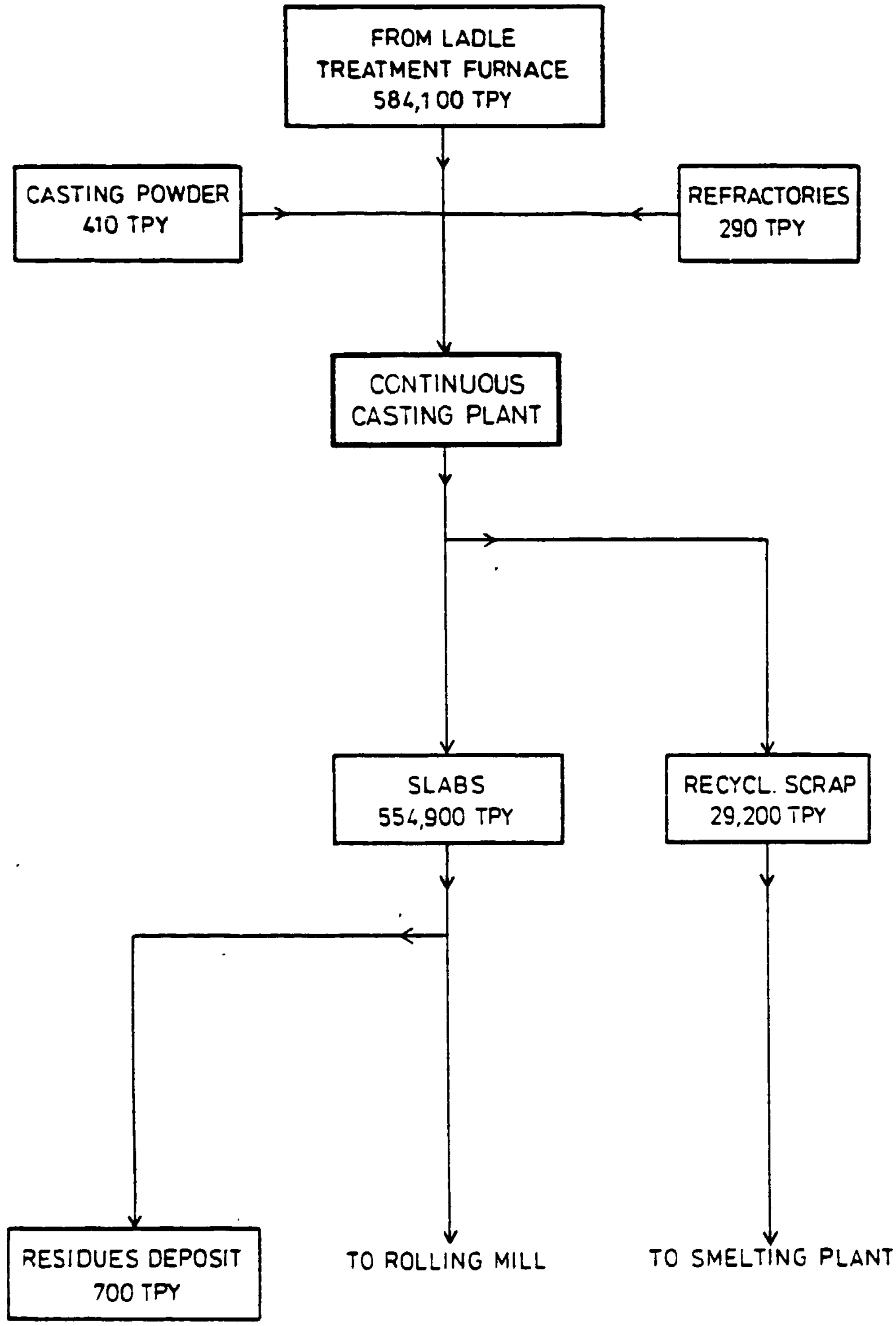
After the cutting table a roller table is installed which operates in combination with a starter bar cage for receiving and storing the starter bar.

After the starter bar has left the withdrawal-straightening machine the starter bar head is disconnected from the cast slab by means of a disconnecting device.

There after the starter bar will be conveyed into the starter bar cage, where it will be shifted by means of shifting device to the right side of the run out rollertable.

The torch cutting table is a car equipped with table rollers. The car is moved back and forth by means of an electrical-mechanical drive to prevent damage on roller table rollers by the cutting torches. The roller table car is supported by four wheels stationary arranged.

After cutting, products run forward on a roller table to the slab handling bay. A tong crane has to be used to remove products from there.



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CONTINUOUS CASTING PLANT
MAIN FLOWSHEET
SLABS (1st STAGE)

S E C T I O N 6.2

Plant Description

Continuous Casting Plant

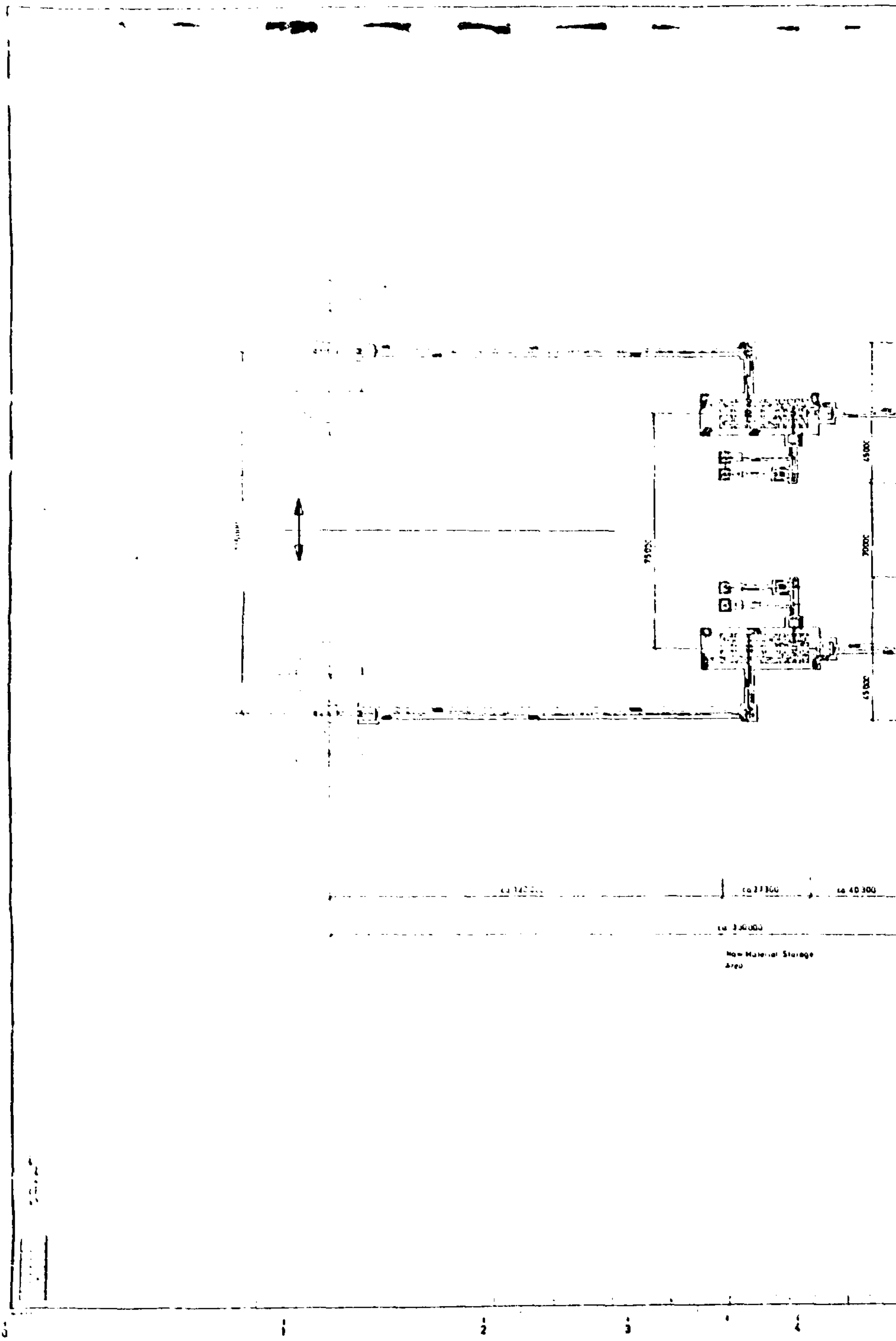
6.2 Plant Description

The continuous casting plant is arranged between column rows D_1 - E_1 and E_1 - F_1.
The equipment in the bay D_1 - E_1 consists mainly of the following items:

- casting machine,
- cutting and run-out facilities,
- preparation area for tundishes and moulds.

In the bay E_1 - F_1 mainly is arranged the run-out equipment of the casting plant, and also the take-over equipment to the rolling mill.
Cooling, inspection and rough conditioning of the bar sections will be provided inside the area close to the run-out respectively take-over facilities.

The transportation of the bar sections is carried out by cranes.



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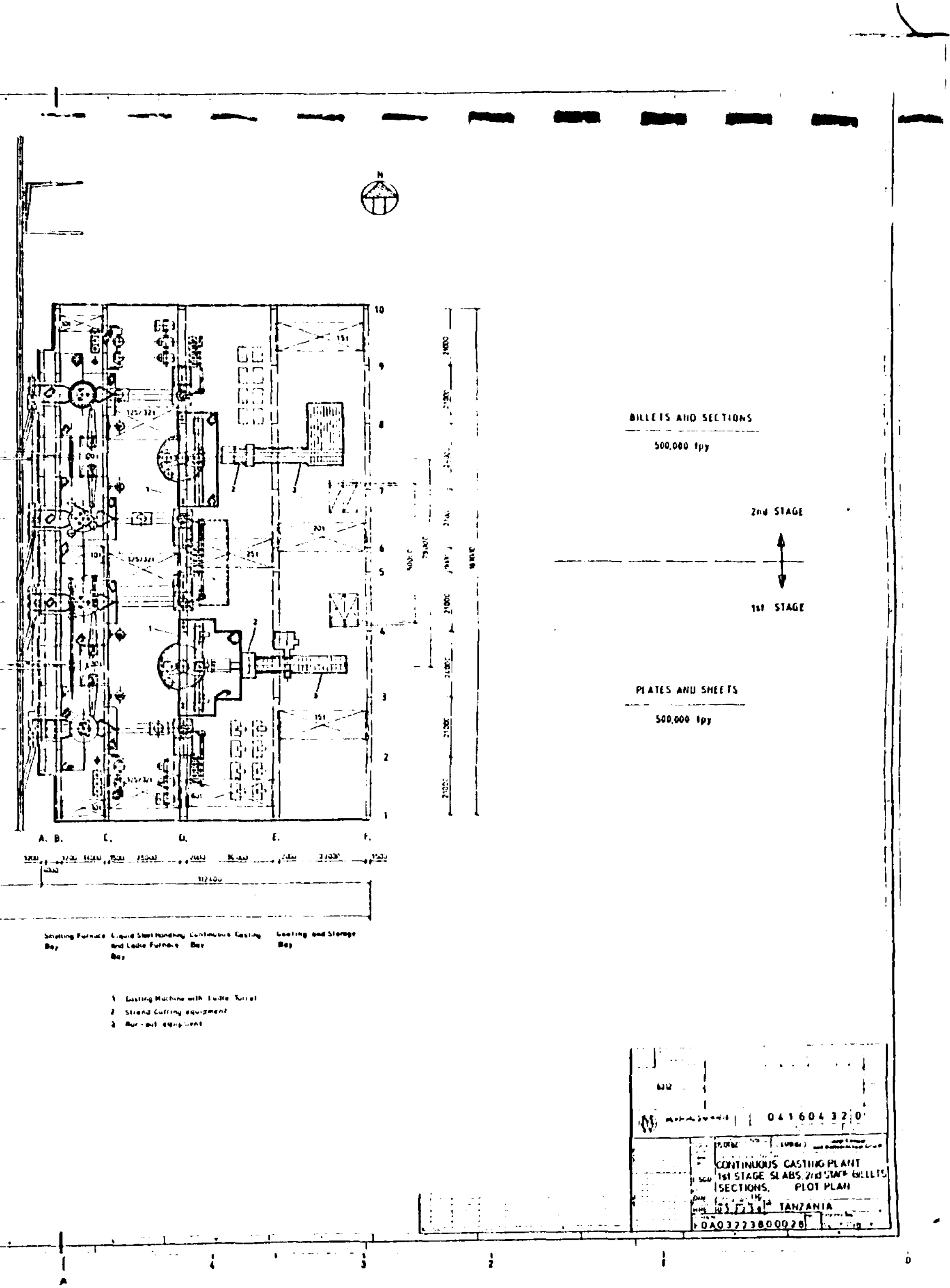
Raw Material Storage Area


N
A. B. C. D. E. F.
Smelting Furnace Bay
Liquid Steel Handling and Ladle Furnace Bay
Continuous Casting Bay
Cooling and Storage Bay
1 Casting Machine with Ladle Turret
2 Strand Cutting equipment
3 Run-out equipment
BILLETS AND SECTIONS
500,000 tpy
2nd STAGE
1st STAGE
PLATES AND SHEETS
500,000 tpy
0 4 1 6 0 4 3 2 0
CONTINUOUS CASTING PLANT
1st STAGE SLABS 2nd STAGE BILLETS
SECTIONS. PLOT PLAN
TANZANIA
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SECTION 6.3

Raw Materials and Products

6.3 Raw Materials and Products

6.3.1 Raw Materials

Liquid steel

Carbon	:	0.08 - 0.12 %
Silicon	:	0.10 - 0.30 %
Manganese	:	0.30 - 0.40 %
Sulphur	:	less 0.05 %
Phosphorus	:	less 0.05 %

Feed rate : 584,100 tpy

Casting powder

commercial export quality,

Feed rate : 410 tpy

6.3.2 Products

Slabs

width	:	750 - 1,050	mm
thickness	:	150	mm
length	:	1,500 - 5,700	mm

Production rate: 554,300 tpy

Recycle Scrap

returned to smeling plant.

Production rate: 29,200 tpy

Residues

like refractories, scale, slag.

Production rate: 700 tpy.

SECTION 6.4

Consumption Figures

and

Workforce Schedule

6.4 Consumption Figures and Workforce Schedule

6.4.1 Consumption Figures

for the production of 554,900 tpy of slabs are as follows:

	per ton slabs		per year	
Liquid steel	1,053	kg	584,100	t
Refractories	0.5	kg	290	t
Casting powder	0.7	kg	410	t
Fuel oil	7.0	kg	3,750	t
Propane	0.2	Nm^3	117,000	Nm^3
Argon	0.2	Nm^3	117,000	Nm^3
Oxygen	2.6	Nm^3	1,460,000	Nm^3
Compressed air	0.3	Nm^3	176,000	Nm^3
Electrical energy	12.5	KWh	7,010	MWh
Workforce	0.6	mhrs	165	men
Cooling water				
- open circuit	110	m^3/h	-	
- closed circuit	490	m^3/h	-	

Remark: All material flow figures contain approx. 5 % margin for handling losses.

6.4.2 <u>Workforce Schedule</u>, Continuous Casting Plant

(G = Graduated; S = Skilled; SS = Semi-Skilled; US = Unskilled)

Based on four shifts, the following personnel will be required inside plant section:

	Shift 1	Shift 2	Shift 3	Shift 4	Day Shift	Total	Qualification Level
Superintendent					1	1	G
Staff					4	4	SS
for plant operation							
foremen	4	4	4	4		16	S
operators	1	1	1	1		4	SS
assistant operators	1	1	1	1		4	SS
unskilled	18	18	18	18		72	US
for plant maintenance:							
foremen	2	2	2	2		8	S
mechanics	3	3	3	3		12	SS
electricians	1	1	1	1		8	SS
instr. technicians	1	1	1	1		4	S
for plant cleaning							
plant cleaners					6	6	US
for waste handling							
unskilled					4	4	US
for laboratory	included in						
chemist	section 4						
technician							
Subtotal	32	32	32	32	15	143	
15 % Absentees	5	5	5	5	2	22	
Total	37	37	37	37	17	165	

S E C T I O N 6.5

Auxiliaries

6.5 Auxiliaries

All media and energy required inside plant sections will be supplied by the corresponding central generating, storing and distributing system.
The distributing systems are outlined under Section 8 and under Section 6.6.1.7.

This mainly refers to the supplies of:

- Propane,
- Argon,
- Oxygen,
- Compressed air,
- Fuel Oil,
- Cooling Water

to the Continuous Casting Plant.

Other input materials, like casting powder and refractories, are handled by the corresponding installations described in the individual plant sections.

SECTION 6.6

Outline Specification

Continuous Casting Plant

(For Slabs, Stage 1)

6.6.1 Mechanical Equipment

Plant Sections

.1 Casting machine

.2 Strand cutting equipment

.3 Run-out equipment

.4 Anchoring parts

.5 Hydraulic equipment

.6 Cranes

.7 Fluids and gases distributing systems

.1 Casting Machine

Basic Data

slabs production	:	appr. 554,100 tpy
heat weight	:	max. 80 t
type of ladle	:	bottom pour
machine equipped to cast		
width	:	750 mm - 1,050 mm
thickness	:	150 mm
length	:	1,500 - 5,700 mm
steel grades	:	carbon steels.

Casting Machine Data

type of machine	:	bow machine with curved moulds
casting radius	:	10.5 m
number of strands	:	1
machine speed	:	0.2 - 2 m/min/ 4m/min dumming bar inserting speed
removal of cut section	:	via roller table and cross transfer

Section 6.6.1.1 mainly comprises:

- ladle turret,
- steel structure,
- cooling chamber,
- ladle operating stand,
- ladle shrouding mechanism,
- tundishes with covers and stopper rod,
- assemblies,

- tundish cars with lifting devices,
- mounting devices for operator's panels,
- tundish preheating stations,
- submerged nozzle heaters,
- spillover buckets,
- overflow launders for tundish cars,
- emergency launder,
- plate moulds,
- dummy bars,
- mould oscillators,
- mould cooling water piping,
- spray cooling water piping,
- machinery cooling water piping,
- steam exhaust system,
- strand guide frames,
- withdrawal-straightening systems,
- dummy bar disconnecting devices,
- central grease lubrication system,
- mould alining stand,
- segm. 0 alining stand,
- segm. 1 - 11 alining stand,
- storage stand and aux. equipment.

.2 Strand Cutting Equipment

Section 6.6.1.2 mainly comprises:

- torch cutting machine,
- length measuring devices (mechanic).

.3 Run-out Equipment

Section 6.6.1.3 mainly comprises:

- dummy bar decoupling device,
- dummy bar receiving devices,
- crop end removal facility,
- run-out roller table,
- torch cutting roller table,
- fixed stops,
- cross transfer.

.4 Anchoring Parts

consisting of:

- anchoring bolts,
- heat protection plates.

.5 Hydraulic Equipment

consisting of:

- oil reservoir with return filter,
- heat-exchanger and accessories,
- high pressure pump stations,
- recirculation pump stations,
- valve stands,
- hydraulic cylinders,
- piping,

.6 Cranes

Section 6.6.1.6 mainly comprises the following items:

1 continuous casting bay crane
capacity: 60 t,

1 run-out and take-over crane
capacity: 20 t,

1 run-out and take-over crane
capacity: 15 t,

1 maintenance hoist, run out and take-over
capacity: 6 t,

- contact lines etc.

.7 Fluids and Gases Distributing Systems

Section 6.6.1.7 mainly comprises the following items:

Distributing systems for:

- oxygen,
- nitrogen,
- compressed air,
- open and closed cooling water circuits.

mainly consisting of:

- pipes,
- assemblings,
- armatures,
- measuring and control equipment.

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6.6.2 Electrical Equipment

inside section 6.6.2 mainly comprises the following items:

- low voltage main distribution,
- motor control centres,
- control and measuring devices,
- safety and protection equipment,
- control panels and desks,
- cabling and erection material,
- earthing,
- lightning system,
- communication systems.

For further details on the outline specifications of electrical equipment, please refer to section 3.6.2.

The special items of electrical equipment supplied with the slab caster mainly comprise:

- electrical equipment for casting plant,
- length measuring for torch cutting machine,
- automatic mould level control systems.

6.6.3 Instrumentation Equipment

The instrumentation equipment for the continuous casting plant mainly comprises:

- field instruments,
- local indicating measuring instruments,
- local measuring detectors,
- transmitters,
- panel instruments incl. indicating instruments and recorders,
- control room panels,
- auxiliary racks and cubicles,
- interfaces and power supply systems,
- all installation material like cables, wiring, fuses, etc.

A detailed description of the lay-out of this equipment is given in section 3.6.3 of this volume.

The plant-related instrumentation equipment for the slab caster mainly comprises:

- instrumentation for mould cooling,
- instrumentation for spray cooling,
- instrumentation of machinery cooling,
- molten steel temperature measurement,
- casting speed recording.

6.6.4 Structural and Civil Works

Main quantities for structural steel and civil works related to the Continuous Casting Plant, are as follows:

Structural Steel	4900	t
Bins	210	t
Roof and Wall Cladding	20060	m^2
Concrete	9650	m^3
Formwork	24200	m^2
Reinforcement	820	t
Excavation	41000	m^3

Price estimations for these works are based on information obtained from Mowlem International Ltd., London, based on the experiences gained with the Mufindi Pulp and Paper Mill.

This section is common to the

- Electric Smelting Plant,
- Ladle Furnace Plant,
- Continuous Casting Plant,

which are located in one common building.

S E C T I O N 6.7

Investment Cost Estimate

6.7 Investment Cost Estimate

- Continuous casting plant -

The budgetary investment costs for the continuous casting plant, capable to produce 555,000 tpy of slabs, are estimated as follows (based on the exchange rates: 1 US $ = 2.7 DM = 12.2 T.Sh.).

	approx. Mio. US $	approx. Mio. T.Sh.
- Plant Equipment delivered free site	24.3	296.5
- Erection, Supervision, Commissioning	8.3	101.3
- Civil Work and Steel Stucture, erected and painted	8.6	104.9
- Related Plant Infrastructure	1.3	15.9
Total Investment Cost	42.5	518.6
- Spare Parts for 2 years plant operation	1.4	17.1

This budget estimate is based on German prices and conditions and on cost factors ruling end of December 1983 for the equipment. It does not include any customs duty, taxes, dues or other levies which may arise outside the Federal Republic of Germany.

The estimation of the civil work and structural steel portion is derived from price information supplied by Mowlem International Ltd., London.

The estimation for plant equipment includes the cost for packing and the freight charges delivered free on site. Our budget prices are estimated on the assumption that all work can be performed continuously and in accordance with the time schedules contained in section IV/5.

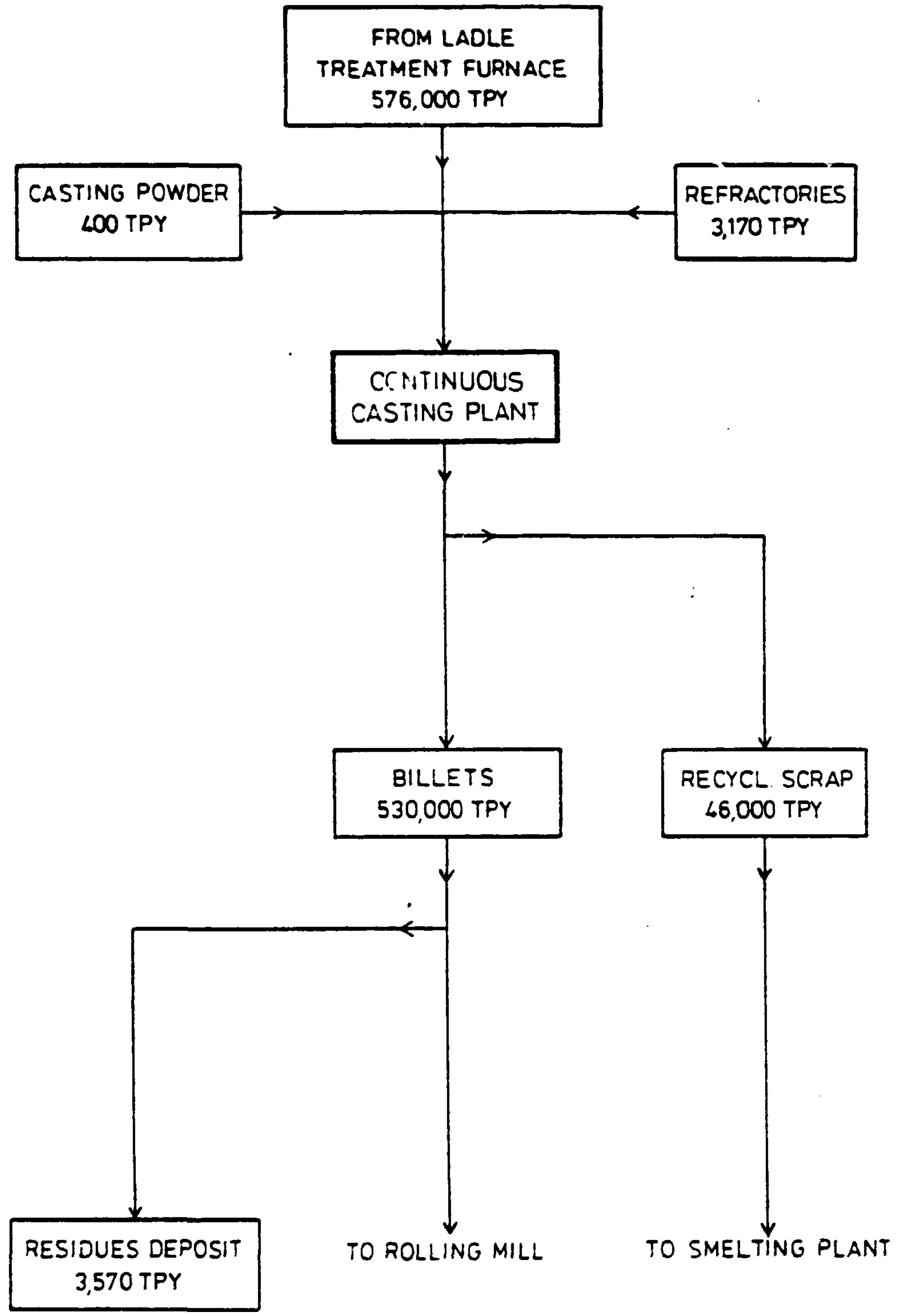
This budget estimate is furthermore based on usual cash terms of payment, allowing an adequate down payment upon signing of contract and progress payments according to the progress of work in the engineering, manufacturing and erection.

All further terms and conditions will have to be agreed upon during the progress of contract negotiations.

A N N E X

Expansion Step

1 Million tpy Steel



CONTINUOUS CASTING PLANT
MAIN FLOWSHEET
BILLETS (2nd STAGE)

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LURGI

S E C T I O N 7

Rolling Mill and Product Finishing

(Hot Strip and Plate Mill, Stage I)

SECTION 7.1

Process Description

Rolling Mill

7.1. Process Description

7.1.1. Hot Strip Rolling

The continously cast slabs are fed from the slab yard into the reheating furnaces and heated up to rolling temperature.
After discharging the furnace scale has to be removed from the slabs to ensure a good strip surface quality.

This descaling procedure is carried out by spraying of high-pressure water (operating pressure 150 bar) on the top and bottom surface of the slab.

The slabs are rolled to strip bars by the reversing roughing mill. The strip width is controlled by an attached vertical edging stand.

After roughing the strip bars proceed to final rolling. Head and tail end are cropped, the strip bars are descaled again to remove the secondary scale, and fed to the reversing strip finishing mill (steckel mill).

As opposed to a multi-stand finishing train, the steckel mill provides for the individual passes being rolled in succession. Following each pass the strip is coiled in one of the two coiling furnaces located in front and back of the steckel mill to prevent a too high temperature drop in the rolling stock.

Along the run-out roller table the finished strip passes through a cooling section which admits the water to the strip without pressure (laminar flow cooling) whereby a very pronounced cooling effect is obtained. The subfloor coiler forms the strip into a coil. The finished coils are transported to the coil storage, tied and signed ready for shipping.

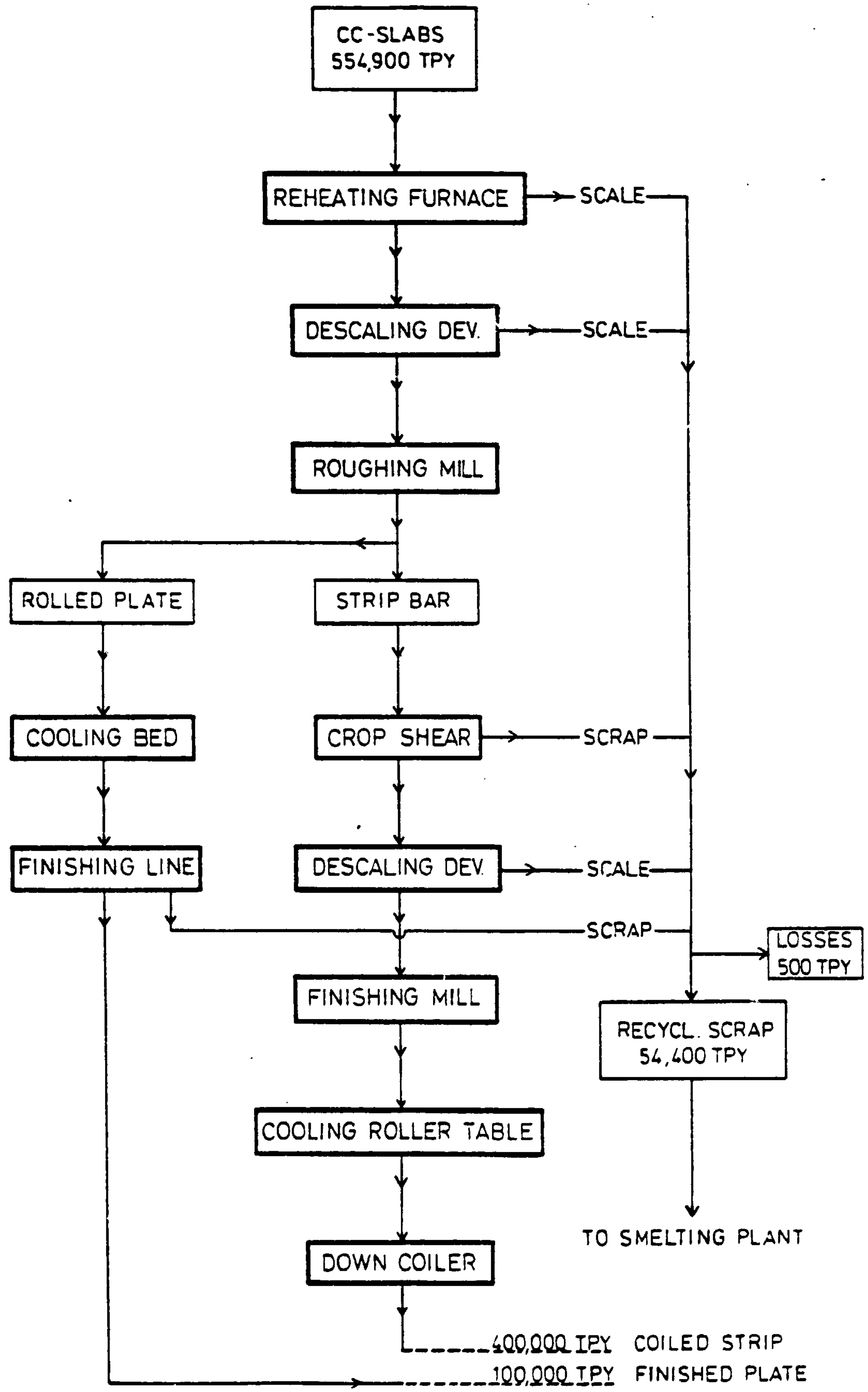
7.1.2. Plate Rolling

For plate rolling CC slabs are reheated to rolling temperature, descaled and rolled to plate by the reversing roughing mill.
The final plate width, which will generally be larger than the slab width is achieved by transversal rolling at the beginning of the rolling process. Thus the slabs for plate have to be not longer than the barrel length of the rolls of the mill.

The rolled plates are delivered and transferred onto a cooling bed. At its end the plates are stored in an intermediate storage.

Plate finishing is provided on an off-line plate finishing line. The plates are levelled, trimmed and cut to final length. The cut-to-size plates are inspected and stored ready for shipping.

Plates of thicknesses, which cannot be handled by the finishing line, are sized by torch cutting at a separate place in the finishing yard.



HOT STRIP AND PLATE MILL
MAIN FLOWSHEET
(1st STAGE)

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MANNESMANN DEMAG

S E C T I O N 7.2

Plant Description

Rolling Mill

7.2. Plant Description

The Hot Strip and Plate Mill is arranged close to the Continuous Casting Plant and the slab yard. The slab feeding grid, which is the starting point of the rolling process, is located within the slab storage area. The slabs are laid down onto the grid by the slab yard crane.

7.2.1. Reheating Furnaces

Especially for plate rolling slabs of very different sizes are used, with a very short length to enable the transversal plate rolling.
For this reason two-row charging of the furnaces must be possible. Feeding grid, slab charging pusher and slab extractor are designed accordingly.

The furnaces themselves are provided as walking beam-type furnaces. This type gives better temperature uniformity of the slabs, allows easier handling of different slab sizes being in the furnace at the same time, and enables to empty the furnace in case of mill stops very easily.

The furnaces will have to be fired by oil (heavy fuel oil) since fuel gas will not be available, neither as natural gas, nor as by-product gas in sufficient quantity from the metallurgical processes. Fuel oil can be transported and stored easier than gas, which would be applied as LPG.

7.2.2. Roughing Mill

Between furnaces and roughing mill the slab descaling device is located. While passing the device along the roller table, the top and the bottom side of the slab is sprayed by high-pressurized water. So the primary scale of the slabs is broken and removed to avoid surface faults on the strip during the rolling process.-

The roughing mill group consists of a reversing mill stand.
This stand is a four-high mill to ensure improved shape and improved flatness, particularly of the wider plate.
The stand is driven by motors in twin-drive arrangement, which enables rapid reversing of the rolling direction and hence short reversing times and temperature losses.
The work rolls are changed by means of a counter weight device. However,the roll chocks are provided for the subsequent installation of a quick changing device.

A vertical edging stand is attached in front of the four-high stand with drive arrangement from the top.

The edger is used to achieve the final strip width so that the CC slabs, which are cast in fixed widths, can be rolled to strips of any width within a certain range.

The work roller tables in front of and behind the mill stand are wide enough to allow the transversal plate rolling of slabs. For this purpose the front work roller table is designed as turning table.

Centering side guides are provided along the work roller tables.

7.2.3. Finishing Mill

The distance between the Roughing Mill and the Finishing Mill Group must be long enough to allow the free run-out of the pre-rolled strip bar.

In front of the finishing mill a drum-type rotary cropping shear is located for cropping the head and tail end of the bar, followed by a second high-pressure water descaling device to remove the secondary scale built up by the roughing process.

The Finishing Mill itself is a four-high reversing strip mill (steckel mill), equipped with a quick-response screw down for the control of the strip thickness deviations in order to produce a finished product within closed strip gauge tolerances.

In front and behind the mill the strip coilers are arranged, placed within the reeling furnaces with attached pinch roll units.

Actually, steckel mill rolling is the eldest strip rolling process which was subsequently replaced by the multi-stand finishing train. In the case of tonnage steels the finishing train offered high production and an improved quality of the finished product. Nowadays the steckel mill is again gaining in importance. It offers economic advantages regarding the processing of speciality steels. Moreover, a perfect product in terms of quality can be obtained by the application of computer and modern mechanical equipment.

7.2.4. Coiling End

The length of the run-out roller table behind the Finishing Mill depends on the mill and coiling speed, i. e. the time being available for controlled strip cooling.
The laminar flow cooling line consists of a number of spray pipes with nozzles, arranged above and below the roller table.
The spray pipes are controlled in groups according to the water flow requirement.

At the end of the roller table the down coiler is located, equipped with entry side guides, pinch rolls, blocker rolls and collapsible mandrel.
The finished coil is pulled from the mandrel and taken up by a coil car with elevating cradle to lift the coil to a coil upender. Here the coil is tilted to its vertical-axle position and laid down onto a coil conveyor. The conveyor consists of a flat chain and transports the coils to the coil storage area.

7.2.5. Plate Finishing Line

The plates which are rolled on the Roughing Mill are drawn from the roughing mill delivery roller table onto a cooling bed.
To avoid surface damages by sliding movement a walking grid-type cooling bed is provided, on which the plates are transported by carrying. Moreover this type of bed allows the optimum utilisation, because plates can placed with a minimum space independent on their width.

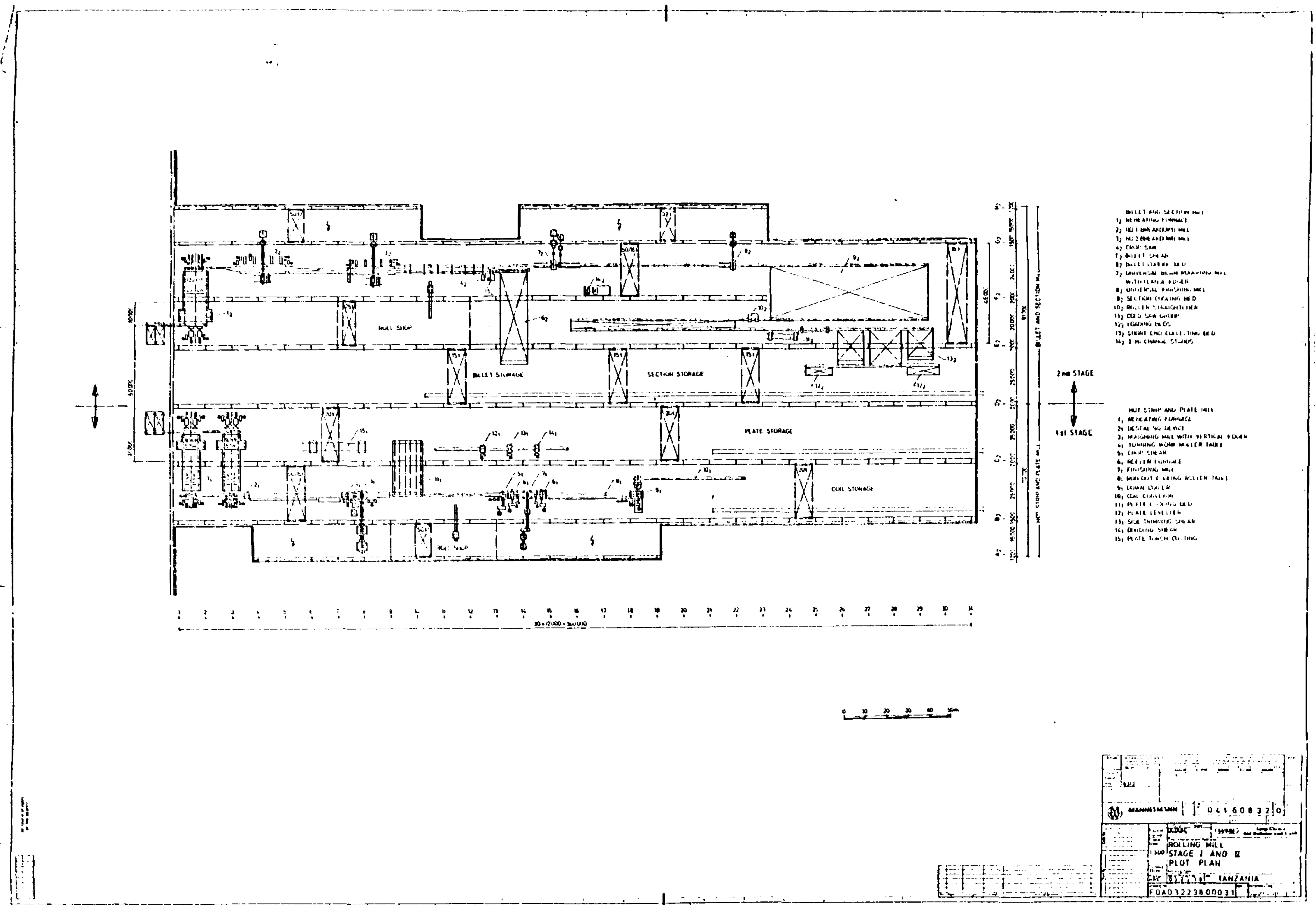
Feeding and delivery transfer are of carrying chain type which ensures careful transportation as well.

The cooled plates are piled by crane in the intermediate plate storage. For finishing they are fed onto a roller table again which forms the plate finishing line by connecting a cold plate leveller, a side trimming shear and a dividing shear.

The cold leveller is a multi-roll type levelling machine. The double side trimming shear consists of two shear stands. One of the stand is shiftable in cross direction to be adjusted according to the finished plate width. The shear is a rocking-cut-type shear, equipped with aligning device, pinch rolls, seam scrap chopping shears and scrap removal and collecting facilities.

The dividing shear is a down-cut shear working with rocking type shear blades, too. It is equipped with aligning device, clamping device, and scrap removal and collecting facilities.

A gauge stop is not provided due to the low plate production.
The finished plates are collected at the end of the roller table and taken away by crane to be piled in the plate storage yard.


BILLET AND SECTION MILL
1₂ REHEATING FURNACE
2₂ NO 1 BREAKDOWN MILL
3₂ NO 2 BREAKDOWN MILL
4₂ CROP SAW
5₂ BILLET SHEAR
7₂ UNIVERSAL BEAM ROUGHING MILL WITH FLANGE EDGER
8₂ UNIVERSAL FINISHING MILL
9₂ SECTION COOLING BED
10₂ ROLLER STRAIGHTENER
11₂ COLD SAW GROUP
12₂ LOADING BEDS
13₂ SHORT END COLLECTING BED
14₂ 2 HI CHANGE STANDS
HOT STRIP AND PLATE MILL
1₁ REHEATING FURNACE
2₁ DESCALING DEVICE
3₁ ROUGHING MILL WITH VERTICAL EDGER
4₁ TURNING WORK ROLLER TABLE
5₁ CROP SHEAR
6₁ REELER FURNACE
7₁ FINISHING MILL
9₁ DOWN COILER
10₁ COIL CONVEYOR
11₁ PLATE COOLING BED
12₁ PLATE LEVELLER
13₁ SIDE TRIMMING SHEAR
14₁ DIVIDING SHEAR
15₁ PLATE TORCH CUTTING
2nd STAGE
1st STAGE
BILLET AND SECTION MILL
HOT STRIP AND PLATE MILL
ROLL SHOP
BILLET STORAGE
SECTION STORAGE
PLATE STORAGE
COIL STORAGE
30 x 12000 = 360 000
0 10 20 30 40 50m
MANNESMANN
ROLLING MILL
STAGE I AND II
PLOT PLAN
TANZANIA
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SECTION 7.3

Raw Materials and Products

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7.3. Raw Material and Products

7.3.1. Input Material

Continuously cast slabs

width:	750-1050 mm
thickness:	150 mm
length:	1500-5700 mm

7.3.2. Products

Rated mill capacity:	coiled strip	400.000 t/a
	heavy plate	100.000 t/a
	total	500.000 t/a

Product sizes

coiled strip:	width:	600-1050 mm
	thickness:	2-10 mm
	coil weight:	max. 7500 kg
		max. 7.1 kg/mm
heavy plate:	width:	1500-2000 mm
	thickness:	6-16 mm
	length:	max.12,000 mm (finished)

The production schedule is as follows:

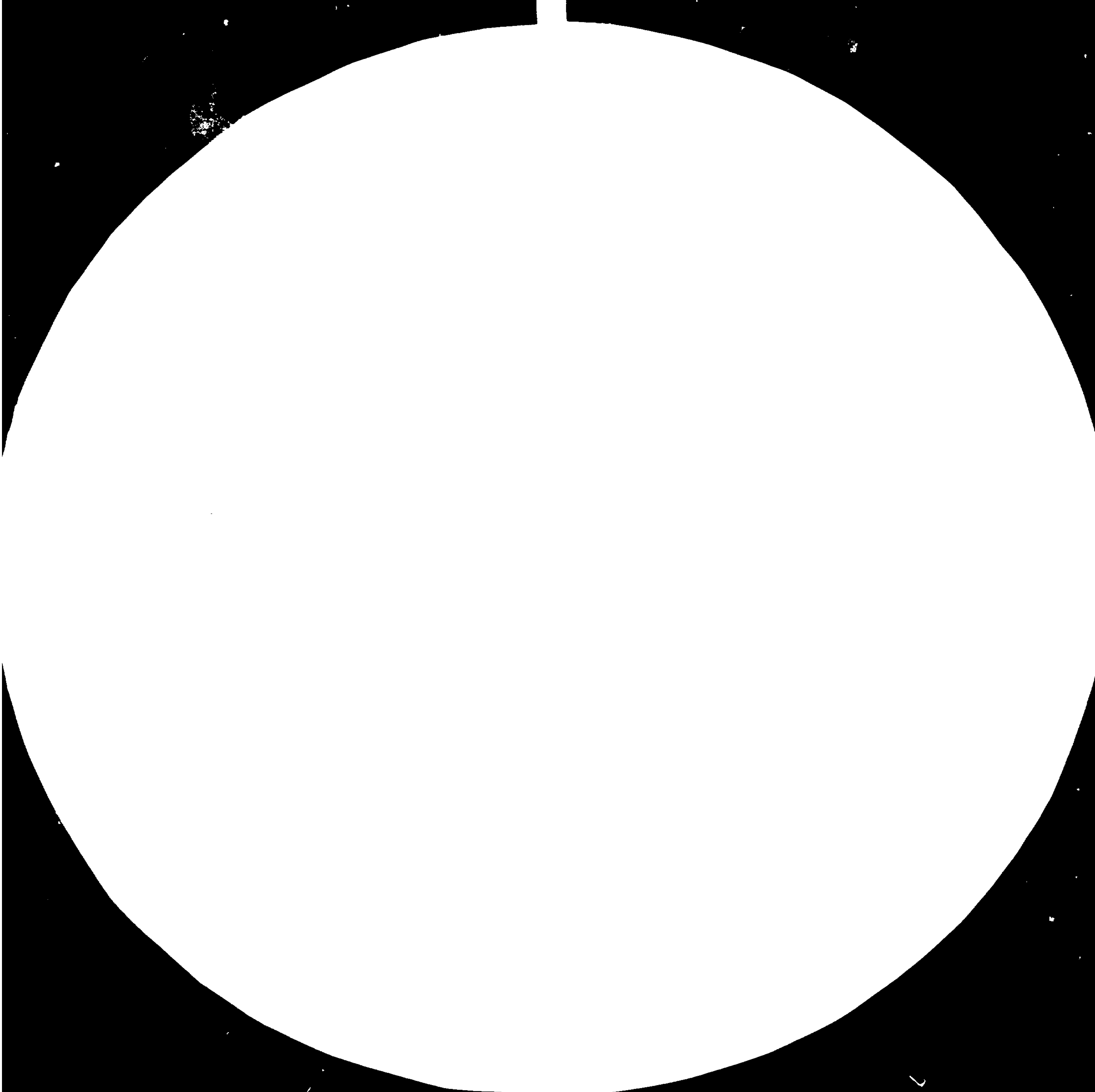
Product Size mm	Slab Size mm	Mill Output t/h	Production t/a	Utilis. Mean Time h/a
Hot Strip				
750 x 2.0)	750 x 150	86	60,000	698
750 x 3.5)	x 5700	131	30,000	229
750 x 6.0)		164	30,000	183
900 x 2.0)	900 x 150	104	60,000	577
900 x 3.5)	x 5700	157	30,000	191
900 x 6.0)		180	30,000	167
1050 x 2.0)	1050 x 150	121	80,000	661
1050 x 3.5)	x 5700	180	40,000	222
1050 x 6.0)		180	40,000	222
		aver. 127 t/h	400,000 t/a	3150 h/a
Heavy Plate				
2000 x 6.0)	1050 x 150	54	50,000	926
2000 x 10.0)	x 1500	73	30,000	411
2000 x 16.0)		94	20,000	213
		64.5 t/h	100,000 t/a	1550 h/a
Total			500,000 t/a	4700 h/a

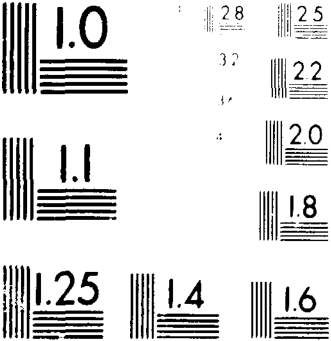
The required utilisation mean time is the net rolling time.

The available plant operating time is assumed with 18 shifts/week x 48 weeks/year = 6912 h/a

Thus the mill utilisation will be: $\frac{4700}{6912} \times 100 = 68$ %

This figure will vary, depending on the final product mix.
The maximum mill utilisation will be approx. 75 %.





MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS

STANDARD REFERENCE MATERIAL 1010a

(ANSI and ISO TEST CHART No. 2)

SECTION 7.4

Consumption Figures

and

Workforce Schedule

7.4 Consumption Figures and Workforce Schedule

7.4.1 Consumption Figures

for the production of 500,000 tpy of plates and strips are as follows:

	per ton product		per year	
Slabs	1,110	kg	554,900	t
Heavy fuel oil	44	kg	22,000	t
Electric energy	80-110	KWh	47,500	MWh/a
Oxygen	0.2	Nm^3	94,000	Nm^3
Compressed air	0.3	Nm^3	141,000	Nm^3
Rolls	4-6	kg	2,500	t
Workforce	1	mhrs	253	men
Cooling water				
- open circuit	1,600	m^3/h	7.5 Mio.	m^3
- closed circuit	1,200	m^3/h	5.6 Mio.	m^3

Remark: All material flow figures contain approx. 5 % margin for handling losses.

7.4.2 Workforce Schedule, Rolling Mill and Product Finishing

(G = Graduated; S = Skilled; SS = Semi-Skilled; US = Unskilled)

Based on four shifts, the following personnel will be required inside plant section:

	Shift 1	2	3	4	Day Shift	Total	Qualification Level
Administration							
Superintendent					1	1	G
Staff					4	4	SS
For Mill Operation							
Foremen	3	3	3	3	1	13	S
Operators	8	8	8	8		32	SS
Assistant Operators	13	13	13	13		52	SS
Skilled Workers	3	3	3	3		12	SS
Unskilled Workers	3	3	3	3		12	US
Roll Shop and Change							
Foremen	1	1	1	-		3	S
Skilled Workers	6	6	6	4	1	23	SS
Repair and Maintenance Post							
Foremen	2	2	2	2	1	9	S
Mechanics, Welder, Filter	5	5	5	5		20	SS
Electricians	3	3	3	3		12	SS
Electronic, Instrumercation	2	2	2	2		8	S
General Plant Services (cleaning, transportation etc.)	5	5	5	5		20	US
Subtotal	54	54	54	51	8	221	
15 % Absentees	8	8	8	7	1	32	
Total	62	62	62	58	9	253	

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S E C T I O N 7.5

Auxiliaries

7.5 Auxiliaries

All media and energy required inside plant sections will be supplied by the corresponding central generating, storing and distributing systems.

This mainly refers to the supplies of:

- compressed air,
- oxygen,
- fuel oil,
- cooling water

for the rolling mill facilities and for the central hydraulic and lubrication system.

The distributing systems are described under Section 8 and under Section 7.6.1.6 of this volume.

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SECTION 7.6

Outline Specification

for

Rolling Mill

7.6.1 OUTLINE SPECIFICATIONS - MECHANICAL EQUIPMENT

Plant Sections

.01 Furnace Area Equipment

.02 Roughing Mill

.03 Finishing Mill

.04 Coil Finishing

.05 Plate Finishing

.06 Auxiliary Equipment

.07 Roll Shop

.08 Cranes and Hoists

.09 Utilities

.1 Furnace Area Equipment

1 slab feeding grid

width	:		2 x 6	m
cooling capcity	:	approx.	100	t

1 furnace charging roller table

with 3 disappearing stops and 1 end stop,

length	:	approx.	42	m

2 double charging pushers

2 slab reheating furnaces

with reference slab 150 x 1050 x 5700 mm

design	:	walking-beam-type, top and bottom fired chargeable in 2 rolls,		
rated capacity	:		90	t/h ea.,
fuel	:	heavy fuel oil,		
distance between roller tables	:	approx.	30	m,
hearth width	:		6,000	m

each furnace comprising:

- furnace housing with doors and refractories,
- walking beam system with water-cooled tube rails, drive system,
- combustion system with burners, air blowers, atomization air compressor,
- recuperators,
- waste gas system with flue, dampers and stack,
- electrical equipment and instrumentation,
- all pipework inside furnace area with control equipment.

2 double slab extractors

.2 Roughing Mill

1 mill approach roller table

length : approx. 72 m,

1 descaling device

operating pressure : 150 bar,
number of headers : 2 + 2,

1 turning work roller table in front of the roughing mill

length : approx. 5 m,
width : 2.9 m,

1 side guide and centering device

in front of the roughing mill,
guide length : approx. 5 m,
max. openin

1 four-high reversing roughing stand

work roll dia.	:	900	mm,
back-up roll dia.	:	1,400	mm,
barrel length	:	2,000	mm,
drive	:	twin drive,	
cut-off torque	:	2 x 1,800	kNm,
motor speed	:	0-60-120	rpm.

mill stand, including

- electrical screw-down,
- breast rollers,
- drive spindles with couplings, spindle carrier,
- rolls, chocks and bearings,
- roll balancing device,
- roll changing device,
- attached pipework for hydraulics, cooling water, lubrication.

1 vertical edging stand

attached in front of the roughing stand,

design	:	top drive, rolls driven by universal joint spindles,	
roll dia.	:	900	mm,
barrel length	:	500	mm,
roll opening	:	min. 600	mm,
		max. 2,000	mm.

edging stand, including:

- main drive gear and coupling,
- intermediate bevel gears,
- drive spindles,
- breast rollers,
- rolls, chocks and bearings.

1	working roller table			
	behind the roughing stand,			
	length	: approx.	5	m
1	rear side guide and centering device			
	length	: approx.	1.0	m,
	max. opening	:	2.8	m.
1	delivery roller table			
	length	: approx.	45	m.

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.3 Finishing Mill

1 entry side guides

in front of the crop shear.

1 rotary cropping shear

design	:	drum type,
shear force	:	7,000 kN,
cutting speed	:	0.8 - 1.85 m/s,

shear including :

- drive,
- scrap removal system with chute and buckets.

2 pinch roll units

on the entry side of the reeler furnaces.

2 front and rear roller tables

length	:	approx. 3 m,

2 reeler furnaces

mandrel dia.	:	1,200 mm.

2 side guides in front and behind the finishing mill

1 four-high reversing finishing stand (Steckel stand)

work roll dia.	:		700	mm,
back-up roll dia.	:		1,200	mm,
barrel length	:		1,200	mm,
main drive	:		5,000	kW,
rolling speed	:	max.	10	m/s.

finishing stand including:

- hydraulic screw-down and roll balancing,
- rolls, checks and bearings,
- main drive with reduction gear, couplings, pinion gear, drive shafts, spindle carrier,
- quick work roll changing device,
- attached pipework.

.4 Coil Finishing

1 run-out roller table

length : approx. 37 m

1 frame for x-ray thickness gauge and width gauge

1 laminar strip cooling system

no. of flow control groups,

top/bottom	:	6/6,
no. of spray headers:		18/18,

1 entry side guide set in front of the coiler

1 coiler pinch roll unit

1 down coiler

design	:	3 blocker roll type,		
mandrel dia.	:	expanded	762	mm,
		collapsed	710	mm,
mandrel length	:		1,200	mm,
max. coil weight	:		8,000	kg,
max. coiling speed	:		10	m/s,
drive power	:		2 x 370	kW.

1 coil car

comprising:

- elevating cradle,
- car track.

1 coil upender

1 coil conveyor

with integrated coil weighing scale,

length : approx. 40 m

1 coil banding device

for steel strip.

.5 Plate Finishing

1 plate cooling bed

design	: walking grid-type,	
length	: approx.	25 m,
width	:	14 m.

comprising:

- carrying chain transfer,
- fixed grid and supports,
- walking grid with drive equipment,
- collecting grid.

1 finishing line roller table

length	: approx.	75 m,

1 plate leveller

max. plate width	:	2,100 mm,
max. plate thickness	:	16 mm.

1 double side trimming shear

max. plate width (finished)	:	2,000 mm,
max. plate thickness	:	16 mm.

shear including:

- plate aligning device,
- pinch roll units,
- one-side stand shifting drive,
- scrap cutting and removal equipment.

1 dividing shear

max. plate width	:	2,000 mm,
max. plate thickness:		16 mm,

shear including:

- plate aligning device,
- clamping device,
- scrap and sample cutting and removal equipment.

2 plate torch cutting tables

for plates of 16 mm,

comprising:

- tables,
- torch cutting equipment,
- aligning and marking devices.

.6 Auxiliary Equipment

- central lubrication systems for: oil, grease, oil mist.
- pressure water generating plant for descaling water.
- interconnecting pipework.
- fire detecting and fire fighting systems.
- Ventilation and Air Conditioning Systems.

.7 Roll Shop

1 roll grinding machine

for work rolls,

grinding dia. : 900 mm,
distance betw. centres: 5,000 mm,

1 roll grinding machine

for work rolls and back up rolls,

grinding dia. : 1,300 mm,
distance betw. centres: 5,000 mm.

1 roll turning lathe

turning dia. : 1,300 mm,
distance betw. centres: 5,000 mm.

- roll dismantling stands and equipment
- chock and bearing washers
- tools and instruments
- roll storage racks

.8 Cranes and Hoists

	Mill bay:		
1	EOT-crane	:	50 t/15 t
	Coil storage		
1	EOT-crane	:	20 t, equipped with coil tong and/or coil hook
	Plate storage:		
2	EOT-cranes	:	20 t, equipped with magnet beam
	Roll shop:		
1	EOT-crane	:	50 t
3	maintenance hoists	:	2 t

All cranes including:

- electrical equipment,
- cabin with air conditioning set,
- conductor rails.

.9 Utilities

Distribution systems for:

- direct cooling water supply,
- indirect cooling water,
- compressed air,
- oxygen,
- fuel oil,
- potable water.

comprising:

- pipework,
- assemblings,
- armatures,
- measuring and control equipment.

7.6.2 ELECTRICAL EQUIPMENT

comprising:

- low voltage main distribution,
- motor control centres,
- main drive motors,
- auxiliary drive motors,
- control devices and instrumentation,
- installation and equipment of control pulpits and desks,
- safety and protection equipment,
- earthing,
- lighting system,
- intercommunication system,
- cables and erection material.

For further details on the Outline Specifications of Electrical Equipment, please refer to Section 3.6.2.

7.6.3 Instrumentation Equipment

The instrumentation equipment for the rolling mill mainly comprises:

- field instruments,
- local indicating measuring instruments,
- local measuring detectors,
- transmitters,
- panel instruments incl. indicating instruments and recorders,
- control room panels,
- auxiliary racks and cubicles,
- interfaces and power supply systems,
- all installation material like cables, wiring, fuses, etc.

A detailed description of the lay-out of this equipment is given in section 3.6.3 of this volume.

7.6.4 Structural and Civil Works

Main quantities for structural steel and civil works related to the Rolling Mill are as follows:

Structural Steel	3950	t
Bins	-	t
Roof and Wall Cladding	35840	m^2
Concrete	30000	m^3
Formwork	84000	m^2
Reinforcement	2850	t
Excavation	113400	m^3

Price estimations for these works are based on information obtained from Mowlem International Ltd., London, based on the experiences gained with the Mufindi Pulp and Paper Mill.

S E C T I O N 7.7

Investment Cost Estimate

7.7 Investment Cost Estimate

- Rolling mill and product finishing -

The budgetary investment costs for the rolling mill and product finishing plant, capable to produce 500,000 tpy of plates and strips, are estimated as follows (based on the exchange rates: 1 US $ = 2.7 DM = 12.2 T.Sh.).

	approx. Mio. US $	approx. Mio. T.Sh.
- Plant Equipment delivered free site	75.9	926.0
- Erection, Supervision, Commissioning	25.8	314.8
- Civil Work and Steel Stucture, erected and painted	28.7	350.1
- Related Plant Infrastructure	1.9	23.2
Total Investment Cost	132.3	1,614.1
- Spare Parts for 2 years plant operation	5.0	61.0

This budget estimate is based on German prices and conditions and on cost factors ruling end of December 1983 for the equipment. It does not include any customs duty, taxes, dues or other levies which may arise outside the Federal Republic of Germany.

The estimation of the civil work and structural steel portion is derived from price information supplied by Mowlem International Ltd., London.

The estimation for plant equipment includes the cost for packing and the freight charges delivered free on site. Our budget prices are estimated on the assumption that all work can be performed continuously and in accordance with the time schedules contained in section IV/5.

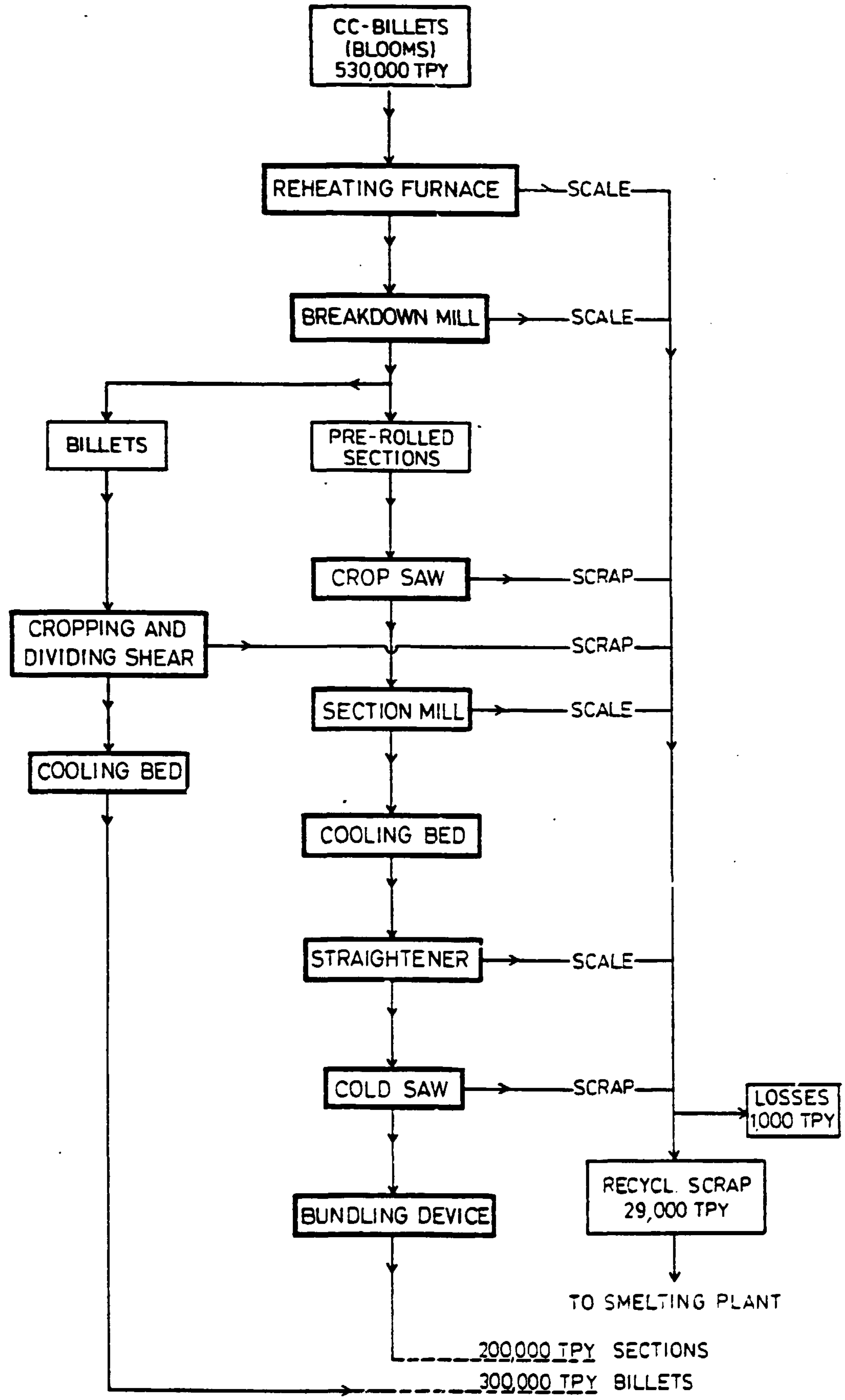
This budget estimate is furthermore based on usual cash terms of payment, allowing an adequate down payment upon signing of contract and progress payments according to the progress of work in the engineering, manufacturing and erection.

All further terms and conditions will have to be agreed upon during the progress of contract negotiations.

A N N E X

Expansion Step

1 Million tpy Steel



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MANNESMANN DEMAG

BILLET AND SECTION MILL
MAIN FLOWSHEET
(2nd STAGE)

LURGI

Tanzania/Volume III

S E C T I O N 8

Off-sites and Auxiliaries "Mahanje"

4303

SECTION 8.1

Description of Facilities

8.1 Description of Facilities

8.1.1 Limestone/Dolomite Facilities

The limestone/dolomite preparation units are divided into the following sections:

.1 Limestone/Dolomite Screening, Crushing, Transport and Storage

.2 Limestone Loading Station

.3 Limestone/Dolomite Calciner, Transport and Storage

.4 Lime Hydrating Plant

In order to provide raw and burnt limestone/dolomite as well as hydrated lime for the metallurgical plants in Liganga and Mahanje, a central limestone preparation and calcining plant will be installed in the Mahanje Steelworks.

This lime plant will utilize the limestone delivered by rails from a source yet to be defined by NDC (Wazo Mill limestone proved to be unsuitable in corresponding tests).
The dolomite will be delivered by rail from Chalinze.

After unloading at the central receiving facilities at Mahanje, limestone and dolomite as delivered will be crushed, screened and stored on a suitable storeyard.

The following quanitities will be required:

- Pelletizing Liganga	:	14,850	tpy	Limestone (raw)
- Direct Reduction	:	66,000	tpy	dolomite (raw)
Mahanje		1,500	tpy	hydrated lime
- Electric Smelter	:	38,260	tpy	dolomite
Mahanje		8,670	tpy	lime
- Ladle Furnace Mahanje	:	6,450	tpy	lime

Total limestone (raw) : 43,000 tpy approx.
Total dolomite (raw) : 124,000 tpy approx.

To provide for the necessary supplies of burnt limestone/dolomite, a parallel-flow regenerative shaft calciner is proposed.

8.1.1.1 Limestone/Dolomite Screening, Crushing, Transport and Storage

The screening and crushing plant is designed for 8 hours operation time/day. The equipment is designed for 80 t/h.

Limestone and dolomite are reclaimed from the storage piles described in section 3.2. The materials are fed by front end loader operation to the feed hopper at the screening and crushing plant.

After passing a screen and impact-crusher, the material grain size will be 0 - 40 mm.

Via a belt conveyor, this material passes a second screen and is screened into two fractions. Grain size 20 - 40 mm is fed via a belt conveyor system to storage piles for the shaft furnace.

Limestone, grain size 0 - 20 mm, is fed via a two-way chute to a stock pile.

Dolomite, grain size 0 - 20 mm, is fed to a hammer mill.

The discharged grain size 0 - 3 mm is fed via bucket elevator and belt conveyor system to the specific storage bins in the direct reduction plant.

8.1.1.2 Limestone Loading Station

Limestone, grain size 0 - 20 mm, needed for the pelletizing plant, is reclaimed from the storage pile, described in section 8.1.1, by front-end loader and transported via truck to the loading station.

The truck feeds the limestone hopper of the loading station. Via vibrating feeder and belt conveyor, the limestone is fed into a loading bin above the railway track.

The loading bin is equipped with slide gate and telescope chute to feed the hopper wagons.

Transfer point dedusting system and shaft furnace dedusting is included in the DR-Plant package.

8.1.1.3 Limestone/Dolomite Calciner, Transport and Storage

The lime kiln is designed for a capacity of 180 t/d of burnt lime/dolomite. Sized and clean limestone and/or dolomitic limestone will be delivered from the storage yard to the lime kiln in a grain size 20 - 40 mm.

Heavy fuel oil has been envisaged for firing the vertical lime kiln and for heating the boiler system. The start-up operation will be carried out with light fuel oil.

The kiln consists of two shafts of rectangular cross sections which rest on a concrete basis. The steel structure is completely welded; no movable anchors are used.

The shafts are armoured with metal plates and reinforced by ribs and profiles. Depending on the process temperatures in the individual zones, the shafts are lined with insulation and refractory materials of 375 to 510 mm thickness.

The shafts have charging and reversing facilities above the kiln top platform. On the next lower platform, the fuel is periodically distributed over the two calcination shafts via 12 burner lances with reversing and proportioning facilities. By admission of air from below, the burnt lime is simultaneously cooled in both shafts and continuously discharged by means of horizontal reciprocating discharge devices. The lime falls into intermediate bins arranged below the reciprocating discharge devices. Flap valves are used as pressure seals.

The flap valves are opened during the reversing operation, i.e. when the kiln is not pressurized. The material passes into a collecting tank from where it is withdrawn periodically or continuously via a vibro feeder.

During the reversing operation, a preweighed limestone quantity is passed from the distribution system above the kiln top to the shaft to be charged. A skip hoist is used for conveying the limestone to the kiln top.

Material for one charge, approx. 3,500 kg of 20 - 40 mm grain size, is withdrawn from the storage bin and filled into the weighing system container by means of a vibro screen which also removes the remaining fines from the limestone.

The limestone quantity weighed is emptied into the skip hoist and transported to the kiln top. The limestone quantity in the weighing system container should preferably be constant, i.e. independant of the adjusted kiln capacity.

With full load, the reversing period is approx. 15 minutes; it is adjusted in accordance with the desired kiln capacity.

The fuel is admitted to one of the shafts while the flue gases leave the second shaft at approx. 100 °C. Before leaving, the flue gases have heated up the charge of the heating zone. The preheating zone also serves as a regenerator for preheating the combustion air since the outlet level of the fuel admitted to the bed of material via lances is arranged below the preheating zone. The flame length can be influenced by the selection of the air ratio. Regenerative air preheating practically renders the heat efficiency of the kiln independant of the air factor.
Roots compressors serve for compressing the combustion and cooling air.

The reversing operation is carried out fully automatically and monitored by a controller in accordance with the kiln capacity adjusted.
The continuous discharge of burnt lime is controlled by measuring the limestone level in the shafts during the calcination period.

As to the kiln operation, it should be mentioned that a reduction of the production down to approx. 50 % of the rated capacity can be carried out without difficulties; the heat consumption will slightly increase in this case while the power consumption will decrease.

Once a year, a maintenance shut-down of approx. 4 weeks will be necessary for checking and/or repairing the burner lances and for exchanging the oil of the hydraulic system and of the blowers.

Every two years, an intermediate repair of the refractory lining will have to be carried out. Duration is approx. 3 weeks.

8.1.1.4 Lime Hydration Plant

The plant is conceived for the processing of quicklime to lime hydrate required for DRI-fines briquetting. This is performed in the slaking machine.

Quicklime is reclaimed via a proportioning screw conveyor with variable speed drive from the storage bin. Material flow and product quantity are controlled by a flow meter. The material is fed by a screw conveyor to the lime slaking machine and at the same time water is added and mixed with the quicklime, resulting in a chemical reaction where CaO is converted into Ca(OH)2 and heat is produced.
Normally, 125 g of Ca(OH)2 are obtained from 100 g of pure lime.

During slaking, a water evaporation temperature of around 100 °C is reached. Part of the required slaking water is evaporated. Water is fed to the slaking machine by a fresh water pump and a regulating pump. The slaking water quantity depends on the reactivity of the burnt lime. It is known from experience that soft burnt lime requires more slaking water than hard burnt qualities. Therefore, the slaking water quantity is adjusted accordingly. This is done manually via valves and the regulating pump.

The hydrate leaving the slaking machine proceeds through a chute with permanent magnets to a Moleculator Mill. The Moleculator Mill ensures that the product is properly fluidized and portion of fines is increased.

Dust collection equipment is required for dust-free operation of the plant. The lime slaking machine is equipped with a wet scrubber. A bay type filter is provided for dedusting the Moleculator Mill. The accumulated dust is added to the finished product.

Measuring and regulating units are provided for quicklime proportioning and the slaking machine. The final product will be transferred to the point of consumption by a pneumatic system.

8.1.1.5 Main Data and Consumptions

For the production of 180 t/d of soft burnt lime in a parallel-flow regenerative shaft calciner (2 x 5.8 m^2 cross section), the following consumption figures per 1,000 kg of burnt product apply for 303 days per year of operating time:

- Limestone	:	approx.	1,730	kg
- Dolomite Chalinze	:	"	1,490	kg
- Fuel Oil (40,100 kJ/kg)	:	"	100	kg
- Electric power	:	"	22	kWh
- Water (Hydrating Plant)	:	"	0.6	m^3
- Electric Power (Hydrating Plant)	:	"	2.5	kWh
- Waste gas (120 °C)	:	"	20,000	Nm^3/h
- Workforce (incl. hydration)	:		30	men

8.1.2 Water Systems

The indoor water system comprises the main distribution lines for industrial water, semi-treated and treated water and the sewage disposal system.

Water will be required as:

- raw water as industrial water and initial water (has to be treated) for cooling and potable water,
- cooling water (open and closed circuit),
- potable water,
- industrial (raw) water.

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8.1.2.1 Raw Water as Industrial Water and Initial Water (has to be treated) for Cooling and Potable Water

The raw water will be used:

Untreated as

- industry water	:	15	m³/h
- fire fighting water	:	80	m³/h (max.)
- WC-flushing water	:	3	m³/h (max.)

semi-treated for:

- washing water	:	4	m³/h (max.)

treated especially for:

- cooling water	:	400	m³/h
- potable water	:	0.3	m³/h
Total consumption	:	502.3	m³/h (peak)
		400	m³/h (normal)

This section mainly comprises:

Connection between the plant battery limit and the take-over points of the several water circuits resp. networks with pipework (incl. pipes, armatures, assemblings) and corresponding control and measuring equipment.

8.1.2.2 Cooling Water Plant

Process Description

Cooling water of various qualities is required for the cooling of mechanical, electrical, hydraulical, and lubrication parts for the regarding equipment of:

- Direct Reduction Plant,
- Smelting Plant,
- Ladle Furnace Plant,
- Casting Plant,
- Rolling Mill,
- Air Fractioning Plant (Oxygen, Nitrogen, Argon),
- Compressed Air Plant.

For reasons of economy and in order to meet design requirements, the cooling water systems will be subdivided into 2 water circuits as follows:

- open circuit

  a) cooling of mechanical parts,
  b) cooling of hot products during the processing as:

  bar sections after casting and also rolling products during the process flow.

- closed circuit

a) electrical parts of furnaces,
b) casting mould and machinery cooling for continuous casting,
c) electrical, hydraulical, lubrication parts of rolling mill and also parts of the reheating furnaces for section parts.

Flow description

The water loss by the direct air/water cooling of about 400 m³/h will be balanced by water out of the raw water system. This raw water will be mechanically and chemically cleaned and conditioned, additionally a treatment equipment for potable water is included.

The open circuit water will be recooled directly by open air coolers; the water will be held intermediarely within basins and cleaned partially by gravel filters.

The closed circuit water will be recooled indirectly by water/water heatexchanges; the secondary water of the heatexchanges will be recooled directly by open air coolers.

The cooling water plant mainly comprises:

1 water treatment equipment,
1 open circuit consisting of:

- 1 set of circuit pumps,
- 1 set of open air coolers,
- 1 set of emergency water holders,
- 1 set of emergency diesel pumps,
- 1 set of gravel filters.

1 closed circuit consisting of:

- 1 set of circuit pumps,
- 1 set of water/water coolers,
- 1 set of open air coolers,
- 1 set of balance tanks,
- 1 set of emergency diesel pumps.

1 internal pipesystem,
1 pipework system between the water recooling plant and the battery limits of the production plants,
1 electrical equipment,
1 control and measuring equipment.

8.1.2.3 Potable Water

As described before, the potable water will be treated out of the raw water.

The potable water will be bottled hygienically within special glas bottles; these bottles will be put into refrigerators with automatical self-close consumption valves.

This section mainly comprises:

- bottle cleaning equipment,
- bottle filling and sealing equipment,
- bottles,
- refrigerators.

8.1.2.4 Industrial Water

One part of the incoming raw water will be led into the industrial water piping system inside the plant.

This water will be used for:

- preparation of mortar for refractories service,
- hydration of lime for briquetting,
- spray and cooling water for operating processes inside hot and dusty areas,
- sanitary purposes.

The corresponding facilities comprise:

- pipework for industrial water, including pipes, armatures and assemblings,
- pipework for fire fighting water including pipes, armatures, hydrants and assemblings,
- control and measuring equipment.

8.1.2.5 Sewage System

The sewage water will be cleaned in the main system of the Mahanje township area.

8.1.3 Air Fractioning Plant

Main Data:

Production capacity

(as used)	Oxygen	:	1,061	Nm^3/h
	Nitrogen	:	1,800	Nm^3/h
	Argon	:	25.7	Nm^3/h

Purity:

Oxygen	:	approx.	99	%
Nitrogen	:	"	99	%
Argon	:		99.5	%

The equipment mainly comprises:

- air compressors,
- refrigerators,
- expander turbines,
- water and CO2 discharge facilities,
- refrigerating box,
- cold gasifier with storage tanks,
- gravity separators for O2, N2, Ar,
- buffer tanks to ensure continuous supply of O2, N2, Ar in the case of discontinuous and short-time peak demand and/or short-time interruption of the gas production,
- electrical equipment,
- control and measuring equipment.

8.1.3.1 Oxygen

Oxygen will be used for cutting and burning operations for the workshops and inside the laboratory for tests.

The oxygen coming from the buffer tank of the air fractioning plant will be led through the pipework to the several consumption points.

The main equipment consists of pipes, armatures, assemblings as well as control and measuring equipment.

8.1.3.2 Nitrogen

Nitrogen especially will be used for purging operation at smelting furnaces. Furthermore, a low amount will be used for laboratory tests.

The Nitrogen coming from the buffer tank of the air fractioning plant will be led through the pipework to the several consumption points.

The main equipment consists of pipes, armatures, assemblings as well as control and measuring equipment.

8.1.3.3 Argon

Argon especially will be used for the ladle furnacing process and casting operation. A low amount will be used for laboratory tests.

The argon, generated inside the air fractioning plant, will be bottled there; the bottles will be arranged inside a storage battery close to the consumers.

This section comprises:

- set of bottles,
- bottle storage battery,
- pipework,
  including pipes, armatures and assemblings,
- control and measuring equipment.

8.1.4 Fuels and Compressed Air

8.1.4.1 Heavy Oil

Heavy oil will be used for the start-up operation of the Direct Reduction Plant and for the reheating of bar sections in the Rolling Mill Furnace.

The heavy oil will be supplied by tank trucks and will be stored within the storage tanks

Capacity : approx. 1,000 t
(equiv. to about a fortnight)

This section mainly comprises the following items:

- take over and pumping station,
- storage tanks,
- accompanying heating,
- pipework with pipes, armatures, assemblings,
- control and measuring equipment.

8.1.4.2 Light Oil

Light oil will be used for the preheating of the ladles and tundishes and for start-up of the lime-stone/dolomite calciner.

The light oil will be supplied by tank trucks and will be stored within the storage tanks.

Capacity : approx. 300 t
(equiv. to about a fort-night)

This section mainly comprises the following items:

- take over and pumping station,
- storage tanks,
- pipework between the tank battery and the battery limits of consumers,
  consisting of pipes, armatures, assemblings,
- control and measuring equipment.

8.1.4.3 Propane

Propane will be used for cutting operations.

The propane, liquified supplied by special tank trucks, will be stored within a plant, equipped with storage tanks and re-gazifiers.

Total Capacity: 1,300 Nm³ (equiv. to 3 days)

This section mainly comprises:

- take over and pumping station,
- storage tanks,
- re-gazifiers,
- pipework between the plant and the corresponding battery limits including pipes, armatures, assemblings,
- control equipment.

8.1.4.4 Acetylene

Acetylene will be used for oxygen cutting and welding inside the plant.

Acetylene will be bottled supplied by trucks; the bottles will be located at the necessary locations.

8.1.4.5 Compressed Air

Main Data of Compressed Air Generation System

Capacity : 400 Nm^3/h
Pressure : 6...8 bar

This section mainly comprises the following items.

- compressor generators with water cooling,
- air receiver,
- water separator,
- oil separator,
- intake filter,
- pipework between the plant and the corresponding battery limits with pipes, armatures, assemblings,
- electrical equipment,
- control and measuring equipment.

The compressed air for the Direct Reduction Plant will be provided in a separate compressor as described in section 3 of this volume.

8.1.5 Electric Energy Distribution System

220 kV Station and Step-down Transformers

In this section, a 220 kV switchyard, two step-down transformers and all necessary accessories are provided. It is of SF 6-gas-insulated outdoor type. The complete switchyard is formed by two incoming feeders and two feeders for transformer connection.

The main electrical data are:

nominal voltage	:	220	kV
highest voltage	:	230	kV
rated frequency	:	50	Hz
rated short circuit current	:	20	kA
busbar current	:	1,250	A
aux. service supply voltage	:	220/380	V AC
		110	V DC

- Step down transformers

  the power transformers are equipped with onload tap changer. By this voltage, regulations under operational conditions are possible. The transformers have Buchholz relay for alarm trip and thermal release.

2 Fields

for incoming overhead line, equipped with:

3 SF 6 outdoor bushings, high speed earthing switch (motor driven), isolator current transformer,
1 SF 6 circuit breaker,
1 busbar isolator with earthing switch (manually driven),
3 1-pole capacitive voltage transformer,
3 1-pole lightning arrester in outdoor design,
- overhead line carrier portal,
- local control cabinet.

63 kV Plant

The 63 kV switchgear consists of 2 single bus bars (which are fed by a 100 MVA transformer each) and 22 outgoing feeders with circuit breakers.

Each bus bar system is fed by an incoming line with circuit breaker which is able to feed both bus bars if one incoming line fails. The two systems of each station can be connected by a tie breaker. Both bus bars can be extended in the second stage.

The switchgear will be situated in the electric station.

Each incoming feeder, tie breaker and outgoing feeder will be controlled manually in the corresponding switch room.

1 Switchgear cabinet

configuration, prepared for expansion in the second stage,

mainly containing:

2 incoming lines

with 1 circuit breaker 2000 A each

1 tie breaker

with 1 circuit breaker 2000 A

2 outgoing feeders

with 1 circuit breaker 360 A each

Location: Electric Station.

1 Auxiliary voltage supply

consisting of:

1 Pb-accu-battery,
1 battery charger,
1 distribution cabinet.

Location: Electric Station.

9 power transformers

primary voltage	:	63	kV
rated secondary voltage	:	400	V
rated power	:	1,600	kVA
connection symbol	:		Dyn 5
short circuit	:	6	%

Location: Electric Station.

2 power transformers

primary voltage	:	63	kV
rated secondary voltage	:	400	V
rated power	:	800	kVA
connection symbol	:		Dyn 5

1 power transformer

primary voltage	:	63	kV
rated secondary voltage	:	6.6	kV
rated power	:	18	MVA

2 power transformers

primary voltage	:	63	kV
rated secondary voltage	:	6.6	kV
rated power	:	3.5	MVA

2 power transformers

primary voltage	:	63	kV
rated secondary voltage	:	6.6	kV
rated power	:	5	MVA

8.1.6 Fume Exhaust and Cleaning Plant

Following exhaust and cleaning facilities will be provided for:

- Smelting Furnaces
- Ladle Furnaces
- Material Handling

8.1.6.1 Smelting Furnace Fume Exhaust and Cleaning Plant

The atmosphere within the furnaces will be low compressed; the gas will be exhausted out of the furnace by disintegrator type suction and cleaned with spray water inside the disintegrator and further inside the fume washing tower. The cleaned gas, mostly CO, will be led through an exhaust stack and burnt by a flare at the top of the stack.

This section mainly comprises the following items:

- water cooled pipes,
- gas feeding pipes,
- rotating hood flaps,
- spray washer (fume washing tower),
- disintegrator,
- water separator,
- overflow valve,
- stack with flare,
- water pumps,
- steel structure, platforms, stairs etc.,
- electrical equipment,
- control and measuring equipment.

8.1.6.2 Ladle Furnace Fume Exhaust and Cleaning Plant

The gas out of the ladle furnacing process will be mixed and cooled with the air from the outer atmosphere and further led through the exhaust pipe above the fume collecting hood. This mixed gas will be sucked by exhaust fans and led through a bag filter system. The cleaned gas will be exhausted through a stack.

This section mainly comprises the following items:

- suction pipes and stack,
- filter and pulsating equipment,
- exhaust fans,
- dust extraction equipment,
- electrical equipment,
- measuring and control equipment.

8.1.6.3 Material Handling Dust Exhaust and Cleaning Plant

The dust will be sucked from many take-over points of the material (at hoppers, vibrofeeders, belt conveyors). The dust polluted air will be sucked by fans and led through a bag filter system. The cleaned gas will be exhausted through a stack.

This section mainly comprises the same items as mentioned under section 8.1.6.2.

8.1.6.4 Remark:

The gas cleaning and inplant dedusting systems of the DR-Plant are described under section 3 of this volume.

8.1.7 Central Workshop

The central workshop, to be manned in three shifts, is responsible for supervising and checking all production equipment and ancillaries and for maintenance and servicing. Moreover, the workshop is tasked with routine changing of wear parts and units and removing faults as well as inspecting the equipment to detect incipient defects.

This section mainly comprises the following items:

- quick repair posts, inside the following plants:
  - direct reduction plant,
  - control electrical distribution plant,
  - water cooling plant,
  - smelting and ladle furnace bay,
  - continuous casting bay,
  - rolling mill.
- main workshop,

  divided into the following departments:
  - mechanical workshop,
  - steel construction workshop,
  - electrical workshop,
  - instruments workshop,
  - tool magazine,
  - spares for quick replacement.

8.1.8 Central Laboratory

This section mainly comprises the following items:

- physical and mechanical tests
- chemical material tests
- metallographic examinations
- special gas laboratory
- water analysis
- sample preparation.

The central laboratory is part of the main office and administration building described under 8.1.15.

8.1.9 Central Magazine

The central store is provided for consumables and spare parts for the plant. Bulky and heavy goods must be stored on a storeyard.

Shelving and cabinets of various types are provided to allow clear storage of the consumables and spare parts.

Moreover, a special issue area for tools, which are needed in special cases only, is provided in the detail store.

One department of the detail store deals with refractories, oil and grease for the steelmaking shop and the auxiliary and ancillary equipment.

This section mainly comprises the following items:

- EOT-cranes,
- store boxes,
- scales,
- movable store elevators,
- oil pumping facilities.

8.1.10 Fire Fighting and Ambulance

These both departments are arranged in one unit in the main administration building.

Fire Fighting

This section mainly comprises the following items:

1 ladder car,
1 fire fighting car (water),
1 fire fighting car (foam and powder),
- equipment of tools for lifting and pressing of wrecked and/or dropped loads,
- various mobile equipment, as dresses, tools, hoses etc.

Ambulance

This section mainly comprises the following items:

- first aid facilities inside plant sections,
- central first aid facilities as mobile reanimation car, moveable reanimation sets,
- medical facilities.

8.1.11 Communication System

This section comprises the following items inside battery limits:

- telephone system,
- wireless communication system,
- change - speaking system.

The central switchboards are located in the main administration building.

8.1.12 Mobile Facilities and Finishings for Shops, Offices and Buildings

This section mainly comprises the following items to be provided for in the main administration building:

Facilities for:
- washrooms,
- changing rooms,
- refreshment posts,
- conference rooms, (meeting)
- laboratories,
- technical offices,
- rest rooms,
- waiting rooms,
- workshop and magazine offices.

8.1.13 Petrol Station

To supply the transport park, a petrol station is provided.

The petrol station mainly comprises:

- complete tank for diesel fuel (40 m^3),
- complete tank for gasoline (40 m^3),
- complete filling station with two pumps station and controller office.

8.1.14 Traffic Facilities

8.1.14.1 Railroad Traffic Facilities

For the internal railroad traffic, an individual traction system will be necessary.
For the reason of flexibility and independance of occupied switches and/or main tracks, one combined track/road tractor will be provided.

This section mainly comprises:

1 combined track/road-going tractor in heavy and robust design,
- diesel propelled,
- pneu - wheels,
- liftable railroad guiding wheels.

8.1.14.2 Road Traffic Facilities

For the reasons of flexibility and independance of outer traffic companies, an individual road traffic system will be provided, all the cars will be diesel propelled.

This section mainly comprises the following items:

Persons Traffic

3 busses, each with 12 places,
10 cars,
20 cycles,
4 land cruiser jeeps,
1 fire fighting truck,
1 ambulance vehicle.

Load Traffic

3 trucks, 10 t,
1 truck, 20 t,
5 pick-up trucks, 3 t,
1 mobile crane, 120 t,
5 shovel loaders, 1.5 m³,
8 fork lifts,
2 tractors,
4 platform cars for heavy loads (unpropelled),
1 mobile crane, 20 t,
1 800 m truck, 10 t,
5 dump trucks, 35 t,
3 tank trucks, 20 t,
4 front end loader, 1.5 t.

Vehicle Repair and Service Station

for maintenance and repair of trucks and cars, equipped with the necessary machines, tools and work benches.

8.1.15 Main Administration Building

The main administration building is designed to provide the necessary facilities for

- commercial and financial functions,
- purchasing and sales,
- personnel administration,
- conference rooms,
- canteen shop,
- fire station and ambulance,
- sanitary rooms,
- vehicle repair,
- safety guard station,
- transportation office,
- telex, telephone centre,
- etc..

and is located with good accessibility from all sections of the Mahanje Steelworks.

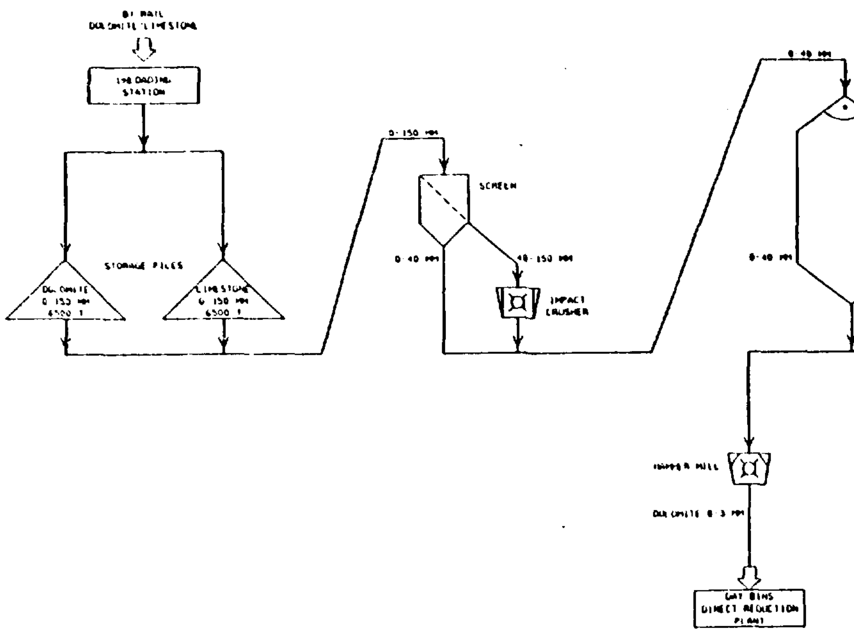
8.1.16 Structural and Civil Works Summary

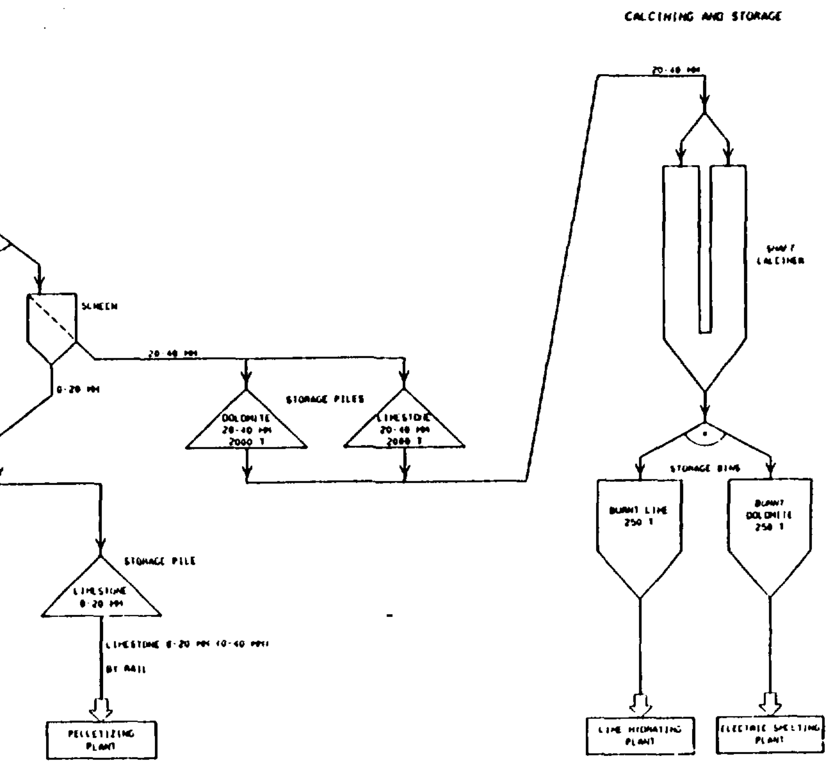
Main quantities for structural steel and civil works related to the Off-sites "Mahanje" are as follows:

Structural Steel	370	t
Bins	410	t
Roof and Wall Cladding	1670	m^2
Concrete	15775	m^3
Formwork	52800	m^2
Reinforcement	1380	t
Excavation	22120	m^3

Price estimations for these works are based on information obtained from Mowlem International Ltd., London, based on the experiences gained with the Mufindi Pulp and Paper Mill.

SCREENING, CRUSHING AND STORAGE





LURGI

LIMESTONE/DOLOMITE FACILITIES
MAHANJE
FLOW DIAGRAM

TANZANIA

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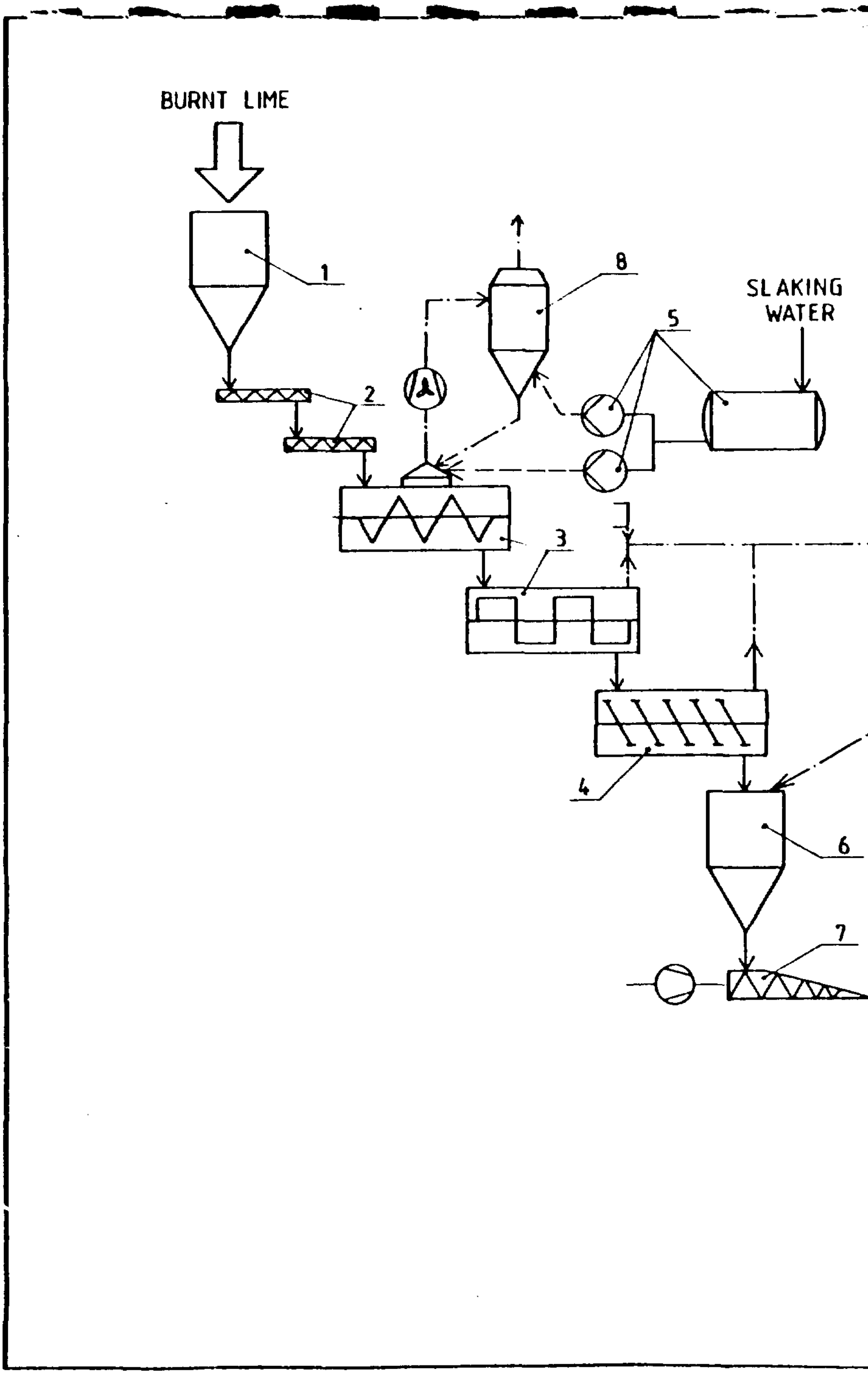

BURNT LIME
1
8
SLAKING
WATER
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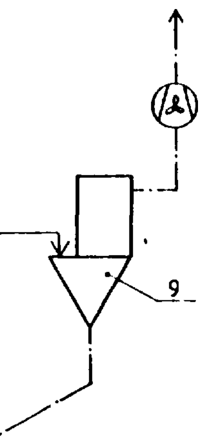

1. STORAGE BIN FOR BURNT LIME
2. PROPORTIONING SCREW CONVEYORS
3. DUPLEX LIME HYDRATING MACHINE WITH SEASONING CHAMBER
4. MOLEKULATOR MILL
5. SLAKING WATER CONTROL
6. STORAGE BIN FOR HYDRATED LIME
7. PNEUMATIC CONVEYOR
8. WET SCRUBBER
9. PLANT DEDUSTING

HYDRATED LIME TO BRIQUETTING PLANT

	Date	Name	
Prepared	21.12.83	TNR	LURGI Lurgi Chemie und Hüttentechnik GmbH
Checked	9.1.84	[signature]	
Original Scale: %.	Title / Characteristic Features: LIME HYDRATING PLANT MAHANJE		
Standard	Drawing Type 205		
Process HRE	Job or Project No 0 3 2 2 3 8	Job TANZANIA	
Drawing No L 3 A 0 3 2 2 3 8 0 0 0 3 3	Rev	Ref Dwg	Original Size A3

S E C T I O N 8.2

Workforce Schedule

8.2 Workforce Schedule

For the various facilities in section 8, following workforce requirements can be estimated:

		G	S	SS	US	Total
.01	Lime plant	1	4	10	15	30
.02	Water systems	1	6	25	18	50
.03	Air fractioning	1	3	5	4	13
.04	Fuels and Compressed Air		3	5	4	12
.05	Electric Grid	1	9	27	2	39
.06	Fume exhaust	1	4	28	23	56
.07	Central Workshop	1	21	68	14	104
.08	Central Laboratory	1	15	2	9	27
.09	Central Magazine	1	9	6	30	46
.10	Fire fighting and ambu-	1	9	19	4	33
	lance	1	5	2	2	10
.11	Communication		5		1	6
.12	not applicable	-	-	-	-	-
.13	Petrol station	-	1	5	5	11
.14	Traffic	1	5	70	20	96
.15	Administration	10	60	80	18	168
	Subtotal	21	159	352	169	701
15%	Absentees	3	24	53	25	105
	Total	24	183	405	194	806

S E C T I O N 8.3

Investment Cost Estimate

8.3 Investment Cost Estimate

- Off-sites and auxiliaries "Mahanje" -

The budgetary investment costs for the off-sites and auxiliaries "Mahanje" are estimated as follows (based on the exchange rates:
1 US $ = 2.7 DM = 12.2 T.Sh.).

	approx. Mio. US $	approx. Mio. T.Sh.
- Plant Equipment delivered free site	44.9	547.7
- Erection, Supervision, Commissioning	13.4	163.2
- Civil Work and Steel Stucture, erected and painted	18.9	230.6
- Related Plant Infrastructure	3.8	46.4
Total Investment Cost	81.0	987.9
- Spare Parts for 2 years plant operation	1.5	18.3

This budget estimate is based on German prices and conditions and on cost factors ruling end of December 1983 for the equipment. It does not include any customs duty, taxes, dues or other levies which may arise outside the Federal Republic of Germany.

The estimation of the civil work and structural steel portion is derived from price information supplied by Mowlem International Ltd., London.

The estimation for plant equipment includes the cost for packing and the freight charges delivered free on site. Our budget prices are estimated on the assumption that all work can be performed continuously and in accordance with the time schedules contained in section IV/5.

This budget estimate is furthermore based on usual cash terms of payment, allowing an adequate down payment upon signing of contract and progress payments according to the progress of work in the engineering, manufacturing and erection.

All further terms and conditions will have to be agreed upon during the progress of contract negotiations.

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(4 of 7)

Final Report

Volume IV

Techno-Economic Evaluation and Project Report

for the

Establishment of an Iron and Steel Industry

in

The United Republic of Tanzania

Unido Project SM/URT/81/004

for

[illegible] ORGANIZATION

LURGI

TECHNO-ECONOMIC EVALUATION AND PROJECT REPORT

FOR THE

ESTABLISHMENT OF AN IRON AND STEEL INDUSTRY

IN

THE UNITED REPUBLIC OF TANZANIA

GENERAL LIST OF CONTENTS

UNIDO Project No. SM/URT/81/004

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GENERAL LIST OF CONTENTS

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LURGI

TECHNO-ECONOMIC EVALUATION AND PROJECT REPORT

FOR THE

ESTABLISHMENT OF AN IRON AND STEEL INDUSTRY

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VOLUME IV General Area Infrastructure and Project Implementation

SECTION 1

General Area Infrastructure

1. General Area Infrastructure

The establishment of an integrated domestic iron and steel industry - i.e. the installation of the Mahanje steelworks with the related raw materials mining and preparation facilities in Mchuchuma and Liganga/Maganga - represents a huge development potential in social, technical and financial terms for the United Republic of Tanzania.

The project will require immense development and investment into infrastructural facilities for transportation, utility supply and housing. Whether the cost incurred must be directly related to the value of production of finished steel products, is a matter of interpretation, since this area development can also be looked at under more general political development aspects for this region of the country.

To clearly separate the interdependencies between the net production cost per ton of product, which include the direct investment into the metallurgical facilities on the one hand, and the secondary project implementation cost on the other hand for railways, roads, power supply, etc. - cost factors of the project which under the national economics point of view mainly are originating from the iron and steel project and as such have to be related to it - the investments into the necessary infrastructure of the project area are being evaluated in the following.

In doing so, LURGI strictly follows the general concept as proposed by NDC in the "Location Study of the 500 000 tpy Iron and Steel Plant" (December 1981).

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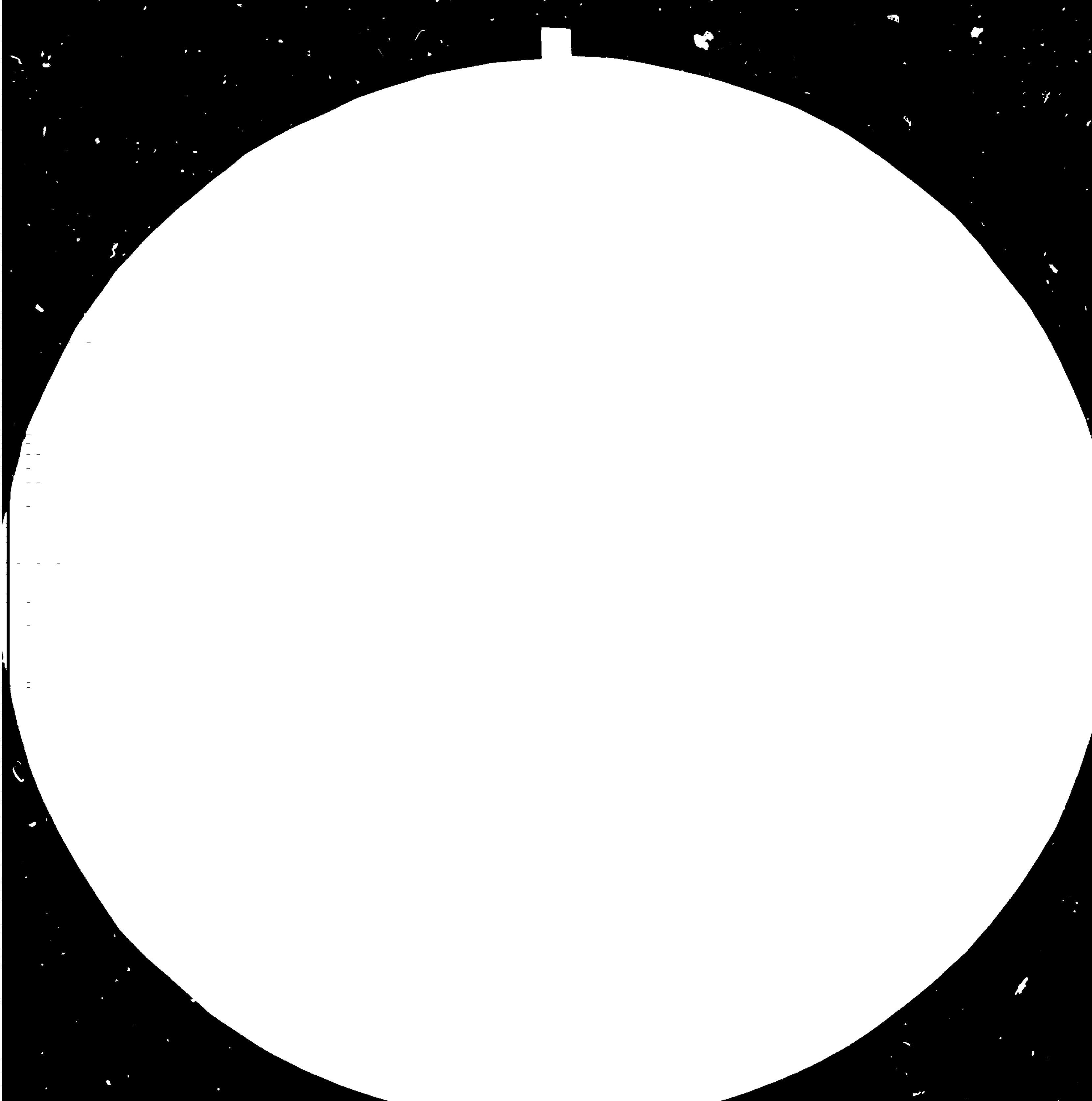

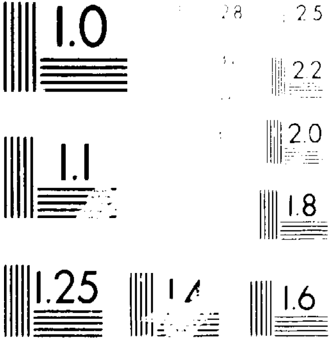
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1.1 Railway System

1.1.1 New Railway Line

The plants of Mchuchuma, Liganga and Mahanje will be connected to the TAZARA railway line at the Mlimba station. The new railway link will comprise approx. 320 km of railway with corresponding signalling equipment, railway sidings, waggons and engines.

The individual connections are as follows:

		Distance approx. km	Height Difference approx. m
Mchuchuma (1000 m above SL)	- Liganga (1500 m above SL)	[illegible]0	+500
Liganga (1500 m above SL)	- Mananje (1000 - 500 m above SL)	60	-500
Mahanje (1000 - 500 m above SL)	- Mlimba (200 - 300 m above SL)	180	-500

This route as proposed by NDC is optimum in terms of utilization of existing transport capacity from Mlimba to Dar Es Salaam and distance/height ratio of the track with corresponding impacts on the tractive power requirement.

The investment for this new railway track can be estimated within certain limits of accuracy comparing three sources of information:

- NDC in January 1983 indicated a cost of 3 000 000 TSh per km including signalling, railway sidings, etc. equivalent to 317 460,- US$. Since then, inflation has increased by 30 % for import goods.
- According to the "Transport Study Mchuchuma coal and Liganga iron ore" submitted by GTZ/Rodeco GmbH in 1977, TAZARA indicated specific cost for laying of private railway sidings of 825 000 TSh/km corresponding to at that time approx. 100 000,- US$. In the same study, investment for railway tracks in difficult terrain were estimated with 1 825 000,- TSh/km corresponding to 220 144,- US$.
- Deutsche Eisenbahn Consulting GmbH (German Railway Consulting) estimated a cost per km of in average 1 670 000 US$ based on experience in a north-east African country with similar type of terrain early 1983.

The latter information seems to be the more reliable figure, as NDC's cost estimate is not based on actual cost calculations for comparable railway projects and no detailed information is available from the TAZARA project which was constructed by the Chinese. Moreover, similar discrepancies in cost estimation have been recently experienced by Beaty Construction Company Ltd. when building the allweather road Morogoro - Dodoma (260 km, mountainous-flat terrain), when the originally estimated price was only a fourth of the actual price in end 1982.

Based on Deutsche Bundesbahn Consulting's cost estimate, the following investment would be required based on November 1983 price conditions.

Location	Distance km	Investment Mio US$	Investment Mio TSh
Mchuchuma - Liganga	80	133.6	1629.9
Liganga - Mahanje	60	100.2	1222.4
Mahanje - Mlimba	180	300.6	3667.3
Total	320	534.4	6529.6

This cost estimate includes all dead stock with related equipment for signalling, communication, sidings, bridges, tunnels, station buildings, station offsites, central maintenance shop, etc.

Further cost minimization will be possible by a detailed selection of the track, which reduces the number of tunnels and bridges even accepting longer distances, as the specific investment per km railway track can vary by a factor of 10 depending on the excavation and construction work necessary.

The above estimate is based on nominal conditions in this sense, i.e. no reserves are contained for added difficulties like piling, large scale water drainage, etc. Estimated construction rate is approx. 5 - 15 km per month depending on terrain conditions.

1.1.2 New Rolling Stock

According to NDC's information, a limited variety of waggon types is available from the TAZARA material pool, which is characterized by a track width of 1067 mm and an axle load of 22 t/axle max.

- flat waggon 50 tons capacity, length 13 metres, width 2.6 metres;
- high sided waggon (open top) 50 tons capacity, 13 metres length, 2.5 metres width and 1.9 metres height;
- tank waggon 31 tons capacity;
- low sided waggon (open top) 50 tons capacity, 13 metres length, 2.5 metres width and 0.5 metres height;
- covered waggon 30 tons capacity, 9.6 metres length. 2.5 metres width, 2.5 metres height;
- wall waggon (low loaders) 90 tons capacity, 9 metres long and 2.7 metres width.

Generallay spoken these waggon types will be suitable for transporting equipment and utilities during the construction phase of the project and to supply the plant facilities with the necessary commodities like fuel oil, spare parts, charcoal, electrode paste, etc. and to transport the steel products into the area of consumption.

For providing the transportation of bulk goods such as pellets, coal, dolomite and limestone, new hopper waggons, 50 t loading capacity, 35 m^3 service volume, 2 axle, 13 m long will have to be provided.

The transport scheme for supplying the raw materials to the metallurgical facilities as well as for commodities and steel product transport between Dar es Salaam and Mahanje is listed below:

Station	Material	Trains per day	Train length	Waggons per train	Waggons per day
Mchuchuma - Mahanje	Coal 500 000 tpy	2 (3)[1]	325 m	25	50 (75)[1]
Mchuchuma - Dar es Salaam	Coal 250 000 tpy	1[3]	325 m	25	25
Liganga - Mahanje	Pellets 990 000 tpy	4 (5)[1]	195 m	15	60 (75)[1]
Dar es Salaam - Mahanje	Limestone Dolomite Commodities	1	299 m	11 12[4]	11 12[4]
Mahanje - Liganga	Limestone	(1)[2]	169 m	13	-
Mahanje - Dar es Salaam	Steel Products	2[3]	90 m	10[4]	20[4]

1) every 5th day 1 additional train

2) every 2 weeks one train

3) 333 operating days per year

4) available TAZARA waggons

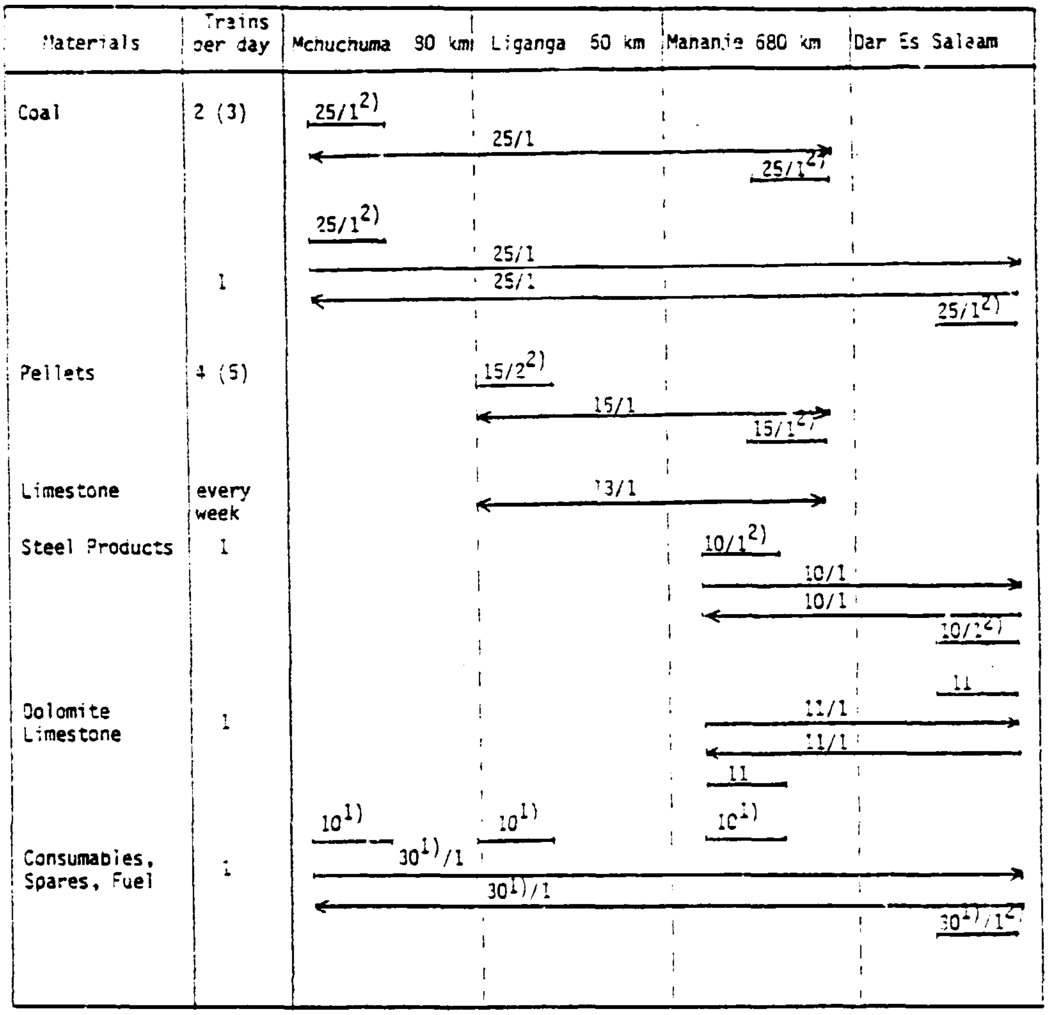
To guarantee the necessary safety of operation of the new transport system, a corresponding traffic scheme should be based on a conservative estimation of loading/unloading periods, delays, transportation speed, etc. Therefore, a schedule was selected which involves

- three complete trains of waggons for the daily transportation requirements between Mchuchuma, Liganga and Mahanje with one train being loaded, one train in transit, one train being unloaded;

- four complete trains of waggons for the daily transportation requirements between Mchuchuma/Mahanje and Dar es Salaam with one train being loaded, two trains in transit (of which one returning) and one train being unloaded at the point of destination;

- one complete train for the weekly transportation of limestone from Mahanje to Liganga.

This schedule as shown below involves an average of 3 switcher engines at each site and a corresponding number of long distance engines for transportation. As compared to a strict revolving schedule of transportation according to a cycle of loading - transit - unloading - transit - loading, the system proposed allows for sufficient reserves for refuelling, lubrication, repair and maintenance of the transportation and loading/unloading equipment, which is more appropriate to the actual operating conditions in the project area.



1) 50% tank waggons, 25% high sided waggons, 25% flat waggons

2) switcher engines

From the transportation schedule proposed, the following rolling stock requirements can be computed, whereby approx. 20 % reserve for equipment in repair and maintenance have been included.

- long distance engines 13
- switcher engines at sites 14 (incl. 1 reserve)
- hopper waggons 330
- high sided waggons 30 (50 % available)
- tank waggons 60 (33 % available)
- flat waggons 70 (50 % available)

The corresponding investment has been calculated on the basis of price information obtained from Deutsche Bundesbahn Consulting GmbH and is listed in the table below. It was assumed that after intensive reconditioning, part of the waggons as indicated above is available from the TAZARA rolling stock material pool. Accordingly, the following investment for new rolling stock will be required:

	Unit Price	Total Price	
	1000 US$	Mio US$	Mio TSh
13 Engines (l.d.)	800	10.4	126.9
14 Engines (switcher)	550	7.7	93.9
320 Waggons (hopper)	45	14.8	181.1
15 Waggons (h.s.)	37	0.6	6.7
40 Waggons (tank)	43	1.7	20.7
35 Waggons (flat)	35	1.2	14.9
Total Investment		36.4	444.2

The engines mentioned above are diesel engines with a tractive power of approx. 750 - 1000 t payload. The exact determination of the actual requirement of long distance engines depends on the height differences of the final railway track, where for some railway sections double engine operation may be required. In this sense, the above figures are to be taken as minimum.

With regard to coal-fired engines, there is no further manufacturer of this type known. The option of a reconditioning of used steam engines should not be considered, as only a limited number will be available mainly from South Africa and as reconditioning cost and social/infrastructural cost of this operation will be commensurate with the investment for new diesel locomotives.

1.2 Road Connections

Besides the railway network for transportation of bulk and consumer goods in the project area, the region will have to be opened up by a new road, allowing for personnel transportation and intercommunication between Dar es Salaam and Mchuchuma/Liganga/Mahanje. On this new road, also the heavy equipment needed for the initial infrastructure development activities will be brought into the project area.

The new road will connect:

Mchuchuma	- Liganga	approx.	80 km
Liganga	- Mahanje	approx.	60 km
Mahanje	- Madaba	approx.	12 km
Total		approx.	152 km

Madaba, located at the new allweather road between Njombe and Songea will be the turn-off point for the project area. The allweather (tamack) road between Njombe and Songea presently nears completion by Beaty Construction Corp. Ltd. / Howard Humphreys of Great Britain and is capable to serve as arterial road for transportation of heavy equipment, whereas the road between Njombe and Dar es Salaam requires a partial reconstruction especially in the Iringa area.

Repair of the existing allweather road to Dar es Salaam and construction of the new road Madaba/Mahanje/Liganga/Mchuchuma will have to be the first activity to be undertaken when starting with the project implementation as it serves to bring in the machinery, equipment, utilities, supplies and personnel for the initial construction work in Mchuchuma. It has to be considered as the first vital communication system in the area connecting the various points of activity with the capital Dar es Salaam.

The new road will have to be built according to the following specification:

- width	6.5 m
- base	mechanically stabilized
- subbase	sand 25 mm
top	double layer centre, single layer sides.

The cost per km of such type of road amounts to approximately 2 500 000 TSh, corresponding to 265 000,- US$ according to information obtained from Howard Humphreys in January 1983. Beaty Construction Corp. Ltd. also strongly emphasized the need for including approx.

50 % reserves for unforeseen charges, costs and services

25 % reserves per annum of construction period for inflation

into the investment estimates for new road construction projects. The costs mentioned above have been taken as basis for the investment cost estimate below, based on US$, escalation was taken with 5 %, based on TSh with 29 % (devaluation) to arrive at today's price basis.

Location		Distance km	Investment Mio US$	Investment Mio TSh
Mchuchuma	- Liganga	80	22.26	271.6
Liganga	- Mahanje	60	16.69	203.7
Mahanje	- Madaba	12	3.33	40.7
	Total	152	42.28	515.8

This estimate is based on a terrain similar to that between Njombe/Songea and applies for a specific construction rate of approx. 8 km per month.

1.3 Power Grid

The project area at present does not possess any electric power distribution systems.

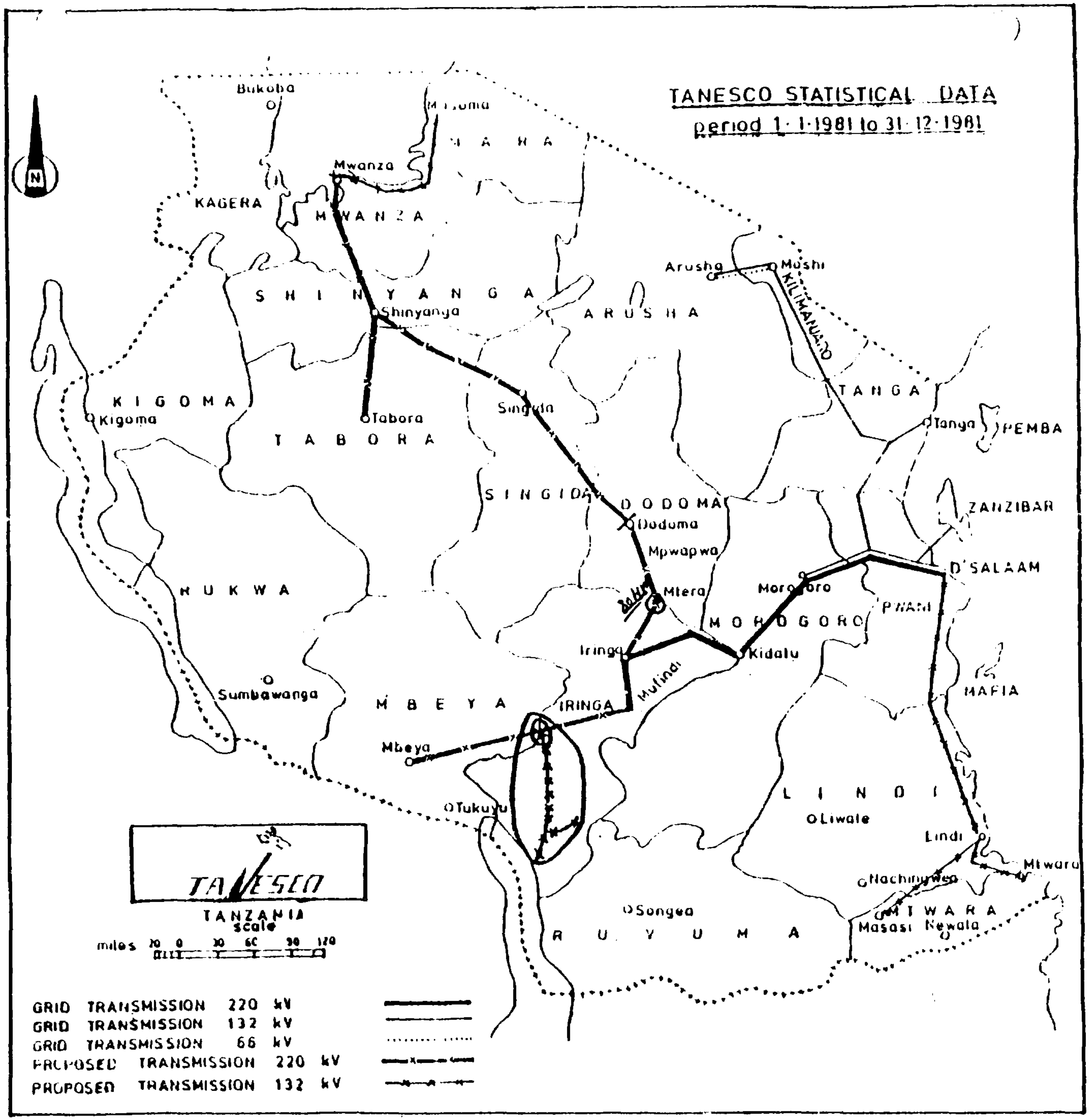
As can be concluded from the enclosed map, provided from TANESCO, Dar es Salaam, the existing electric power grids are concentrated in the coastal area (Dar es Salaam, Zanzibar, Tanga) and in the north-west (Arusha, Moshi, Morogoro, Kidatu).

Mufindi Pulp and Paper Mill is the point next to the project area and is connected to the 220 kV line leading from Kidatu to Iringa. This line is planned to be extended to Njambe in the near future.

However, the overall electric power requirement of approx. 300 MW for the integrated iron and steel project will not permit to utilize the existing power generating and distribution systems. Therefore, a new thermal power plant at Mchuchuma is planned to supply the energy to the plant sites of Mchuchuma, Liganga and Mahanje.

For connection of the individual plant areas with the power generation plant, it is recommended to provide an overhead 220-kV transmission line for power distribution.

The design of the transmission network is based on the demand figures and its distribution on the planned generating facilities.


TANESCO STATISTICAL DATA
period 1·1·1981 to 31·12·1981
N
Bukoba
Mwanza
KAGERA
MWANZA
SHINYANGA
Shinyanga
ARUSHA
Arusha
Moshi
KILIMANJARO
KIGOMA
Kigoma
Tabora
TABORA
Singida
SINGIDA
DODOMA
Dodoma
Mpwapwa
Mtera
TANGA
Tanga
PEMBA
ZANZIBAR
D'SALAAM
Morogoro
MOROGORO
Kidatu
PWANI
MAFIA
RUKWA
Sumbawanga
MBEYA
Mbeya
IRINGA
Iringa
Mufindi
Tukuyu
LINDI
Liwale
Lindi
Mtwara
Nachingwea
MTWARA
Masasi
Newala
Songea
RUVUMA
TANESCO
TANZANIA
scale
miles
GRID TRANSMISSION 220 kV
GRID TRANSMISSION 132 kV
GRID TRANSMISSION 66 kV
PROPOSED TRANSMISSION 220 kV
PROPOSED TRANSMISSION 132 kV

Following peak power demands can be estimated for the technical installations at the individual sites in the first capacity stage (peak/normal = 1.6):

Mchuchuma

coal mine (2.4 million tpy)	:	6.5	MW
coal washing plant	:	1	MW
off-sites	:	0.5	MW

Liganga

iron ore mine	:	0.5	MW
iron ore beneficiation	:	9.0	MW
iron ore pelletizing	:	6.2	MW
off-sites	:	0.8	MW

Mahanje

direct reduction	:	14.5	MW
steelmaking	:	101.5	MW
rolling mill	:	9.5	MW
off-sites	:	4.0	MW
other consumers: of projected area	:	120	MW
total demand (approx.)	:	273	MW

Based on climatic conditions and given technical data such as rated voltage, conductor cross section and material as well as short circuit capacities, a 220 kV high-voltage board has been selected for economical reasons.

For transmission safety reasons, a double circuit line, 2 x 2 x 300/50 mm^2 (2-bundle conductor Aldrey), has been selected. This is a configuration which meets the requirements imposed on voltage conditions and offers furthermore a high operational safety and flexibility coping uncertainties in local and generation development.

For the supporting of the overhead line, the required number and types of towers highly depend on the route. The towers are of the latice type made of hot dip galvanized angle iron. Concrete foundations as well as required grounding for the towers will also depend on the routing selected whereby the need for piling work may arise depending on the soil characteristics in the different regions.

Under the assumption of nominal implementation conditions in a mountainous/flat country, the average price for installing the new power transmission line has been estimated by AEG, Frankfurt, based on recent experiences in a Westafrican country, to be approx. 580,000. DM/km.

For the new power line connecting Mchuchuma power station with the Mchuchuma mining facilities, Liganga and Mahanje industrial complexes, the following investment can be estimated under the assumption that the grid routing follows the routing of the railway track to be implemented between Mchuchuma and Mahanje via Liganga:

Location	Distance	Investment	
	km	Mio. US $	Mio. T.Sh
Mchuchuma - Liganga	80	17.2	209.8
Liganga - Mahanje	60	12.9	157.4
Total	140	30.1	367.2

The implementation of these power lines will have to run parallel to the erection work of the Mchuchuma power plant.

1.4 Intercommunication Systems

The intercommunication of the proposed plants needs an installation of determined and approved transmission systems for text, speech and data handling.

To achieve a high grade of reliable transmission, subsequent systems are to be installed.

1.4.1 Telephone system

The telephone system proposed includes an automatic switching equipment with main distribution frames as well as switchboards, allocated to the corresponding plants.

Defined groups of extension with direct access to outside trunks in the interest of interplant coordination are essential.

The system is designed for both dialing and push button calling, estimated are approx. 150 customers per plant and housing area.

For Mahanje, a sub-system has to be provided.

Besides the general facilities, to which all extensions have acces, provisions for central exchange are necessary to guarantee simultaneous connections to a public or nationwide respectively internation telephone network.

1.4.2 Teleprinter system

For text and speech communication, a four-wire inter-dialing equipment which can operate as switching system, network mode or termination exchange, has been chosen, providing a 2-32 line termination.

The system designed will be installed in all plants, simularly. It is to be ensured that the location of the main equipment is the ore beneficiation plant.

Altogether, it is proposed to install 3 teleprinters at each site. In that case, the system can be used as telephone, teleprinter or data and text subscribers in any desired combination including outside link for nationwide or international communication. It can handle local and long distance communication, full availability being ensured for all lines.

The terminal equipment comprises teleprinters for all common codes and speeds up to 300 bits/s.

1.4.3 Radio link system

The radio link system consists of a multiplex system with 24-channel-outputs designed for duplex operation. Teleprinting data handling and speech are based on a frequency level of 300 MHz until 400 MHz.

These facilities are required at the Liganga site from where by double termination exchange, the above-mentioned informations are transmitted to Mchuchuma and Mahanje with their corresponding housing area. In this context, towers with an average height of approx. 60 m are to be installed under the assumption that 2 repeaters are sufficient and the optical conditions at site permit an unrestricted sight.

The investment costs for the above-mentioned systems have been estimated by AEG, Frankfurt, to be

approx. US $ 1,850,000.--
approx. T. Sh. 34,770,000.--

corresponding to the latest price basis 1983 and assuming nominal implementation conditions for the structural and civil works involved such as towers, antennas etc.

The communication system will have to be implemented prior or parallel to the main construction activities in the project area.

SECTION 2

Electric Power Plant Mchuchuma

2. Electric Power Plant Mchuchuma

2.1 General Aspects

The project area will be supplied with electric power generated in a new power plant at Mchuchuma coal fields, which will be fed with the non-metallurgical coal from the Mchuchuma coal mine.

The power plant will have to meet the approximate power requirements as follows:

- Mchuchuma mining and coal preparation	8 MW
- Liganga mining, benefication, pelletizing	17 MW
- Mahanje steelworks	130 MW
- Townships Mchuchuma/Liganga/Mahanje power plant internal consumptions, lighting, social facilities, communication, small scale industries, craftmanship, etc. in project area	120 MW

Corresponding plans by TANESCO (Tanzania Electricity Supply Corporation) indicate a new 22 kV power line - the so-called "Southern Grid" - planned to connect Mufindi with Mbeya, from which a linkage at Njombe/Makambako can be extended to the south.

However, the situation is yet unclear, as controverse information indicates plans to

- install a 200 MW power plant at the Songwe Kiwira coal fields (Tanesco-Project);

- install a 200 MW power plant at the Mchuchuma coal fields (Stamico-Project) by 1987/1988.

In the same way, as coal deposit development plans with NDC and Stamico are partially contradictory with regards to mining capacities and mining layouts, this is the case with the plans for new electro-thermal power plants, too.

However, the plans mentioned so far will not be sufficient to supply the planned mining/iron and steel facilities in Mchuchuma, Liganga and Mahanje with the necessary electric power.

Providing for a 10 % reserve in power supplies, the following evaluation is based on a 300 MW coal-fired power station in Mchuchuma.

2.2 Brief Plant Description

The fresh coal required for the coal-fired steam generators of the power station is supplied by a conveyor system from the coal mine to the coal yard into two beds with a capacity of approx. 3 000 tons each.

An automatic scraper loader transfers coal to the belt conveyor, feeding the boiler bins of 4 x 80 tons capacity.

The steam generator is designed as once-through boiler with single reheating and circulation equipment. This equipment is used for both low-load operation and start-up and shut-down. The double-pass boiler works with pulverized coal front type furnaces and dry ash removal. They have been designed for sliding pressure; operating pressure at the live-steam outlet varies between 80 and 200 bar depending on load.

The furnace section is 24 x 10 m. Safety of the air and flue gas paths of the steam generator is provided by impeller-controlled axial ID fans, which take in fresh air either 100 % from the boiler house or 50 % from the open air. In case one ID fan fails, appropriate repair dampers allow the plant to continue operating to 60 % of the capacity.

Flue gas heated air heaters with rotary hoods heat the combustion and mill air.

Gas-sides of the steam generators are operated at underpressure. The necessary ID fans are also impeller-controlled axial fans. They are located between the electrostatic precipitator and the stack.

2.3 Main Technical Data

Turbine Plant

Rated capacity	MW	300
HP steam	bar/° C	183/530
Reheat steam	bar/° C	52/530
Condensers		2
Cooling surface	m2	20 600
Condenser pressure	bar	0.056

Electrical Equipment

Generator

Rated Capacity	MVA	1.400
Rated terminal voltage	kV	21 plus/minus 5 %
Rated current	kA	12.1
Coolant pressure	bar	4.0

Main Transformer

Rated capacity	MVA	400
Auxiliary Transformer		1

Closed Cooling Systems

Cooling tower		1
Type		cross counterflow natural-draught cooler with wooden packing, concrete stack 114 m high.
Capacity	m3/h	46 000
Cooling water pumps		2
Capacity	m3/h	23 000

Boiler Plant

Type		p.f. furnace with dry ash removal, single reheat, 2 circulating pumps each.
Steam output max.	t/h	1 080
Steam conditions (Design data)		
HP	bar/°C	213/535
Cold reheat line	bar/°C	60/400
Hot reheat line	bar/°C	60/535
Furnace type		front type
Number of burners		16, 3 levels
Air heaters		2
Exit gas temperature	°C	140
Mills (bowl mills)		4
Electrostatic precipitator		1 flue gas precipitator each efficiency 99.4 %
Stack		height approx. 150 m

Water Steam Cycle

Half-size feed pumps

Capacity	t/h	540
Delivery pressure max.	bar	275
Power requirements	kW	6 200

Quarter-size pumps

Capacity	t/h	280
Delivery pressure max.	bar	275
Power requirements	kW	3 200
Motor power	KW	4 200/ 4 800

Condensate pumps

Capacity	t/h	860
Head	bar	26
Power requirements	kW	805
Motor power	kW	1 000

Condensate coolers	2 x 2
LP heaters	2 x 4
HP heaters	2 x 2
Desuperheater	2 x 1

Fuel

Fuel:	hard coal Mchuchuma
Central coal handling:	2 raker cars of 900 t/h each 1 conveyor 900 t/h automatic stacker
Coal Yards:	open air yards 2 x 3 000 t each, automatically working scraper loader 200 t/h, conveyor bunkers 4 x 80 t (fully automatic operation)

Decarbonizer Plant

comprising:

- reactor
- double-chamber gravel filters
- lime hydrate bins
- lime milk

Demineralizer Plant

comprising:

- cation filters
- anion filters
- mixed bed filter

2.4 Investment Cost Estimate

The information on the 200 MW Mchuchuma power plant was provided by VEBA Kraftwerke Ruhr AG, Gelsenkirchen, Germany. From the same source, the investment for this plant was estimated inside battery limits, turnkey and late 1983 price basis:

approx.:	US $	240 million
approx.:	TSh	2937 million

This prices indication does not include the necessary facilities for outdoor infrastructure like long-distance water pipelines, township, external roads, etc. and is based on a 30 months construction time.

2.5 Energy Distribution System

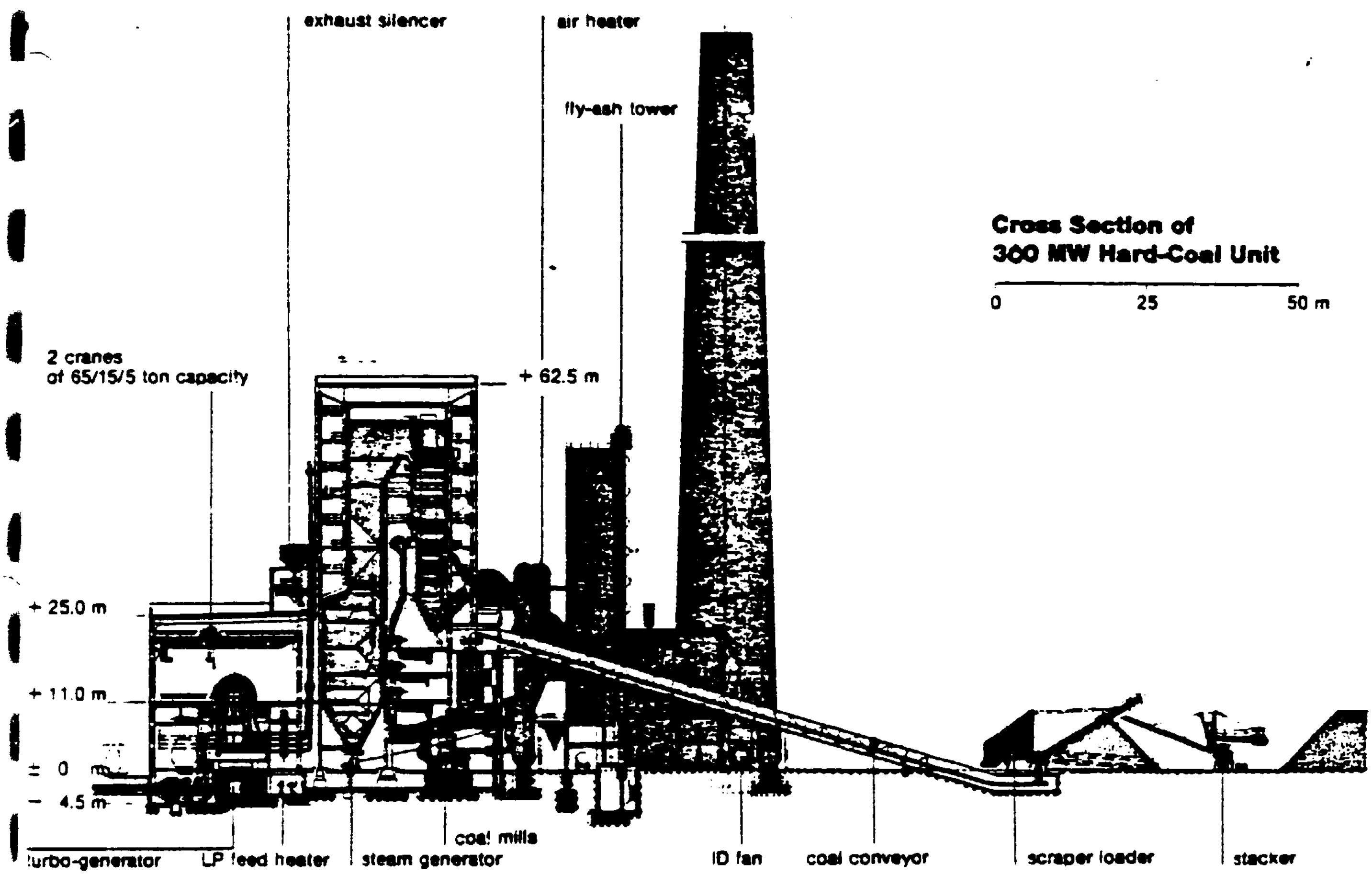
The power station generator will supply the total required electric energy, which has to be distibuted to the areas of consumption. Power distribution will by done by a 220 kV distribution system. The electric power generated will be transformed by two 21/220 kV step-up transformers and supplied to a 220 kV double bus bar system within a 220 kV switch yard. The complete switch yard is formed by two supply feeders and the required number of outgoing feeders for transformers as well as for overhead transmission lines. The bus bar system will consist of stranded aluminium conductors for rated current complete with strain and midspan bus bar steelstructure as well as insulators and damps, suitable to accommodate the required number of bays. The individual overhead line bays will consist of circuit breaker, motor operated line isolators, current transformers etc.

A 6 kV-switch gear plant at each site will distribute the electric energy to the individual plants/offsites/townships. Two additional step-down transformers (220/6 kV) will supply the 6 kV switch gear.

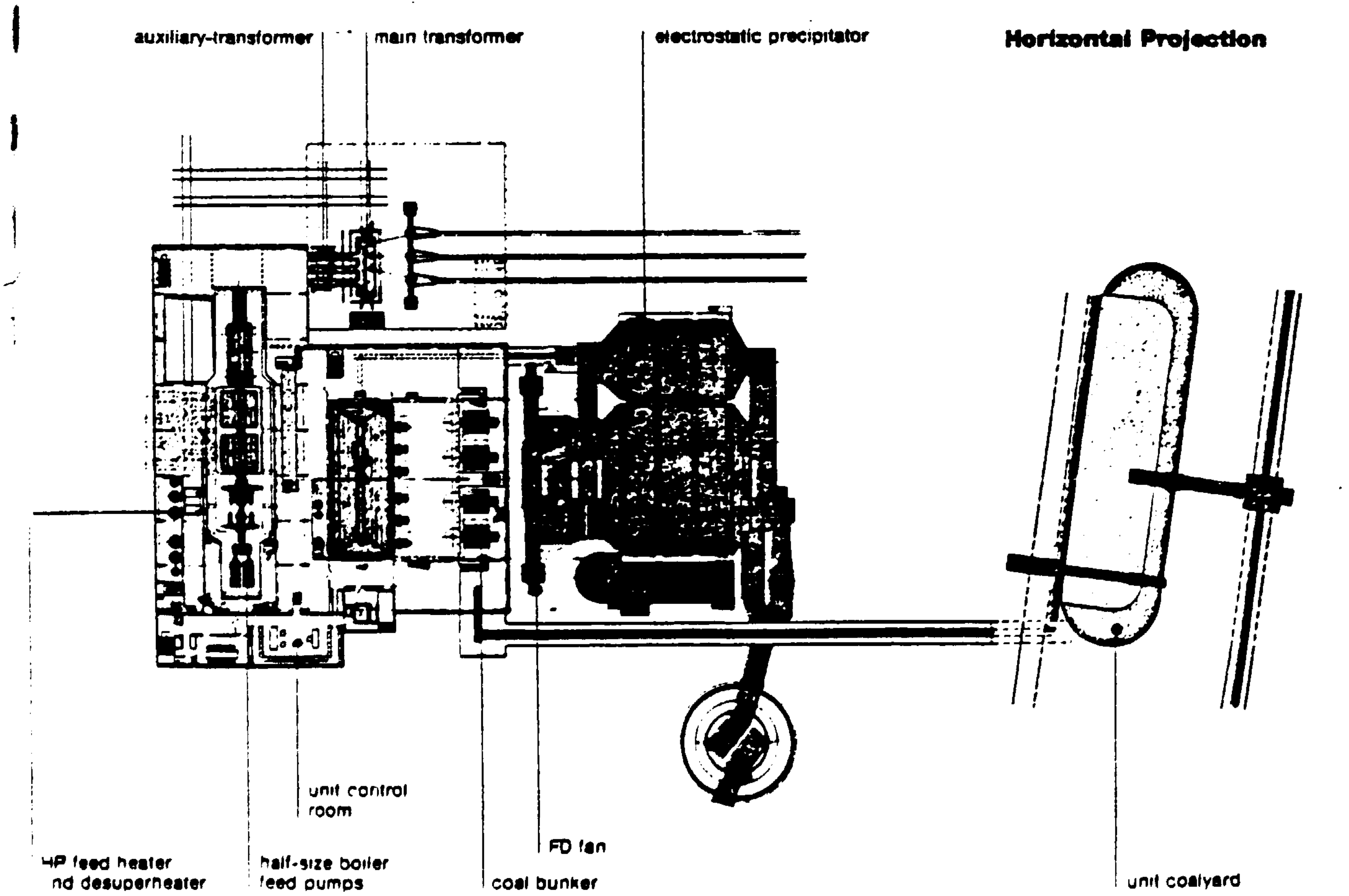
The investment for the above mentioned general area stationary energy distributing system in Mchuchuma can be estimated on late 1983 price basis to amount to:

approx.:	US $	18 million
approx.:	TSh	219 million

Cross Section of 300 MW Hard-Coal Unit



Horizontal Projection



S E C T I O N 3

Townships

3.1 General Remarks

The project area presently is not in the position to provide the sources for recruiting of skilled and semi-skilled personnel required for the industrial operations at Mchuchuma, Liganga and Mahanje.

Correspondingly a larger number of staff will have to be recruited from the Dar es Salaam area or from abroad, for which housing facilities have to be provided at the three individual sites.

Also the unskilled labour force of the project area will have to be concentrated at the sites for prompt availability of workforce.

The creation of corresponding townships will have to start with the first project activities, the worker's camp forming the first nucleus. Whereas the camps normally are designed for easy removal and short-time supplies of the necessary auxiliaries and in this sense are only of temporary nature, the new townships represent independent projects in terms of infrastructural and municipal development with special attention paid to the multiplicator effects of the project on secondary industries and services.

In the following, a brief estimation has been carried out on the township development cost based on the following formula for calculation of the municipal population.

$$N = (W \times 5) \times M$$

with N = Number of population
W = Number of primary employees
M = Multiplicator factor for secondary employment effects
M = 1.2

The following calculation is based on price information supplied by Mowlem International Ltd., London and applies an exchange rate of 1 US$ = 12.2 TSh.

3.2 Township Mchuchuma

Total Square Dimensions	500 m x 800 m
Employees	approx. 1 200
Capita	approx. 6 000
Total Population	approx. 6 600
Family Houses	approx. 1 320
Roads and Open Areas	80 000 m^2

Municipal facilities include:

community centre, townhall, police station, school, fire station, church, hospital, department store, sports facility, pump stations, electric substations, etc.

Cost Estimate		Million TSh
- site development (400 000 m^2)		45.66
- housing (1 320)		391.78
- roads (65 000 m^2)		44.52
- open areas (15 000 m^2)		19.86
- municipal facilities (85 000 m^3)		194.06
- Contingencies (15%)		104.38
TOTAL	Million TSh	800.26

3.3 Township Liganga

Total Square Dimensions		350 m x 600 m
Employees	approx.	500
Capita	approx.	2 500
Total Population	approx.	3 000
Family Houses	approx.	600
Roads and Open Areas		40 000 m^2

Municipal facilities include:

community centre, townhall, police station, school, fire station, church, hospital, department store, sports facility, pump stations, electric substations, etc.

Cost Estimate		Million TSh
- site development (210 000 m^2)		23.97
- housing (600)		178.08
- roads (29 000 m^2)		19.86
- open areas (11 000 m^2)		15.48
- municipal facilities (60 000 m^3)		136.98
- Contingencies (15%)		56.15
TOTAL	Million TSh	430.53

03

3.4 Township Mahanje

Total Square Dimensions		650 m x 1000 m
Employees	approx.	1 800
Capita	approx.	9 000
Total Population	approx.	12 000
Family Houses	approx.	2 400
Roads and Open Areas		105 000 m^2

Municipal facilities include:

community centre, townhall, police station, school, fire station, church, hospital, department store, sports facility, pump stations, electric substations, etc.

Cost Estimate	Million TSh
- site development (650 000 m^2)	74.20
- housing (2 400)	712.32
- roads (80 000 m^2)	54.79
- open areas (25 000 m^2)	23.97
- municipal facilities (100 000 m^3)	228.31
- Contingencies (10%)	109.36
TOTAL Million TSh	1 202.95

SECTION 4

Manpower Training Requirements

4. Manpower training requirements

4.1 General Training of Personnel

The training of managing and operating personnel should start approximately one year prior to plant start-up and should be performed in three phases:

Phase I

Technical theoretical training at the contractor's and subcontractors facilities and works abroad for a duration of approx. 2 months.

Phase II

Practical training on operational plants of the type as installed for the NDC project, duration approx. 2-3 months.

Phase III

In-plant training in the plants at Mchuchuma, Liganga and Mahanje during end of construction and during commissioning.

The details of the training are as follows:

Phase I

Training comprises a theoretical training at the contractor's facilities which is desirable to achieve optimum efficiency, since all specialists of various disciplines will be directly involved in the training of the managing and operating staff.

A direct connection between training and the project is thus guaranteed. Furthermore, the laboratories and experimental plants of the contractor at the trainees disposal. Operation of the pilot plant ensures that the theoretical knowledge gained during training is put into practice.

During Phase I, each of the trainees is given theoretical information on the corresponding metallurgical process. This is followed by intensive classroom instructions on process techniques, operation, equipment, theory of operation, plant maintenance and all specific systems incorporated into NDC's plant.

In the various groups, the operating and management personnel will be introduced to the groups specific equipment components of the plants. The relevant subsuppliers will be involved in the schooling of the trainees in their factories.

The training period of Phase I is approximately two months.

Phase II

This phase of training is devoted to on-the-job-training at operational plants employing the processes similar to NDC's project.

It consists of plant equipment orientation and operation, as well as student participation in the operation of the plants.

Besides the operators and controllers, also electrician and instrumentation people for the repair and maintemance will be trained within the same plants.

It is proposed that the foreign plant training will mainly be given to the key personnel from the level of foreman and operators to the level of superintendents for the operation, production and maintenance of the plant.

Training groups are also formed in Phase II comprising the process, electric, instrumentation and control related personnal for each plant.

These groups participate in normal shifts after they acquainted themselves with the plants, the plant systems and plant equipment.

The duration of this practical education is approximately two to three months.

Phase III

During this phase, the trainee participates in the pre-operational activities of his own new NDC plant. This includes the final erection activities, cold trials, start-up and plant operation, to learn the necessary practices related to equipment and operation.

The in-plant training will also be performed in groups up to the end of the commissioning period under the guidance of the contractor's training and start-up personnel in Tanzania.

4.2 Lists of Trainees

In the following, a list of trainees has been compiled for the technical key personnel of the metallurgical facilities. In this list, key functions of the administration and commercial plant sectors are excluded, as fully skilled personnel will have to be employed already in the period of project implementation.

The technical functions however require special skill and training related to the plant equipment. In this sense, the training mentioned above is to be considered as a post graduate skill, a precondition of which is the availability of graduated and skilled engineers/foremans to be trained according to the phases described before.

1. Trainees Mchuchuma Coal Colleries

No.	Title
1	Mine-Superintendent
1	Mining Engineer
1	Mechanical Engineer
1	Electrical Engineer
1	Safety Engineer
1	Safety Captain
2	Surveying Technican
3	Foreman Development
3	Foreman Exploitation (safety)
3	Foreman Repair and Maintenance
1	Clerc
15	Drifting Specialists
20	Exploitation Specialists (incl. safety, air control, water control)
10	Stope Preparation Specialists
5	Mechanics Special Duties
5	Electricians Special Duties
73	TOTAL

2. Trainees Linganga Iron Ore Mines

No.	Title
1	Mine Superintendent
1	Mining Engineer
1	Foreman Drilling
1	Foreman Blasting
1	Foreman Loading
1	Foreman Haulage
3	Blasthole Drill Operators
2	Blaster
3	Operator Excavator
10	Truck Driver Special Trucks
5	Operator Aux. Equipment
1	Mechanical Engineer
1	Foreman Trucks, Vehicles
5	Mechanics
2	Electricians
38	TOTAL

3. Trainees Coal Washing Plant

No.	Title
1	Assistant Manager (Plant Superintendent)
3	Shift Foremen (Production)
1	Shift Foremen Electrical Maintenance
1	Shift Foremen Mechanical Maintenance
6	TOTAL

4. Trainees Iron Ore Benefication Plant

No.	Title
1	Assistant Manager (Plant Superintendent)
4	Shift Foremen (Production)
4	Process Controller (Control Room Operator)
4	Shift Foremen Electrical Maintenance
1	Shift Foremen Instrumentation and Control Maintenance
4	Shift Foremen Mechanical Maintenance
1	Shift Foremen Raw Materials
19	TOTAL

5. Trainees Pellet Plant

No.	Title
1	Assistant Mananger (Plant Superintendent)
4	Shift Foremen (Production)
8	Process Controller (Control Room Operator)
1	Shift Foremen Electrical Maintenance
1	Shift Foremen Instrumentation and Control Maintenance
1	Shift Foremen Mechanical Maintenance
1	Operator Raw Materials
1	Operator Products
1	Refractory Lining Specialist
19	TOTAL

6. Trainees DR Plant

No.	Title
4	Assistant Managers (Plant Superintendent)
1	Process Engineer (Asst. Plant Superintendent)
9	Shift Foremen (Production)
9	Process Controller (Control Room Operator)
3	Shift Foremen Electrical Maintenance
3	Shift Foremen Instrumentation and Control Maintenance
6	Shift Foremen Mechanical Maintenance
2	Shift Foremen Raw Materials
2	Shift Foremen Products
1	Refractory Lining Specialist
2	Controllers Raw Materials
2	Controllers Products
44	TOTAL

7. Trainees Electric Smelting Plant

No.	Title
1	Assistant Manager (Plant Superintendent)
1	Process Engineer (Asst. Plant Superintendent)
4	Shift Foremen (Production)
2	Process Controller (Control Room Operator)
2	Shift Foremen Electrical Maintenance
1	Shift Foremen Instrumentation and Control Maintenance
2	Shift Foremen Mechanical Maintenance
1	Refractory Lining Specialist
14	TOTAL

8. Trainees Ladle Furnace Plant

No.	Title
1	Assistant Manager (Plant Superintendent)
6	Shift Foremen (Production)
4	Process Controller (Control Room Operator)
2	Shift Foremen Electrical Maintenance
1	Shift Foremen Instrumentation and Control Maintenance
4	Shift Foremen Mechanical Maintenance
1	Refractory Lining Specialist
19	TOTAL

9. Trainees Continuous Casting Plant

No.	Title
1	Assistant Manager (Plant Superintendent)
8	Shift Foremen (Production)
4	Process Controller (Control Room Operator)
1	Shift Foremen Electrical Maintenance
1	Shift Foremen Instrumentation and Control Maintenance
2	Shift Foremen Mechanical Maintenance
17	TOTAL

10. Trainees Rolling Mill and Product Finishing

No.	Title
1	Assistant Manager (Plant Superintendent)
1	Process Engineer (Asst. Plant Superintendent)
4	Shift Foremen (Production)
4	Process Controller (Control Room Operator)
4	Shift Foremen Electrical Maintenance
2	Shift Foremen Instrumentation and Control Maintenance
4	Shift Foremen Mechanical Maintenance
2	Controllers Products
22	TOTAL

11. Trainees Auxiliaries and Offsites

- Mchchuma

3 Ventilation
2 Water Systems
2 Electric Grids
2 Workshops

---

9 Subtotal

- Liganga

1 Water Systems
2 Workshops
3 Laboratory
2 Electric Grids

---

8 Subtotal

- Mahanje

5 Lime Plant
7 Water Systems
4 Air Fractioning
10 Electric Grid
5 Environment Protection
6 Central Workshop
6 Central Laboratory

---

43 Subtotal

---

60 TOTAL

SECTION 5

Time Schedules

5. Time Schedule

5.1 Milestone Diagram

When implementing the NDC integrated steelworks project, a complex sequence of activities has to be followed up as shown on the enclosed milestone diagram.

Before start of the actual implementation of the industrial facilities, infrastructure development, i.e. road and railway construction, will have to be initiated as a precondition for bringing in the initial equipment. This preparatory phase lasts for approx. 18 months, with parallel investigations of the raw materials deposits being made, to secure more reliable exploration data.

Site preparation and first erection work for the industrial plants starts after completion of the link road Madaba/Mahanje/Liganga/Mchuchuma.

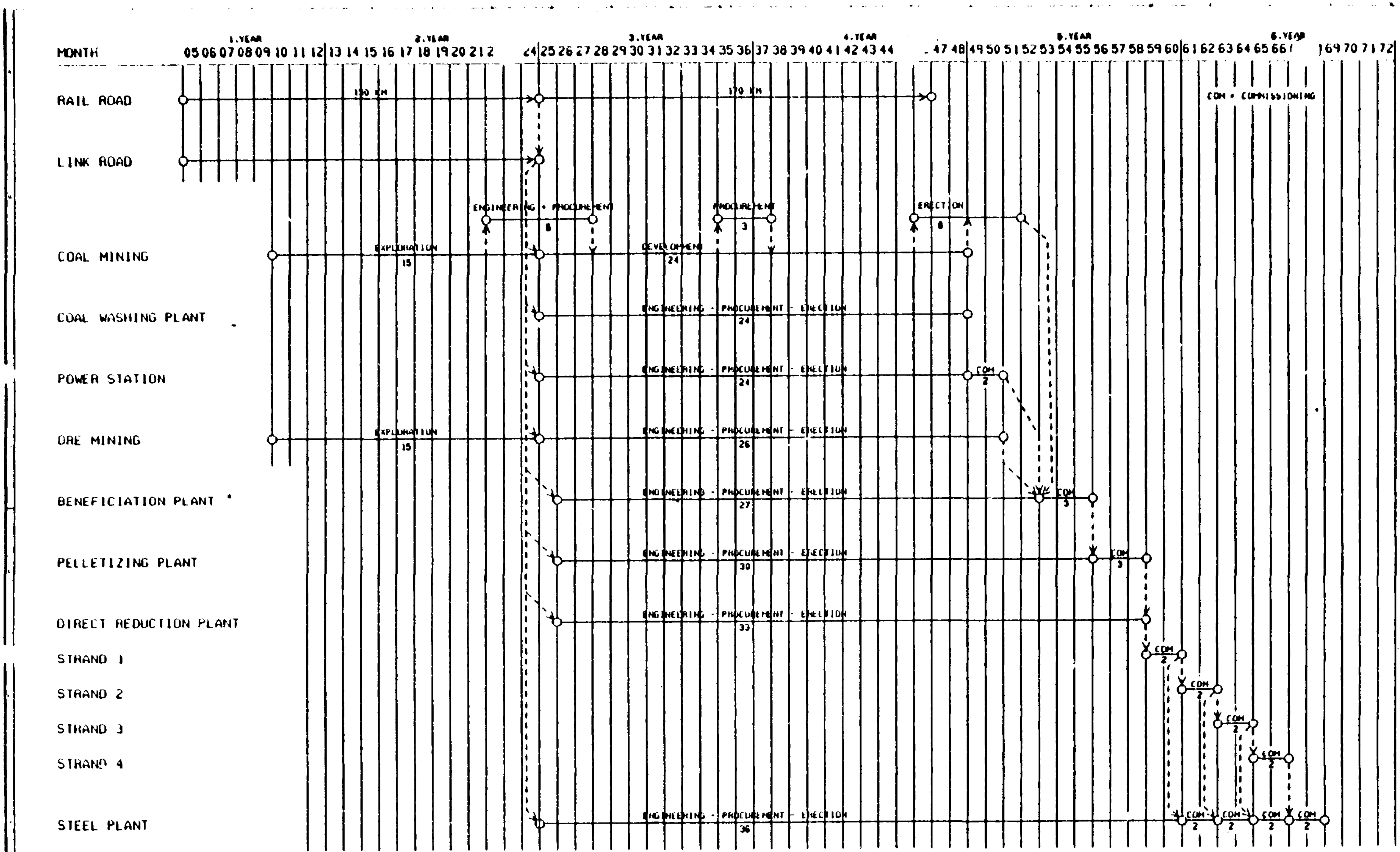
After approx. 18 months - completion of the railway line Mchuchuma/Liganga/Mahanje/Mlimba still continues - main activities begin simultaneously at the sites of Mchuchuma (coal mine, washing plant, power station, township), Liganga (iron ore mine, beneficiation plant, pelletizing plant, township) and Mahanje (DR plant, steel plant, township).

The commissioning phase follows the sequence of the raw materials to be provided for the various facilities with iron ore mine/beneficiation/pelletizing forming the critical path in securing the input materials supply to the DR plant and subsequent facilities.

Total commissioning phase is planned for a duration of 18 months.

Summarizing, a minimum based time planning would allow for

approx. 18 months	preparatory phase
approx. 28 months	engineering, erection
approx. 18 months	cold trials and commissioning
approx. 64 months	Total Project



MILE-STONE DIAGRAM
INTEGRATED STEEL PROJEC
TANZANIA

5.2 Bar Charts

In the following, the bar chart time schedules for every main industrial plant are enclosed, representing the time requirements for the main implementation activities, such as

- engineering,
- civil works,
- structural steel,
- equipment supply,
- erection,
- cold tests and commissioning.

For every single plant, the bar chart starts with a date thought of becoming effective of a contract, i.e. first month. The individual bar charts are subjected to the sequences given in the main milestone diagram.

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LURGI	TIME SCHEDULE	NAME: BELZER	JOB-NO.: HRE - 03 - 2238	SAT-NO.: 1520	SHEET 1	DISTRIBUTION:
		DATE: 04.01.84	CODE: TANZANIA		OF 8 SHEETS	

SPEC./DRWGS. ENG..COMP..ORDER SUPPLIER DRWGS. DELIVERY TIME TRANSPORT ERECTION

DESCRIPTION	ITEM NO.:	WT T	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
COAL - MINING			
EXPLORATION			
-DRILLING			
-HYDROGEOLOGICAL INVESTIGATIONS			
-ROCK MECHANICS			
-ANALYTICAL WORK			
ENGINEERING RESERVE ASSESSMENT MINE PLANNING			
PROCUREMENT			
DEVELOPMENT			
ERECTION			

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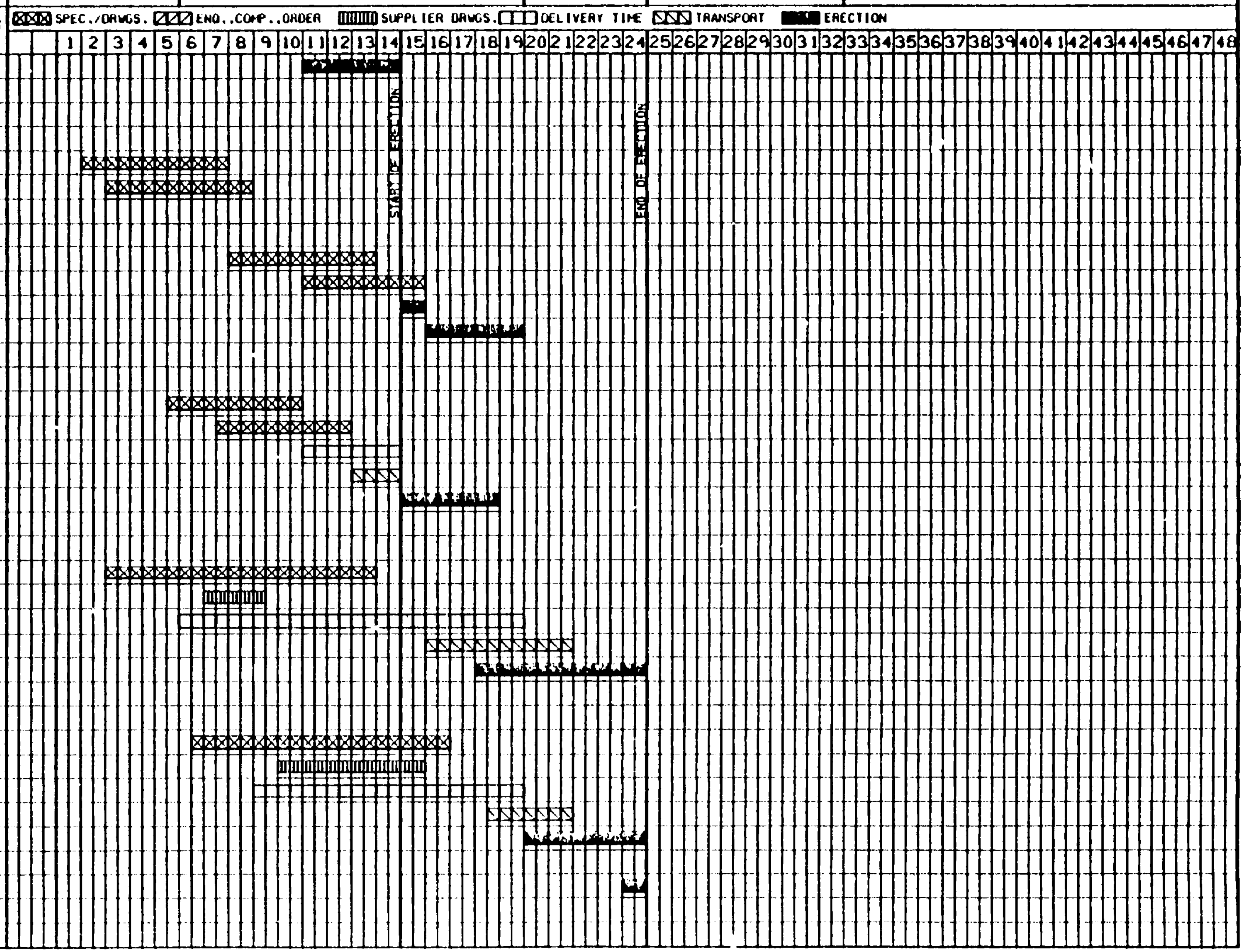
LURGI — TIME SCHEDULE	NAME: BELZER	JOB-NO.: HRE - 03 - 2238	SAT-NO.: 1520	SHEET 2	DISTRIBUTION:
	DATE: 04.01.84	CODE: TANZANIA		OF 8 SHEETS	

DESCRIPTION | ITEM NO.: | WT

- SITE PREPARATION
- COAL WASHING PLANT
- PROCESS ENGINEERING
- PLANT ENGINEERING
- CIVIL WORK
  - BASIC ENGINEERING
  - DETAIL ENGINEERING
  - PILING
  - CONCRETE WORK
- STRUCTURAL STEEL
  - BASIC ENGINEERING
  - DETAIL ENGINEERING
  - PROCUREMENT
  - TRANSPORT
  - ERECTION
- MECHANICAL EQUIPMENT
  - ENGINEERING
  - SUPPLIER DRAWINGS
  - PROCUREMENT
  - TRANSPORT
  - ERECTION
- ELECTRICALS + INSTRUMENTS
  - ENGINEERING
  - SUPPLIER DRAWINGS
  - PROCUREMENT
  - TRANSPORT
  - ERECTION
- FUNCTION + COLD TEST



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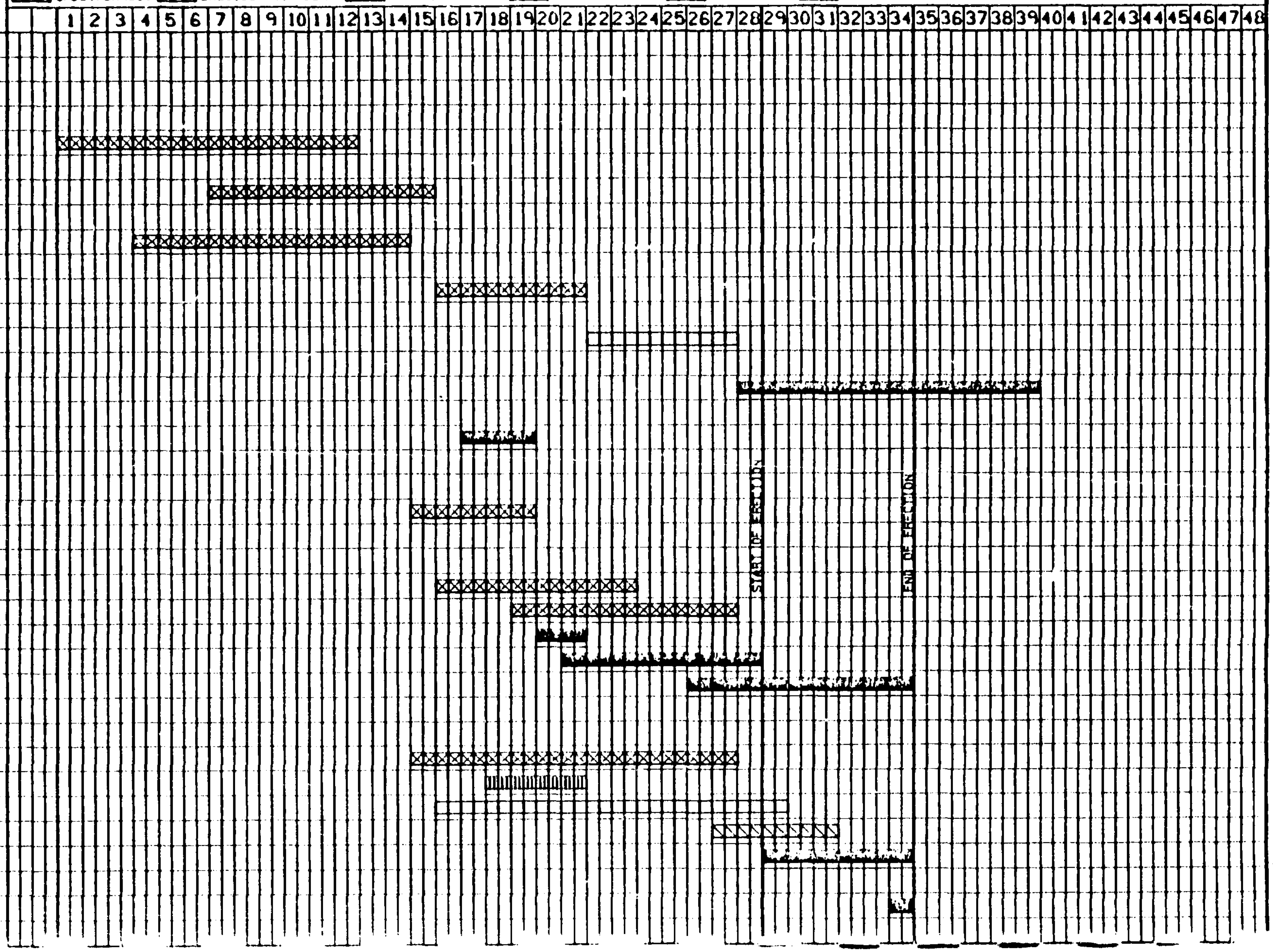
		DATE: 04.01.84	CODE: TANZANIA		OF 8 SHEETS	

SPEC./DRWGS. — ENG..COMP..ORDER — SUPPLIER DRWGS. — DELIVERY TIME — TRANSPORT — ERECTION

DESCRIPTION	ITEM NO.:	WT T
ORE - MINING		
EXPLORATION		
-DRILLING		
-ROCK MECHANICS		
-ANALYTICAL WORK		
-ENGINEERING RESERVE ASSESSMENT MINE PLANNING		
PROCUREMENT		
MINE PREPARATION		
SITE PREPARATION		
OFF-SITES		
PLANT ENGINEERING		
CIVIL WORK		
-BASIC ENGINEERING		
-DETAIL ENGINEERING		
-PILING		
-CONCRETE WORK		
-BUILDERS WORK		
ELECTRICAL EQUIPMENT		
-ENGINEERING		
-SUPPLIER DRAWINGS		
-PROCUREMENT		
-TRANSPORT		
-ERECTION		
FUNCTION TEST		



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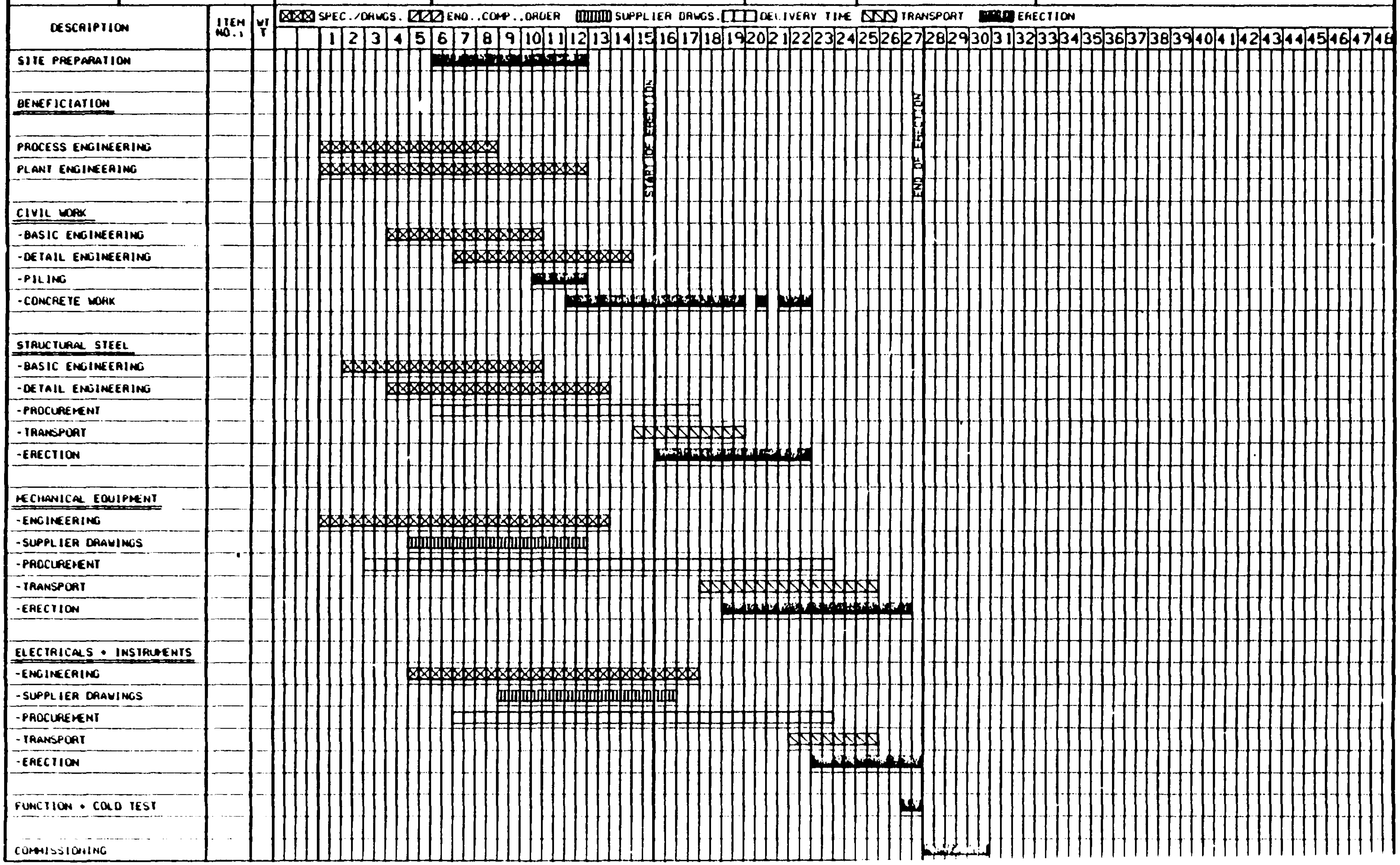

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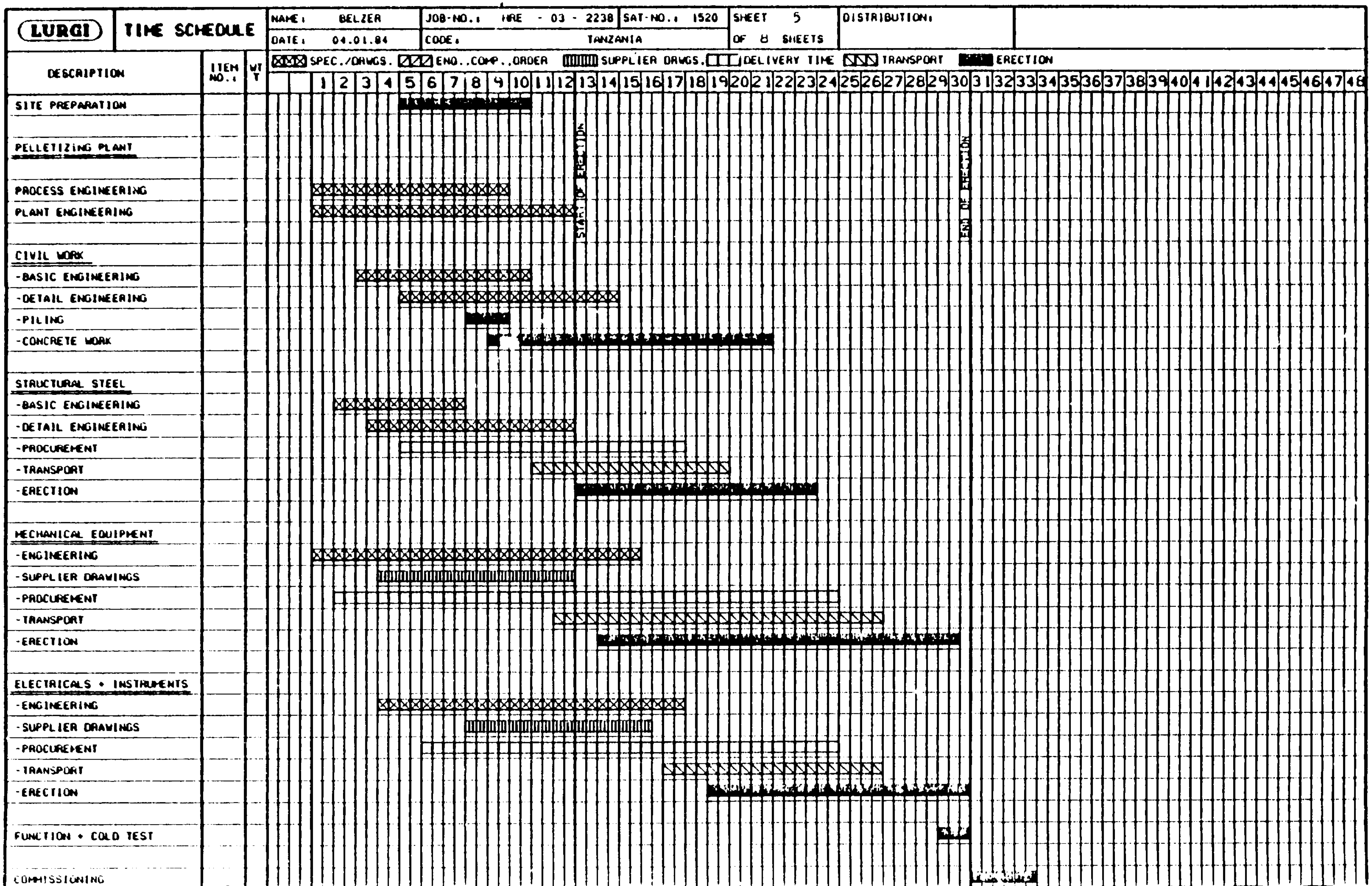

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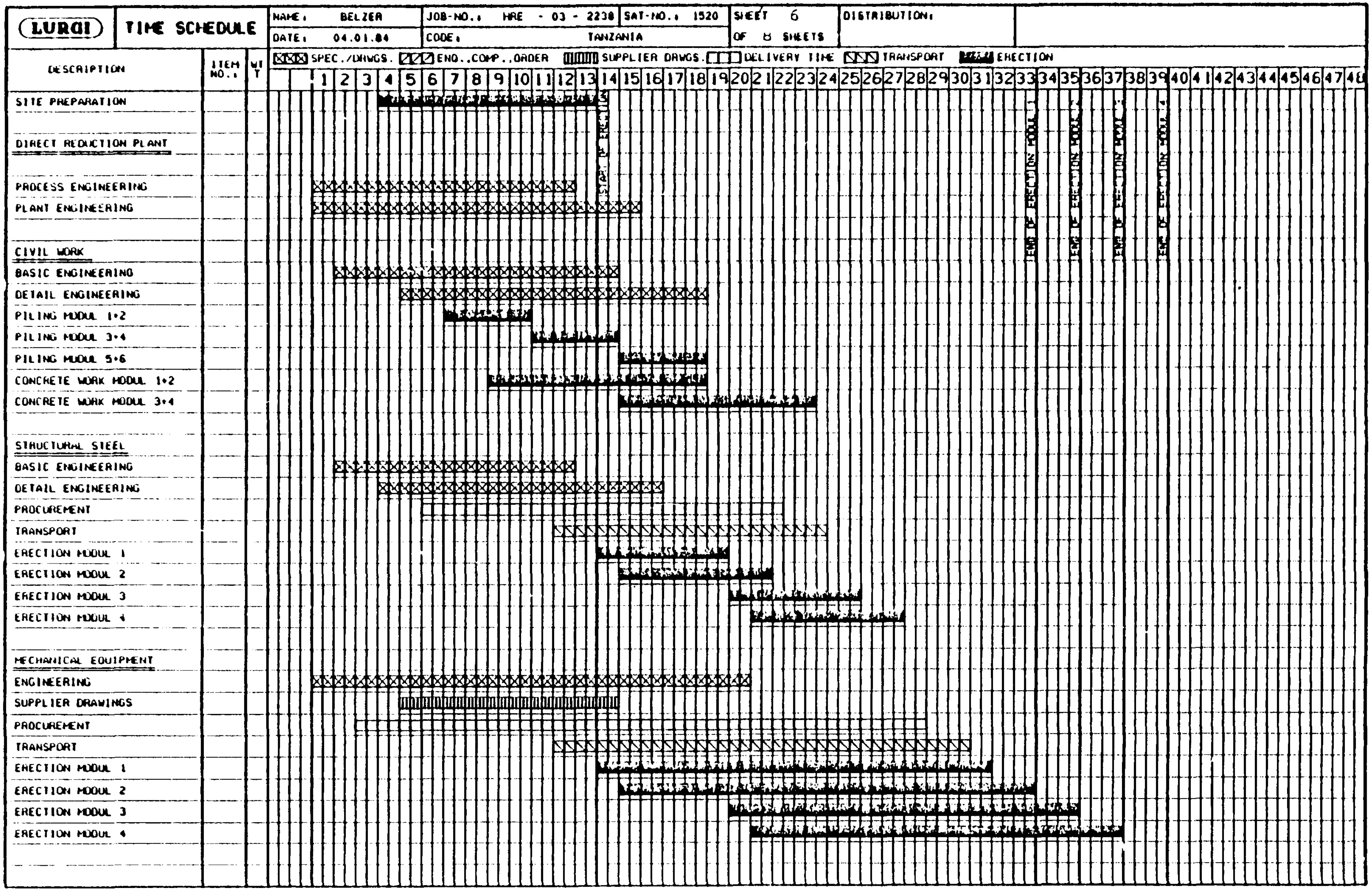

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LURGI TIME SCHEDULE

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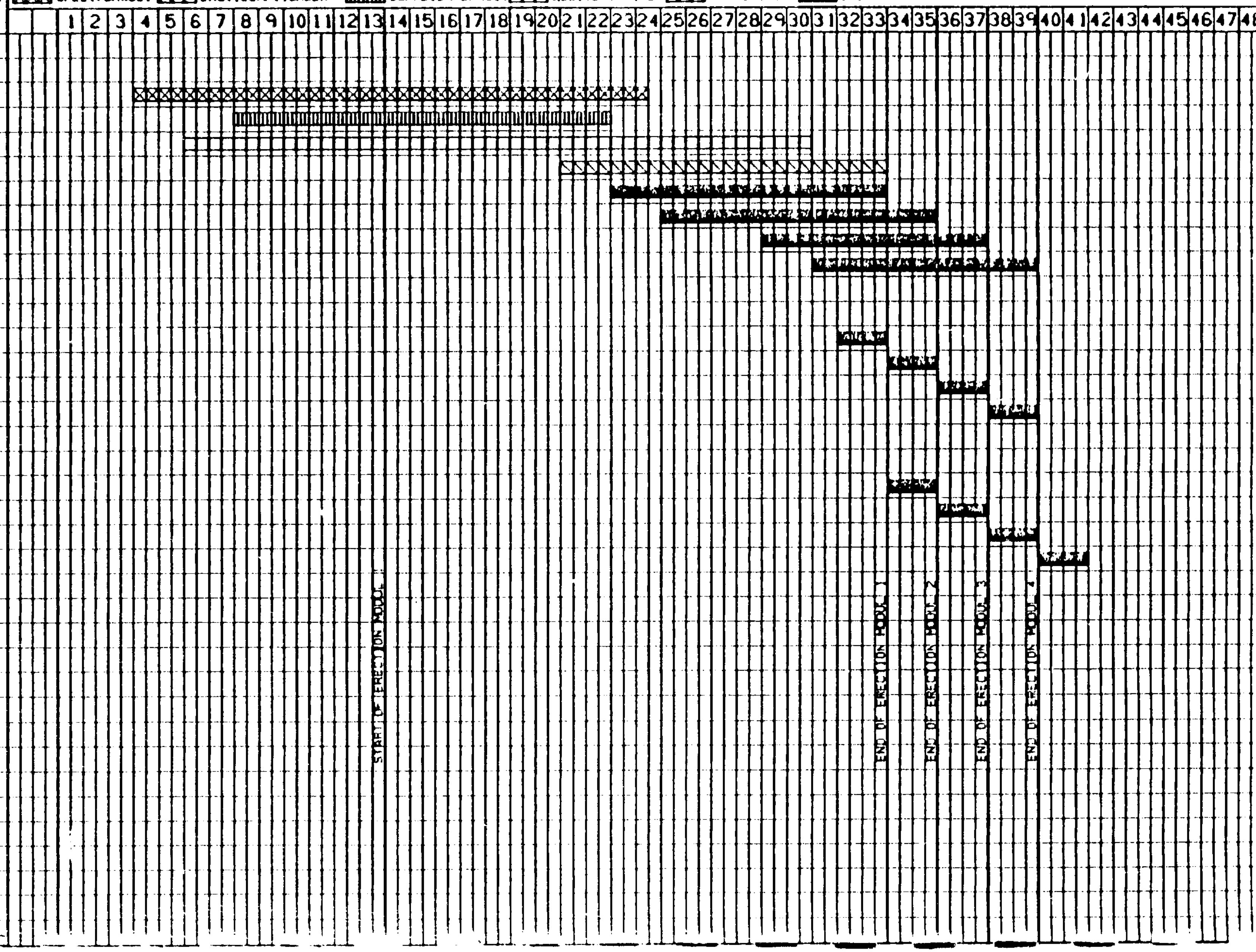
DATE: 04.01.84	CODE: TANZANIA		OF 8 SHEETS	REV.

Legend: SPEC./DRWGS. — ENQ..COMP..ORDER — SUPPLIER DRWGS. — DELIVERY TIME — TRANSPORT — ERECTION

DESCRIPTION	ITEM NO.:	WT
ELECTRICAL EQUIPMENT &		
INSTRUMENTATION		
ENGINEERING		
SUPPLIER DRAWINGS		
PROCUREMENT		
TRANSPORT		
ERECTION MODUL 1		
ERECTION MODUL 2		
ERECTION MODUL 3		
ERECTION MODUL 4		
FUNCTION TESTS,COLD TEST		
-MODUL 1		
-MODUL 2		
-MODUL 3		
-MODUL 4		
COMMISSIONING		
-MODUL 1		
-MODUL 2		
-MODUL 3		
-MODUL 4		



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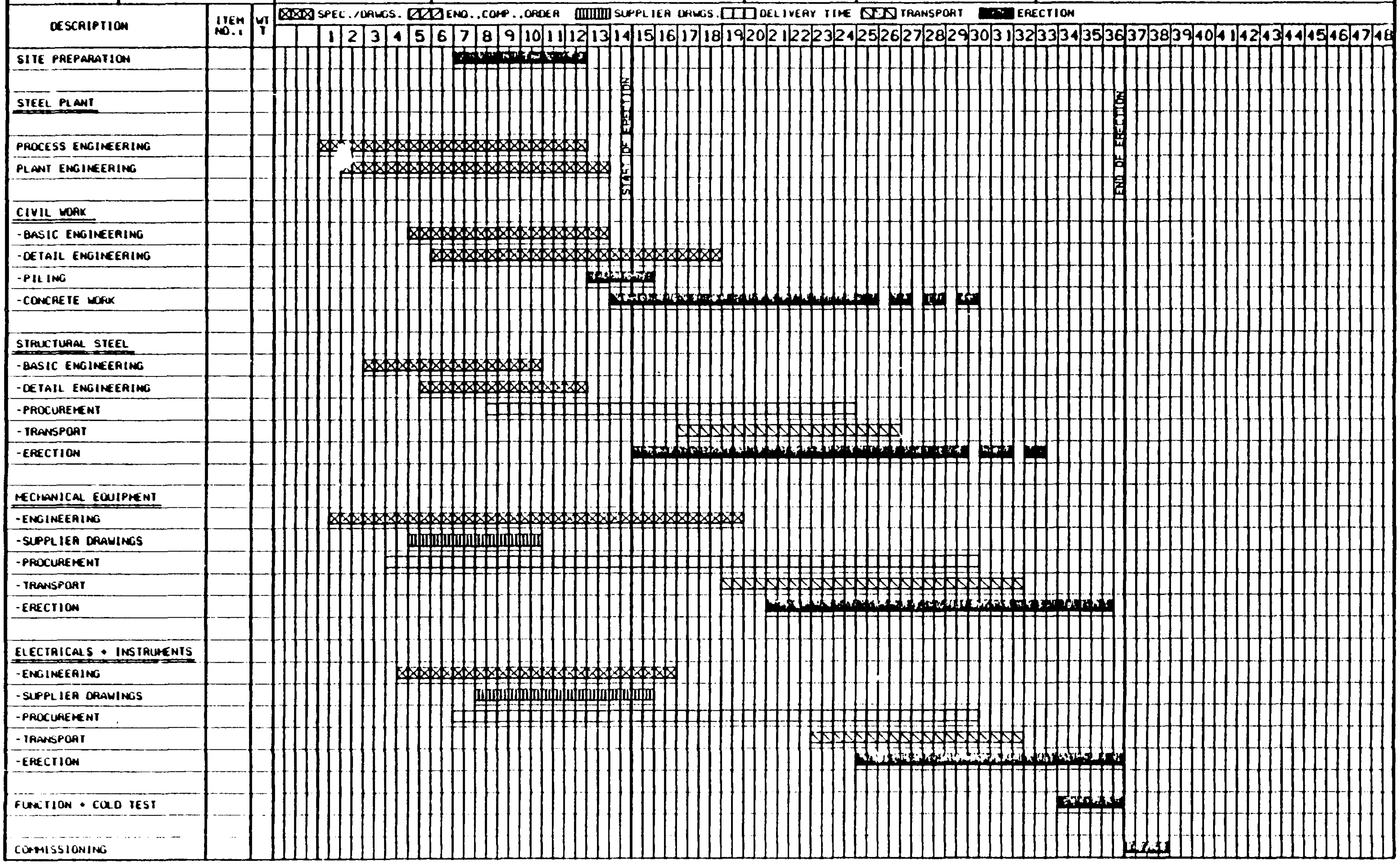

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13848

Final Report

Volume V

Techno-Economic Evaluation and Project Report

for the

Establishment of an Iron and Steel Industry

in

The United Republic of Tanzania

Unido Project SM/URT/81/004

for

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

April 1984

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TECHNO-ECONOMIC EVALUATION AND PROJECT REPORT

FOR THE

ESTABLISHMENT OF AN IRON AND STEEL INDUSTRY

IN

THE UNITED REPUBLIC OF TANZANIA

GENERAL LIST OF CONTENTS

UNIDO Project No. SM/URT/81/004

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GENERAL LIST OF CONTENTS

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2. General Layout and Capacity Expansion Concept

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VOLUME V Economic Evaluation

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TECHNO-ECONOMIC EVALUATION AND PROJECT REPORT

FOR THE

ESTABLISHMENT OF AN IRON AND STEEL INDUSTRY

IN

THE UNITED REPUBLIC OF TANZANIA

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S E C T I O N O

Executive Summary

0. Executive summary

0.1 General remarks

In the following the economic evaluation of the total project has been carried out applying the internationally accepted method of discounted cash flow. The most important standards for the profitability base upon this method.

The main results have been calculated by the computer, and summarized in comprehensive tables.

The project to be evaluated comprises the total iron and steel plant complex, that is the iron ore mine and the pelletizing plant in Liganga and the direct reduction and steel plant in Mahanje. The coal mine and the coal washing plant as well as the power plant and the general area infrastructure are not included in the economic evaluation. The main reason for this procedure was to avoid charging the project with installations, serving not exclusively the iron and steel production.

0.2 Compilation of the most important parameter

0.2.1 Investment capital requirement

Total initial plant investment for the total project amounts to 6 973 071 000 TSh. Replacement of equipment with a short lifetime adds 795 157 000 TSh over the operating period of the project. Cost before start-up amount to 244 948 000 TSh. Interest during construction is calculated at an interest rate of 10,0 % applied to the total capital requirement and amounts to 718 379 000 TSh.

The total investment capital is estimated to be 7 936 398 000 TSh.

The figures are discussed in detail in chapter V/2.

0.2.2 Working capital requirement

The working capital comprises inventories for raw materials intermediate and finished products and spare parts, treasury, accounts receivable and payable.
The total working capital requirement was estimated to be 791 551 000 TSh (see chapter V/3).

0.2.3 Operating and production cost

The operating and production cost are estimated for the total plant complex.
Tables V/4.3/1 and V/4.3/2 give the detailed cost evaluation for every item.
The results can be stated as follows:

Total operating cost:	2 072 324 000 TSh per year
	4 144,65 TSh/t steel
Total production cost including depreciation and interest:	2 965 075 000 TSh per year
	5 929,65 TSh/t steel

0.2.4 Annual revenues

When Tanzanian domestic prices are applied, the revenue per t of average steel amounts to 8 250,5 TSh/t or 4 125 230 000 TSh per year. When import prices free Dar es Salaam without domestic duties are applied, the respective revenues amount to

4 737,2 TSh/t or
2 368 600 000 TSh per year.

0.3 Savings in foreign exchange

The project will require at least 15 605 066 000 TSh over the lifetime of 19 years (15,664 operating years). The savings achieved amount to 37 101 750 000 TSh when an import of 500 000 tpy of steel can be avoided at import prices prevailing at the moment (December 1983). The total saving results in 21 496 684 000 TSh over 19 years.
When the interest for the raised funds to finance the project will be paid in foreign exchange the total savings fall down to 14 089 387 000 TSh over 19 years. The sequence of foreign payments may not be favourable since the foreign exchange has to be paid at the beginning the savings are achieved from the 10th to 15th year on.

0.4 Results of the profitability evaluation

The result of the profitability estimation is listed in table V/6/1.
The discounted cash flow rate of return before tax of 19,0 % may look attractive and may be a good reason to encourage the investment in the project. One has to bear in mind, that the interest rate for investment in Tanzania, as given by NDC, lies at 10 %.

The difference of 9 % may be high enough, to cover the risk involved in such a large project. The average ROI 11,83 % could also be considered as a good result. A main objection may be found in the question of steel prices. As can be obtained from the results of the sensitivity analysis, the steel prices applied play the most important role to evaluate the project. Tanzanian domestic steel prices are very high, compared with import prices. When import prices are applied, the project will not be economically feasible. The DCFRR falls to negative values. Even a decrease of the price level down to 80 % of its original value (approx. 6 410 TSh/t for plates and 6 648 TSh/t for strips) will result in a downfall of the DCFRR to 10,19 % after tax and the average ROI to 3,35 %.It can be stated, that even a slight variation of the steel prices affect the profitability very serously.

It could further be stated, that under these circumstances no export of surplus steel could be achieved under conditions assuring the economics of steel production.

6.6.2 Results of the sensitivity analysis

The most important parameter, the steel prices have already been discussed before. The results summarised in table V/6/2 show, that the availability is the next parameter in the sequence of importance. At an availability of 60 % the project will not be economically feasible. DCFRR rates will fall significantly under the interest rate of 10,0 % and

the ROI will be only 1,5 %.
At an availability of 80 %, profitability is reduced to 13,92 % before tax. So the project is vulnerable with respect to decrease of steel price and availability.

Investment capital and energy cost play a minor role in the face of the discussed parameters. The variation does not affect the project's profitability so seriously. The result of the sensitivity analysis is illustrated in fig. V/6/1 and V/6/2.

0.5 Benefits to the country arising from the project

The benefits to the country beyond the economic evaluation could be described and summarised in the following way:

Quantitative benefits:

1. Creation of jobs: For 2 294 Tanzanians jobs are created within the plant complex. Additional 1200 jobs are created in the coal mine, the power plant and the coal washing plant.

2. Paying of tax: The United Republic of Tanzania may gain about 8 219 812 000 TSh over the lifetime cf the plant complex.

3. Earnings of directly employed persons will amount to 53 233 000 TSh annually.

4. Savings of foreign exchange of about 1 154 to 1 762 Million US $ over 15,664 years

Qualitative benefits:

1. Independence from imports of finished steel and scrap. Up to 1990 a total demand of 210 000 t/y of flat products have to be supplied with imported steel.

2. Utilisation of domestic raw materials limestone, coal, dolomit, iron ore, quartzite and others.

3. Installation of general area infrastructure railroad, roads, townships which will populate a great area on the Tanzanian border.

4. Electrification of the district Ludewa.

5. Development of an underdeveloped area in the district Ludewa.

6. The potential of the plant complex to increase education in the area.

7. Increase in local market production and agriculture to supply the increasing population.

8. Multiplicator effect on the development of small scale industries, and craftmanship.

9. Growing importance of Dar es Salaam as the main harbour to handle the necessary plant supply.

Result of economic evaluation

	Values
DCFRR before tax	19,043 %
DCFRR after tax	15,629 %
NPV before tax	5 260 789 000 TSh
NPV after tax	2 766 018 000 TSh
Pay-out time	4,416 years
ROI	11,83 %
Break-even point average	55,40 %
Accumulated figures	
Acc. cash flow before tax	24 715,832 Mill TSh
Acc. cash flow after tax	16 496,016 "
Acc. profit before tax	18 026,931 "
Acc. profit after tax	9 807,119 "
Acc. tax	8 219,812 "
Acc. interest	6 688,918 "
Acc. investment	9 523,102 "

Results of the sensitivity analysis

	DCFRR %		NPV [Mill. TSh]		Acc. Cash-flow [Mill. TSh]		ROI [%]	Pay-out time [Y]	BEP [%]
	before tax	after tax	before tax	after tax	before tax	after tax			
Base case	19.043	15.629	5 261	2 766	24 716	16 496	11.83	4.416	55.401
Investment + 20 %	15.844	13.479	3 880	2 003	23 258	16 505	8.87	5.197	62.136
Investment - 20 %	23.385	19.525	6 642	3 887	26 174	17 229	16.53	3.516	48.666
Energy + 20 %	17.024	14.762	3 998	2 344	21 533	15 489	9.74	4.824	60.297
Energy - 20 %	20.989	17.835	6 524	3 883	27 899	18 936	13.92	3.942	51.2[illegible]
Availability 80 %	13.915	12.726	2 150	1 361	16 876	13 522	6.69	5.713	69.251
Availability 60 %	8.119	8.119	- 960	- 960	9 037	9 037	1.54	8.294	92.335
Steel price 80 %	10.253	10.186	133	97	11 792	11 592	3.35	7.144	82.653
Steel price 70 %	5.031	5.031	- 2 431	- 2 431	5 330	5 330	- 0.46	10.899	109.612
Steel import price	- 3.029	- 3.028	- 5 657	- 5 657	- 2 801	- 2 801	- 6.21	17.901	185.914

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S E C T I O N 1

Methods Applied

1. Methods applied

The economic evaluation has been carried out according to international standards which are carefully observed. The main profitability standard is the discounted cash flow rate of return which is an internationally accepted standard for evaluating industrial projects.

In order to compute this standard, the calculation of the net cash flow plays a central role in the evaluation.

On the way to this procedure, all relevant parameters have to be compiled, summarized and broken down into annual figures. Those main parameters are

Investment capital requirement
Working capital requirement
Operating cost
Depreciation
Interest cost
Revenues

All factors to be irrelevant in this respect are not considered. Such factors are the coal mining and beneficiation, the power plant and all general area infrastructure. It may not be justified to charge the project with the tremendous cost involved to develop urban life, transportation and electrification of a large district. The evaluation is carried out by computer, which is able to consider details in annual cost as well as the variation of main parameters according to possible but real situations.
After the computation of the most important profitability standards, a sensitivity analysis is elaborated by variation of the following parameters:

Steel prices
Plant availability
Investment capital requirement
Energy cost.

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Tanzania/Volume V

S E C T I O N 2

Investment Cost Compilation

2. Investment cost compilation

2.1 General remarks

In this chapter the investment cost for the different plant sections is compiled for the total iron and steel complex. All capital related cost is calculated for the whole project.

The capital requirement for the following plant sections and cost items are excluded:

1. Coal mine in Mchuchuma
2. Coal washing plant
3. General area infrastructure
4. Cost for land

The coal mine may serve also for other customers. The cost is borne by the coal price charged to the steel plant.

The investment capital requirement has to be broken down into items which the same depreciation rate can be applied on. The cost before start up and the interest during construction have to be evaluated and added to the total initial plant investment capital requirement.

Only the initial capital requirement has to be evaluated. The replacement of parts of the equipment has been considered in the annual cash flow computation. The capital requirement has to be transformed into a sequence of annual instalments in order to carry out the cash flow computation. The transformation has been based upon the milestone diagram in chapter IV/5. The time period was assumed to begin with the signing of the contract for the total plant complex. In the milestone diagram the count down will begin with rail road and link road construction which begins approx. 2 years earlier. Time counting in the economic evaluation thus will start in month 25 of the milestone diagram.

2.2 Compilation of plant investment and requirements for auxiliary plants and infrastructure for all plant sections

This compilation of investment cost has been prepared under the aspect of the economic evaluation and according to the aim to generate suitable input data for the computer. The compiled investment figures are issued in more detail in volume II and III under chapters II/1.2.6, II/2.2.6, III/3.7, III/4.7, III/5.7, III/6.7, III/7.7, III/8.3.
All the investment figures for the site Liganga are compiled in table V/2/1. These investment cost comprise the investment for the iron ore mine and the pelletizing plant including ore benefication. The investment requirement for internal infrastructure and auxilary plants are also added.

The investment figures were broken down into items such as vehicles, installed equipment, and civil work. Each item requires a different depreciation rate. The vehicles of the pellet plant are summarised under "infrastructure" but extracted from the position "installed equipment". In the investment cost figures of volume II and III, vehicles are included in the equipment cost.

The investment cost of the ore mine comprise only the initial investment. The replacement for short-living vehicles and equipment as well as the capital requirement for mine extension is taken into account in the computer evaluation. The same holds true for the pellet plant.

The investment figures of the ore mine originally contain a 10 % addition to cover the spare parts delivery. The spare parts have been excluded in order to transfer them into the working capital. The total investment of 109 468 000 TSh converts to 99 958 000 TSh and 9 510 000 TSh for spare parts. The investment requirement for civil work comprises the steel structure, foundations, buildings, masonry as well as the related plant infrastructure.

In table V/2/1 all figures were converted from DM to TSh applying an exchange rate of 4,52 TSh = 1 DM.
In table V/2/2 the investment figures which have to be paid completely in foreign exchange are expressed in US$. The exchange rate of 2,7 DM = 1 US$ has been applied.
Table V/2/3 shows the compilation of the investment cost for the iron and steel work Mahanje. The same procedure is followed as for the site Liganga. The figures are also expressed in US$ in table V/2/4.

2.3 Cost before start up

2.3.1 Definition

The cost before start up cannot be recovered by any salable production. In order to enable the company to recover this expense they usually are added to the investment capital requirement and depreciated over an extended time period.

Cost before start up comprise all expenses of the customer or plant owner related to the establishment of the industrial plant besides the expenses for the plant construction itself (cost for equipment, erection and civil work which are procured under the responsibility of the contractor).

Cost before start up comprise the following cost items.

1. Expenses and fees for approval by local authorities for installing the plant, fees for legal establishment of a company etc.

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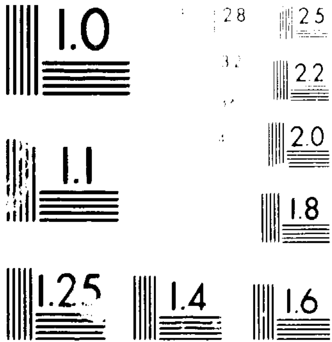

MICROCOPY RESOLUTION TEST CHART

2. Project supervision by the customer.
3. Employment of key personnel before start up.
4. Training of key personnel in foreign countries.
5. Operating cost of preceding plant sections before the start up of the final production unit, which produces salable finished steel.

2.3.2 Expenses and fees

According to our experience we have assumed a fixed amount of 2 000 000 TSh which corresponds approximately with 200 000 US$.

2.3.3 Project supervision

NDC will supervise the project from the beginning to a certain time period after start up until all performance guarantees of the contractor may be fulfilled. We have assumed, that 10 persons may be able to supervise the establishment of such a large plant complex. The 10 persons comprise 1 manager and 9 experienced engineers costing 937 500 TSh a year.

Supervision time shall be 4 years.
Total cost 3 750 000 TSh.

2.3.4 Employment of key personnel before plant start up

It may be necessary to employ the key personnel (i.e. all qualified and skilled personnel but without unskilled helpers) prior to plant start up from the beginning of plant installation and erection work.

Since the plant sections have different time schedules for start up, the following table V/2/5 reviews the different cost.

Table V/2/5

Key personnel cost

Plant section	Begin erection	Start up	Labour cost
	month	month	1 000 TSh
Iron ore mine	included in operating cost before start up		
Pellet plant	13	33	9 865
DR + steel plant	14	36	29 310
Auxiliary plants, internal infrastructure	20	36	19 803
Total			58 978

2.3.5 Training of key personnel in foreign countries

Table V/2/6 reviews the total training expenses. Based upon experience, a daily allowance charge of 200 US$ per person may cover all expenses related to the training. A total training time period of 4,5 month (i.e. 135 days) is required. The domestic salary of the persons to be trained remains unaffected.

2.3.6 Operating cost before start up

The iron ore mine, the pellet plant and the DR-plant will start up prior to the steel plant. The steel plant itself has operating cost during the 36 month for the first operational runs during those the generated steel is recycled as scrap.

All operating cost before the 37 month is considered as cost before start up.
Since the plants operate at reduced capacity the cost items were broken down into variable and fixed cost. Fixed cost remain constant, variable cost are proportional to plant availability. The cost of build up of inventories were deducted from the operating cost before start up.

The following table V/2/7 shows the total operating cost before the steel plant begins to produce steel for the market as well as the break-down according to the plant sections.

2.3.7 Total cost before start up

Table V/2/8 summarises the cost before start up, giving a total of 244 948 000 TSh. The cost are distributed over the years after signing the contract to obtain the annual capital requirement.

Cost before start up amounts to 3,5 % of total plant investment.

2.4 Interest during construction

An interest rate of 10,0 % was applied. This rate was submitted to Lurgi at the Tripartite Meeting.

The interest rate is applied to the total capital requirement for the following reasons:

1. The way of financing the project has not been determined and is therefore not considered in the economic evaluation.
2. Equity capital may gain interest at the rate of 10,0 % when credited to a bank instead of being invested in the project.

The interest during construction is determined as an average of the annual instalments in table V/2/11 and amounts in total to 718 379 000 TSh or 9,05 of total plant investment.

2.5 Total investment requirement

Total investment capital requirement is listed in table V/2/9 and V/2/10. The total plant investment of the whole iron and steel plant complex at Liganga and Mahanje amounts to 6 973 071 000 TSh or 571 562 000 US$. The total has to be paid in foreign exchange.

Cost before start up is partly paid in foreign exchange which amount can be obtained from table V/2/8.

Since plant financing and the sources of funds are not taken into consideration, the currency in which the interest during construction has to be paid in total or partly cannot be determined.

Table V/2/10 shows the requirement of foreign exchange for the establishment of the Liganga-Mahanje plant comlex. The total amount is 581 377 000 US$.

2.6 Distribution of capital outlays over time period of plant construction

For the purpose of cash flow computation the initial capital requirement has to be considered as a sequence of different annual instalments.

Basic data for the splitting are obtained from the milestone diagram which can be seen under chapter IV/5. The years are counted from the moment assumed for the signing of the contract for the iron and steel plant complex.

In year 1 a 10 % allowance of the equipment cost is provided for a capital requirement to cover engineering, initial procurement etc.
The remaining equipment cost are distributed according to the progress of the work. The same procedure was applied to the erection work. Both figures are summarised to "Installed Equipment". The annual capital requirement for the iron ore mine can be obtained from chapter II/2.2.6.

The erection work is continued until year 4 some month after start up.

The kiln 4 of the direct reduction plant is already erected in the first month of year 4 as well as parts of the equipment for the auxiliary plant sections and infrastructure.

The civil work was distributed between year 1 and 4. Some piling and concrete work will occur already in year 1. Civil work for auxiliary plants and infrastructure may occur in year 4 when final completion of warehouses, guards, stockgards and other off sites will take place.

Table V/2/11 shows the annual instalments of investment capital. The figures of cost before start up are taken from table V/2/8.

Investment requirement for extension of ore mine operation as well as replacement of equipment is not considered in table V/2/11. Only in year 4 as a foot-note the mine extension requirement is mentioned. Replacement of investment occurs according to invest-ment schedule of the ore mine under chapter II/2.2.6. Replacement of vehicles of other plant sections occurs periodically every 4 years.

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Table V/2/1

Investment for Iron Ore Mine and Pelletizing Plant at Liganga

1000 TSh

PLANT SECTION	VEHICLES	INSTALLED EQUIPMENT	CIVIL WORK STEEL STRUCTURE BUILDINGS	TOTAL INVESTMENT
IRON ORE MINE*	66 296	19 302	14 360	99 958
PELLETIZING PLANT BENEFICIATION		386 460	151 420	537 880
PELLETIZING		271 652	156 392	428 044
INFRASTRUCTURE	48 002	57 766	90 852	196 620
TOTAL PELLETIZING PLANT	48 002	715 878	398 664	1 162 544
TOTAL INVESTMENT LIGANGA	114 298	735 180	413 024	1 262 502

* Only initial investment was considered

Table V/2/2

Investment for Iron Ore Mine and Pelletizing Plant at Liganga

1000 US-$

PLANT SECTION	VEHICLES	INSTALLED EQUIPMENT	CIVIL WORK STEEL STRUCTURE BUILDINGS	TOTAL INVESTMENT
IRON ORE MINE*	5 434	1 582	1 177	8 193
PELLETIZING PLANT BENEFICIATION		31 677	12 411	44 088
PELLETIZING		22 266	12 819	35 085
INFRASTRUCTURE	3 935	4 735	7 447	16 117
TOTAL PELLETIZING PLANT	3 935	58 678	32 677	95 290
TOTAL INVESTMENT LIGANGA	9 369	60 260	33 854	103 483

* Only initial investment was considered

Table V/2/3

Investment for Iron and Steel plant at Mahanje

1000 TSh

PLANT SECTION	VEHICLES	INSTALLED EQUIPMENT	CIVIL WORK STEEL STRUCTURE BUILDINGS	TOTAL INVESTMENT
1. DIRECT REDUCTION	47 606	1 427 868	497 652	1 973 126
2. ELECTRIC SMELTING		327 368	104 412	431 780
3. LADLE MET.		163 040	54 240	217 280
4. CONT. CASTING		384 600	120 684	505 284
5. ROLLING MILL		1 199 724	373 352	1 573 076
6. OFFSITES, AUXILIARY PLANTS		625 116	175 828	800 944
7. INFRA-STRUCTURE	70 912	37 371	100 796	209 079
TOTAL INVESTMENT IRON AND STEEL PLANT MAHANJE	118 518	4 165 087	1 426 964	5 710 569

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Table V/2/4

Investment for Iron and Steel plant at Mahanje

1000 US-$

PLANT SECTION	VEHICLES	INSTALLED EQUIPMENT	CIVIL WORK STEEL STRUCTURE BUILDINGS	TOTAL INVESTMENT
1. DIRECT REDUCTION	3 902	117 038	40 791	161 731
2. ELECTRIC SMELTING		26 833	8 558	35 391
3. LADLE MET.		13 364	4 446	17 810
4. CONT. CASTING		31 525	9 892	41 417
5. ROLLING MILL		98 338	30 603	128 941
6. OFFSITES, AUXILIARY PLANTS		51 239	14 412	65 651
7. INFRA-STRUCTURE	5 813	3 063	8 262	17 138
TOTAL INVESTMENT IRON AND STEEL PLANT MAHANJE	9 715	341 400	116 964	468 079

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Table V/2/6

Training expenses

	Trainees	Expenses 1000 US-$	Expenses 1000 TSh
Iron ore mine	38	1 026	12 517
Beneficiation and Pellet plant	38	1 026	12 517
DR and steel plant	114	3 078	37 552
Infrastructure and Auxiliary plants	60	1 620	19 764
Total	250	6 750	82 350

Table V/2/7

Operating cost before steel plant starts to produce salable products

Plant section	Operating cost 1000 TSh
Iron ore mine	15 523
Pellet plant	7 807
Direct reduction	14 220
Steel plant	60 220
Total	97 870

Cost of build up the inventories are excluded

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Table V/2/8

Cost before start up

	Total amount 1000 TSh	Part of total which has to be paid in 1000 US-$
1. Expenses related to plant construction approval, administration of law etc.	2 000	-
2. Project supervision by NDC	3 750	-
3. Key personal before start up	58 978	1 209
4. Training of personal in foreign countries	82 350	6 750
5. Cost before start up of steel plant related to ore mine and pellet plant operation	97 870	1 856
Total	244 948	9 815

Distribution

Year 1	1 900
2	28 738
3	213 372
4	938

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Table V/2/9

Plant Investment Capital Requirement for the Project

1000 TSh

	Iron Ore Mine	Pelletizing plant	Iron and Steel Work	Total project
1. Vehicles	66 296	48 002	118 518	232 816
2. Installed Equipment	19 302	715 878	4 165 087	4 900 267
3. Civil Work	14 360	398 664	1 426 964	1 839 988
4. Total plant Investment	99 958	1 162 544	5 710 569	6 973 071
5. Cost before start up				244 948
6. Interest during construction				718 379
7. Total Investment Capital				7 936 398

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Table V/2/10

Plant Investment Capital Requirement for the Project

1000 US-$

	Iron Ore Mine	Pelletizing plant	Iron and Steel Work	Total project
1. Vehicles	5 434	3 935	9 715	19 084
2. Installed Equipment	1 582	58 678	341 400	401 660
3. Civil Work	1 177	32 677	116 964	150 818
4. Total plant Investment	8 193	95 290	468 079	571 562
5. Cost before start up	part which has to be paid in foreign exchange			9 815
6. Interest during construction	not available			-
7. Total Investment Capital paid in US-$				581 377

Table V/2/11

Schedule of Capital Outlay during Construction Period - 1000 TSh

	Year 1	Year 2	Year 3	Year 4	Total
Vehicles	-	36 270	196 546	-	232 816
Installed Equipment	410 778	1 867 801	2 151 833	469 854	4 900 266
Civil work	150 000	802 416	786 776	100 796	1 839 988
Cost before start up	1 900	28 738	213 372	938	244 948
Interest during construction	28 134	193 029	497 216	-	718 379
Total	590 812	2 928 254	3 845 743	571 588	7 936 397
Mine extension				10 199	

S E C T I O N 3

Working Capital Requirements

3. Working capital requirement

3.1 Raw material, intermediate and finished products inventories

In order to maintain a continuous production, raw material and intermediate product inventories are necessary at the different plant sites. Table V/3/1 gives a review of the respective inventories, showing the site of stocks, the amount to be stocked as well as the evaluation of the inventories. The inventories have been calculated under the assumption, that a continuous transportation service could be maintained all over the year between the different plant sections. The iron ore raw material stock at the pellet plant is kept low because of the proximity of mine and pellet plant and the ability of the mine to vary the iron ore output within a short time period.

On the other hand, the stock for washed coal from Mchuchuma which is stocked in the steel plant corresponds to more than a month's consumption. The same refers to the other raw materials quartzite, limestone and fuels. All raw materials and fuels which have to be purchased from other companies have been evaluated with the purchase price free plant site. The same procedure was followed with the coal from Mchuchuma. The coal mine produces not only for the steel plant but also for other customers. The coal mine and washing plant therefore are not considered to be parts of the iron and steel complex. Washed coal stock at the steel plant is evaluated with an estimated purchase price. The raw coal stock at the coal mine does not belong to the plant complex. All intermediate product stocks such as raw ore, concentrate slurry, pellets and DRI have been evaluated with their operating cost. The products will be consumed by the iron and steel plant complex. The operating cost include also the cost for iron containing raw material

from the preceding plant section. So, for instance in the operating cost of the pellets, the cost of raw iron ore is included. The evaluation basis can be obtained from tables V/4.2/2;3;5;6;8 for the intermediate product stocks.
The finished product inventory is capable to store 42.000 t of finished steel plates and strips which corresponds to 1 month production at rated capacity.
The stock has been evaluated with operating cost including raw materials as can be obtained from table V/4.3/1 to be 4.144,65 TSh/t.

3.2 Spare parts

The spare parts inventory covers a consumption of 2 years of repair and maintenance spares.

1. Iron ore mine Liganga: In the investment cost a 10 % charge for spare parts is included for items of equipment and vehicles. The investment cost of the mine has been therefore reduced from 109 468 000 TSh to 99 958 000 TSh in order to transfer the spare parts of 9 510 000 TSh to the working capital.

2. Pellet plant Liganga and infrastructure: Spare parts requirement: 21 696 000 TSh.

3. Iron and steel plant auxiliaries and infrastructure: Spare parts requirement: 163 624 000 TSh.

4. Total spare parts requirement: 194 830 000 TSh.

This amount corresponds to 2,8 % of the total plant investment or 3,8 % of total installed equipment.

3.3 Treasury

The company has to lay a fixed amount of cash readily at hand in order to pay the daily bills for purchased raw materials, utilities and other consumables as well as to pay wages and salaries. The order of magnitude of that cash inventary is usually determined in the following way:

One month operating cost for

1. Raw materials cost
2. Energy cost
3. Consumables
4. Maintenance material
5. Transportation for pellets

For paying wages and salaries an average has to be held available of 50 % of total labour cost for one month time period.
Total treasury to be laid readily at hand amounts to be (according to table V/4.3/2): 169 141 000 TSh.

3.4 Accounts payable and accounts receivable

Usually the clients which purchase the finished product of a plant will pay their bill approximately 30 days after delivery. A complete 30 days production of finished steel has therefore to be financed in advance by the company; in our case by the owner of the iron and steel plant complex. As an evaluation basis of that account receivable the average revenues of 1 month production of steel can be applied.
On the other hand the company itself pays the bill for the delivery of purchased raw materials, utilities and consumables also 30 days later.

These accounts payable help to finance the company and have therefore to be deducted from working capital requirement. Usually only the difference between accounts receivable and payable will add to the working capital. The accounts payable usually will be evaluated by the same procedure as the treasury.

Accounts receivable:	343 769 000
Accounts payable:	- 169 141 000
Total :	174 628 000

3.5 Total requirement of working capital

The total working capital requirement amounts to 791 551 000 TSh. The breakdown of this figure can be obtained from table V/3/2.

3.6 Distribution of working capital requirement during time period of plant commissioning

The working capital will be required during the years 3 and 4 according to inventory build up.
Spare parts will be stored only in year 3.
The treasury as well as accounts receivable and accounts payable will be required according to the plant availability in the years 4 to 5. The total amount to be required is assumed to be proportionally to the availability of the steel plant estimated in table V/5/3.

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Table V/3/1

WORKING CAPITAL ESTIMATION OF RAW MATERIAL
INTERMEDIATE PRODUCT AND FINISHED PRODUCT INVENTORIES

	SITE	INVENTORY	EVALUATION	EVALUATION TSh/t	VALUE 1000 TSh
Raw Iron Ore	Pellet Plant	25 000 t	Operating Cost+	20,98	525
Concentrate Slurry	Pellet Plant	1 800 t	Operating Cost+	102,22	184
Coal Washed	Steel Plant	50 000 t	Estimated Price	454,70	22 735
Pellets	Pellet Plant	25 000 t	Operating Cost+	176,15	4 404
	Steel Plant	60 000 t	"	311,65	18 700
DRI	Steel Plant	15 000 t	"	1 039,0	15 585
Fuel Oil Heavy	Pellet Plant	1 000 t	Purchase Price	2 368,0	2 368
	Steel Plant	1 000 t	"	2 368,0	2 368
Fuel Oil Light	Steel Plant	335 t	"	4 945,0	1 657
Propane Liquid	Steel Plant	700 t	"	5 725,0	4 008
Gasoline	Steel Plant	35 t	"	12 229,0	428
Dolomite	Steel Plant	6 500 t	"	280,0	1 820
Limestone	Steel Plant	6 500 t	"	350,0	2 275
Quartzite	Steel Plant	6 500 t	"	280,0	1 820
Finished Steel	Steel Plant	42 000 t	Operating Cost+	4 144,65	174 075

+ Operating cost includes raw materials cost

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Table V/3/2

WORKING CAPITAL REQUIREMENT - 1000 TSh

	WORKING CAPITAL
1. INVENTORIES:	
Raw materials	39 479
Intermediate products	39 398
Finished products	174 075
2. SPARE PARTS	194 830
3. TREASURY	169 141
4. ACCOUNTS RECEIVABLE LESS ACCOUNTS PAYABLE	174 628
TOTAL WORKING CAPITAL REQUIREMENT	791 551
ANNUAL REQUIREMENT	
year 3	272 912
year 4	438 870
year 5	79 769

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S E C T I O N 4

Production Cost Comparison

4. Production cost compilation

4.1 General remarks

The estimation of the total production cost of the whole project per ton of steel produced and its direct comparison with the unit price of the finished steel product can be considered as the main purpose. Production cost serves as a basis for the determination of the tax to be payed as well as for the profit and loss account. On the other hand, it may be of general interest to calculate the operating cost of the intermediate products such as iron ore, pellets, and DRI in order to determine the evaluation of the intermediate products inventories at various plant sections and sites. The production cost therefore are estimated stepwise for the different plant sections at different sites as well as in general for the total project beginning with the iron ore mining and ending with the finished steel output.

4.1.1 Method applied

The total plant complex comprises all necessary installations for the production of utilities, and services inevitable for plant operation. This will include, lime burning, oxygen, nitrogen and argon production, supply of electrical energy, water, compressed air as well as transportation, telecommunication and sanitary services. All necessary off-sites such as workshops, magazines, firehouses, ambulance, sanitary installations, administration buildings etc. will be provided. The cost for all those utilities and services is included in the investment cost, the personnel requirement, the consumption of energy, fuel and other respective consumables.

In the overall production cost estimation therefore, no separate cost items for such consumption figures are calculated. The same holds true regarding the raw materials extracted in the iron ore mine.
The coal of Mchuchuma on the other hand is regarded as a raw material consumed by the plant complex. The investment and all consumption figures of coal mining are not included in the evaluation of the project.
The main reason for this is that the coal mine also has to supply other consumers rather than the steel complex, such as the power plant and maybe local consumers. An estimated purchase price of coal therefore is calculated, comprising all respective cost items as well as a defined profit of 10 % of production cost.
This coal price is charged to the DR plant as the main consumer of coal.
The power plant is also excluded from the iron and steel plant complex. Electrical power is assumed to be supplied at an ordinary TANESCO tariff.
Excluded also from the cost estimates are all general area infrastructure installations which may not exclusively serve the iron and steel plant complex. This will comprise roads, railroads, transmission lines for electricity, townships and other similar installations.
The weight units refer to the metric system.

4.1.2 Unit prices for consumables

NDC has submitted to Lurgi all unit prices for those consumables which are available in Tanzania*. NDC also indicated the locations from where the locally available raw materials could be delivered.

* Reference: Telexes txe 245 07/04/83, txe 232 12/02/83 and information package handed over by NDC to Lurgi during visit of Lurgi experts from 16/01/ to 31/01/83.

For all those deliveries transportation to plant site by railway was determined. The quarzite was considered as a locally available raw material with a unit price similar to dolomite and lime-stone. The price for liquid propane was estimated to correspond with the diesel price related to its calorific value. Steel for casings and tools is assumed to be manufactured from finished steel products produced in the plant.

All other consumables are assumed to be imported from outside. These consumables are mainly specialties for the iron ore mining, and the liquid and finished steel production. The respective quantities do not exceed more than 10 000 t a year. The price basis for the imported materials is determined to be German domestic prices valid for December 1983 fob Rotterdam.
The estimation of transportation cost to the plant site is given below.
The exchange rate is established at

1 $ = 12,2 TSh
1 DM = 4,52 TSn

All unit prices are listed in table V/4.1/1. Imported prices are expressed in German DM. The price for electrical energy is calculated according to tariff No. 4.
A total installed electric power supply of 170 000 KVA was charged with 75 TSh per KVA as fixed charge and the total 800 000 000 KWh/a consumption with 0,7 TSh/KWh thus achieving a composite price of 0,716 TSh/KWh.

4.1.3 Transportation cost to plant site

The following procedure has been applied in order to estimate the transportation cost.

1. Domestically available materials

1.1 Establishment of a main distance schedule of material sources and plant site for domestically available consumables. Table V/4.1/2 shows the distances by road and railroad.

1.2 Determination of freight rates.
Freight rates at TRC and TAZARA railroad system were submitted by NDC. For transshipment between TRC and TAZARA, the connecting point Kidatu is chosen and 4 TSh/t transshipment charge is applied.

The following freight rates are applied;
TRC: Rate10 applied according to distance
TAZARA: Iron ore, concentrates, pellets: 135,5 TSh/t
Other materials: 367,6 TSh/t

Materials from Dar es Salaam are charged with 367,6 TSh/t over the distance of 1000 km to plant site.
Materials from other locations are charged with freight rates of 367,6 TSh/1000 tkm proportional to real distance.

2. Imported materials
All imported materials are transported from Bremen (Germany) to Dar es Salaam by ship in containers of 28 ft lenght. The loading weight of such a container approaches 18 t.

Table V/4.1/3 shows the estimation procedure of transportation cost in general. For some special materials, such as drill bites, and tires, the yearly consumption is very small and does not exceed 18 t. Transportation costs are calculated for a complete container or estimated to be approx. 2 % of the delivery price.

4.2 Operating cost estimate for the main intermediate products and plant sections

4.2.1 Iron ore and Liganga ore mine

The production cost for the Liganga iron ore mine is calculated annually in order to cope with the rising mining cost during the progress of extraction grade. The deeper the mining level will fall the higher the mining cost will be. For estimation reason, the cost per ton of iron ore mined is calculated as an average over the total lifetime period. In the final computerised economic evaluation procedure, the average annual cost figure will be applied. The table V/4.2/1 shows the annual operating cost for the iron ore mining operation over 20 years.

Table V/4.2/2 shows the estimation of the specific operating cost per ton of mined ore which turn out to be 20,98 TSh/t iron ore. Labour cost will be discussed separately under chapter 4.3.3.

The consumption figures for auxiliary plants and for internal infrastructure are already included in the cost estimation given above so that no extra overhead cost is estimated.

4.2.2 Pelletizing plant

In table V/4.2/3 the operating cost for pellet production can be obtained. The total annual operating cost of iron ore production (table V/4.2/1)enters the table in line "raw ore". The overhead cost comprises the cost for consumables in auxiliary plant sections and internal infrastructure installations for the ore beneficiation and pelletizing plant at Liganga.

The result shows the operating cost free pellet plant site and serves as a basis for the estimation of pellet inventories in Liganga. The addition of transportation cost to Mahanje gives the basis for the estimation of the pellet stock at Mahanje.

The cost for auxiliary plants and internal infrastructure is given in table V/4.2/4. The total of 4 818 000 TSh is considered as overhead cost for the pellet production.

4.2.3 Mchuchuma coal mine and coal washing plant

The coal mine and the washing plant are not comprised in the iron and steel plant complex. The main reason is that the mine already will produce coal to supply the direct reduction plant as well as other customers such as the power plant and maybe other consumers. The total capacity of the mine is determined to be 2,4 Mill tpy of raw coal which will by far exceed the demand of the iron and steel complex. It is for this reason that the coal is considered as a raw material purchased from outside. Therefore a suitable price for the washed coal has to be estimated which may comprise the overall production cost including depreciation and interest charges as well as an approxiate profit for the mine and washing plant.

The interest and depreciation rates are determined in accordance with the rates applied generally within the project.
Table V/4.2/5 shows the production cost for raw coal, table V/4.2/6 gives a review of the cost of coal washing operation up to the estimated price free Mahanje, including an appropriate profit as well as

the transportation cost from Mchuchuma to Mahanje. This estimated price will be 454,70 TSh/t washed coal.

4.2.4 Direct reduction plant section

In order to evaluate the DRI stock, the operating cost of DRI has to be estimated. The consumption figures refer to the data given in chapter III/4.1. The cooling water is considered as an internally generated utility, which cost is included in the cost of the auxiliary plants.

In order to obtain this cost items, the cost of auxiliary plant and internal infrastructur has to be estimated. Table V/4.2/7 shows the cost estimation for auxiliary plants and infrastructure for the iron and steel plant at Mahanje.

This auxiliary plant sections are necessary for the supply of the main plant sections with the necessary utilities and services. The respective cost will cover all the utilities such as cooling, process and potable water, compressed air, burned and hydrated lime, oxygen, nitrogen and argon as well as the services for transportation, communication, administration, medical care, safety, sanitary installations and others.

The total annual cost of 104 678 000 TSh is distributed between the direct reduction plant section and the steelmaking. The distribution factor is the relative labour requirement in annual man hours. For the direct reduction plant, average annual cost of 26 878 000 TSh is charged as overhead cost.

Table V/4.2/8 shows the operating cost estimation of DRI which results in 1 039 TSh/t DRI and 685 419 000 TSh annually.

4.3 Production cost estimate for the main products

As the main products steel plates and strips are defined. DRI, pellets and iron ore are defined as intermediate products which are consumed only internally and are not sold to other customers.

4.3.1 Raw materials consumption and cost

In table V/4.3/1 all operating cost of the whole iron and steel plant complex is compiled. The unit consumption figures related to the metric ton of steel produced are calculated from the annual cost.
Annual raw materials cost amounts to 346 062 000 TSh or 692,12 TSh/t steel. About 14,6 % of this figure has to be payed in foreign exchange. (4 141 000 US $ corresponds to 50 518 000 TSh for ferroalloys).
(See tables V/4.3/2 and 3).
The most important item is the coal cost which requires 65,6 % of the total raw materials cost. The estimated coal price of 454,7 TSh/t is low compared with German prices but approximately in the same range as domestic prices in the USA.

4.3.2 Energy and utilities consumption and cost and consumables

Energy cost consists of electricity, fuel oil and propane. Total energy cost amounts to 1 015 939 000 TSh (table V/4.3/2) or 49 % of the total operating cost.
Electrical energy consumption of 1580,6 KWh/t steel amounts to 565 855 000 TSh annually representing 27,3 % of the total operating cost.
The total energy cost is considered to be of domestic supply although the crude oil has to be imported.

Prices for fuels are given ex refinery Dar es Salaam and therefore considered as domestic supply. Total energy cost per ton of steel amounts to 2031,88 TSh/t. The consumables consist of numerous minor cost items which are mainly consumed in the iron and steel plant. The item "Other Consumables" comprises a variety of minor items such as lubricants, detergents, tools, special chemicals for cleaning, dissolvents glues etc. which cannot be specified in detail. They were estimated generally according to experience. The consumables have to be imported almost completely. Total consumption amounts to 456 223 000 TSh annually and 912,45 TSh/t of steel. An equivalent of 365 610 000 TSh or 80 % has to be imported, costing 29 968 000 US $ annually.

4.3.3 Total personnel requirement

The personnel requirement is summarized for every process step and major plant sections in the following tables V/4.3/4 to 12. Since the workforce requirement of the iron ore mine is increasing during the time period of mine operation, an average personnel requirement has been applied. The estimation is shown in table V/4.3/5. The different plant sections are listed separately:

Iron ore mine Liganga: table V/4.3/6
Beneficiation and pelletizing plant Liganga: table V/4.3/7
Auxiliaries and infrastructure Liganga: table V/4.3/9
Steelmaking plant Mahanje: table V/4.3/8
Auxiliaries and infrastructure Mahanje: table V/4.3/10

The estimation of the total man hour for the iron and steel plant complex is done in table V/4.3/11. It shows a total personnel requirement of 2294 persons.

Personnel requirement has been calculated according to the workforce schedule of every plant section adding 15 % to cover absence, for reasons of disease, vacation and weekend.
Table V/4.3/12 gives a breakdown of personnel requirement according to qualification and salary level as defined in telex txe 232 of 12.2.1983 by NDC.
Total expatriate personnel will be 35, local personnel will amount to 2259.
It has to be carefully noted that the personnel of the coal mine and the coal washing plant at Mchuchuma is not included in the figures as well as any general area infrastructure such as power plant, roads, railways, townships, etc.
An estimation of the total man hour requirement as well as the annual labour cost is shown in table V/4.3/11.
Labour cost has been calculated according to the salary schedule as defined in txe 232 by NDC adding 25 % for fringe benefits and social cost.
A total of 4 588 000 man hours is required assuming that each person works 2000 h a year. Total labour cost will be 53 233 000 TSh/year or 106,47 TSh per ton of steel produced.

4.3.4 Maintenance cost

Maintenance cost comprises different cost items which are already included in other costs. Maintenance labour is totally included in the labour cost. Many maintenance materials are listed under consumables such as refractory demand, electrode graphite, the rolls, mill liners and steel for casings and tools. The remaining maintenance materials are estimated generally according to experience to be 1 543 500 US$ for the pellet plant and to be 2 650 000 US$ for the DR and steel plant. Maintenance material have in total to be imported.

4.3.5 Other cost items

Insurance cost for the whole plant installation has assumed to be 0,23 % of total plant investment.

Transportation cost for pellets between Liganga and Mahanje over a distance of 120 km amounts to 135,5 TSh/t pellets or 134 145 000 TSh annually (268,29 TSh/t steel).

4.3.6 Total operating cost

Total operating cost is listed in table V/4.3/2 and amounts to 2 072 324 000 TSh per year or 4 144,65 TSh/t steel.

4.3.7 Depreciation

Depreciation rates to be applied in the economic evaluation have been submitted by NDC (letter of January 3rd 1983).

Vehicles: 25 % annually, straight line basis

Installed equipment: 12,5 % declined balance basis

Buildings, civil work: 4 % annually, straight line basis

Cost before start up: 20 % annually, straight line basis

In analogy, the depreciation rate for the interest during construction was also set at 20 % annually (straight line basis).
The breakdown of total investment capital requirement is given in table V/2/9. The estimation of depreciation is carried out by the computer, taking into account also the investment requirements during plant operation for mine extension and replacements.

Average annual depreciation as well as specific depreciation per ton of steel therefore is calculated by dividing the total accumulated depreciation during the lifetime of the project by the respective number of operational years or the accumulated steel production during the lifetime of the project. The accumulated steel production until the year 19 is 7 832 350 t steel. Total accumulated depreciation is 7 291 562 000 TSh. The respective average values per ton of steel and per year are as follows.

Average depreciation per t steel: 931,0 TSh
Average annual depreciation: 465 617 000 TSh/a.

4.3.8 Interest

Since no financiation schedule of the project has been considered the estimated interest cost has been applied to the total capital required (investment and working capital). Interest charges have been calculated taking the accumulated investment minus the accumulated depreciation as a basis.
The interest rate applied is 10,0 % as discussed at the Tripartite Meeting.
Total accumulated interest as shown in the computer print page 8 is 6 688 918 000 TSh. The respective average values per year and per t of steel are as follows:

Average interest per t steel: 854,00 TSh.
Average annual interest: 427 134 000 TSh.

4.3.9 Production cost summary

In table V/4.3/2 the total production cost is summarised. Total production cost turns out to be 5 929,65 TSh/t steel or 2 965 075 000 TSh annually.

4.3.10 Breakdown of production cost

4.3.10.1 Variable cost

Variable cost will change proportionally with the plant output. Variable cost is mainly composed by direct consumed materials. Variable cost are determined to be the total raw materials and energy cost. Consumables are partly considered to be variable cost. The cost items are defined in more detail below.
Transportation cost of pellets is considered to be variable.
Total variable cost amount to 1 622 934 000 TSh annually and 3 245,87 TSh/t steel as can be obtained in table V/4.3/2.

4.3.10.2 Fixed cost

As fixed cost elements the following cost items have been determined.

1. Consumables which have the character of maintenance material. These are refractories and rolls.

2. Consumables which can partly be considered as fixed cost (50 %). These are drill bites, tires, grinding balls, mill liners, electrode paste, steel for casings and tools, other consumables.

3. Labour cost
4. Maintenance materials cost
5. Insurance cost
6. Depreciation
7. Interest.

Fixed operating cost (items 1 to 5) amounts to 449 390 000 TSh annually or 898,78 TSh/t steel. Fixed production cost amounts to 2 683,78 TSh/t steel and 1 342 141 000 TSh per year.

4.3.10.3 Production cost to be payed in foreign exchange

As already mentioned before during the discussion of the production cost, table V/4.3/ 3, summarises the cost items which base upon imported materials. This amounts to 39 306 000 US$. The equivalent cost in Tanzanian shillings is added. Foreign exchange cost will be 23 % of the total operating cost and 15,3 % of the total production cost.

4.4 Production cost during initial phase of plant operation

As had been said in chapter V/2.3 all production cost which occur before the start up of the steel plant are considered as cost before start up. After the steel plant starts up to produce salable finished products beginning with the 37 month (4th year) after signing the contract, the cost have to be related to plant output. The plant output is listed in table V/5/3 to be 76,8 % of design capacity in year 4 and 98 % in year 5. In year 6 full operation will be achieved.

Variable cost therefore has been set proportionally with the plant output except in year 4 where the inventory build up has to be taken into account. The fixed cost is assumed to be constant every year. At a plant availability of about 77 % no reasons for reduction of fixed cost items could be found.

Table V/4.4/1 shows the production cost during initial phase of plant operation.

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Table V/4.1/1

UNIT PRICES FOR CONSUMPTION FIGURES AND MAIN PRODUCTS FREE PLANT SITE

BASIS: 1983

	ORIGIN	Prices ex Work per ton	to site TSh/t	Price free plant site TSh/t
Limestone	Kigoma	50 TSh	300	350
Dolomite	Chalinze	50 TSh	230	280
Benonite	Arusha	50 TSh	280	330
Quartzite	Chalinze	50 TSh	230	280
Fuel oil (heavy)	Dar	2 000 TSh	368	2 368
Fuel oil (light)	Dar	4 577 TSh	368	4 945
Diesel	Dar	4 577 TSh	368	4 945
Propane	Dar	4 975 TSh	750	5 725
Electrical energy	Loc	-	-	0,716
Charcoal	Loc	-	-	1 360
Steel for casings and tools	Loc	9 000 TSh	-	9 000
Briquetting binder	Loc	50 TSh	200	250
Mill liners	Imported	8 500 DM	1 930	40 350
Electrode paste	"	1 200 DM	1 930	7 355
Electrode graphite	"	5 800 DM	1 930	28 150
Grinding balls	"	1 500 DM	1 930	8 700
Ferroalloys	"	1 500 DM	1 930	8 710
Refractories for:	"			
Arc furnace	"	1 000 DM	} 1 930	6 450
Ladles	"	1 000 DM		6 450
Slide gates	"	9 500 DM		44 870
Argon purging	"	9 500 DM		44 870
Cont. casting	"	800 DM		5 550
Casting powder	"	1 500 DM	1 930	8 710
Rolls	"	4 500 DM	1 930	22 270
Drill bites*	"	93 272 DM	8 230**	429 680
Tires*	"	30 726 DM	2 777**	141 617
Anfo	"	1 550 DM	1 930	8 934
Explosive slurry	"			8 428
6 % Diesel	Diesel already included in fuel consumption of mine			
94 % Anfo				

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Table V/4.1/1: continued

Transportation: cost comprising freight and transshipment

* Prices per ton: drill bites at 5,5 kg/piece tires at 2,7t/set

** Transportation was estimated to be 2 % of purchase price

1 $ = 12,20 TSh

1 DM = 4,52 TSh

Table V/4.1/ 2

Main distances between plant site and other locations in Tanzania

from	to	Distance in km	
DAR	MAHANJE	700	Rail
		860	Road
DAR	LIGANGA	740	Rail
		900	Road
DAR	MCHUCHUMA	840	Rail
		1000	Road
LIGANGA	MAHANJE	40	Rail
		40	Road
MCHUCHUMA	MAHANJE	140	Rail
		140	Road
KIGOMA	MAHANJE	1465+	Rail
		1072	TRC
		393	TAZARA
CHALINZE	MAHANJE	750	Road
ARUSHA	MAHANJE	1265+	Rail
		873	TRC
		392	TAZARA

+ Transshipment point between TRC und TAZARA is KIDATU

Table V/4.1/3

TRANSPORTATION COST OF DELIVERY TO PLANT SITE FOR IMPORTED MATERIALS

	CONTAINER 20 ft = 18 t	
	per container	per t
German inland transport to Bremen	1 600 DM	88,90 DM
Freight Bremen - DAR	1 630 $	90,55 $
Transshipment DAR	900 TSh	50,00 TSh
Tazara DAR - site	-	367,60 TSh
Total transportation cost		1 930,00 TSh+

+ Including freight insurance of 0,1 % of delivery price

Table V/4.2/1 ANNUAL CONSUMPTION AND OPERATING COST FOR IRON ORE MINING

BASIS: 1,56 MILL TPY IRON ORE

YEAR	Drill bites		Explosives+		Fuel		Tires		Power		spares	sub total	Personnel	Total
	pieces	10^3 TSh	t	10^3 TSh	10^3 l	10^2 TSh	Sets	10^3 TSh	10^6 kWh	10^3 TSh	10^3 TSh	10^3 TSh	10^3 TSh	10^3 TSh
1	247	584	244,6	2062	1892	8419	5	1929	2,1	1504	2345	16842	3770	20612
2	382	902	378,7	3192	2373,1	10560	6	2315	2,1	1504	2523	20996	3992	24988
3	512	1210	506,7	4271	2770,2	12327	8	3086	2,1	1504	2832	25230	4261	29491
4	543	1284	538	4534	2847,5	12671	8	3086	2,1	1504	2832	25911	4261	30172
5	544	1286	538,6	4539	2719,7	12103	7	2700	2,1	1504	3088	25220	4261	29481
6	544	1286	538,9	4542	2685,7	11951	7	2700	2,1	1504	3088	25071	"	29332
7	552	1305	546,7	4608	2767,0	12313	7	2700	2,1	1504	"	25518	"	29779
8	537	1269	531,8	4482	2660,	11832	7	2700	2,1	1504	"	24881	"	29145
9	549	1298	543,7	4582	2798,2	12452	8	3086	2,1	1504	"	26010	"	30271
10	568	1343	562,7	4743	2796,8	12446	8	3086	"	"	"	26209	"	30470
11	595	1407	589,7	4970	2878,8	12811	8	3086	"	"	"	26865	"	31126
12	631	1492	625,3	5270	3178,1	14143	8	3086	"	"	"	28582	"	32843
13	647	1530	640,8	5401	3326,6	14803	9	3472	"	"	"	29797	"	34058
14	669	1582	662,5	5582	3428,8	15258	9	3472	"	"	"	30387	4537	35024
15	697	1648	690,1	5816	3575,0	15909	10	3858	"	"	"	31822	4629	36452
16	728	1721	721	6077	3792,6	16877	11	4243	"	"	"	33510	4722	38232
17	752	1778	744,6	6276	3935,7	17514	11	4243	"	"	"	34402	4814	39216
18	780	1844	772,8	6513	4016,8	17875	12	4629	"	"	"	35453	4814	40267
19	798	1886	790,2	6660	4296,8	19121	13	5015	"	"	"	37274	4998	42272
20	798	1886	790,2	6660	4296,8	19121	13	5015	"	"	"	37274	4998	42272
Average	604	1427	598	5039	3152	14026	8,75	3375	2,1	1504	2997	28368	4361	32729

+ as slurry

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Table V/4.2/2

OPERATING COST ESTIMATION FOR IRON ORE PRODUCTION (AVERAGE OF 20 YEARS)

COST ITEM	CONSUMPTION PER 10^3t IRON ORE	OPERATING COST TSh/t IRON ORE	ANNUAL OPERATING COST 1000 TSh
Energy			
2.1 Fuel	2020,51 l	8,991	14 026
2.2 Electr.	1346,15 kWh	0,964	1 504
Utilites			
3.1 Explosives	383,333 kg	3,230	5 039
3.2 Drill bites	0,38718 pieces	0,915	1 427
3.3 Tires	$5{,}60897 \cdot 10^{-3}$ sets	2,163	3 375
Labour	-	2,800	4 361
Maintennance	-	1,921	2 997
TOTAL OPERATING COST		20,984	32 729

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Table V/4.2/3

OPERATING COST ESTIMATION FOR PELLET PRODUCTION

COST ITEM	CONSUMPTION PER t PELLETS	OPERATING COST TSh PER t	ANNUAL OPERATING COST 1000 TSh
Raw ore	1.576 t	33.06	32 729
Limestone	15.0 kg	5.25	5 198
Bentonit	7.0 kg	2.31	2 287
Heavy fuel oil	11.07 kg	26.10	25 835
Light fuel oil	0.05 kg	0.25	247
Electric power	76.45 kWh	54.75	54 200
Labour	0.406 mhrs	6.06	6 001
Mill liners	0.126 kg	5.09	5 044
Grinding balls	1.82 kg	15.82	15 660
Consumables, Spares, repairs		22.56	22 334
Overhead		4.90	4 818
TOTAL OPERATING COST		176.15	174 353
Transport to steel plant		135.50	134 145
TOTAL COST FREE MAHANJE		311.65	308 500

Table V/4.2/4

COST ESTIMATION FOR INTERNAL INFRASTRUCTURE AND AUXILIARY PLANT SECTIONS FOR THE ORE BENEFICIATION AND PELLET PLANT AT LIGANGA

COST ITEM	CONSUMPTION PER YEAR	ANNUAL COST 1000 TSh
Electric power	3,2 Mill kWh	2 291
Labour	196 000 mh	2 027
Consumables		500
TOTAL		4 818
Cost per t pellets		4,90 TSh

Table V/4.2/5

PRODUCTION COST AND PRICE ESTIMATION FOR RAW COAL
PRODUCTION AT MCHUCHUMA Capacity: 2,4 Mill t annually

	CONSUMPTION PER T RAW COAL	COST/ T COAL	ANNUAL COST
		TSh	1000 TSh
1. Diesel	0,4375 t	1,95	4 673
2. Electricity	12,335 kWh	8,83	21 196
3. Labour cost		6,49	15 581
4. Explosives	0,01604 kg	0,14	324
5. Maintenance materials		75,23	180 559
6. Other consumables	-	14,23	34 159
Operating cost		106,87	256 493
Depreciation		15,07	36 143
Interest		4,89	11 746
Production cost mine		126,83	304 382

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Table V/4.2/6

COST ESTIMATION FOR WASHED COAL PRODUCED IN MCHUCHUMA:
CAPECITY 500 000 m t WASHED COAL

	CONSUMPTION	COST PER t WASHED COAL	ANNUAL COST
		TSh/t	1000 TSh
Raw coal	1,9 t	240,98	120 489
Electric power	9,0 kWh	6,44	3 222
Water		0,64	322
Labour			
1 dept Manager exp			400
1 Engineer 1			50
26 skilled workers		1,65	343
4 unskilled			33
Maintenance material		4,88	2 440
Other consumables		1,22	610
Total Operating Cost		255,83	127 909
Depreciation		21,31	10 654
Interest		13,05	6 526
Total Production Cost		290,18	145 089
10 % est. profit		29,02	14 509
Estim. Price ex work		319,20	159 598
Transportation to Mahanje		135,50	67 750
Estim. Price free Mahanje		454,70	227 348

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Table V/4.2/7

COST ESTIMATION FOR INTERNAL INFRASTRUCTURE AND AUXILIARY PLANT SECTIONS FOR THE DR AND STEEL PLANT AT MAHANJE

COST ITEM	CONSUMPTION PER YEAR	ANNUAL COST 1000 TSh
Electric power	16,29 Mill kWh	11 664
Fuel oil (heavy)	5000 t	11 840
Labour	1 612 000 mh	20 154
Other Consumables		61 000
Total		104 678
Direct reduction	Distribution among the respective plant section according to labour requirement in annual man hours	26 878
Steel plant		77 800

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Table V/4.2/8

OPERATING COST ESTIMATION FOR DRI PRODUCTION

COST ITEM	CONSUMPTION PER t DRI	OPERATING COST PER t DRI	ANNUAL OPERATING COST
		TSh/t	1000 TSh
Pellets	1,50 t	467,42	308 500
Coal	0,76 t	345,57	227 348
Dolomite	0,10 t	28,00	18 480
Electric power	110 kWh	78,76	51 982
Briquetting binders	3,5 kg	1,77	1 167
Labour		10,27	6 778
Maintenance material } Other consumables }	5,5	67,10	44 286
Overhead		40,70	26 878
TOTAL OPERATING COST		1 039	685 419

Table V/4.3/1 PRODUCTION COST SUMMARY FOR THE COMPLETE IRON AND STEEL COMPLEX

Cost item	Unit price TAS/ unit	Consumption per ton of steel	Annual consumption	Production cost per ton of steel	Annual production cost 1000 TSh
1. Raw Materials					
Coal	454.70	1.0000 t	500 000 t	454.70	227 848
Limestone	350	0.0852 t	42 600 t	29.82	14 910
Dolomite	280	0.2460 t	123 000 t	68.88	34 440
Quarzite	280	0.0459 t	22 960 t	12.86	6 429
Charcoal	1 360	0,0183 t	9 130 t	24.83	12 417
Ferroalloys	8 710	0.0116 t	5 800 t	101.04	50 518
2. Energy					
Electrical energy	0,716	1580,6 kWh	$790,3\cdot 10^6$ kWh	1 131.71	565 855
Heavy fuel oil	2 368	0.0880 t	44 010 t	208.43	104 216
Light fuel oil or Diesel	4 945	0.0058 t	2 887 t	28.55	14 276
Propane	5 725	0.116 t	57 920 t	663.18	331 592
3. Consumables					
Briquetting binder	250	0.0020 t	1 000 t	0.50	250
Bentonite	330	0.0139 t	6 930 t	4.57	2 287
Drill bites	2 364	$1.2\cdot 10^{-3}$ Pc	604 Pc	2.86	1 427
Explosives	8 428	0.0012 t	598 t	10.08	5 039
Tires	385 764	$1.8\cdot 10^{-5}$ sets	8,75 sets	6.75	3 375
Grinding balls	8 700	0.0036 t	1 800	31.32	15 660
Mill liners	40 350	0.0003 t	125 t	10.09	5 044
Electrode paste	7 355	0.0095 t	4 750 t	69.87	34 936

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Table V/4.3/1 Continued

Cost Item	Unit Price TAS/ Unit	Consumption per ton of Steel	Annual consumption	Production Cost per ton of Steel	Annual Production cost 1000 TAS
Steel for casings and tools	9 000	0.0029 t	1 472 t	26.50	13 248
Electrode graphite	28 150	0.0012 t	584 t	32.88	16 440
Refractories					
EAF, ladles	6 450	0.0211 t	10 570 t	136.35	68 177
Gates/Purging	44 870	0.0047 t	2 335 t	209.54	104 771
Cont Casting	5 550	0.0006 t	290 t	3.22	1 610
Casting powder	8 710	0.0008 t	410 t	7.14	3 571
Rolls	22 270	0.0050 t	2 500 t	111.35	55 675
Other consumables	-	-	-	349.43	124 713
4. <u>Labour</u>	-	9 176 mh	4 588 000 mh	106.47	53 233
5. <u>Maintenance material</u>	-			101.41	50 707
6. <u>Insurance cost</u>	-			32.03	16 015
7. <u>Transportation cost</u> Pellets to steel plant	-			268.29	134 145
Operating Cost				4 144.65	2 072 324

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Table V/4.3/2 Production Cost Estimation for Iron and Steel Plant Complex and Cost Breakdown

Cost item	Production cost per ton of steel (TSh)	Annual production cost, 1000 TSh
1. Raw materials	692.12	346 062
2. Energy	2 031.88	1 015 939
3. Consumables	912.45	456 223
4. Labour	106.47	53 233
5. Maintenance material	101.41	50 707
6. Insurance cost	32.03	16 015
7. Transportation cost for pellets	268.29	134 145
8. Operating cost	4 144.65	2 072 324
9. Depreciation	931.00	465 617
10. Interest	854.00	427 134
11. Production cost	5 929.65	2 965 075
12. Cost breakdown		
Fixed operating cost	898,78	449 390
Depreciation, interest	1 785.00	892 751
Fixed production cost	2 683.78	1 342 141
Variable production cost	3 245.87	1 622 934
Total production cost	5 929.65	2 965 075

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Table V/4.3/ 3 Annual Production Cost in Foreign Exchange

Cost item	Annual production cost for imported materials and foreign labour	
	1000 US$	1000 TSh
Raw material	4 141	50 518
Consumables	29 968	365 610
Labour (expatriates)	1 041	12 700
Maintenance material	4 156	50 707
Cost in foreign exchange	39 306	
Equivalent in domestic currency	-	479 535

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Table V/4.3/4

MANAGEMENT PERSONNEL REQUIREMENT AND ANNUAL LABOUR COST, IRON ORE MINE

LIGANGA	REQUIREMENT	
		TSh
Managing director	1	500. 000
Deputy managing director	1	400. 000
Mining engineer	1	300. 000
Accountant	1	40. 000
Mechanical engineer		50. 000
TOTAL	5	1.290. 000
+ 15 % Absences	1	194. 000
		1.484. 000
+ 25 % Social affairs	6	371. 000
TOTAL management personnel cost	6	1.855. 000

Table V/4.3/5

ANNUAL PERSONNEL REQUIREMENT AND LABOUR COST FOR SHIFT PERSONNEL
IRON ORE MINE LIGANGA

YEAR	SKILLED PERSONNEL	LABOUR COST TSh	UNSKILLED PERSONNEL	LABOUR COST TSh	SUBTOTAL	15 % ABSENCE	25 % SOCIAL AFFAIRS	TOTAL LABOUR COST TSh
1	70	924 000	50	408 000	1 332 000	199 800	382 950	1 914 750
2	78	1 029 600	56	456 960	1 486 560	222 984	427 386	2 136 930
3	86	1 135 200	66	538 560	1 673 760	251 064	481 206	2 406 030
to		.	.	.	.	.	.	.
		.	.	.	.	.	.	.
13	86	1 135 200	66	538 560	1 673 760	251 064	481 206	2 406 030
14	95	1 254 000	75	612 000	1 866 000	279 900	536 475	2 682 375
15	98	1 293 600	78	636 480	1 930 080	289 512	554 898	2 774 490
16	101	1 333 200	81	660 960	1 994 160	299 124	573 321	2 866 605
17	104	1 372 800	84	685 440	2 058 240	308 736	591 744	2 958 720
18	104	1 372 800	84	685 440	2 058 240	308 736	591 744	2 958 720
19	110	1 452 000	90	734 400	2 186 400	327 960	628 590	3 142 950
20	110	1 452 000	90	734 400	2 186 400	327 960	628 590	3 142 950
AVERAGE	91	1 201 200	71	542 560	1 743 760	261 060	501 205	2 506 025

Table V/4.3/6

Average Personnal Requirement and Labour cost

Iron Ore Mine Liganga

	Personnel Requirement	Annual Labour cost TSh
Management	5	1 290 000
Skilled personnel	91	1 201 200
Unskilled personnel	71	542 560
Subtotal	167	3 033 760
15 % Absence	25	455 060
Total Personnel	192	3 488 820
25 % Social affairs		872 205
Total labour cost		4 361 025
Total annual man hours	384 000	

Table V/4.3/7

Estimation of Labour Cost for Benefication and Pellet Plant

Workforce	Total personnel requirement	Qualification	Unit salaries per year TSh	Annual labour cost TSh
Plant manager	1	gen. manager, exp.	500 000	500 000
Assistant manager	1	dep. manager, exp.	400 000	400 000
Process engineer	2	engineer , exp.	300 000	600 000
Shift foremen	8	skilled	13 200	105 600
Operators	78	skilled	13 200	1 029 600
Helpers	8	unskilled	8 160	65 280
<u>Maintenance</u>				
Maint. Engineer	2	engineer , exp.	300 000	600 000
Fitters	52	skilled	13 200	686 400
Helpers	23	unskilled	8 160	187 680
Subtotal	175	-	-	4 174 560
+ 15 % Absence	26			626 184
+ 25 % Social affairs	-	-	-	1 200 186
Total labour cost	201	-	-	6 000 930
Labour cost/t pellets				6.06
Total man hour per t pellets	0,406			

Table V/4.3/8

Estimation of Labour Cost for DR and Steelmaking Plants

Work force	Total personnel requirement	Qualification	Unit salaries per year TSh	Annual labour cost Tsh
Plant manager	1	Gen. manager, exp.	500 000	500 000
Assistant managers	8	Dep. manager, exp.	400 000	3 200 000
Staff	14	skilled	36 000	504 000
Engineers	2	Engineer , exp.	300 000	600 000
Shift foreman	127	skilled	13 200	1 676 400
Operator, Controllers	243	skilled	13 200	3 207 600
Technicians	10	Technician	30 000	300 000
Helpers	309	unskilled	8 160	2 521 440
Maintenance				
Fitters	126	skilled	13 200	1 663 200
Helpers	27	unskilled	8 160	220 320
Subtotal	867			14 392 960
+ 15 % Absence	130			2 158 944
+ 25 % Social affairs	-			4 137 976
Total labour cost	997			20 689 880
labour cost / t steel				41,38
Total man hour per ton of steel	3,988			

Table V/4.3/9 Estimation of Labour Cost for Auxiliaries and Indoor Infrastructure for Pellet Plant

Work force	Total ersonnel requirement	Qualification	Unit salaries per year (TSh)	Annual labour cost (TSh)
Manager accountance	1	Manager exp	300 000	300 000
Accountants	2	Economist	40 000	80 000
Clerks	2	Administrator	36 000	72 000
Superintendents	2	Engineer	50 000	100 000
Foremen	4	skilled	13 200	580 000
Craftsmen	40	skilled	13 200	
Helpers	34	unskilled	8 160	277 440
Subtotal	85	-	-	1 410 240
15 % absence	13	-	-	211 540
25 % social affairs	-	-	-	405 440
Total labour cost	98	-	-	2 027 220
Labour cost per t pellets				2,05
Total man hour / t pellets	0,198			

Table V/4.3/10 Estimation of Labour Cost for Auxiliaries and Infrastructure for the Steel Plant Mahanje

Work force	Total personnel requirement	Qualification	Unit salaries per year TSh	Annual labour cost TSh
Department manager	10	Dept. manager exp	400 000	4 000 000
Engineers	2	Engineer	50 000	100 000
Medicine Doctor	1	Manager	400 000	400 000
Public Relations Officer	1	Manager	300 000	300 000
Superintendents	10	Engineer	50 000	500 000
Technicians	3	Technician	30 000	90 000
Administrators	45	Administrator	36 000	1 620 000
Accountants	15	Economist	40 000	600 000
Foremen	120	skilled	13 200	1 584 000
Craftsmen, Employees	405	skilled	13 200	5 346 000
Helpers	194	unskilled	8 160	1 583 040
Subtotal	806			16 123 040
25 % Social affairs	-			4 030 760
Total Labour Cost	806			20 153 800
Labour cost per t steel				40,31
Total man hour per t steel	3,22			

Table V/4.3/11

Estimation of Annual Manhour Requirement and Labour Cost of the Total Iron and Steel Plant Complex

	Personnel requirement	Annual manhours	Annual Labour cost 1000 TSh
1. Iron ore mine average	192	384 000	4 361
2. Pelletizing plant	201	402 000	6 001
3. DR and Steel Plant	997	1 994 000	20 690
4. Internal Infrastructure			
4.1 Liganga	98	196 000	2 027
4.2 Mahanje	806	1 612 000	20 154
Total	2 294	4 588 000	53 233
Manhour per ton of steel		9.176	
Labour cost per ton of steel, TSh			106.47
2000 annual working hours per man is assumed			

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Table V/4.3/12

Breakdown of Personnel Requirement of Total Iron and Steel Plant Complex According to Qualification

	Original requirement	15 % Absence	Total
General Manager	3	-	3
Department managers	20	3	23
Engineers (exp)	8	1	9
Engineers (local)	13	2	15
Administrators	55	8	63
Economists, accountants	16	2	18
Technicians	13	2	15
Skilled personnel	1 225	185	1 410
Unskilled personnel	641	97	738
Total personnel	1 994	300	2 294
Personnel of the same qualification (salary) level is combined			

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Table V/4.4/1 Annual Production Cost during Initial Phase of Plant Operation

	Year 4 1000 TSh	Year 5 1000 TSh	Year 6 to 19 1000 TSh
Variable cost	1 110 573	1 590 475	1 622 934
Fixed cost	1 342 141	1 342 141	1 342 141
Production cost	2 452 714	2 932 616	2 965 075
Relation	0,827	0,99	1,0

S E C T I O N 5

Estimation of Annual Revenues

5. Estimation of annual revenues

5.1 Projected main steel products

The projected annual production schedule for finished steel in Mahanje is described in Volume III and may be recalled again.

Table V/5/1 - Main steel products

Product Size mm		Slab Size mm	Mill Output t/h	Production t/a	Utilis. Mean Time h/a
Hot Strip					
750 x 2.0	)	750 x 150	86	60,000	698
750 x 3.5	)	x 5700	131	30,000	229
750 x 6.0	)		164	30,000	183
900 x 2.0	)	900 x 150	104	60,000	577
900 x 3.5	)	x 5700	157	30,000	191
900 x 6.0	)		180	30,000	167
1050 x 2.0	)	1050 x 150	121	80,000	661
1050 x 3.5	)	x 5700	180	40,000	222
1050 x 6.0	)		180	40,000	222
			aver. 127 t/h	400,000 t/a	3150 h/a
Heavy Plate					
2000 x 6.0	)	1050 x 150	54	50,000	926
2000 x 10.0	)	x 1500	73	30,000	411
2000 x 16.0	)		94	20,000	213
			64.5 t/h	100,000 t/a	1550 h/a
Total				500,000 t/a	4700 h/a

The projected steel products may be partly absorbed by the Tanzanian demand for flat products arriving at approx. 210 000 tpy in 1990. Since it is expected, that the project may produce steel a certain time period later than 1990, the domestic demand may even be higher. The export of a part of the production shall be envisaged as far as the domestic demand cannot absorb the steel produced at Mahanje completely.

5.2 Projected prices of the steel products

NDC has submitted a complete price list for steel products in Tanzania distributed by the National Steel Corp. Ltd. and prepared according to the guidelines of the National Price Commission which is attached to in the annex.
It can be observed, that the dimensions of strips and steel plates produced at Mahanje do not coincide with those retailed by NSC. Nevertheless the unit prices per ton given in the NSC-price list could be used as indicative prices since the thickness of the steel plates and strips may be an important factor for determining the unit price.
For the heavy plates in the range from 6,0 to 16,0 mm thickness the prices for mild steel plain plates were used as indicative basis.
Heavy plates, 6 mm thick will cost 8420 TSh/t,for plates with 10,0 and 16,0 mm thickness the price of 8343 TSh/t (referred to 12 mm thickness) was chosen. Taking into account the respective annual production rates a composite unit price per ton of steel plates is estimated to be 8381,5 TSh/t steel plates.

For hot strips in the range of 2,0 to 6,0 mm thickness, the respective unit price in the price list for plates 3,0 to 4,0 mm thickness was chosen. This price is 8680,20 TSh/t uniformely.

The prices are based ex steel yard in Dar es Salaam.

Table V/5/2 - Prices and revenues for main steel products.

	Amount tpy	Price ex work Mahanje TSh/t	Transportation TSh/t	Price free steel yard Dar TSh/t	Import price TSh/t
Plates 6,0-10,0 mm	100 000	8011,50	370	8381,5	5600*
Strips 2,0-6,0 mm	400 000	8310,20	370	8680,2	4984*
Annual revenue 1000 TSh		4 125 230			

* Freight from Rotterdam to Dar: 1940 TSh/t

Table V/5/2 shows the calculation of the ex-work price for Mahanje steel products taken into account the transportation cost between Dar es Salaam and the plant site.

The import prices are based on current steel prices for plates and strips in Germany end of December 1983 fob Rotterdam which is 300 $/t for plates and 250 $/t for hot rolled strips.

Transportation cost was submitted by Montan-Transport to be 1940 TSh free Dar including freight for bulk material, transshipment in Dar es Salaam and insurance.

The great difference between Tanzanian domestic steel prices and the world market prices attracts the attention. Although there is a depressed price level on the world market for steel at the moment because of the crisis of the steel industry, the price difference cannot be fully explained by this reason only. Obviously high import custom duties maybe another important reason.

The low import prices may prevent any export of the produced steel by the project since the production cost by far will exceed the sales price of steel. Moreover the site of the plant approximately 1 000 km away from the next harbour is a main disadvantage when steel export overseas is envisaged. For the revenue estimation the Tanzanian domestic prices have been applied upon request of NDC.

The estimated average annual revenue thus obtained turns out to be 4 125 230 000 TSh and correspond to a unit revenue of 8 250,50 TSh per ton of steel.

5.3 Annual steel production with respect to start up period

The above mentioned revenue of 4 125 230 000 TSh refers to the period of normal operation at designed capacity. For the annual cash flow computation it is necessary to compute the steel production for the time period immediately after start up.

As can be obtained from IV/5, the start up and commissioning schedule given in the mile stone diagram serve as a basis for the determination of the projected plant output.

5.3.1 Annual production pattern of major plant sections of the iron and steel plant complex

The start up of the iron and steel plant will be at the end of the 4th year (60th month) according to the mile stone diagram. That corresponds with the end of the 3rd year (36th month), in the economic evaluation. The start up and the output of the first DR-strand occurs at the same moment. All preceding plant sections have to start up earlier in order to guarantee a steady supply and to build up the necessary stocks for intermediate products. The start up and the production rate thereafter will be dominated by the needs of the steel and direct reduction plants. The production level of the direct reduction plant, the pellet plant and the iron ore mine are adjusted to the demand of the steel plant. All intermediate products were either stored or consumed internally. Table V/5/3 reviews the output of all major plant sections during initial operation period as well as the build-up of inventories (see chapter V/3).

In the year 3 the mine produces 195 000 tpy raw ore (after deducting the inventory) for the pelletizing plant. The pellet plant produces 123 750 t pellets of which 85 000 t were stored in Liganga and Mahanje and delivers 38 750 t pellets to the DR-plant in order to feed the kilns of strand 1 and 2. In the same way the DR-plant delivers 12 500 t DRI in the 36th month to the steel plant.

According to the demand of the steel plant there is an increase in production rate of 78 % design capacity in the year 4 up to 98,8 % design capacity in the year 5. After year 5 all plant sections will produce at design capacity.

Since no scrap is available in Tanzania the steel plant has to generate the necessary scrap by itself. This will be achieved in such a way, that the first throughput of the steel plant sections will be recycled as scrap. The low quality of initial quantities produced may encourage such a procedure. Therefore quantities of steel produced for sale will be generated at the beginning of the 4th year (37th month). In order to generate the necessary scrap the steel plant increases its salable production from 76,8 % in the year 4 to full capacity in the year 6.

5.3.2 Annual steel production and revenues

Table V/5/4 shows the annual steel production in the years immediately after start up, broken up in plates and strips.

A finished product inventory of 42 000 t is built up in year 4.
The respective annual revenues are estimated according to this production pattern.

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Table V/5/3

AVERAGE PRODUCTION OUTPUT OF PLANT SECTIONS DURING INITIAL TIME PERIOD OF STEEL PRODUCTION

start up (between Year 3 and Year 4)

	YEAR 3	YEAR 4	YEAR 5	YEAR 6
MINING	220 000	1 219 800	1 540 650	1 560 000
AVAILABILITY	42.3 %	78.3 %	98.8 %	100 %
INVENTORY	25 000	-	-	-
PELLETIZING	123 750	774 100	977 700	990 000
AVAILABILITY	50 %	78.2 %	98.8 %	100 %
INVENTORY	82 450	2 550	-	-
DIRECT REDUCTION	27 500	514 250	651 750	660 000
AVAILABILITY	25 %	77.9 %	98.8 %	100 %
INVENTORY	15 000	-	-	-
STEEL PLANT	-	384 150	490 200	500 000
AVAILABILITY	0	76.8 %	98 %	100 %
INVENTORY	-	42 000	-	-

THE AVAILABILITY DURING START UP PERIOD IS RELATED TO RATED CAPACITY OF THE RESPECTIVE PLANT SECTION

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Table V/5/4

ANNUAL STEEL PRODUCTION AFTER START UP

1000 mt

PRODUCTION	YEAR 4	YEAR 5	YEAR 6
PLATES	76 830	98 040	100 000
STRIPS	307 320	392 160	400 000
TOTAL STEEL PRODUCTION	384 150	490 200	500 000
% OF RATED CAPACITY	76.8	98.0	100.0
INVENTORY BUILD UP	42 000	-	-
STEEL PRODUCTION FOR SALE	342 150	490 200	500 000
ANNUAL REVENUE	2 822 895	4 044 376	4 125 230

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S E C T I O N 6

Economic Evaluation of the Total Project

6. Economic evaluation of the total project

6.1 Description of the model

The calculation starts with the evaluation of the annual operating cost and the revenue.
The annual variable cost is calculated as a sum of the products of specific consumption (SP. CONS) x unit price (PRICE) x total annual steel production (AMOUNT).
The result is printed on pages 1 to 3 for the years 4 to 6. We have summarised those cost items of minor importance in that way that the specific consumption shows already the specific annual cost and the unit price has been set to 1.0. To give an example the annual cost of limestone, dolomite and quartzite (which is denoted to LDQ) amounts to (refering to 500 000 tpy steel):

Limestone	14 910 x 10^3	TSh
Dolomite	34 440 x "	"
Quartzite	6 429 x "	"
LDQ	55 779 x "	"

This results in specific cost of:

111,558 TSh/t steel

After calculating the variable cost the fixed cost are added. The sum of both are shown as total annual operating cost. In the same way the annual revenue is obtained.
When this computation is completed a profit and loss account is carried out in order to determine the tax to be paid and the annual profit achieved (lines 2 to 10).

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In the second block (lines 11 to 21) the annual cash flow before and after tax is calculated. In the last block (lines 22 to 27) some important figures are accumulated over the lifetime of the project until the 20th year. The 20th year is used as a closing of accounts. In this year the working capital and the salvage and residual values are liquefied. These amounts are considered as an income on which no tax is levied. Based on this results the profitability standards showed on page 8 are determined.

All figures in the prints are quoted in million Tanzanian shillings.
The figures in the prints and in the study differ very slightly (approx. < 0.5 %) from each other because of rounding procedure in the computer calculation.

The start of the first year coincides with the moment of signing the contract.

6.2 Profit and loss account

On page 4 of the computer prints for the base case the profit and loss account is carried out in the first block (lines 2 to 10). Revenues and operating cost are held constant over the years 6 to 19 when the plant operates at full design capacity. In the years before, revenues and cost are reduced because of lower availability immediately after start up. That problem has been discussed in detail in chapters V/4.4 and V/5.4.
No price escalation has been considered because the time of plant establishment cannot yet be determined. From the annual revenues the operating cost are deducted resulting in a profit margin.

From the profit margin the annual depreciation and interest cost are deducted. The resulting profit before tax has been charged with a 50 % tax rate to give the profit before tax. This value is the basis for the estimation of the return on investment.

6.2.1 Estimation of tax

The tax rate was submitted by NDC to be 50 % of the profit before tax. A tax allowance has to be considered, which could amount up to 20 % of the total investment capital of 7 936 398 000 TSh. To the tax allowance of 1 587 280 000 TSh the loss carried forward from year 4 of 389 550 000 TSh has been added, giving a total of 1 976 830 000 TSh. The total tax allowance thus obtained has been deducted from the profit before tax until the total allowance has been utilised. The tax is accumulated over the lifetime (line 26) up to 8 219 812 000 TSh resulting in average figures per year of 524 758 170 TSh and per ton of steel of 1 049,47 TSh.

6.2.2 Results

Total accumulated profit before tax amounts to 18 026 931 000 TSh, the profit after tax is 9 807 119 000 TSh. (The year 20 is not included) Table V/6/1 shows the results.

6.3 Cash flow analysis

6.3.1 Method applied

The cash flow has been calculated according to the folowing equation:

Revenues
./. Operating cost

Profit margin
./. Investment
./. Working capital

Cash flow before tax
./. Tax

Cash flow after tax

Cash flow computation is carried out in block 2 (lines 11-21). From the profit and loss account the profit margin and the tax are carried forward to the cash flow computation. The investment capital requirement in line 18 with detailed breakdown in lines 12 to 17 is deducted.

6.3.2 Results

The annual net cash flows are listed in line 19 (cash flow before tax) and in line 21 (cash flow after tax). The accumulated values of the two cash flows are listed in line 24 and 25 giving the total of all the annual cash flows from the actual and previous years. This accumulation is the basis for the computation of the pay-out time or pay-back period.
Total accumulated cash flow obtained over the project's lifetime is given on page 8 (see table V/6/1). For the base case the figures are as follows:

Accumulated cash flow before tax:

24 715 832 000 TSh

Accumulated cash flow after tax:

16 496 016 000 TSh

The cash flow is listed in table V/6/3.

6.4 Main profitability standards achieved

6.4.1 Discounted cash flow rate of return

This profitability standard is listed on page 8 of the prints denoted to DCFRR.

DCFRR before tax 19.043 %
DCFRR after tax 15.629 %

6.4.2 Net present value

The annual cash flows are discounted with a discount rate of 10 % which is standard in most profitability evaluations.
The net present values (NPV) are shown on page 8 to be as follows:

NPV before tax: 5 260 789 000 TSh
NPV after tax: 2 766 018 000 TSh

6.4.3 Pay-out time

The pay-out time is defined to be that time period from start up to the moment when the project have earned all the expenses occurred from the beginning. This will be equivalent with the point of time when the accumulated cash flow arrives at zero (change of sign). An equivalent liquidation of working capital was considered since the value of the enterprise is still higher than zero because of the value of the stocks.
The result is given on page 8:
Pay-out time after tax: 4.416 years.

Calculating the pay-out time without considering the liquefaction of the working capital results in a pay-out time of 4,952 years.
In table V/6/1 all main profitability standards are summarised.

6.4.4 Break-even point analysis

The break-even point is defined to be the plant availability which all cost will equal the revenues achieved at. The break-even point is calculated according to the following formula:

$$BEP = \frac{\text{fixed cost}}{\text{revenues - variable cost}}$$

Since depreciation and interest will change from year to year, the break-even point is annually computed and the result is listed in line 27 of the prints. The average BEP has been estimated as a mean average over the years 4 to 19. Average BEP amounts to 55,4 %. When the plant output is 55,4 % of the designed capacity, the cost will equal the revenues.

6.4.5 Average ROI

The return on investment has been calculated before tax, dividing the accumulated profit before tax by the total investment capital and the number of years (16). The result is

$$ROI = \frac{18\ 026\ 931}{16\ .\ 9\ 523\ 102} = 0{,}1183$$

or 11,83 %.

One has to note that the profit before tax is obtained before the tax allowance has been deducted.

6.5 Sensitivity analysis

In order to evaluate the relative influence of main economic parameters upon the profitability standards notably the discounted cash flow rate of return (DCFRR) after tax, the following sensitivity analysis has been worked out.

1. Investment capital requirement

   Since the estimation of investment is within an accuracy range of ± 20 %, the impact of changing the total investment capital requirement as well as all replacement and extension investment between ± 20 % has been investigated. The investment requirement influencesthe cash flow directly, as a constituting part but also indirectly via the tax which is influenced by depreciation and interest cost.

2. Energy cost

   The cost for purchased energy, that is electricity, fuel oil and propane has also a strong influence on the profitability. Energy cost will make up about 49 % of total operating cost. The basis is 1 015 939 000 TSh annual energy cost as revealed in table V/4.3/2.
   The smelting of DRI in an electric arc furnace is a high energy consuming process which requires capable power generating facilities. Electrical energy consumption and price therefore has a strong influence on smelting cost of iron and steel.

3. Availability

   The availability is defined as the ratio between actual capacity utilization and nominal capacity. At an availability for instance of 60 % the plant produces only 300 000 tpy of steel instead of 500 000 tpy and all plant sections are affected proportionally.

Plant availability influences the revenues as well as the variable operating cost. It is therefore important to know which influence the reduced output will have on profitability.

A plant availability below 60 % was not taken into account. The reason is that below 50 % capacity utilization, the operation of some plant section may become critical.

4. Steel price

As discussed before in chapter V/5.2 the great difference between Tanzanian domestic prices for steel and prices for imported steel is remarkable.
Therefore an alternative has been evaluated by calculation of the revenues by applying the import prices for steel. The import prices have been calculated to be valid free Mahanje i.e. deducting the transport cost from Dar es Salaam to Mahanje of 370 TSh/t from the import prices revealed in table V/5/2. The obtained prices are 5 230 TSh/t plates and 4 614 TSh/t for strips.
A variation of the Tanzanian prices to be 80 % and 70 % of the original value is done also in order to obtain intermediate values.

6.6 Results of the economic evaluation

6.6.1 Result of the profitability estimation

The result of the profitability estimation is listed in table V/6/1.
The discounted cash flow rate of return before tax of 19.0 % may look attractive and may be a good reason to encourage the investment in the project. One has to bear in mind, that the interest rate for investment in Tanzania, as given by NDC, lies at

10 %. The difference of 9 % may be high enough, to cover the risk involved in such a large project. The average ROI 11,83 % could also be considered as a good result. A main objection may be found in the question of steel prices. As can be obtained from the results of the sensitivity analysis, the steel prices applied play the most important role to evaluate the project. Tanzanian domestic steel prices are very high, compared with import prices. When import prices are applied, the project will not be economically feasible. The DCFRR falls to negative values. Even a decrease of the price level down to 80 % of its original value (approx. 6 410 TSh/t for plates and 6 648 TSh/t for strips) will result in a downfall of the DCFRR to 10,19 % after tax and the average ROI to 3,35 %.It can be stated, that even a slight variation of the steel prices affect the profitability very serously.

It could further be stated, that under these circumstances no export of surplus steel could be achieved under conditions assuring the economics of steel production.

6.6.2 Results of the sensitivity analysis

The most important parameter, the steel prices have already been discussed before. The results summarised in table V/6/2 show, that the availability is the next parameter in the sequence of importance. At an availability of 60 % the project will not be economically feasible. DCFRR rates will fall significantly under the interest rate of 10,0 % and

the ROI will be only 1,5 %.
At an availability of 80 %, profitability is reduced to 13,92 % before tax. So the project is vulnerable with respect to decrease of steel price and availability.

Investment capital and energy cost play a minor role in the face of the discussed parameters. The variation does not affect the project's profitability so seriously. The result of the sensitivity analysis is illustrated in fig. V/6/1 and V/6/2.

6.6.3 Savings of foreign exchange by the project

In order to evaluate the requirements of foreign exchange when the project is realised as well as the savings, the following balance based upon the total operating time period of 15,664 years of the project can be established.

1. Requirements of foreign exchange

1) Investment	
Initial plant investment, Cost before start-up, Replacement, Working capital	8 093 630 000 TSh
2) Operating cost	
Annual op.cost over 15,66 years	7 511 436 200 TSh
Subtotal requirement	15 605 066 000 TSh
3) Interest during construction and accumulated interest	7 407 297 000 TSh
Total requirement	23 012 363 000 TSh

2. Savings of foreign exchange

1) Avoidance of steel imports

1. Alternative 1: Demand of 1990 steel import of 210 000 t flat products is avoided: 15 582 735 000 TSh

2. Alternative 2: Demand of 500 000 t steel annually is avoided: 37 101 750 000 TSh.

The total saving is in the most favourable alternative 21 496 684 000 TSh or 1 762 023 000 US$.

When only a demand of 210 000 t import steel is avoided, the total foreign exchange input cannot be recovered by the potential savings.
When the financing of the project will be undertaken by international financing organisation and the loan is granted in US$, the interest during construction and during plant operation has also to be paid in foreign exchange. In this case the saving is 14 089 387 000 TSh or 1 154 867 800 US$.
It can be stated, that the sequence of foreign payments and savings is not very favourable.
Tanzania has to spent a huge amount of foreign exchange initially in order to save foreign exchange about 10-15 years later. The average annual saving amounts only to 112,5 Million US$ a year in the most favourable case.

6.6.4 Benefits to the country arising from the project

The benefits to the country beyond the economic evaluation could be described and summarised in the following way:

Quantitative benefits:

1. Creation of jobs: For 2 294 Tanzanians jobs are created within the plant complex.
   Additional 1200 jobs are created in the coal mine, the power plant and the coal washing plant.

2. Paying of tax: The United Republic of Tanzania may gain about 8 219 812 000 TSh over the lifetime of the plant complex.

3. Earnings of directly employed persons will amount to 53 233 000 TSh annually.

4. Savings of foreign exchange of about 1 154 to 1 762 Million US $ over 15,664 years

Qualitative benefits:

1. Independence from imports of finished steel and scrap. Up to 1990 a total demand of 210 000 t/y of flat products have to be supplied with imported steel.

2. Utilisation of domestic raw materials limestone, coal, dolomit, iron ore, quartzite and others.

3. Installation of general area infrastructure railroad, roads, townships which will populate a great area on the Tanzanian border.

4. Electrification of the district Ludewa.

5. Development of an underdeveloped area in the district Ludewa.

6. The potential of the plant complex to increase education in the area.

7. Increase in local market production and agriculture to supply the increasing population.

8. Multiplicator effect on the development of small scale industries, and craftmanship.

9. Growing importance of Dar es Salaam as the main harbour to handle the necessary plant supply.

Table V/6/1

Result of economic evaluation

	Values
DCFRR before tax	19,043 %
DCFRR after tax	15,629 %
NPV before tax	5 260 789 000 TSh
NPV after tax	2 766 018 000 TSh
Pay-out time	4,416 years
ROI	11,83 %
Break-even point average	55,40 %
Accumulated figures	
Acc. cash flow before tax	24 715,832 Mill TSh
Acc. cash flow after tax	16 496,016 "
Acc. profit before tax	18 026,931 "
Acc. profit after tax	9 807,119 "
Acc. tax	8 219,812 "
Acc. interest	6 688,918 "
Acc. investment	9 523,102 "

Table V/6/2

Results of the sensitivity analysis

	DCFRR %		NPV [Mill. TSh]		Acc. Cash-flow [Mill. TSh]		ROI [%]	Pay-out time [Y]	BEP [%]
	before tax	after tax	before tax	after tax	before tax	after tax			
Base case	19.043	15.629	5 261	2 766	24 716	16 496	11.83	4.416	55.401
Investment + 20 %	15.844	13.479	3 880	2 003	23 258	16 505	8.87	5.197	62.136
Investment - 20 %	23.385	19.525	6 642	3 887	26 174	17 229	16.53	3.516	48.066
Energy + 20 %	17.024	14.762	3 998	2 344	21 533	15 489	9.74	4.824	60.297
Energy - 20 %	20.989	17.835	6 524	3 883	27 899	18 936	13.92	3.942	51.24
Availability 80 %	13.915	12.726	2 150	1 361	16 876	13 522	6.69	5.713	69.251
Availability 60 %	8.119	8.119	- 960	- 960	9 037	9 037	1.54	8.294	92.335
Steel price 80 %	10.253	10.186	133	97	11 792	11 592	3.35	7.144	82.653
Steel price 70 %	5.031	5.031	- 2 431	- 2 431	5 330	5 330	- 0.46	10.899	109.612
Steel import price	- 3.029	- 3.028	- 5 657	- 5 657	- 2 801	- 2 801	- 6.21	17.901	185.914

LURGI

Table V/6/3: Annual cash flow 1000 TSh

Year	Cash flow before tax annual	Cash flow before tax accumulated	Cash flow after tax annual	Cash flow after tax accumulated
1	- 590 812	- 590 812	- 590 812	- 590 812
2	- 2 928 253	- 3 519 065	- 2 928 253	- 3 519 065
3	- 4 118 652	- 7 637 715	- 4 118 652	- 7 637 715
4	242 275	- 7 395 437	242 275	- 7 395 437
5	1 913 624	- 5 481 812	1 913 624	- 5 481 812
6	2 052 904	- 3 428 909	2 052 904	- 3 428 909
7	2 022 400	- 1 406 509	2 022 400	- 1 406 509
8	1 852 217	445 708	1 476 747	70 238
9	2 039 086	2 484 794	1 469 319	1 539 558
10	2 046 060	4 530 852	1 436 056	2 975 614
11	2 049 281	6 580 129	1 403 906	4 379 520
12	2 021 085	8 601 211	1 341 569	5 721 086
13	1 866 576	10 467 785	1 148 173	6 869 258
14	2 017 744	12 485 527	1 296 694	8 165 949
15	2 039 014	14 524 539	1 297 938	9 463 887
16	2 046 132	16 570 668	1 284 461	10 748 348
17	2 016 429	18 587 094	1 233 279	11 981 625
18	1 863 154	20 450 246	1 054 311	13 035 934
19	2 034 049	22 484 293	1 228 545	14 264 477
20	2 231 539	24 715 832	2 231 539	16 496 016

Fig. V/6/1 - Sensitivity analysis: Variation of availability and steel price

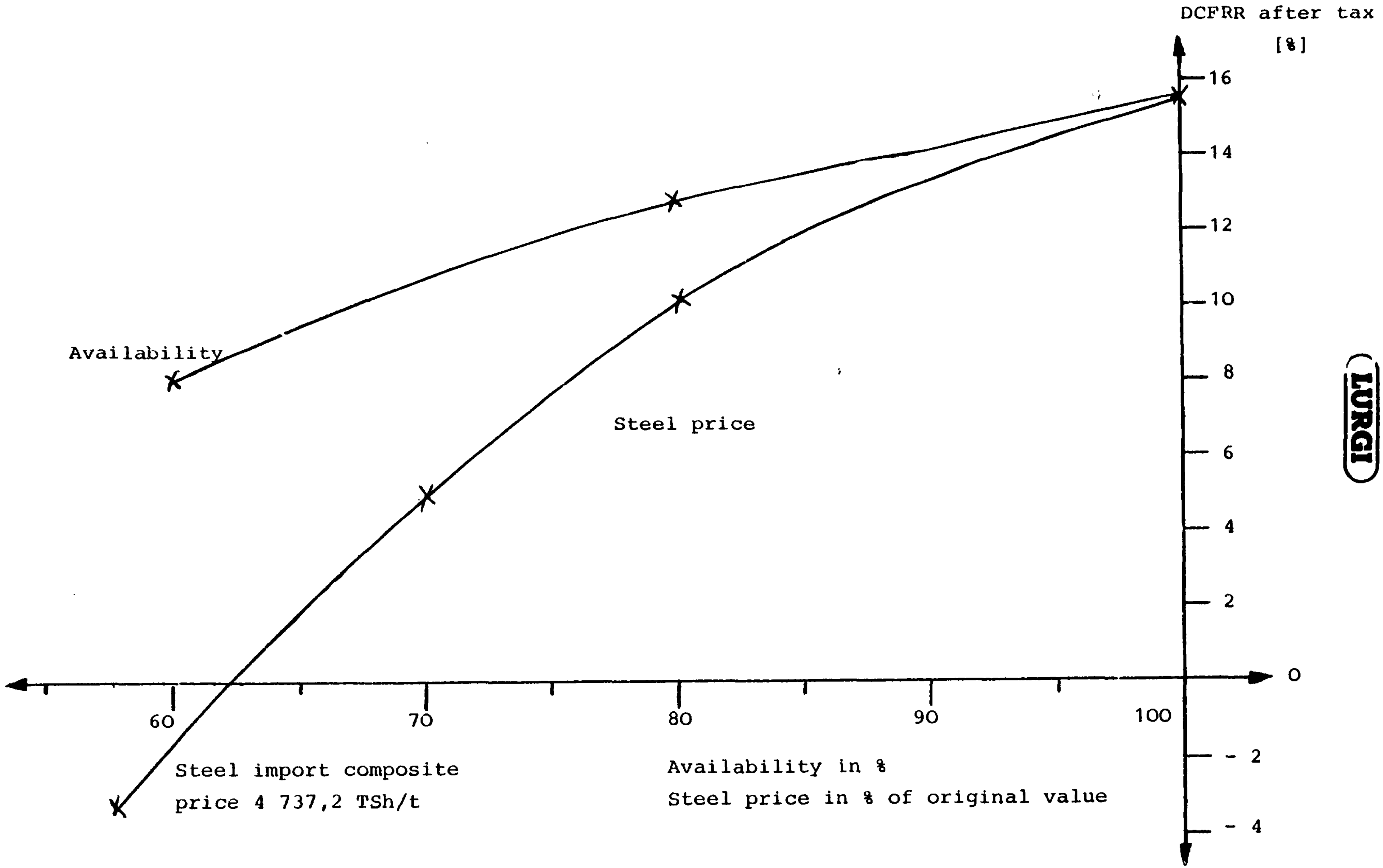
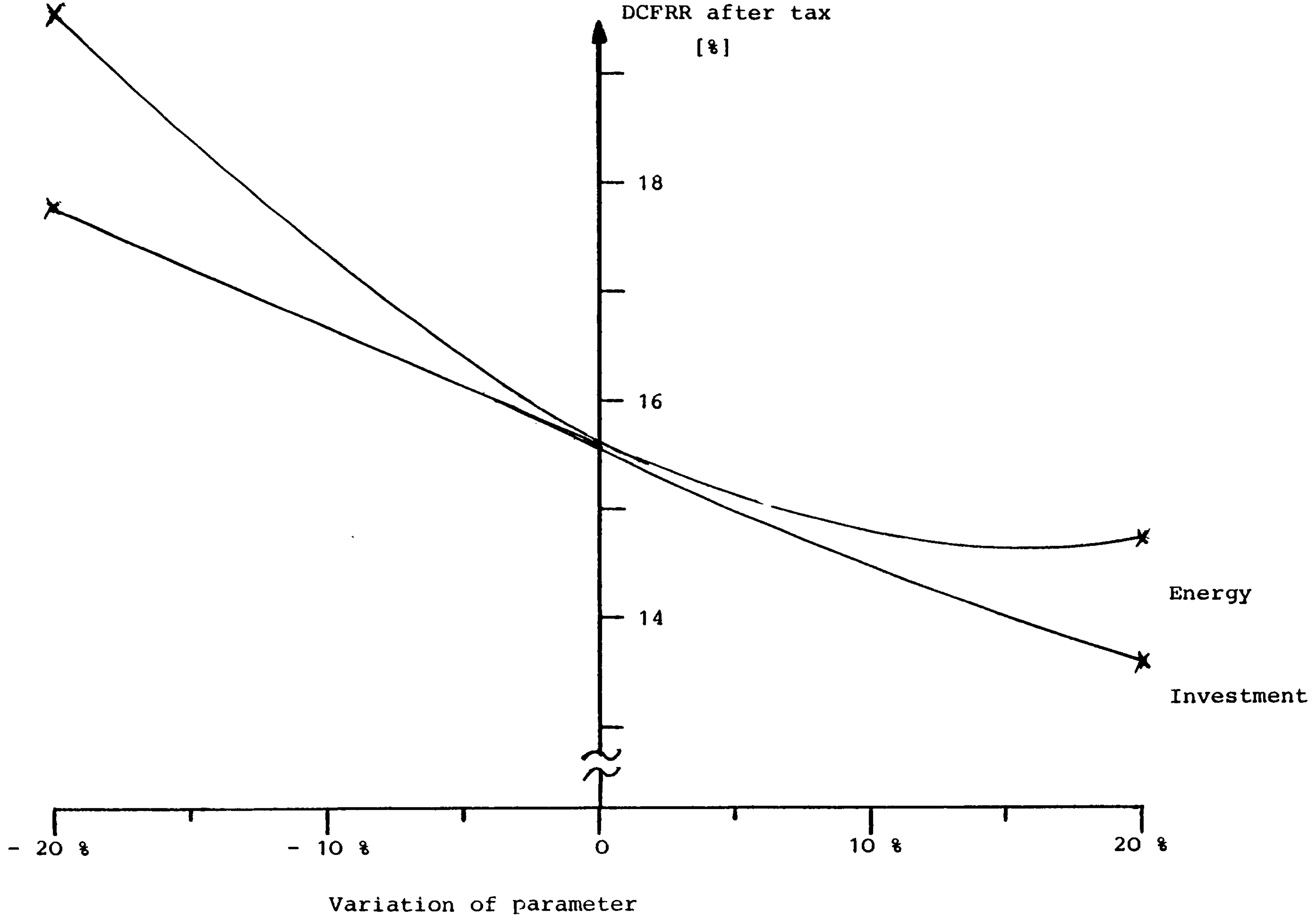


Fig. V /2 - Sensitivity analysis: Va: .tion of energy price and inve ıent capital requirement ± 20



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ANNEX

LURGI CHEMIE — ECONOMIC ANALYSIS
11. 4.84 - 14/ 5/45 — STEEL WORK FOR TANZANIA 1984 (MIO TSH) — 1 —

OPERATING COST IN THE YEAR 4

VARIABLE COST

ITEM	SP. CONS	* PRICE	* AMOUNT	= COST
COAL	1.000	0.455	342.150	155.576
ELECTR.	1.581	0.716	342.150	387.214
H.FUEL	0.088	2.368	342.150	71.315
L.FUEL	0.006	4.945	342.150	9.769
PROPANE	0.116	5.725	342.150	226.908
CHAR	0.018	1.360	342.150	8.497
ALLOYS	0.012	8.710	342.150	34.569
BINDER	0.002	0.250	342.150	0.171
BENTON.	0.014	0.330	342.150	1.565
BITES	0.001	2.364	342.150	0.489
EXPLOS.	0.001	8.428	342.150	3.449
TIRES	0.009	0.386	342.150	1.155
MILL U.	0.021	1.000	342.150	7.084
PASTE	0.005	7.355	342.150	11.953
CC-STEEL	0.001	9.000	342.150	4.533
GRAPHITE	0.001	28.150	342.150	11.250
POWDER	0.001	8.710	342.150	2.444
OTHER	0.125	1.000	342.150	42.671
TRANSP.	0.268	1.000	342.150	91.795
L.D.O.	0.112	1.000	342.150	38.170
SUB TOTAL				1110.573

FIXED COST

ITEM	COST
BITES	0.714
TIRES	1.698
MILL UT.	10.352
PASTE	17.468
CC-STEEL	6.624
REFRACT.	174.558
OTHER	118.031
LABOUR	53.233
MAINTEN.	50.707
INSURAN.	16.015
SUB TOTAL	449.389
TOTAL	1559.961

SALES IN THE YEAR 4

ITEM	PRICE	* AMOUNT	= REVENUE
PLATES	8.012	68.430	548.227
STRIPS	8.310	273.720	2274.666
TOTAL			2822.893

OPERATING COST IN THE YEAR 5

VARIABLE COST

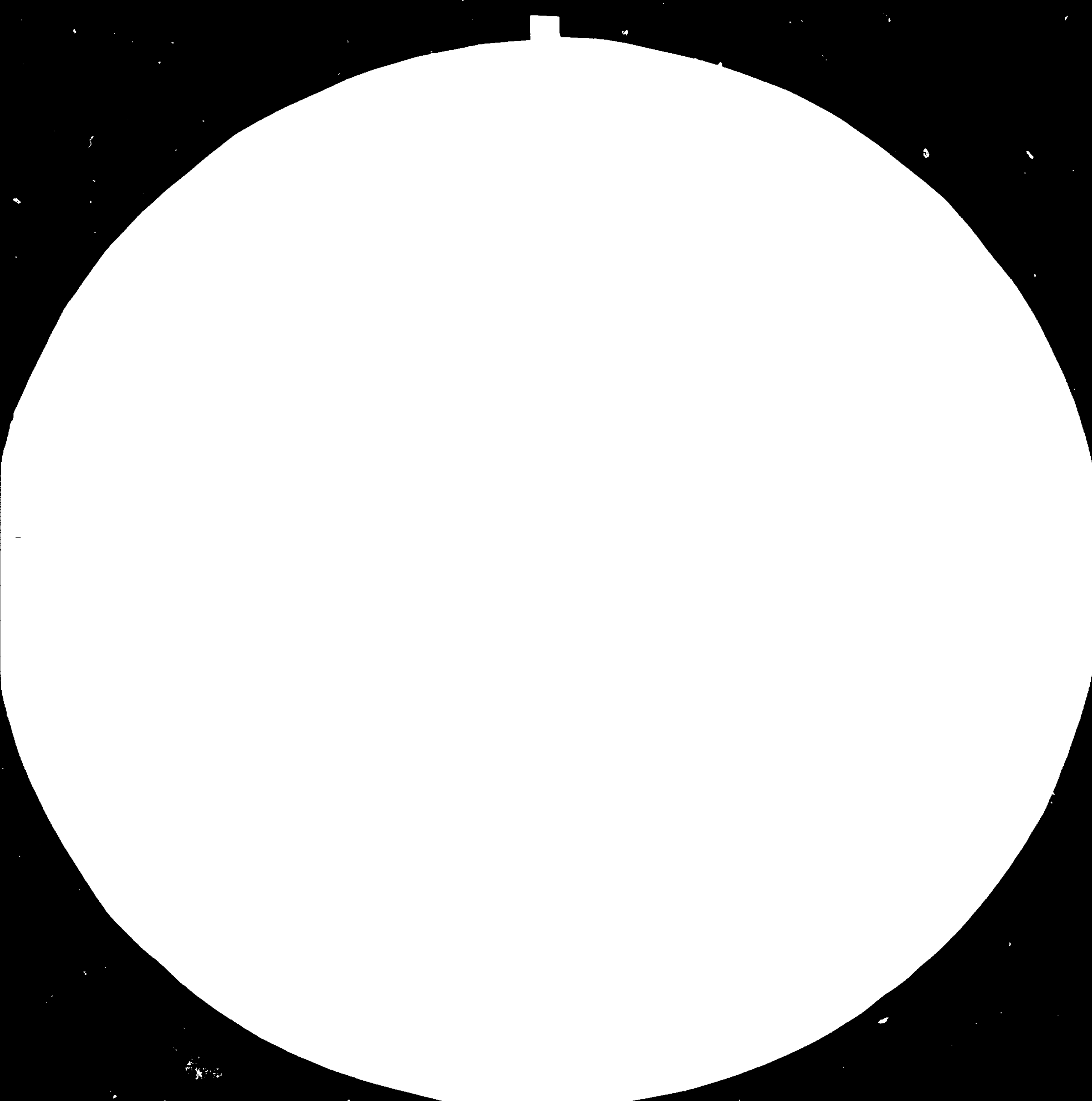
ITEM	SP. CONS *	PRICE *	AMOUNT =	COST
COAL	1.000	0.455	490.200	222.894
ELECTR.	1.581	0.716	490.200	554.764
H.FUEL	0.088	2.368	490.200	102.173
L.FUEL	0.006	4.945	490.200	13.996
PROPANE	0.116	5.725	490.200	325.093
CHAR	0.018	1.360	490.200	12.173
ALLOYS	0.012	8.710	490.200	49.528
BINDER	0.002	0.250	490.200	0.245
BENTON.	0.014	0.330	490.200	2.242
BITES	0.001	2.364	490.200	0.700
EXPLOS.	0.001	8.428	490.200	4.941
TIRES	0.009	0.386	490.200	1.655
MILL UT.	0.021	1.000	490.200	10.149
PASTE	0.005	7.355	490.200	17.126
CO-STEEL	0.001	9.000	490.200	6.494
GRAPHITE	0.001	29.150	490.200	16.117
POWDER	0.001	8.710	490.200	3.501
OTHER	0.125	1.000	490.200	61.134
TRANSP.	0.248	1.000	490.200	131.518
L.D.O.	0.112	1.000	490.200	54.686
SUB TOTAL				1591.125

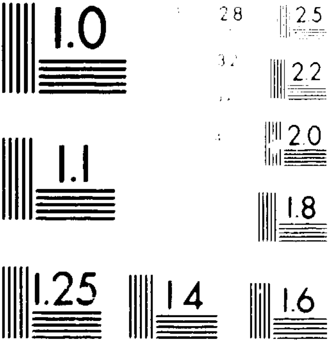
FIXED COST

ITEM	COST
BITES	0.714
TIRES	1.698
MILL UT.	10.352
PASTE	17.468
CO-STEEL	6.624
REFRACT.	174.558
OTHER	118.031
LABOUR	53.233
MAINTEN.	50.707
INSURAN.	16.015
SUB TOTAL	449.399
TOTAL	2040.513

SALES IN THE YEAR 5

ITEM	PRICE *	AMOUNT =	REVENUE
PLATES	8.012	98.040	785.447
STRIPS	8.310	392.160	3258.927
TOTAL			4044.374





MICROCOPY RESOLUTION TEST CHART

LURGI CHEMIE — ECONOMIC ANALYSIS

11.4.86 - 14/5/65 — STEEL WORKS FOR TANZANIA 1984 ([illegible])

-3-

OPERATING COST IN THE YEAR 6

VARIABLE COST

ITEM	SP. CONS. *	PRICE *	AMOUNT =	COST
COAL	1.000	0.455	500.000	227.350
ELECTR.	1.581	0.715	500.000	565.354
H.FUEL	0.088	2.368	500.000	104.216
L.FUEL	0.004	4.045	500.000	14.276
PROPANE	0.116	5.725	500.000	331.592
CHAR	0.018	1.360	500.000	12.417
ALLOYS	0.012	8.710	500.000	50.518
BINDER	0.002	0.250	500.000	0.250
ELECTRON.	0.014	0.330	500.000	2.287
BITES	0.001	2.364	500.000	0.714
EXPERTS.	0.001	9.428	500.000	5.240
TIRES	0.009	0.386	500.000	1.698
FEED OIL	0.021	1.000	500.000	10.352
PASTE	0.005	7.355	500.000	17.468
GC-STEEL	0.001	9.000	500.000	5.424
GRAPHITE	0.001	29.150	500.000	14.449
POWDER	0.001	9.710	500.000	3.471
OTHER	0.125	1.000	500.000	62.356
TRANSP.	0.268	1.000	500.000	134.145
L.D.O.	0.112	1.000	500.000	55.779
SUB TOTAL				1622.935

FIXED COST

ITEM	COST
BITES	0.714
TIRES	1.698
FEED OIL	10.352
PASTE	17.468
GC-STEEL	5.424
REFRACT.	174.659
OTHER	119.31[illegible]
LABOUR	63.233
MAINTEN.	36.707
INSURAN.	15.[illegible]15
SUB TOTAL	449.389
TOTAL	2072.323

SALES IN THE YEAR 6

ITEM	PRICE *	AMOUNT =	REVENUE
PLATES	8.012	100.000	801.150
STRIPS	8.310	400.000	3324.[illegible]
TOTAL			4125.227

LURGI CHEMIE
11. 4.84 - 14/ 5/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH)

	YEAR	1	2	3	4	5
2	REVENUE	0.0	0.0	0.0	2822.893	4044.374
3	OPERAT. COST	0.0	0.0	0.0	1559.961	2040.513
4	PROFIT MARG.	0.0	0.0	0.0	1262.932	2003.861
5	INTEREST	0.0	0.0	0.0	778.432	700.493
6	DEPRECIATION	0.0	0.0	0.0	874.050	869.621
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	433.747
8	PROFIT B TAX	0.0	0.0	0.0	-389.550	0.0
9	TAXES	0.0	0.0	0.0	0.0	0.0
10	PROFIT	0.0	0.0	0.0	-389.550	433.747
11	PROFIT MARG.	0.0	0.0	0.0	1262.932	2003.861
12	EQUIPMENT	410.778	1867.801	2151.833	469.854	0.0
13	CIVIL WORK	150.000	802.416	786.776	104.151	0.0
14	VEHICLES	0.0	36.270	196.546	6.844	10.468
15	COST B STU	1.900	28.738	213.372	0.938	0.0
16	INT. D.C.	28.134	193.029	497.216	0.0	0.0
17	WORK CAPIT.	0.0	0.0	272.912	438.870	79.769
18	TOT INVESTM.	590.812	2928.253	4118.652	1020.657	90.237
19	CASH FLOW BT	-590.812	-2928.253	-4118.652	242.275	1913.624
20	TAXES	0.0	0.0	0.0	0.0	0.0
21	CASH FLOW AT	-590.812	-2928.253	-4118.652	242.275	1913.624
22	ACC. DEPREC.	0.0	0.0	0.0	874.050	1743.671
23	ACC. INVEST.	590.812	3519.065	7637.715	8658.371	8748.605
24	ACC. C.F. BT	-590.812	-3519.065	-7637.715	-7395.437	-5481.812
25	ACC. C.F. AT	-590.812	-3519.065	-7637.715	-7395.437	-5481.812
26	ACC. TAXES	0.0	0.0	0.0	0.0	0.0
27	BREAK EVEN P	0.0	0.0	0.0	122.750	82.319

LURGI CHEMIE
11. 4.84 - 14/ 5/45

STEEL WORK FOR TANZANIA 1984 ECONOMI

	YEAR	6	7
2	REVENUE	4125.227	4125.227
3	OPERAT. COST	2072.323	2072.323
4	PROFIT MARG.	2052.904	2052.904
5	INTEREST	620.061	548.621
6	DEPRECIA..ON	804.324	744.900
7	TAX ALLOWAN.	628.519	759.383
8	PROFIT B TAX	0.0	0.0
9	TAXES	0.0	0.0
10	PROFIT	628.519	759.383
11	PROFIT MARG.	2052.904	2052.904
12	EQUIPMENT	0.0	0.0
13	CIVIL WORK	0.0	0.0
14	VEHICLES	0.0	30.504
15	COST B STU	0.0	0.0
16	INT. D.C.	0.0	0.0
17	WORK CAPIT.	0.0	0.0
18	TOT INVESTM.	0.0	30.504
19	CASH FLOW BT	2052.904	2022.400
20	TAXES	0.0	0.0
21	CASH FLOW AT	2052.904	2022.400
22	ACC. DEPREC.	2547.995	3292.895
23	ACC. INVEST.	8748.605	8779.109
24	ACC. C.F. BT	-3428.909	-1406.509
25	ACC. C.F. AT	-3428.909	-1406.509
26	ACC. TAXES	0.0	0.0
27	BREAK EVEN P	74.882	69.652

C ANALYSIS
(MIO ISH)

8	9	10
4125.227	4125.227	4125.227
2072.323	2072.323	2072.323
2052.904	2052.904	2052.904
504.457	460.558	419.948
642.326	452.812	412.949
155.182	0.0	0.0
750.939	1139.534	1220.007
375.469	569.767	610.004
530.652	569.767	610.004
2052.904	2052.904	2052.904
0.0	0.0	0.0
0.0	3.350	0.0
200.687	10.468	6.844
0.0	0.0	0.0
0.0	0.0	0.0
0.0	0.0	0.0
200.687	13.818	6.844
1852.217	2039.086	2046.060
375.469	569.767	610.004
1476.747	1469.319	1436.056
3935.221	4388.031	4800.977
8979.793	8993.609	9000.453
445.708	2484.794	4530.852
70.238	1539.558	2975.614
375.469	945.236	1555.240
63.788	54.460	51.244

LURGI CHEMIE
11. 4.84 - 142 5745

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH)

	YEAR	11	12	13	14	15
2	REVENUE	4125.227	4125.227	4125.227	4125.227	4125.227
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	2072.323
4	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	2052.904
5	INTEREST	382.327	351.246	342.521	316.619	289.925
6	DEPRECIATION	379.826	342.626	273.576	294.186	280.828
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	0.0
8	PROFIT B TAX	1290.750	1359.031	1436.806	1442.099	1482.151
9	TAXES	645.375	679.515	718.403	721.050	741.075
10	PROFIT	645.375	679.516	718.403	721.050	741.076
11	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	2052.904
12	EQUIPMENT	0.0	1.316	0.0	0.0	0.0
13	CIVIL WORK	0.0	0.0	0.0	0.0	0.0
14	VEHICLES	3.623	30.503	186.328	35.160	13.890
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	3.623	31.819	186.328	35.160	13.890
19	CASH FLOW BT	2049.281	2021.085	1866.576	2017.744	2039.014
20	TAXES	645.375	679.515	718.403	721.050	741.075
21	CASH FLOW AT	1403.906	1341.569	1148.173	1296.694	1297.938
22	ACC. DEPREC.	5180.801	5523.426	5797.000	6091.184	6372.008
23	ACC. INVEST.	9004.074	9035.891	9222.215	9257.371	9271.258
24	ACC. C.F. BT	6580.129	8601.211	10467.785	12485.527	14524.539
25	ACC. C.F. AT	4379.520	5721.086	6869.258	8165.949	9463.887
26	ACC. TAXES	2200.615	2880.130	3598.533	4319.582	5060.656
27	BREAK EVEN P	48.417	45.688	42.580	42.369	40.768

LURGI CHEMIE
11. 4.84 - 14/ 5/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH)

	YEAR	16	17	18	19	20
2	REVENUE	4125.227	4125.227	4125.227	4125.227	0.0
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	0.0
4	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	2231.539
5	INTEREST	264.051	243.375	243.143	223.154	0.0
6	DEPRECIATION	265.512	243.229	192.075	218.743	0.0
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	0.0
8	PROFIT B TAX	1523.341	1566.299	1617.686	1611.007	2231.539
9	TAXES	761.670	783.149	808.843	805.503	0.0
10	PROFIT	761.670	783.149	808.843	805.503	2231.539
11	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	2231.539
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	3.350	0.0	0.0	0.0	0.0
14	VEHICLES	3.422	36.475	189.750	18.855	0.0
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	6.772	36.475	189.750	18.855	0.0
19	CASH FLOW BT	2046.132	2016.429	1863.154	2034.049	2231.539
20	TAXES	761.670	783.149	808.843	805.503	0.0
21	CASH FLOW AT	1284.461	1233.279	1054.311	1228.545	2231.539
22	ACC. DEPREC.	6637.520	6880.746	7072.820	7291.562	7291.562
23	ACC. INVEST	9278.027	9314.500	9504.250	9523.102	9523.102
24	ACC. C.F. BT	16570.668	18587.094	20450.246	22484.293	24715.832
25	ACC. C.F. AT	10748.348	11981.625	13035.934	14264.477	16496.016
26	ACC. TAXES	5822.324	6605.473	7414.312	8219.812	8219.812
27	BREAK EVEN P	39.122	37.405	35.352	35.619	0.0

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH)

PROFITABILITY CALCULATIONS

DCFRR: BEFORE TAX: 19.043(%) AFTER TAX: 15.629(%)

NET PRESENT VALUE: BEFORE TAX: 5260.789 DISCOUNT RATE: 10.000(%)

AFTER TAX : 2766.018 DISCOUNT RATE: 10.000(%)

PAY OUT TIME (AFTER TAX): 4.416(YEARS)

ACC. CASH FLOW BEFORE TAX: 24715.832

ACC. CASH FLOW AFTER TAX : 16496.016

ACC. TAXES: 8219.812

ACC. INTEREST: 6688.918

TOTAL CAPITAL REQUIREMENT: 9523.102 WORKING CAPITAL: 791.551

AVERAGE BREAK EVEN POINT: 55.401(%)

LURGI CHEMIE
11. 4.84 - 14/ 5/45

ECONOMIC ANALYSIS

STEEL WORK FOR TANZANIA 1984 (MIO TSH) INVEST +20 %

S-1-

	YEAR	1	2	3	4	5
2	REVENUE	0.0	0.0	0.0	2822.893	4044.374
3	OPERAT. COST	0.0	0.0	0.0	1559.961	2040.513
4	PROFIT MARG.	0.0	0.0	0.0	1262.932	2003.861
5	INTEREST	0.0	0.0	0.0	919.883	824.761
6	DEPRECIATION	0.0	0.0	0.0	1048.860	1043.545
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	135.554
8	PROFIT B TAX	0.0	0.0	0.0	-705.811	0.0
9	TAXES	0.0	0.0	0.0	0.0	0.0
10	PROFIT	0.0	0.0	0.0	-705.811	135.554
11	PROFIT MARG.	0.0	0.0	0.0	1262.932	2003.861
12	EQUIPMENT	492.934	2241.361	2582.200	563.825	0.0
13	CIVIL WORK	180.000	562.900	944.131	124.981	0.0
14	VEHICLES	0.0	43.524	235.855	8.213	12.562
15	COST B STU	2.280	34.486	256.046	1.126	0.0
16	INT. D.C.	33.761	231.635	596.659	0.0	0.0
17	WORK CAPIT.	0.0	0.0	272.912	438.870	79.769
18	TOT INVESTM.	708.975	3513.906	4887.801	1137.014	92.331
19	CASH FLOW BT	-708.975	-3513.906	-4887.801	125.918	1911.530
20	TAXES	0.0	0.0	0.0	0.0	0.0
21	CASH FLOW AT	-708.975	-3513.906	-4887.801	125.918	1911.530
22	ACC. DEPREC.	0.0	0.0	0.0	1048.860	2092.405
23	ACC. INVEST.	708.975	4222.879	9110.680	10247.691	10340.020
24	ACC. C.F. BT	-708.975	-4222.879	-9110.680	-8984.762	-7073.230
25	ACC. C.F. AT	-708.975	-4222.879	-9110.680	-8984.762	-7073.230
26	ACC. TAXES	0.0	0.0	0.0	0.0	0.0
27	BREAK EVEN P	0.0	0.0	0.0	141.220	94.474

LURGI CHEMIE

11. 4.84 - 142 5245

S -2-

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) INVEST +20 %

	YEAR	6	7	8	9	10
2	REVENUE	4125.227	4125.227	4125.227	4125.227	4125.227
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	2072.323
4	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	2052.904
5	INTEREST	728.242	642.514	589.518	536.838	488.106
6	DEPRECIATION	965.189	893.880	770.791	543.375	495.539
7	TAX ALLOWAN.	359.472	516.509	692.595	972.691	5.819
8	PROFIT B TAX	0.0	0.0	0.0	0.0	1063.440
9	TAXES	0.0	0.0	0.0	0.0	531.720
10	PROFIT	359.472	516.509	692.595	972.691	537.539
11	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	2052.904
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	0.0	0.0	0.0	4.020	0.0
14	VEHICLES	0.0	36.605	240.824	12.561	8.213
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	0.0	36.605	240.824	16.581	8.213
19	CASH FLOW BT	2052.904	2016.299	1812.080	2036.323	2044.691
20	TAXES	0.0	0.0	0.0	0.0	531.720
21	CASH FLOW AT	2052.904	2016.299	1812.080	2036.323	1512.970
22	ACC. DEPREC.	3057.594	3951.474	4722.266	5265.637	5761.172
23	ACC. INVEST.	10340.020	10376.621	10617.441	10634.020	10642.230
24	ACC. C.F. BT	-5020.324	-3004.026	-1191.946	844.377	2889.067
25	ACC. C.F. AT	-5020.324	-3004.026	-1191.946	844.377	2357.347
26	ACC. TAXES	0.0	0.0	0.0	0.0	531.720
27	BREAK EVEN P	85.634	79.359	72.322	61.128	57.269

LURGI CHEMIE
11. 4.84 - 147 5/45

ECONOMIC ANALYSIS

STEEL WORK FOR TANZANIA 1984 (MIO TSH) INVEST +20 %

S-3-

	YEAR	11	12	13	14	15
2	REVENUE	4125.227	4125.227	4125.227	4125.227	4125.227
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	2072.323
4	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	2052.904
5	INTEREST	442.962	405.664	395.195	364.112	332.080
6	DEPRECIATION	455.792	411.152	328.292	353.022	336.993
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	0.0
8	PROFIT B TAX	1154.150	1236.087	1329.417	1335.770	1383.831
9	TAXES	577.075	618.043	664.709	667.885	691.916
10	PROFIT	577.075	618.044	664.709	667.885	691.916
11	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	2052.904
12	EQUIPMENT	0.0	1.579	0.0	0.0	0.0
13	CIVIL WORK	0.0	0.0	0.0	0.0	0.0
14	VEHICLES	4.348	36.604	223.594	42.192	16.668
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	4.348	38.183	223.594	42.192	16.668
19	CASH FLOW BT	2048.556	2014.721	1829.310	2010.712	2036.236
20	TAXES	577.075	618.043	664.709	667.885	691.916
21	CASH FLOW AT	1471.480	1396.677	1164.601	1342.827	1344.320
22	ACC. DEPREC.	6216.961	6628.113	6956.402	7309.422	7646.414
23	ACC. INVEST.	10646.578	10684.758	10908.352	10950.543	10967.211
24	ACC. C.F. BT	4937.621	6952.340	8781.648	10792.359	12828.594
25	ACC. C.F. AT	3828.828	5225.504	6390.102	7732.926	9077.242
26	ACC. TAXES	1108.795	1726.839	2391.548	3059.432	3751.348
27	BREAK EVEN P	53.876	50.602	46.872	46.618	44.697

LURGI CHEMIE
11. 4.84 - 14/ 5/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) INVEST +20 %

S -4-

	YEAR	16	17	18	19	20
2	REVENUE	4125.227	4125.227	4125.227	4125.227	0.0
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	0.0
4	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	2519.555
5	INTEREST	301.031	276.221	275.942	251.956	0.0
6	DEPRECIATION	318.615	291.875	230.490	262.492	0.0
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	0.0
8	PROFIT B TAX	1433.258	1484.808	1546.472	1538.457	2519.555
9	TAXES	716.629	742.404	773.236	769.228	0.0
10	PROFIT	716.629	742.404	773.236	769.228	2519.555
11	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	2519.555
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	4.020	0.0	0.0	0.0	0.0
14	VEHICLES	4.106	43.770	227.700	22.626	0.0
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	8.126	43.770	227.700	22.626	0.0
19	CASH FLOW BT	2044.777	2009.134	1825.204	2030.278	2519.555
20	TAXES	716.629	742.404	773.236	769.228	0.0
21	CASH FLOW AT	1328.148	1266.730	1051.968	1261.049	2519.555
22	ACC. DEPREC.	7965.027	8256.898	8487.387	8749.875	8749.875
23	ACC. INVEST.	10975.336	11019.105	11246.805	11269.430	11269.430
24	ACC. C.F. BT	14873.371	16882.504	18707.707	20737.984	23257.539
25	ACC. C.F. AT	10405.391	11672.117	12724.082	13985.129	16504.684
26	ACC. TAXES	4467.977	5210.379	5983.613	6752.840	6752.840
27	BREAK EVEN P	42.722	40.662	38.198	38.518	0.0

LURGI CHEMIE
11. 4.84 - 10/58/34

ECONOMIC ANALYSIS

STEEL WORK FOR TANZANIA 1984 (MIO TSH) INVEST +20 %

S-5-

PROFITABILITY CALCULATIONS

DCFRR: BEFORE TAX: 15.844(%) AFTER TAX: 13.479(%)

NET PRESENT VALUE: BEFORE TAX: 3879.646 DISCOUNT RATE:10.000(%)

AFTER TAX : 2003.096 DISCOUNT RATE:10.000(%)

PAY OUT TIME (AFTER TAX): 5.197(YEARS)

ACC. CASH FLOW BEFORE TAX: 23257.539

ACC. CASH FLOW AFTER TAX : 16504.684

ACC. TAXES: 6752.840

ACC. INTEREST: 7775.004

TOTAL CAPITAL REQUIREMENT: 11269.430 WORKING CAPITAL: 791.551

AVERAGE BREAK EVEN POINT: 62.136(%)

LURGI CHEMIE
11. 4.84 - 147 5745

S-6-

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) INVEST -20 %

	YEAR	1	2	3	4	5
2	REVENUE	0.0	0.0	0.0	2822.893	4044.374
3	OPERAT. COST	0.0	0.0	0.0	1559.961	2040.513
4	PROFIT MARG.	0.0	0.0	0.0	1262.932	2003.861
5	INTEREST	0.0	0.0	0.0	636.981	576.226
6	DEPRECIATION	0.0	0.0	0.0	699.240	695.696
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	731.939
8	PROFIT B TAX	0.0	0.0	0.0	-73.289	0.0
9	TAXES	0.0	0.0	0.0	0.0	0.0
10	PROFIT	0.0	0.0	0.0	-73.289	731.939
11	PROFIT MARG.	0.0	0.0	0.0	1262.932	2003.861
12	EQUIPMENT	328.622	1494.241	1721.466	375.883	0.0
13	CIVIL WORK	120.000	641.933	629.421	83.321	0.0
14	VEHICLES	0.0	29.016	157.237	5.475	8.374
15	COST B STU	1.520	22.990	170.698	0.750	0.0
16	INT. D.C.	22.507	154.423	397.773	0.0	0.0
17	WORK CAPIT.	0.0	0.0	272.912	438.870	79.769
18	TOT INVESTM.	472.649	2342.603	3349.507	904.299	88.143
19	CASH FLOW BT	-472.649	-2342.603	-3349.507	358.633	1915.718
20	TAXES	0.0	0.0	0.0	0.0	0.0
21	CASH FLOW AT	-472.649	-2342.603	-3349.507	358.633	1915.718
22	ACC. DEPREC.	0.0	0.0	0.0	699.240	1394.936
23	ACC. INVEST.	472.649	2815.251	6164.758	7069.055	7157.195
24	ACC. C.F. BT	-472.649	-2815.251	-6164.758	-5806.121	-3890.403
25	ACC. C.F. AT	-472.649	-2815.251	-6164.758	-5806.121	-3890.403
26	ACC. TAXES	0.0	0.0	0.0	0.0	0.0
27	BREAK EVEN P	0.0	0.0	0.0	104.280	70.164

LURGI CHEMIE
11. 4.84 - 147 S/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) INVEST -20 %

S -7-

	YEAR	6	7	8	9	10
2	REVENUE	4125.227	4125.227	4125.227	4125.227	4125.227
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	2072.323
4	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	2052.904
5	INTEREST	511.880	454.728	419.396	384.277	351.788
6	DEPRECIATION	643.459	595.919	513.859	362.249	330.358
7	TAX ALLOWAN.	897.565	1002.257	124.169	0.0	0.0
8	PROFIT B TAX	0.0	0.0	995.480	1306.378	1370.757
9	TAXES	0.0	0.0	497.740	653.189	685.378
10	PROFIT	897.565	1002.257	621.909	653.189	685.379
11	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	2052.904
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	0.0	0.0	0.0	2.680	0.0
14	VEHICLES	0.0	24.400	160.550	8.374	5.475
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	0.0	24.400	160.550	11.054	5.475
19	CASH FLOW BT	2052.904	2028.504	1892.354	2041.850	2047.429
20	TAXES	0.0	0.0	497.740	653.189	685.378
21	CASH FLOW AT	2052.904	2028.504	1394.614	1388.660	1362.050
22	ACC. DEPREC.	2038.395	2634.314	3148.173	3510.421	3840.780
23	ACC. INVEST.	7157.195	7181.594	7342.141	7353.191	7358.664
24	ACC. C.F. BT	-1837.499	191.004	2083.358	4125.207	6172.633
25	ACC. C.F. AT	-1837.499	191.004	1585.618	2974.279	4336.328
26	ACC. TAXES	0.0	0.0	497.740	1150.929	1836.307
27	BREAK EVEN P	64.130	59.946	55.255	47.793	45.220

LURGI CHEMIE
11. 4.84 - 14/ 5/45

ECONOMIC ANALYSIS

STEEL WORK FOR TANZANIA 1984 (MIO TSH) INVEST =20 %

S-8-

	YEAR	11	12	13	14	15
2	REVENUE	4125.227	4125.227	4125.227	4125.227	4125.227
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	2072.323
4	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	2052.904
5	INTEREST	321.692	296.827	289.847	269.125	247.770
6	DEPRECIATION	303.861	274.102	218.861	235.348	224.662
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	0.0
8	PROFIT B TAX	1427.351	1481.975	1544.196	1548.431	1580.472
9	TAXES	713.676	740.988	772.098	774.216	790.236
10	PROFIT	713.676	740.988	772.098	774.216	790.236
11	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	2052.904
12	EQUIPMENT	0.0	1.053	0.0	0.0	0.0
13	CIVIL WORK	0.0	0.0	0.0	0.0	0.0
14	VEHICLES	2.898	24.400	149.062	28.128	11.112
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	2.898	25.453	149.062	28.128	11.112
19	CASH FLOW BT	2050.006	2027.451	1903.842	2024.776	2041.792
20	TAXES	713.676	740.988	772.098	774.216	790.236
21	CASH FLOW AT	1336.330	1286.463	1131.744	1250.560	1251.556
22	ACC. DEPREC.	4144.637	4418.738	4637.598	4872.945	5097.605
23	ACC. INVEST.	7361.559	7387.008	7536.066	7564.191	7575.301
24	ACC. C.F. BT	8222.637	10250.086	12153.926	14178.699	16220.488
25	ACC. C.F. AT	5672.656	6959.117	8090.859	9341.418	10592.973
26	ACC. TAXES	2549.983	3290.970	4063.068	4837.281	5627.516
27	BREAK EVEN P	42.958	40.775	38.289	38.119	36.839

[illegible]ORGI CHEMIE
11. 4.84 - 147 5/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) INVEST -20 %

S-9-

	YEAR	16	17	18	19	20
2	REVENUE	4125.227	4125.227	4125.227	4125.227	0.0
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	0.0
4	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	1943.531
5	INTEREST	227.071	210.531	210.344	194.353	0.0
6	DEPRECIATION	212.409	194.584	153.660	174.995	0.0
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	0.0
8	PROFIT B TAX	1613.424	1647.790	1688.899	1683.556	1943.531
9	TAXES	806.712	823.895	844.449	841.778	0.0
10	PROFIT	806.712	823.895	844.450	841.778	1943.531
11	PROFIT MARG.	2052.904	2052.904	2052.904	2052.904	1943.531
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	2.680	0.0	0.0	0.0	0.0
14	VEHICLES	2.738	29.180	151.800	15.084	0.0
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	5.418	29.180	151.800	15.084	0.0
19	CASH FLOW BT	2047.486	2023.724	1901.104	2037.820	1943.531
20	TAXES	806.712	823.895	844.449	841.778	0.0
21	CASH FLOW AT	1240.774	1199.829	1056.654	1196.042	1943.531
22	ACC. DEPREC.	5310.012	5504.594	5658.254	5833.246	5833.246
23	ACC. INVEST.	7580.719	7609.898	7761.695	7776.777	7776.777
24	ACC. C.F. BT	18267.973	20291.695	22192.797	24230.613	26174.145
25	ACC. C.F. AT	11833.746	13033.574	14090.227	15286.266	17229.797
26	ACC. TAXES	6434.227	7258.121	8102.570	8944.348	8944.348
27	BREAK EVEN P	35.522	34.149	32.506	32.719	0.0

LURGI CHEMIE
11.4.84 - 10758/34

ECONOMIC ANALYSIS

STEEL WORK FOR TANZANIA 1984 (MIO TSH) INVEST =20 %

S-10-

PROFITABILITY CALCULATIONS

DCFRR: BEFORE TAX: 23.385(%) AFTER TAX: 19.525(%)

NET PRESENT VALUE: BEFORE TAX: 6641.937 DISCOUNT RATE: 10.000(%)

AFTER TAX : 3886.990 DISCOUNT RATE: 10.000(%)

PAY OUT TIME (AFTER TAX): 3.516(YEARS)

ACC. CASH FLOW BEFORE TAX: 26174.145

ACC. CASH FLOW AFTER TAX : 17229.797

ACC. TAXES: 8944.348

ACC. INTEREST: 5602.824

TOTAL CAPITAL REQUIREMENT: 7776.777 WORKING CAPITAL: 791.551

AVERAGE BREAK EVEN POINT: 48.666(%)

LURGI CHEMIE ECONOMIC ANALYSIS

[illegible] STEEL WORK FOR TANZANIA [illegible]

[illegible]

OPERATING COST IN THE YEAR 6

S-11-

VARIABLE COST

ITEM	SP. CONS.	* PRICE	* AMOUNT	= COST
COAL	1.000	[illegible]	500.000	[illegible]
ELECTR.	1.581	0.359	500.000	479.026 ✓
H.FUEL	[illegible]	[illegible]	[illegible]	[illegible]
L.FUEL	0.006	5.934	500.000	17.131 ✓
PROPANE	[illegible]	[illegible]	500.000	[illegible]
CHAR	0.018	1.360	500.000	12.417 ✓
ALLOYS	[illegible]	[illegible]	500.000	[illegible]
BINDER	0.002	0.250	500.000	0.250
CARBON.	[illegible]	[illegible]	500.000	2.297
BITES	0.001	2.364	500.000	0.714
EXPLOS.	[illegible]	[illegible]	[illegible]	[illegible]
TIRES	0.009	0.386	500.000	1.688
MILL. IT.	0.021	1.000	500.000	10.352
PASTE	0.005	7.355	500.000	17.468
CO-STEEL	[illegible]	[illegible]	500.000	5.524
GRAPHITE	0.001	28.150	500.000	16.440
POWDER	[illegible]	[illegible]	500.000	3.571
OTHER	0.125	1.000	500.000	62.356
TRANSP.	[illegible]	1.000	500.000	[illegible]
L.O.O.	0.112	1.000	500.000	55.779
SUB TOTAL				1826.123

FIXED COST

ITEM	COST
BITES	0.714
TIRES	1.688
MILL. IT.	10.352
PASTE	17.468
CO-STEEL	5.524
REFRACT.	174.558
OTHER	[illegible]
LABOUR	53.233
MAINTEN.	[illegible]
INSURAN.	16.015
SUB TOTAL	[illegible]
TOTAL	[illegible]

SALES IN THE YEAR 6

ITEM	PRICE	* AMOUNT	= REVENUE
PLATES	[illegible]	[illegible]	[illegible]
STRIPS	8.310	400.000	3324.040
TOTAL			4125.227

LURGI CHEMIE ECONOMI

11. 4.84 - 14/ 5/45 STEEL WORK FOR TANZANIA 1984

	YEAR	1	2
2	REVENUE	0.0	0.0
3	OPERAT. COST	0.0	0.0
4	PROFIT MARG.	0.0	0.0
5	INTEREST	0.0	0.0
6	DEPRECIATION	0.0	0.0
7	TAX ALLOWAN.	0.0	0.0
8	PROFIT B TAX	0.0	0.0
9	TAXES	0.0	0.0
10	PROFIT	0.0	0.0
11	PROFIT MARG.	0.0	0.0
12	EQUIPMENT	410.778	1867.801
13	CIVIL WORK	150.000	802.416
14	VEHICLES	0.0	36.270
15	COST B STU	1.900	28.738
16	INT. D.C.	28.134	193.029
17	WORK CAPIT.	0.0	0.0
18	TOT INVESTM.	590.812	2928.253
19	CASH FLOW BT	-590.812	-2928.253
20	TAXES	0.0	0.0
21	CASH FLOW AT	-590.812	-2928.253
22	ACC. DEPREC.	0.0	0.0
23	ACC. INVEST.	590.812	3519.065
24	ACC. C.F. BT	-590.812	-3519.065
25	ACC. C.F. AT	-590.812	-3519.065
26	ACC. TAXES	0.0	0.0
27	BREAK EVEN P	0.0	0.0

C ANALYSIS
(MIO TSH) ENERGY'+20 %

S -12-

3	4	5
0.0	2822.893	4044.374
0.0	1699.002	2239.719
0.0	1123.891	1804.656
0.0	778.432	700.493
0.0	874.050	869.621
0.0	0.0	234.541
0.0	-528.591	0.0
0.0	0.0	0.0
0.0	-528.591	234.541
0.0	1123.891	1804.656
2151.833	469.854	0.0
786.776	104.151	0.0
196.546	6.844	10.468
213.372	0.938	0.0
497.216	0.0	0.0
272.912	438.870	79.769
4119.652	1020.657	90.237
-4118.652	103.234	1714.419
0.0	0.0	0.0
-4118.652	103.234	1714.419
0.0	874.050	1743.671
7637.715	8658.371	8748.605
-7637.715	-7534.480	-5820.059
-7637.715	-7534.480	-5820.059
0.0	0.0	0.0
0.0	133.598	89.595

LURGI CHEMIE
11. 4.84 - 142 5745

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) ENERGY +20 %

S-13-

	YEAR	6	7	8	9	10
2	REVENUE	4125.227	4125.227	4125.227	4125.227	4125.227
3	OPERAT. COST	2275.510	2275.510	2275.510	2275.510	2275.510
4	PROFIT MARG.	1849.716	1849.716	1849.716	1849.716	1849.716
5	INTEREST	620.061	548.621	504.457	460.558	419.948
6	DEPRECIATION	804.324	744.900	642.326	452.812	412.949
7	TAX ALLOWAN.	425.331	556.195	702.933	936.346	429.174
8	PROFIT B TAX	0.0	0.0	0.0	0.0	587.645
9	TAXES	0.0	0.0	0.0	0.0	293.823
10	PROFIT	425.331	556.195	702.933	936.346	722.997
11	PROFIT MARG.	1849.716	1849.716	1849.716	1849.716	1849.716
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	0.0	0.0	0.0	3.350	0.0
14	VEHICLES	0.0	30.504	200.687	10.468	6.844
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	0.0	30.504	200.687	13.818	6.844
19	CASH FLOW BT	1849.716	1819.212	1649.029	1835.898	1842.872
20	TAXES	0.0	0.0	0.0	0.0	293.823
21	CASH FLOW AT	1849.716	1819.212	1649.029	1835.898	1549.050
22	ACC. DEPREC.	2547.995	3292.895	3935.221	4388.031	4800.977
23	ACC. INVEST.	8748.605	8779.109	8979.793	8993.609	9000.453
24	ACC. C.F. BT	-3970.343	-2151.131	-502.102	1333.797	3176.669
25	ACC. C.F. AT	-3970.343	-2151.131	-502.102	1333.797	2882.846
26	ACC. TAXES	0.0	0.0	0.0	0.0	293.823
27	BREAK EVEN P	81.500	75.808	69.426	59.273	55.773

LURGI CHEMIE ECONOMI

11. 4.84 - 14/ 5/45 STEEL WORK FOR TANZANIA 1984

	YEAR	11	12
2	REVENUE	4125.227	4125.227
3	OPERAT. COST	2275.510	2275.510
4	PROFIT MARG.	1849.716	1849.716
5	INTEREST	382.327	351.246
6	DEPRECIATION	379.826	342.626
7	TAX ALLOWAN.	0.0	0.0
8	PROFIT B TAX	1087.562	1155.843
9	TAXES	543.781	577.922
10	PROFIT	543.781	577.922
11	PROFIT MARG.	1849.716	1849.716
12	EQUIPMENT	0.0	1.316
13	CIVIL WORK	0.0	0.0
14	VEHICLES	3.623	30.503
15	COST B STU	0.0	0.0
16	INT. D.C.	0.0	0.0
17	WORK CAPIT.	0.0	0.0
18	TOT INVESTM.	3.623	31.819
19	CASH FLOW BT	1846.093	1817.897
20	TAXES	543.781	577.922
21	CASH FLOW AT	1302.312	1239.975
22	ACC. DEPREC.	5180.801	5523.426
23	ACC. INVEST.	9604.074	9635.891
24	ACC. C.F. BT	5022.762	6840.656
25	ACC. C.F. AT	4185.156	5425.129
26	ACC. TAXES	837.604	1415.525
27	BREAK EVEN P	52.696	49.726

C ANALYSIS
(MID TSH) ENERGY +20 %

S-14-

13	14	15
4125.227	4125.227	4125.227
2275.510	2275.510	2275.510
1849.716	1849.716	1849.716
342.521	316.619	289.925
273.576	294.186	280.828
0.0	0.0	0.0
1233.619	1238.912	1278.963
616.809	619.456	639.482
616.809	619.456	639.482
1849.716	1849.716	1849.716
0.0	0.0	0.0
0.0	0.0	0.0
186.328	35.160	13.890
0.0	0.0	0.0
0.0	0.0	0.0
0.0	0.0	0.0
186.328	35.160	13.890
1663.388	1814.556	1835.826
616.809	619.456	639.482
1046.579	1195.100	1196.344
5797.000	6091.184	6372.008
9222.215	9257.371	9271.258
8504.043	10318.598	12154.422
6471.707	7666.805	8863.148
2032.334	2651.790	3291.272
46.343	46.113	44.371

KORGI CHEMIE
11. 4.84 - 14/ 5/45

S-15-

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) ENERGY +20 %

	YEAR	16	17	18	19	20
2	REVENUE	4125.227	4125.227	4125.227	4125.227	0.0
3	OPERAT. COST	2275.510	2275.510	2275.510	2275.510	0.0
4	PROFIT MARG.	1849.716	1849.716	1849.716	1849.716	2231.539
5	INTEREST	264.051	243.375	243.143	223.154	0.0
6	DEPRECIATION	265.512	243.229	192.075	218.743	0.0
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	0.0
8	PROFIT B TAX	1320.153	1363.111	1414.498	1407.819	2231.539
9	TAXES	660.076	681.555	707.249	703.909	0.0
10	PROFIT	660.076	681.556	707.249	703.909	2231.539
11	PROFIT MARG.	1849.716	1849.716	1849.716	1849.716	2231.539
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	3.350	0.0	0.0	0.0	0.0
14	VEHICLES	3.422	36.475	189.750	18.855	0.0
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	6.772	36.475	189.750	18.855	0.0
19	CASH FLOW BT	1842.944	1813.241	1659.966	1830.861	2231.539
20	TAXES	660.076	681.555	707.249	703.909	0.0
21	CASH FLOW AT	1182.867	1131.686	952.717	1126.951	2231.539
22	ACC. DEPREC.	6637.520	6880.746	7072.820	7291.562	7291.562
23	ACC. INVEST.	9278.027	9314.500	9504.250	9523.102	9523.102
24	ACC. C.F. BT	13997.363	15810.602	17470.566	19301.426	21532.965
25	ACC. C.F. AT	10046.016	11177.699	12130.414	13257.363	15488.902
26	ACC. TAXES	3951.348	4632.902	5340.148	6044.055	6044.055
27	BREAK EVEN P	42.580	40.711	38.476	38.767	0.0

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) ENERGY +20 %

PROFITABILITY CALCULATIONS

DCFRR: BEFORE TAX: 17.024(%) AFTER TAX: 14.762(%)

NET PRESENT VALUE: BEFORE TAX: 3997.917 DISCOUNT RATE: 10.000(%)
AFTER TAX : 2343.842 DISCOUNT RATE: 10.000(%)

PAY OUT TIME (AFTER TAX): 4.824(YEARS)

ACC. CASH FLOW BEFORE TAX: 21532.965

ACC. CASH FLOW AFTER TAX : 15488.902

ACC. TAXES: 6044.055

ACC. INTEREST: 6688.918

TOTAL CAPITAL REQUIREMENT: 9523.102 WORKING CAPITAL: 791.551

AVERAGE BREAK EVEN POINT: 60.297(%)

LURGI CHEMIE ECONOMIC ANALYSES

[illegible] STEEL WORK FOR TANZANIA [illegible]

[illegible]

OPERATING COST IN THE YEAR 5

S-17

VARIABLE COST

ITEM	SP. CONS.	PRICE	AMOUNT	COST
COAL	[illegible]	[illegible]	500.000	227.350
ELECTR.	1.581	0.573	500.000	452.694
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
L.FUEL	0.006	3.956	500.000	11.421
PROPANE	[illegible]	[illegible]	500.000	[illegible]
CHAR	0.018	1.360	500.000	12.417
ALLOYS	[illegible]	[illegible]	500.000	[illegible]
BINDER	0.002	0.250	500.000	0.250
[illegible]	[illegible]	[illegible]	500.000	2.237
BITES	0.001	2.364	500.000	0.714
[illegible]	[illegible]	[illegible]	500.000	[illegible]
TIRES	0.009	0.386	500.000	1.488
[illegible]	[illegible]	[illegible]	500.000	[illegible]
PASTE	0.005	7.355	500.000	17.468
[illegible]	[illegible]	[illegible]	500.000	[illegible]
GRAPHITE	0.001	28.150	500.000	16.440
[illegible]	[illegible]	[illegible]	500.000	[illegible]
OTHER	0.125	1.000	500.000	62.356
TRANSP.	[illegible]	[illegible]	500.000	[illegible]
L.O.O.	0.112	1.000	500.000	55.779
SUB TOTAL				1419.747

FIXED COST

ITEM	COST
BITES	[illegible]
TIRES	1.488
[illegible]	[illegible]
PASTE	17.468
[illegible]	[illegible]
REFRACT.	174.558
OTHER	[illegible]
LABOUR	53.233
MAINTEN.	[illegible]
INSURAN.	16.015
SUB TOTAL	[illegible]
TOTAL	[illegible]

SALES IN THE YEAR 5

ITEM	PRICE	AMOUNT	REVENUE
PLATES	[illegible]	100.000	[illegible]
STRIPS	8.310	400.000	3324.080
TOTAL			4125.227

C ANALYSIS
(MIO TSH) ENERGY -20 %

S -18-

3	4	5
0.0	2822.893	4044.374
0.0	1420.920	1841.308
0.0	1401.973	2203.066
0.0	778.432	700.493
0.0	874.050	869.621
0.0	0.0	632.952
0.0	-250.509	0.0
0.0	0.0	0.0
0.0	-250.509	632.952
0.0	1401.973	2203.066
2151.833	469.854	0.0
786.776	104.151	0.0
196.546	6.844	10.468
213.372	0.938	0.0
497.216	0.0	0.0
272.912	438.870	79.769
4118.652	1020.657	90.237
-4118.652	381.316	2112.829
0.0	0.0	0.0
-4118.652	381.316	2112.829
0.0	874.050	1743.671
7637.715	8658.371	8748.605
-7637.715	-7256.398	-5143.566
-7637.715	-7256.398	-5143.566
0.0	0.0	0.0
0.0	113.531	76.137

FORGI CHEMIE
11, 4,84 - 147 5745

ECONOMI
STEEL WORK FOR TANZANIA 1984

	YEAR	1	2
2	REVENUE	0.0	0.0
3	OPERAT. COST	0.0	0.0
4	PROFIT MARG.	0.0	0.0
5	INTEREST	0.0	0.0
6	DEPRECIATION	0.0	0.0
7	TAX ALLOWAN.	0.0	0.0
8	PROFIT B TAX	0.0	0.0
9	TAXES	0.0	0.0
10	PROFIT	0.0	0.0
11	PROFIT MARG.	0.0	0.0
12	EQUIPMENT	410.778	1867.801
13	CIVIL WORK	150.000	802.416
14	VEHICLES	0.0	36.270
15	COST B STU	1.900	28.738
16	INT. D.C.	28.134	193.029
17	WORK CAPIT.	0.0	0.0
18	TOT INVESTM.	590.812	2928.253
19	CASH FLOW BT	-590.812	-2928.253
20	TAXES	0.0	0.0
21	CASH FLOW AT	-590.812	-2928.253
22	ACC. DEPREC.	0.0	0.0
23	ACC. INVEST	590.812	3519.065
24	ACC. C.F. BT	-590.812	-3519.065
25	ACC. C.F. AT	-590.812	-3519.065
26	ACC. TAXES	0.0	0.0
27	BREAK EVEN P	0.0	0.0

LURGI CHEMIE
11. 4.84 - 14/ 5/65

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) ENERGY -20 %

S-19-

	YEAR	6	7	8	9	10
2	REVENUE	4125.227	4125.227	4125.227	4125.227	4125.227
3	OPERAT. COST	1869.135	1869.135	1869.135	1869.135	1869.135
4	PROFIT MARG.	2256.092	2256.092	2256.092	2256.092	2256.092
5	INTEREST	620.061	548.621	504.457	460.558	419.948
6	DEPRECIATION	804.324	744.900	642.326	452.812	412.949
7	TAX ALLOWAN.	831.706	962.571	1107.801	0.0	0.0
8	PROFIT B TAX	0.0	0.0	1.508	1342.721	1423.195
9	TAXES	0.0	0.0	0.754	671.361	711.597
10	PROFIT	831.706	962.571	1108.555	671.361	711.598
11	PROFIT MARG.	2256.092	2256.092	2256.092	2256.092	2256.092
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	0.0	0.0	0.0	3.350	0.0
14	VEHICLES	0.0	30.504	200.687	10.468	6.844
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	0.0	30.504	200.687	13.818	6.844
19	CASH FLOW BT	2256.092	2225.587	2055.405	2242.274	2249.248
20	TAXES	0.0	0.0	0.754	671.361	711.597
21	CASH FLOW AT	2256.092	2225.587	2054.650	1570.913	1537.650
22	ACC. DEPREC.	2547.995	3292.895	3935.221	4388.031	4800.977
23	ACC. INVEST.	8748.605	8779.109	8979.793	8993.609	9000.453
24	ACC. C.F. BT	-2887.475	-661.887	1393.517	3635.791	5885.035
25	ACC. C.F. AT	-2887.475	-661.887	1392.763	2963.676	4501.324
26	ACC TAXES	0.0	0.0	0.754	672.115	1383.712
27	BREAK EVEN P	69.258	64.421	58.998	50.370	47.396

LURGI CHEMIE
11.4.84 - 147 5745

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH)

	YEAR	11	12	13
2	REVENUE	4125.227	4125.227	4125.227
3	OPERAT. COST	1869.135	1869.135	1869.135
4	PROFIT MARG.	2256.092	2256.092	2256.092
5	INTEREST	382.327	351.246	342.521
6	DEPRECIATION	379.826	342.626	273.576
7	TAX ALLOWAN.	0.0	0.0	0.0
8	PROFIT B TAX	1493.938	1562.219	1639.994
9	TAXES	746.969	781.109	819.997
10	PROFIT	746.969	781.109	819.997
11	PROFIT MARG.	2256.092	2256.092	2256.092
12	EQUIPMENT	0.0	1.316	0.0
13	CIVIL WORK	0.0	0.0	0.0
14	VEHICLES	3.623	30.503	186.328
15	COST B SIU	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0
18	TOT INVESTM.	3.623	31.819	186.328
19	CASH FLOW BT	2252.469	2224.272	2069.763
20	TAXES	746.969	781.109	819.997
21	CASH FLOW AT	1505.500	1443.163	1249.766
22	ACC. DEPREC.	5180.801	5523.426	5797.000
23	ACC. INVEST.	900[illegible].074	9035.891	9222.215
24	ACC. C.F. BT	8137.500	10361.770	12431.531
25	ACC. C.F. AT	6006.820	7449.980	8699.746
26	ACC. TAXES	2130.681	2911.790	3731.787
27	BREAK EVEN P	44.781	42.257	39.382

ENERGY -20 %

S-20-

14	15
4125.227	4125.227
1869.135	1869.135
2256.092	2256.092
316.619	289.925
294.186	280.828
0.0	0.0
1645.287	1685.339
822.644	842.669
822.644	842.669
2256.092	2256.092
0.0	0.0
0.0	0.0
35.160	13.890
0.0	0.0
0.0	0.0
0.0	0.0
35.160	13.890
2220.931	2242.201
822.644	842.669
1398.288	1399.532
6091.184	6372.008
9257.371	9271.258
14652.461	16894.660
10098.031	11497.562
4554.430	5397.098
39.187	37.706

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) ENERG. -20 %

	YEAR	16	17	18	19	20
2	REVENUE	4125.227	4125.227	4125.227	4125.227	0.0
3	OPERAT. COST	1869.135	1869.135	1869.135	1869.135	0.0
4	PROFIT MARG.	2256.092	2256.092	2256.092	2256.092	2231.539
5	INTEREST	264.051	243.375	243.143	223.154	0.0
6	DEPRECIATION	265.512	243.229	192.075	218.743	0.0
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	0.0
8	PROFIT B TAX	1726.528	1769.487	1820.873	1814.194	2231.539
9	TAXES	863.264	884.743	910.437	907.097	0.0
10	PROFIT	863.264	884.743	910.437	907.097	2231.539
11	PROFIT MARG.	2256.092	2256.092	2256.092	2256.092	2231.539
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	3.350	0.0	0.0	0.0	0.0
14	VEHICLES	3.422	36.475	189.750	18.855	0.0
15	COST E STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	6.772	36.475	189.750	18.855	0.0
19	CASH FLOW BT	2249.319	2219.616	2066.342	2237.236	2231.539
20	TAXES	863.264	884.743	910.437	907.097	0.0
21	CASH FLOW AT	1386.055	1334.873	1155.905	1330.139	2231.539
22	ACC. DEPREC.	6637.520	6880.746	7072.820	7291.562	7291.562
23	ACC. INVEST.	9278.027	9314.500	9504.250	9523.102	9523.102
24	ACC. C.F. BT	19143.977	21363.590	23429.930	25667.164	27898.703
25	ACC. C.F. AT	12883.617	14218.488	15374.391	16704.527	18936.066
26	ACC. TAXES	6260.359	7145.102	8055.535	8962.629	8962.629
27	BREAK EVEN P	36.184	34.596	32.697	32.944	0.0

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) ENERGY -20 %

PROFITABILITY CALCULATIONS

DCFRR: BEFORE TAX: 20.989(%) AFTER TAX: 17.835(%)

NET PRESENT VALUE: BEFORE TAX: 6523.668 DISCOUNT RATE: 10.000(%)

AFTER TAX : 3882.573 DISCOUNT RATE: 10.000(%)

PAY OUT TIME (AFTER TAX): 3.942(YEARS)

ACC. CASH FLOW BEFORE TAX: 27898.703

ACC. CASH FLOW AFTER TAX : 18936.066

ACC. TAXES: 8962.629

ACC. INTEREST: 6688.918

TOTAL CAPITAL REQUIREMENT: 9523.102 WORKING CAPITAL: 791.551

AVERAGE BREAK EVEN POINT: 51.240(%)

LURGI CHEMIE ECONOMIC ANALYSIS

[illegible]

AVAIL. [illegible]

S-23-

OPERATING COST IN THE YEAR 4

VARIABLE COST

ITEM	SP. CONS. *	PRICE *	AMOUNT =	COST
COAL	[illegible]	[illegible]	273.720	[illegible]
ELECTR.	1.581	0.715	273.720	309.771
H.FUEL	[illegible]	[illegible]	273.720	[illegible]
L.FUEL	0.006	4.945	273.720	7.815
[illegible]	[illegible]	[illegible]	273.720	[illegible]
CHAR	0.018	1.360	273.720	6.797
ALLOYS	[illegible]	[illegible]	273.720	[illegible]
BINDER	0.002	0.250	273.720	0.137
[illegible]	[illegible]	[illegible]	273.720	[illegible]
BITES	0.001	2.364	273.720	0.391
EXPLOS.	[illegible]	[illegible]	273.720	[illegible]
TIRES	0.009	0.386	273.720	0.924
MISC. UT.	[illegible]	[illegible]	273.720	[illegible]
PASTE	- 0.005	7.355	273.720	9.563
[illegible]	[illegible]	[illegible]	273.720	[illegible]
GRAPHITE	0.001	28.150	273.720	9.000
[illegible]	[illegible]	[illegible]	273.720	[illegible]
OTHER	0.125	1.000	273.720	34.136
TRANSP.	[illegible]	[illegible]	273.720	[illegible]
L.D.O.	0.112	1.000	273.720	30.536
SUB TOTAL				888.458

FIXED COST

ITEM	COST
BITES	[illegible]
TIRES	1.488
MISC. UT.	[illegible]
PASTE	17.448
[illegible]	[illegible]
REFRACT.	174.558
[illegible]	[illegible]
LABOUR	53.233
MAINTEN.	[illegible]
INSURAN.	16.015
SUB TOTAL	[illegible]
TOTAL	[illegible]

SALES IN THE YEAR 4

ITEM	PRICE *	AMOUNT =	REVENUE
PLATES	[illegible]	[illegible]	[illegible]
STRIPS	8.310	213.974	1319.734
TOTAL			2258.315

LURGI CHEMIE ECONOMI

11. 4.84 - 14/ 5/45 STEEL WORK FOR TANZANIA 1984

	YEAR	1	2
2	REVENUE	0.0	0.0
3	OPERAT. COST	0.0	0.0
4	PROFIT MARG.	0.0	0.0
5	INTEREST	0.0	0.0
6	DEPRECIATION	0.0	0.0
7	TAX ALLOWAN.	0.0	0.0
8	PROFIT B TAX	0.0	0.0
9	TAXES	0.0	0.0
10	PROFIT	0.0	0.0
11	PROFIT MARG.	0.0	0.0
12	EQUIPMENT	410.778	1867.801
13	CIVIL WORK	150.000	802.416
14	VEHICLES	0.0	36.270
15	COST B STU	1.900	28.738
16	INT. D.C.	28.134	193.029
17	WORK CAPIT.	0.0	0.0
18	TOT INVESTM.	590.812	2928.253
19	CASH FLOW BT	-590.812	-2928.253
20	TAXES	0.0	0.0
21	CASH FLOW AT	-590.812	-2928.253
22	ACC. DEPREC.	0.0	0.0
23	ACC. INVEST.	590.812	3519.065
24	ACC. C.F. BT	-590.812	-3519.065
25	ACC. C.F. AT	-590.812	-3519.065
26	ACC. TAXES	0.0	0.0
27	BREAK EVEN P	0.0	0.0

C ANALYSIS S-24

(MIO TSH) AVAIL. 80 %

3	4	5
0.0	2258.315	3235.499
0.0	1337.846	1722.287
0.0	920.469	1513.212
0.0	778.432	700.493
0.0	874.050	869.621
0.0	0.0	0.0
0.0	-732.013	-56.903
0.0	0.0	0.0
0.0	-732.013	-56.903
0.0	920.469	1513.212
2151.833	469.854	0.0
786.776	104.151	0.0
196.546	6.844	10.468
213.372	0.938	0.0
497.216	0.0	0.0
272.912	438.870	79.769
4118.652	1020.657	90.237
-4118.652	-100.188	1422.975
0.0	0.0	0.0
-4118.652	-100.188	1422.975
0.0	874.050	1743.671
7637.715	8658.371	8748.605
-7637.715	-7737.902	-6314.926
-7637.715	-7737.902	-6314.926
0.0	0.0	0.0
0.0	153.437	102.899

ECONOMI

STEEL WORK FOR TANZANIA 1984

	YEAR	6	7
2	REVENUE	3300.183	3300.183
3	OPERAT. COST	1747.736	1747.736
4	PROFIT MARG.	1552.448	1552.448
5	INTEREST	620.061	548.621
6	DEPRECIATION	804.324	744.900
7	TAX ALLOWAN.	128.062	258.927
8	PROFIT B TAX	0.0	0.0
9	TAXES	0.0	0.0
10	PROFIT	128.062	258.927
11	PROFIT MARG.	1552.448	1552.448
12	EQUIPMENT	0.0	0.0
13	CIVIL WORK	0.0	0.0
14	VEHICLES	0.0	30.504
15	COST B STU	0.0	0.0
16	INT. D.C.	0.0	0.0
17	WORK CAPIT.	0.0	0.0
18	TOT INVESTM.	0.0	30.504
19	CASH FLOW BT	1552.448	1521.943
20	TAXES	0.0	0.0
21	CASH FLOW AT	1552.448	1521.943
22	ACC. DEPREC.	2547.995	3292.895
23	ACC. INVEST.	8748.605	8779.109
24	ACC. C.F. BT	-4762.477	-3240.533
25	ACC. C.F. AT	-4762.477	-3240.533
26	ACC. TAXES	0.0	0.0
27	BREAK EVEN P	93.603	87.066

C ANALYSIS

(MID TSH) AVAIL. 80 %

S-25-

8	9	10
3300.183	3300.183	3300.183
1747.736	1747.736	1747.736
1552.448	1552.448	1552.448
504.457	460.558	419.948
642.326	452.812	412.949
405.665	639.077	719.551
0.0	0.0	0.0
0.0	0.0	0.0
405.665	639.077	719.551
1552.448	1552.448	1552.448
0.0	0.0	0.0
0.0	3.350	0.0
200.687	10.468	6.844
0.0	0.0	0.0
0.0	0.0	0.0
0.0	0.0	0.0
200.687	13.818	6.844
1351.760	1538.630	1545.604
0.0	0.0	0.0
1351.760	1538.630	1545.604
3935.221	4388.031	4800.977
8979.793	8993.609	9000.453
-1888.773	-350.143	1195.461
-1888.773	-350.143	1195.461
0.0	0.0	0.0
79.735	68.075	64.055

LURGI CHEMIE
11. 4.84 - 14/ 5/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) AVAIL. 80 %

S-26-

	YEAR	11	12	13	14	15
2	REVENUE	3300.183	3300.183	3300.183	3300.183	3300.183
3	OPERAT. COST	1747.736	1747.736	1747.736	1747.736	1747.736
4	PROFIT MARG.	1552.448	1552.448	1552.448	1552.448	1552.448
5	INTEREST	382.327	351.246	342.521	316.619	289.925
6	DEPRECIATION	379.826	342.626	273.576	294.186	280.828
7	TAX ALLOWAN.	790.294	858.575	466.889	0.0	0.0
8	PROFIT B TAX	0.0	0.0	469.461	941.643	981.695
9	TAXES	0.0	0.0	234.731	470.822	490.847
10	PROFIT	790.294	858.575	701.619	470.822	490.847
11	PROFIT MARG.	1552.448	1552.448	1552.448	1552.448	1552.448
12	EQUIPMENT	0.0	1.316	0.0	0.0	0.0
13	CIVIL WORK	0.0	0.0	0.0	0.0	0.0
14	VEHICLES	3.623	30.503	186.328	35.160	13.890
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	3.623	31.819	186.328	35.160	13.890
19	CASH FLOW BT	1548.824	1520.628	1366.119	1517.287	1538.557
20	TAXES	0.0	0.0	234.731	470.822	490.847
21	CASH FLOW AT	1548.824	1520.628	1131.389	1046.466	1047.710
22	ACC. DEPREC.	5180.801	5523.426	5797.000	6091.184	6372.008
23	ACC. INVEST.	9004.074	9035.891	9222.215	9257.371	9271.258
24	ACC. C.F. BT	2744.285	4264.910	5631.027	7148.312	8686.867
25	ACC. C.F. AT	2744.285	4264.910	5396.297	6442.762	7490.469
26	ACC. TAXES	0.0	0.0	234.731	705.552	1195.400
27	BREAK EVEN P	60.522	57.111	53.225	52.961	50.960

LURGI CHEMIE
11. 4.84 - 147 5/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) AVAIL. 80 %

S -27-

	YEAR	16	17	18	19	20
2	REVENUE	3300.183	3300.183	3300.183	3300.183	0.0
3	OPERAT. COST	1747.736	1747.736	1747.736	1747.736	0.0
4	PROFIT MARG.	1552.448	1552.448	1552.448	1552.448	2231.539
5	INTEREST	264.051	243.375	243.143	223.154	0.0
6	DEPRECIATION	265.512	243.229	192.075	218.743	0.0
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	0.0
8	PROFIT B TAX	1022.884	1065.843	1117.229	1110.550	2231.539
9	TAXES	511.442	532.921	558.615	555.275	0.0
10	PROFIT	511.442	532.921	558.615	555.275	2231.539
11	PROFIT MARG.	1552.448	1552.448	1552.448	1552.448	2231.539
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	3.350	0.0	0.0	0.0	0.0
14	VEHICLES	3.422	36.475	189.750	18.855	0.0
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	6.772	36.475	189.750	18.855	0.0
19	CASH FLOW BT	1545.675	1515.972	1362.698	1533.592	2231.539
20	TAXES	511.442	532.921	558.615	555.275	0.0
21	CASH FLOW AT	1034.233	983.051	804.083	978.317	2231.539
22	ACC. DEPREC.	6637.520	6880.746	7072.820	7291.562	7291.562
23	ACC. INVEST.	9278.027	9314.500	9504.250	9523.102	9523.102
24	ACC. C.F. BT	10232.539	11748.508	13111.203	14644.793	16876.332
25	ACC. C.F. AT	8524.699	9507.750	10311.832	11290.148	13521.687
26	ACC. TAXES	1707.842	2240.763	2799.377	3354.653	3354.653
27	BREAK EVEN P	48.903	46.757	44.190	44.523	0.0

LURGI CHEMIE
11. 4.84 - 10/58/34

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) AVAIL. 80 %

PROFITABILITY CALCULATIONS

DCFRR: BEFORE TAX: 13.915(%) AFTER TAX: 12.726(%)

NET PRESENT VALUE: BEFORE TAX: 2150.287 DISCOUNT RATE:10.000(%)

AFTER TAX : 1361.044 DISCOUNT RATE:10.000(%)

PAY OUT TIME (AFTER TAX): 5.713(YEARS)

ACC. CASH FLOW BEFORE TAX: 16876.332

ACC. CASH FLOW AFTER TAX : 13521.687

ACC. TAXES: 3354.653

ACC. INTEREST: 6688.918

TOTAL CAPITAL REQUIREMENT: 9523.102 WORKING CAPITAL: 791.551

AVERAGE BREAK EVEN POINT: 69.251(%)

LURGI CHEMIE ECONOMIC ANALYSES

[illegible]

OPERATING COST IN THE YEAR 4

5-29-

VARIABLE COST

ITEM	SP. CONS.	PRICE	AMOUNT	COST
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ELECTR.	1.581	0.716	205.290	232.329
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
L.FUEL	0.006	4.945	205.290	5.362
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CHAR	0.018	1.360	205.290	5.398
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BINDER	0.002	0.250	205.290	0.103
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BITES	0.001	2.364	205.290	0.293
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TIRES	0.009	0.386	205.290	0.693
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PASTE	0.005	7.355	205.290	7.172
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GRAPHITE	0.001	28.150	205.290	6.750
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OTHER	0.125	1.000	205.290	25.602
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
L.O.O.	0.112	1.000	205.290	22.962
SUB TOTAL				666.343

FIXED COST

ITEM	COST
[illegible]	[illegible]
TIRES	1.598
[illegible]	[illegible]
PASTE	17.468
[illegible]	[illegible]
REFRACT.	174.558
[illegible]	[illegible]
LABOUR	53.233
[illegible]	[illegible]
INSURAN.	15.415
[illegible]	[illegible]
[illegible]	[illegible]

SALES IN THE YEAR 4

ITEM	PRICE	AMOUNT	REVENUE
[illegible]	[illegible]	[illegible]	[illegible]
STRIPS	9.310	144.232	1344.801
TOTAL			1693.734

FORGI CHEMIE
11. 4.84 - 14/ 5/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) AVAIL. 60 %

S-30-

	YEAR	1	2	3	4	5
2	REVENUE	0.0	0.0	0.0	1693.736	2426.624
3	OPERAT. COST	0.0	0.0	0.0	1115.731	1404.062
4	PROFIT MARG.	0.0	0.0	0.0	578.005	1022.561
5	INTEREST	0.0	0.0	0.0	778.432	700.493
6	DEPRECIATION	0.0	0.0	0.0	874.050	869.621
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	0.0
8	PROFIT B TAX	0.0	0.0	0.0	-1074.477	-547.553
9	TAXES	0.0	0.0	0.0	0.0	0.0
10	PROFIT	0.0	0.0	0.0	-1074.477	-547.553
11	PROFIT MARG.	0.0	0.0	0.0	578.005	1022.561
12	EQUIPMENT	410.778	1867.801	2161.833	469.854	0.0
13	CIVIL WORK	150.000	802.416	786.776	104.151	0.0
14	VEHICLES	0.0	36.270	196.546	6.844	10.468
15	COST B STU	1.900	28.738	213.372	0.938	0.0
16	INT. D.C.	28.134	193.029	497.216	0.0	0.0
17	WORK CAPIT.	0.0	0.0	272.912	438.870	79.769
18	TOT INVESTM.	590.812	2928.253	4118.652	1020.657	90.237
19	CASH FLOW BT	-590.812	-2928.253	-4118.652	-442.652	932.324
20	TAXES	0.0	0.0	0.0	0.0	0.0
21	CASH FLOW AT	-590.812	-2928.253	-4118.652	-442.652	932.324
22	ACC. DEPREC.	0.0	0.0	0.0	874.050	1743.671
23	ACC. INVEST.	590.812	3519.065	7637.715	8658.371	8748.605
24	ACC. C.F. BT	-590.812	-3519.065	-7637.715	-8080.363	-7148.035
25	ACC. C.F. AT	-590.812	-3519.065	-7637.715	-8080.363	-7148.035
26	ACC. TAXES	0.0	0.0	0.0	0.0	0.0
27	BREAK EVEN P	0.0	0.0	0.0	204.583	137.199

LORGI CHEMIE
11. 4.84 - 14/ 5/45

STEEL WORK FOR TANZANIA 1984 ECONOMI[illegible]

	YEAR	6	7
2	REVENUE	2475.137	2475.137
3	OPERAT. COST	1423.148	1423.148
4	PROFIT MARG.	1051.989	1051.989
5	INTEREST	620.061	548.621
6	DEPRECIATION	804.324	744.900
7	TAX ALLOWAN.	0.0	0.0
8	PROFIT B TAX	-372.396	-241.532
9	TAXES	0.0	0.0
10	PROFIT	-372.396	-241.532
11	PROFIT MARG.	1051.989	1051.989
12	EQUIPMENT	0.0	0.0
13	CIVIL WORK	0.0	0.0
14	VEHICLES	0.0	30.504
15	COST B STU	0.0	0.0
16	INT. D.C.	0.0	0.0
17	WORK CAPIT.	0.0	0.0
18	TOT INVESTM.	0.0	30.504
19	CASH FLOW BT	1051.989	1021.485
20	TAXES	0.0	0.0
21	CASH FLOW AT	1051.989	1021.485
22	ACC. DEPREC.	2547.995	3292.895
23	ACC. INVEST.	8748.605	8779.109
24	ACC. C.F. BT	-6096.043	-5074.555
25	ACC. C.F. AT	-6096.043	-5074.555
26	ACC TAXES	0.0	0.0
27	BREAK EVEN P	124.804	116.087

S -31-

C ANALYSIS
(MTO TSH) AVAIL. 60 %

8	9	10
2475.137	2475.137	2475.137
1423.148	1423.148	1423.148
1051.989	1051.989	1051.989
504.457	460.558	419.948
642.326	452.812	412.949
0.0	138.619	219.092
-94.794	0.0	0.0
0.0	0.0	0.0
-94.794	138.619	219.092
1051.989	1051.989	1051.989
0.0	0.0	0.0
0.0	3.350	0.0
200.687	10.468	6.844
0.0	0.0	0.0
0.0	0.0	0.0
0.0	0.0	0.0
200.687	13.818	6.844
851.302	1038.171	1045.145
0.0	0.0	0.0
851.302	1038.171	1045.145
3935.221	4388.031	4800.977
8979.793	8993.609	9000.453
-4223.250	-3185.079	-2139.934
-4223.250	-3185.079	-2139.934
0.0	0.0	0.0
106.314	90.767	85.407

LURGI CHEMIE
11. 4.84 - 14/ 5/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) AVAIL. 60 %

S -32-

	YEAR	11	12	13	14	15
2	REVENUE	2475.137	2475.137	2475.137	2475.137	2475.137
3	OPERAT. COST	1423.148	1423.148	1423.148	1423.148	1423.148
4	PROFIT MARG.	1051.989	1051.989	1051.989	1051.989	1051.989
5	INTEREST	382.327	351.246	342.521	316.619	289.925
6	DEPRECIATION	379.826	342.626	273.576	294.186	280.828
7	TAX ALLOWAN.	289.835	358.116	435.891	441.184	481.236
8	PROFIT B TAX	0.0	0.0	0.0	0.0	0.0
9	TAXES	0.0	0.0	0.0	0.0	0.0
10	PROFIT	289.835	358.116	435.891	441.184	481.236
11	PROFIT MARG.	1051.989	1051.989	1051.989	1051.989	1051.989
12	EQUIPMENT	0.0	1.316	0.0	0.0	0.0
13	CIVIL WORK	0.0	0.0	0.0	0.0	0.0
14	VEHICLES	3.623	30.503	186.328	35.160	13.890
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM	3.623	31.819	186.328	35.160	13.890
19	CASH FLOW BT	1048.366	1020.170	865.661	1016.829	1038.099
20	TAXES	0.0	0.0	0.0	0.0	0.0
21	CASH FLOW AT	1048.366	1020.170	865.661	1016.829	1038.099
22	ACC. DEPREC.	5180.801	5523.426	5797.000	6091.184	6372.008
23	ACC. INVEST	9004.074	9035.891	9222.215	9257.371	9271.258
24	ACC. C.F. BT	-1091.568	-71.399	794.262	1811.091	2849.189
25	ACC. C.F. AT	-1091.568	-71.399	794.262	1811.091	2849.189
26	ACC TAXES	0.0	0.0	0.0	0.0	0.0
27	BREAK EVEN P	80.695	76.147	70.967	70.615	67.947

LURGI CHEMIE
11. 4.84 - 14/ 5/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) AVAIL. 60 %

S-33-

	YEAR	16	17	18	19	20
2	REVENUE	2475.137	2475.137	2475.137	2475.137	0.0
3	OPERAT. COST	1423.148	1423.148	1423.148	1423.148	0.0
4	PROFIT MARG.	1051.989	1051.989	1051.989	1051.989	2231.539
5	INTEREST	264.051	243.375	243.143	223.154	0.0
6	DEPRECIATION	265.512	243.229	192.075	218.743	0.0
7	TAX ALLOWAN.	522.426	565.384	616.771	610.092	0.0
8	PROFIT B TAX	0.0	0.0	0.0	0.0	2231.539
9	TAXES	0.0	0.0	0.0	0.0	0.0
10	PROFIT	522.426	565.384	616.771	610.092	2231.539
11	PROFIT MARG.	1051.989	1051.989	1051.989	1051.989	2231.539
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	3.350	0.0	0.0	0.0	0.0
14	VEHICLES	3.422	36.475	189.750	18.855	0.0
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	6.772	36.475	189.750	18.855	0.0
19	CASH FLOW BT	1045.217	1015.514	862.239	1033.134	2231.539
20	TAXES	0.0	0.0	0.0	0.0	0.0
21	CASH FLOW AT	1045.217	1015.514	862.239	1033.134	2231.539
22	ACC. DEPREC.	6637.520	6880.746	7072.820	7291.562	7291.562
23	ACC. INVEST.	9278.027	9314.500	9504.250	9523.102	9523.102
24	ACC. C.F. BT	3894.406	4909.918	5772.156	6805.289	9036.828
25	ACC. C.F. AT	3894.406	4909.918	5772.156	6805.289	9036.828
26	ACC. TAXES	0.0	0.0	0.0	0.0	0.0
27	BREAK EVEN P	65.204	62.342	58.920	59.364	0.0

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) AVAIL. 60 %

PROFITABILITY CALCULATIONS

DCFRR: BEFORE TAX: 8.119(%) AFTER TAX: 8.119(%)

NET PRESENT VALUE: BEFORE TAX: -960.232 DISCOUNT RATE: 10.000(%)
AFTER TAX : -960.232 DISCOUNT RATE: 10.000(%)

PAY OUT TIME (AFTER TAX): 8.294(YEARS)
ACC. CASH FLOW BEFORE TAX: 9036.828
ACC. CASH FLOW AFTER TAX : 9036.828

ACC. TAXES: 0.0
ACC. INTEREST: 6688.918
TOTAL CAPITAL REQUIREMENT: 9523.102 WORKING CAPITAL: 791.551

AVERAGE BREAK EVEN POINT: 92.335(%)

LURGI CHEMIE ECONOMIC ANALYSES

12. 1.36 3/21/36 STEEL WORK FOR TANZANIA 1996 (MIO TSH)

STEEL PRICE 30 %

OPERATING COST IN THE YEAR 4

S-35-

VARIABLE COST

ITEM	SP. CONS	*	PRICE	*	AMOUNT	=	COST
COAL	1.000		0.455		342.150		155.576
ELECTR.	1.581		0.716		342.150		397.214
H.FUEL	0.088		2.369		342.150		71.315
L.FUEL	0.006		4.945		342.150		9.769
PROPANE	0.115		5.728		342.150		225.304
CHAR	0.013		1.360		342.150		8.497
ALLOYS	0.012		8.71[illegible]		342.150		34.569
BINDER	0.002		0.250		342.150		0.171
[illegible]	0.014		0.330		342.150		1.565
BITES	0.001		2.364		342.150		0.499
[illegible]	0.001		9.423		342.150		3.449
TIRES	0.009		0.386		342.150		1.155
MILL UT.	0.021		1.000		342.150		7.184
PASTE	0.005		7.355		342.150		11.953
C-STEEL	0.001		9.200		342.150		4.533
GRAPHITE	0.001		28.150		342.150		11.250
POWDER	0.001		9.715		342.150		2.644
OTHER	0.125		1.000		342.150		42.471
TRANSP.	0.254		1.000		342.150		31.795
L.D.O.	0.112		1.000		342.150		38.170
SUB TOTAL							1110.573

FIXED COST

ITEM	COST
BITES	0.714
TIRES	1.488
MILL UT.	10.362
PASTE	17.448
C-STEEL	6.524
REFRACT.	174.559
OTHER	119.331
LABOUR	53.233
MAINTEN.	56.707
INSURAN.	16.115
SUB TOTAL	449.189
TOTAL	1559.761

SALES IN THE YEAR 4

ITEM	PRICE	*	AMOUNT	=	REVENUE
PLATES	6.409		68.430		438.381
STRIPS	4.644		273.720		1319.732
TOTAL					2258.314

LURGI CHEMIE ECONOMI
11. 4.84 - 14/ 5/45 STEEL WORK FOR TANZANIA 1984

	YEAR	1	2
2	REVENUE	0.0	0.0
3	OPERAT. COST	0.0	0.0
4	PROFIT MARG.	0.0	0.0
5	INTEREST	0.0	0.0
6	DEPRECIATION	0.0	0.0
7	TAX ALLOWAN.	0.0	0.0
8	PROFIT B TAX	0.0	0.0
9	TAXES	0.0	0.0
10	PROFIT	0.0	0.0
11	PROFIT MARG.	0.0	0.0
12	EQUIPMENT	410.778	1867.801
13	CIVIL WORK	150.000	802.416
14	VEHICLES	0.0	36.270
15	COST B STU	1.900	28.738
16	INT. D.C.	28.134	193.029
17	WORK CAPIT.	0.0	0.0
18	TOT INVESTM.	590.812	2928.253
19	CASH FLOW BT	-590.812	-2928.253
20	TAXES	0.0	0.0
21	CASH FLOW AT	-590.812	-2928.253
22	ACC. DEPREC.	0.0	0.0
23	ACC. INVEST.	590.812	3519.065
24	ACC. C.F. BT	-590.812	-3519.065
25	ACC. C.F. AT	-590.812	-3519.065
26	ACC. TAXES	0.0	0.0
27	BREAK EVEN P	0.0	0.0

C ANALYSIS
(MIO TSH) STEEL PRICE 80 %

S -36-

3	4	5
0.0	2258.314	3235.499
0.0	1559.961	2040.513
0.0	698.353	1194.986
0.0	778.432	700.493
0.0	874.050	869.621
0.0	0.0	0.0
0.0	-954.129	-375.128
0.0	0.0	0.0
0.0	-954.129	-375.128
0.0	698.353	1194.986
2151.833	469.854	0.0
786.776	104.151	0.0
196.546	6.844	10.468
213.372	0.938	0.0
497.216	0.0	0.0
272.912	438.870	79.769
4118.652	1020.657	90.237
-4118.652	-322.304	1104.749
0.0	0.0	0.0
-4118.652	-322.304	1104.749
0.0	874.050	1743.671
7637.715	8658.371	8748.605
-7637.715	-7960.016	-6855.266
-7637.715	-7960.016	-6855.266
0.0	0.0	0.0
0.0	183.131	122.813

LURGI CHEMIE
11.4.84 - 147 5/45

ECONOMIC ANALYSIS

STEEL WORK FOR TANZANIA 1984 (MIO TSH) STEEL PRICE 80 %

S-37-

	YEAR	6	7	8	9	10
2	REVENUE	3300.183	3300.183	3300.183	3300.183	3300.183
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	2072.323
4	PROFIT MARG.	1227.860	1227.860	1227.860	1227.860	1227.860
5	INTEREST	620.061	548.621	504.457	460.558	419.948
6	DEPRECIATION	804.324	744.900	642.326	452.812	412.949
7	TAX ALLOWAN.	0.0	0.0	81.078	314.490	394.964
8	PROFIT B TAX	-196.525	-65.661	0.0	0.0	0.0
9	TAXES	0.0	0.0	0.0	0.0	0.0
10	PROFIT	-196.525	-65.661	81.078	314.490	394.964
11	PROFIT MARG.	1227.860	1227.860	1227.860	1227.860	1227.860
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	0.0	0.0	0.0	3.350	0.0
14	VEHICLES	0.0	30.504	200.687	10.468	6.844
15	COST B STU.	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	0.0	30.504	200.687	13.818	6.844
19	CASH FLOW BT	1227.860	1197.356	1027.173	1214.043	1221.016
20	TAXES	0.0	0.0	0.0	0.0	0.0
21	CASH FLOW AT	1227.860	1197.356	1027.173	1214.043	1221.016
22	ACC. DEPREC.	2547.995	3292.895	3935.221	4388.031	4800.977
23	ACC. INVEST.	8749.605	8779.109	8979.793	8993.609	9000.453
24	ACC. C.F. BT	-5627.402	-4430.043	-3402.870	-2188.827	-967.811
25	ACC. C.F. AT	-5627.402	-4430.043	-3402.870	-2188.827	-967.811
26	ACC. TAXES	0.0	0.0	0.0	0.0	0.0
27	BREAK EVEN P	111.717	103.915	95.166	81.250	76.452

FORGI CHEMIE
11. 4.84 - 14/ 5/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) STEEL PRICE 80 %

	YEAR	11	12	13	14	15
2	REVENUE	3300.183	3300.183	3300.183	3300.183	3300.183
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	2072.323
4	PROFIT MARG.	1227.860	1227.860	1227.860	1227.860	1227.860
5	INTEREST	382.327	351.246	342.521	316.619	289.925
6	DEPRECIATION	379.826	342.626	273.576	294.186	280.828
7	TAX ALLOWAN.	465.707	533.988	611.763	617.056	657.108
8	PROFIT B TAX	0.0	0.0	0.0	0.0	0.0
9	TAXES	0.0	0.0	0.0	0.0	0.0
10	PROFIT	465.707	533.988	611.763	617.056	657.108
11	PROFIT MARG.	1227.860	1227.860	1227.860	1227.860	1227.860
12	EQUIPMENT	0.0	1.316	0.0	0.0	0.0
13	CIVIL WORK	0.0	0.0	0.0	0.0	0.0
14	VEHICLES	3.623	30.503	186.328	35.160	13.890
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	3.623	31.819	186.328	35.160	13.890
19	CASH FLOW BT	1224.237	1196.041	1041.532	1192.700	1213.970
20	TAXES	0.0	0.0	0.0	0.0	0.0
21	CASH FLOW AT	1224.237	1196.041	1041.532	1192.700	1213.970
22	ACC. DEPREC.	5180.801	5523.426	5797.000	6091.184	6372.008
23	ACC. INVEST.	9004.074	9035.891	9222.215	9257.371	9271.258
24	ACC. C.F. BT	256.427	1452.468	2494.000	3686.700	4900.668
25	ACC. C.F. AT	256.427	1452.468	2494.000	3686.700	4900.668
26	ACC. TAXES	0.0	0.0	0.0	0.0	0.0
27	BREAK EVEN P	72.234	68.163	63.526	63.210	60.822

LURGI CHEMIE
11. 4. 84 - 14/ 5/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) STEEL PRICE 80 %

	YEAR	16	17	18	19	20
2	REVENUE	3300.183	3300.183	3300.183	3300.183	0.0
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	0.0
4	PROFIT MARG.	1227.860	1227.860	1227.860	1227.860	2231.539
5	INTEREST	264.051	243.375	243.143	223.154	0.0
6	DEPRECIATION	265.512	243.229	192.075	218.743	0.0
7	TAX ALLOWAN.	698.297	741.255	792.642	387.301	0.0
8	PROFIT B TAX	0.0	0.0	0.0	398.662	2231.539
9	TAXES	0.0	0.0	0.0	199.331	0.0
10	PROFIT	698.297	741.255	792.642	586.632	2231.539
11	PROFIT MARG.	1227.860	1227.860	1227.860	1227.860	2231.539
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	3.350	0.0	0.0	0.0	0.0
14	VEHICLES	3.422	36.475	189.750	18.855	0.0
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	6.772	36.475	189.750	18.855	0.0
19	CASH FLOW BT	1221.088	1191.385	1038.110	1209.005	2231.539
20	TAXES	0.0	0.0	0.0	199.331	0.0
21	CASH FLOW AT	1221.088	1191.385	1038.110	1009.674	2231.539
22	ACC. DEPREC.	6637.520	6880.746	7072.820	7291.562	7291.562
23	ACC. INVEST.	9278.027	9314.500	9504.250	9523.102	9523.102
24	ACC. C.F. BT	6121.754	7313.137	8351.246	9560.250	11791.789
25	ACC. C.F. AT	6121.754	7313.137	8351.246	9360.918	11592.457
26	ACC. TAXES	0.0	0.0	0.0	199.331	199.331
27	BREAK EVEN P	58.367	55.805	52.741	53.140	0.0

LURGI CHEMIE
11. 4.84 - 10/58/34

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) STEEL PRICE 80 %

PROFITABILITY CALCULATIONS

DCFRR: BEFORE TAX: 10.253(%) AFTER TAX: 10.186(%)

NET PRESENT VALUE: BEFORE TAX: 132.872 DISCOUNT RATE: 10.000(%)
AFTER TAX: 97.020 DISCOUNT RATE: 10.000(%)

PAY OUT TIME (AFTER TAX): 7.144(YEARS)

ACC. CASH FLOW BEFORE TAX: 11791.789

ACC. CASH FLOW AFTER TAX: 11592.457

ACC. TAXES: 199.331

ACC. INTEREST: 6688.918

TOTAL CAPITAL REQUIREMENT: 9523.102 WORKING CAPITAL: 791.551

AVERAGE BREAK EVEN POINT: 82.653(%)

LURGI CHEMIE ECONOMIC ANALYSIS

[illegible]

[illegible]

OPERATING COST IN THE YEAR 4

VARIABLE COST

ITEM	SP. CONS. *	PRICE *	AMOUNT =	COST
[illegible]	1.000	[illegible]	342.150	[illegible]
ELECTR.	1.581	0.716	342.150	387.214
[illegible]	[illegible]	[illegible]	342.150	[illegible]
L.FUEL	0.006	4.945	342.150	9.769
[illegible]	[illegible]	[illegible]	342.150	[illegible]
CHAR	0.019	1.360	342.150	8.497
[illegible]	[illegible]	[illegible]	342.150	[illegible]
BINDER	0.002	0.250	342.150	0.171
[illegible]	[illegible]	[illegible]	342.150	[illegible]
BITES	0.001	2.364	342.150	0.489
[illegible]	[illegible]	[illegible]	342.150	[illegible]
TIRES	0.009	0.386	342.150	1.155
[illegible]	[illegible]	[illegible]	342.150	[illegible]
PASTE	0.005	7.355	342.150	11.953
[illegible]	[illegible]	[illegible]	342.150	[illegible]
GRAPHITE	0.001	28.150	342.150	11.250
[illegible]	[illegible]	[illegible]	342.150	[illegible]
OTHER	0.125	1.000	342.150	42.671
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
L.D.O.	0.112	1.000	342.150	38.170
SUB TOTAL				1110.573

FIXED COST

ITEM	COST
[illegible]	[illegible]
TIRES	1.688
[illegible]	[illegible]
PASTE	17.468
[illegible]	[illegible]
REFRACT.	174.558
[illegible]	[illegible]
LABOUR	53.233
[illegible]	[illegible]
INSURAN.	16.015
SUB TOTAL	[illegible]
TOTAL	[illegible]

SALES IN THE YEAR 4

ITEM	PRICE *	AMOUNT =	REVENUE
[illegible]	[illegible]	[illegible]	[illegible]
STRIPS	5.817	273.720	1592.268
TOTAL			1976.025

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LURGI CHEMIE
11. 4.84 - 147 5/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) STEEL PRICE 70 %

S-42-

	YEAR	1	2	3	4	5
2	REVENUE	0.0	0.0	0.0	1976.025	2831.062
3	OPERAT. COST	0.0	0.0	0.0	1559.961	2040.513
4	PROFIT MARG.	0.0	0.0	0.0	416.064	790.549
5	INTEREST	0.0	0.0	0.0	778.432	700.493
6	DEPRECIATION	0.0	0.0	0.0	874.050	869.621
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	0.0
8	PROFIT B TAX	0.0	0.0	0.0	-1236.418	-779.565
9	TAXES	0.0	0.0	0.0	0.0	0.0
10	PROFIT	0.0	0.0	0.0	-1236.418	-779.565
11	PROFIT MARG.	0.0	0.0	0.0	416.064	790.549
12	EQUIPMENT	410.778	1867.801	2151.833	469.854	0.0
13	CIVIL WORK	150.000	802.416	786.776	104.151	0.0
14	VEHICLES	0.0	36.270	196.546	6.844	10.468
15	COST B STU	1.900	28.738	213.372	0.938	0.0
16	INT. D.C.	28.134	193.029	497.216	0.0	0.0
17	WORK CAPIT.	0.0	0.0	272.912	438.870	79.769
18	TOT INVESTM.	590.812	2928.253	4118.652	1020.657	90.237
19	CASH FLOW BT	-590.812	-2928.253	-4118.652	-604.593	700.312
20	TAXES	0.0	0.0	0.0	0.0	0.0
21	CASH FLOW AT	-590.812	-2928.253	-4118.652	-604.593	700.312
22	ACC. DEPREC.	0.0	0.0	0.0	874.050	1743.671
23	ACC. INVEST.	590.812	3519.065	7637.715	8658.371	8748.605
24	ACC. C.F. BT	-590.812	-3519.065	-7637.715	-8242.306	-7541.992
25	ACC. C.F. AT	-590.812	-3519.065	-7637.715	-8242.305	-7541.992
26	ACC. TAXES	0.0	0.0	0.0	0.0	0.0
27	BREAK EVEN P	0.0	0.0	0.0	242.864	162.871

LURGI CHEMIE
11. 4.84 - 14/ 5/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) STEEL PRICE 70 %

S-43-

	YEAR	6	7	8	9	10
2	REVENUE	2887.660	2887.660	2887.660	2887.660	2887.660
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	2072.323
4	PROFIT MARG.	815.337	815.337	815.337	815.337	815.337
5	INTEREST	620.061	548.621	504.457	460.558	419.948
6	DEPRECIATION	804.324	744.900	642.326	452.812	412.949
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	0.0
8	PROFIT B TAX	-609.048	-478.184	-331.445	-98.033	-17.559
9	TAXES	0.0	0.0	0.0	0.0	0.0
10	PROFIT	-609.048	-478.184	-331.445	-98.033	-17.559
11	PROFIT MARG.	815.337	815.337	815.337	815.337	815.337
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	0.0	0.0	0.0	3.350	0.0
14	VEHICLES	0.0	30.504	200.687	10.468	6.844
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	0.0	30.504	200.687	13.818	6.844
19	CASH FLOW BT	815.337	784.833	614.650	801.520	808.493
20	TAXES	0.0	0.0	0.0	0.0	0.0
21	CASH FLOW AT	815.337	784.833	614.650	801.520	808.493
22	ACC. DEPREC.	2547.995	3292.895	3935.221	4388.031	4800.977
23	ACC. INVEST.	8748.605	8779.109	8979.793	8993.609	9000.453
24	ACC. C.F. BT	-6726.652	-5941.816	-5327.164	-4525.641	-3717.147
25	ACC. C.F. AT	-6726.652	-5941.816	-5327.164	-4525.641	-3717.147
26	ACC. TAXES	0.0	0.0	0.0	0.0	0.0
27	BREAK EVEN P	148.156	137.809	126.207	107.751	101.388

LURGI CHEMIE
11. 4.84 - 147 5245

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) STEEL PRICE 70 %

S-44-

	YEAR	11	12	13	14	15
2	REVENUE	2887.660	2887.660	2887.660	2887.660	2887.660
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	2072.323
4	PROFIT MARG.	815.337	815.337	815.337	815.337	815.337
5	INTEREST	382.327	351.246	342.521	316.619	289.925
6	DEPRECIATION	379.826	342.626	273.576	294.186	280.828
7	TAX ALLOWAN.	53.184	121.465	199.240	204.533	244.585
8	PROFIT B TAX	0.0	0.0	0.0	0.0	0.0
9	TAXES	0.0	0.0	0.0	0.0	0.0
10	PROFIT	53.184	121.465	199.240	204.533	244.585
11	PROFIT MARG.	815.337	815.337	815.337	815.337	815.337
12	EQUIPMENT	0.0	1.316	0.0	0.0	0.0
13	CIVIL WORK	0.0	0.0	0.0	0.0	0.0
14	VEHICLES	3.623	30.503	186.328	35.160	13.890
15	COST B STU.	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	3.623	31.819	186.328	35.160	13.890
19	CASH FLOW BT	811.714	783.518	629.009	780.177	801.447
20	TAXES	0.0	0.0	0.0	0.0	0.0
21	CASH FLOW AT	811.714	783.518	629.009	780.177	801.447
22	ACC. DEPREC.	5180.801	5523.426	5797.000	6091.184	6372.008
23	ACC. INVEST.	9004.074	9035.891	9222.215	9257.371	9271.258
24	ACC. C.F. BT	-2905.433	-2121.915	-1492.905	-712.728	88.719
25	ACC. C.F. AT	-2905.433	-2121.915	-1492.905	-712.728	88.719
26	ACC. TAXES	0.0	0.0	0.0	0.0	0.0
27	BREAK EVEN P	95.795	90.396	84.246	83.828	80.661

FORGI CHEMIE
11. 4.84 - 14/ 5/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) STEEL PRICE 70 %

S-45-

	YEAR	16	17	18	19	20
2	REVENUE	2887.660	2887.660	2887.660	2887.660	0.0
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	0.0
4	PROFIT MARG.	815.337	815.337	815.337	815.337	2231.539
5	INTEREST	264.051	243.375	243.143	223.154	0.0
6	DEPRECIATION	265.512	243.229	192.075	218.743	0.0
7	TAX ALLOWAN.	285.774	328.732	380.119	373.440	0.0
8	PROFIT B TAX	0.0	0.0	0.0	0.0	2231.539
9	TAXES	0.0	0.0	0.0	0.0	0.0
10	PROFIT	285.774	328.732	380.119	373.440	2231.539
11	PROFIT MARG.	815.337	815.337	815.337	815.337	2231.539
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	3.350	0.0	0.0	0.0	0.0
14	VEHICLES	3.422	36.475	189.750	18.855	0.0
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	6.772	36.475	189.750	18.855	0.0
19	CASH FLOW BT	808.565	778.862	625.587	796.482	2231.539
20	TAXES	0.0	0.0	0.0	0.0	0.0
21	CASH FLOW AT	808.565	778.862	625.587	796.482	2231.539
22	ACC. DEPREC.	6637.520	6880.746	7072.820	7291.562	7291.562
23	ACC. INVEST.	9278.027	9314.500	9504.250	9523.102	9523.102
24	ACC. C.F. BT	897.284	1676.147	2301.734	3098.216	5329.754
25	ACC. C.F. AT	897.284	1676.147	2301.734	3098.216	5329.754
26	ACC. TAXES	0.0	0.0	0.0	0.0	0.0
27	BREAK EVEN P	77.404	74.008	69.944	70.473	0.0

PROFITABILITY CALCULATIONS

DCFRR: BEFORE TAX: 5.031(%) AFTER TAX: 5.031(%) EQUITY:*******(%)

NET PRESENT VALUE: BEFORE TAX: -2431.093 DISCOUNT RATE: 10.000(%)

AFTER TAX : -2431.093 DISCOUNT RATE: 10.000(%)

EQUITY : 2102.862 DISCOUNT RATE: 10.000(%)

PAY OUT TIME (AFTER TAX): 10.899(YEARS)

ACC. CASH FLOW BEFORE TAX: 5329.754

ACC. CASH FLOW AFTER TAX : 5329.754

ACC. CASH FLOW EQUITY : 7661.727

ACC. TAXES: 0.0

ACC. INTEREST: 6688.918

TOTAL CAPITAL REQUIREMENT: 9523.102 WORKING CAPITAL: 791.551 LAND: 4900.262

RETURN ON ORIGINAL INVESTMENT: -2.330 (%)

TOTAL EQUITY: 0.0 TOTAL LOANS: 9020.918 MIXED INTEREST RATE: -3.935(%)

AVERAGE BREAK EVEN POINT: 109.612(%) MAX:******(%) (YEAR: 0) MIN:69.944(%) (YEAR:18)

LURGI CHEMIE ECONOMIC ANALYSIS

12. 1.84 - [illegible] STEEL WORK FOR TANZANIA 1984 (110 TSD)

STEEL IMPORT PRICE

S-47

OPERATING COST IN THE YEAR 6

VARIABLE COST

ITEM	SP. CONS *	PRICE *	AMOUNT =	COST
COAL	1.000	[illegible]	500.000	227.359
ELECTR.	1.581	0.716	500.000	565.954
H.FUEL	0.088	2.365	500.000	104.216
L.FUEL	0.006	4.945	500.000	14.276
PROPANE	0.115	5.725	500.000	331.592
CHAR	0.018	1.360	500.000	12.417
ALLOYS	0.012	[illegible]	500.000	[illegible]
BINDER	0.002	0.250	500.000	0.250
[illegible]	0.014	0.330	500.000	2.297
BITES	0.001	2.364	500.000	0.714
[illegible]	0.001	[illegible]	500.000	[illegible]
TIRES	0.009	0.386	500.000	1.688
MILL OP.	0.021	1.000	500.000	10.352
PASTE	0.005	7.355	500.000	17.468
[illegible]	0.001	[illegible]	500.000	[illegible]
GRAPHITE	0.001	28.150	500.000	16.440
POWDER	0.001	[illegible]	500.000	[illegible]
OTHER	0.125	1.000	500.000	62.356
TRANSP.	0.268	1.000	500.000	[illegible]
L.D.O.	0.112	1.000	500.000	55.779
SUB TOTAL				1622.335

FIXED COST

ITEM	COST
BITES	0.714
TIRES	1.688
MILL OP.	10.352
PASTE	17.448
[illegible]	[illegible]
REFRACT.	174.559
OTHER	118.331
LABOUR	53.233
MAINTEN.	[illegible]
INSURAN.	16.015
SUB TOTAL	449.389
TOTAL	2072.323

SALES IN THE YEAR 6

ITEM	PRICE *	AMOUNT =	REVENUE
PLATES	5.230	100.000	523.000
STRIPS	4.614	400.000	1845.400
TOTAL			2368.400

1

LURGI CHEMIE | ECONOMI

11. 4.84 - 14/ 5/45 | STEEL WORK FOR TANZANIA 1984

	YEAR	1	2
2	REVENUE	0.0	0.0
3	OPERAT. COST	0.0	0.0
4	PROFIT MARG.	0.0	0.0
5	INTEREST	0.0	0.0
6	DEPRECIATION	0.0	0.0
7	TAX ALLOWAN.	0.0	0.0
8	PROFIT B TAX	0.0	0.0
9	TAXES	0.0	0.0
10	PROFIT	0.0	0.0
11	PROFIT MARG.	0.0	0.0
12	EQUIPMENT	410.778	1867.801
13	CIVIL WORK	150.000	802.416
14	VEHICLES	0.0	36.270
15	COST B STU	1.900	28.738
16	INT. D.C.	28.134	193.029
17	WORK CAPIT.	0.0	0.0
18	TOT INVESTM.	590.812	2928.253
19	CASH FLOW BT	-590.812	-2928.253
20	TAXES	0.0	0.0
21	CASH FLOW AT	-590.812	-2928.253
22	ACC. DEPREC.	0.0	0.0
23	ACC. INVEST.	590.812	3519.065
24	ACC. C.F. BT	-590.812	-3519.065
25	ACC. C.F. AT	-590.812	-3519.065
26	ACC. TAXES	0.0	0.0
27	BREAK EVEN P	0.0	0.0

C ANALYSIS

(MIO TSH) STEEL IMPORT PRICE

S -48-

3	4	5
0.0	1620.832	2322.175
0.0	1559.961	2040.513
0.0	60.871	281.662
0.0	778.432	700.493
0.0	874.050	869.621
0.0	0.0	0.0
0.0	-1591.611	-1288.453
0.0	0.0	0.0
0.0	-1591.611	-1288.453
0.0	60.871	281.662
2151.833	469.854	0.0
786.776	104.151	0.0
196.546	6.844	10.468
213.372	0.938	0.0
497.216	0.0	0.0
272.912	438.870	79.769
4118.652	1020.657	90.237
-4118.652	-959.786	191.425
0.0	0.0	0.0
-4118.652	-959.786	191.425
0.0	874.050	1743.671
7637.715	8658.371	8748.605
-7637.715	-8597.500	-8406.074
-7637.715	-8597.500	-8406.074
0.0	0.0	0.0
0.0	411.923	276.247

LURGI CHEMIE
11. 4.84 - 14/ 5/45

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) STEEL IMPORT PRICE

S-49-

	YEAR	6	7	8	9	10
2	REVENUE	2368.600	2368.600	2368.600	2368.600	2368.600
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	2072.323
4	PROFIT MARG.	296.277	296.277	296.277	296.277	296.277
5	INTEREST	620.061	548.621	504.457	460.558	419.948
6	DEPRECIATION	804.324	744.900	642.326	452.812	412.949
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	0.0
8	PROFIT B TAX	-1128.108	-997.244	-850.506	-617.093	-536.619
9	TAXES	0.0	0.0	0.0	0.0	0.0
10	PROFIT	-1128.108	-997.244	-850.506	-617.093	-536.619
11	PROFIT MARG.	296.277	296.277	296.277	296.277	296.277
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	0.0	0.0	0.0	3.350	0.0
14	VEHICLES	0.0	30.504	200.687	10.468	6.844
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	0.0	30.504	200.687	13.818	6.844
19	CASH FLOW BT	296.277	265.773	95.590	282.459	289.433
20	TAXES	0.0	0.0	0.0	0.0	0.0
21	CASH FLOW AT	296.277	265.773	95.590	282.459	289.433
22	ACC. DEPREC.	2547.995	3292.895	3935.221	4388.031	4800.977
23	ACC. INVEST.	8748.605	8779.109	8979.793	8993.609	9000.453
24	ACC. C.F. BT	-8109.797	-7844.023	-7748.430	-7465.969	-7176.535
25	ACC. C.F. AT	-8109.797	-7844.023	-7748.430	-7465.969	-7176.535
26	ACC. TAXES	0.0	0.0	0.0	0.0	0.0
27	BREAK EVEN P	251.289	233.739	214.060	182.757	171.965

FORGI CHEMIE ECONOMI

11. 4.84 - 14/ 5/45 STEEL WORK FOR TANZANIA 1984

	YEAR	11	12
2	REVENUE	2368.600	2368.600
3	OPERAT. COST	2072.323	2072.323
4	PROFIT MARG.	296.277	296.277
5	INTEREST	382.327	351.246
6	DEPRECIATION	379.826	342.626
7	TAX ALLOWAN.	0.0	0.0
8	PROFIT B TAX	-465.877	-397.596
9	TAXES	0.0	0.0
10	PROFIT	-465.877	-397.596
11	PROFIT MARG.	296.277	296.277
12	EQUIPMENT	0.0	1.316
13	CIVIL WORK	0.0	0.0
14	VEHICLES	3.623	30.503
15	COST B STU	0.0	0.0
16	INT. D.C.	0.0	0.0
17	WORK CAPIT.	0.0	0.0
18	TOT INVESTM.	3.623	31.819
19	CASH FLOW BT	292.654	264.458
20	TAXES	0.0	0.0
21	CASH FLOW AT	292.654	264.458
22	ACC. DEPREC.	5180.801	5523.426
23	ACC. INVEST.	9004.074	9035.891
24	ACC. C.F. BT	-6883.879	-6619.418
25	ACC. C.F. AT	-6883.879	-6619.418
26	ACC. TAXES	0.0	0.0
27	BREAK EVEN P	162.478	153.321

C ANALYSIS

(MIO TSH) STEEL IMPORT PRICE S-50-

13	14	15
2368.600	2368.600	2368.600
2072.323	2072.323	2072.323
296.277	296.277	296.277
342.521	316.619	289.925
273.576	294.186	280.828
0.0	0.0	0.0
-319.820	-314.527	-274.476
0.0	0.0	0.0
-319.820	-314.527	-274.476
296.277	296.277	296.277
0.0	0.0	0.0
0.0	0.0	0.0
186.328	35.160	13.890
0.0	0.0	0.0
0.0	0.0	0.0
0.0	0.0	0.0
186.328	35.160	13.890
109.949	261.117	282.387
0.0	0.0	0.0
109.949	261.117	282.387
5797.000	6091.184	6372.008
9222.215	9257.371	9271.258
-6509.469	-6248.352	-5965.961
-6509.469	-6248.352	-5965.961
0.0	0.0	0.0
142.891	142.181	136.809

LURGI CHEMIE ECONOMIC ANALYSIS

11. 4.84 - 147 5745 STEEL WORK FOR TANZANIA 1984 (MIO TSH) STEEL IMPORT PRICE S-51-

	YEAR	16	17	18	19	20
2	REVENUE	2368.600	2368.600	2368.600	2368.600	0.0
3	OPERAT. COST	2072.323	2072.323	2072.323	2072.323	0.0
4	PROFIT MARG.	296.277	296.277	296.277	296.277	2231.539
5	INTEREST	264.051	243.375	243.143	223.154	0.0
6	DEPRECIATION	265.512	243.229	192.075	218.743	0.0
7	TAX ALLOWAN.	0.0	0.0	0.0	0.0	0.0
8	PROFIT B TAX	-233.286	-190.328	-138.941	-145.620	2231.539
9	TAXES	0.0	0.0	0.0	0.0	0.0
10	PROFIT	-233.286	-190.328	-138.941	-145.620	2231.539
11	PROFIT MARG.	296.277	296.277	296.277	296.277	2231.539
12	EQUIPMENT	0.0	0.0	0.0	0.0	0.0
13	CIVIL WORK	3.350	0.0	0.0	0.0	0.0
14	VEHICLES	3.422	36.475	189.750	18.855	0.0
15	COST B STU	0.0	0.0	0.0	0.0	0.0
16	INT. D.C.	0.0	0.0	0.0	0.0	0.0
17	WORK CAPIT.	0.0	0.0	0.0	0.0	0.0
18	TOT INVESTM.	6.772	36.475	189.750	18.855	0.0
19	CASH FLOW BT	289.505	259.802	106.527	277.422	2231.539
20	TAXES	0.0	0.0	0.0	0.0	0.0
21	CASH FLOW AT	289.505	259.802	106.527	277.422	2231.539
22	ACC. DEPREC.	6637.520	6880.746	7072.820	7291.562	7291.562
23	ACC. INVEST.	9278.027	9314.500	9504.250	9523.102	9523.102
24	ACC. C.F. BT	-5676.453	-5416.648	-5310.121	-5032.699	-2801.160
25	ACC. C.F. AT	-5676.453	-5416.648	-5310.121	-5032.699	-2801.160
26	ACC. TAXES	0.0	0.0	0.0	0.0	0.0
27	BREAK EVEN P	131.286	125.524	118.633	119.529	0.0

LURGI CHEMIE
11. 4.84 - 10/58/34

ECONOMIC ANALYSIS
STEEL WORK FOR TANZANIA 1984 (MIO TSH) STEEL IMPORT PRICE

PROFITABILITY CALCULATIONS

DCFRR: BEFORE TAX: -3.028(%) AFTER TAX: -3.028(%)

NET PRESENT VALUE: BEFORE TAX: -5657.215 DISCOUNT RATE: 10.000(%)
AFTER TAX : -5657.215 DISCOUNT RATE: 10.000(%)

PAY OUT TIME (AFTER TAX): 17.901(YEARS)

ACC. CASH FLOW BEFORE TAX: -2801.160

ACC. CASH FLOW AFTER TAX : -2801.160

ACC. TAXES: 0.0

ACC. INTEREST: 6688.918

TOTAL CAPITAL REQUIREMENT: 9523.102 WORKING CAPITAL: 791.551

AVERAGE BREAK EVEN POINT: 185.914(%)

ESTIMATED FINAL PRODUCTS

50% blooms

of this 50%

10-15% rails 90 lbs/yard weight ~~load~~ of rails

10-15% beams 12inch max

10-15% chanels 350 mm.

10-15% angles (120 to 150mm max

Rest billets 120 □ max

max: 60% of 50%

min. 40% of 50%

all by single casting

50% slabs

20% of 50% will plates 300 mm thickness

rest hot rolled coils going up to 2. to 3 mm

deping on Cr-content.

single coils 7t max each.

500.000 tpy 1. stage.

bloom caster 2. stager

slab caster 1. stage

THIS PAGE SHALL BE UNDERSTOOD AS A SUMMARY OF DISCUSSION AND IS OF INFORMATIC CHARACTER

P.A.R 28.01.83

For NDC [signature]

For Mannesmann DEMAG [signature]

Cable: NATDEV
Phone: 26271
Telex No. 41068

NATIONAL DEVELOPMENT CORPORATION

NDC DEVELOPMENT HOUSE - P.O. BOX 2669 - DAR ES SALAAM - TANZANIA

Ref. ID/3705

July 5, 1983

Lurgi Chemie und Huttentechnik GmbH,
Lurgi Haus,
Gervinusstrasse 17/19,
D-6000 Frankfurt am Main 1,
West Germany.

Attention: Dr. Schlebusch

Dear Sir,

Re: FINANCIAL AND ECONOMIC ANALYSIS

In working out the financial and economic analysis of the Liganga Iron ore project, it may turn out to be necessary to use the current prices of various types of steel being sold by subsidiary company - National Steel Corporation rather than international prices.

We are therefore sending you a copy of the price list from National Steel Corporation. Along with this price list please find a copy of annexure of the feasibility study on Pulp and Paper Project. You may wish to look at the /used format/in the calculations and also some of the assumptions made.

Yours faithfully,
NATIONAL DEVELOPMENT CORPORATION

Dr. G. E. MARIKI
DIRECTOR OF INDUSTRIAL DEVELOPMENT

NATIONAL STEEL CORPORATION LIMITED

MILD STEEL PLAIN PLATES

SIZE IN INCHES	APPROXIMATE SIZE IN MM	WEIGHT METRE KGS	WEIGHT PIECES KGS	WHOLE SALE	Rev Rc	RETAIL
8 x 4 x I/8	2438 x I2I9 x 3	-	78.00	-	656.50	8,420/=
8 x 4 x 3/I6	2438 x I2I9 x 4.5	-	III.82	-	941.35	8,420/=
8 x 4 x ¼	2438 x I2I9 x 6	-	I48.00	-	1246.20	8,420/=
8 x 4 x 5/I6	2438 x I2I9 x 8	-	I85.80	-	1355.60	7,3I2/=
8 x 4 x ½	2438 x I2I9 x I2	-	302.73	-	2525.70	8,343/=
8 x 4 x ¾	2438 x I2I9 x 20	-	522.63	-	3710.75	7,I00.I5

MILD STEEL CHEQUERED PLATES:

8 x 4 x I/8	2438 x I2I9 x 3	-	90.75	-	787.75	8,680.20
8 x 4 x 3/I6	2438 x I2I9 x 4.5	-	I25.95	-	1093.30	8,680.20

MILD STEEL COLD ROLLED SHEETS (CRCA)

8 x 4 x 22G	2438 x I2I9 x 0.80	-	20.52	-	166.00	8,089/=
8 x 4 x 20G	2438 x I2I9 x I.00	-	25.00	-	239.20	9,568/=
8 x 4 x I8G	2438 x I2I9 x I25	-	30.90	-	249.95	8,089/=
8 x 4 x I6G	2438 x I2I9 x I.60	-	38.67	-	350.35	9,060/=
8 x 4 x I4G	2438 x I2I9 x 2.00	-	48.39	-	536.10	II,078/=

HIGH TENSILE BARS

¼	6	0.229	2.75	-	23.10	I0,222.60
5/I6	8	0.407	4.88	-	[illegible]	9.92I.20

ROUNDS

¼	6	-	2.75	-	20.90	7,594.90
5/I6	8	-	4.88	-	35.50	7,33I.90

MILD STEEL SHAFTING BARS BRIGHT

DRAWN 6M LONG

¼	6	0.20	I.33	-	8,3I4.5
5/I6	8	0.39	2.34	7,883.00	8,626.0
7/I6	II	0.746	4.49	7,676.00	8,399.
5/8	I6	I.578	9,47	7,48I.00	8,I84.00
¾	20	2.467	I4.80	8,079.00	8,887.60
7/8	22	2.983	I7.90	8,I07.00	8,7I7.00
I	25	3.853	23.I2	8,022.00	8,824.00
I¼	30	5.567	33.40	8,022.00	8,024.00
I3/8	35	7.554	45.32	7,936.00	8,728.00

NATIONAL STEEL CORPORATION LIMITED

STEEL YARD CHANG'OMBE

P. O. BOX 2818 OR 40031

DAR ES SALAAM

TELEPHONE NO. 64743, 64448, 64954, 64914

TELEX: 41002

TELEGRAMS: NASTEEL

PRICE LIST OF STEEL PRODUCTS

PERIOD JANUARY - JUNE, 1983

This price list has been prepared in accordance with the guideliness issued by the National Price Commission.

Effective for the period January - June, 1983.

Yours faithfully,
NATIONAL STEEL CORPORATION LIMITED

....

A. Z. Mamuya
GENERAL MANAGER

$1\frac{1}{2}$	40	9.800	58.80	8,022.00	8,824.00
$1\frac{3}{4}$	45	13.083	78.50	8,107.00	8,717.00
-	50	-	99.90	-	7,817.20
23/8	60	18.867	133.20	7,357.35	8,048.10
$2\frac{1}{2}$	65	-	156.36	7,997.00	8,797.00
3	75	-	231.00	8,143.00	8,958.00
$3\frac{1}{2}$	90	50.00	300.00	7,884.00	8,626.00
4	100	-	397.00	8,418.00	9,260.00
7	175	188.608	1,131.00	11,396.00	12,490.00

HARD RAIL ANGLES

$1\frac{1}{2}$ x $1\frac{1}{2}$ x 1/8	38 x 38 x 2.6	1.475	8.85	- [illegible]	8,406.80

MILD STEEL FLATS (6METRE LONG)

5/8 x 3/16	16 x 4	0.565	3.39	- 25.40	7,488.00
1¼ x 3/16	30 x 5	-	7.13	- [illegible]	6,716.00
$1\frac{1}{2}$ x $\frac{1}{4}$	40 x 6	-	11.32	- 80.50	7,110.00
$1\frac{1}{2}$ x 3/8	40 x 10	3.176	19.47	- [illegible]	6,610.00
4 x $\frac{1}{4}$	100 x 6	-	28.33	- 187.30	6,610.00

MILD STEEL UNEQUAL ANGLES

3 x 2 x $\frac{1}{4}$	75 x 50 x 6	-	33.60	- 258.30	7,688.00

MILD STEEL EQUAL ANGLES

$\frac{3}{4}$ x $\frac{3}{4}$ x 1/8	20 x 20 x 3	-	5.46	39.20 -	7,222.00
1 x 1 x 1/8	25 x 25 x 3	-	7.07	47.50 -	6,718.60
$1\frac{1}{4}$ x $1\frac{1}{4}$ x 3/16	30 x 30 x 4.5	2.080	12.48	81.60 -	6,539.00
[illegible] x 1½ x 3/16	40 x 40 x 5	2.950	17.70	110.30 -	6,258.00
2 x 2 x $\frac{1}{4}$	50 x 50 x 6	-	27.90	179.50 -	6,435.00
$2\frac{1}{2}$ x $2\frac{1}{2}$ x $\frac{1}{4}$	65 x 65 x 6	-	37.00	245.60 -	6,638.60
3 x 3 x $\frac{1}{4}$	75 x 75 x 6	-	41.10	264.50 -	6,435.00
4 x 4 x 5/16	100 x 100 x 7	-	65.00	[illegible] -	6,434.15

MILD STEEL HOT ROLLED CHANNEL

$\frac{3}{4}$ x $\frac{3}{4}$ x 1/8	20 x 20 x 3	-	5.29	-	10,082.00
3 x 2 x 3/16	75 x 40 x 5	-	41.50	-	8,000.00
4 x 2 x $\frac{1}{4}$	100 x 50 x 6	10.617	62.50	-	8,000.00
$4\frac{3}{4}$ x 3/16 x 5/16	120 x 5 x 7	26.667	160.00	5,602.00	6,117.00
5 x $2\frac{1}{2}$ x 5/16	125 x 65 x 7	13.427	80.56	6,339.10	6,928.05
63/8 x $2\frac{1}{2}$ x 5/16	160 x 65 x 7.5	37.667	226.00	5,602.00	6,117.00
7 x $2\frac{3}{4}$ x 5/16	180 x 70 x 8	-	-	-	7,010.30
$7\frac{1}{4}$ x 3 x 5/16	180 x 75 x 7 x 6mt	-	128.1	-	7,010.30

... 3 ...

MILD STEEL HEXAGONAL BARS

3/8	I0	-	4.II	-	8,634.00
	I2	-	6.I0	-	8,428.00
I¼	32	-	24.00	-	8,600.00
I	25	-	I7.00	-	8,600.00

MILD STEEL SQUARE HOLLOW SECTION

I x I x I/8	25 x 25 x I.2	-	5.25	-	9,I87.00
2 x 2 x I/I6	50 x 50 x I.5	-	I3.4I3	-	9,I87.00

B E A M S

LPE	I20 x I2MT	-	I25.20	-	7,592.00
LPE	200 x I2 MT	-	3I5.32	-	6,895.00
LPE	300 x I2MT	-	645.53	-	6,877.00

TANGA STEEL ROLLING MILLS PRODUCTS

3/8	I0	0.6I7	7.40	-	II,293.00
½	I2	0.888	I0.65	-	II,[illegible].00
5/8	I6	I.570	I8.95	-	II.293.00
¾	20	2.466	29.60	-	II.267.00
I	25	3.854	46.25	-	II.267.00

HIGH TENSILE DEFORMED BARS

3/8	I0	0.6I7	7.40	-	II,567.00
½	I2	0.888	I0.65	-	II,567.00
5/8	I6	I.570	I8.95	-	II,567.00
¾	20	2.466	29.60	-	II,567.00
I	25	3.854	46.25	-	II,566.00

WIRE ROD COILS

5/I6	8	0.395	-	-	7,028.00
¼	6	0.222	-	-	7,035.00
-	5.5mm	-	-	-	7,04I.00

MILD STEEL FLATS

2 x 4	50 x 6	2.355	I4.I2	-	II,240.00

... 4 ...

NB
Shs 57/- charged
1/- Crane Charges

SHORT HTD/RIB

I. Up to I2M 3,947.00

2. Above I2m - Normal full length price less IO%

NB:

I. W/S Whole sales (applicable to RTCS only.
2. MM - Millimetres
3. M - Metre
4. No discounts allowed (Cash / Quantity)
5. Prices are ruling at the time of delivery
6. Local products are quoted ex-steel yard
7. Prices shown per metric ton.

Yours faithfully,
NATIONAL STEEL CORPORATION LIMITED,

A. Z. MANUYA
GENERAL MANAGER

****

LURGI

13848

(6 ...)

Final Report

Volume VI

Techno-Economic Evaluation and Project Report

for the

Establishment of an Iron and Steel Industry

in

The United Republic of Tanzania

Unido Project SM/URT/81/004

for

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

April 1984

LURGI

TECHNO-ECONOMIC EVALUATION AND PROJECT REPORT

FOR THE

ESTABLISHMENT OF AN IRON AND STEEL INDUSTRY

IN

THE UNITED REPUBLIC OF TANZANIA

GENERAL LIST OF CONTENTS

UNIDO Project No. SM/URT/81/004

LURGI

GENERAL LIST OF CONTENTS

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LURGI

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1.2 Coal Mine

1.3 Coal Washing Plant

1.4 Offsites and Auxiliaries "Mchuchuma"

2. Liganga Iron Ore

2.1 General Aspects

2.2 Iron Ore Mine

2.3 Iron Ore Beneficiation Plant

2.4 Pelletizing Plant

2.5 Offsites and Auxiliaries "Liganga"

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LURGI

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LURGI

LIST OF DRAWINGS

VOLUME II, PLANT DESIGN "RAW MATERIALS"

1. MCHUCHUMA COAL

1.1 Coal Mine

LOA 00 2238 00001	-Geological Map scale 1 : 10 000
LOA 00 2238 00002	-Mineable Reserves scale 1 : 10 000
L1A 00 2238 00003	-General Mining Layout scale 1 : 10 000
L1A 00 2238 00004	-Section Mine Entry System scale 1 : 5 000
LOA 00 2238 00005	-Two Wing Retreat Long Wall Stoping, scale 1 : 100

1.3 Coal Washing Plant

L2A 01 2238 00009	-Coal Washing Plant Mchuchuma Topographical Map, scale 1 : 25 000
L3A 01 2238 00004	-Coal Washing Plant Mchuchuma Feed 950 000 t/a Block Diagram (1st stage)
L3A 01 2238 00005	-Coal Washing Plant Mchuchuma Feed 1 900 000 t/a Block Diagram (2nd stage)
L1A 01 2238 00008	-Coal Washing Plant Mchuchuma Key Plan, scale 1 : 2000
L1A 01 2238 00007	-Coal Washing Plant Mchuchuma Plot Plan, scale 1 : 500

4303

2. LIGANGA IRON ORE

2.2 Iron Ore Mine

LOA 00 2238 00006	-Topographic Map with Location of Sections, scale 1 : 1000
L2A 00 2238 00007	-Section 1 - 3, scale 1 : 2 000
L2A 00 2238 00008	-Section 4 - 5, scale 1 : 2 000
L2A 00 2238 00009	-Section 6 - 7, scale 1 : 2 000
L2A 00 2238 00010	-Section 8 - 9, scale 1 : 2 000
L2A 00 2238 00011	-Section 10 - 11, scale 1 : 2 000
L2A 00 2238 00012	-Section 12 - 13, scale 1 : 2 000
L2A 00 2238 00013	-Section 14, scale 1 : 2 000
L2A 00 2238 00014	-Section 15, scale 1 : 2 000
L2A 00 2238 00015	-General Plot Plan, scale 1 : 5 000
LOA 00 2238 00016	-Mine Configuration End Year 5 (1662.5), scale 1 : 1 000
LOA 00 2238 00017	-Mine Configuration End Year 10 (1600), scale 1 : 1 000
LOA 00 2238 00018	-Mine Configuration End Year 15 (1562.5), scale 1 : 1 000
LOA 00 2238 00019	-Mine Configuration End Year 19 (1525), scale 1 : 1 000

2.3 Iron Ore Beneficiation

L2A 01 2238 00010	-Iron Ore Beneficiation and Pelletizing Plant Liganga Topographical Map, scale 1 : 25 000
L2A 01 2238 00001	-Iron Ore Beneficiation Plant Liganga 1,6 Mio t/a Ore Feed Block Diagram (1st stage)
L2A 01 2238 00002	-Iron Ore Beneficiation Plant Liganga 3,2 Mio t/a Ore Feed Block Diagram (2nd stage)
L3A 01 2238 00006	-Limestone and Bentonite Handling Liganga Block Diagram (1st and 2nd stage)
LOA 02 2238 00004	-Beneficiation and Pelletizing Plant Liganga Key Plan, scale 1 : 2000
L1A 01 2238 00003	-Crusher and Ore Storage Liganga Plot Plan, scale 1 : 500
LOA 02 2238 00003	-Beneficiation and Pelletizing Plant Liganga Plot Plan, scale 1 : 500

2.4 Pelletizing Plant

L3A 02 2238 00001	-Iron Ore Pelletizing Plant Liganga 0,95 Mio t/a Product Block Diagram (1st stage)
L3A 02 2238 00002	-Iron Ore Pelletizing Plant Liganga 1,98 Mio t/a Product Block Diagram (2nd stage)
LOA 02 2238 00004	-Beneficiation and Pelletizing Plant Liganga Key Plan, scale 1 : 2000
LOA 02 2238 00003	-Beneficiation and Pelletizing Plant Liganga Plot Plan, scale 1 : 500

VOLUME III, PLANT DESIGN "STEELWORKS"

2. General Layout

L2A 03 2238 00015	-Steelworks Mahanje Topographical Map, scale 1 : 25 000
LOA 03 2238 00016	-Steelworks Mahanje Key Plan, scale 1 : 2000

3. Direct Reduction Plant

L1A 03 2238 00017	-Direct Reduction Plant 660 000 t/a DRI Block Diagram
LOA 03 2238 00018	-Direct Reduction Plant Plot Plan, scale 1 : 500

4. Electric Smelting Plant

F3A 03 2238 00020	-Electric Semi Steel Smelting Main Flowsheet Slabs (1st stage)
F3A 03 2238 00021	-Electric Semi Steel Smelting Main Flowsheet Billets (2nd stage)
FOA 03 2238 00022	-Electric Smelting Plant Sections Plot Plan, scale 1 : 500

5. Ladle Metallurgy

F3A 03 2238 00023	-Liquid Steel Handling and Ladle Furnaces Main Flowsheet Slabs (1st stage)
F3A 03 2238 00024	-Liquid Steel Handling and Ladle Furnaces Main Flowsheet Billets (2nd stage)
F0A 03 2238 00025	-Ladle Metallurgy Plant and Steel Transfer Sections Plot Plan, scale 1 : 500

6. Continuous Casting Plant

F3A 03 2238 00026	-Continuous Casting Plant Main Flowsheet Slabs (1st stage)
F3A 03 2238 00027	-Continuous Casting Plant Main Flowsheet Billets (2nd stage)
F0A 03 2238 00028	-Continuous Casting Plant 1st stage slabs/2nd stage Billets Sections Plot Plan, scale 1 : 500

7. Rolling Mill and Product Finishing

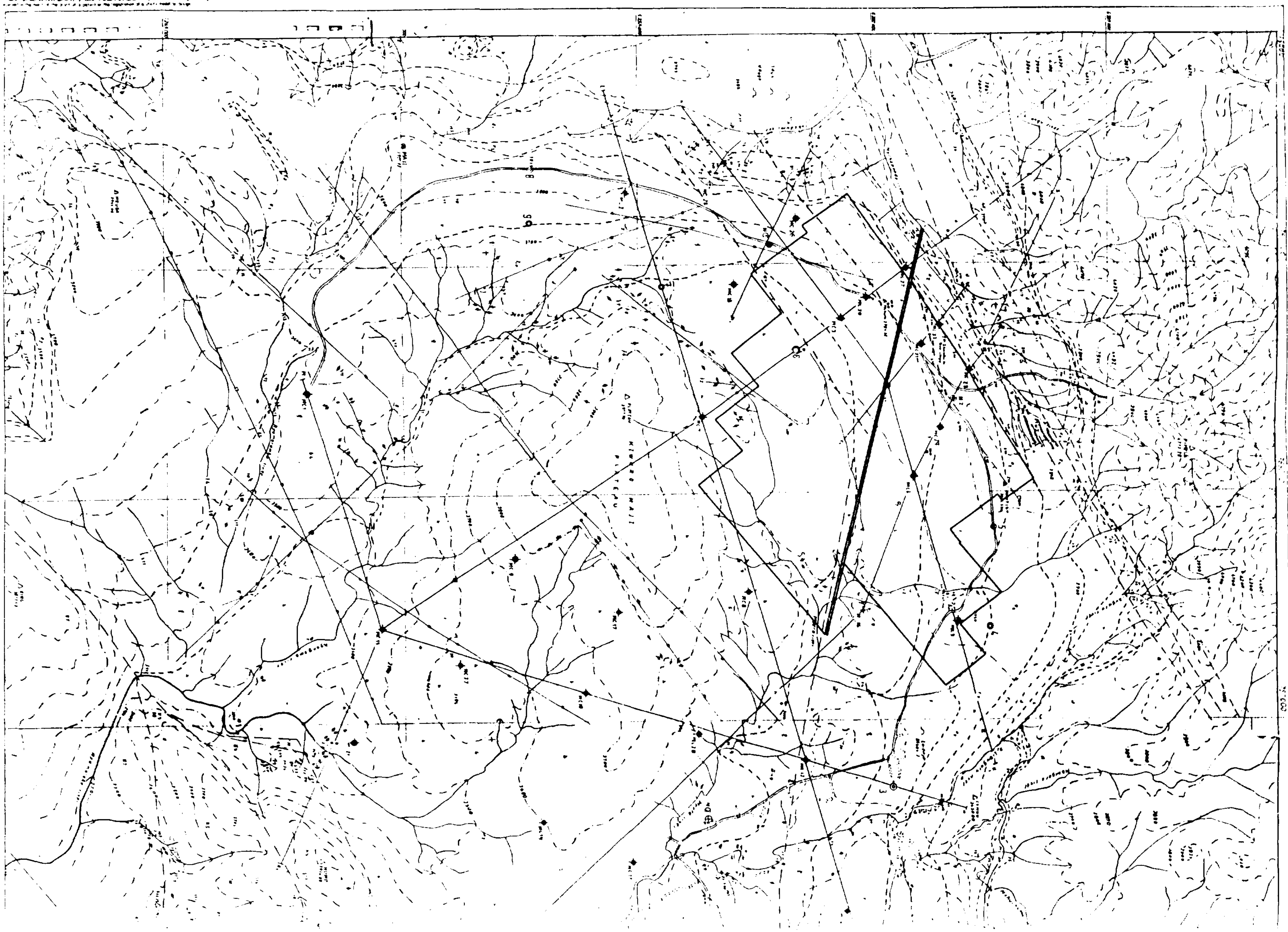
F3A 03 2238 00029	-Hot Strip and Plate Mill Main Flowsheet (1st stage)
F3A 03 2238 00030	-Billet and Section Mill Main Flowsheet (2nd stage)
F0A 03 2238 00031	-Rolling Mill Stage I and II, Plot Plan scale 1 : 500

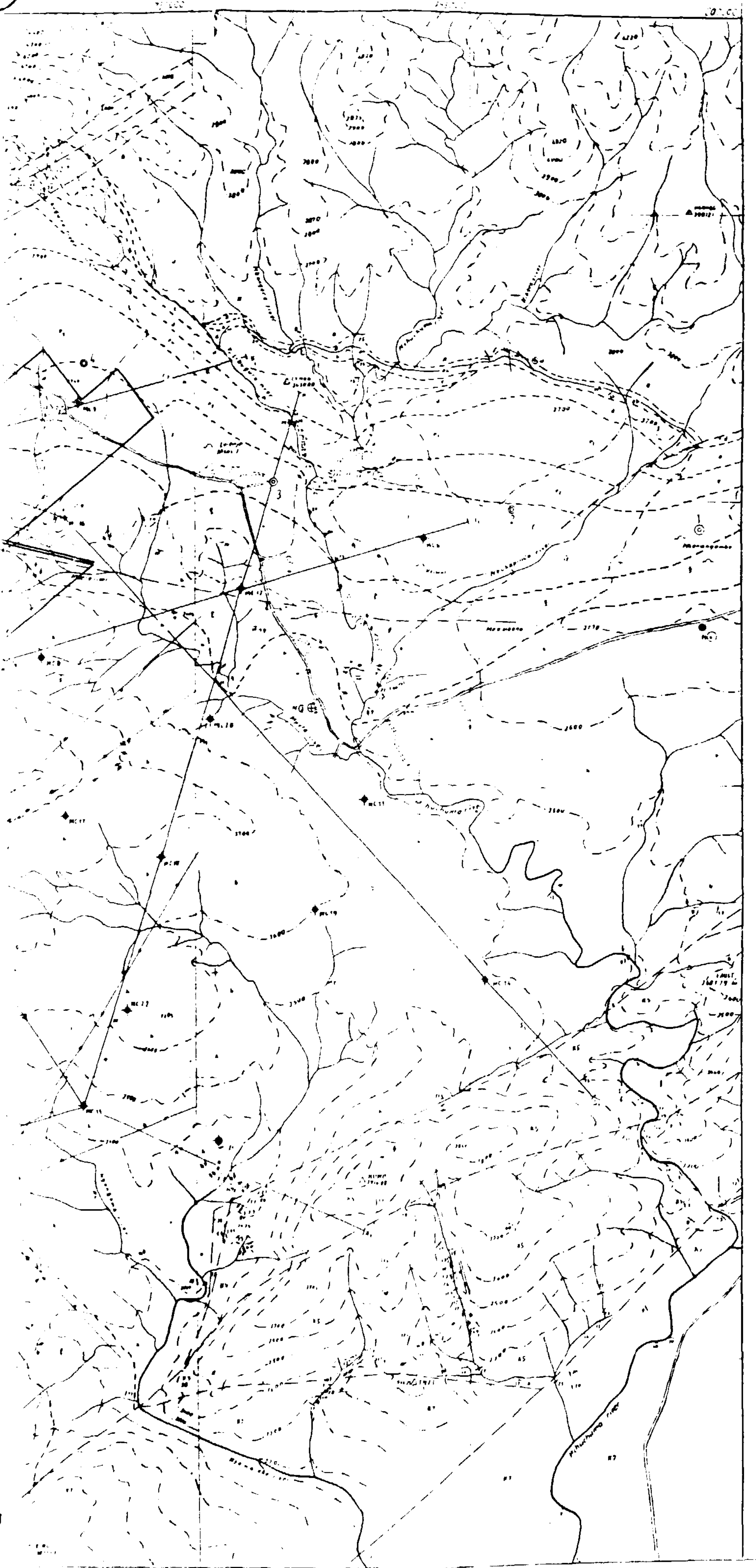
8. Off-sites and Auxiliaries "MAHANJE"

8.1.1 Limestone / Dolomite Facilities

L1A 03 2238 00032	-Limestone/Dolomite Facilities Mahanje Flow Diagram
L3A 03 2238 00033	-Lime Hydrating Plant Mahanje

SECTION 1





GEOLOGICAL MAP
MCHUCHUMA COALFIELD

Based on Geological Survey (C.D.C) 1952

Scale 1:10 000

0 — 1000 — 2000 — 3000 — 4000 — 5000 Feet

¼ — ½ — ¾ — 1 Mile

Symbol	Description	Period		
	Quartz Intrusions	TERTIARY		
K 8	Manda Beds and micaceous mudst and grey felspathic		MEZOZOIC	KARROO
K 7	Kingori sandstone Massive quartzitic sandstone	TRIAS	MEZOZOIC	KARROO
K 6	Lower bone bed	TRIAS	MEZOZOIC	KARROO
K 5	Ruhuhu Beds Calcareous greenish sst silts and mudst	TRIAS	MEZOZOIC	KARROO
K 4	Upper Coal Measures Carbonaceous mudst and shales and tuff to grey sst with plant remains.	TRIAS	MEZOZOIC	KARROO
K 3	Sandstones and mudstones mostly red	PERMIAN	UPPER PALAEOZOIC	KARROO
K 3	Sandstones and mudstones mostly green [g]	PERMIAN	UPPER PALAEOZOIC	KARROO
K 2	Scarp sandstones (f)	PERMIAN	UPPER PALAEOZOIC	KARROO
K 2	Coal shale (e_1)	PERMIAN	UPPER PALAEOZOIC	KARROO
K 2	Coal sandstone (e_2)	CARBONIFEROUS	UPPER PALAEOZOIC	KARROO
K 2	Sandstones and siltstones interbedded (d)	CARBONIFEROUS	UPPER PALAEOZOIC	KARROO
K 2	Dark shales (c)	CARBONIFEROUS	UPPER PALAEOZOIC	KARROO
K 1	Green paper shale varved	CARBONIFEROUS	UPPER PALAEOZOIC	KARROO
K 1	Basal green sandstone Tillite (a)		UPPER PALAEOZOIC	KARROO
	Waterberg or Bukoban Quartzitic conglomerate (B)	LOWER PALAEOZOIC		
	Lower basement complex (B	PRE-CAMBREAN		

Note: K1 – 10 terminology following (G.M. STOCKLEY (1931) (1932)

GEOLOGICAL STRUCTURE

- Dip and strike Horizontal bedding
- Quartz veining
- Vertical joint dip of joint with direction of striation
- Pronounced jointing
- Joint trends mapped from air photos — Fault
- Zone boundary — Fault inferred
- Zone boundary-inferred
- C D C Profil Lines

COAL SEAMS

- Top seams
- Upper seam
- Coking seam
- Middle seam
- Lower seam

BOREHOLES

- Borehole economic results
- Borehole-uneconomic results

MINING

- Boundary of Mine Field with main entry

TOPOGRAPHICAL

- Trigonometrical Station
- Spotheight
- Contour line

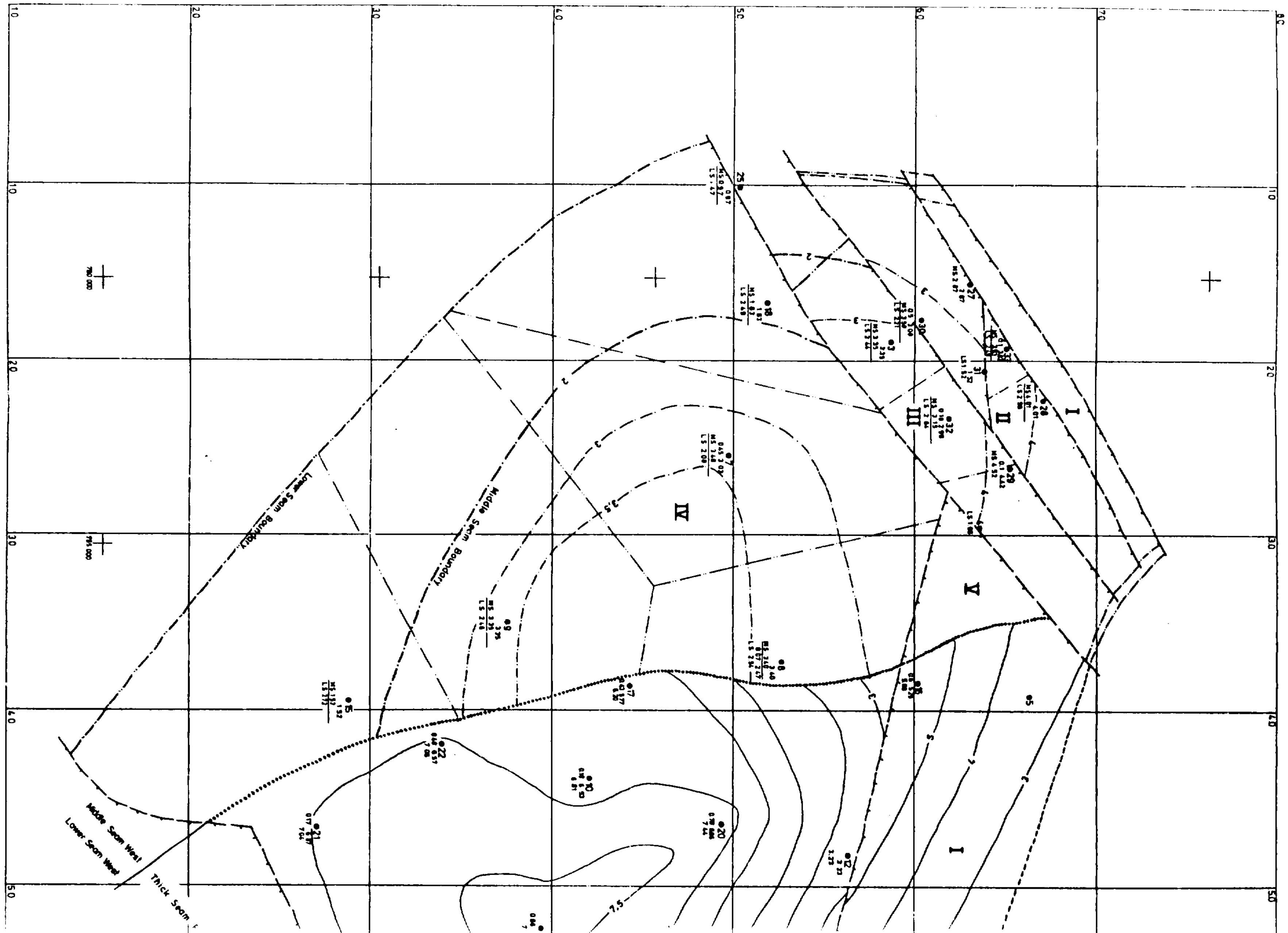
GENERAL

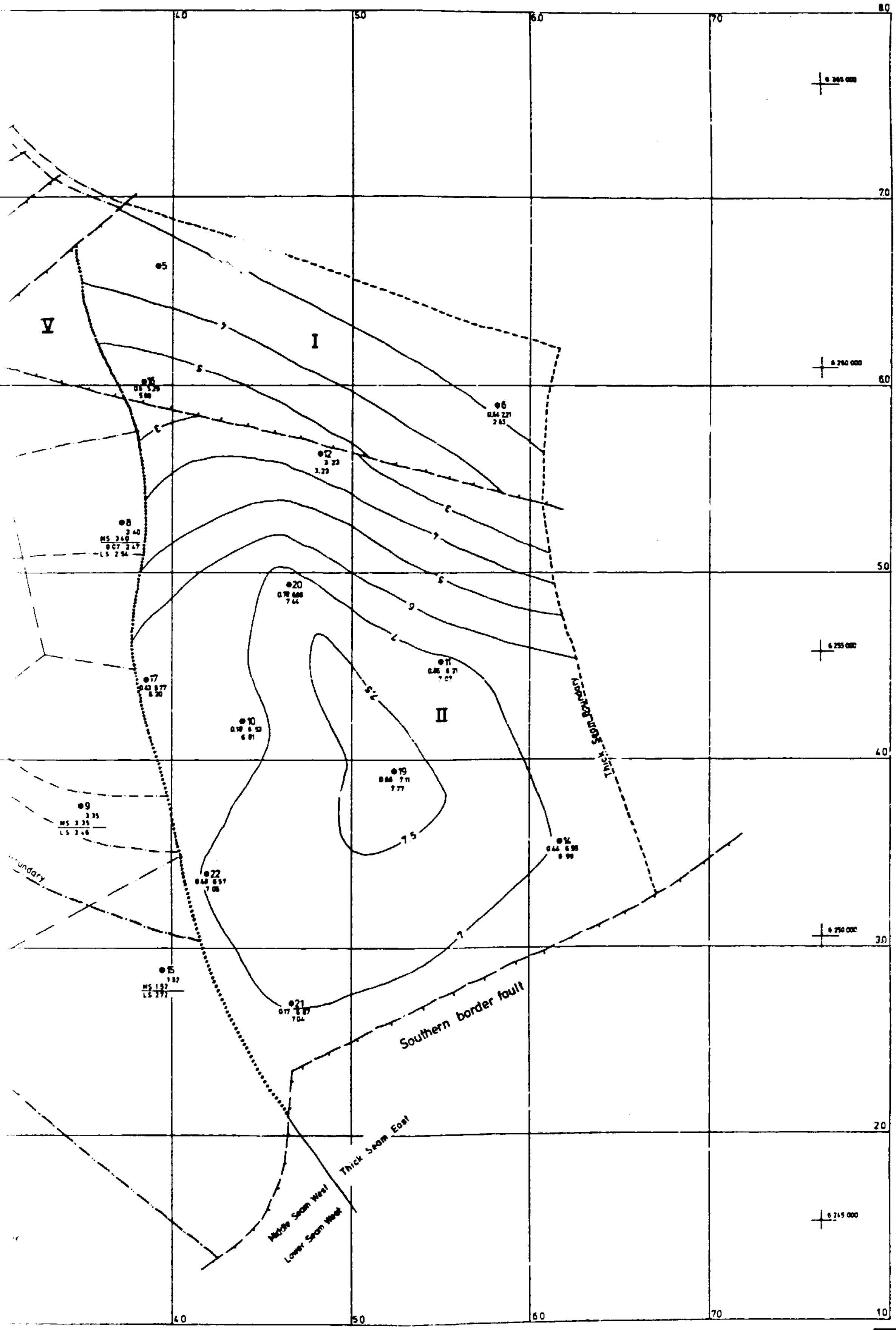
- Motorable track
- Centre of African settlement and cultivation
- Waterholes
- Indications of surface water
- European house or office or store

SECTION 2

Scale 1:10000	LURGI — Lurgi Chemie und Hüttentechnik GmbH
	MINING MCHUCHUMA Geological Map
	TANZANIA
	CA00 2238 00001

SECTION 1


Lower Seam Boundary
Middle Seam Boundary
Middle Seam Wall
Lower Seam Wall
Thick Seam
I
II
III
IV
V



Reserve Calculation

Middle Seam	34.0 mill t
Lower Seam	43.0 mill t
Middle + Lower Seam	79.0 mill t
Total	155.0 mill t

detailed Calculction under 1.2.1.1 "Mineable Reserves"

Legend:

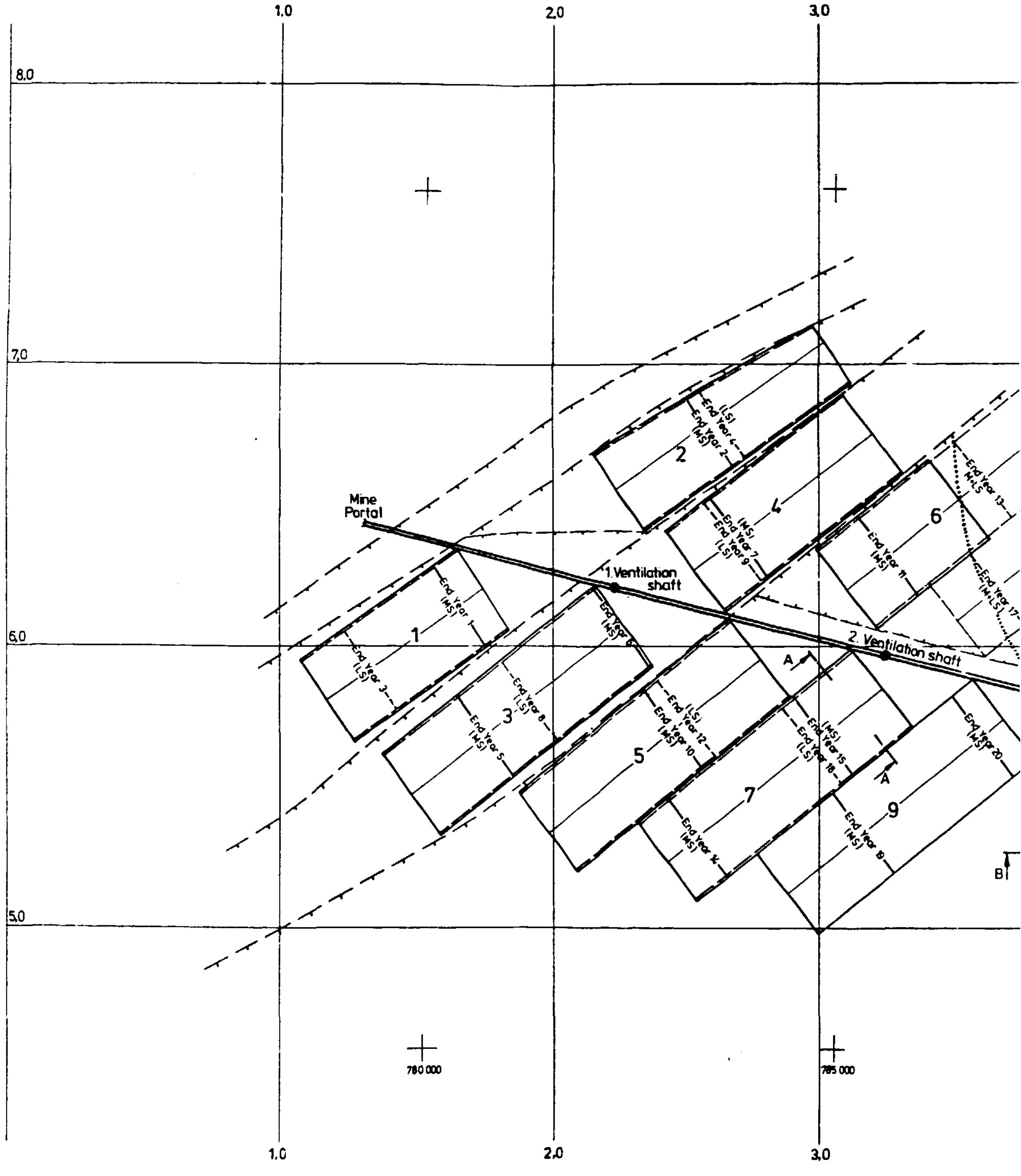
- - - - Calculation Boundary Thick Seam
-·-·- Calculation Boundary Middle Seam
-··-- Calculation Boundary Lower Seam
Interburden Thickness
Borehole No. 7
Coal Thickness
Total Coal + Interburden Thickness for Mining
Coal Thickness for Mining
Lower Seam
Middle Seam

II Calculated Section
Fault
········ Calculation Line
Middle Seam West | Thick Seam East
Lower Seam West

— 5 — Seam Thickness Isolines

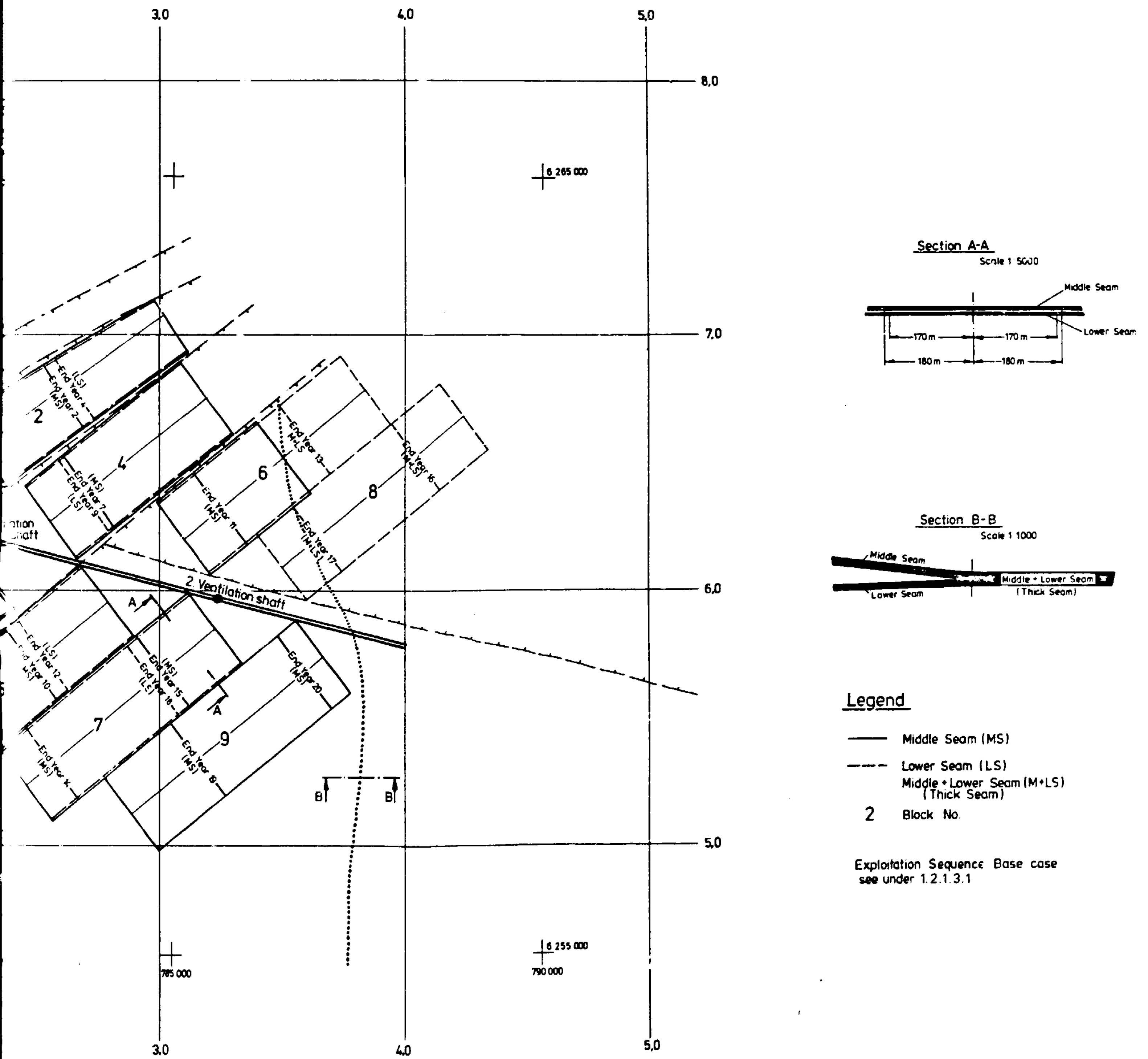
SECTION 2

Original Scale 1:10000	MINING MCHUCHUMA Mineable Reserves
HB	0 0 2 2 3 8
	TANZANIA
Drawing No	L0A 0 0 2 2 3 8 0 0 0 0 2



1.0
2.0
3.0
8.0
7.0
6.0
5.0
Mine Portal
1. Ventilation shaft
2. Ventilation shaft
End Year 1 (MS)
End Year 2 (MS)
End Year 3 (LS)
End Year 4 (LS)
End Year 5 (MS)
End Year 6 (MS)
End Year 7 (MS)
End Year 8 (LS)
End Year 9 (LS)
End Year 10 (MS)
End Year 11 (MS)
End Year 12 (LS)
End Year 13 M+LS
End Year 14 (MS)
End Year 15 (MS)
End Year 16 (LS)
End Year 17 (M+LS)
End Year 20 (MS)
A
B
780 000
785 000

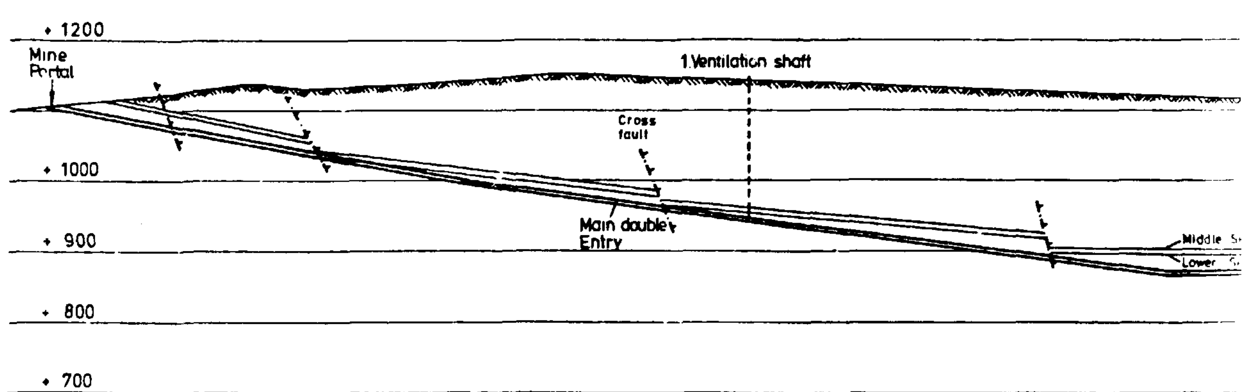
SECTION 1



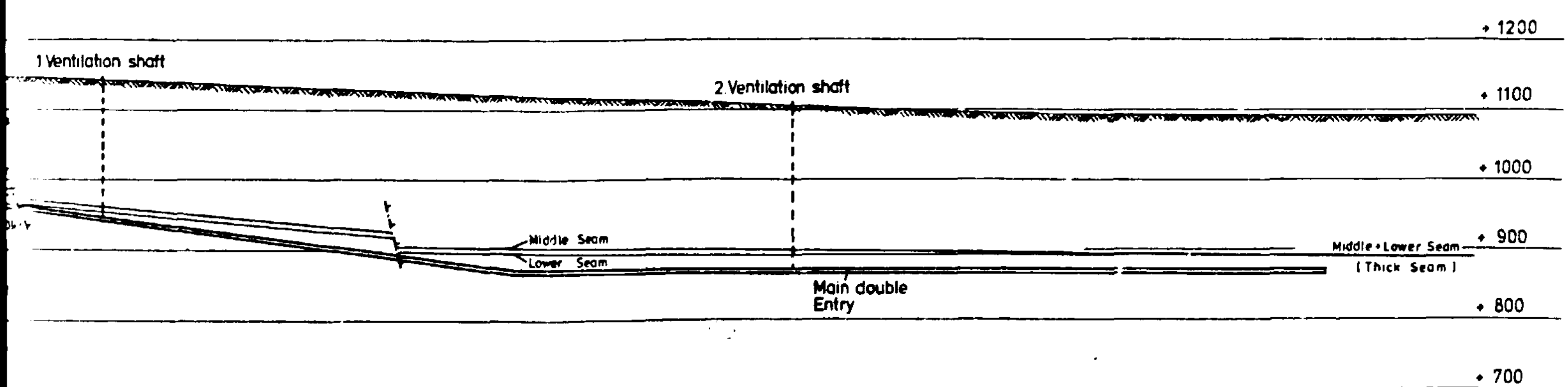
SECTION 2

Prepared 10.1.84	LURGI	Lurgi Chemie und Huttentechnik GmbH
Original Scale 1.10000	Title/Characteristic Features	MINING MCHUCHUMA General Mining Layout
Process HB	Job or Project No 0 0 2 2 3 8	TANZANIA
Drawing No	L1A00223800003	

SECTION 1



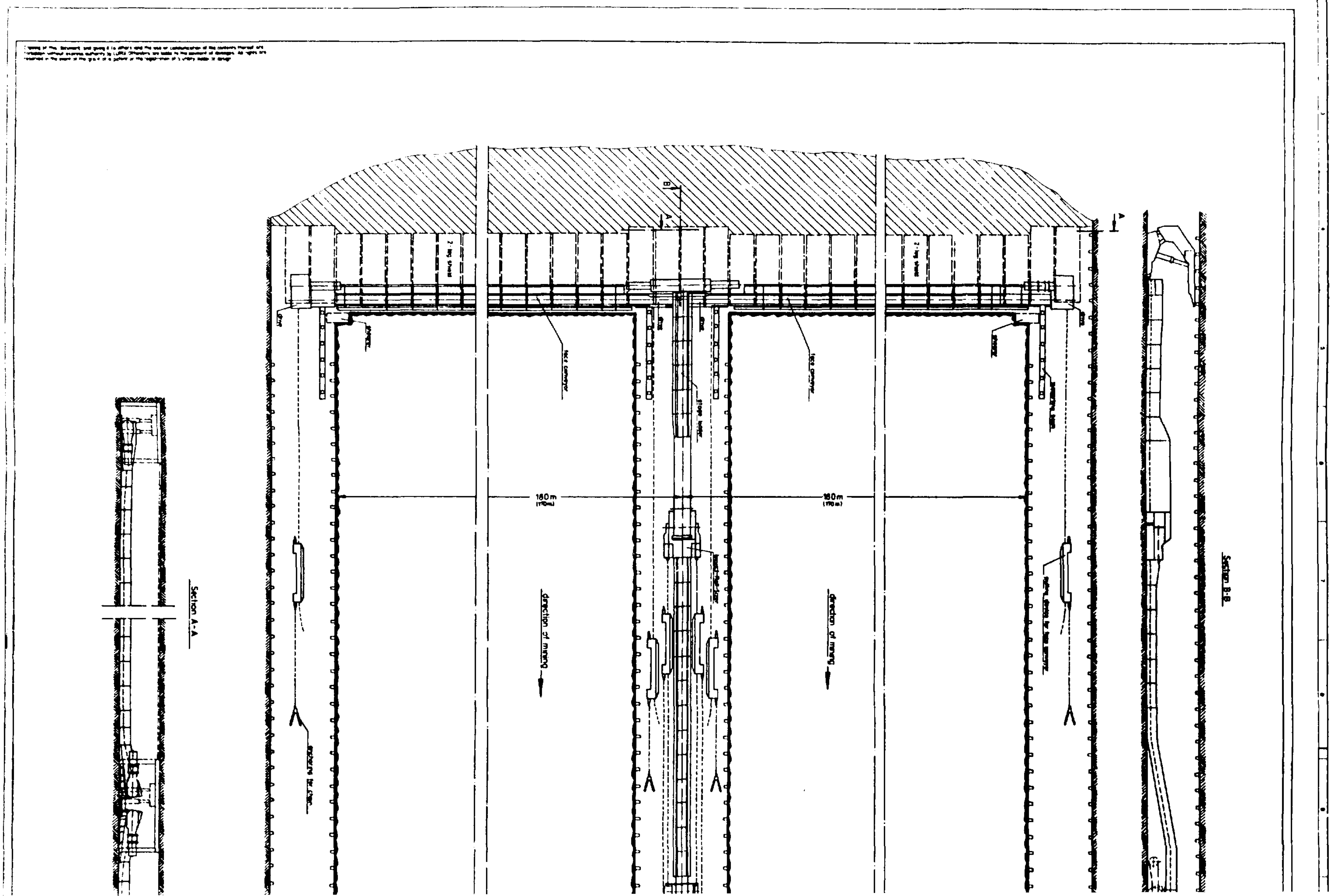
+ 1200
Mine Portal
1.Ventilation shaft
Cross fault
+ 1000
+ 900
Main double Entry
Middle
Lower
+ 800
+ 700



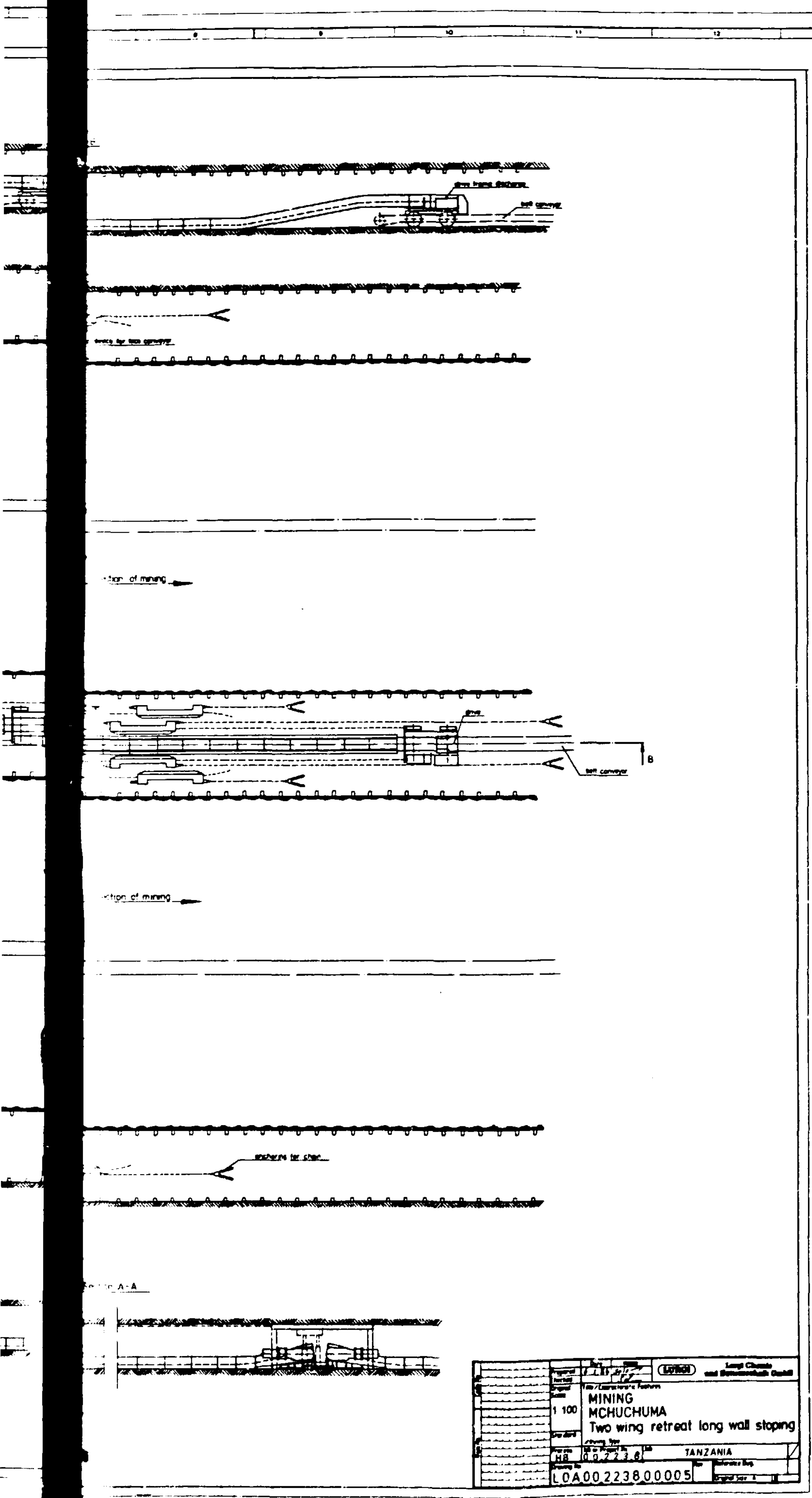
SECTION 2

	Date	Name	LURGI — Lurgi Chemie und Hüttentechnik GmbH
Prepared	11.1.84		
Checked			
Original Scale: 1:5000	Title/Characteristic features: MINING MCHUCHUMA Section Mine entry System		
Standard	Drawing Type		
Process: HB	Job or Project No: 0 0 2 2 3 8	Job: TANZANIA	
Drawing No: L1A00223800004	Rev	Reference Dwg	Original Size A

SECTION 1

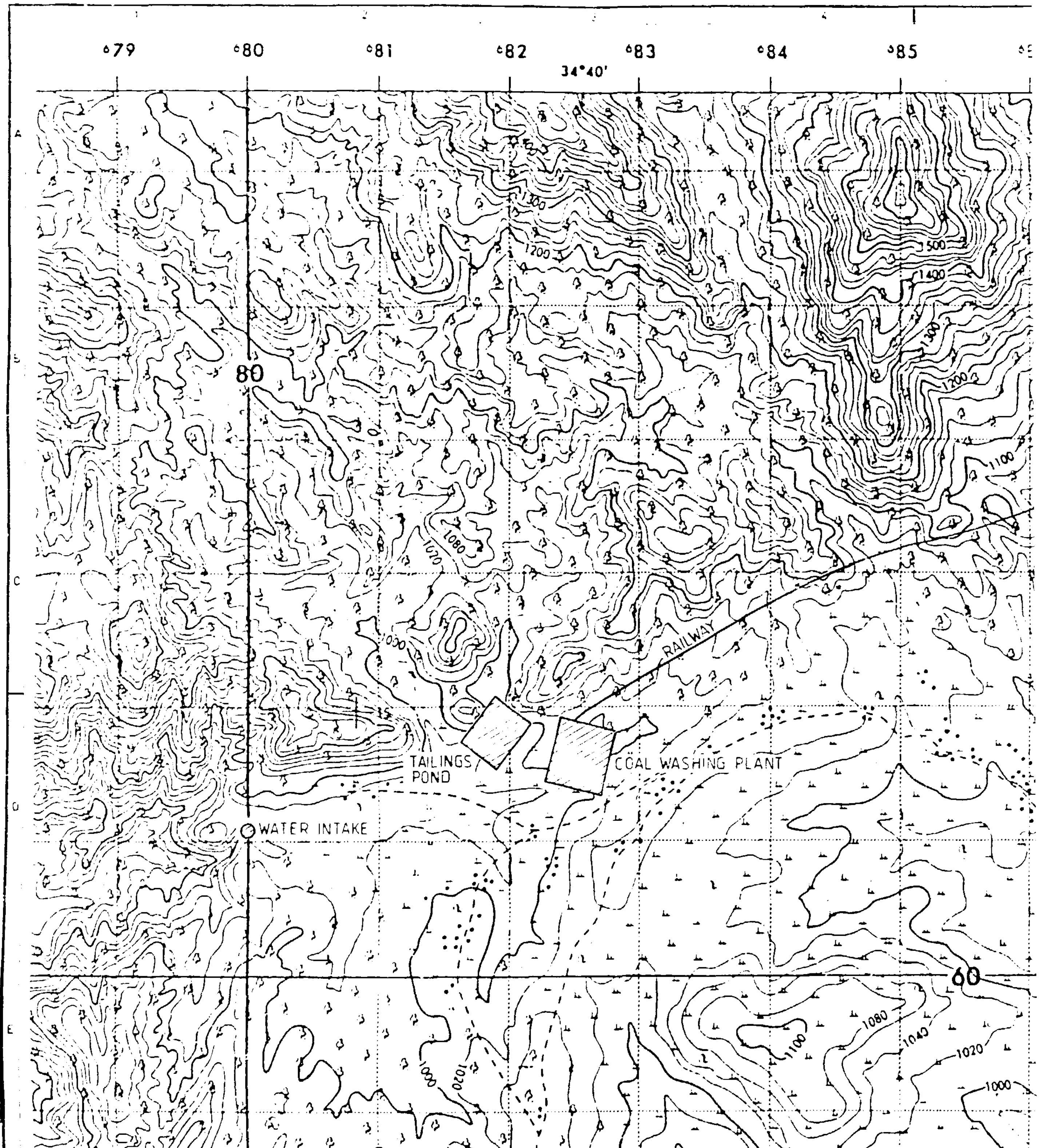


Section A-A
Section B-B
180m
(170m)
180m
(170m)
direction of mining
direction of mining
face conveyor
face conveyor
2-leg shield
2-leg shield
stage loader



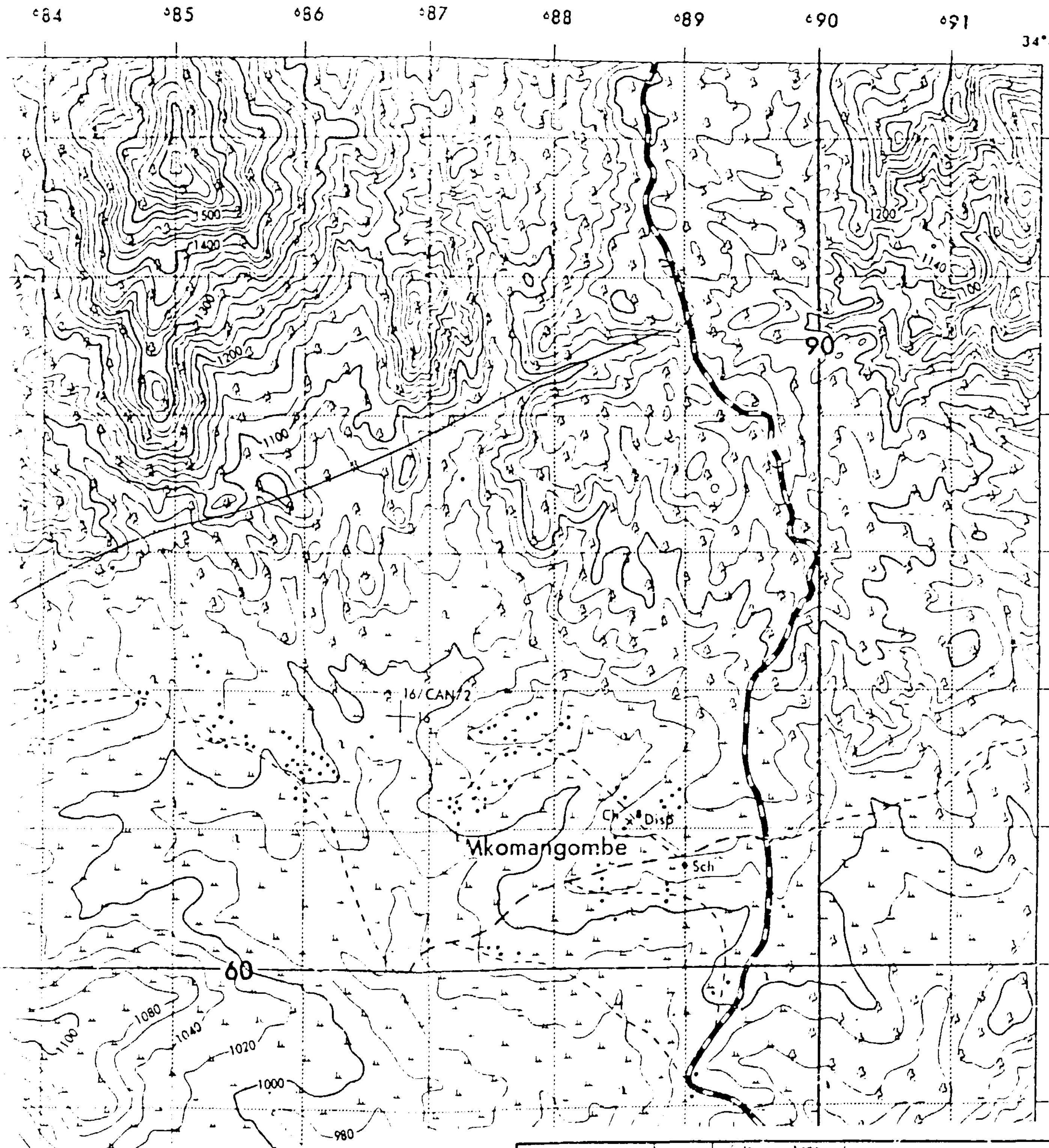
belt conveyor
drive
belt conveyor
B
A-A
MINING
MCHUCHUMA
Two wing retreat long wall stoping
1:100
TANZANIA
L0A00223800005

SECTION 2



NOTE:
ENLARGED SECTION MADE FROM
MANDA MAP: EDITION 1-TSD,
SERIES Y742, SHEET 285/3

SECTION 1

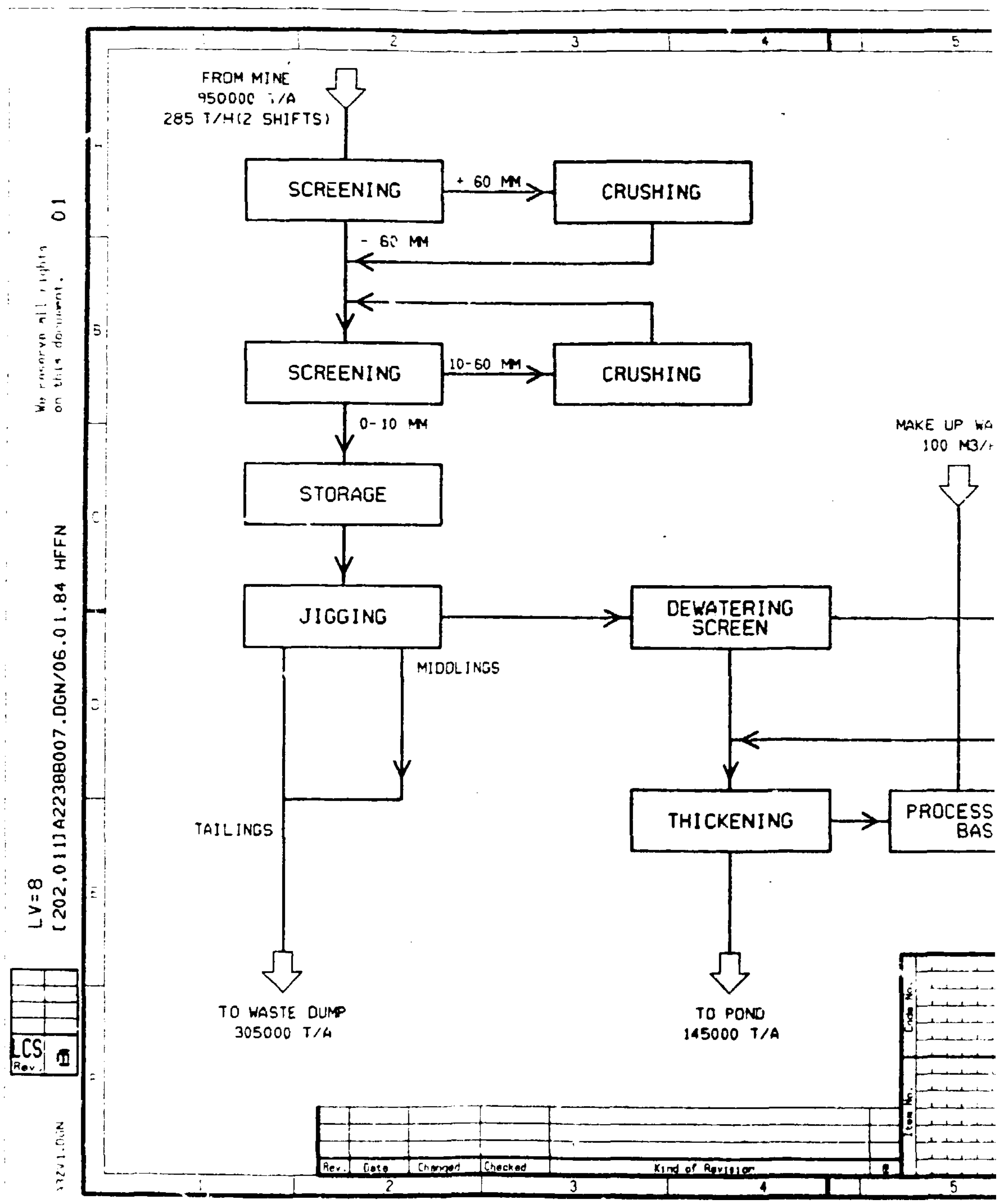


Prepared	12.1.84 Pu
Checked	
Scale	1:25000
Title / Characteristic Features	COAL WASHING PLANT MCHUCHUMA TOPOGRAPHICAL MAP
Process	HAA
Job / Proposal No.	C 1 2 2 3 8
Job Title	TANZANIA
Drawing No	L 2 A 0 1 2 2 3 8 0 0 0 0 9

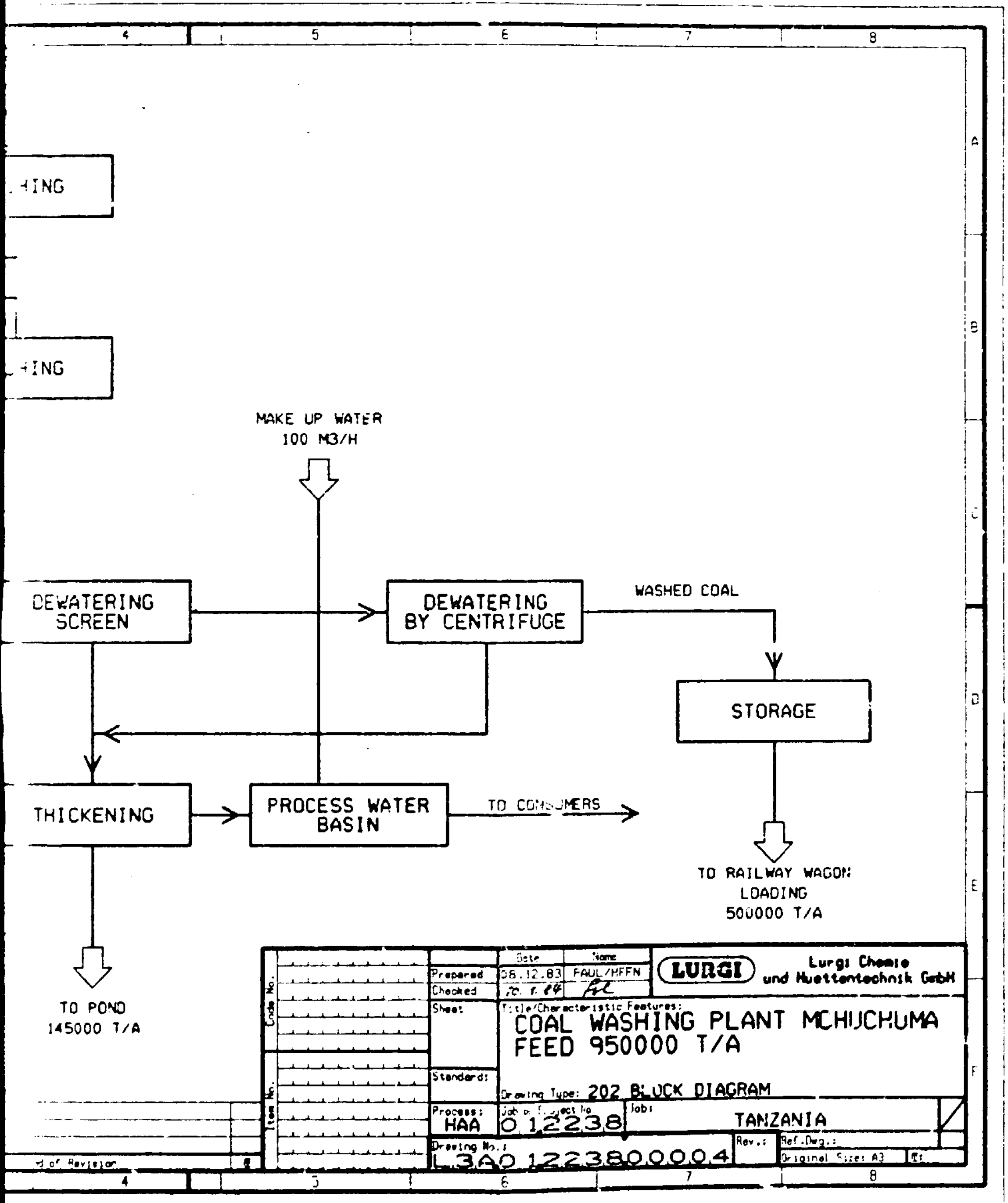
LURGI Lurgi Chemie und Huttentechnik GmbH

SECTION 2

SECTION 1



FROM MINE
285 T/H(2 SHIFTS)
SCREENING
+ 60 MM
CRUSHING
- 60 MM
SCREENING
10-60 MM
CRUSHING
0-10 MM
STORAGE
JIGGING
MIDDLINGS
TAILINGS
DEWATERING SCREEN
THICKENING
MAKE UP WA
100 M3/
PROCESS
BAS
TO WASTE DUMP
305000 T/A
TO POND
145000 T/A
LV=8
[202,011]A2238B007.DGN/06.01.84 HFFN
Rev.
Date
Changed
Checked
Kind of Revision



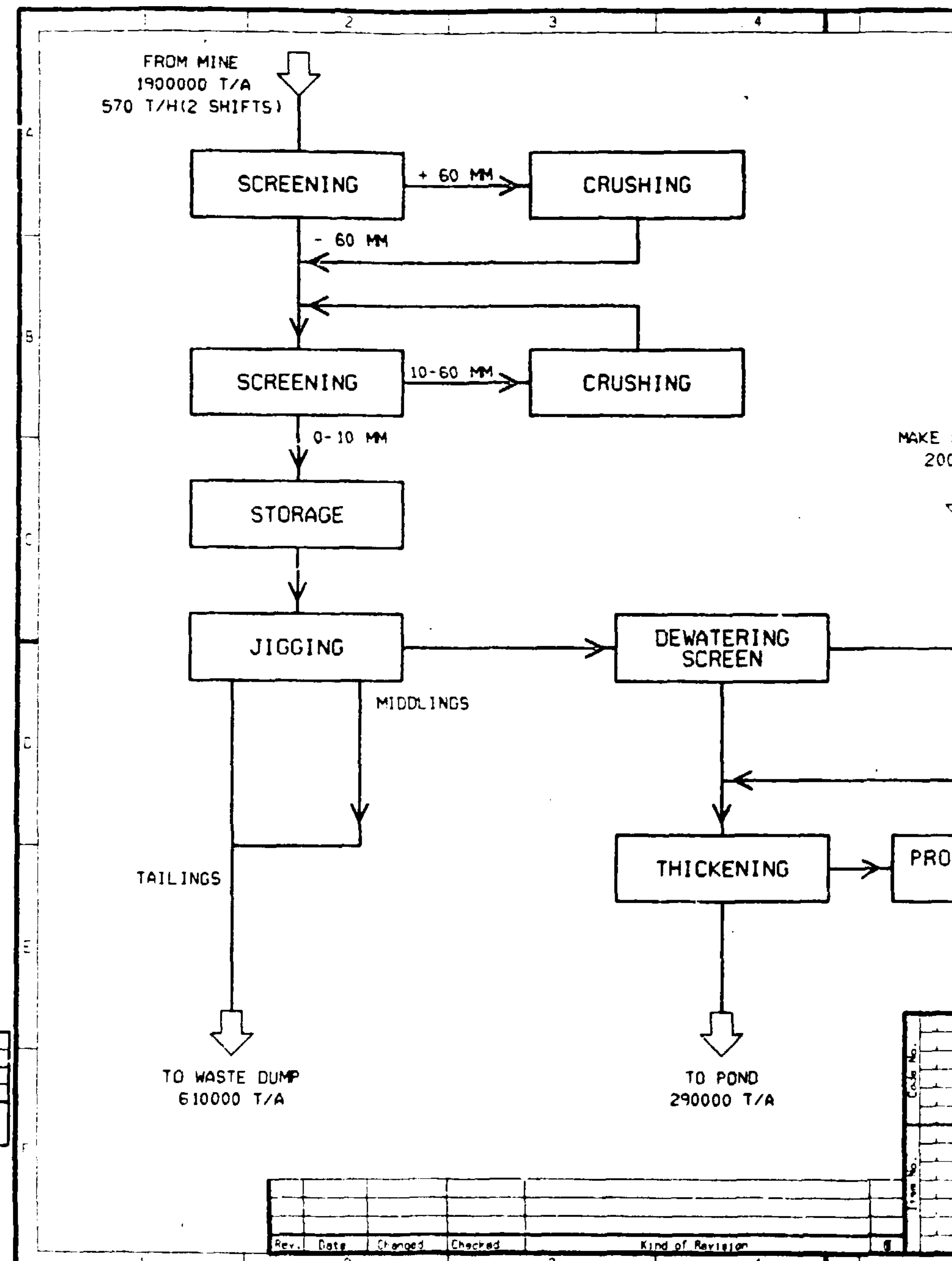
HING
HING
MAKE UP WATER
100 M3/H
DEWATERING SCREEN
DEWATERING BY CENTRIFUGE
WASHED COAL
STORAGE
THICKENING
PROCESS WATER BASIN
TO CONSUMERS
TO RAILWAY WAGON LOADING
500000 T/A
TO POND
145000 T/A
Prepared 06.12.83 FAUL/HFFN
Checked
LURGI
Lurgi Chemie und Huettentechnik GmbH
COAL WASHING PLANT MCHUCHUMA
FEED 950000 T/A
Drawing Type: 202 BLOCK DIAGRAM
Process: HAA
0.12238
TANZANIA
Drawing No.: L3A0 122380000 4

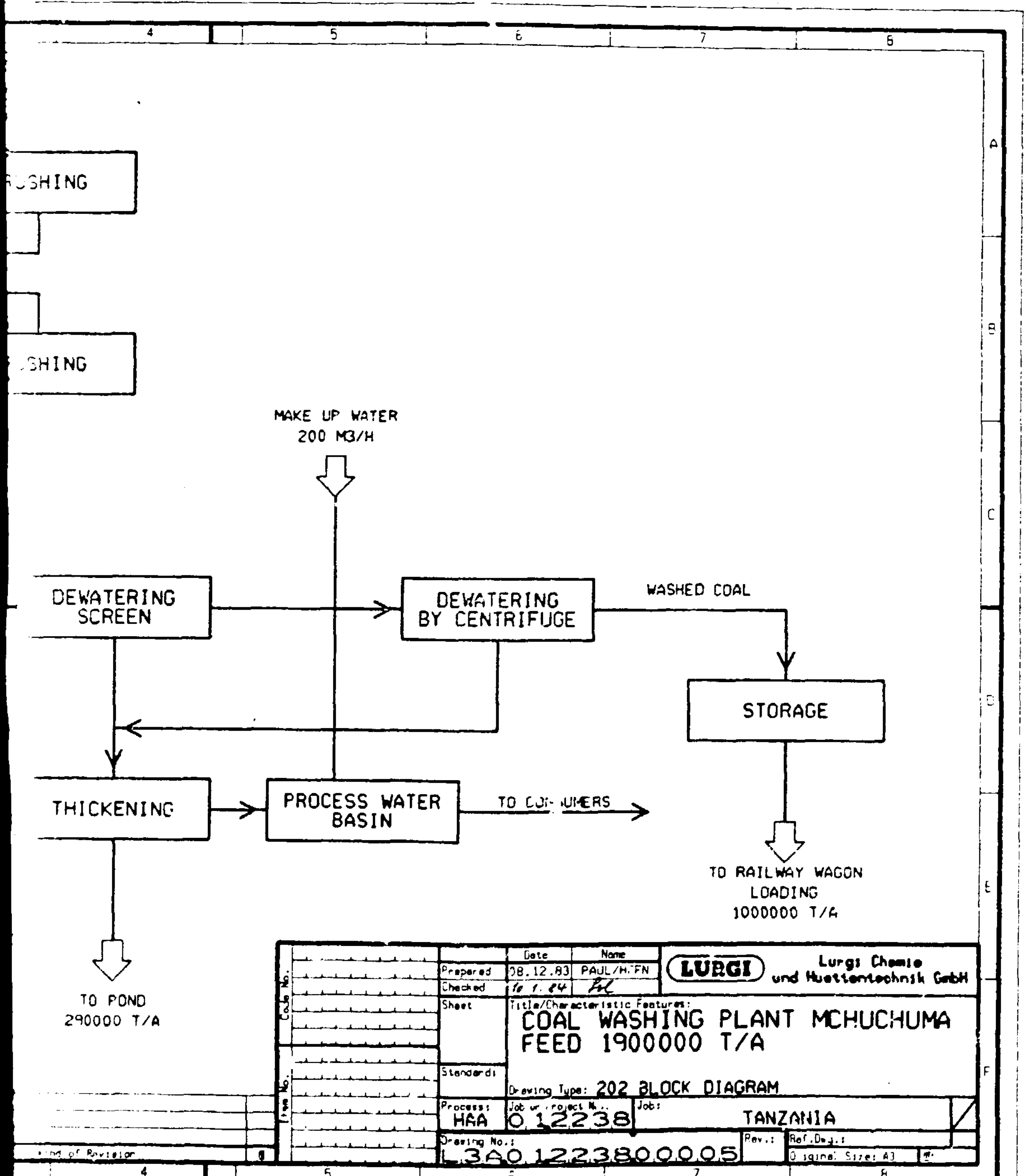
SECTION 2

SECTION 1

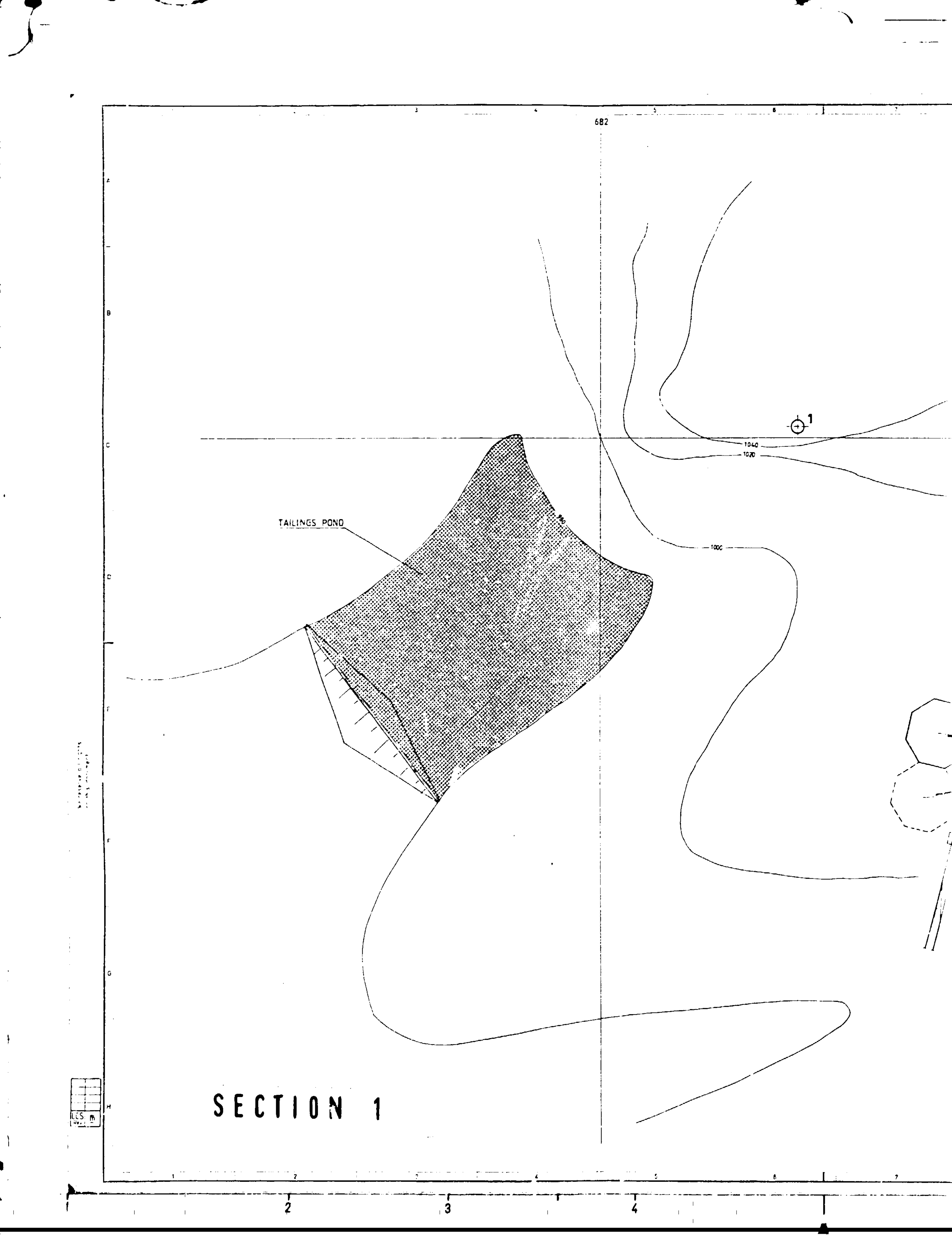
LV=9
[202.01]]A2238B007.DGN/06.01.84 HFFN

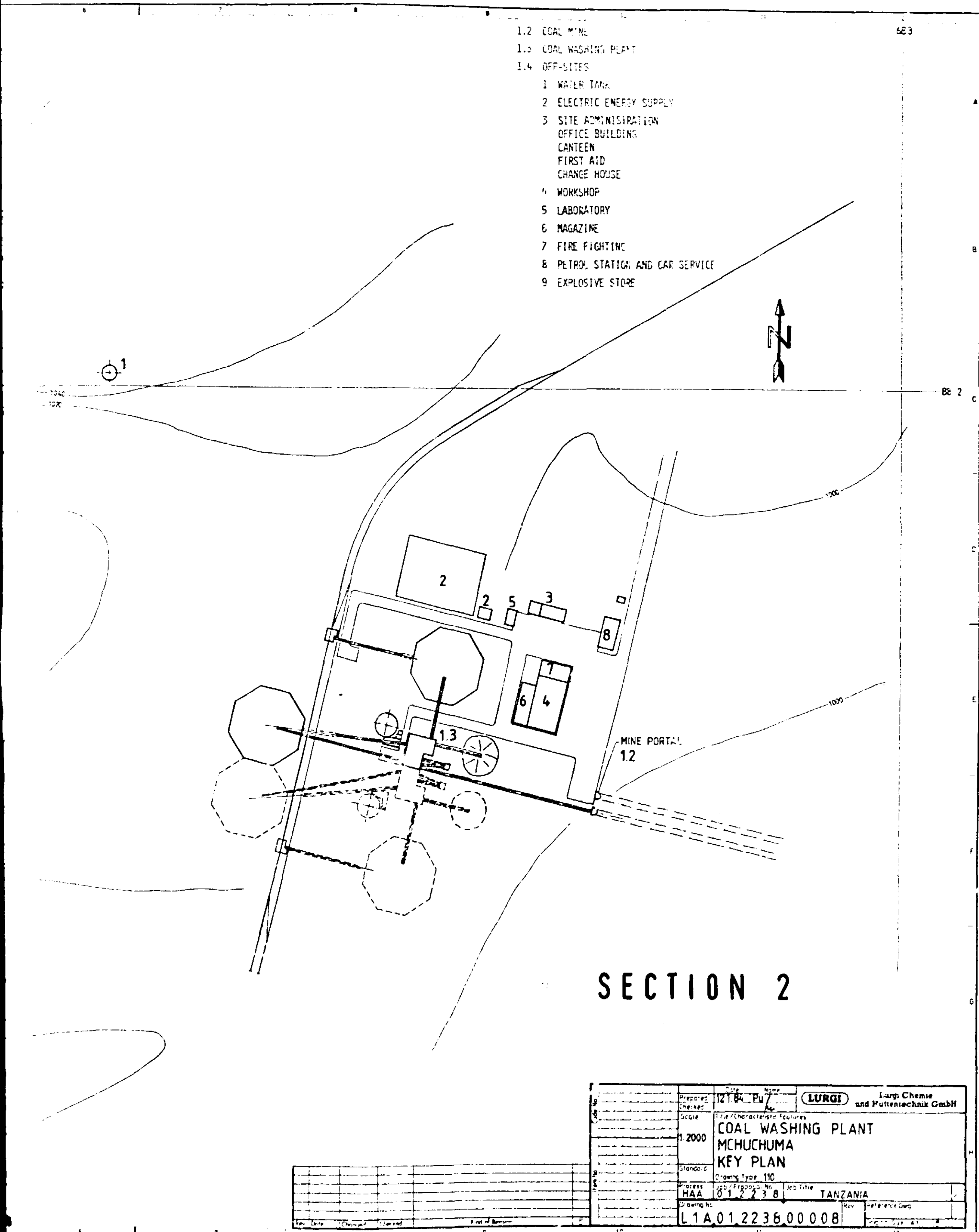
01

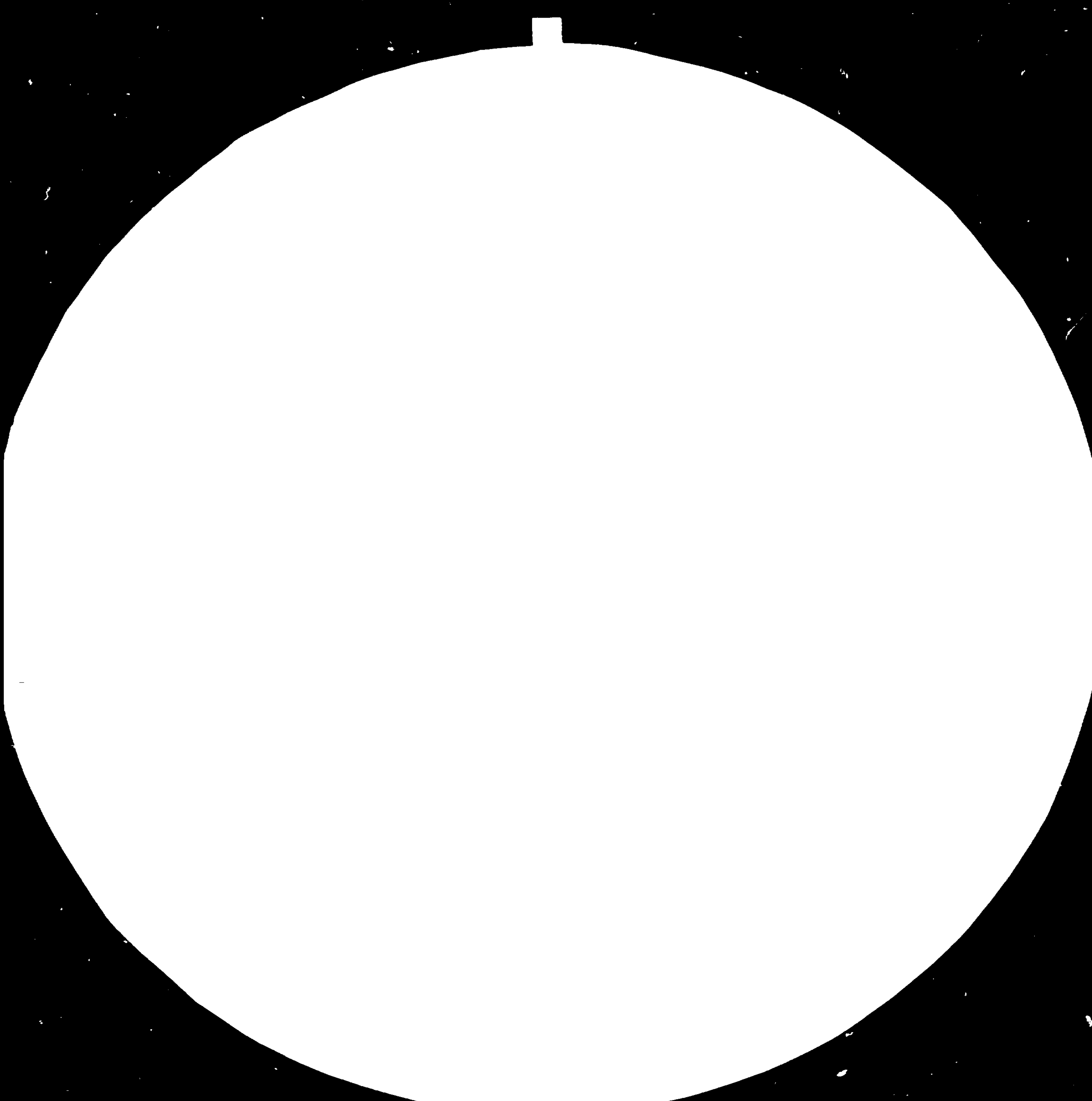


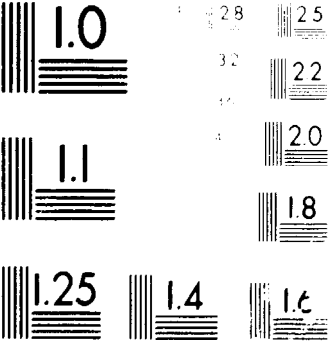

SHING
SHING
MAKE UP WATER
200 M3/H
DEWATERING SCREEN
DEWATERING BY CENTRIFUGE
WASHED COAL
STORAGE
THICKENING
PROCESS WATER BASIN
TO CONSUMERS
TO RAILWAY WAGON LOADING
1000000 T/A
TO POND
290000 T/A
Prepared 08.12.83 PAUL/H.FN
LURGI
Lurgi Chemie und Huettentechnik GmbH
COAL WASHING PLANT MCHUCHUMA
FEED 1900000 T/A
Drawing Type: 202 BLOCK DIAGRAM
Process: HAA
0 12238
TANZANIA
L3A0 12238000005
Original Size: A3

SECTION 2

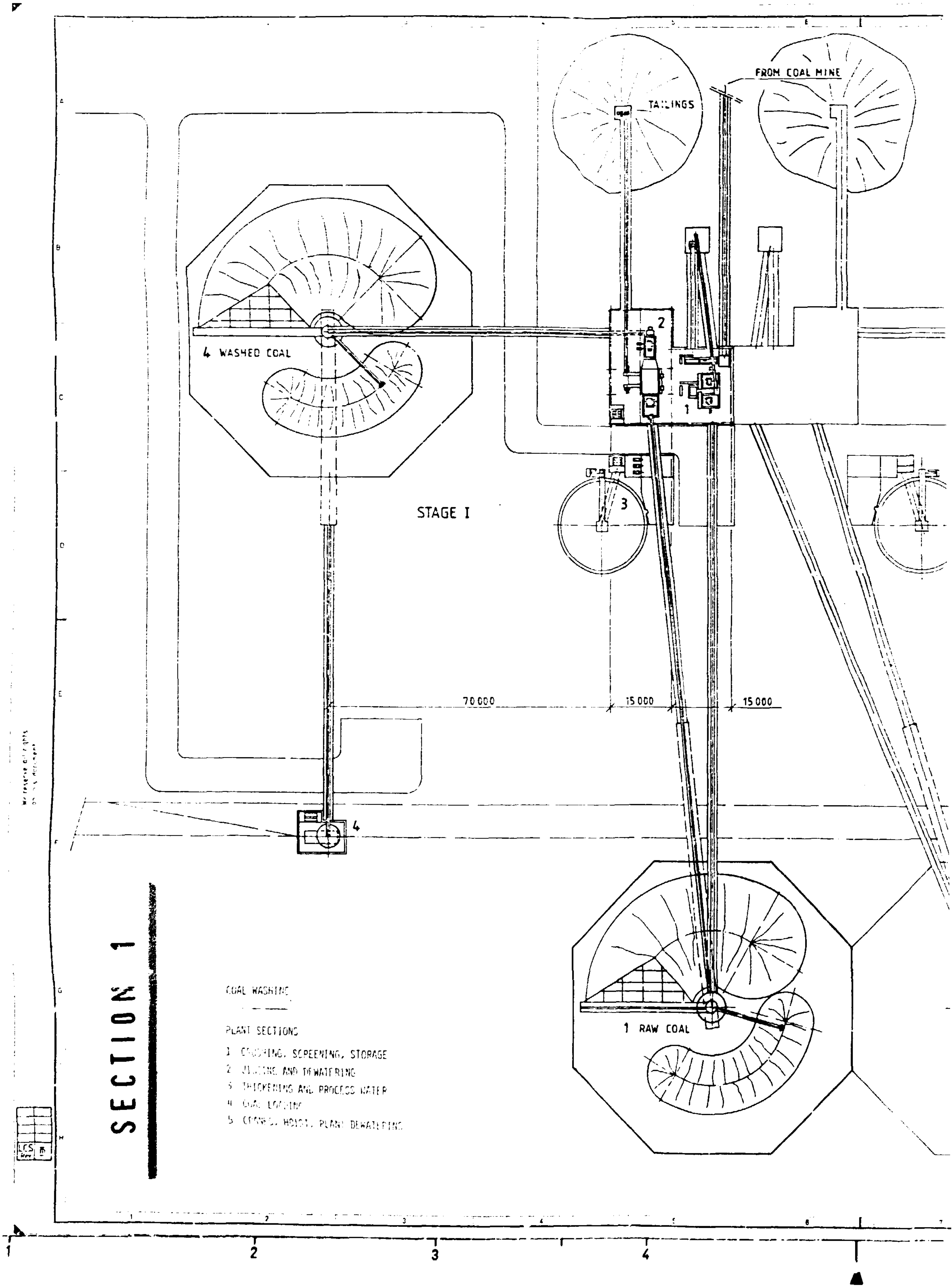

682
TAILINGS POND
1040
1020
1000
1
SECTION 1

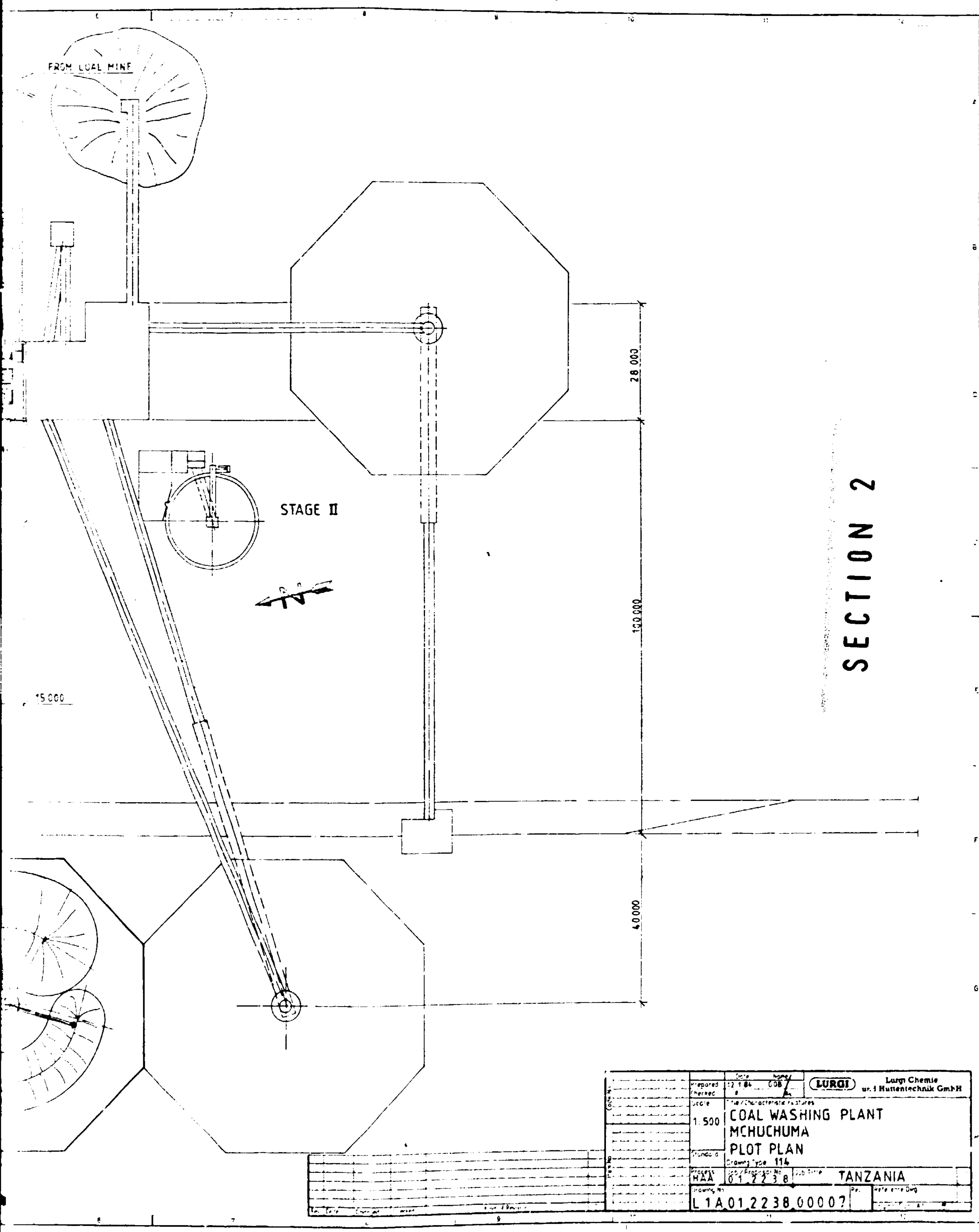

1.2 COAL MINE
1.3 COAL WASHING PLANT
1.4 OFF-SITES
1 WATER TANK
2 ELECTRIC ENERGY SUPPLY
3 SITE ADMINISTRATION
OFFICE BUILDING
CANTEEN
FIRST AID
CHANGE HOUSE
4 WORKSHOP
5 LABORATORY
6 MAGAZINE
7 FIRE FIGHTING
8 PETROL STATION AND CAR SERVICE
9 EXPLOSIVE STORE
N
MINE PORTAL
1.2
1.3
SECTION 2
LURGI
Lurgi Chemie und Huttentechnik GmbH
Scale 1:2000
COAL WASHING PLANT
MCHUCHUMA
KEY PLAN
Drawing Type 110
HAA
0 1 2 2 3 8
TANZANIA
L 1 A 0 1 2 2 3 8 0 0 0 0 8





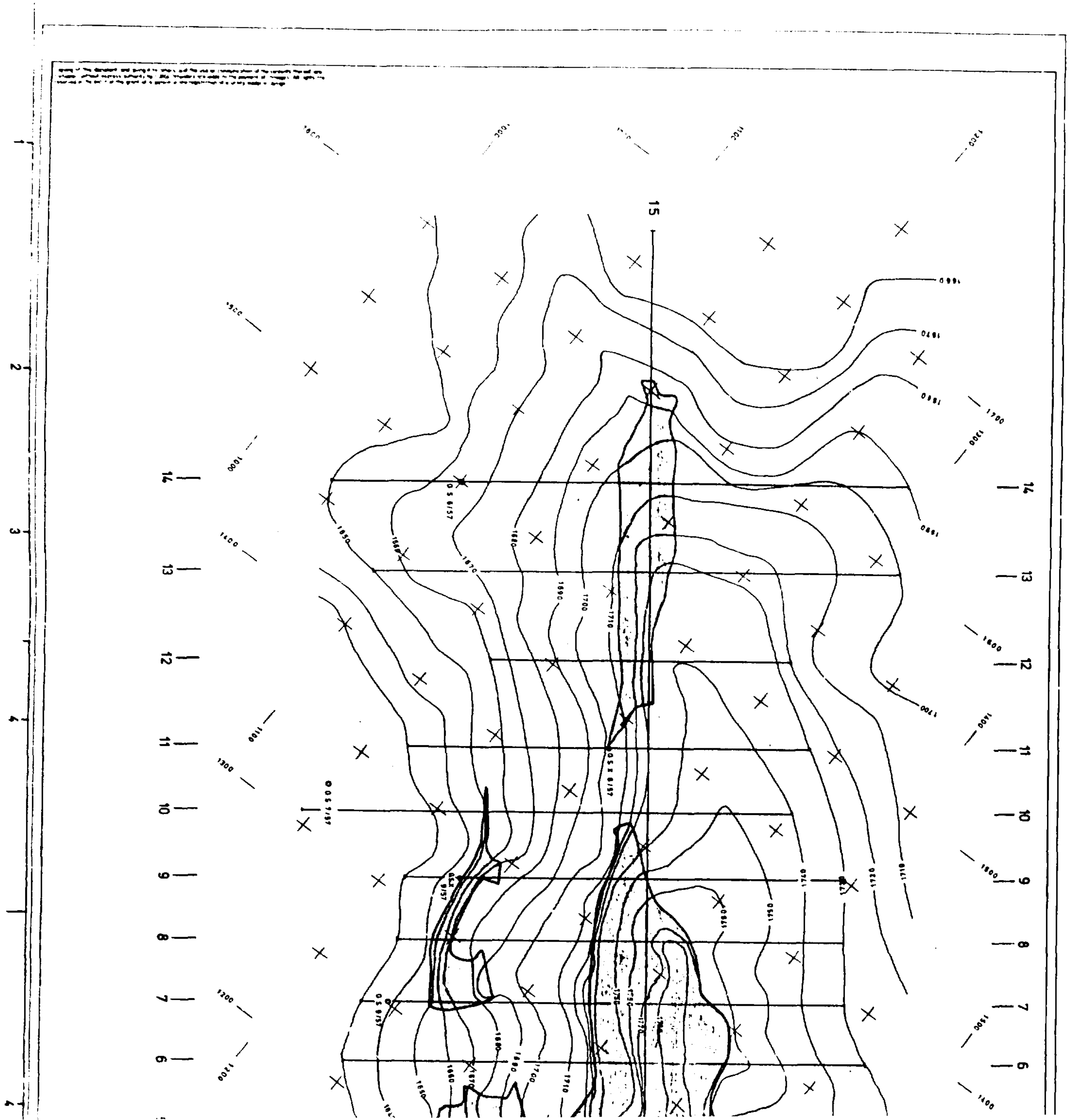
MICROCOPY RESOLUTION TEST CHART


FROM COAL MINE
TAILINGS
4 WASHED COAL
STAGE I
70 000
15 000
15 000
1 RAW COAL
SECTION 1
COAL WASHING
PLANT SECTIONS
1 CRUSHING, SCREENING, STORAGE
2 JIGGING AND DEWATERING
3 THICKENING AND PROCESS WATER
4 COAL LOADING
5 HOIST, PLANT DEWATERING

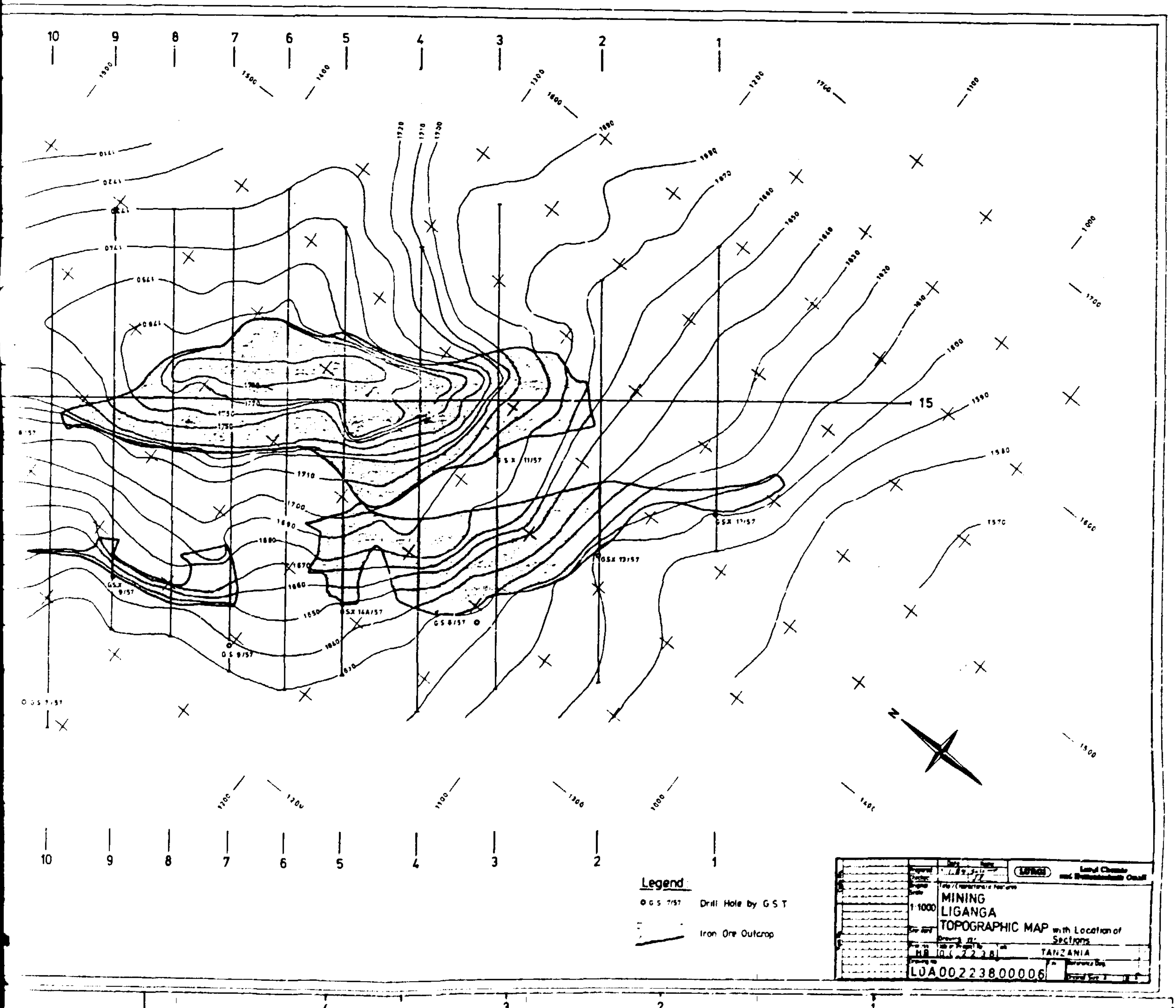


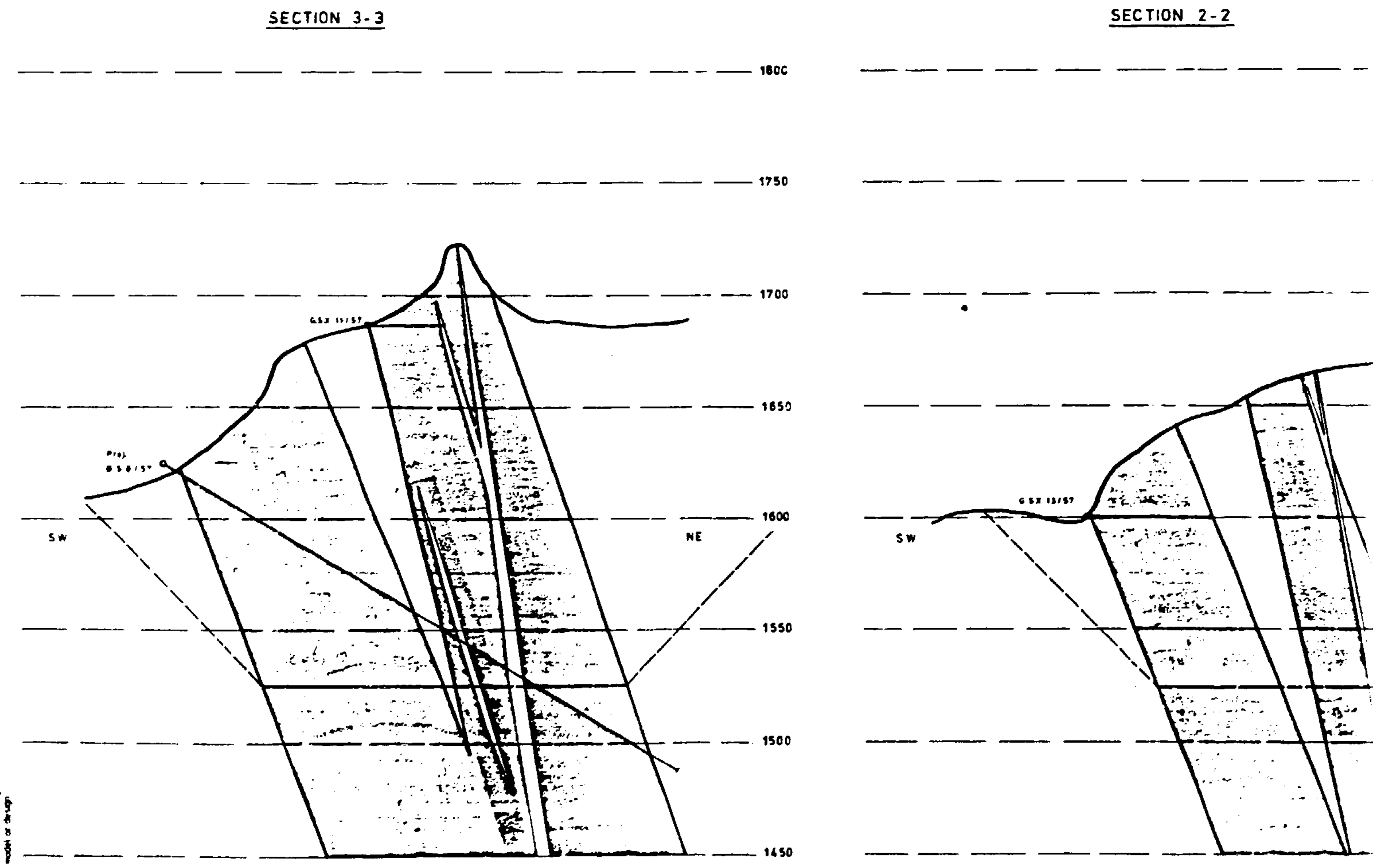
FROM COAL MINE
STAGE II
28 000
100 000
40 000
15 000
SECTION 2
Prepared 12.1.84 GOB
Checked
LURGI
Lurgi Chemie und Huttentechnik GmbH
Scale 1:500
COAL WASHING PLANT
MCHUCHUMA
PLOT PLAN
Drawing Type 114
Process HAA
Job/Proposal No 01 2238
TANZANIA
Drawing No L1A01 2238 00007

SECTION 1

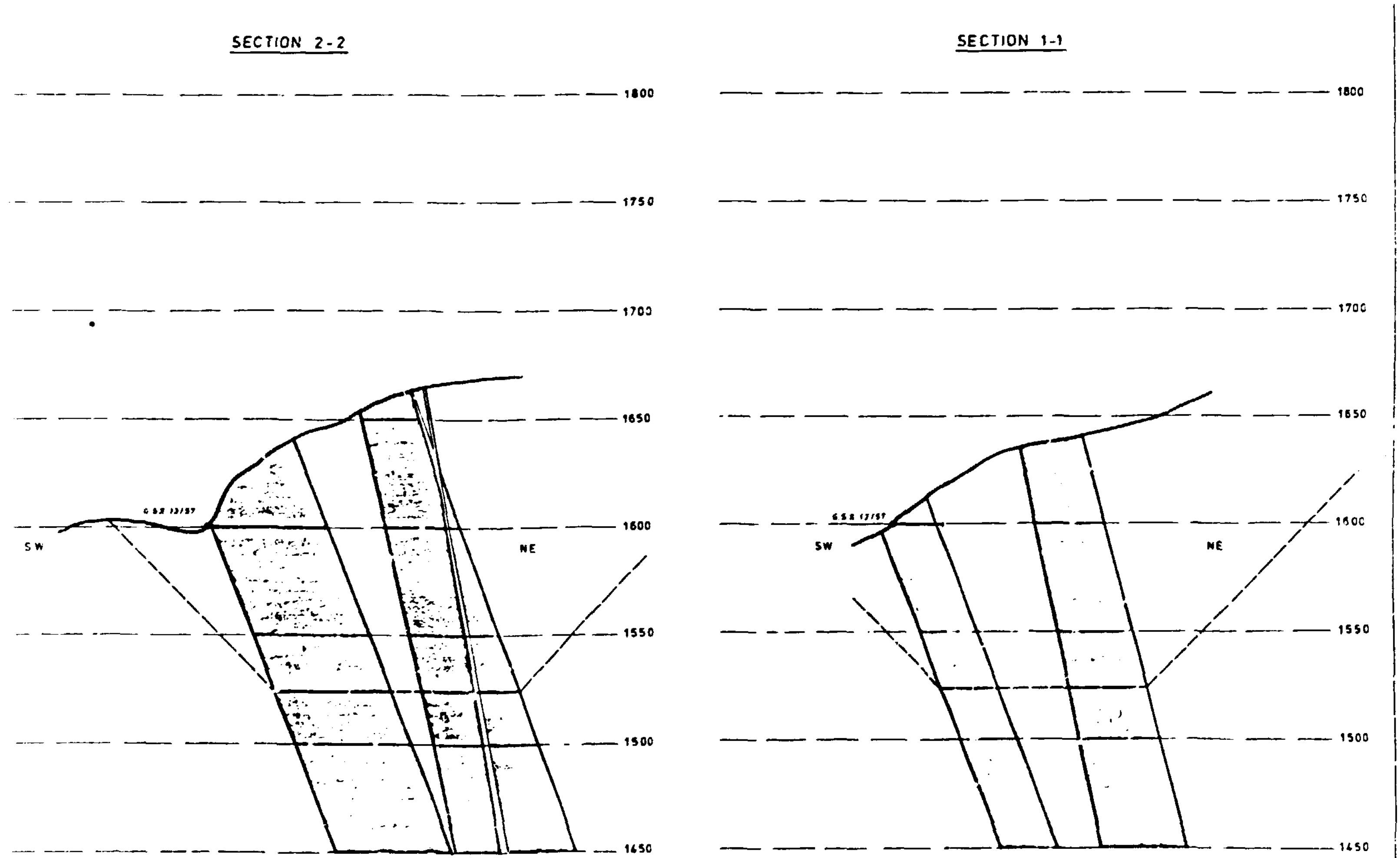


SECTION 2


10
9
8
7
6
5
4
3
2
1
15
Legend
Drill Hole by G S T
Iron Ore Outcrop
1:1000
MINING
LIGANGA
TOPOGRAPHIC MAP with Location of Sections
TANZANIA
LUA00223800006


SECTION 3-3
1800
1750
1700
1650
1600
1550
1500
1450
SW
NE
SECTION 2-2
SW

SECTION 1



Final Pit Configuration

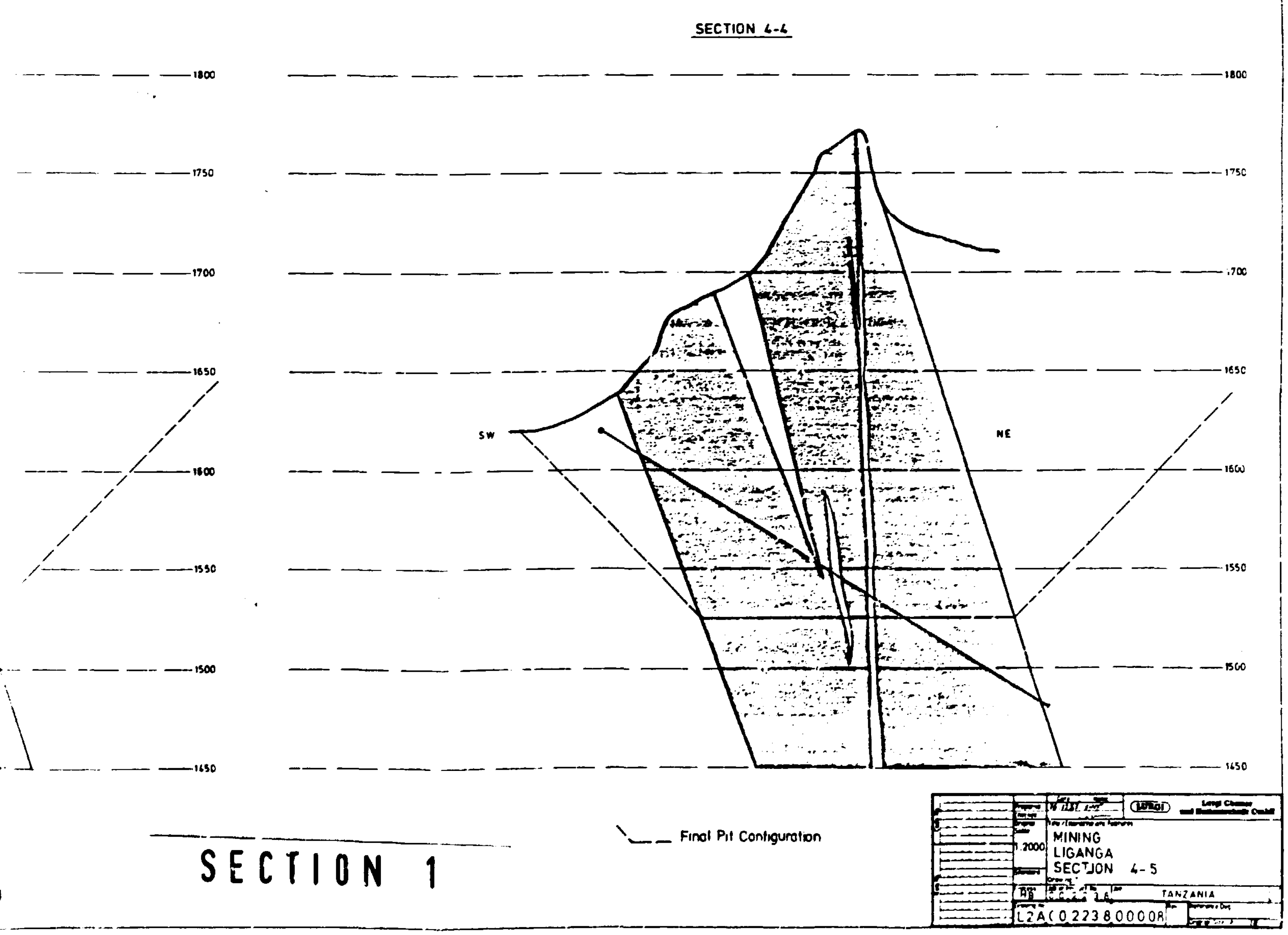
SECTION 2

MINING
LIGANGA
SECTION 1-3

1:2000

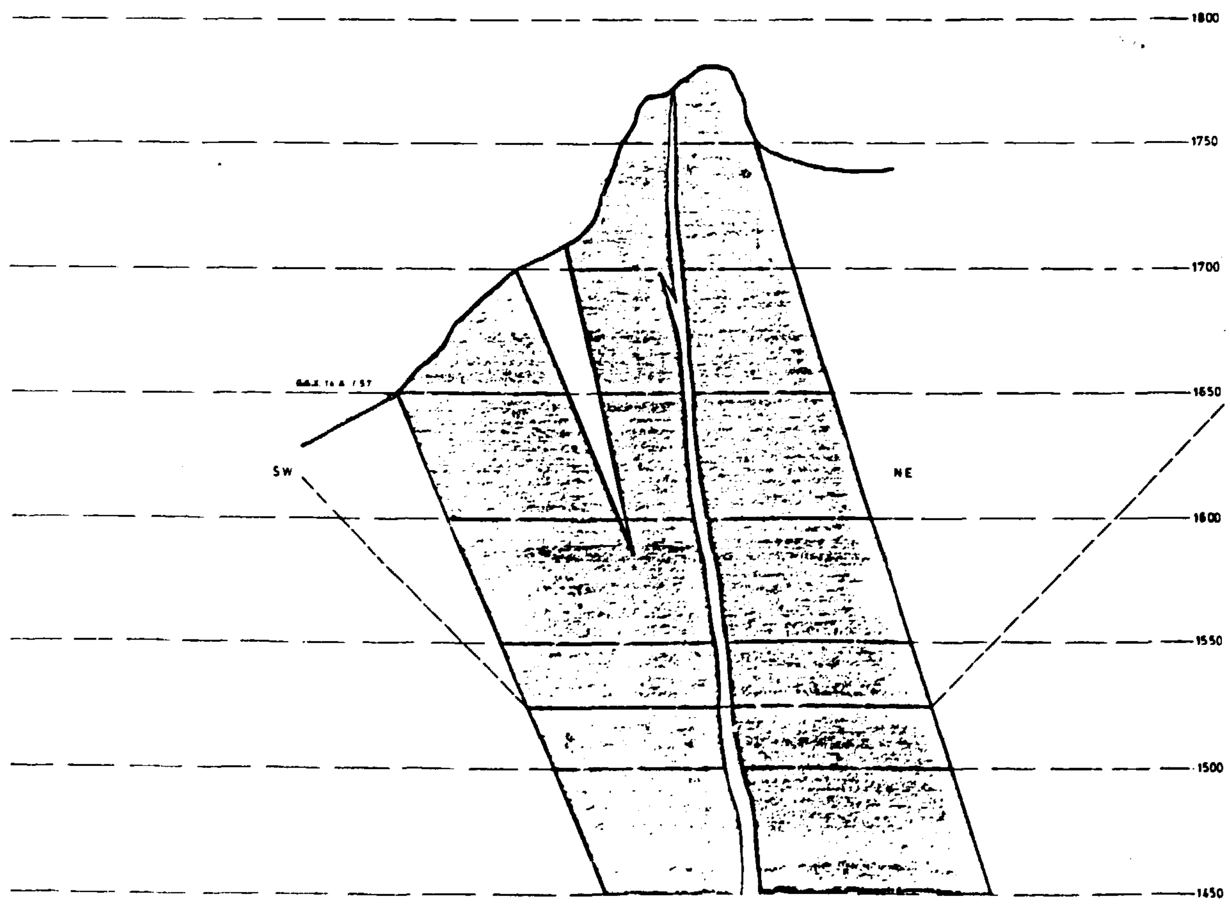
TANZANIA

L2A00223800007

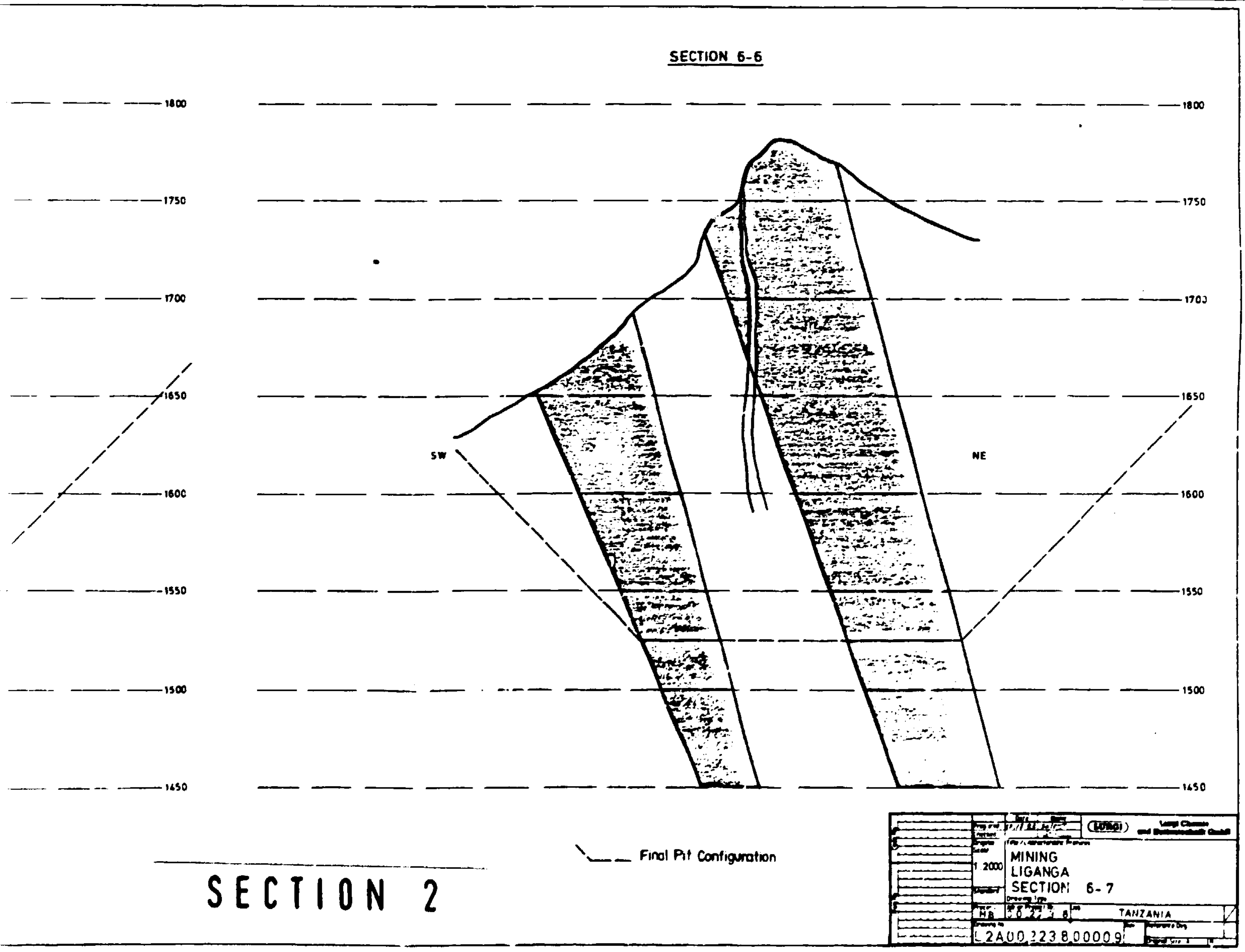

SECTION 4-4
1800
1750
1700
1650
1600
1550
1500
1450
SW
NE
Final Pit Configuration
1:2000
MINING
LIGANGA
SECTJON 4-5
TANZANIA
L2A(0223800008

SECTION 1

SECTION 5-5

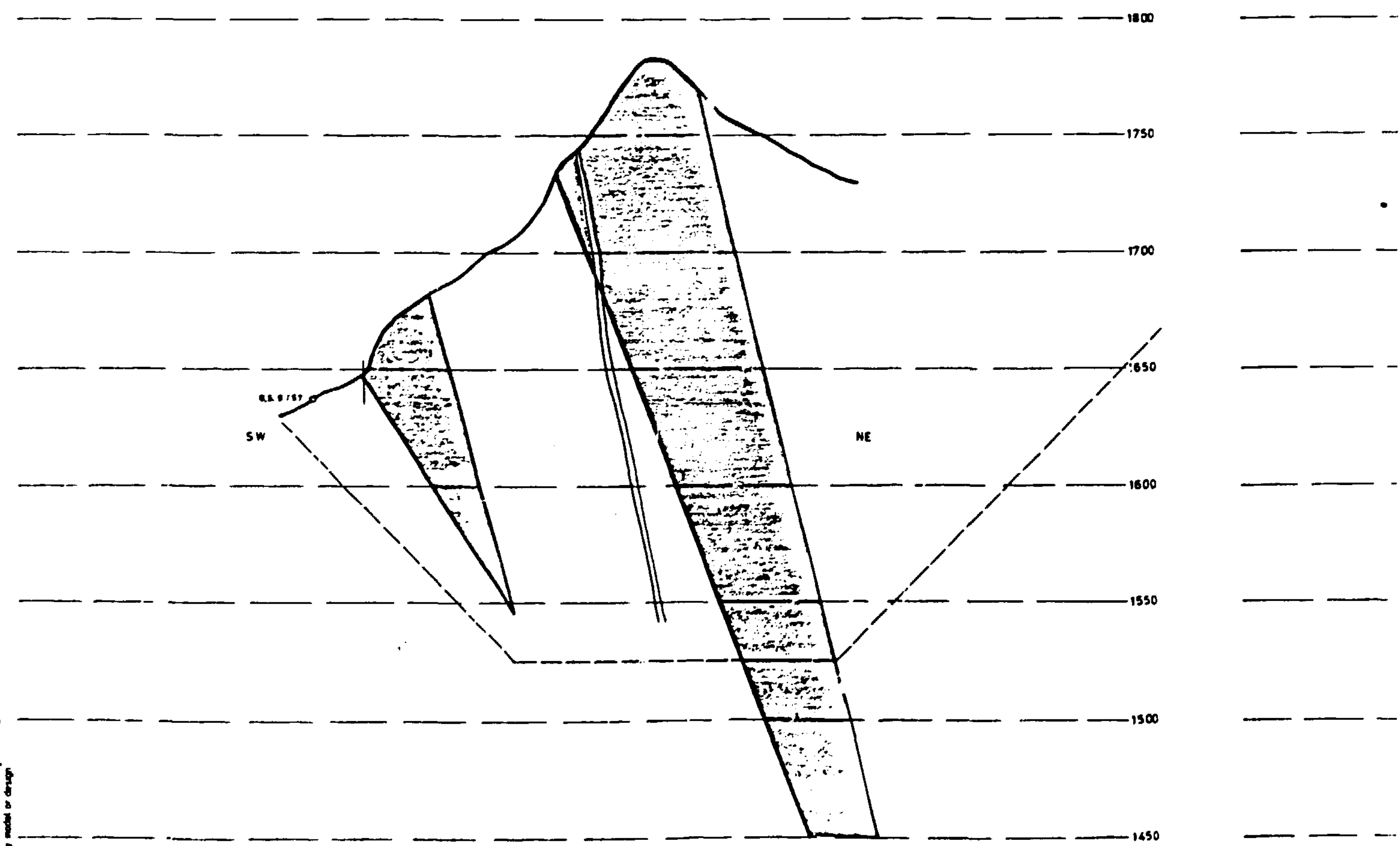


SECTION 2


SECTION 6-6
1800
1750
1700
1650
1600
1550
1500
1450
SW
NE
Final Pit Configuration
MINING
LIGANGA
SECTION 6-7
1 2000
TANZANIA
L 2A00 223 8 00009

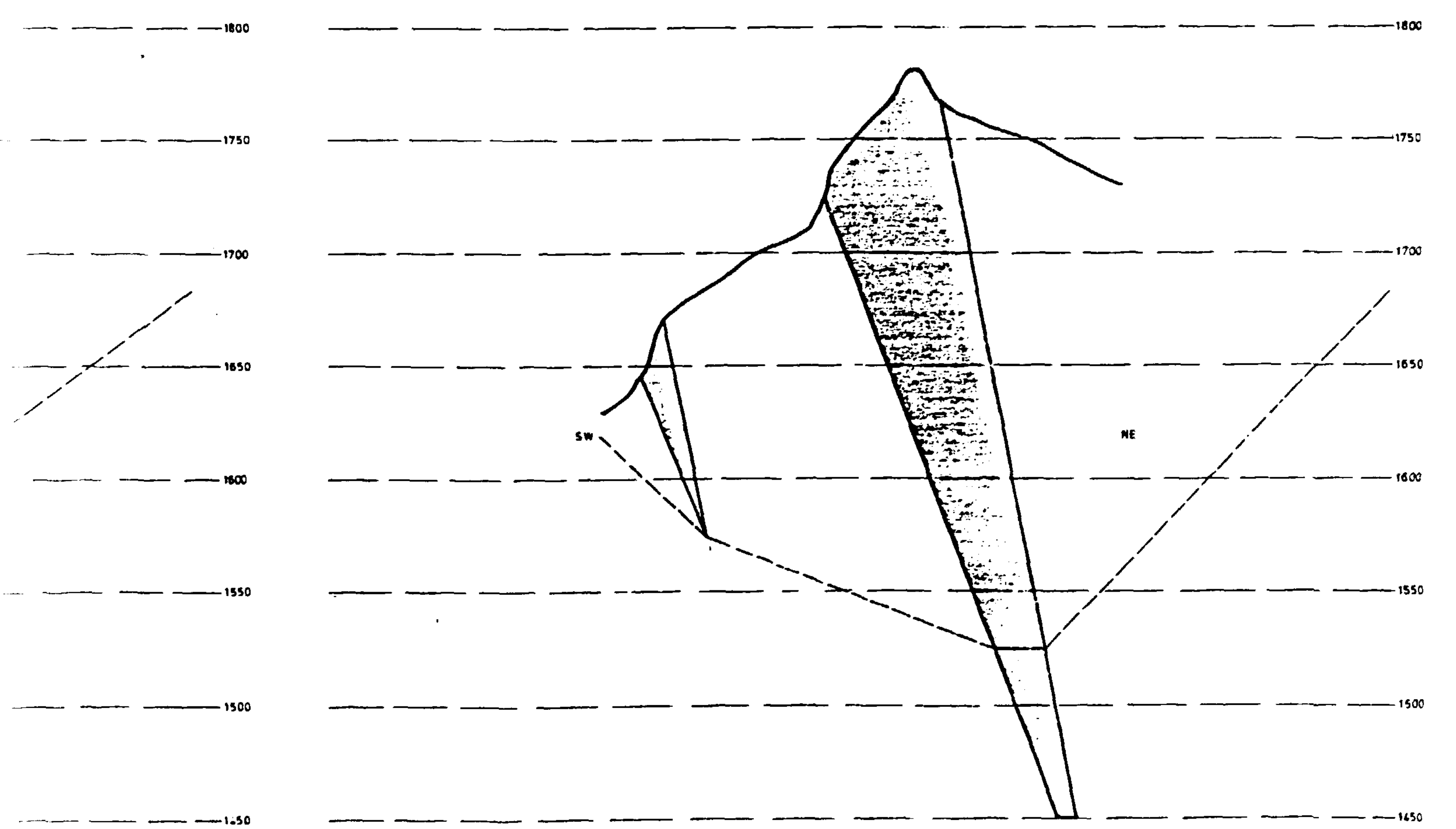
SECTION 2

SECTION 7-7



SECTION 2

SECTION 8-8



Final Pit Configuration

SECTION 1

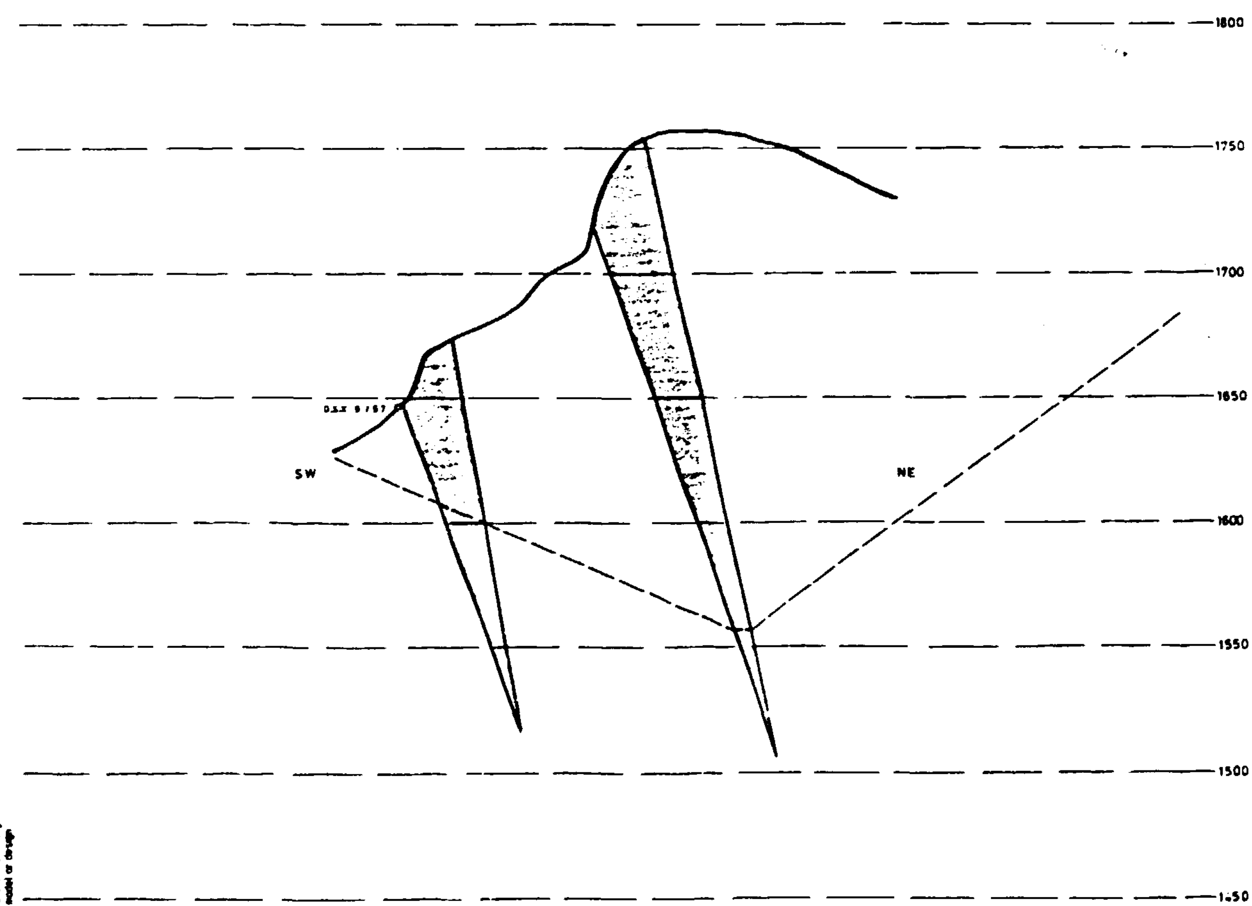
MINING
LIGANGA
SECTION 8-9

1:2000

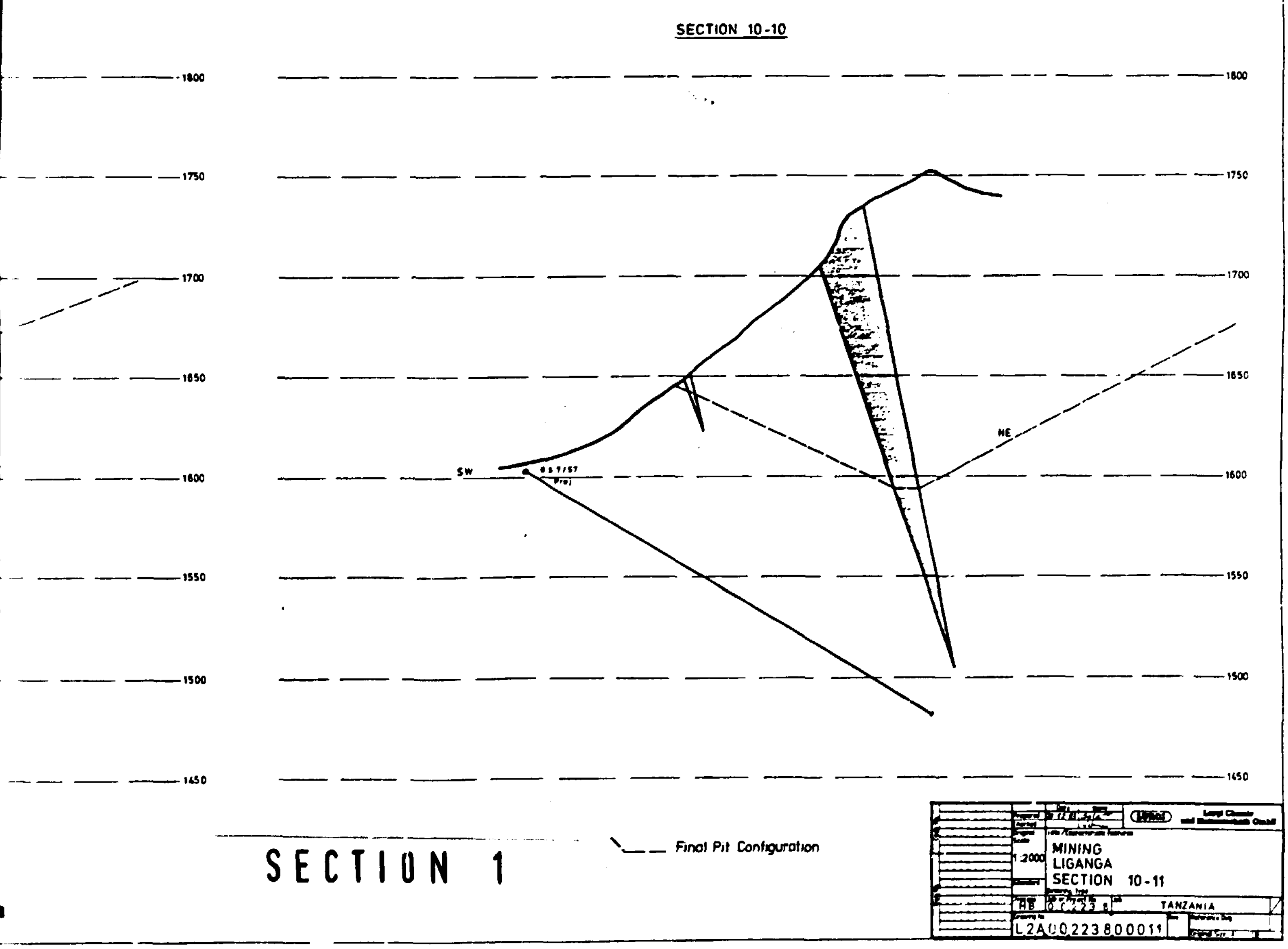
TANZANIA

L2A00 23800010

SECTION 9-9

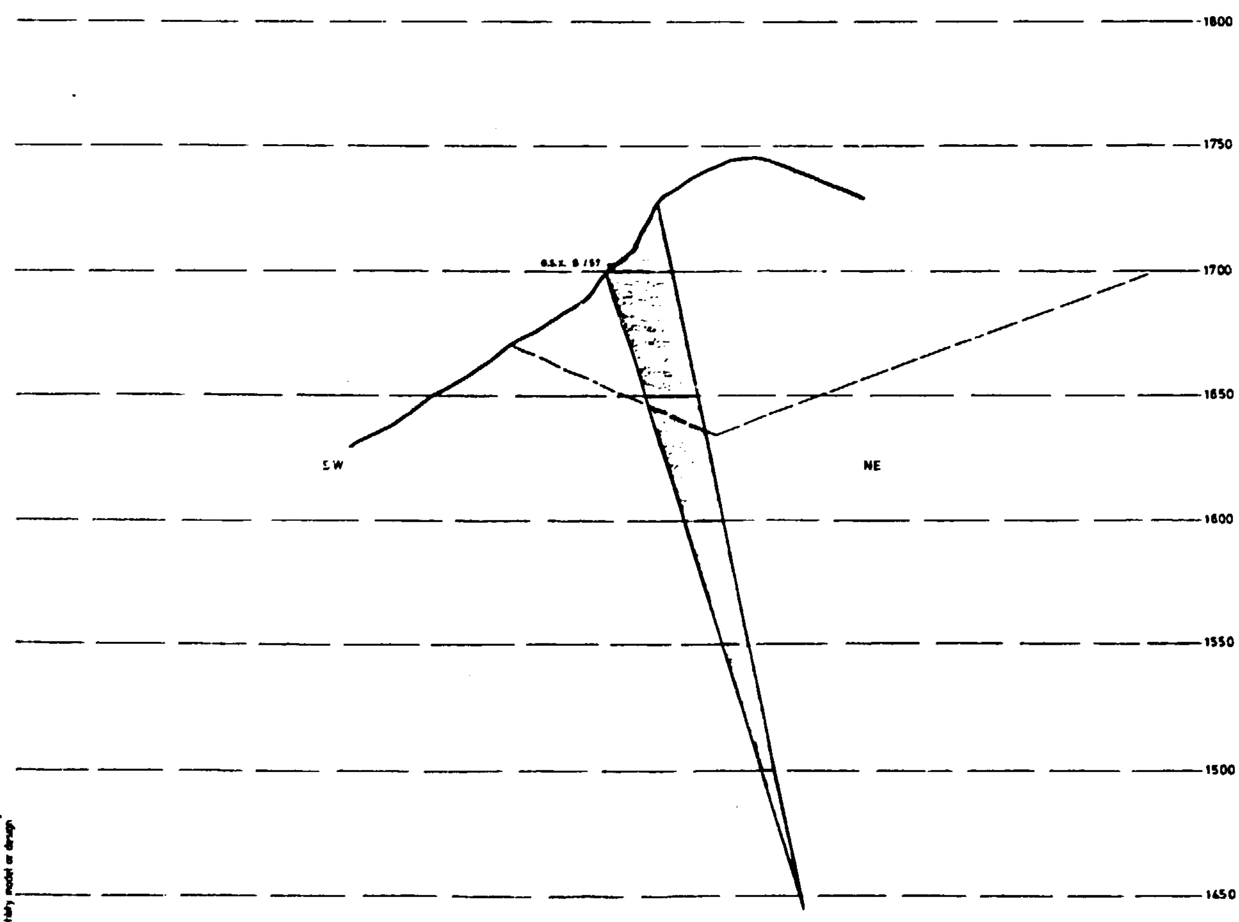


SECTION 2


SECTION 10-10
1800
1750
1700
1650
1600
1550
1500
1450
SW
NE
Final Pit Configuration
1:2000
MINING
LIGANGA
SECTION 10-11
HB
TANZANIA
L2A00223800011

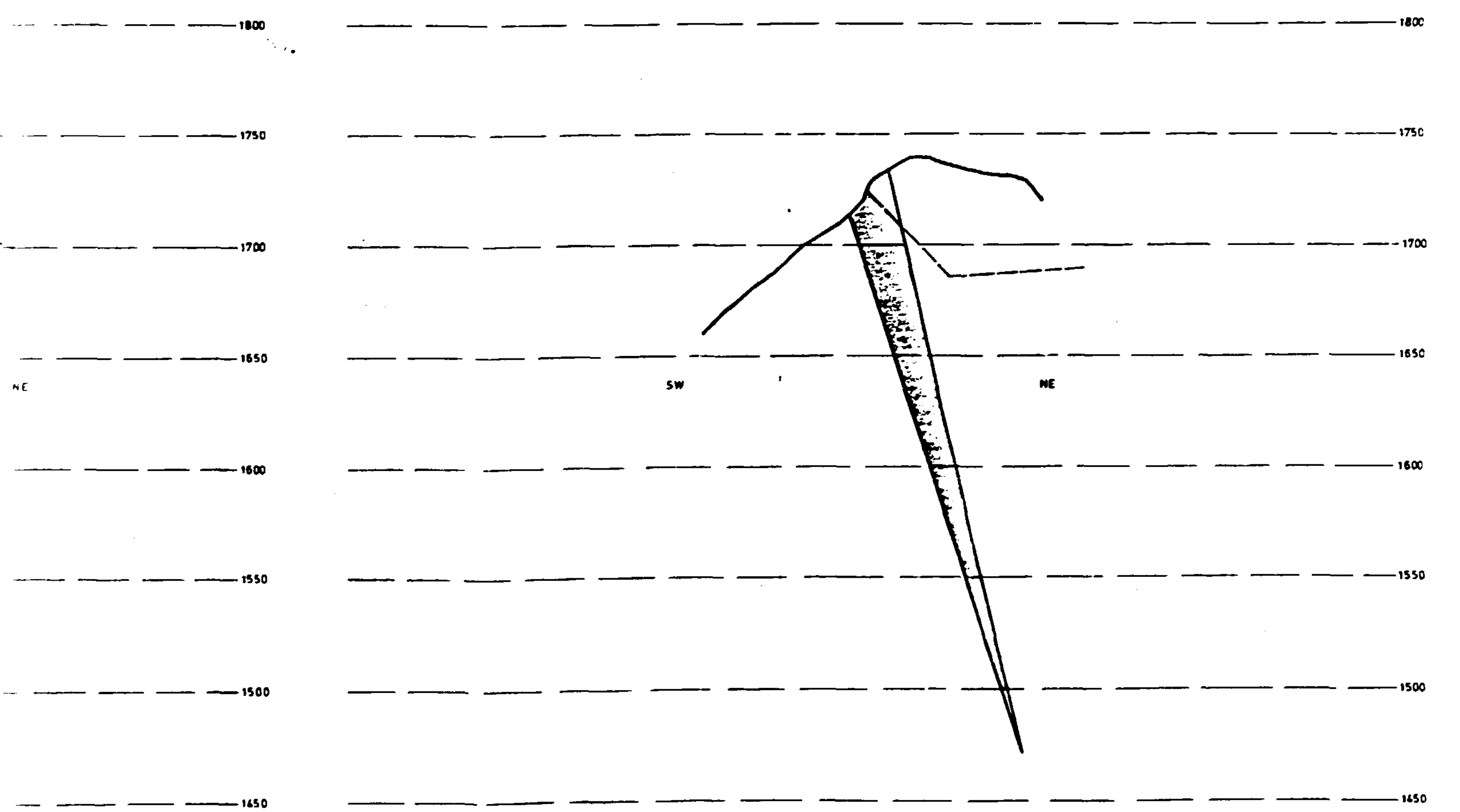
SECTION 1

SECTION 11-11



SECTION 2

SECTION 12-12

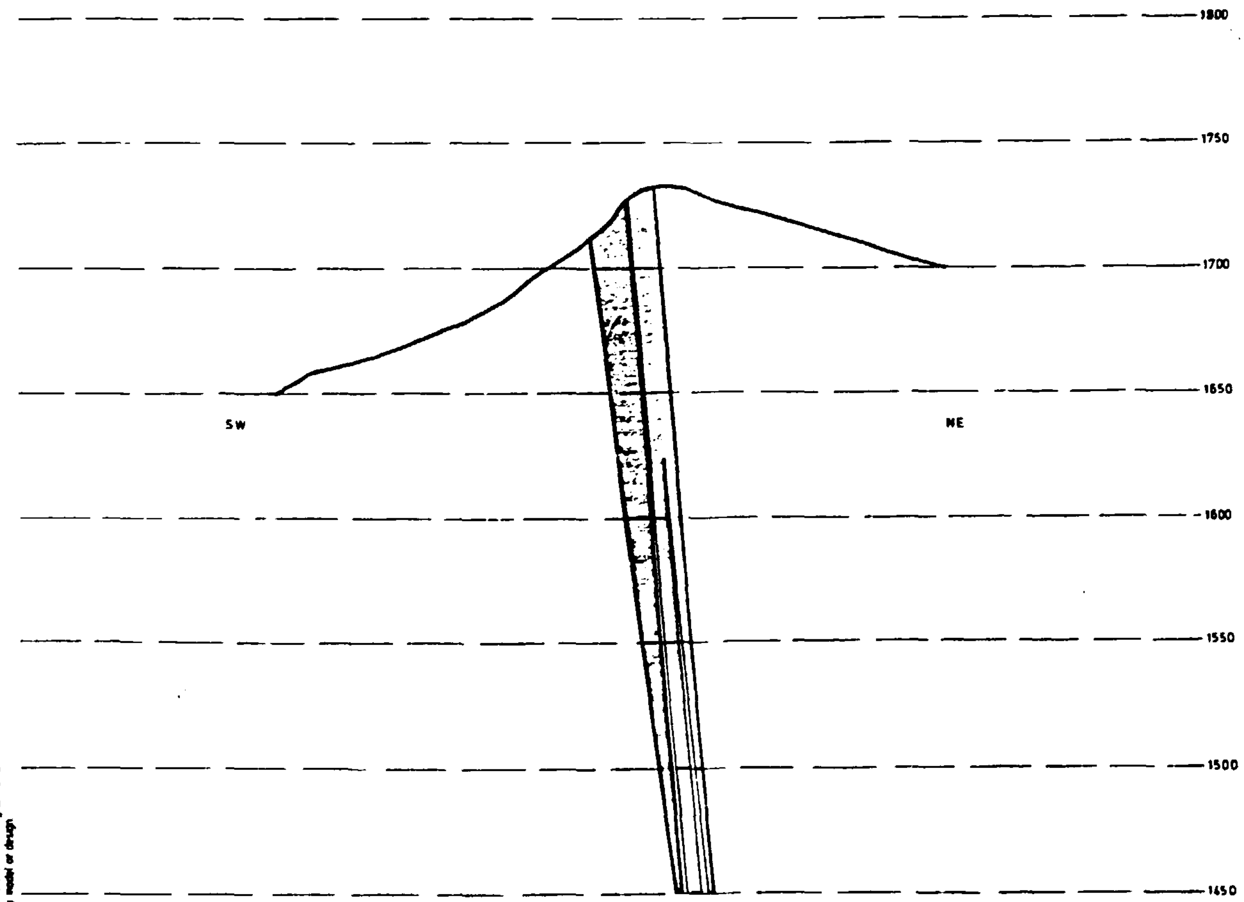


SECTION 1

Final Pit Configuration

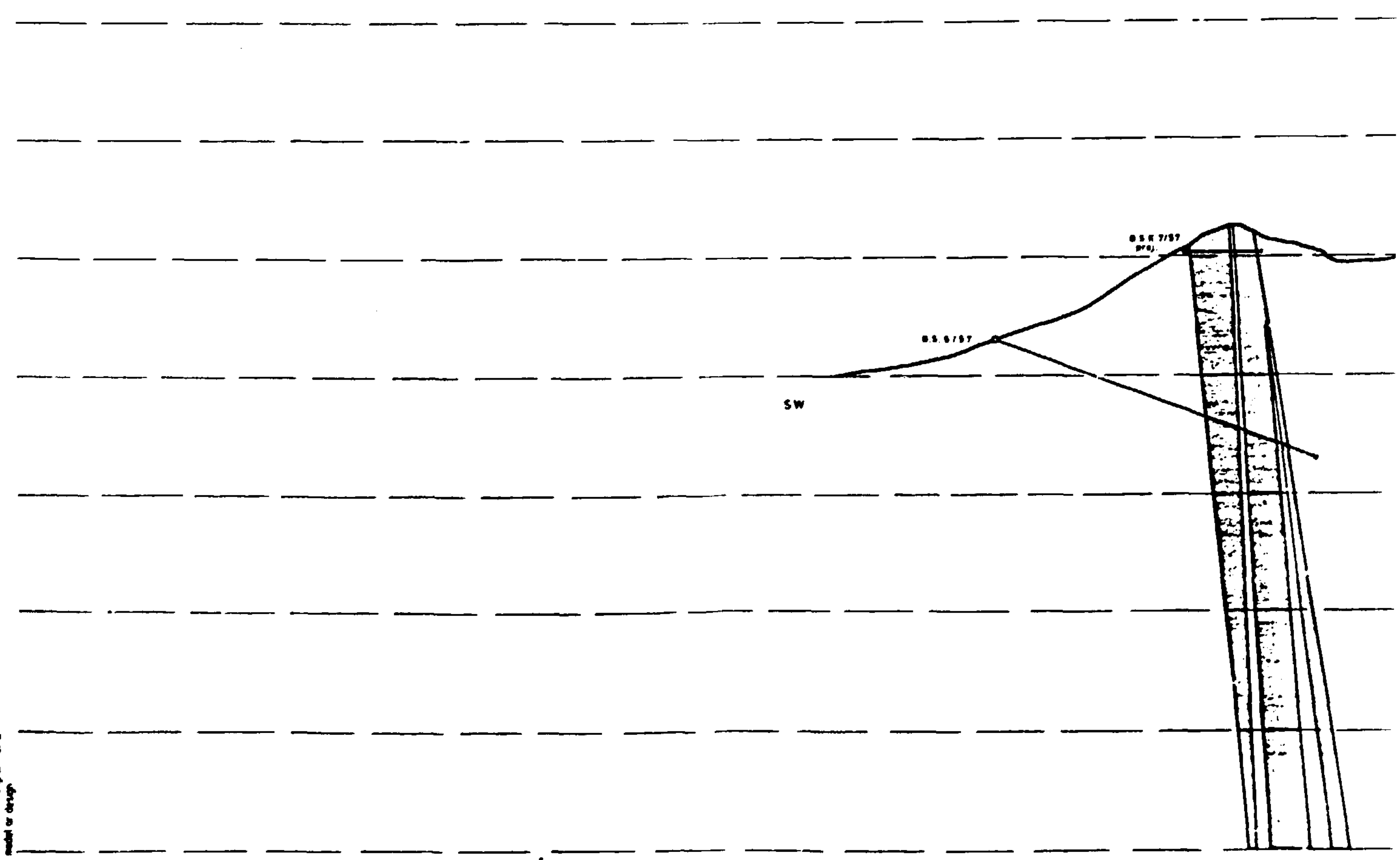
1:2000
MINING
LIGANGA
SECTION 12-13
TANZANIA
L2A 00223800012

SECTION 13-13



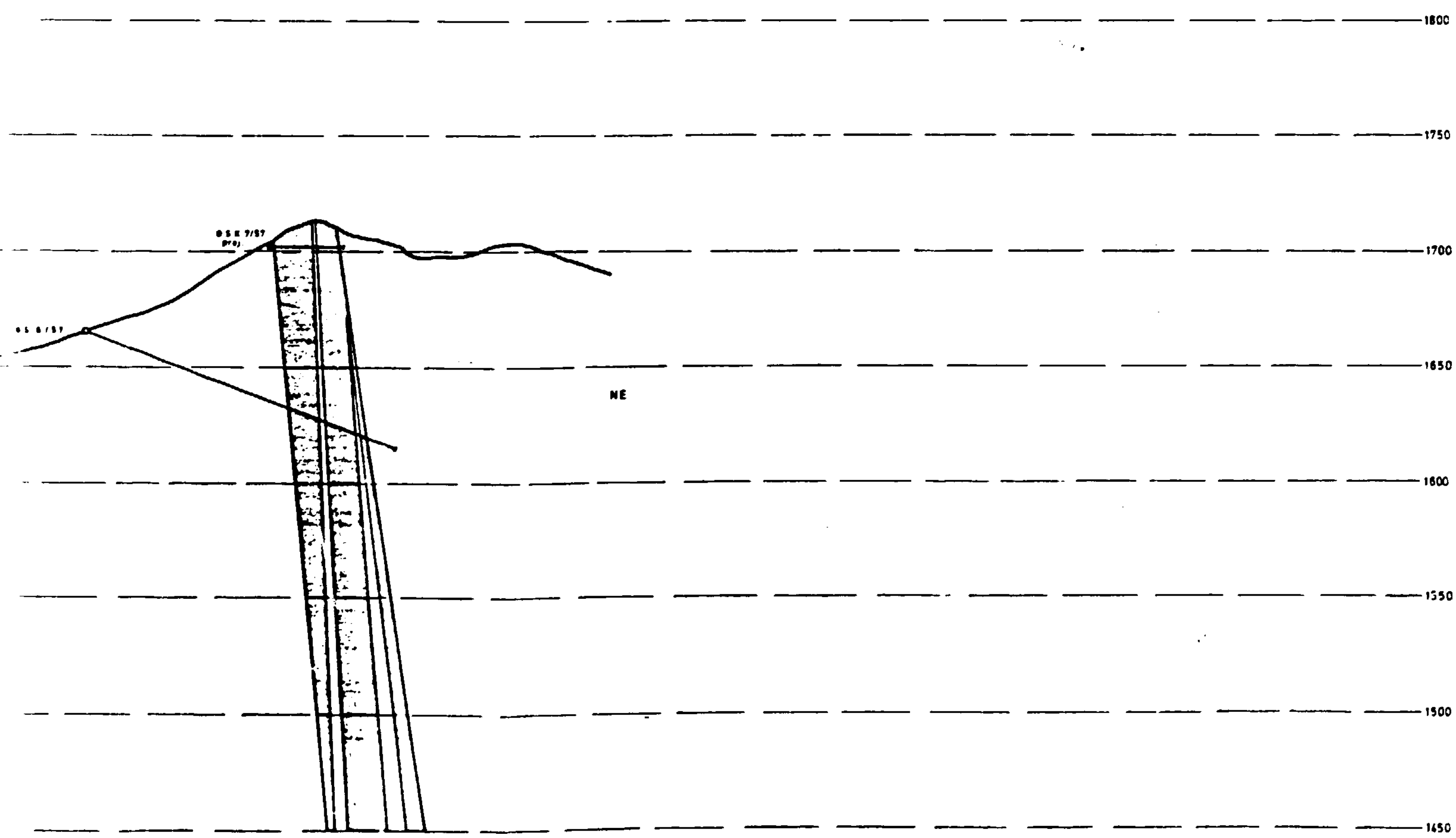
SECTION 2

SECTION 14-14



SECTION 1

SECTION 14-14



SECTION 2

MINING
LIGANGA
SECTION 14

1:2000

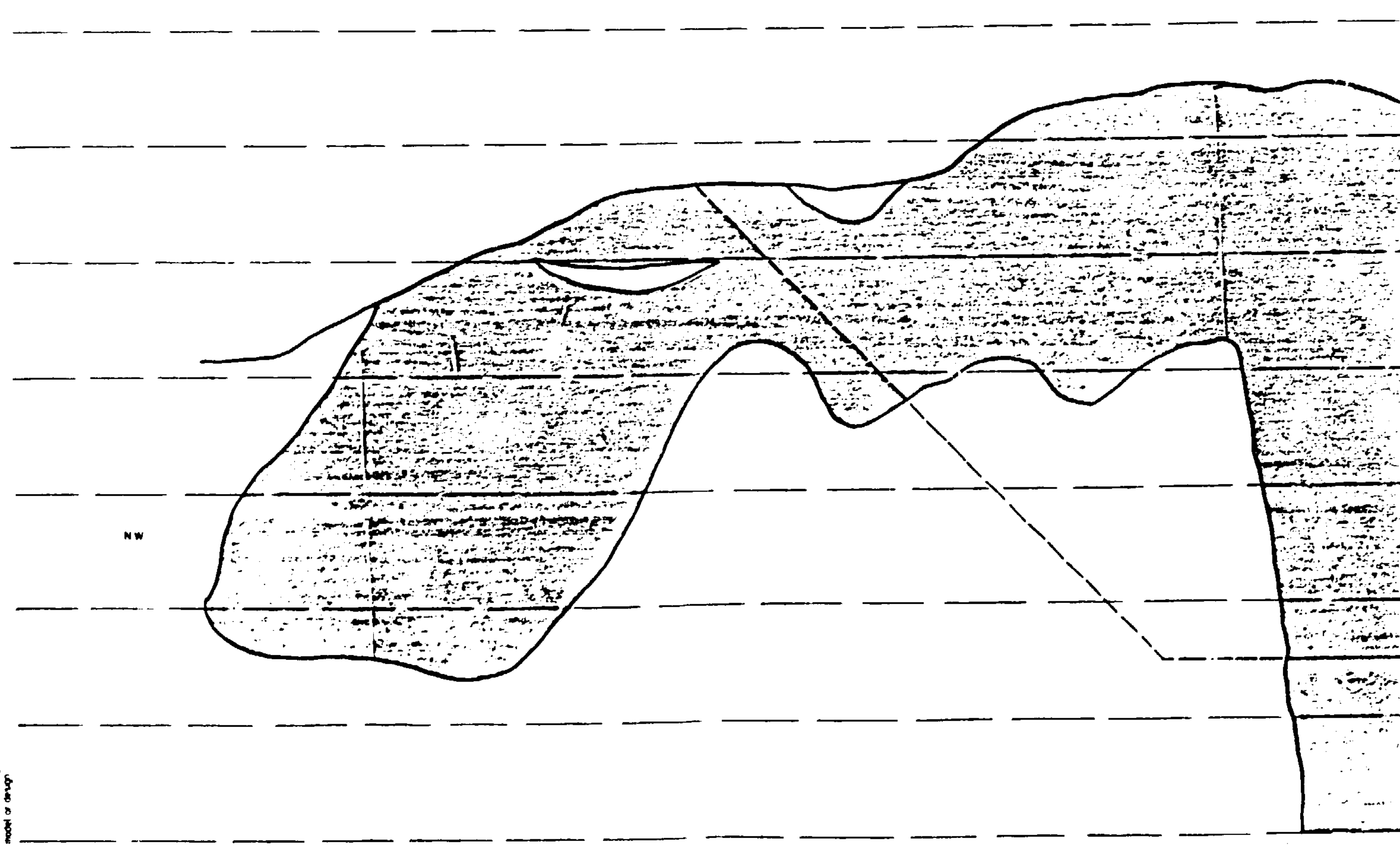
HB

0 0 2 2 3 8

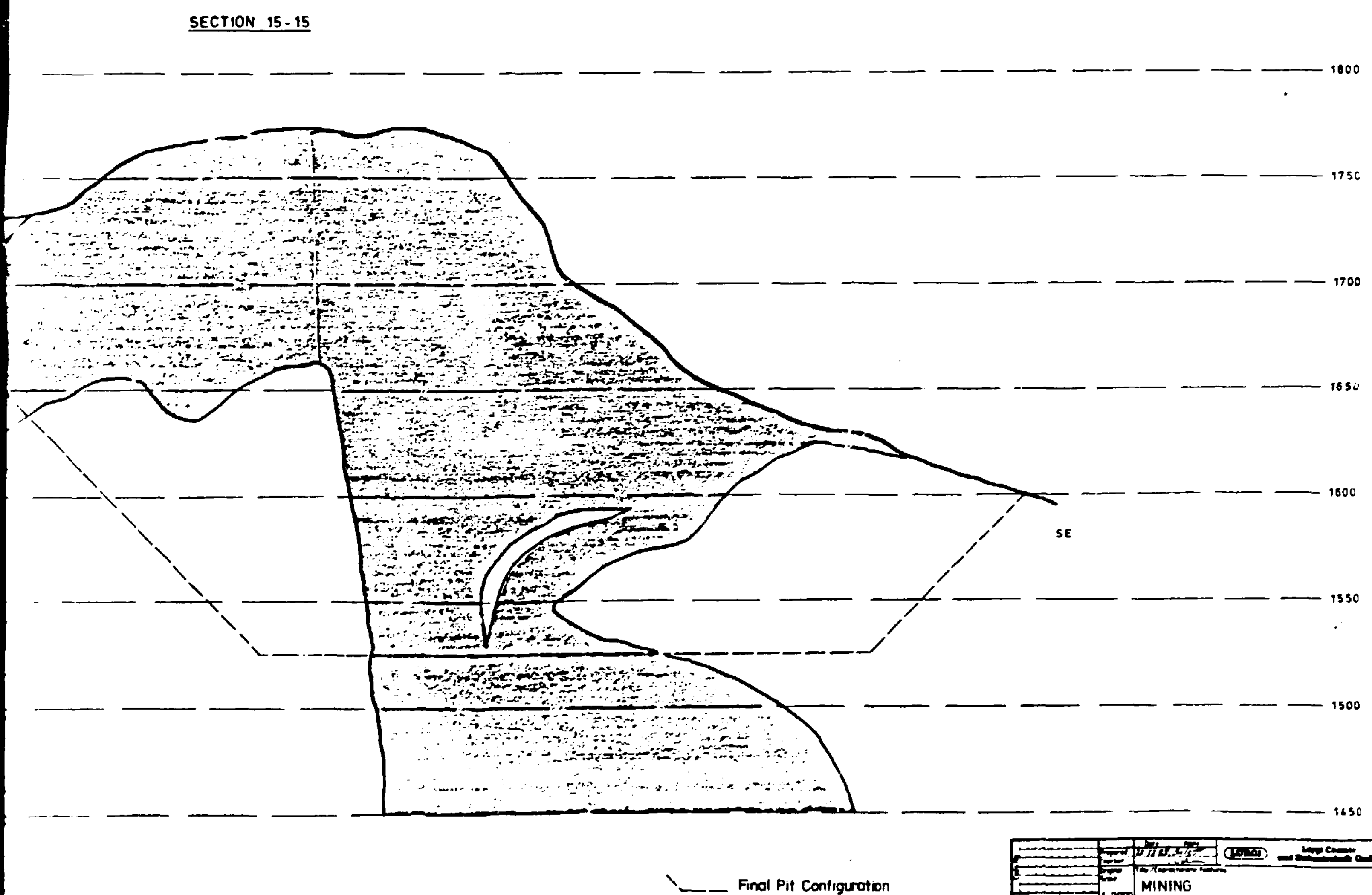
TANZANIA

L2AC0223800013

SECTION 15-15

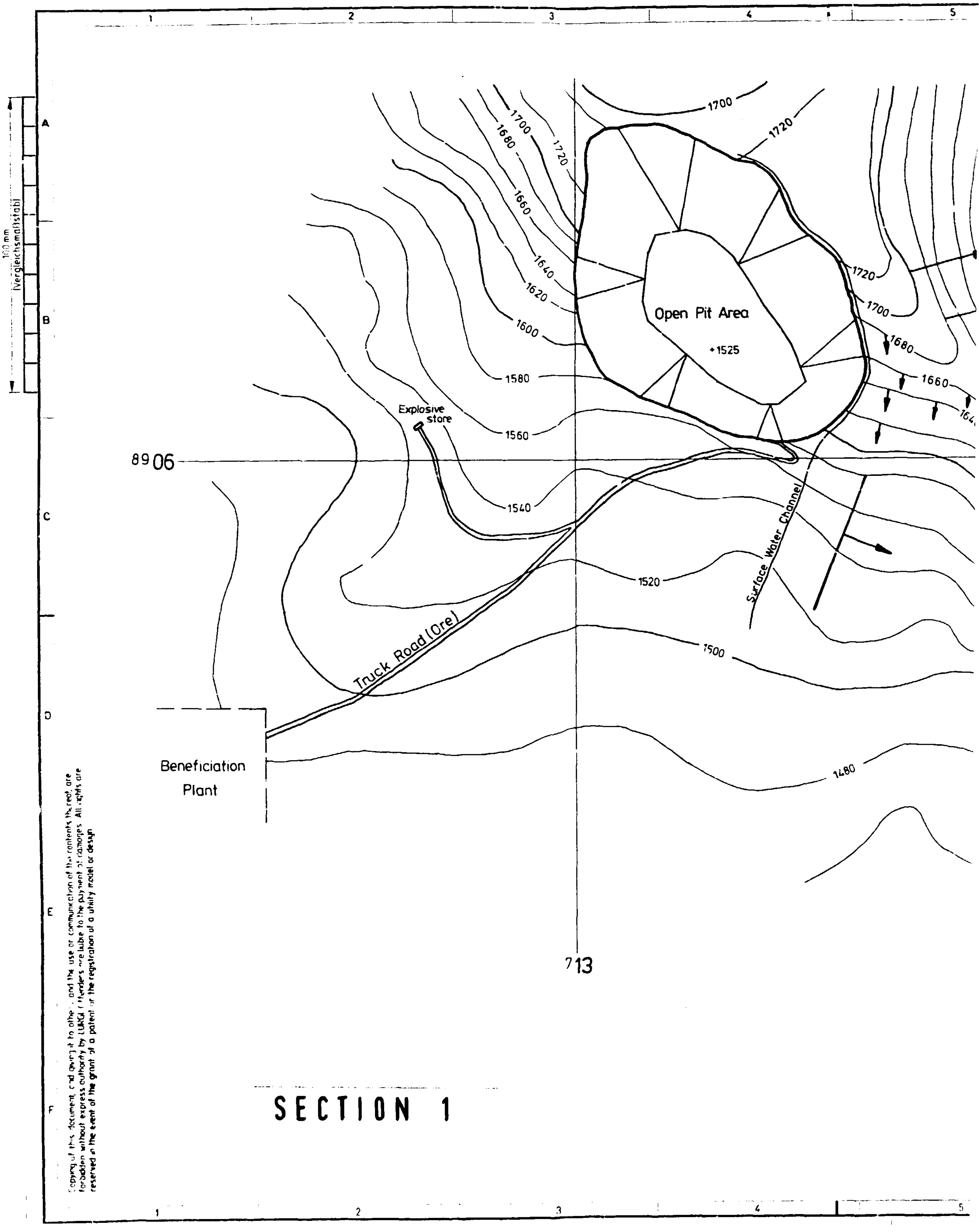


SECTION 1

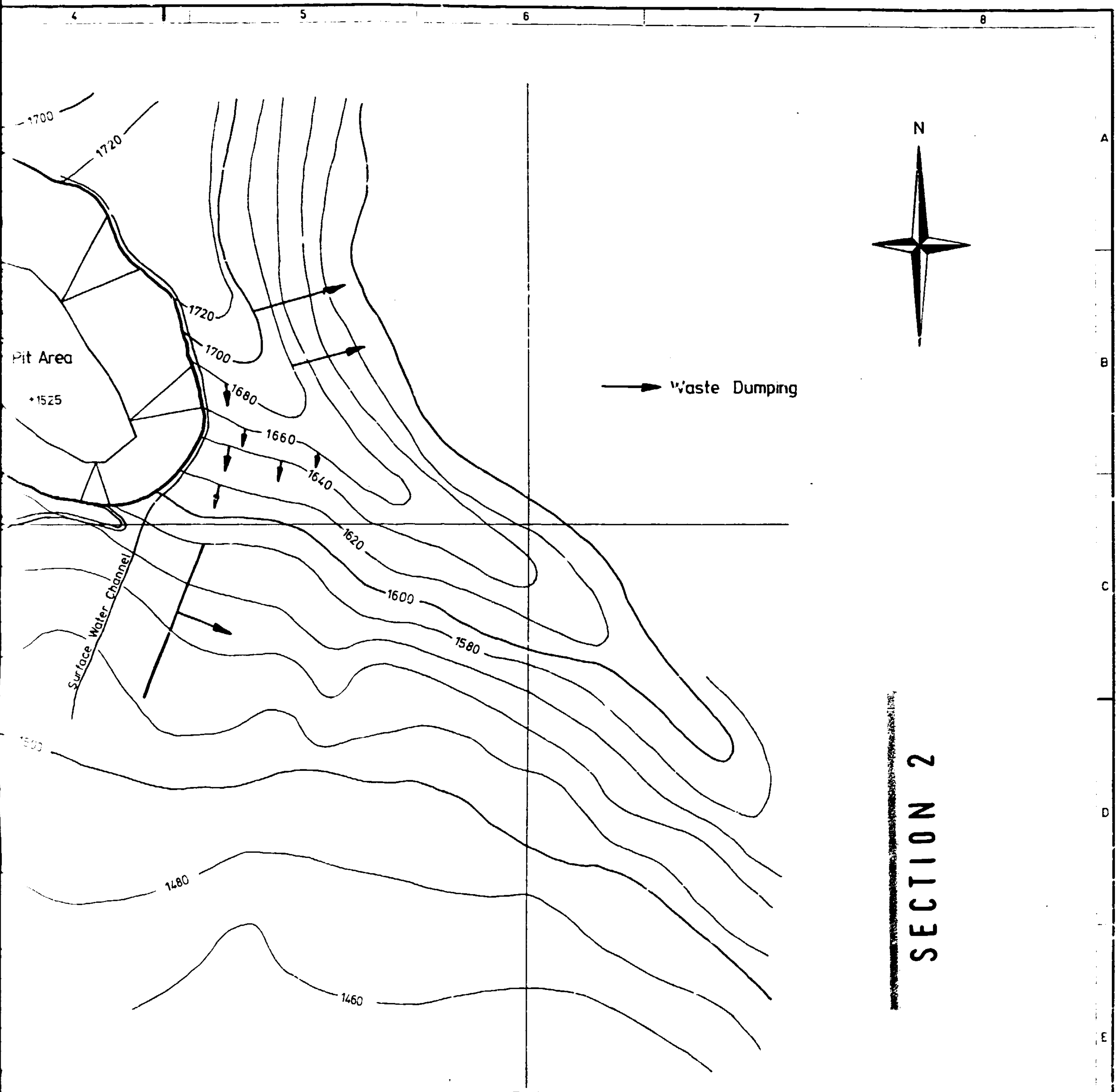


1:2000	MINING LIGANGA SECTION 15
HS	TANZANIA
L2A0C2238000014	

SECTION 2


100 mm
(Vergleichsmaßstab)
1700
1720
1680
1660
1640
1620
1600
1580
1560
1540
1520
1500
1480
Open Pit Area
+1525
Explosive store
8906
Surface Water Channel
Truck Road (Ore)
Beneficiation Plant
713

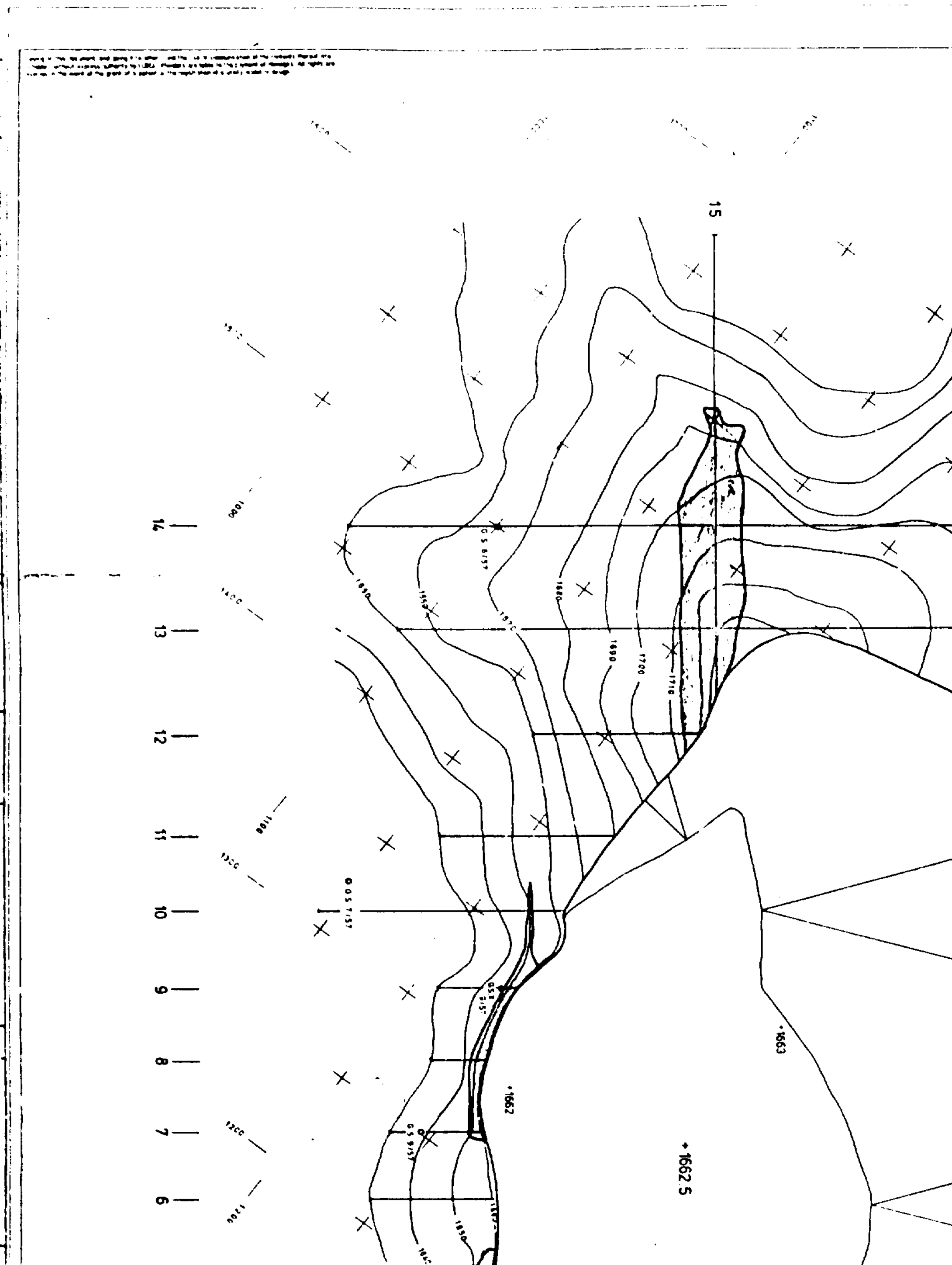
SECTION 1

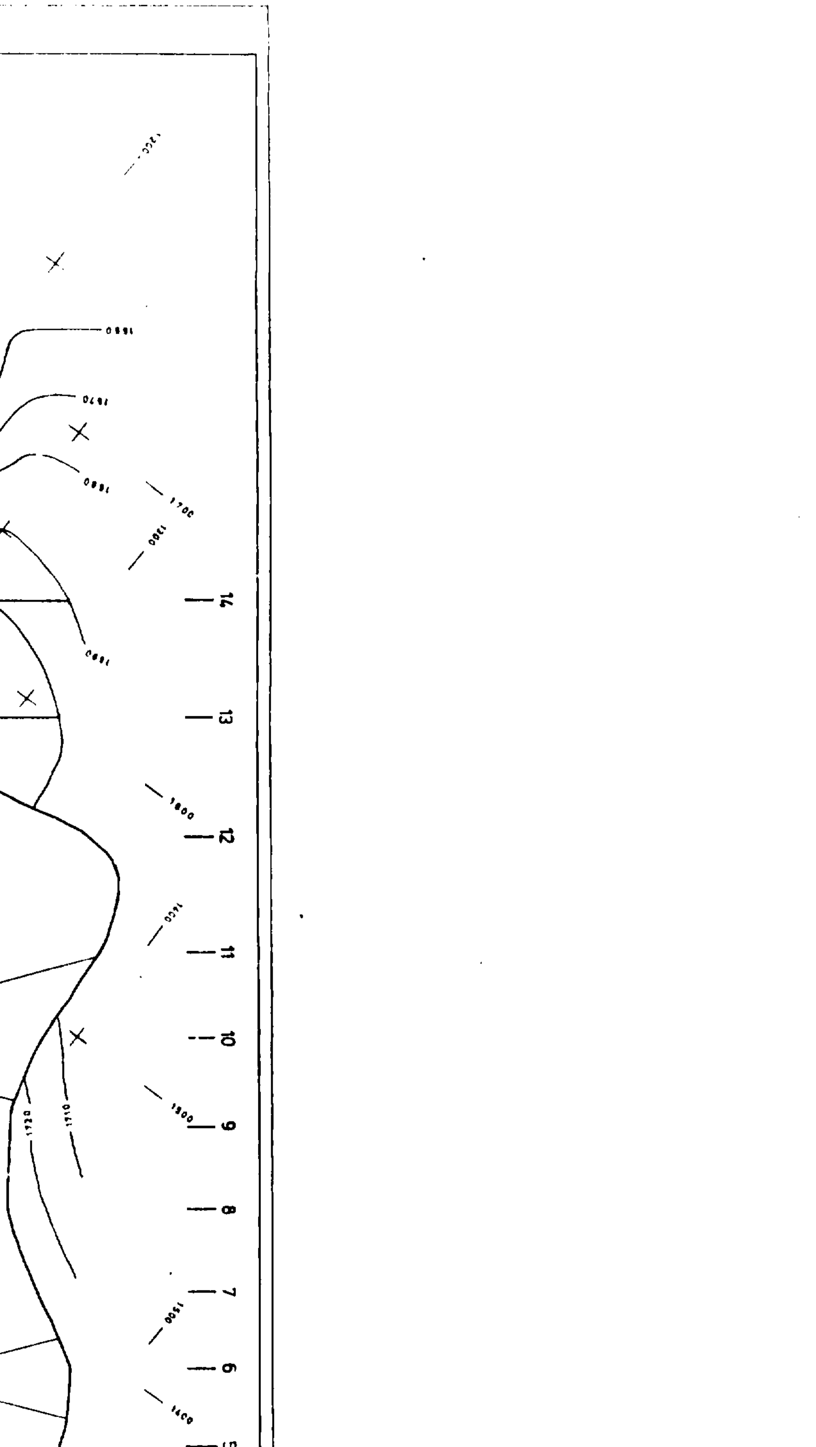


7 1/4

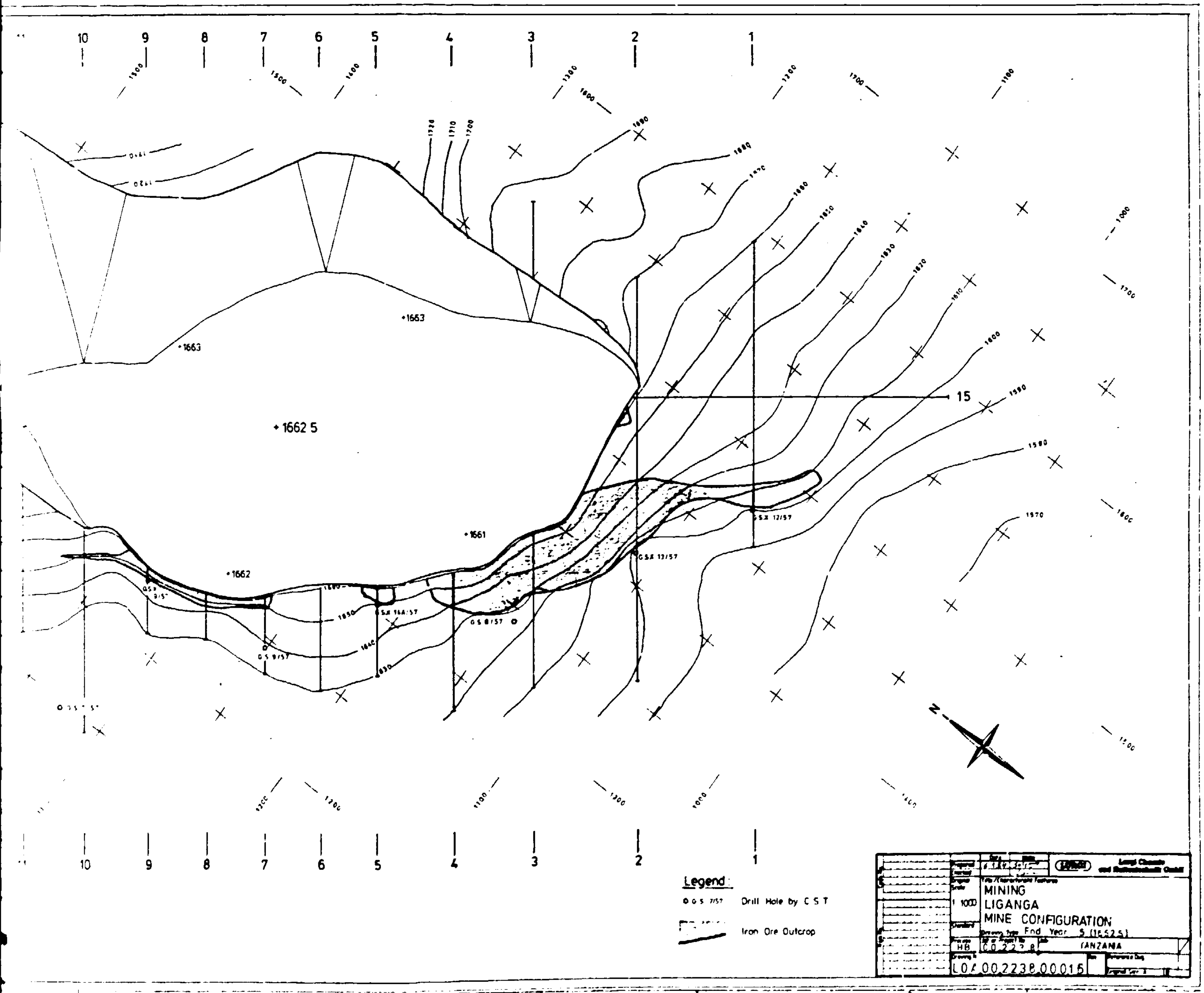
	Date	Name	LURGI — Lurgi Chemie und Hüttentechnik GmbH
Prepared	3. 1. 84		
Checked			
Original Scale 1:5000	Title / Characteristic Features: MINING LIGANGA GENERAL PLOT PLAN		
Standard	Drawing Type		
Process HB	Job or Project No 0 0 2 2 3 8	Job	TANZANIA
Drawing No L2A 00 2238 00015	Rev	Reference Dwg	Original Size A

SECTION 1



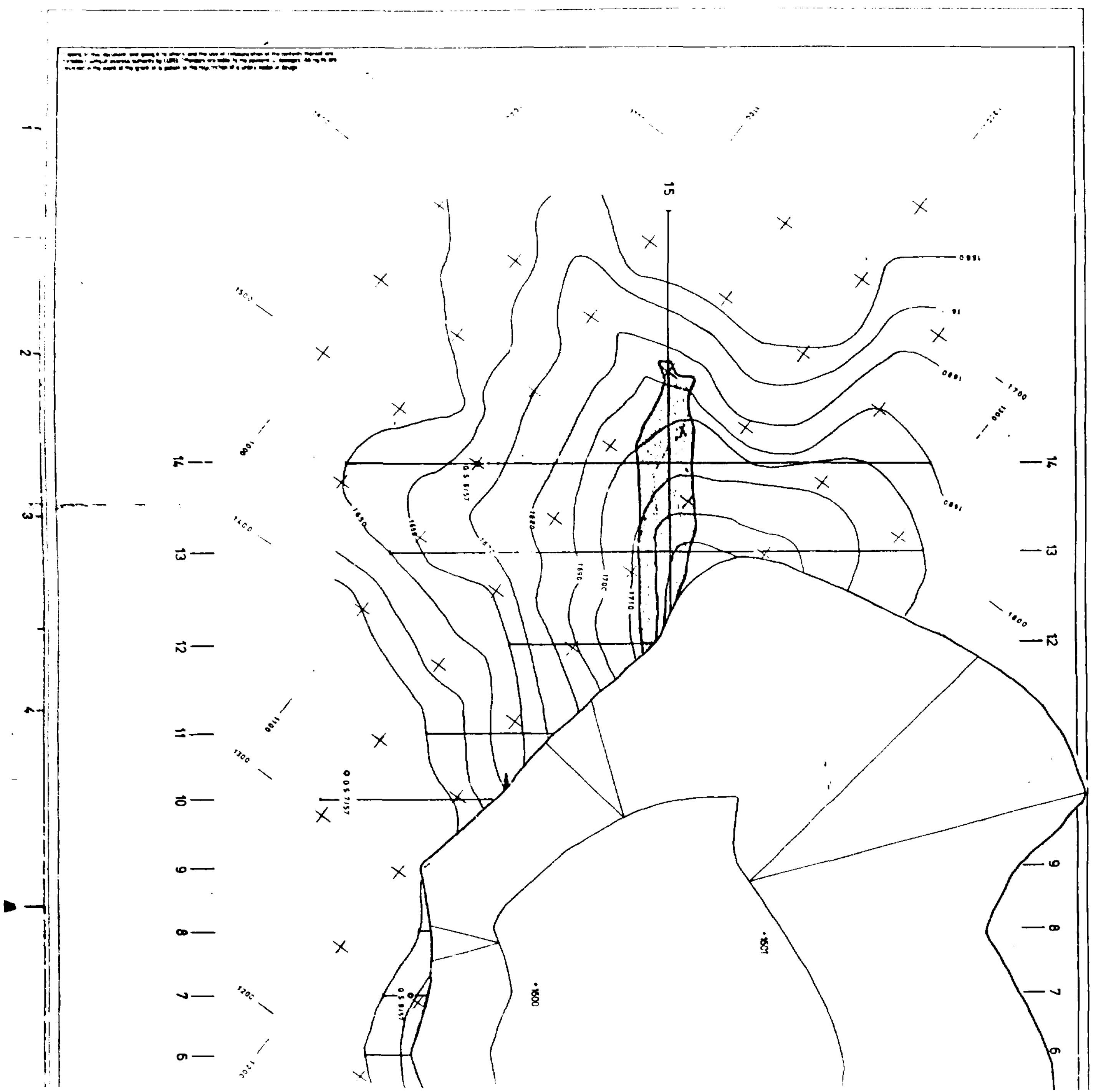

14
13
12
11
10
9
8
7
6

SECTION 2

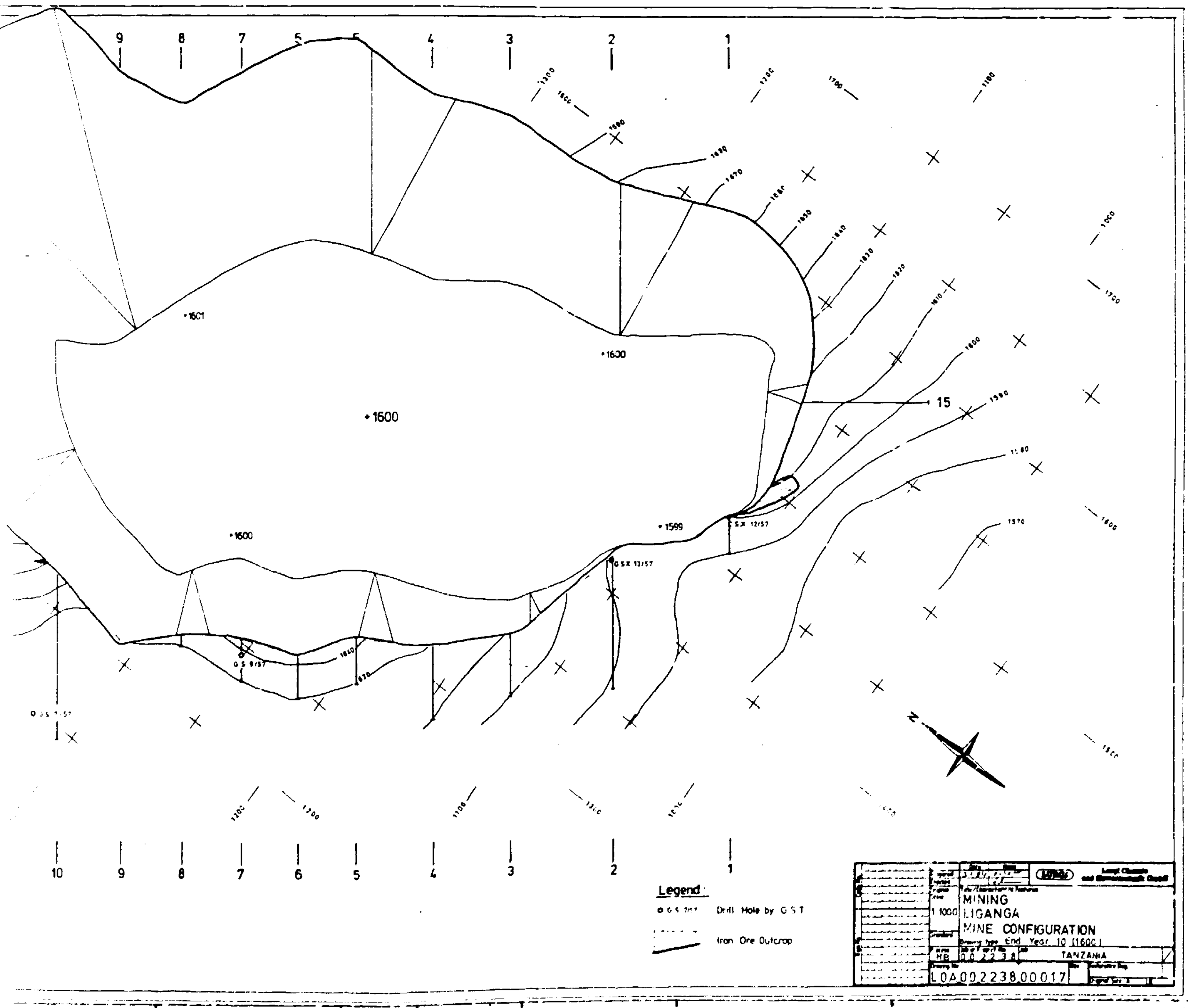


10 9 8 7 6 5 4 3 2 1
+1663
+1663
+1662.5
+1661
+1662
15
Legend:
Drill Hole by C.S.T
Iron Ore Outcrop
1:1000
MINING
LIGANGA
MINE CONFIGURATION
End Year 5 (1652.5)
TANZANIA

SECTION 1

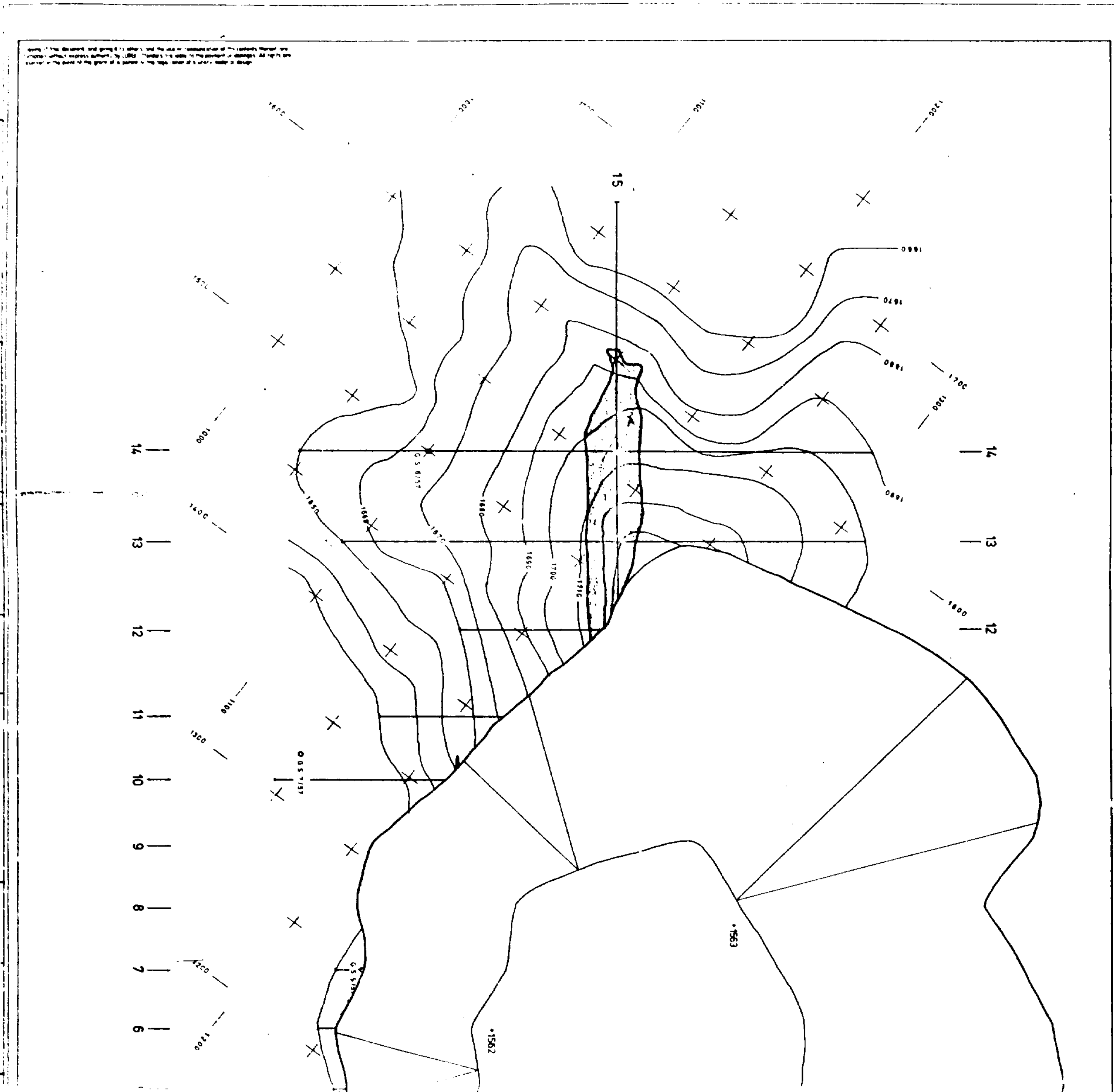


SECTION 2

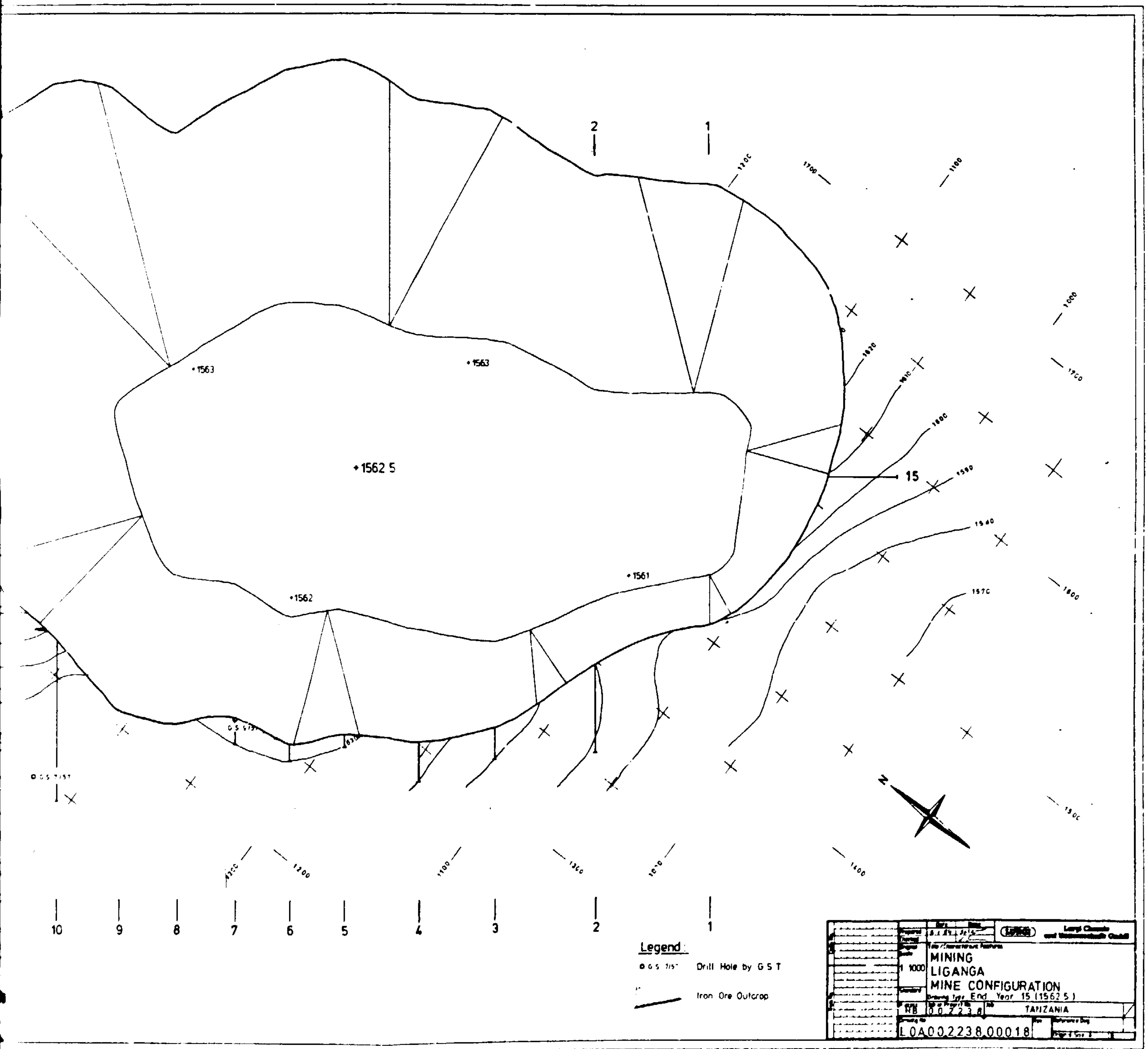


+1601
+1630
+1600
+1600
+1599
15
GSX 13/57
Legend:
Drill Hole by G.S.T.
Iron Ore Outcrop
MINING
LIGANGA
MINE CONFIGURATION
End Year 10 (1600)
1:1000
HB
TANZANIA
L0A002238.00017

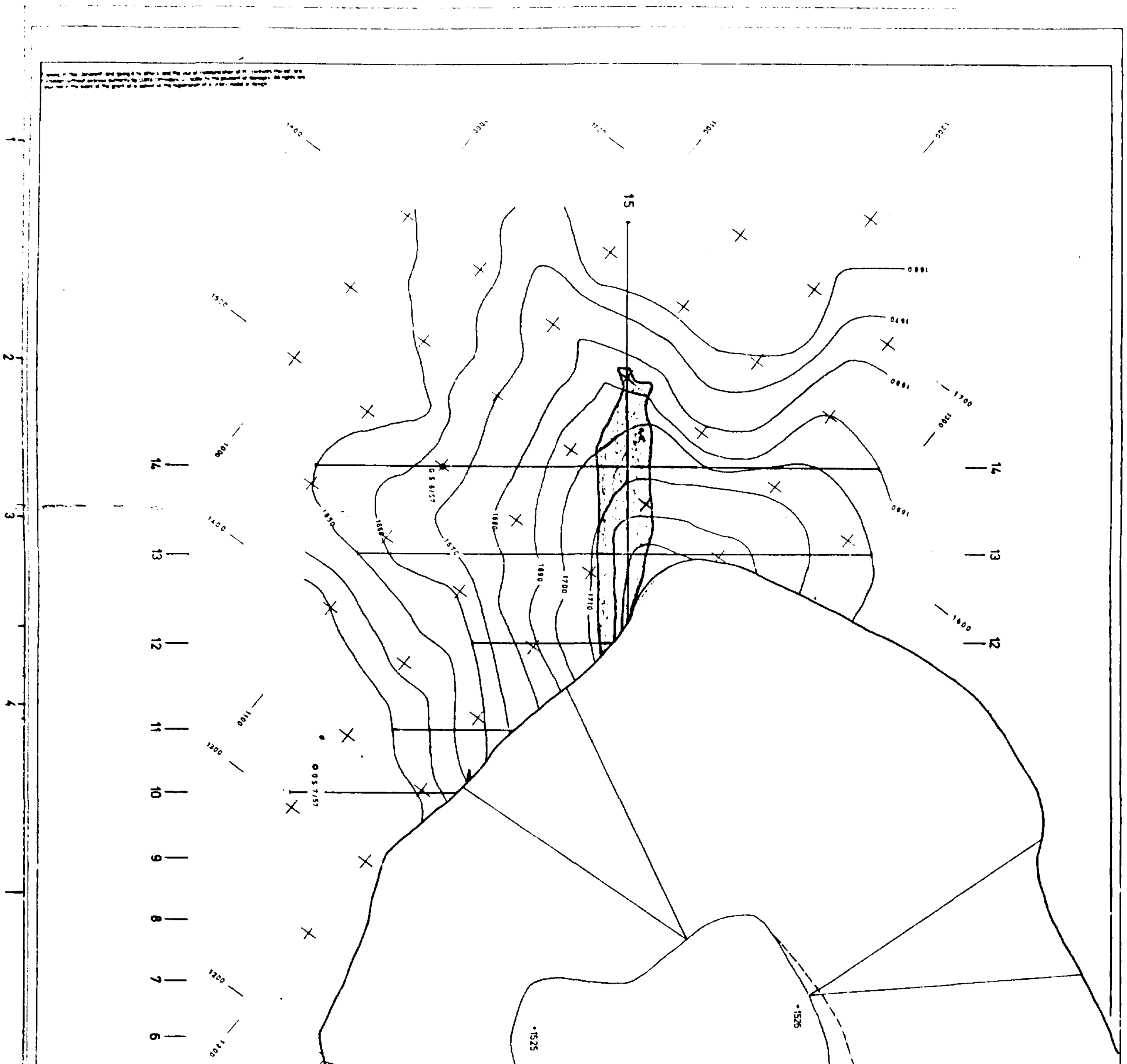
SECTION 1



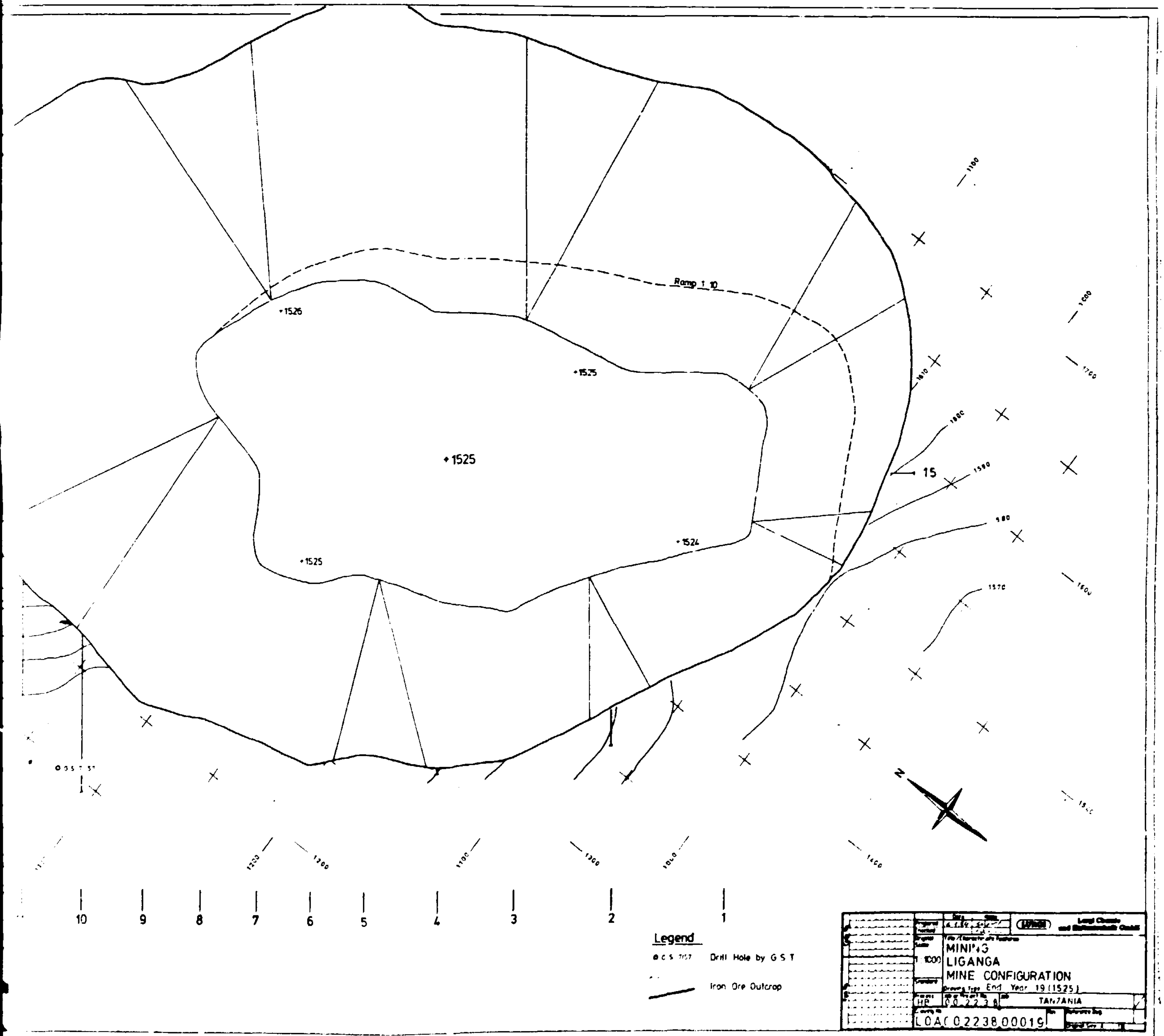
SECTION 2


2
1
15
+1563
+1563
+1562 5
+1561
+1562
10
9
8
7
6
5
4
3
2
1
Legend:
Drill Hole by G S T
Iron Ore Outcrop
1 1000
MINING
LIGANGA
MINE CONFIGURATION
End Year 15 (1562 5)
RB
0 0 2 2 3 8
TANZANIA
L 0 A 0 0 2 2 3 8 0 0 0 1 8

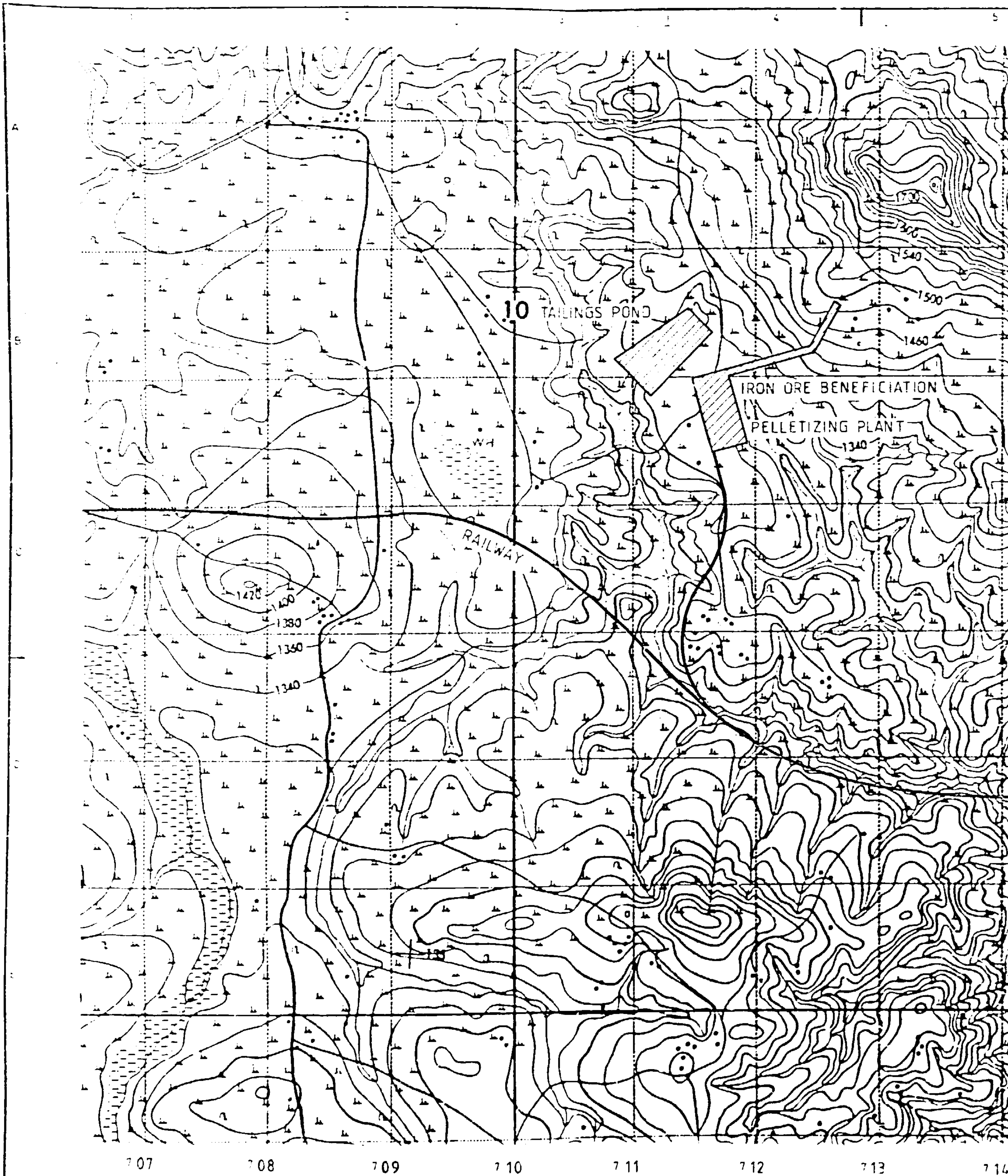
SECTION 1



SECTION 2


Ramp 1:10
+1526
+1525
+1525
+1525
+1524
15
10
9
8
7
6
5
4
3
2
1
Legend
Drill Hole by G S T
Iron Ore Outcrop
1:1000
MINING
LIGANGA
MINE CONFIGURATION
End Year 19 (1525)
HP
TANZANIA
LOA(02238 00019

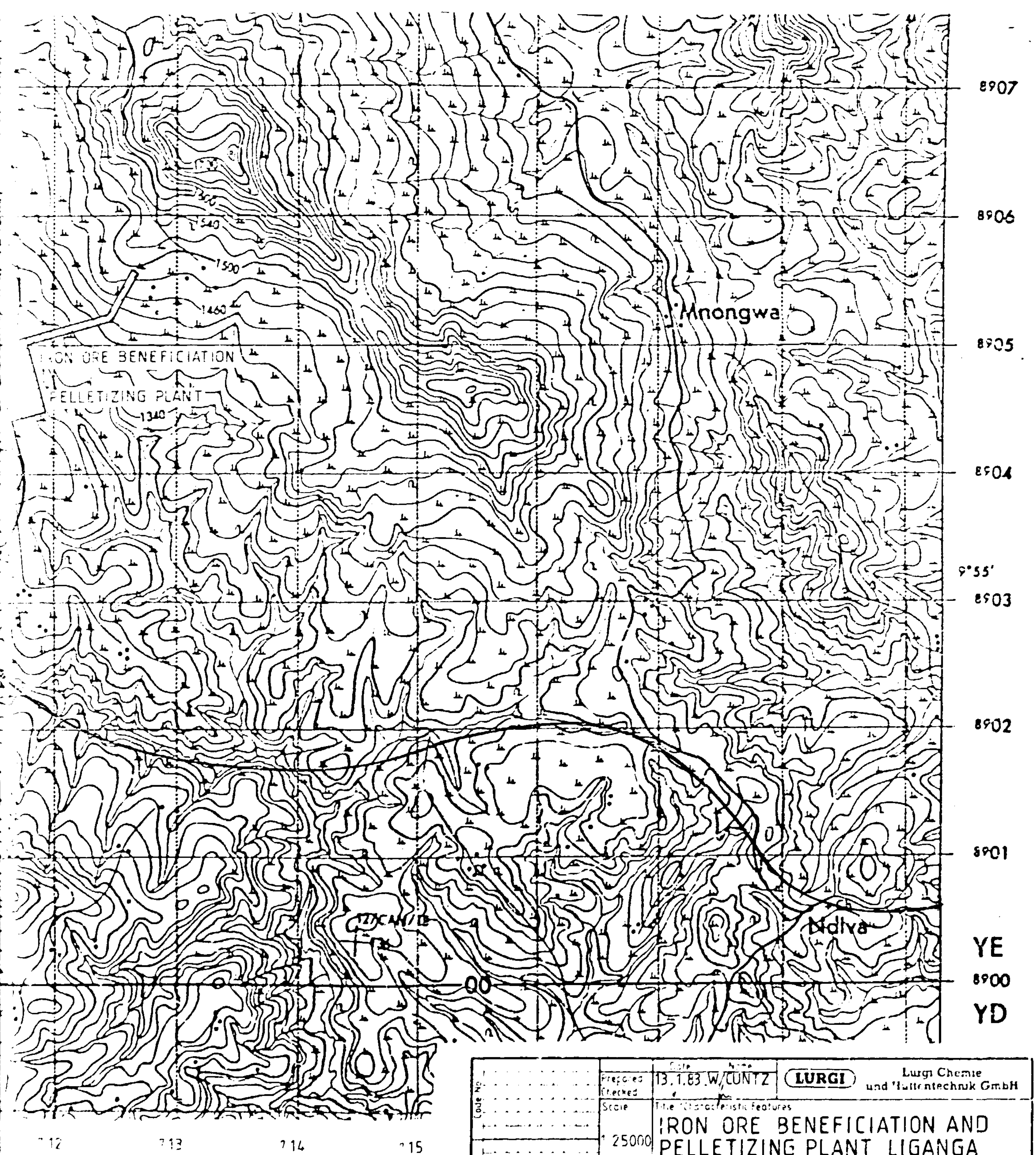
SECTION 1



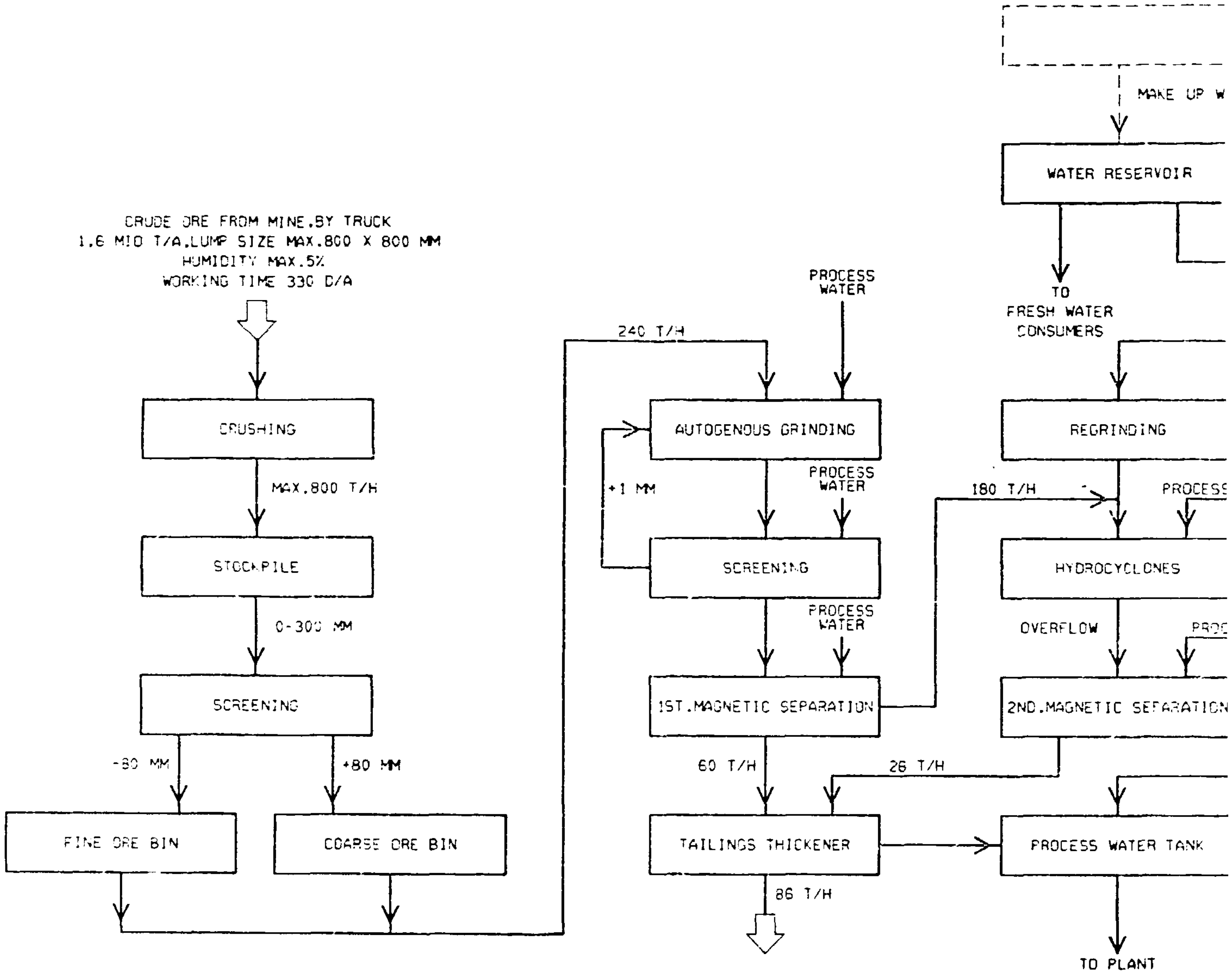
NOTE:
ENLARGED SECTION MADE FROM
MKUTANO MAP: EDITION 1-TSD
SERIES Y 742 , SHEET 274/4

3 4

SECTION 2

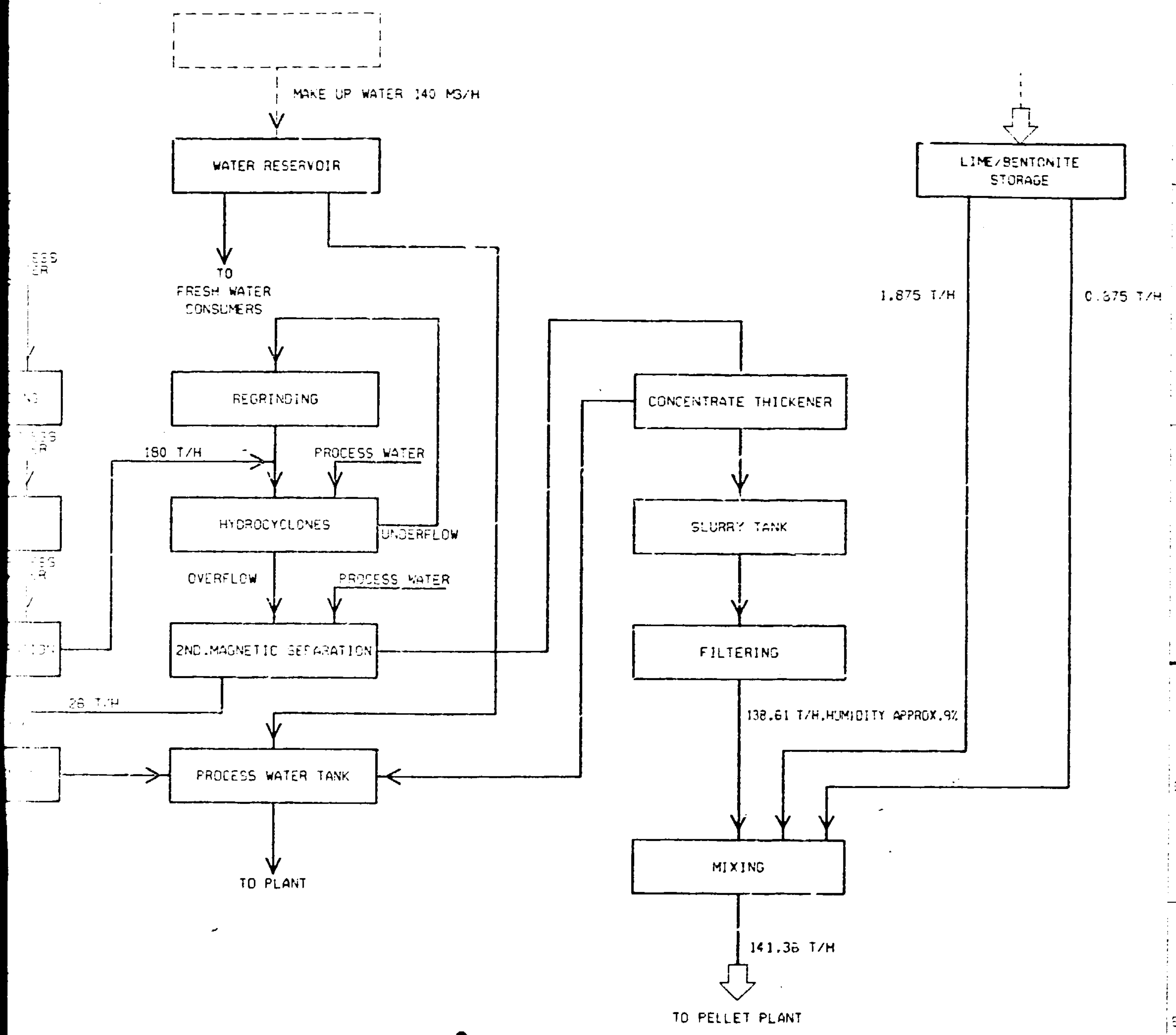


Prepared / Checked	13.1.83 W. CUNTZ
	LURGI — Lurgi Chemie und Hüttentechnik GmbH
Scale 1:25000	IRON ORE BENEFICIATION AND PELLETIZING PLANT LIGANGA TOPOGRAPHICAL MAP
Process HAA	Job / Process No 0 1 2 2 3 8 — Job Title TANZANIA
Drawing No	L2A01 223800010



SECTION 1

[202,011]A2238B001.DGN/06.01.84 HFFN



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Checked	10.1.84
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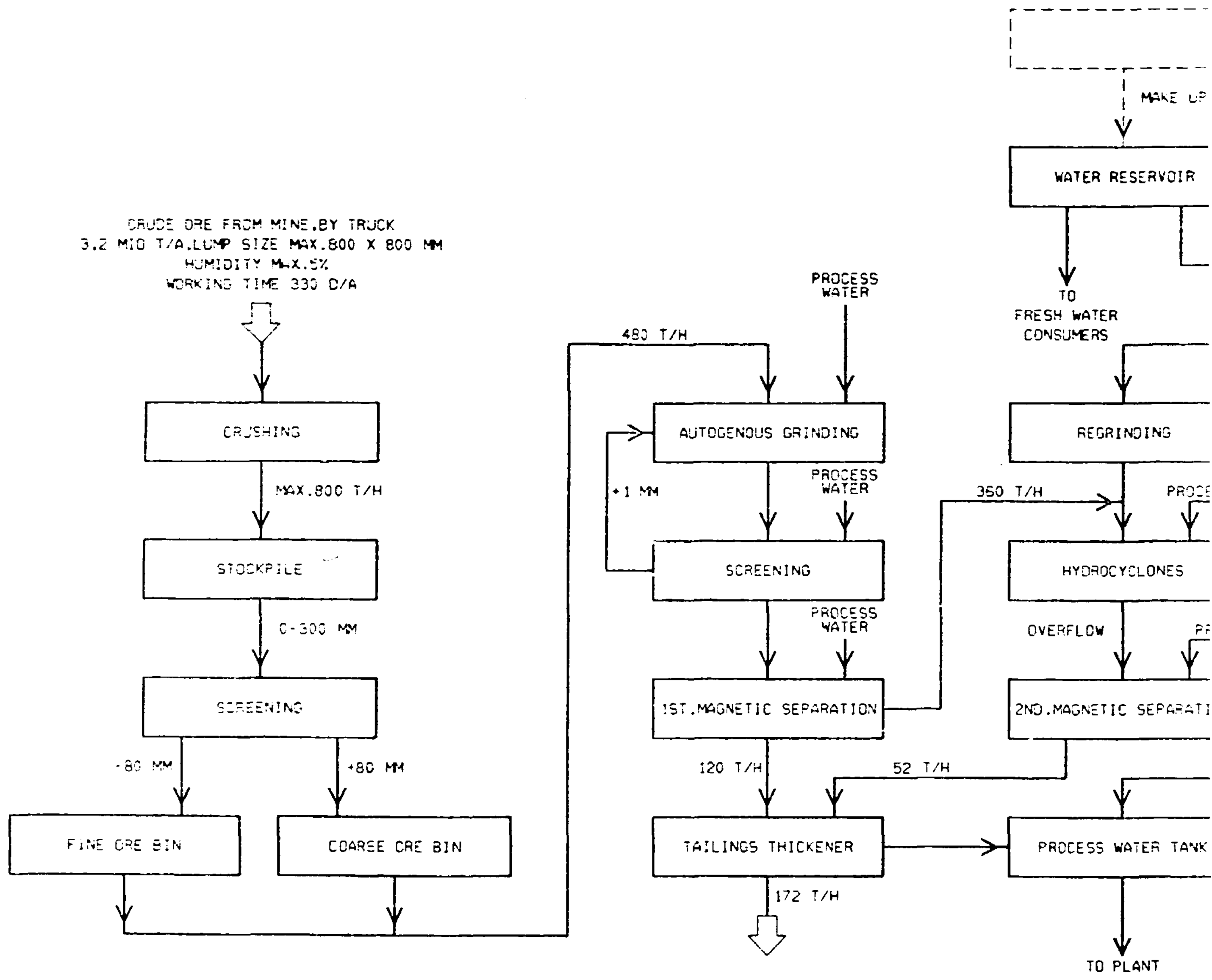

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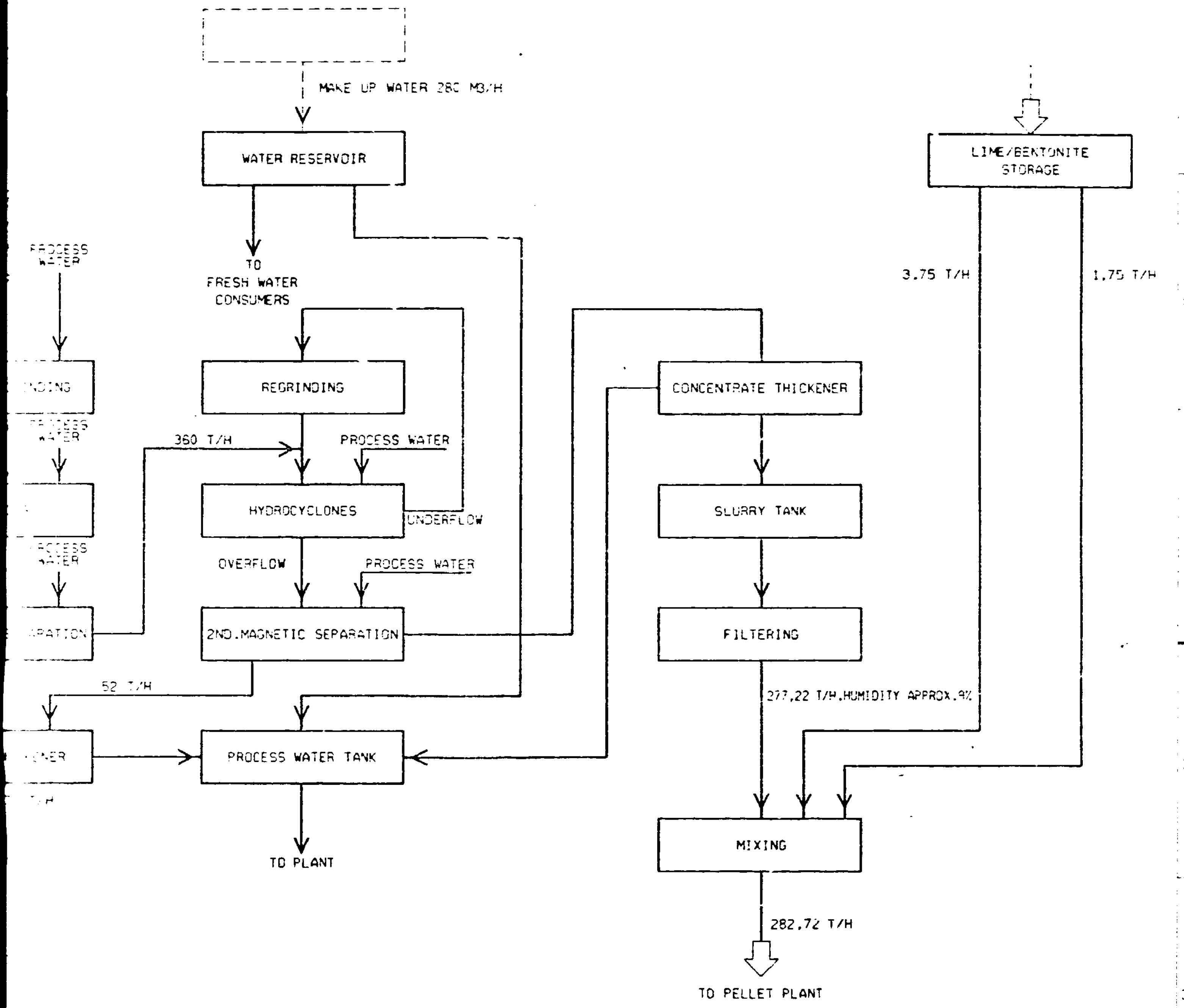

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Prepared 08.11.83 PAUL/HEEN

LURGI Lurgi Chemie und Huettentechnik GmbH

IRON ORE BENEFICIATION PLANT
LIGANGA
3,2 MIO T/A ORE FEED

202 BLOCK DIAGRAM

HAA 0 12238 TANZANIA

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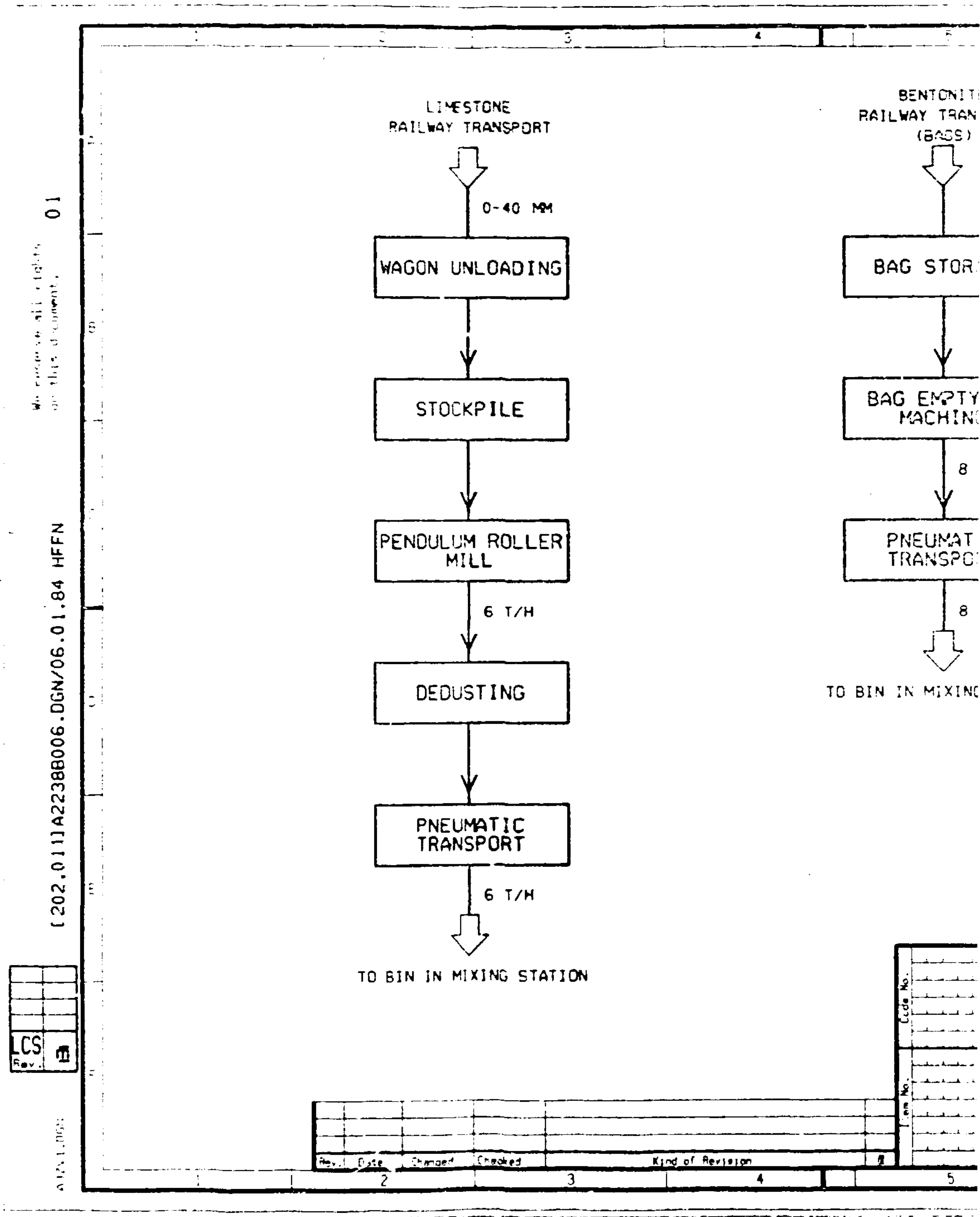
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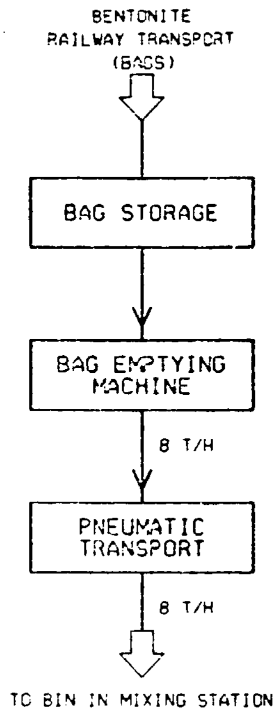
01
LIMESTONE
RAILWAY TRANSPORT
0-40 MM
WAGON UNLOADING
STOCKPILE
PENDULUM ROLLER MILL
6 T/H
DEDUSTING
PNEUMATIC TRANSPORT
6 T/H
TO BIN IN MIXING STATION
BENTONIT
RAILWAY TRAN
(BAGS)
BAG STOR
BAG EMPTY
MACHIN
8
PNEUMAT
TRANSPO
8
TO BIN IN MIXING
LCS
Rev.
Rev. Date Changed Checked Kind of Revision
Code No.

SECTION 1



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2.STAGE: 2 SHIFT OPERATION

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Prepared	08.12.83	PAUL/HFFN	
Checked	10. 7. 84		
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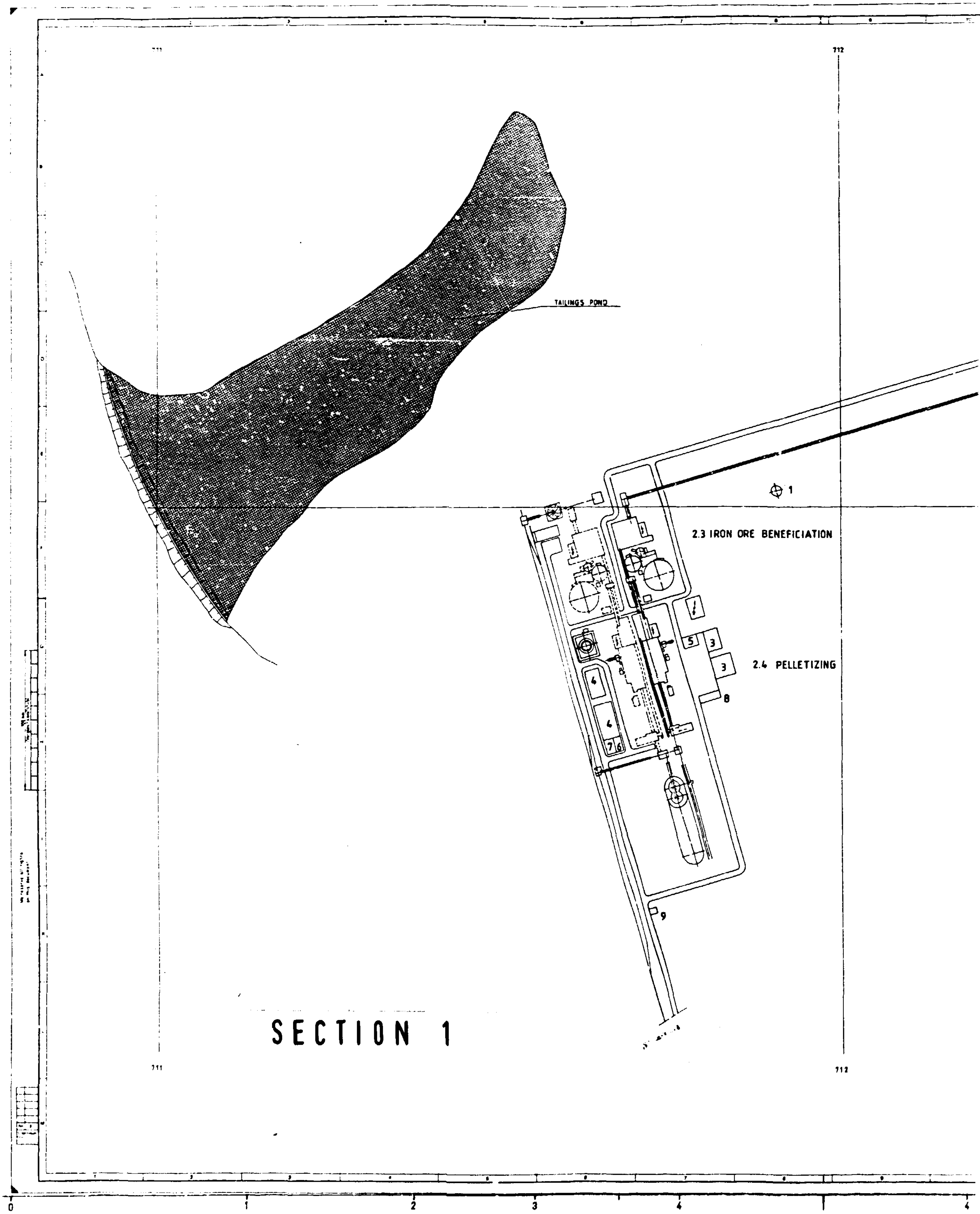
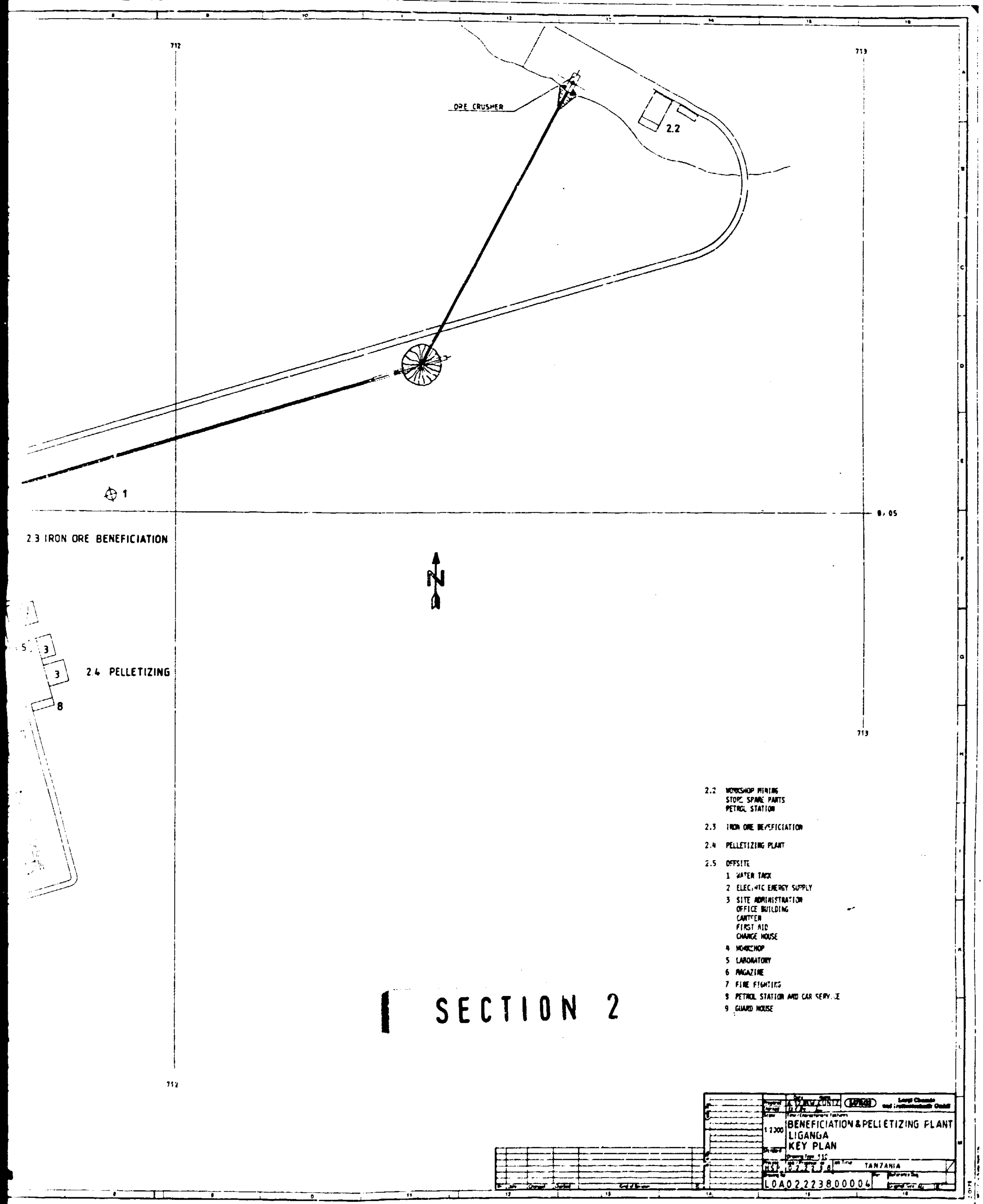


TAILINGS POND
2.3 IRON ORE BENEFICIATION
2.4 PELLETIZING
SECTION 1



2.2 WORKSHOP MINING
STORE SPARE PARTS
PETROL STATION

2.3 IRON ORE BENEFICIATION

2.4 PELLETIZING PLANT

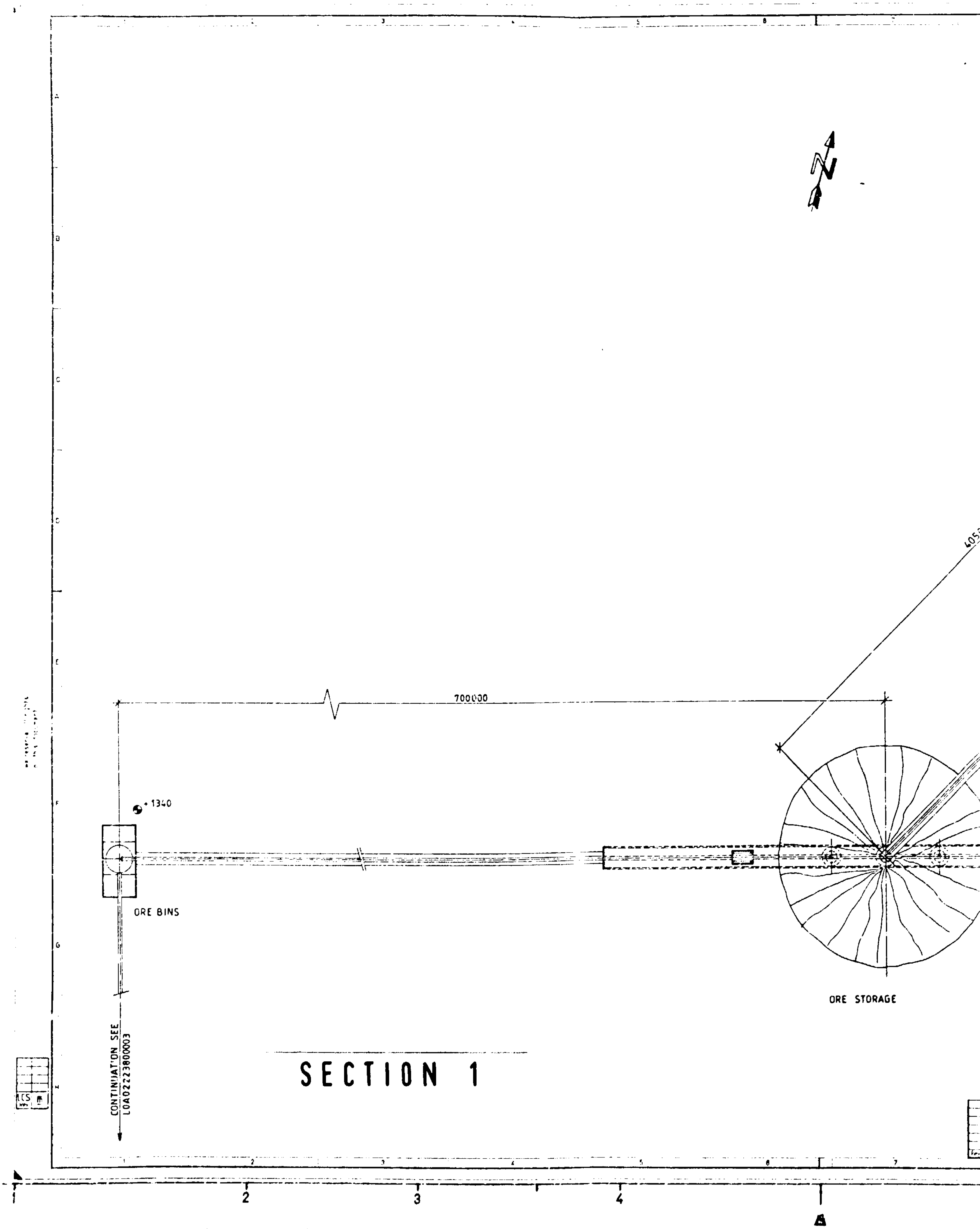
2.5 OFFSITE
1 WATER TANK
2 ELECTRIC ENERGY SUPPLY
3 SITE ADMINISTRATION
OFFICE BUILDING
CANTEEN
FIRST AID
CHANGE HOUSE
4 WORKSHOP
5 LABORATORY
6 MAGAZINE
7 FIRE FIGHTING
8 PETROL STATION AND CAR SERVICE
9 GUARD HOUSE

SECTION 2

1:2000
BENEFICIATION & PELLETIZING PLANT
LIGANGA
KEY PLAN

TANZANIA

LOA02223800004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ORE BINS
ORE STORAGE
CONTINUATION SEE
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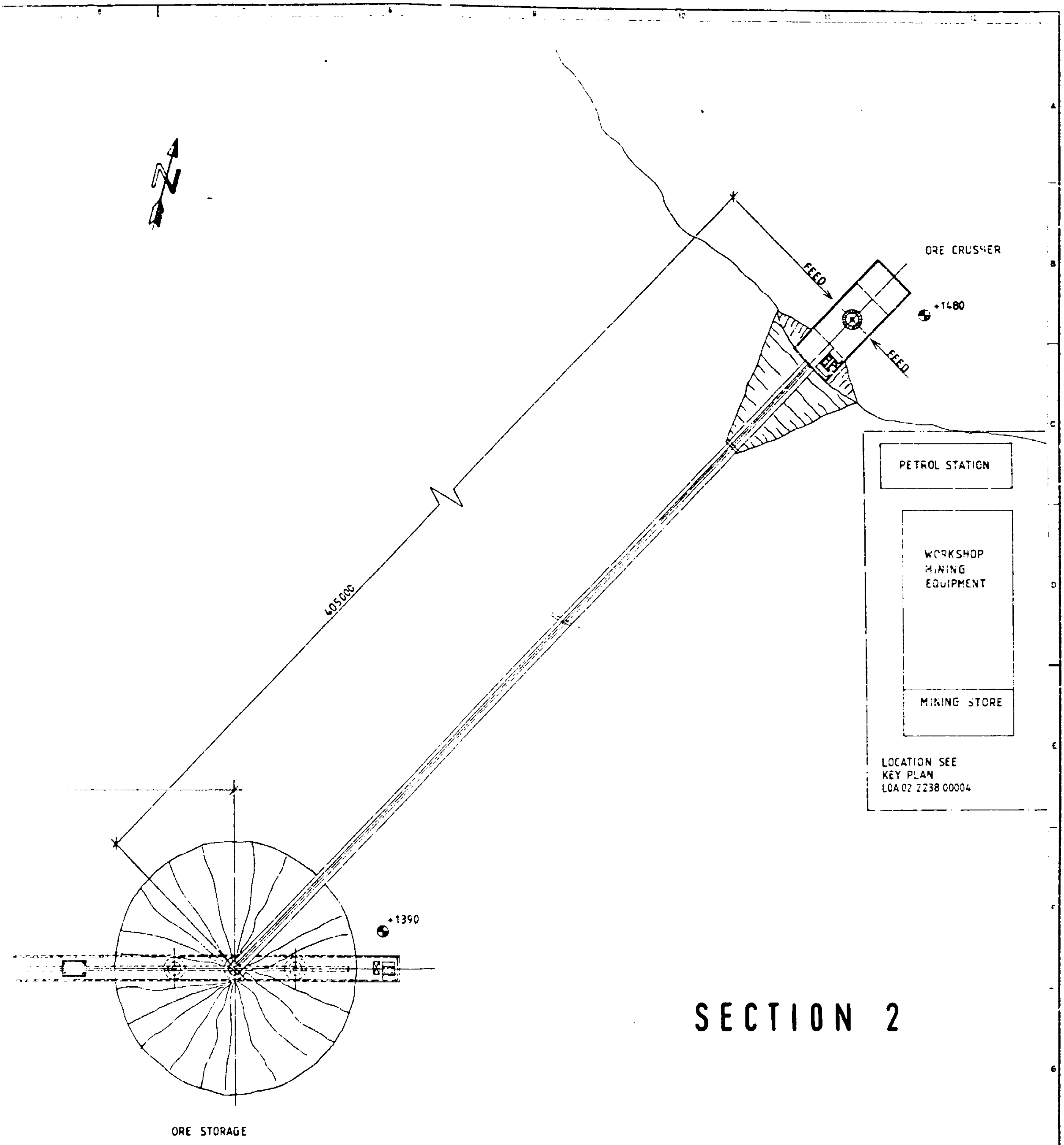

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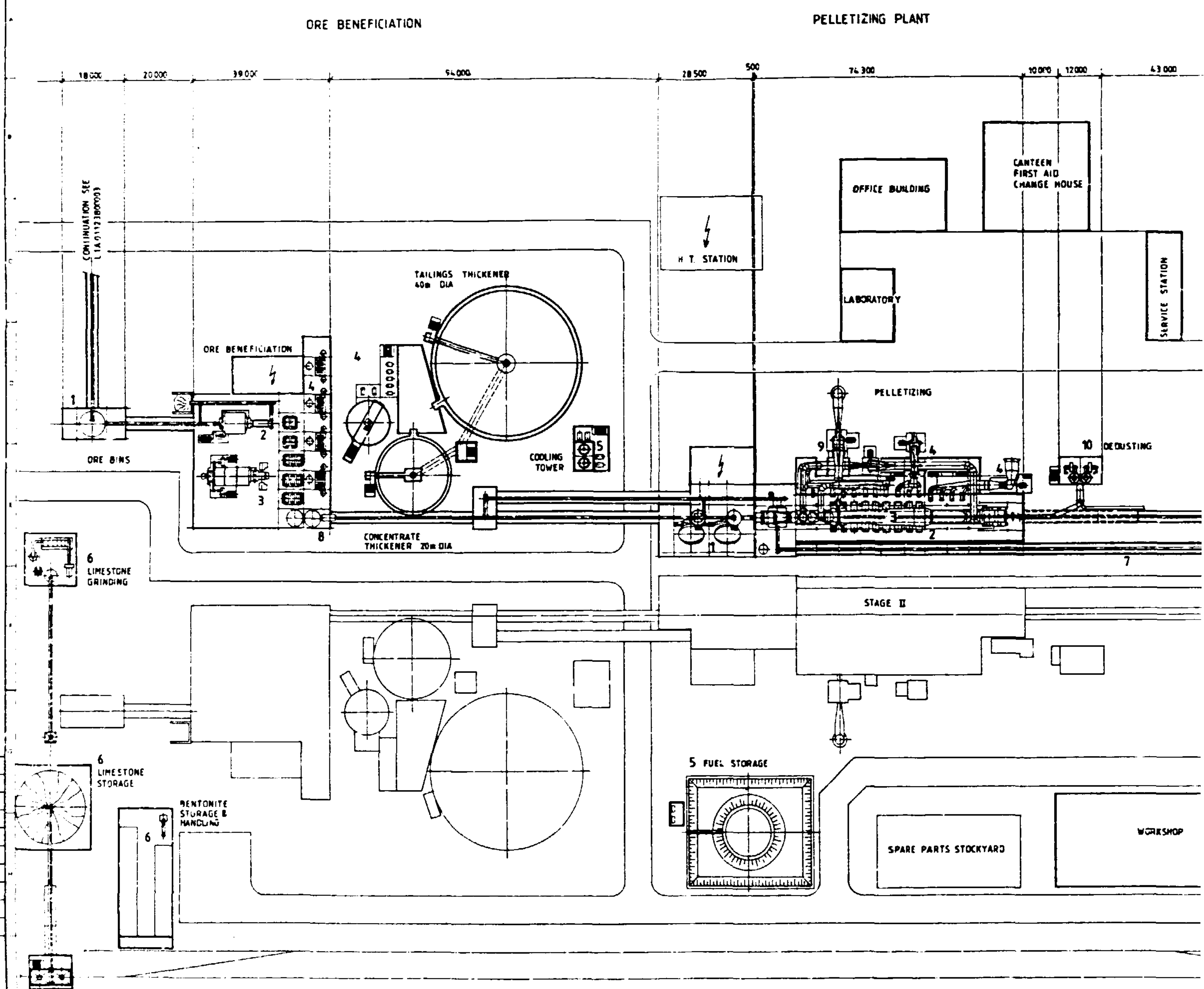
Lurgi Chemie und Huttentechnik GmbH



ORE BENEFICIATION

PLANT SECTIONS

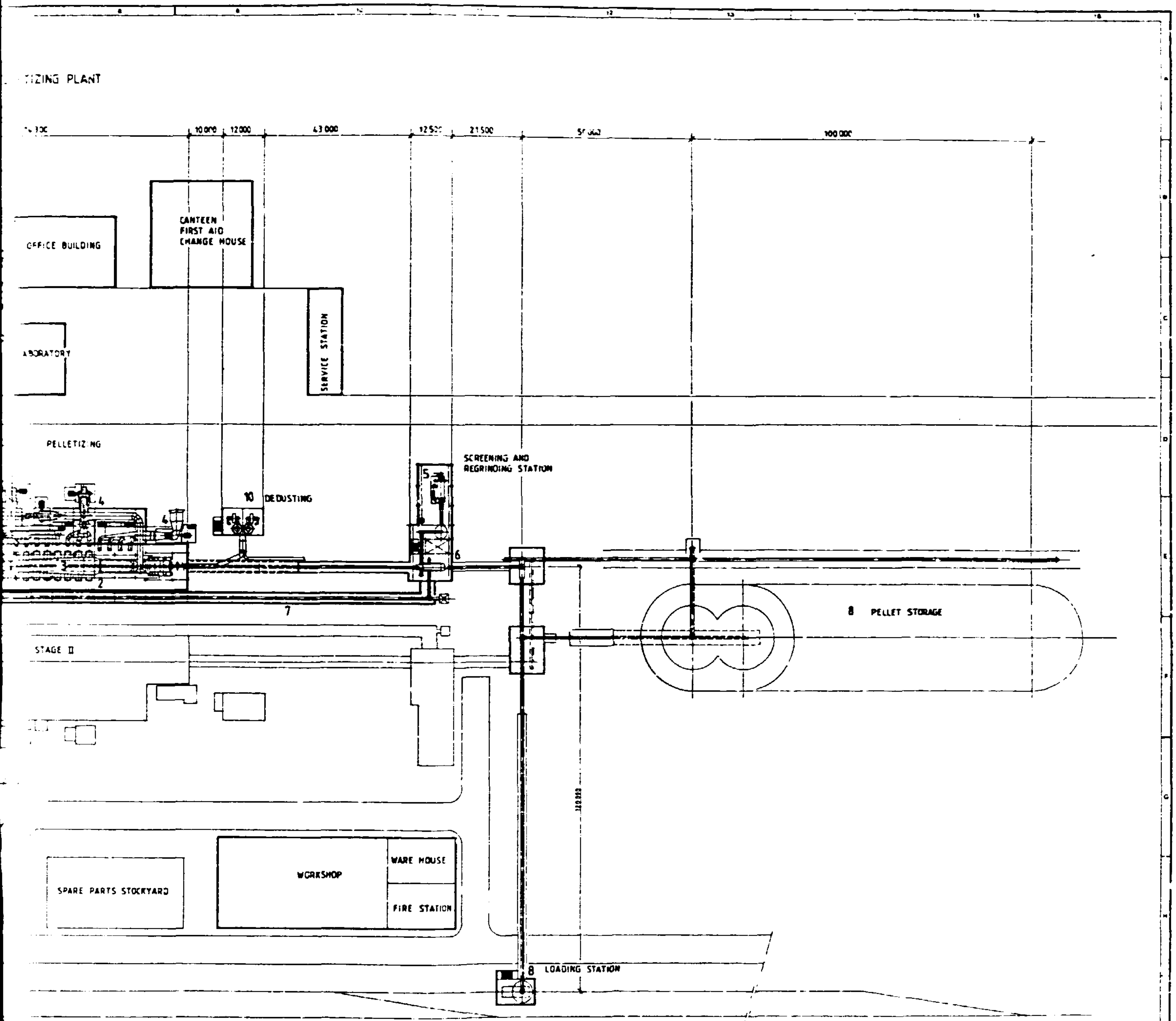
1 CRUSHING AND RAW ORE STORAGE
2 AUTOGENOUS GRINDING AND PRIMARY MAGNETIC SEPARATION
3 FINAL GRINDING AND SECONDARY MAGNETIC SEPARATION
4 THICKENERS AND FILTERING PLANT
5 RETURN FINES GRINDING
6 LIMESTONE GRINDING AND BENTONITE HANDLING
7 CRANES, HOISTS, PLANT DEWATERING
8 MIXING STATION

PELLETIZING PLANT

PLANT SECTIONS

1 BALLING
2 PELLETIZING MACHINE
3 FURNACE HOOD
4 PROCESS FANS AND GAS MAINS
5 COMPRESSED AIR, FUEL OIL SUPPLY AND COOLING WATER SYSTEM
6 PELLET CONVEYING AND SCREENING SYSTEM
7 HEARTH- AND SIDE LAYER CONVEYING SYSTEM
8 PELLET PRODUCT CONVEYING, STORAGE AND LOADING
9 WASTE GAS DEDUSTING
10 PLANT DEDUSTING
11 CRANES AND HOISTS
12 AUXILIARY AND EMERGENCY FACILITIES

SECTION 1



PELLETIZING PLANT

PLANT SECTIONS

1 BALLING
2 PELLETIZING MACHINE
3 FURNACE HOOD
4 PROCESS FANS AND GAS MAINS
5 COMPRESSED AIR, FUEL OIL SUPPLY AND COOLING WATER SYSTEM
6 PELLET CONVEYING AND SCREENING SYSTEM
7 HEARTH- AND SIDE LAYER CONVEYING SYSTEM
8 PELLET PRODUCT CONVEYING, STORAGE AND LOADING
9 WASTE GAS DEDUSTING
10 PLANT DEDUSTING
11 CRANES AND HOISTS
12 AUXILIARY AND EMERGENCY FACILITIES

SECTION 2

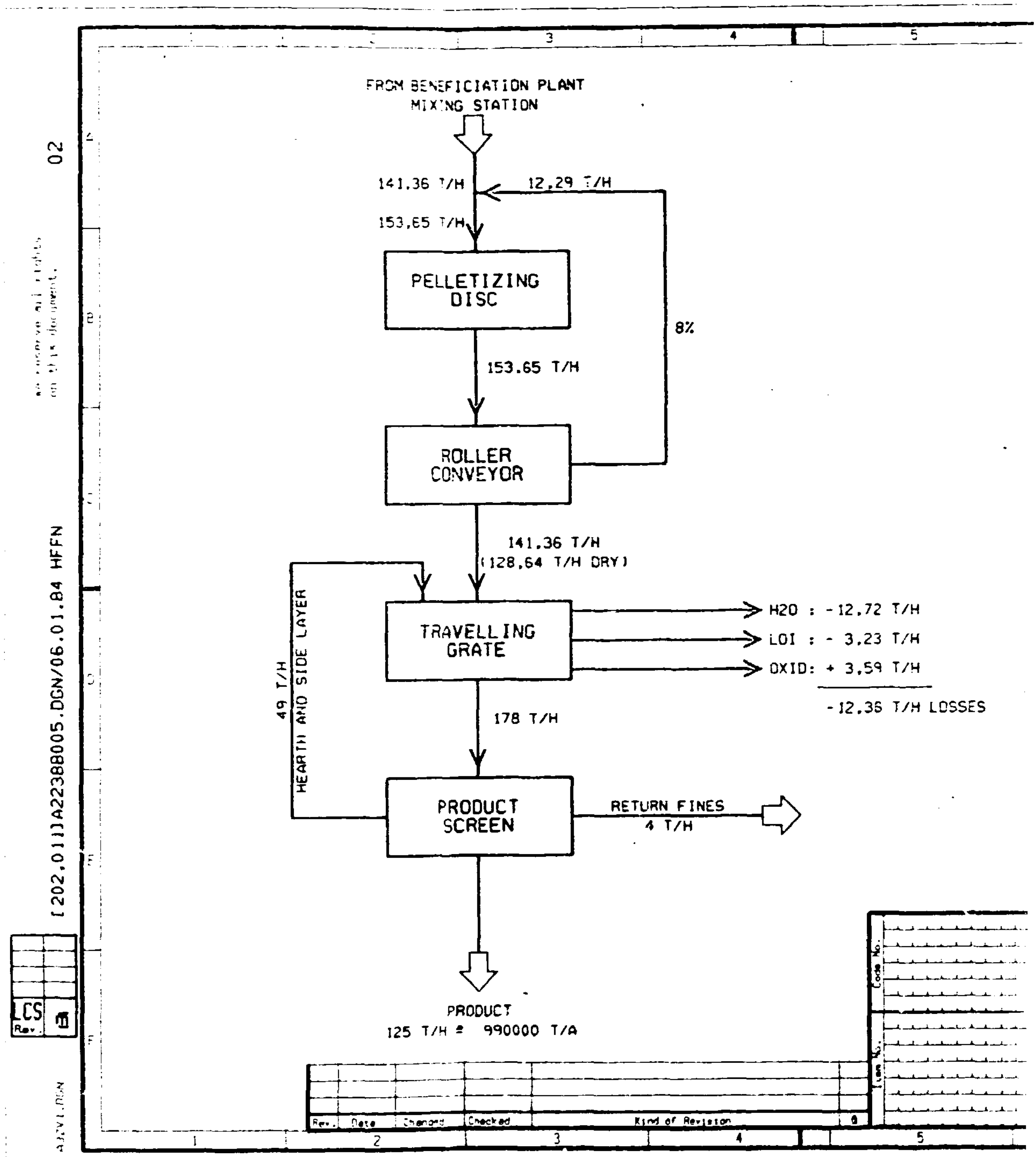
BENEFICIATION & PELLETIZING PLANT
LIGANGA
PLOT PLAN

1:500

MSP 022238

TANZANIA

L0A02223800003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MIXING STATION
141.36 T/H
12.29 T/H
153.65 T/H
PELLETIZING DISC
8%
153.65 T/H
ROLLER CONVEYOR
141.36 T/H
(128.64 T/H DRY)
49 T/H
HEARTH AND SIDE LAYER
TRAVELLING GRATE
H2O : -12.72 T/H
LOI : - 3.23 T/H
OXID: + 3.59 T/H
-12.36 T/H LOSSES
178 T/H
PRODUCT SCREEN
RETURN FINES
4 T/H
PRODUCT
125 T/H ≙ 990000 T/A
[202,011]A22388005.DGN/06.01.84 HFFN
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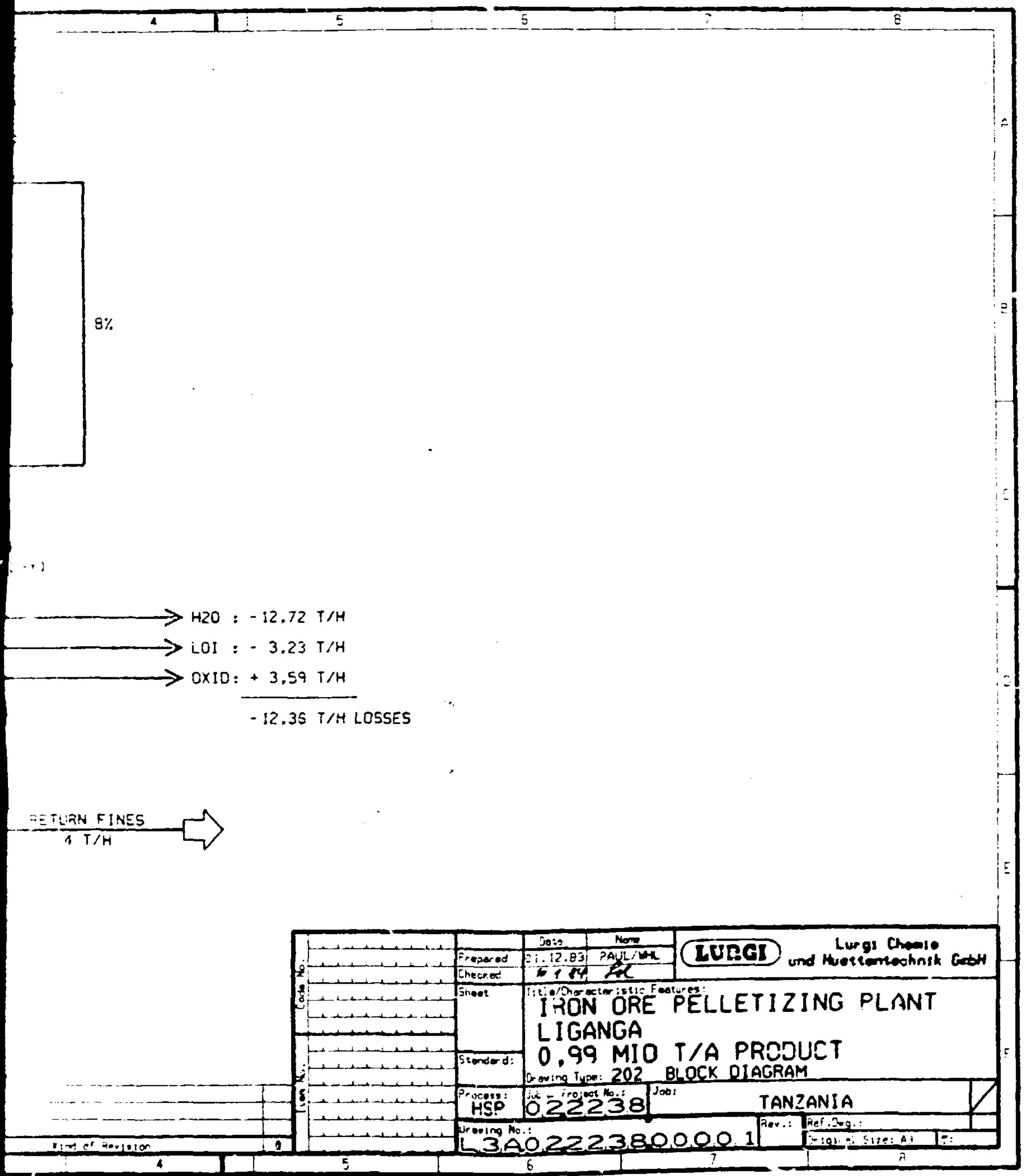
SECTION 1


8%
H2O : -12,72 T/H
LOI : - 3,23 T/H
OXID: + 3,59 T/H
-12,36 T/H LOSSES
RETURN FINES
4 T/H
Date
Name
Prepared
PAUL/WHL
Checked
Sheet
Standard:
LURGI
Lurgi Chemie und Huettentechnik GmbH
Title/Characteristic Features:
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LIGANGA
0,99 MIO T/A PRODUCT
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Process:
HSP
Job:
TANZANIA
022238
Drawing No.:
L3A022238000 1
Rev.:
Ref.Dwg.:

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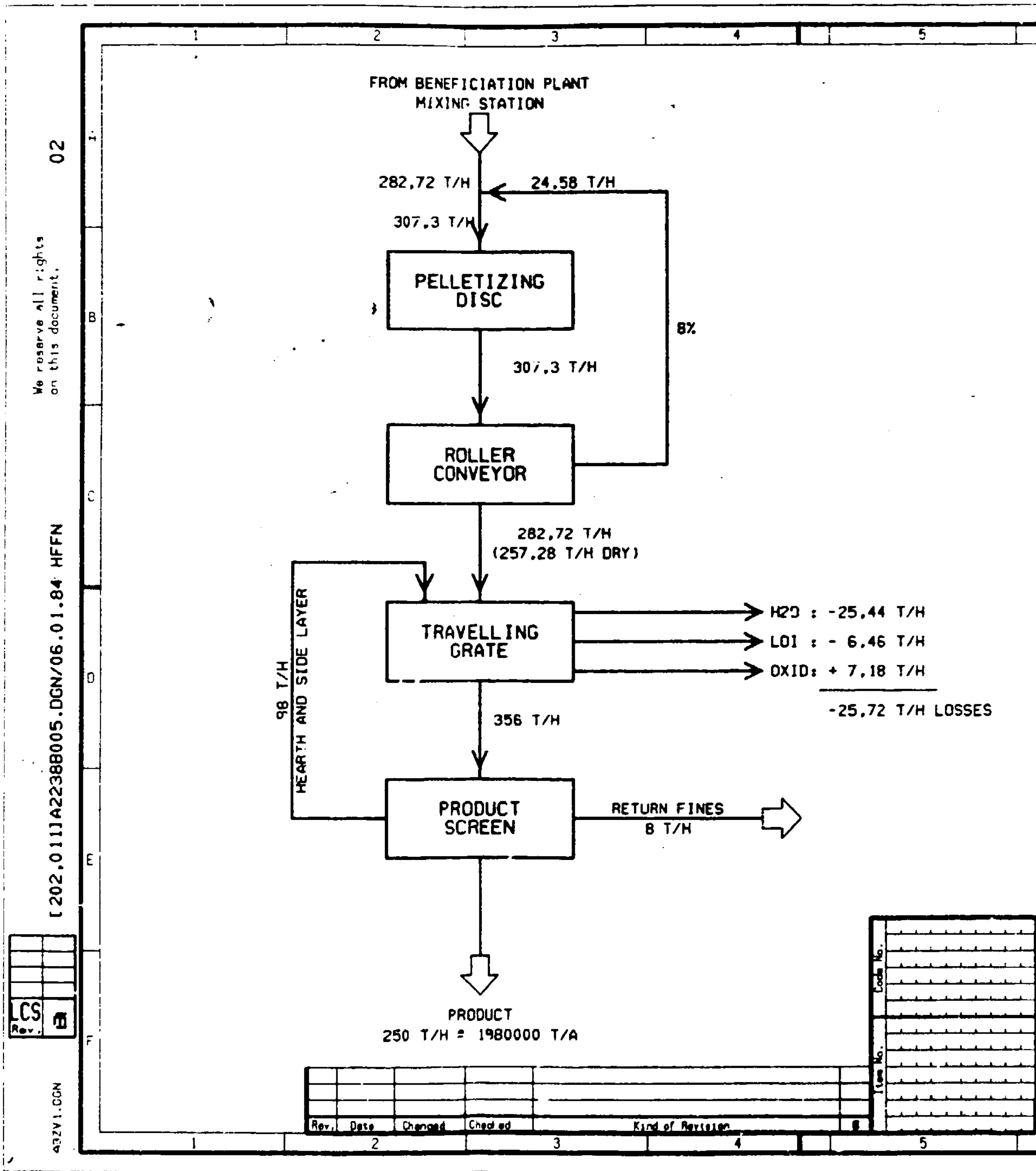
FROM BENEFICIATION PLANT
MIXING STATION
282,72 T/H
24,58 T/H
307,3 T/H
PELLETIZING DISC
8%
307,3 T/H
ROLLER CONVEYOR
282,72 T/H
(257,28 T/H DRY)
TRAVELLING GRATE
H2O : -25,44 T/H
LOI : - 6,46 T/H
OXID: + 7,18 T/H
-25,72 T/H LOSSES
98 T/H
HEARTH AND SIDE LAYER
356 T/H
PRODUCT SCREEN
RETURN FINES
8 T/H
PRODUCT
250 T/H ≙ 1980000 T/A
We reserve all rights on this document.
02
[202,011]A2238B005.DGN/06.01.84 HFFN
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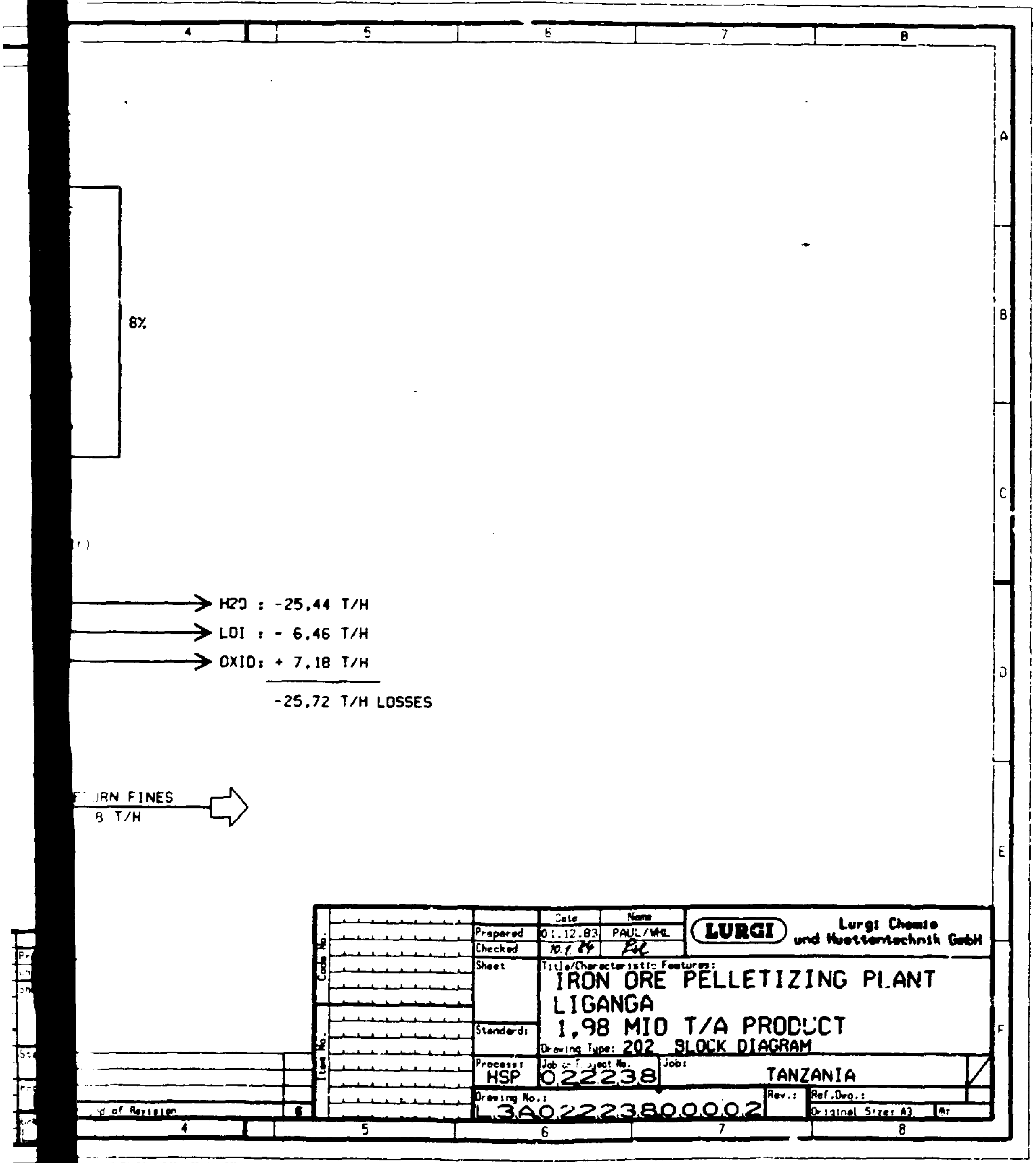
Rev.
Date
Changed
Checked
Kind of Revision

SECTION 1


8%
H2O : -25,44 T/H
LOI : - 6,46 T/H
OXID: + 7,18 T/H
-25,72 T/H LOSSES
URN FINES
8 T/H
Prepared 01.12.83 PAUL/WHL
Checked 10.1.84
LURGI
Lurgi Chemie und Huettentechnik GmbH
Sheet
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IRON ORE PELLETIZING PLANT
LIGANGA
1,98 MIO T/A PRODUCT
Drawing Type: 202 BLOCK DIAGRAM
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Rev.:
Ref.Dwg.:
Original Size A3

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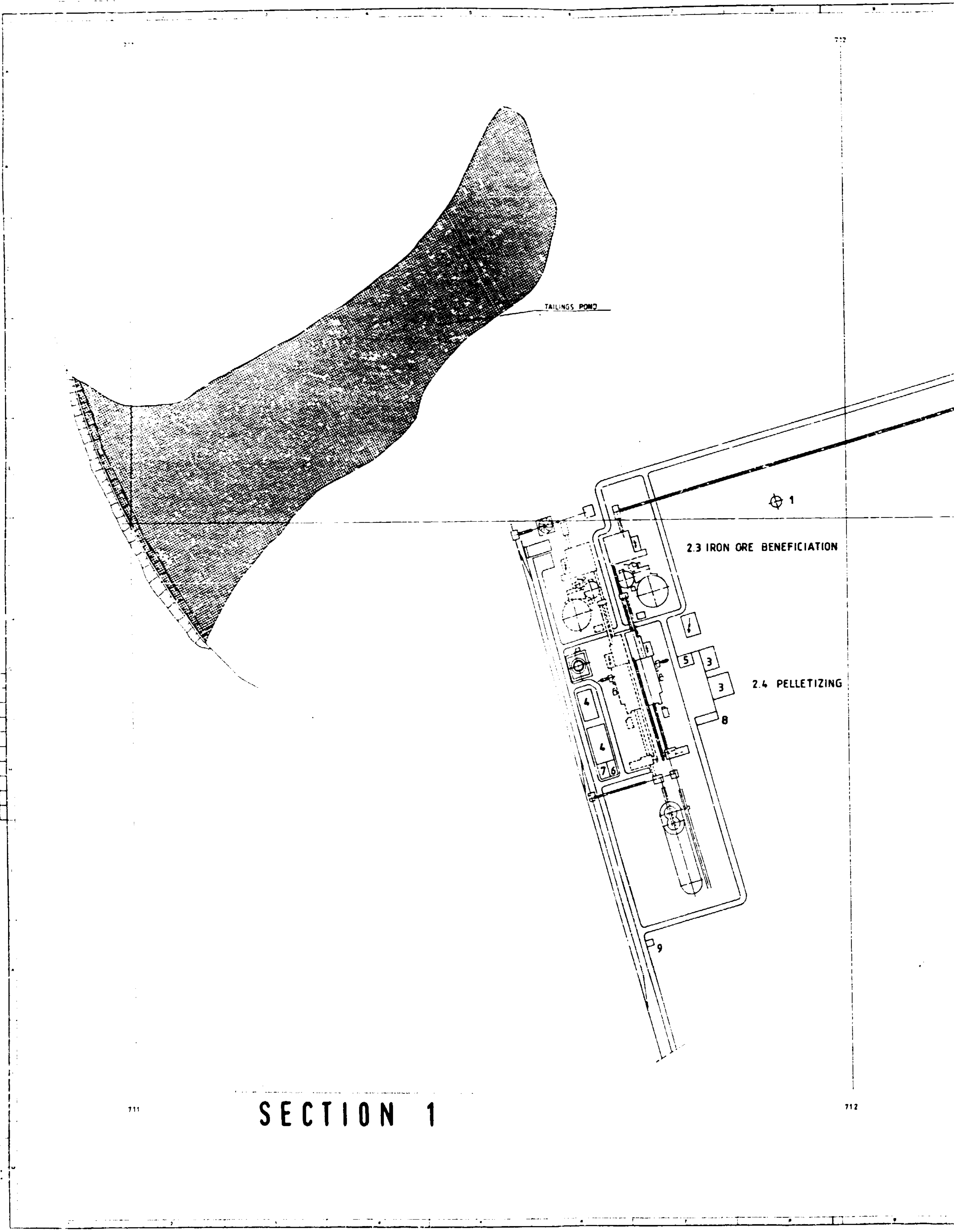
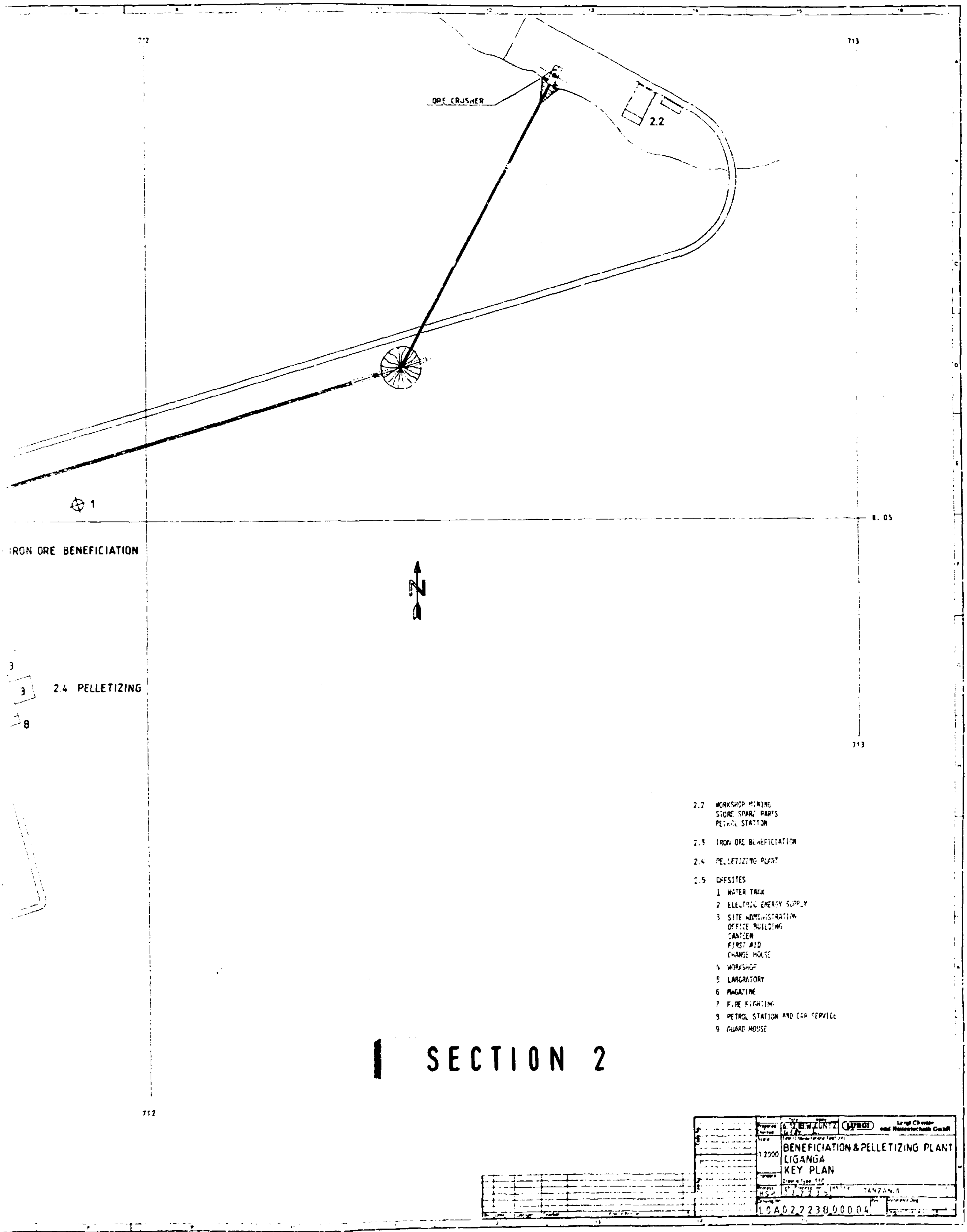
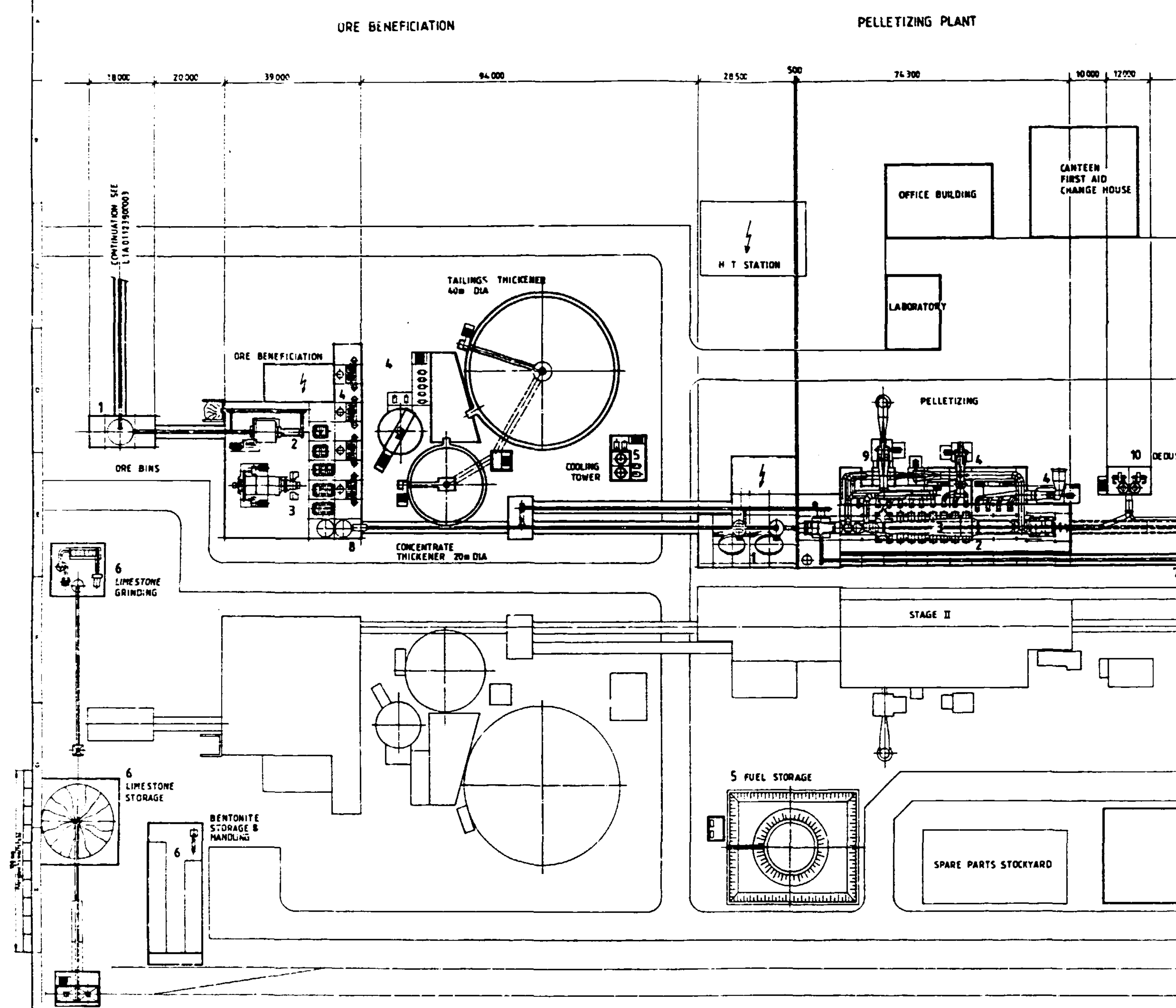

TAILINGS POND
2.3 IRON ORE BENEFICIATION
2.4 PELLETIZING
711
712

SECTION 1



ORE CRUSHER
2.2
1
IRON ORE BENEFICIATION
N
2.4 PELLETIZING
3
3
8
712
713
2.2 WORKSHOP MINING
STORE SPARE PARTS
PETROL STATION
2.3 IRON ORE BENEFICIATION
2.4 PELLETIZING PLANT
.5 OFFSITES
1 WATER TANK
2 ELECTRIC ENERGY SUPPLY
3 SITE ADMINISTRATION
OFFICE BUILDING
CANTEEN
FIRST AID
CHANGE HOUSE
4 WORKSHOP
5 LARGRATORY
6 MAGAZINE
7 FIRE FIGHTING
9 PETROL STATION AND CAR SERVICE
9 GUARD HOUSE
LURGI
1:2000
BENEFICIATION & PELLETIZING PLANT
LIGANGA
KEY PLAN
HSP
TANZANIA
L0A02223000004

SECTION 2



ORE BENEFICIATION

PLANT SECTIONS

1 CRUSHING AND RAW ORE STORAGE
2 AUTOGENOUS GRINDING AND PRIMARY MAGNETIC SEPARATION
3 FINAL GRINDING AND SECONDARY MAGNETIC SEPARATION
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8 MIXING STATION

PELLETIZING PLANT

PLANT SECTIONS

1 BALLING
2 PELLETIZING MACHINE
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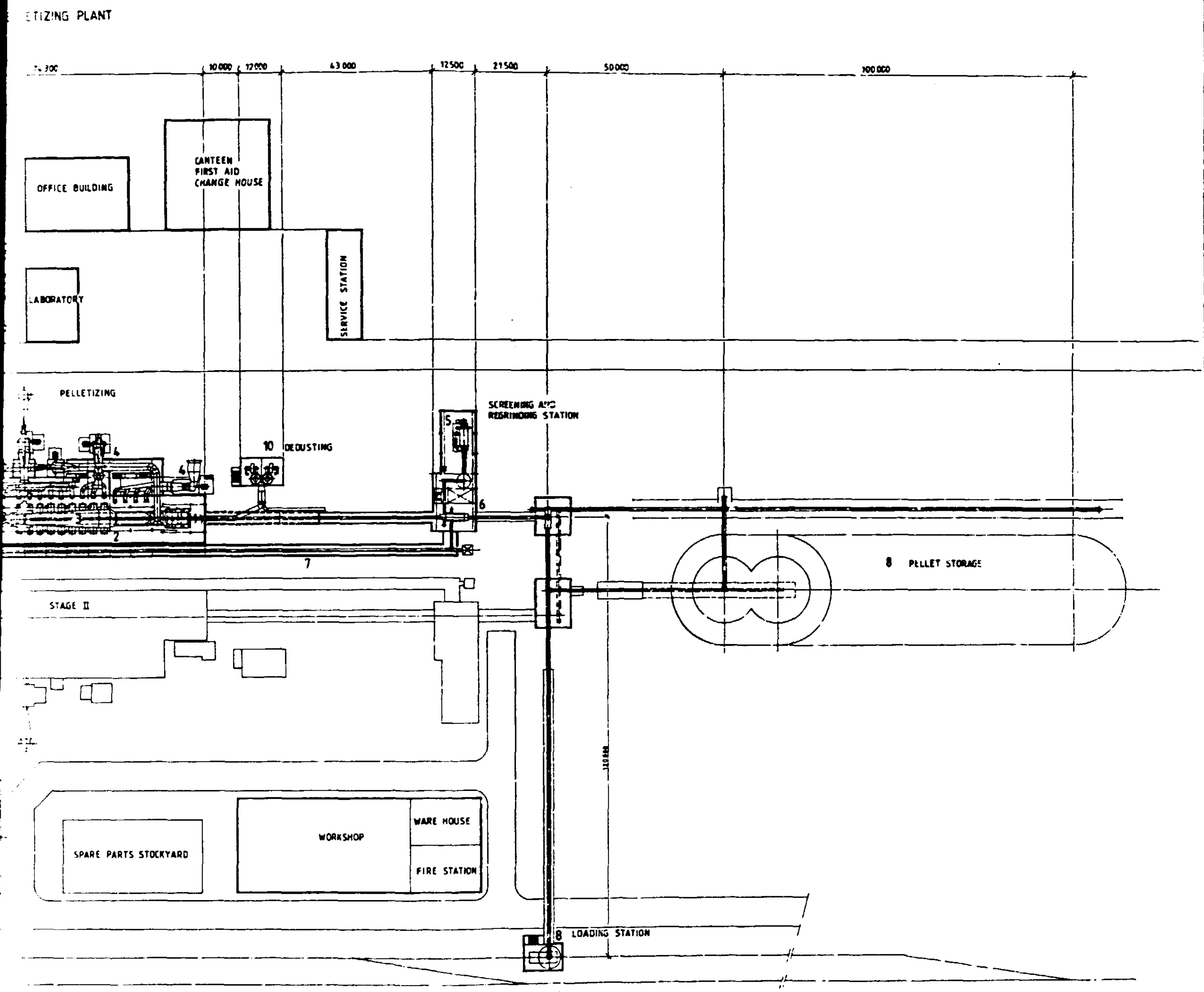
4 PROCESS FANS AND GAS MAINS
5 COMPRESSED AIR, FUEL OIL SUPPLY AND COOLING WATER SYSTEM
6 PELLET CONVEYING AND SCREENING SYST
7 HEARTH- AND SIDE LAYER CONVEYING SY
8 PELLET PRODUCT CONVEYING, STORAGE A
9 WASTE GAS DEDUSTING
10 PLANT DEDUSTING
11 CRANES AND HOISTS
12 AUXILIARY AND EMERGENCY FACILITIES

SECTION 1



PELLETIZING PLANT

PLANT SECTIONS

1 BALLING
2 PELLETIZING MACHINE
3 FURNACE HOOD
4 PROCESS FANS AND GAS MAINS
5 COMPRESSED AIR, FUEL OIL SUPPLY AND COOLING WATER SYSTEM
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9 WASTE GAS DEDUSTING
10 PLANT DEDUSTING
11 CRANES AND HOISTS
12 AUXILIARY AND EMERGENCY FACILITIES

SECTION 2

1:500

BENEFICIATION & PELLETIZING PLANT
LIGANGA
PLOT PLAN

MSP 0 2 2 2 3 8 TANZANIA

L0A02 2238 00003

LURGI

13848

Final Report

Volume VII

Techno-Economic Evaluation and Project Report

for the

Establishment of an Iron and Steel Industry

in

The United Republic of Tanzania

Unido Project SM/URT/81/004

for

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

April 1984

LURGI

TECHNO-ECONOMIC EVALUATION AND PROJECT REPORT

FOR THE

ESTABLISHMENT OF AN IRON AND STEEL INDUSTRY

IN

THE UNITED REPUBLIC OF TANZANIA

GENERAL LIST OF CONTENTS

UNIDO Project No. SM/URT/81/004

LURGI

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1.1 General Aspects

1.2 Coal Mine

1.3 Coal Washing Plant

1.4 Offsites and Auxiliaries "Mchuchuma"

2. Liganga Iron Ore

2.1 General Aspects

2.2 Iron Ore Mine

2.3 Iron Ore Beneficiation Plant

2.4 Pelletizing Plant

2.5 Offsites and Auxiliaries "Liganga"

LURGI

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2. General Layout and Capacity Expansion Concept

3. Direct Reduction Plant

4. Electric Smelting Plant

5. Ladle Furnace Plant

6. Continuous Casting Plant

7. Rolling Mill and Product Finishing

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VOLUME IV General Area Infrastructure and Project Implementation

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1.1 Railway System

1.2 Road Connections

1.3 Electric Power Grid

1.4 Communication System

2. Power Plant Mchuchuma

3. Townships

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5. Time Schedules

LURGI

VOLUME V Economic Evaluation

0 Executive Summary

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2. Investment Cost Compilation

3. Working Capital Requirements

4. Production Cost Compilation

5. Estimation of Annual Revenues

6. Economic Evaluation of the Total Project

VOLUME VI Drawings I

VOLUME VII Drawings II

LURGI

2. LIGANGA IRON ORE

2.2 Iron Ore Mine

LOA 00 2238 00006	-Topographic Map with Location of Sections, scale 1 : 1000
L2A 00 2238 00007	-Section 1 - 3, scale 1 : 2 000
L2A 00 2238 00008	-Section 4 - 5, scale 1 : 2 000
L2A 00 2238 00009	-Section 6 - 7, scale 1 : 2 000
L2A 00 2238 00010	-Section 8 - 9, scale 1 : 2 000
L2A 00 2238 00011	-Section 10 - 11, scale 1 : 2 000
L2A 00 2238 00012	-Section 12 - 13, scale 1 : 2 000
L2A 00 2238 00013	-Section 14, scale 1 : 2 000
L2A 00 2238 00014	-Section 15, scale 1 : 2 000
L2A 00 2238 00015	-General Plot Plan, scale 1 : 5 000
LOA 00 2238 00016	-Mine Configuration End Year 5 (1662.5), scale 1 : 1 000
LOA 00 2238 00017	-Mine Configuration End Year 10 (1600), scale 1 : 1 000
LOA 00 2238 00018	-Mine Configuration End Year 15 (1562.5), scale 1 : 1 000
LOA 00 2238 00019	-Mine Configuration End Year 19 (1525), scale 1 : 1 000

2.3 Iron Ore Beneficiation

L2A 01 2238 00010	-Iron Ore Beneficiation and Pelletizing Plant Liganga Topographical Map, scale 1 : 25 000
L2A 01 2238 00001	-Iron Ore Beneficiation Plant Liganga 1,6 Mio t/a Ore Feed Block Diagram (1st stage)
L2A 01 2238 00002	-Iron Ore Beneficiation Plant Liganga 3,2 Mio t/a Ore Feed Block Diagram (2nd stage)
L3A 01 2238 00006	-Limestone and Bentonite Handling Liganga Block Diagram (1st and 2nd stage)
LOA 02 2238 00004	-Beneficiation and Pelletizing Plant Liganga Key Plan, scale 1 : 2000
L1A 01 2238 00003	-Crusher and Ore Storage Liganga Plot Plan, scale 1 : 500
LOA 02 2238 00003	-Beneficiation and Pelletizing Plant Liganga Plot Plan, scale 1 : 500

2.4 Pelletizing Plant

L3A 02 2238 00001	-Iron Ore Pelletizing Plant Liganga 0,95 Mio t/a Product Block Diagram (1st stage)
L3A 02 2238 00002	-Iron Ore Pelletizing Plant Liganga 1,98 Mio t/a Product Block Diagram (2nd stage)
LOA 02 2238 00004	-Beneficiation and Pelletizing Plant Liganga Key Plan, scale 1 : 2000
LOA 02 2238 00003	-Beneficiation and Pelletizing Plant Liganga Plot Plan, scale 1 : 500

VOLUME III, PLANT DESIGN "STEELWORKS"

2. General Layout

L2A 03 2238 00015 -Steelworks Mahanje
Topographical Map, scale 1 : 25 000

LOA 03 2238 00016 -Steelworks Mahanje
Key Plan, scale 1 : 2000

3. Direct Reduction Plant

L1A 03 2238 00017 -Direct Reduction Plant
660 000 t/a DRI
Block Diagram

LOA 03 2238 00018 -Direct Reduction Plant
Plot Plan, scale 1 : 500

4. Electric Smelting Plant

F3A 03 2238 00020 -Electric Semi Steel Smelting
Main Flowsheet
Slabs (1st stage)

F3A 03 2238 00021 -Electric Semi Steel Smelting
Main Flowsheet
Billets (2nd stage)

FOA 03 2238 00022 -Electric Smelting Plant Sections
Plot Plan, scale 1 : 500

5. Ladle Metallurgy

F3A 03 2238 00023 -Liquid Steel Handling and Ladle
Furnaces
Main Flowsheet
Slabs (1st stage)

F3A 03 2238 00024 -Liquid Steel Handling and Ladle
Furnaces
Main Flowsheet
Billets (2nd stage)

F0A 03 2238 00025 -Ladle Metallurgy Plant and
Steel Transfer Sections
Plot Plan, scale 1 : 500

6. Continuous Casting Plant

F3A 03 2238 00026	-Continuous Casting Plant Main Flowsheet Slabs (1st stage)
F3A 03 2238 00027	-Continuous Casting Plant Main Flowsheet Billets (2nd stage)
F0A 03 2238 00028	-Continuous Casting Plant 1st stage slabs/2nd stage Billets Sections Plot Plan, scale 1 : 500

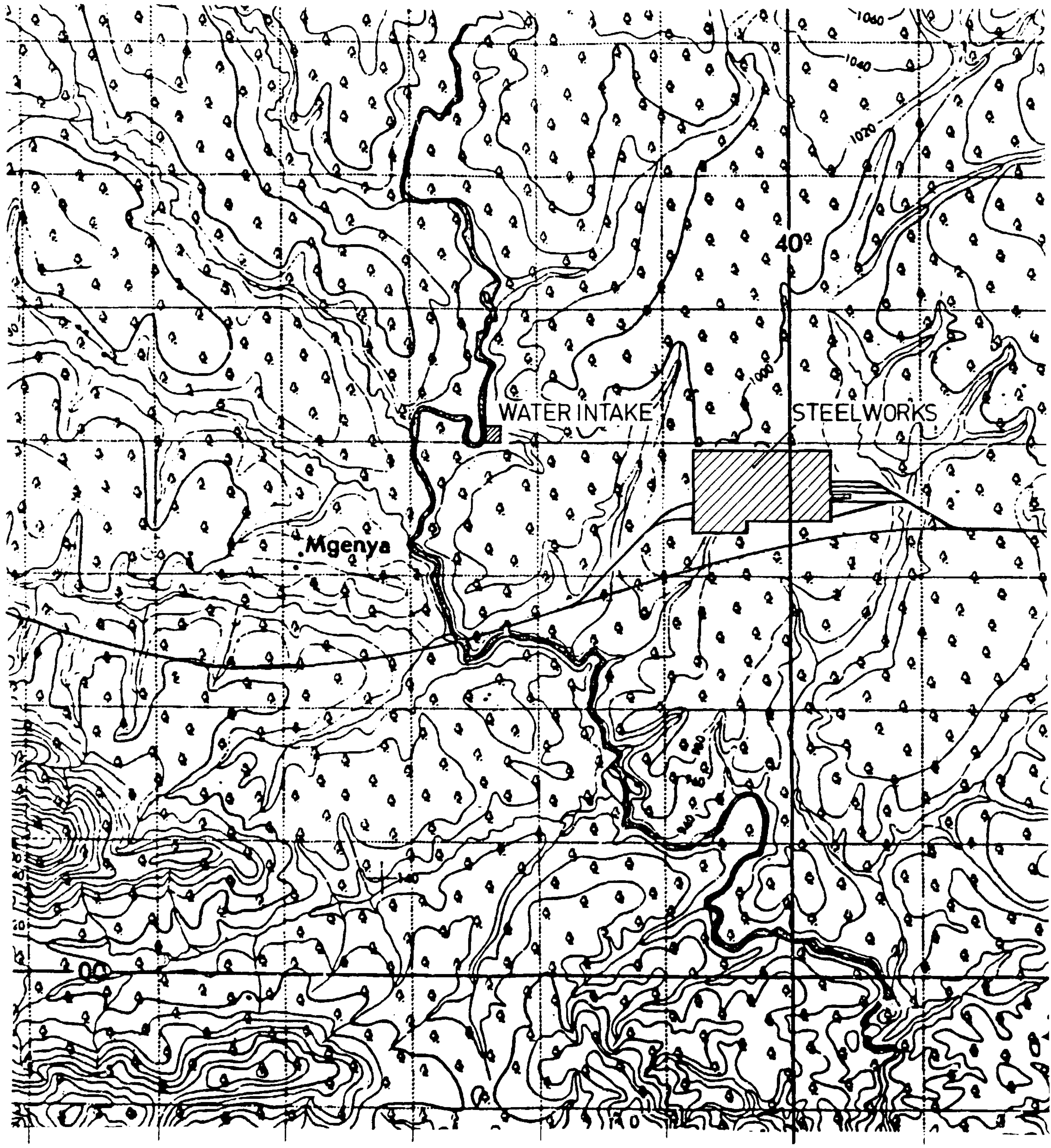
7. Rolling Mill and Product Finishing

F3A 03 2238 00029	-Hot Strip and Plate Mill Main Flowsheet (1st stage)
F3A 03 2238 00030	-Billet and Section Mill Main Flowsheet (2nd stage)
F0A 03 2238 00031	-Rolling Mill Stage I and II, Plot Plan scale 1 : 500

8. Off-sites and Auxiliaries "MAHANJE"

8.1.1 Limestone / Dolomite Facilities

L1A 03 2238 00032	-Limestone/Dolomite Facilities Mahanje Flow Diagram
L3A 03 2238 00033	-Lime Hydrating Plant Mahanje



SECTION 1

NOTE:
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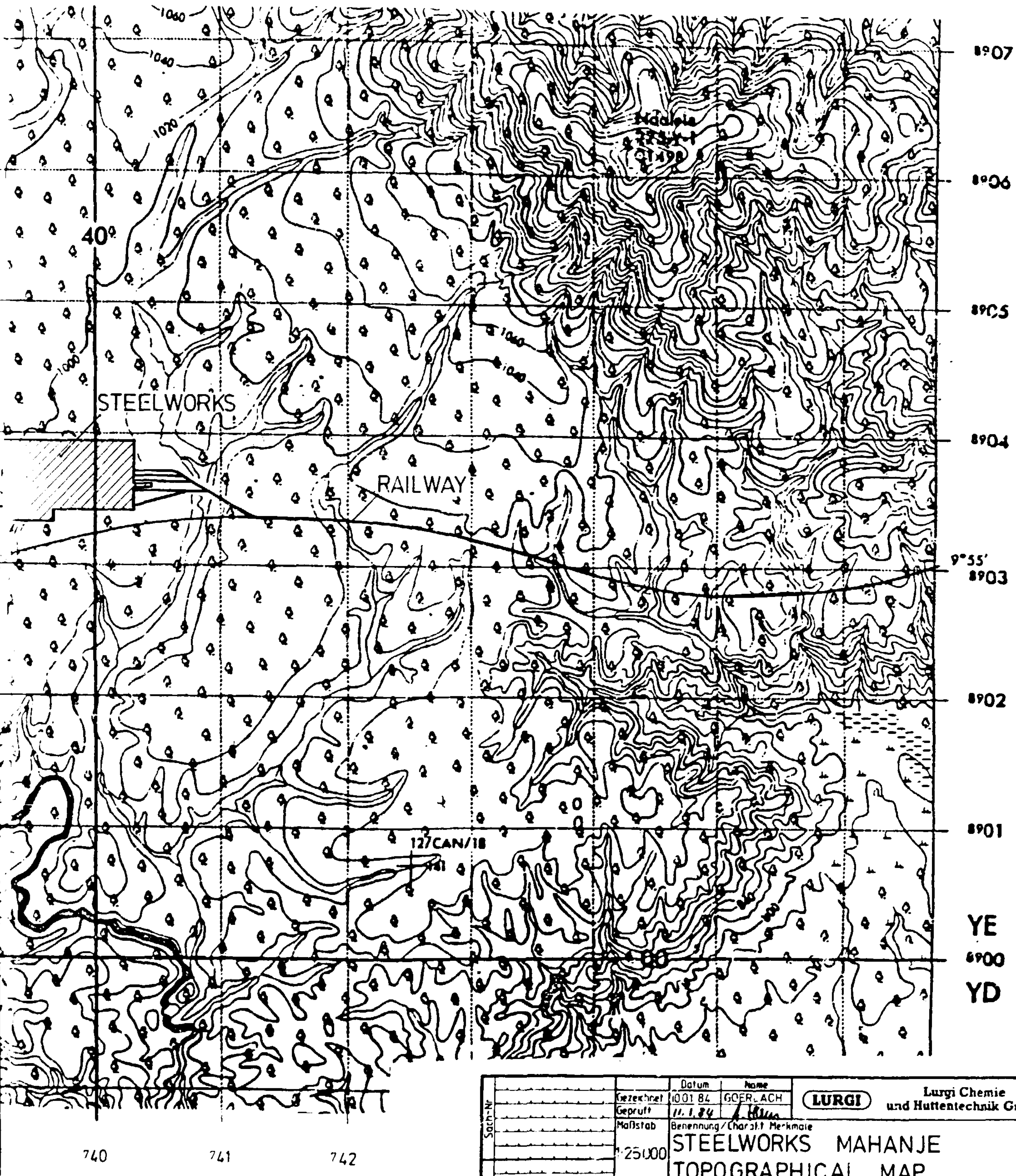
Rev	Datum	Geändert	Geprüft	Art der Änd.



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Geprüft	11.1.84	

LURGI Lurgi Chemie und Huttentechnik GmbH

Maßstab 1:25000

STEELWORKS MAHANJE
TOPOGRAPHICAL MAP

Zeichnungsart 701

Verfahren HRE | Auftrags-/Angebots-Nr 0 3 2 2 3 8 | Kennwort TANZANIA

Zeichnungs-Nr L2A03223800015 | Rev | Entst aus

Originalgröße A2

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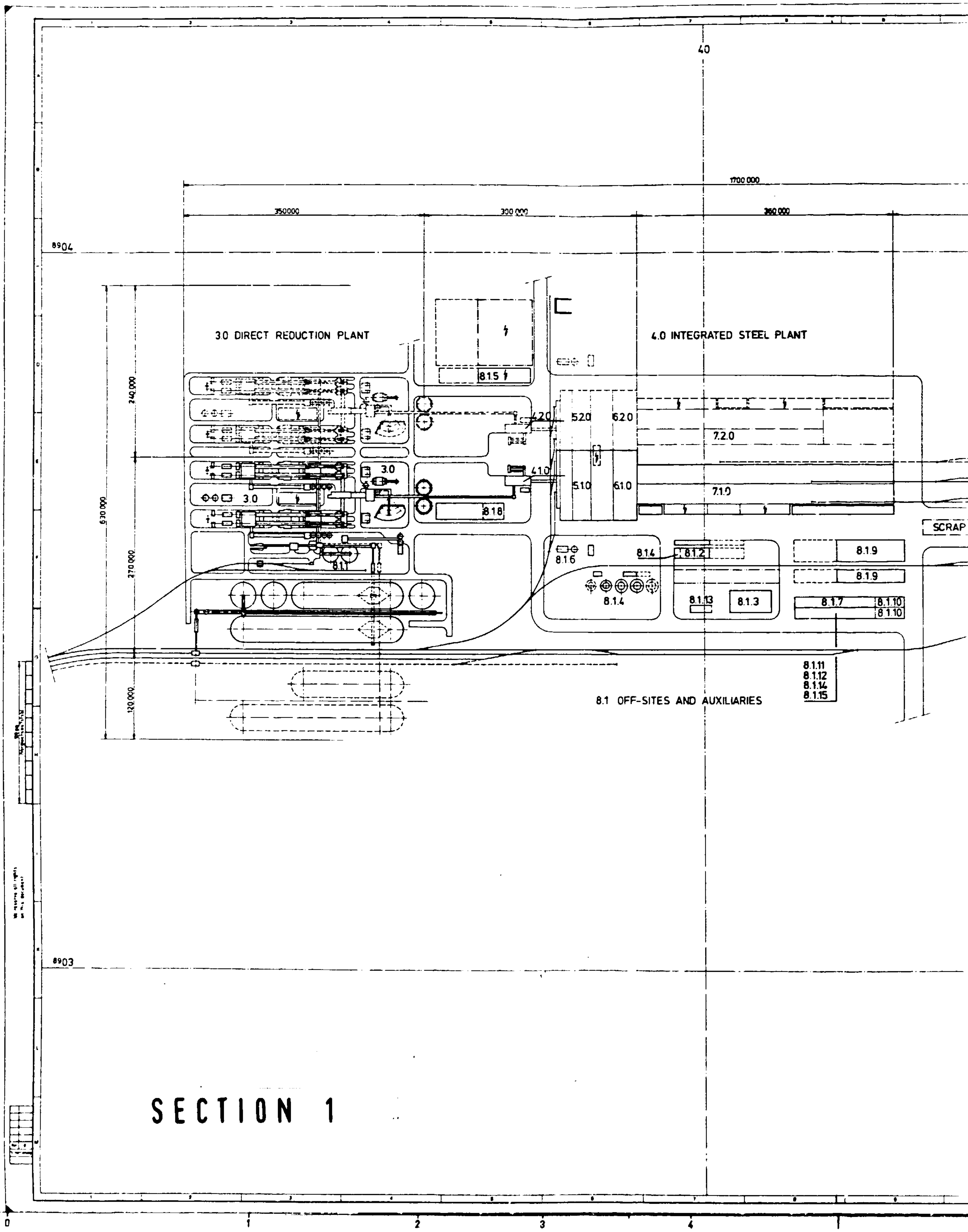

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270 000
120 000
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4.2.0
5.2.0
6.2.0
7.2.0
3.0
4.1.0
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6.1.0
7.1.0
8.1.8
SCRAP
8.1.6
8.1.4
8.1.2
8.1.9
8.1.1
8.1.13
8.1.3
8.1.7
8.1.10
8.1.11
8.1.12
8.1.14
8.1.15
8.1 OFF-SITES AND AUXILIARIES
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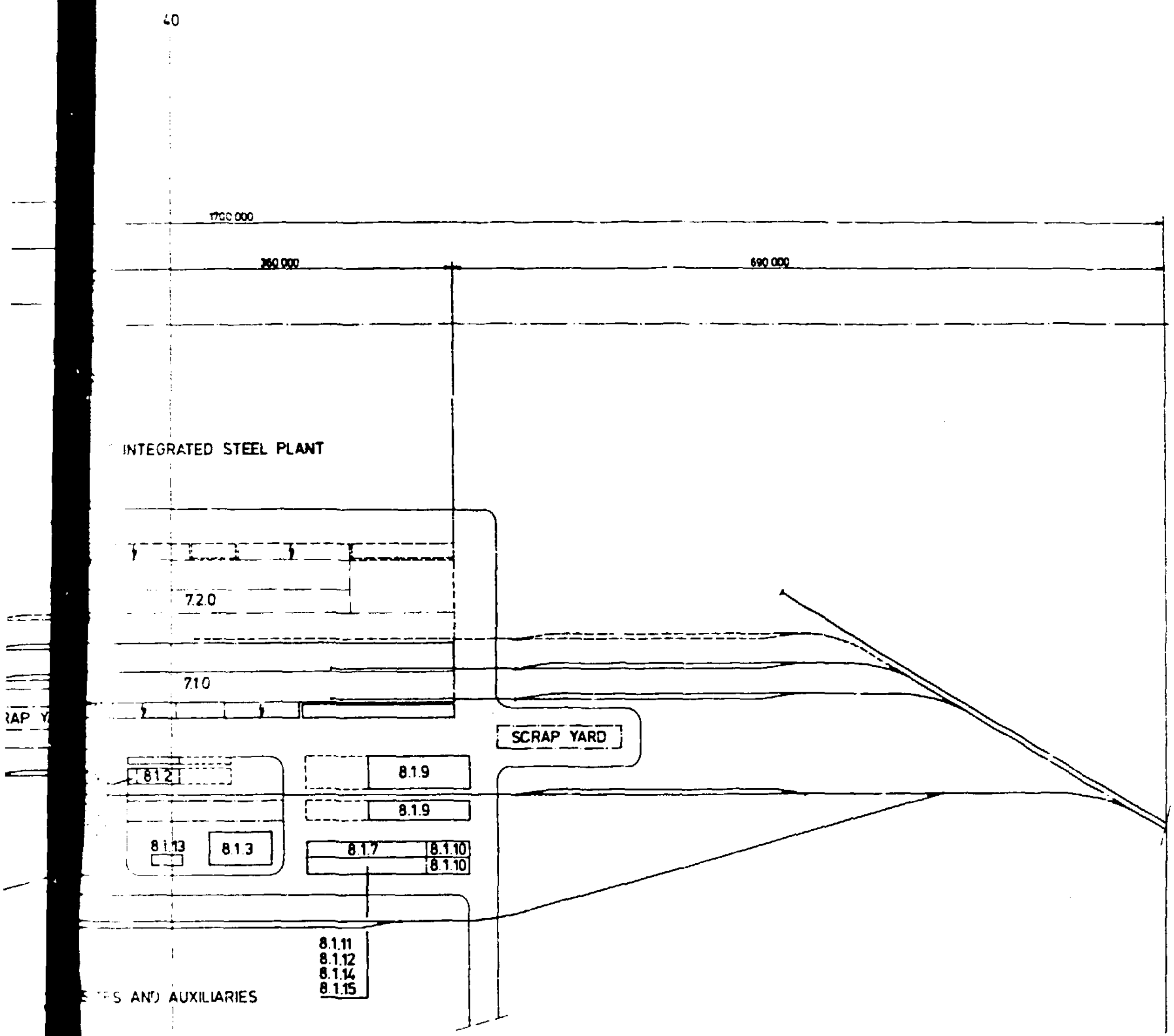
SECTION 1



3.0 DIRECT REDUCTION PLANT

4.0 INTEGRATED STEEL PLANT

4.1.0 ELECTRIC SMELTING PLANT FOR SLABS (1st STAGE)
4.2.0 ELECTRIC SMELTING PLANT FOR BILLETS (2nd STAGE)
5.1.0 LADLE FURNACE PLANT (1st STAGE)
5.2.0 LADLE FURNACE PLANT (2nd STAGE)
6.1.0 CONTINUOUS CASTING PLANT FOR SLABS (1st STAGE)
6.2.0 CONTINUOUS CASTING PLANT FOR BILLETS (2nd STAGE)
7.1.0 HOT STRIP AND PLATE MILL (1st STAGE)
7.2.0 BILLET AND SECTION MILL (2nd STAGE)

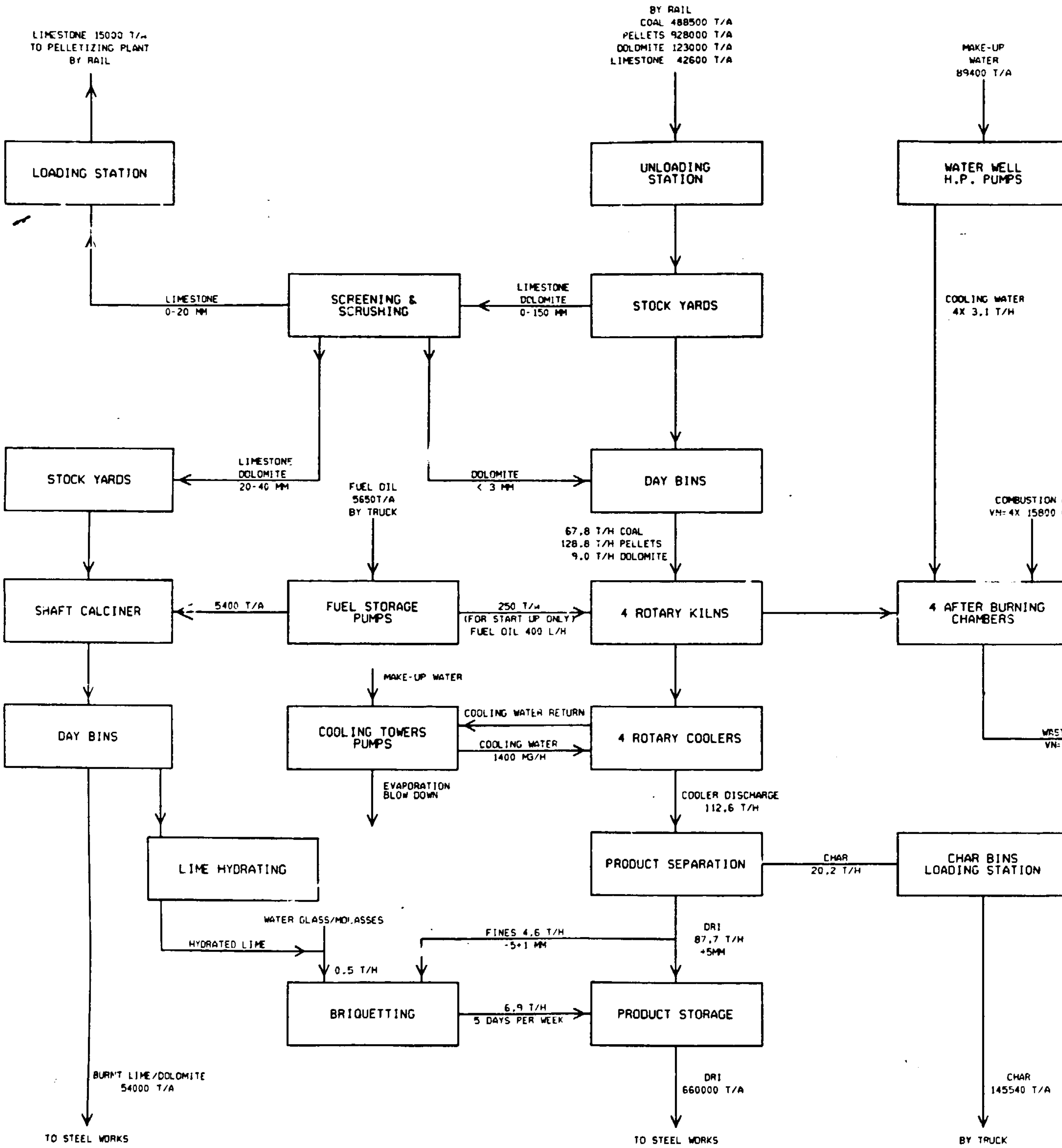
8.1 OFF-SITES AND AUXILIARIES

8.1.1 LIMESTONE / DOLOMITE FACILITIES
8.1.2 WATER SYSTEMS
8.1.3 AIR FRACTIONING PLANT
8.1.4 FUELS AND COMPRESSED AIR
8.1.5 ELECTRIC ENERGY DISTRIBUTION
8.1.6 FUME EXHAUST AND CLEANING
8.1.7 CENTRAL WORKSHOP
8.1.8 CENTRAL LABORATORY
8.1.9 CENTRAL MAGAZINE
8.1.10 FIRE FIGHTING AND AMBULANCE
8.1.11 COMMUNICATION SYSTEM
8.1.12 MOBILE FACILITIES AND FINISHINGS
8.1.13 PETROL STATION
8.1.14 TRAFFIC FACILITIES
8.1.15 MAIN ADMINISTRATION BUILDING

SECTION 2

NOTE:
2nd STAGE IS SHOWN IN DOTTED LINES

1:2000
STEELWORKS MAHANJE
KEY PLAN
DIN
TANZANIA
LCA03223800016



SECTION 1

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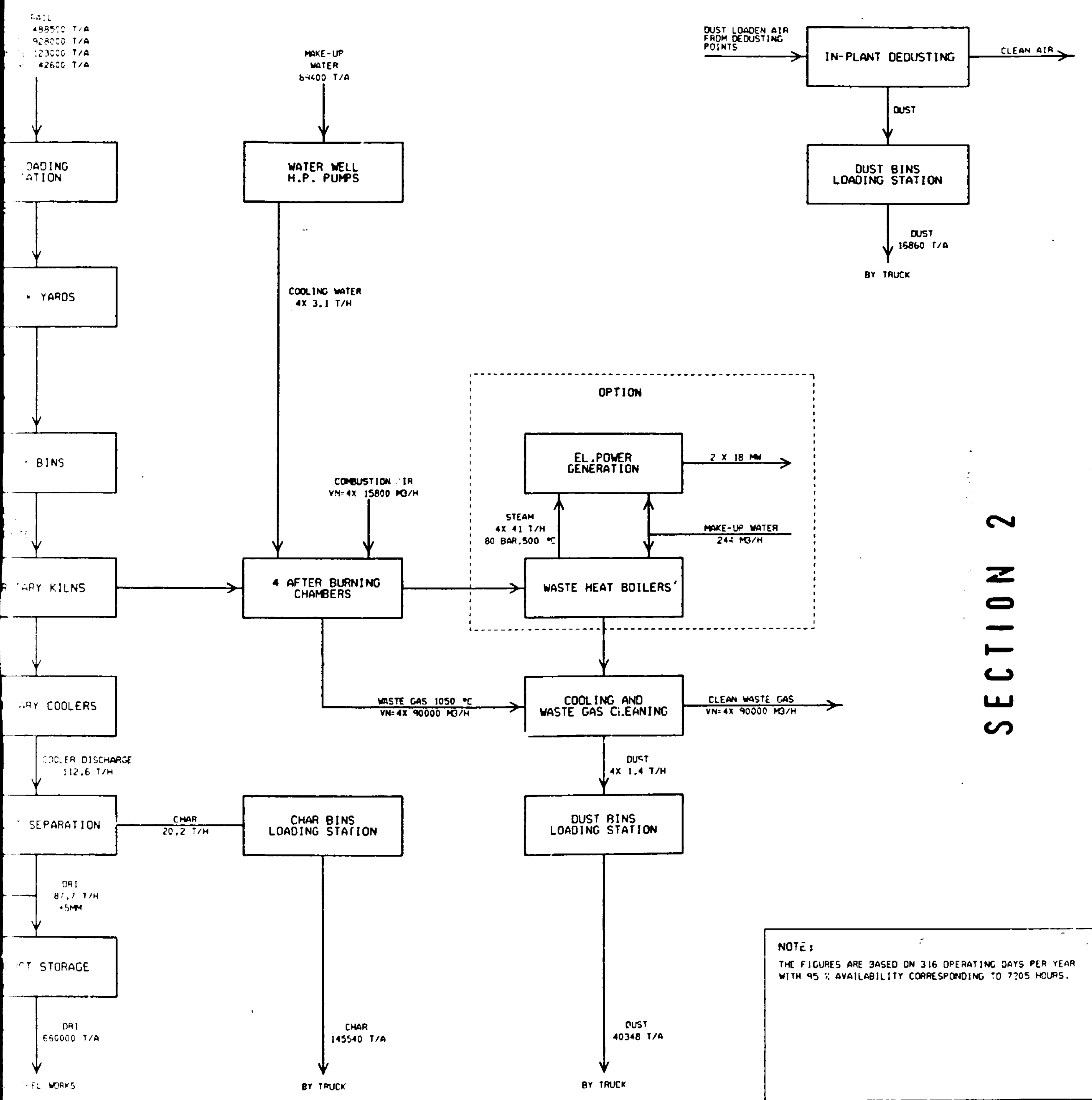


SECTION 2

NOTE:

THE FIGURES ARE BASED ON 316 OPERATING DAYS PER YEAR WITH 95 % AVAILABILITY CORRESPONDING TO 7205 HOURS.

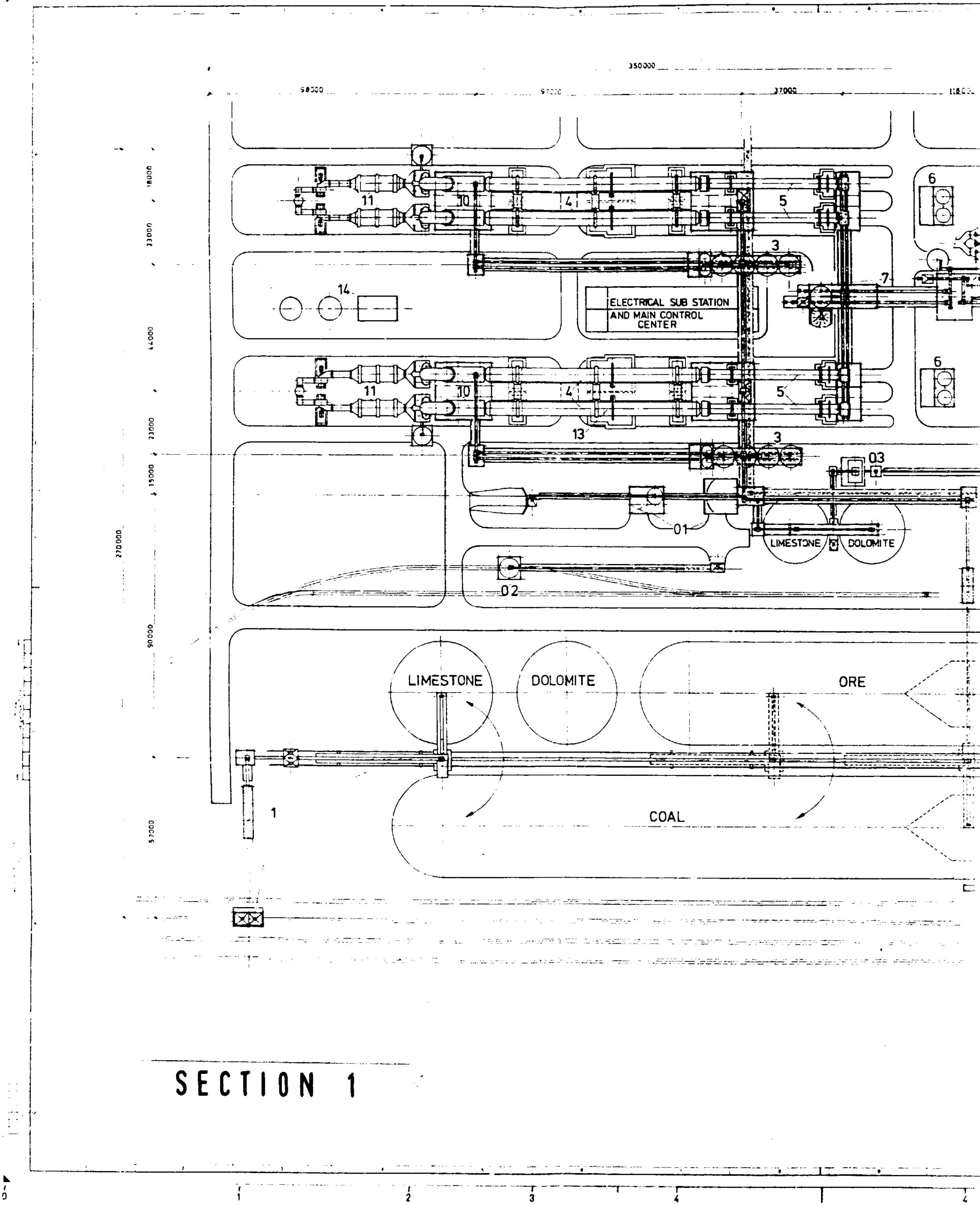
LURGI — Lurgi Chemie und Huettentechnik GmbH

SL/RN DIRECT REDUCTION PLANT
660000 T/A DRI
BLOCK DIAGRAM

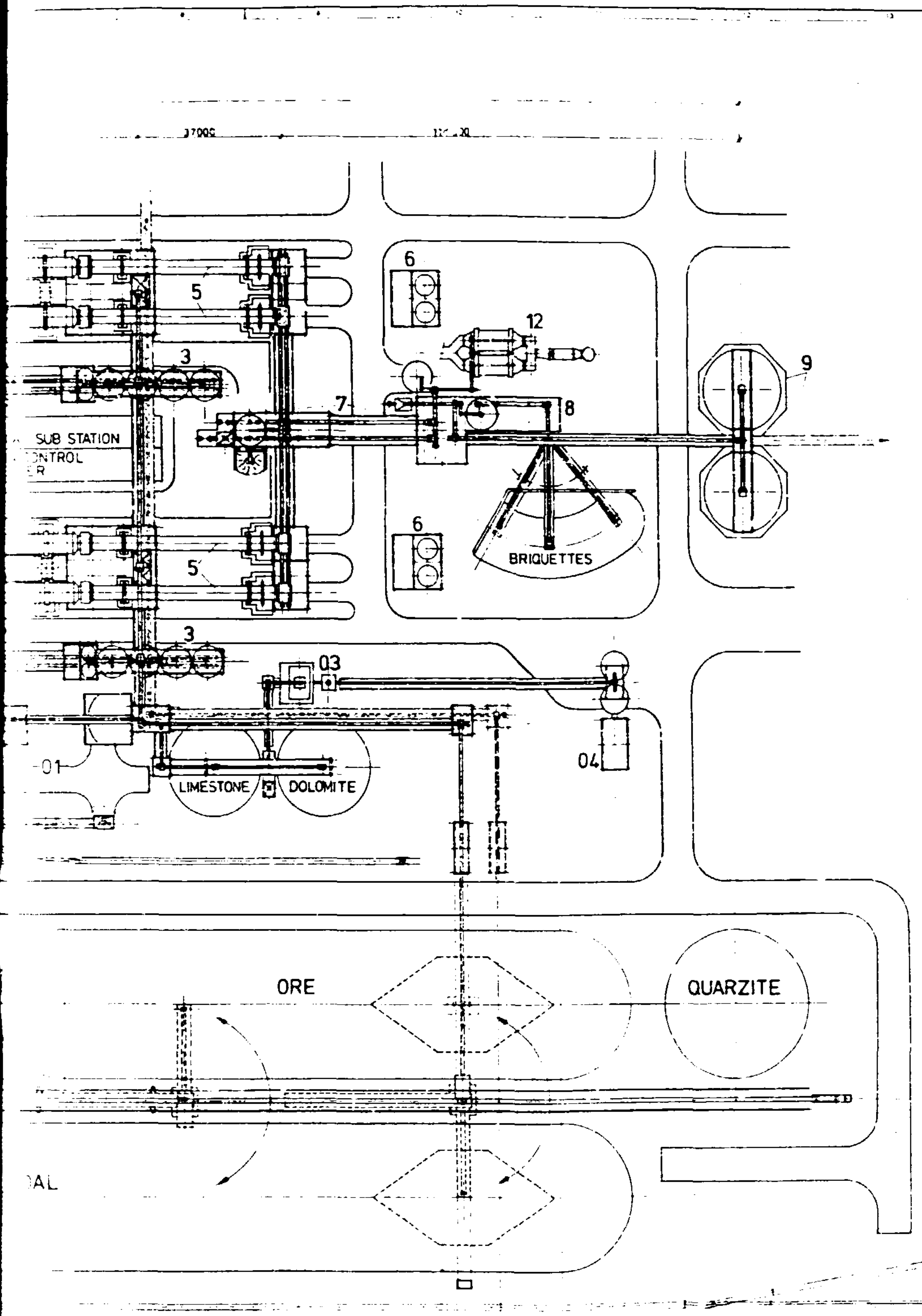
DIN — Drawing type: 202

HRE — 032238 — TANZANIA

1A032238000 17


350000
6
14
ELECTRICAL SUB STATION
AND MAIN CONTROL CENTER
11
10
4
5
3
7
13
03
01
02
LIMESTONE
DOLOMITE
ORE
COAL
1

SECTION 1



30 DIRECT REDUCTION PLANT
PLANT SECTIONS:

.1 RAW MATERIALS UNLOADING, STORAGE AND HANDLING
.2
.3 RAW MATERIALS BINS, METERING AND HANDLING TO THE ROTARY REDUCTION KILNS
.4 ROTARY REDUCTION KILNS AND AUXILIARY EQUIPMENT
.5 ROTARY COOLERS AND AUXILIARY EQUIPMENT
.6 COOLING WATER SYSTEMS FOR ROTARY COOLERS
.7 PRODUCT SEPARATION SYSTEMS AND INTERMEDIATE STORAGE FACILITIES
.8 PRODUCT FINES BRIQUETTING
.9 PRODUCT STORAGE
.10 WASTE GAS AFTERBURNING SYSTEMS
.11 WASTE GAS DEDUSTING SYSTEMS
.12 PLANT DEDUSTING SYSTEM
.13 COMPRESSED AIR SYSTEM
.14 PLANT SAFETY SYSTEM

81.1.00 LIMESTONE / DOLOMITE FACILITIES
PLANT SECTIONS:

01 LIMESTONE / DOLOMITE SCREENING, CRUSHING TRANSPORT AND STORAGE
02 LIMESTONE LOADING STATION
03 LIME / DOLOMITE CALCINER, TRANSPORT AND STORAGE
04 LIME HYDRATING PLANT

SECTION 2

LURGI Lurgi Chemie und Hüttentechnik GmbH
1:500 SL/RN DIRECT REDUCTION PLANT
PLOT PLAN
TANZANIA
L0A03 2238 00018

This sheet is the cover sheet for all subsequent sheets having the same document number The revision index and a brief description of the revision shall be entered on the cover sheet The last revision index shall be added to the document number on the cover sheet and equally applies to all sheets having that document number On these sheets where no revisions have been made the previous revision index shall be retained

m	Rev	Revised		Checked	Sheet	Kind of Revision
		Name	Date	Name		

Rev	m
S-Verfügung	

	Date	Name	LURGI — Lurgi Chemie und Hüttentechnik GmbH
Prepared	6.1.84	Goel	
Checked			
Scale	Title/Characteristic Features: ELECTRIC SEMI STEEL SMELTING MAIN FLOWSHEET SLABS 1st STAGE		
Standard: DIN	Document Type: 705		
Process: HRE	Job or Project No.: 03 2 2 3 8	Job: TANZANIA	
Document No.: F3A 03 2 2 3 8 000 20	Rev	Based on:	Cover Sheet 0 of Sheet 1 to 1

Code No

Item No

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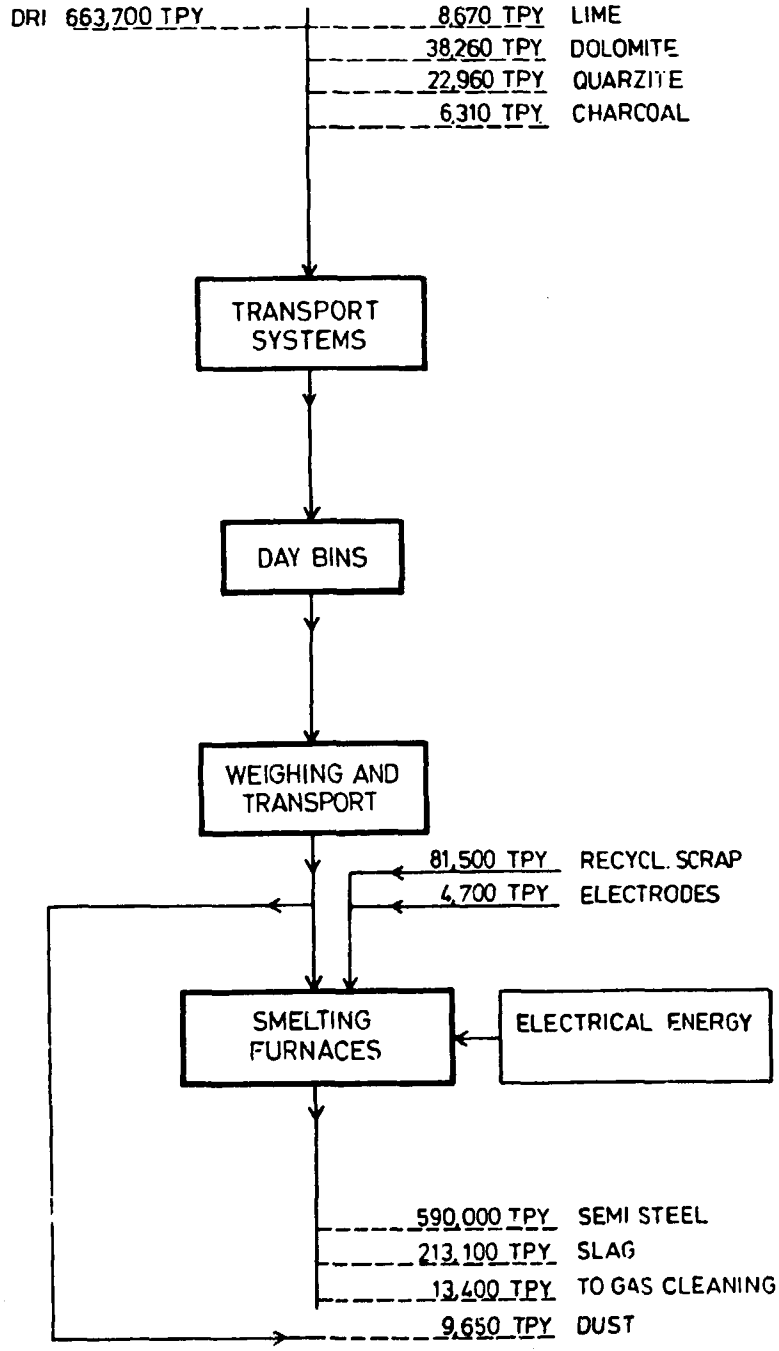

ELECTRIC SEMI STEEL SMELTING
MAIN FLOWSHEET
SLABS (1st STAGE)

F 3A03223800020 LURGI

MANNESMANN DEMAG

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⩩	Rev	Revised		Checked	Sheet	Kind of Revision
		Name	Date	Name		

Rev | ⩩
S-Verfilmung

Prepared	Date: 6.1.84	Name: Goel	LURGI Lurgi Chemie und Hüttentechnik GmbH
Checked			
Scale	Title/Characteristic Features: ELECTRIC SEMI STEEL SHELTING MAIN FLOWSHEET BILLETS (2nd STAGE)		
Standard: DIN	Document Type: 205		
Process: HRE	Job or Project No: 03 22 38	Job: TANZANIA	
Document No: F 3 A 03 22 38 00 02 1	Rev	Based on: Cover Sheet ∅ of Sheet 1 to 1	

Code No

Item No

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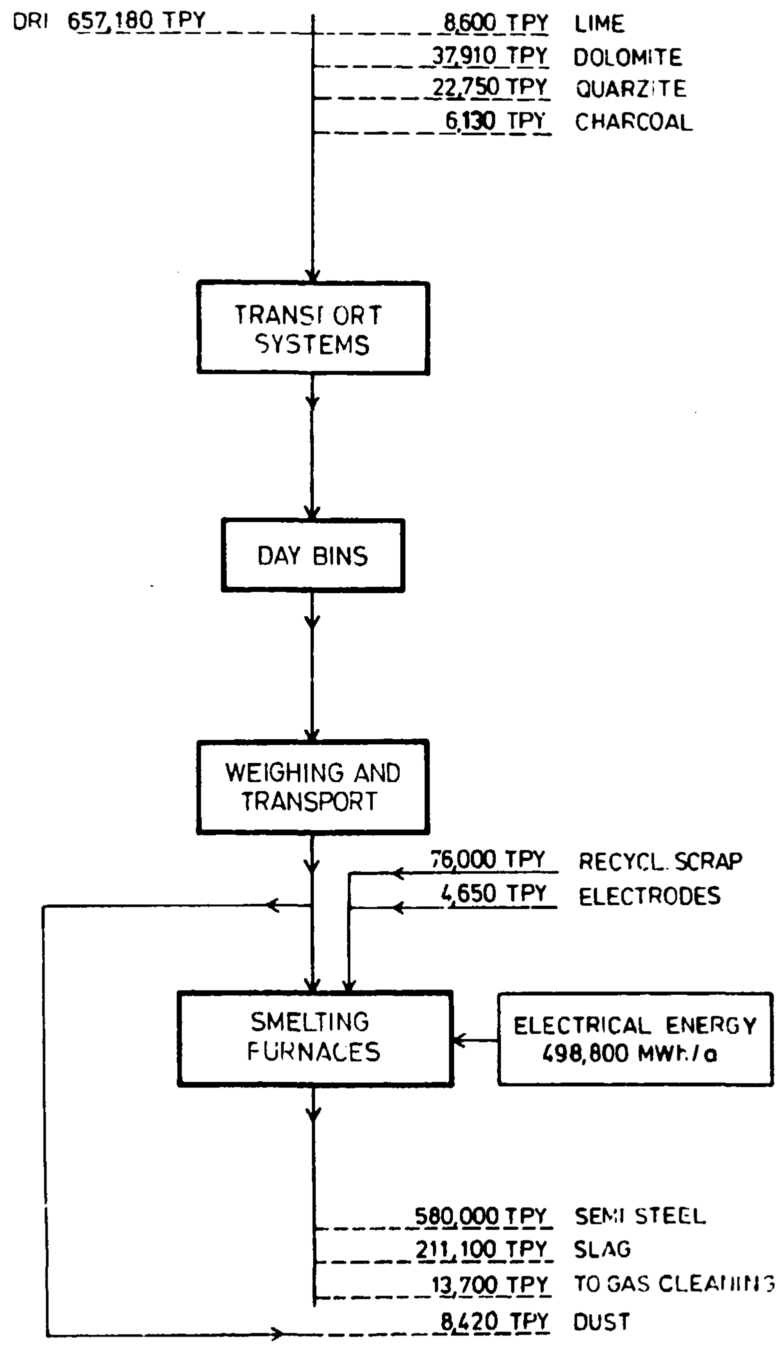
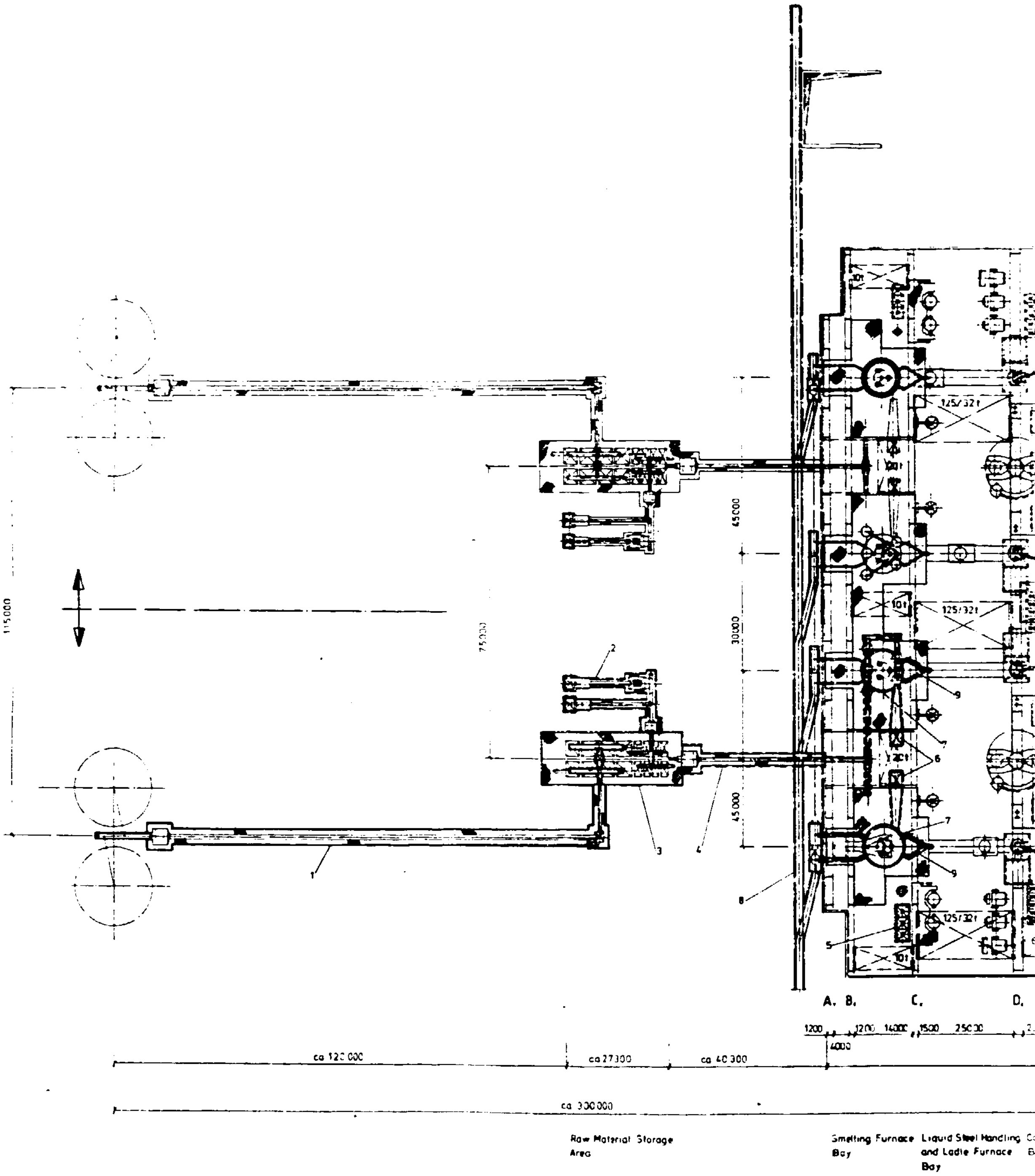


F3A03 223800021 LURGI

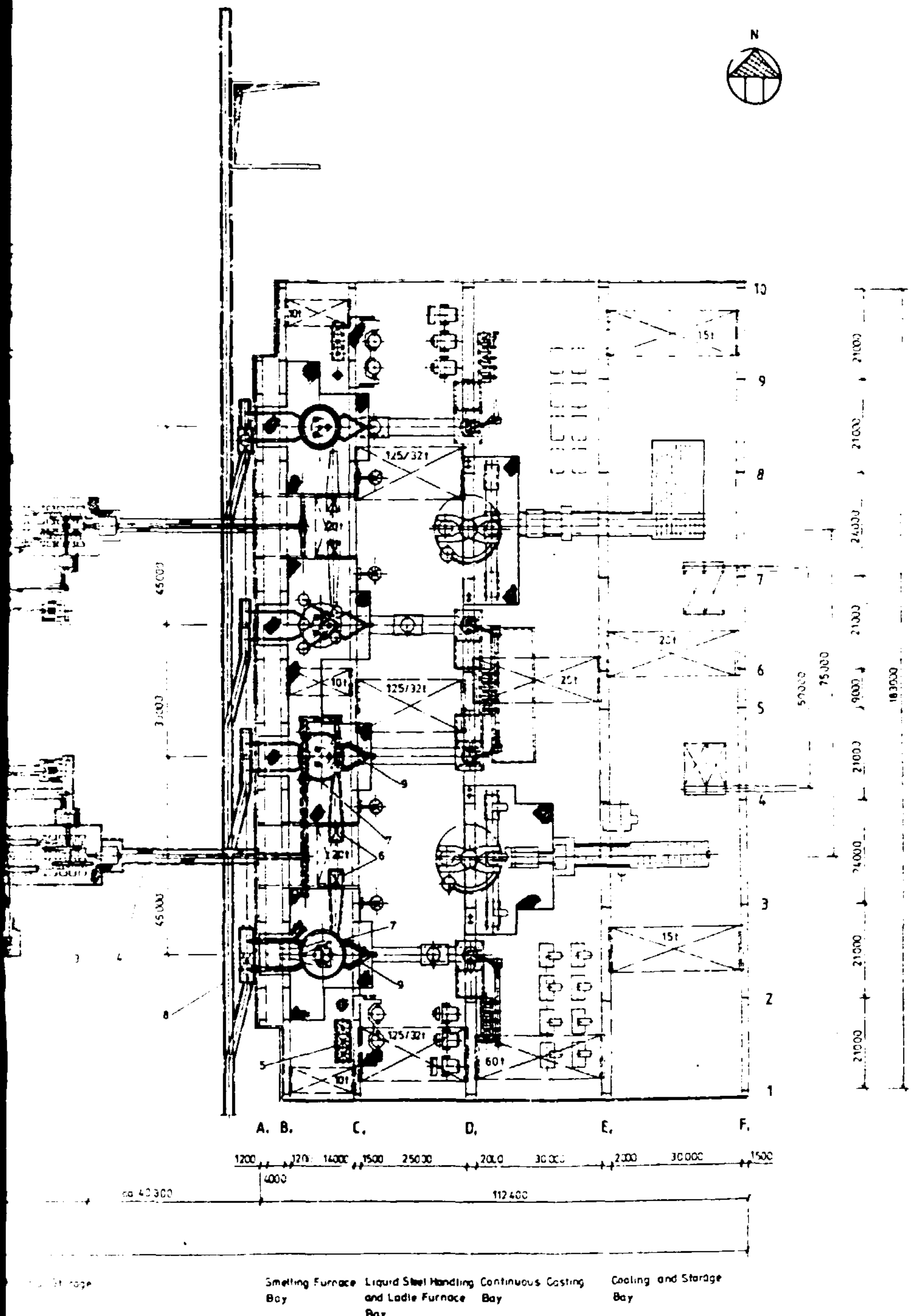
MANNESMANN DEMAG

ELECTRIC SEMI STEEL SMELTING
MAIN FLOWSHEET
BILLETS (2nd STAGE)



1 DRI TRANSFER SYSTEM
2 ADDITIVES AND CHAR COAL RECEIV
TRANSPORT SYSTEM
3 DAY BINS
4 BURDEN WEIGHING AND TRANSFER S
5 CORRECTION MATERIAL STORAGE
6 SCRAP CHARGING SYSTEM
7 SMELTING FURNACES
8 TAPPING AND TRANSFER EQUIPMEN
9 TAPPING EQUIPMENT STEEL

SECTION 1



BILLETS AND SECTIONS
500,000 tpy

2nd STAGE

1st STAGE

PLATES AND SHEETS
500,000 tpy

SECTION 2

1 DRI TRANSFER SYSTEM
2 ADDITIVES AND CHAR COAL RECEIVING AND TRANSPORT SYSTEM
3 DAY BINS
4 BURDEN WEIGHING AND TRANSFER SYSTEM
5 CORRECTION MATERIAL STORAGE
6 SCRAP CHARGING SYSTEM
7 SMELTING FURNACES
8 TAPPING AND TRANSFER EQUIPMENT SLAG
9 TAPPING EQUIPMENT STEEL

6312

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ELECTRIC SMELTING PLANT
SECTIONS
PLOT PLAN
1:500
TANZANIA
F0A03223800022

This sheet is the cover sheet for all subsequent sheets having the same document number. The revision index and a brief description of the revision shall be entered on the cover sheet. The last revision index shall be added to the document number on the cover sheet and equally applies to all sheets having that document number. On those sheets where no revisions have been made the previous revision index shall be retained.

m	Rev.	Revised Name	Revised Date	Checked Name	Sheet	Kind of Revision

Rev.	m
Sivertimung	

	Date	Name	
Prepared	6. 1. 84	Goel	LURGI Lurgi Chemie und Hüttentechnik GmbH
Checked			

Scale

Title / Characteristic Features: LIQUID STEEL HANDLING AND LADLE FURNACES MAIN FLOWSHEET SLABS (1st STAGE)

Standard: DIN

Document Type: 205

Process: HRE

Job or Project No.: 03.22.38

Job: TANZANIA

Document No.: F3A.03.22.38.000.23

Rev:

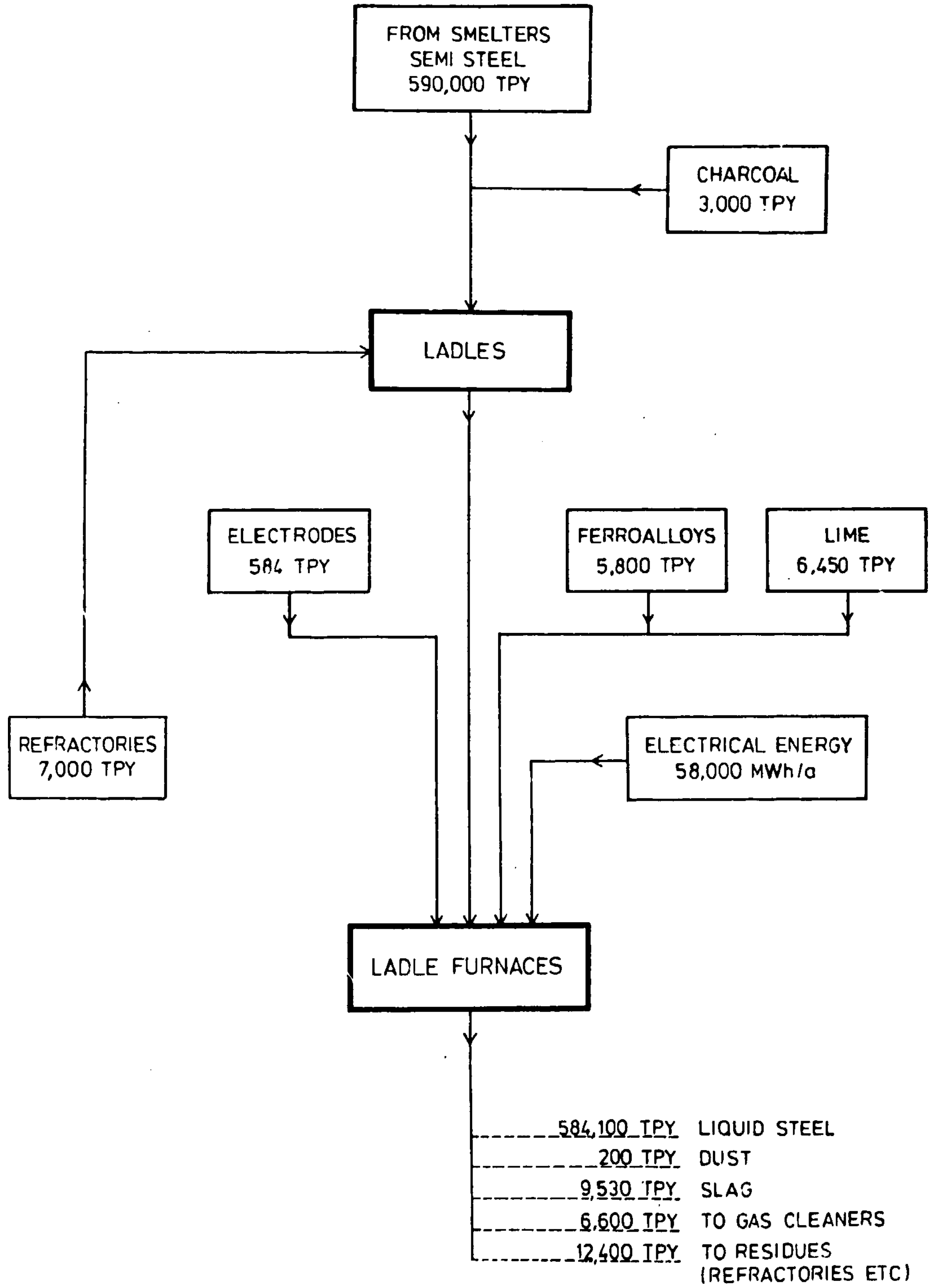
Based on:

Cover Sheet 0 of Sheet 1 to 1

Code No

Item No

3 4 4 3



F3A03 223800023 LURGI

MANNESMANN

LIQUID STEEL HANDLING AND LADLE FURNACES
MAIN FLOWSHEET
SLABS (1st STAGE)

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		Name	Date	Name		

Rev	
S-Verfilmung	

	Date	Name
Prepared	6.1.84	Goel
Checked		

LURGI — Lurgi Chemie und Hüttentechnik GmbH

Scale:

Title / Characteristic Features: LIQUID STEEL HANDLING AND LADLE FURNACES MAIN FLOWSHEET BILLETS (2nd STAGE)

Standard: DIN

Document Type: 205

Process: HRE

Job or Project No: 03 2238

Job: TANZANIA

Document No: F3A 03 2238 00024

Rev:

Based on:

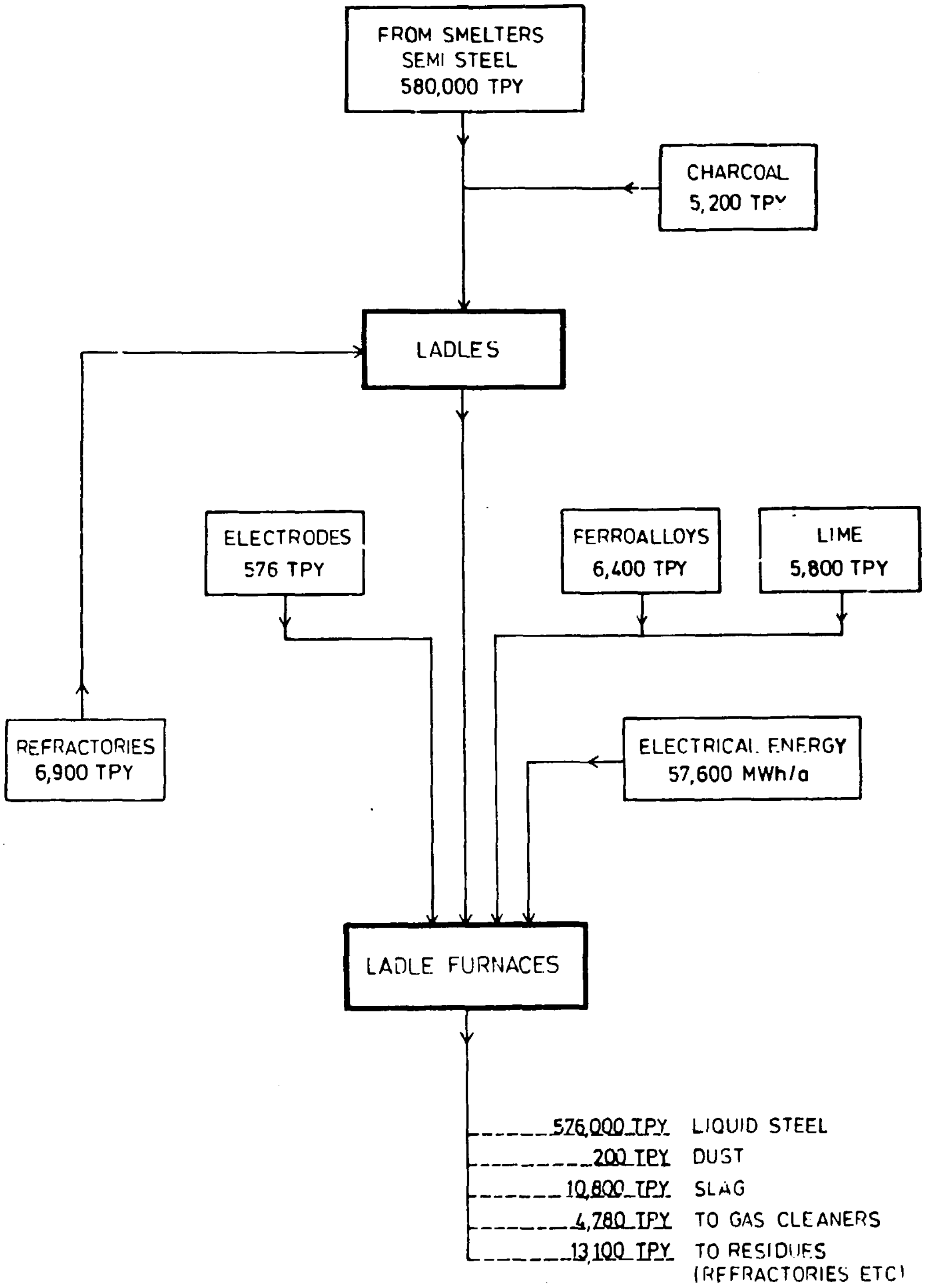
Cover Sheet 0 of Sheet 1 to 1

Code No

Item No

2 328

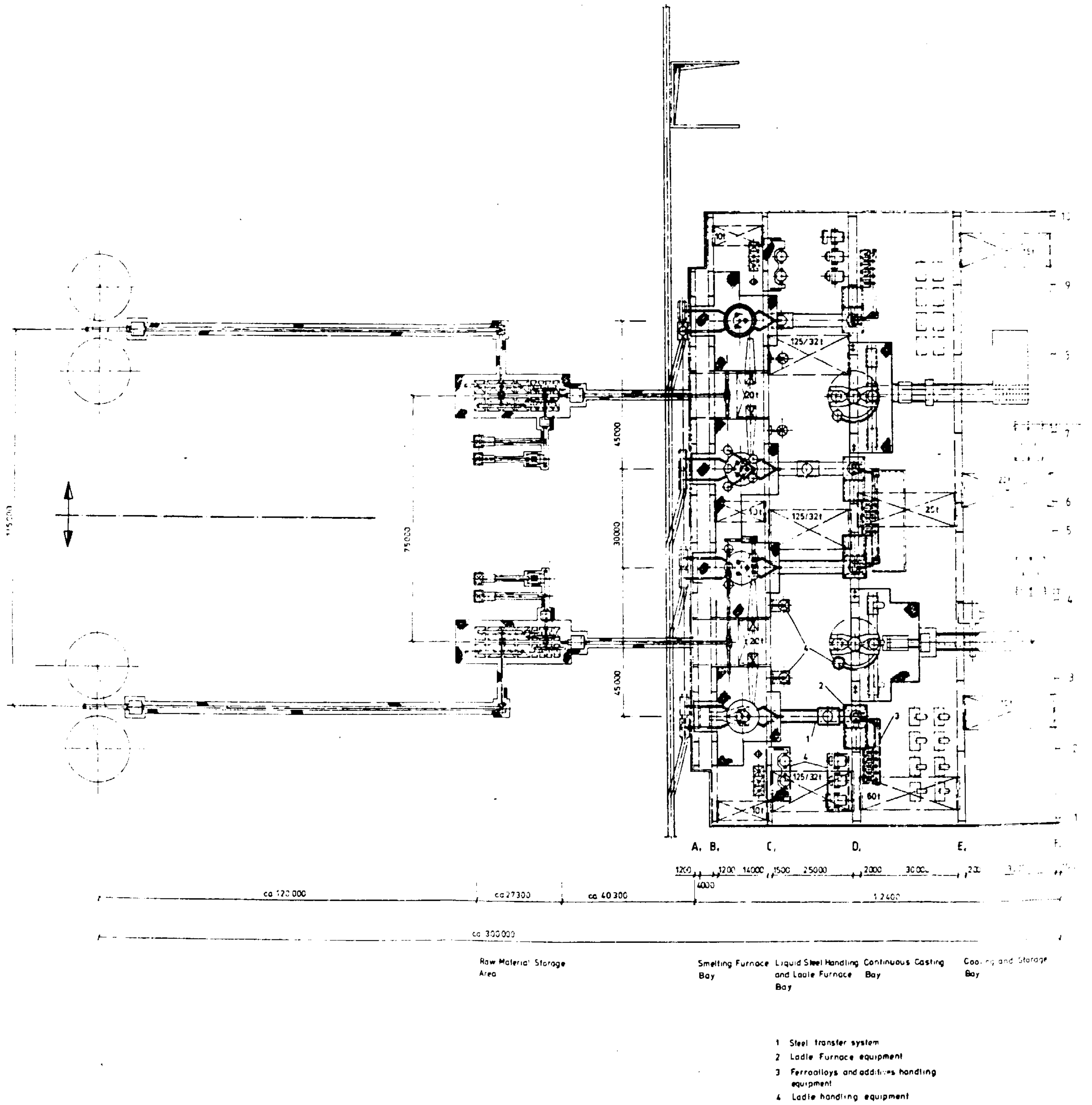
3 4 4 3



LIQUID STEEL HANDLING AND LADLE FURNACES
MAIN FLOWSHEET
BILLETS (2nd STAGE)

F3A03223800024 LURGI

MANNESMANN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B.
C.
D.
E.
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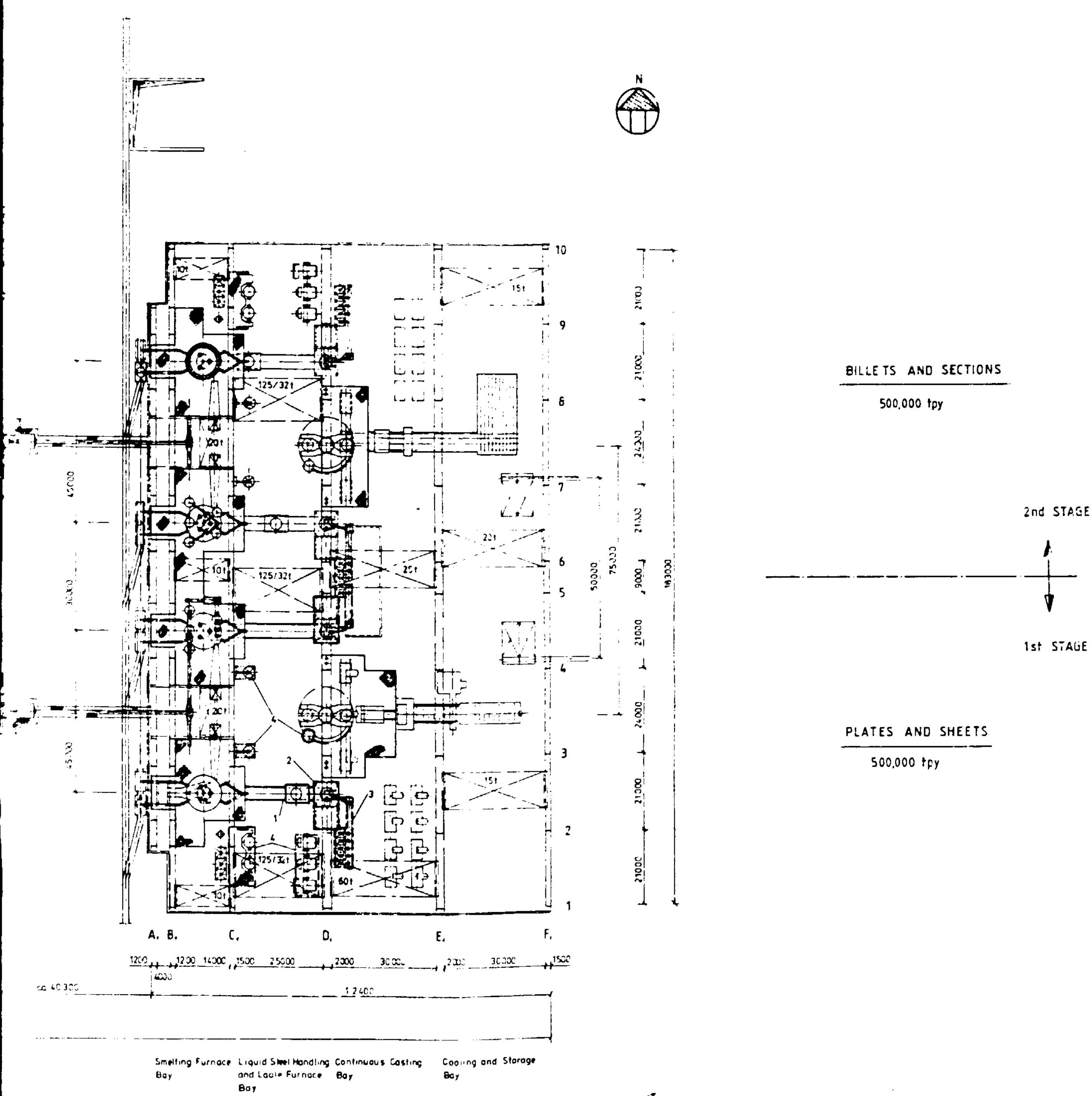
1500
25000
2000
30000
4000
ca 120 000
ca 27300
ca 40 300
ca 300000
Raw Material Storage Area
Smelting Furnace Bay
Liquid Steel Handling and Ladle Furnace Bay
Continuous Casting Bay
Bay
1 Steel transfer system
2 Ladle Furnace equipment
3 Ferroalloys and additives handling equipment
4 Ladle handling equipment

SECTION 1



1 Steel transfer system
2 Ladle Furnace equipment
3 Ferroalloys and additives handling equipment
4 Ladle handling equipment

SECTION 2

MANNESMANN

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LADLE METALLURGY PLANT & STEEL TRANSFER SECTIONS PLOT PLAN

TANZANIA

This sheet is the cover sheet for all subsequent sheets having the same document number The revision index and a brief description of the revision shall be entered on the cover sheet The last revision index shall be added to the document number on the cover sheet and equally applies to all sheets having that document number On those sheets where no revisions have been made the previous revision index shall be retained

⊞	Rev	Revised		Checked	Sheet	Kind of Revision
		Name	Date	Name		

Rev	⊞
Silverfilmung	

	Date	Name	
Preparer	6.1.84	Goel	LURGI Lurgi Chemie und Hüttentechnik GmbH
Checked			
Scale	Title/Characteristic Features: CONTINUOUS CASTING PLANT MAIN FLOWSHEET SLABS (1st STAGE)		
Standard: DIN	Document Type 205		
Process: HRE	Job or Project No. 03.22.38	Job: TANZANIA	
Document No: F3A.03.2238.00026	Rev	Based on	
		Cover Sheet 0 of Sheet 1 to 1	

Code No

Item No

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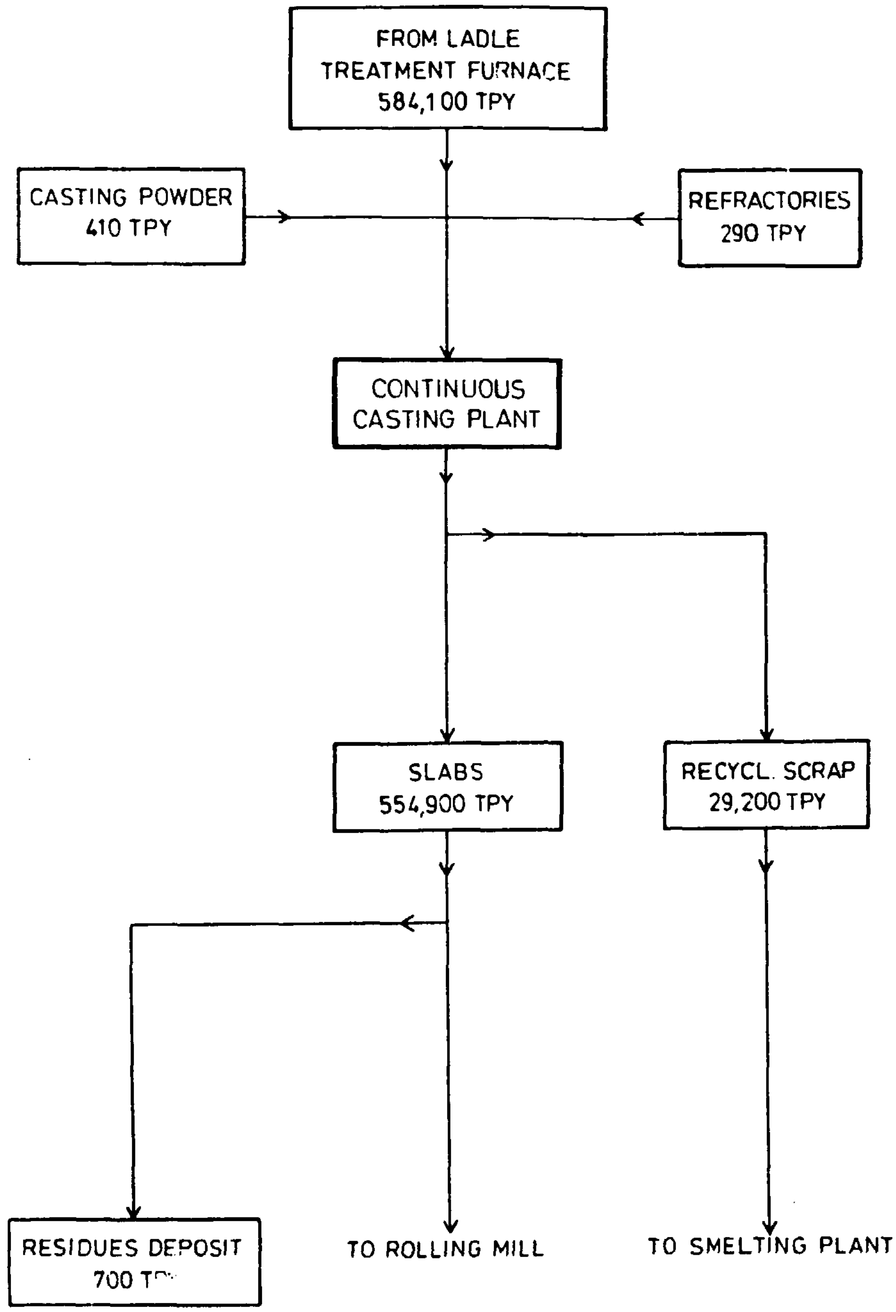

F3A03 223800026 (LURGI)

MANNESMANN
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CONTINUOUS CASTING PLANT
MAIN FLOWSHEET
SLABS (1st STAGE)

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m	Rev	Revised		Checked	Sheet	Kind of Revision
		Name	Date	Name		

Rev	m
S-Verfilmung	

	Date	Name	LURGI Lurgi Chemie und Hüttentechnik GmbH
Prepared	6.1.84	Goel	
Checked			
Scale	Title / Characteristic Features: CONTINUOUS CASTING PLANT MAIN FLOWSHEET BILLETS (2nd STAGE)		
Standard: DIN	Document Type 205		
Process: HRE	Job or Project No: 032238	Job: TANZANIA	
Document No: F3A 032238 00027	Rev	Based on	Cover Sheet 0 of Sheet 1 to 1

Code No

Item No

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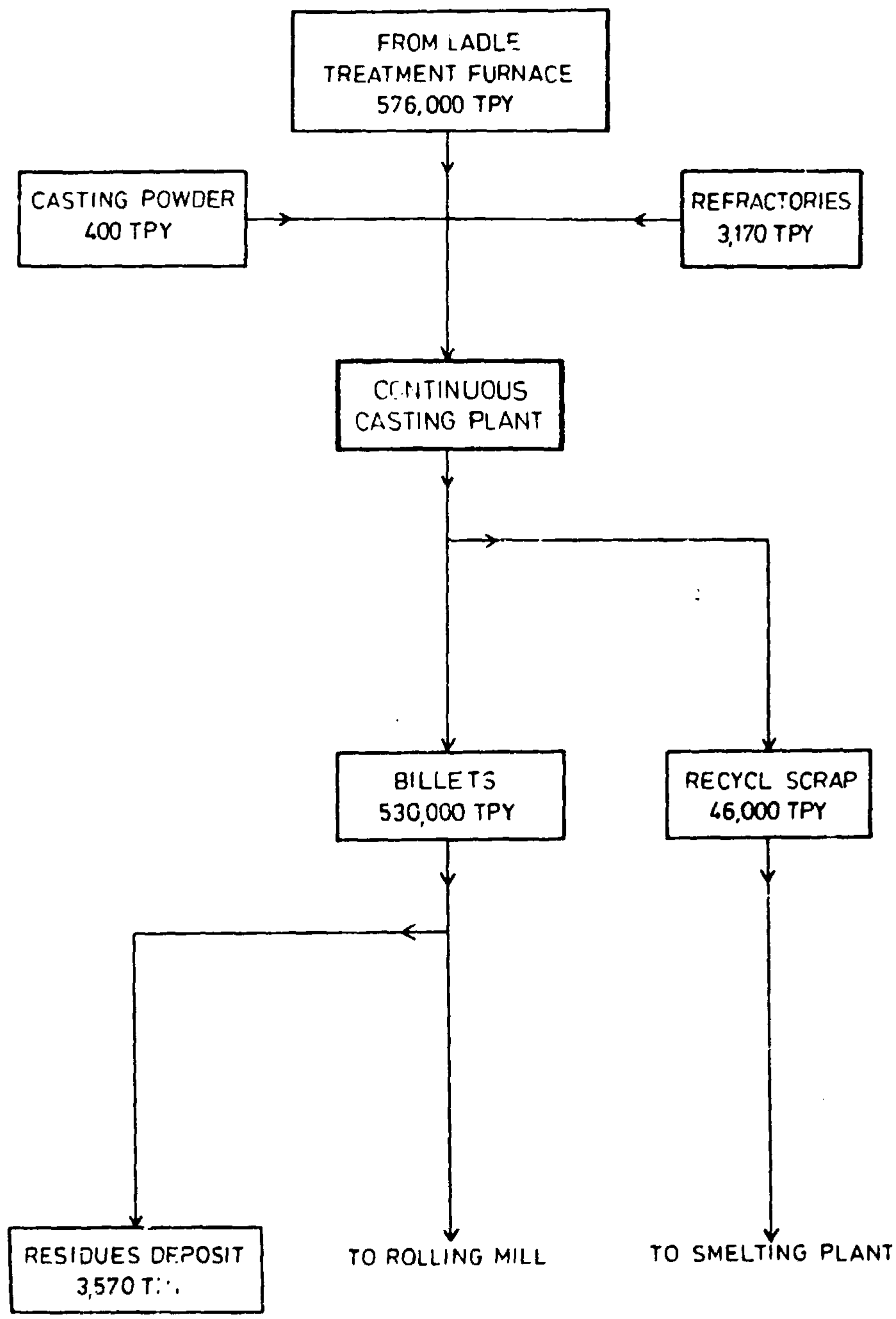

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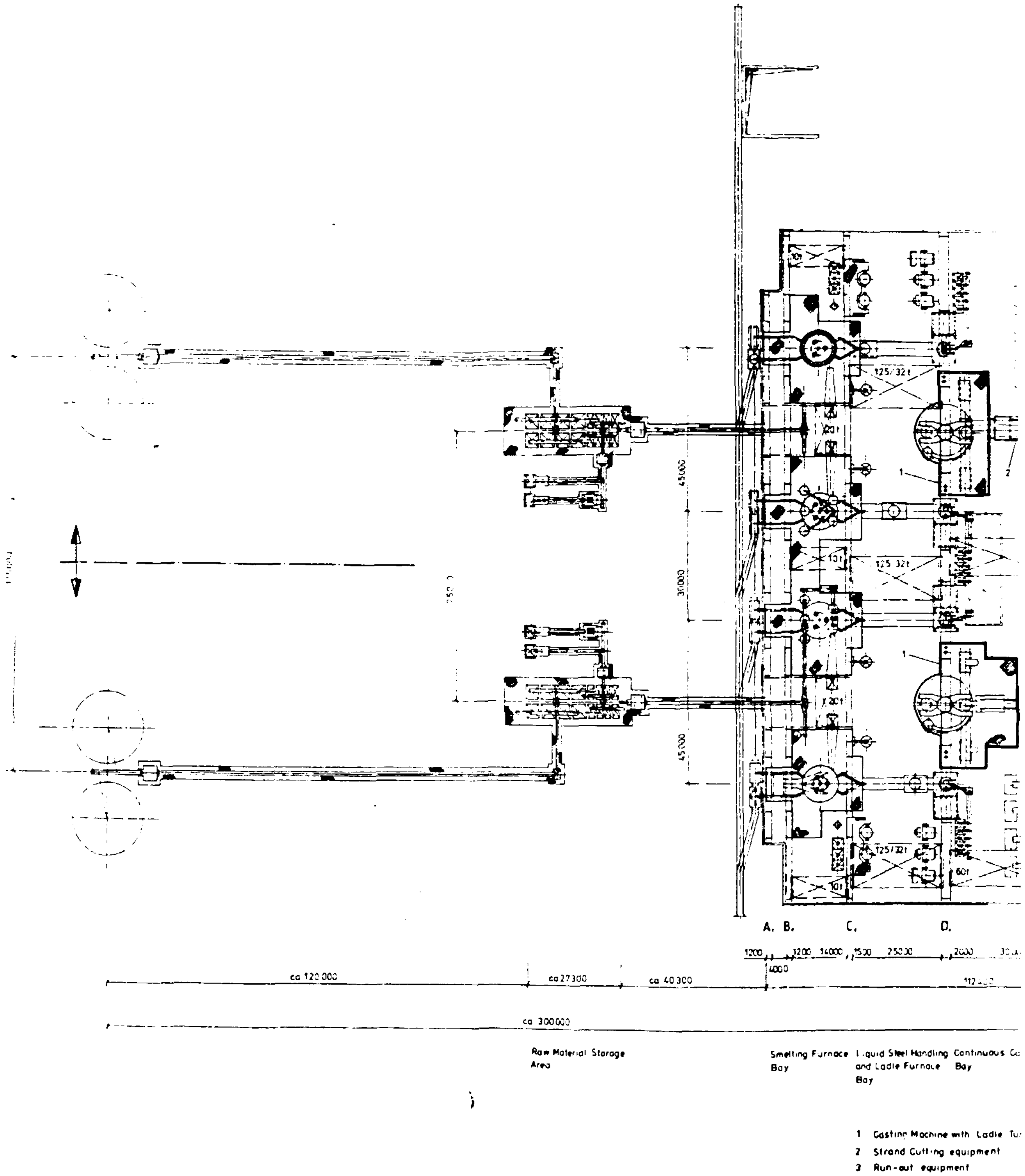
MANNESMANN DEMAG

CONTINUOUS CASTING PLANT
MAIN FLOWSHEET
BILLETS (2nd STAGE)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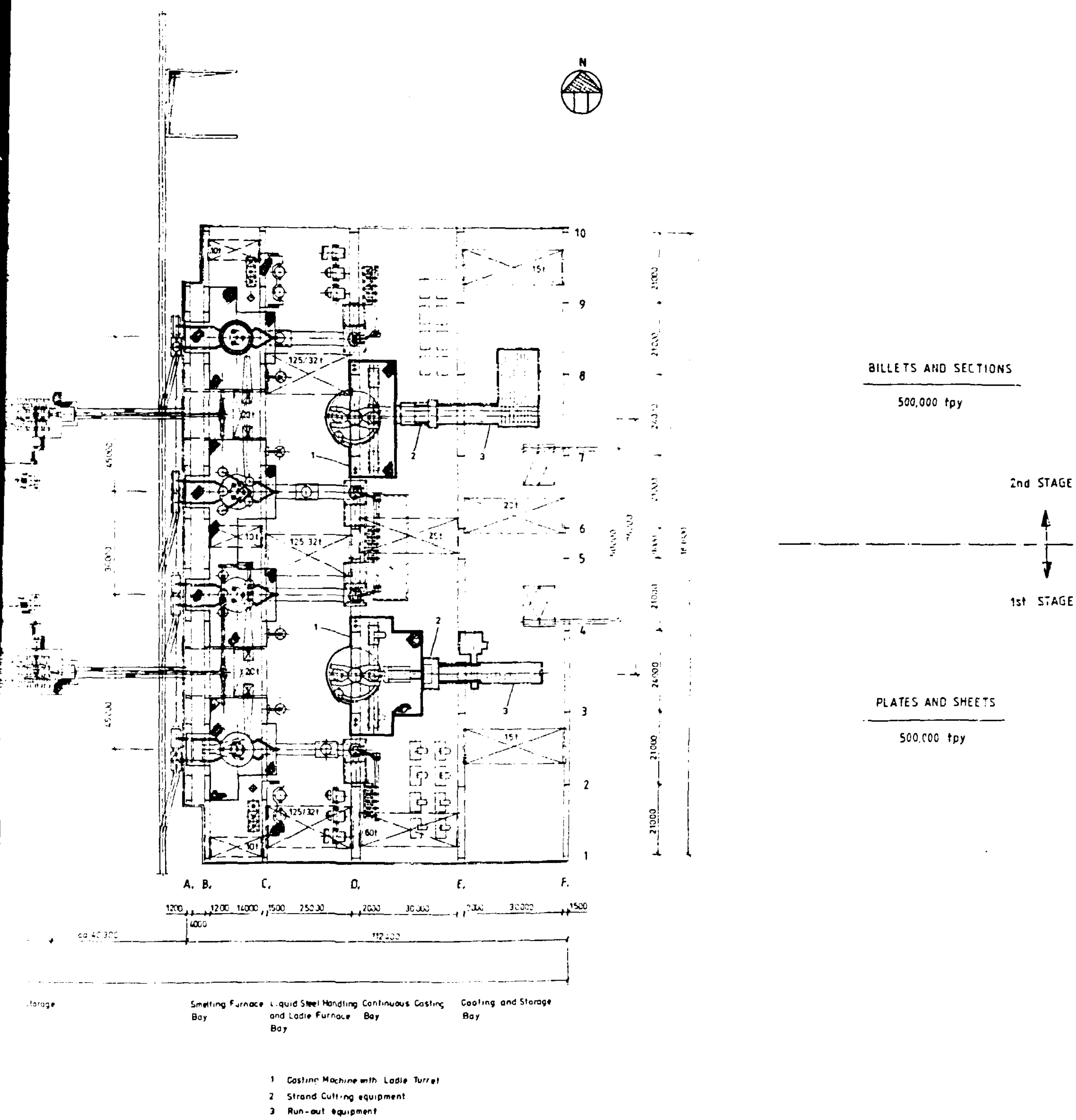
ca 40 300
ca 300000
Raw Material Storage Area
Smelting Furnace Bay
Liquid Steel Handling and Ladle Furnace Bay
1 Casting Machine with Ladle
2 Strand Cutting equipment
3 Run-out equipment

SECTION 1



SECTION 2

6312

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LURGI

CONTINUOUS CASTING PLANT
1st STAGE SLABS, 2nd STAGE BILLETS
SECTIONS, PLOT PLAN

1:500

TANZANIA

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		Name	Date	Name		

Rev	
Gelegenheit	

	Date	Name
Prepared	6.1.84	Goel
Checked		

LURGI Lurgi Chemie und Hüttentechnik GmbH

Scale

Title/Characteristic Features
HOT STRIP AND PLATE MILL
MAIN FLOW SHEET
(1st STAGE)

Standard: DIN

Document Type: 205

Process: HRE

Job or Project No: 03 2238

Job: TANZANIA

Document No: F3A 03 2238 00029

Rev

Based on

Cover Sheet 0 of Sheet 1 to 1

Z 32 E

Code No

Item No

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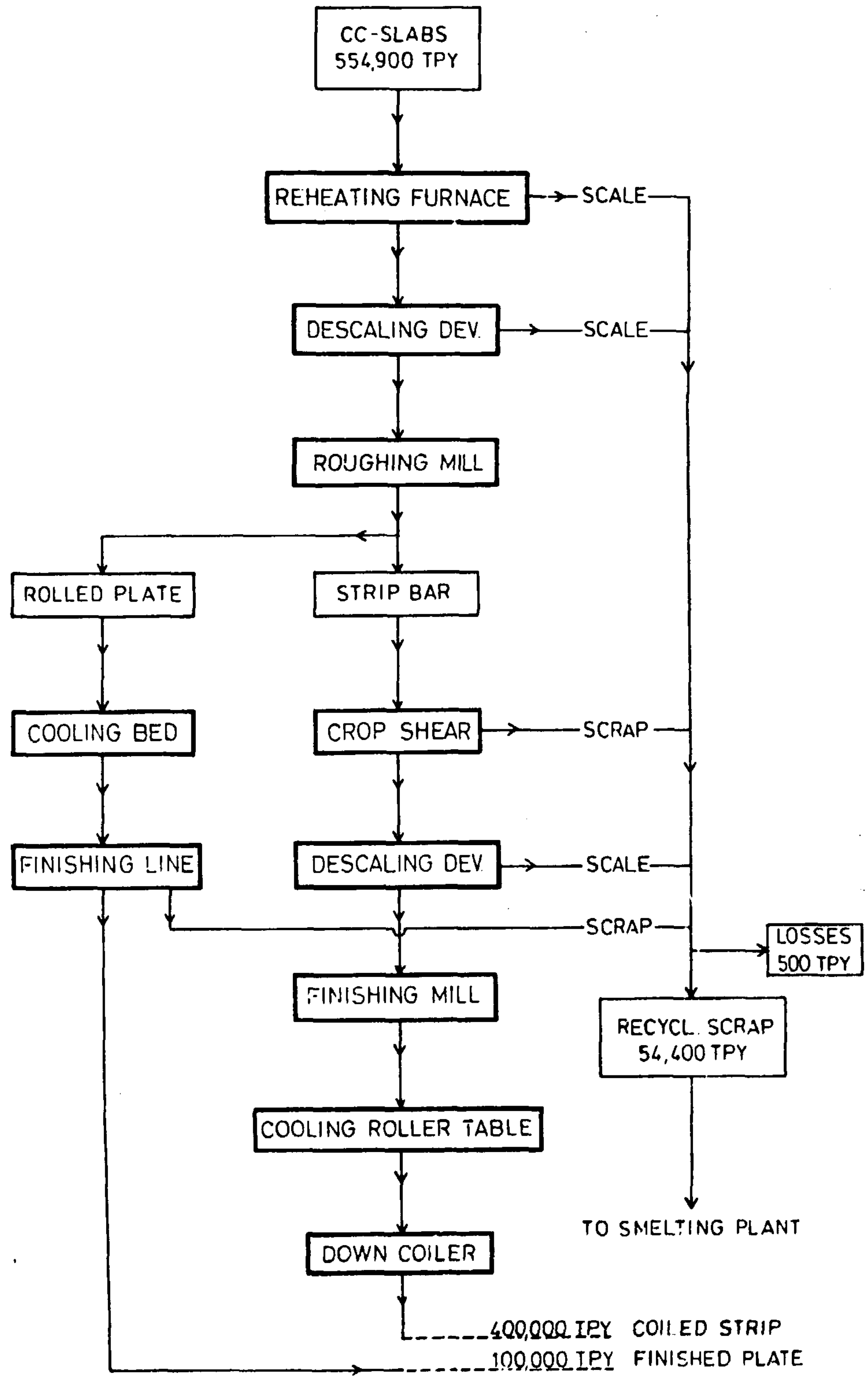

HOT STRIP AND PLATE MILL
MAIN FLOWSHEET
(1st STAGE)

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		Name	Date	Name		

Rev	⩫
S-Vertraulung	

	Date	Name	LURGI — Lurgi Chemie und Hüttentechnik GmbH
Prepared	6.1.84	Guel	
Checked			
Scale	Title/Characteristic Features: BILLET AND SECTION MILL MAIN FLOWSHEET (2nd STAGE)		
Standard: DIN	Document Type 205		
Process: HRE	Job or Project No. 03 22 38	Job: TANZANIA	
Document No.: F3A 03 22 38 00 030	Rev	Based on:	Cover Sheet 0 of Sheet 1 to 1

Code No

Item No

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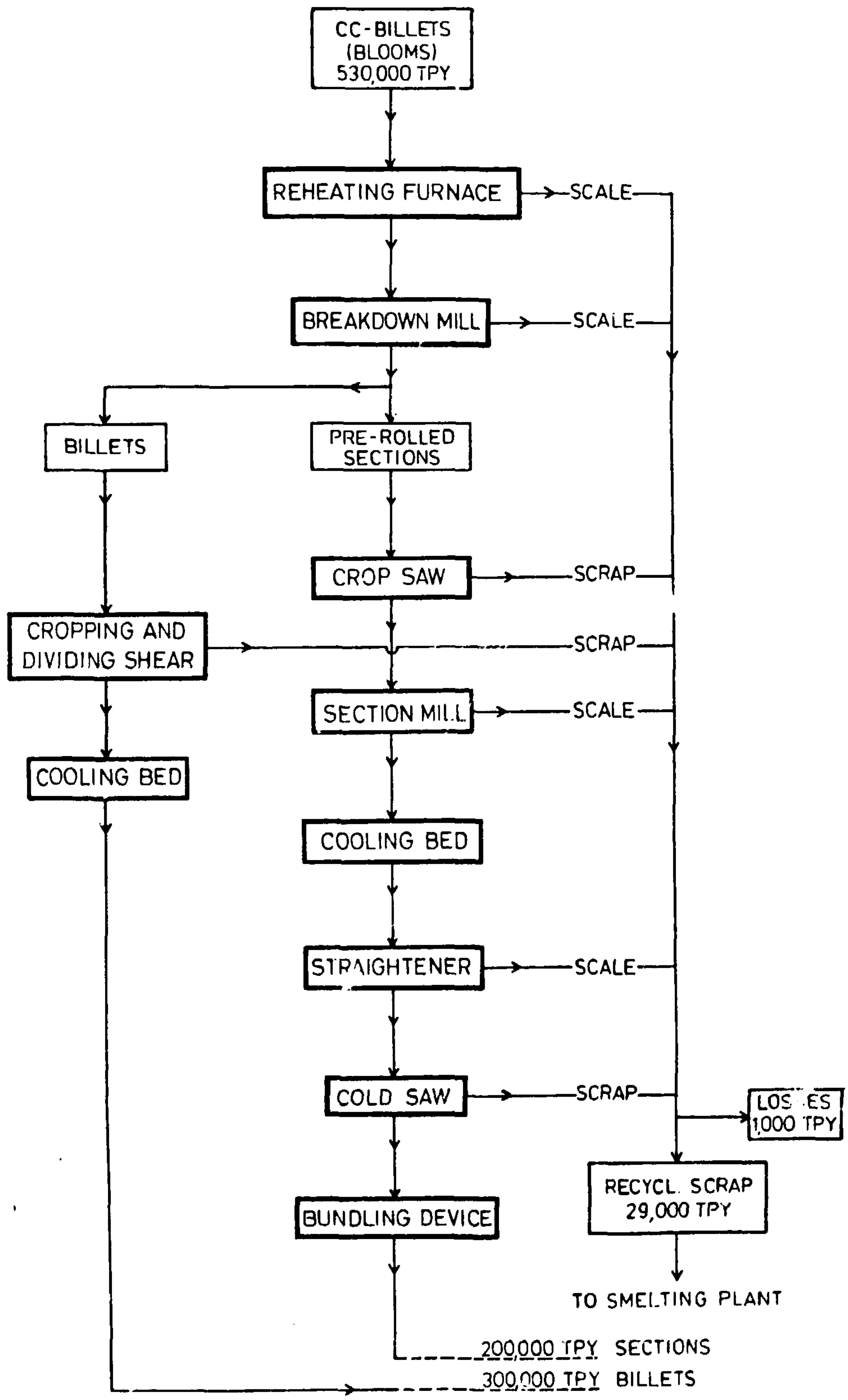

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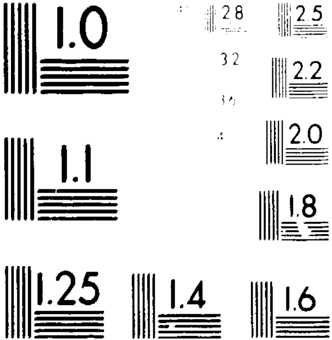
MANNESMANN

BILLET AND SECTION MILL
MAIN FLOWSHEET
(2nd STAGE)

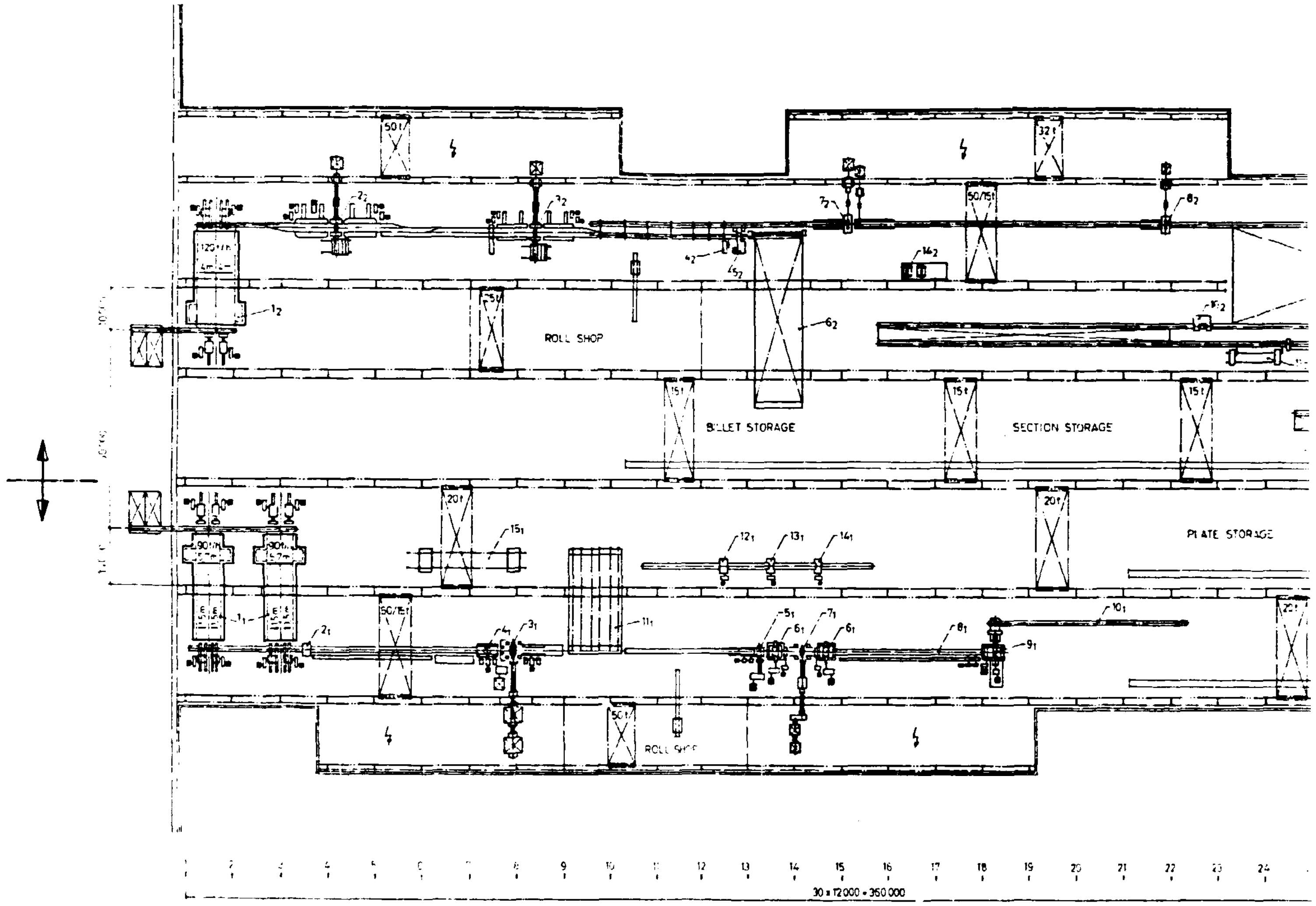


MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS

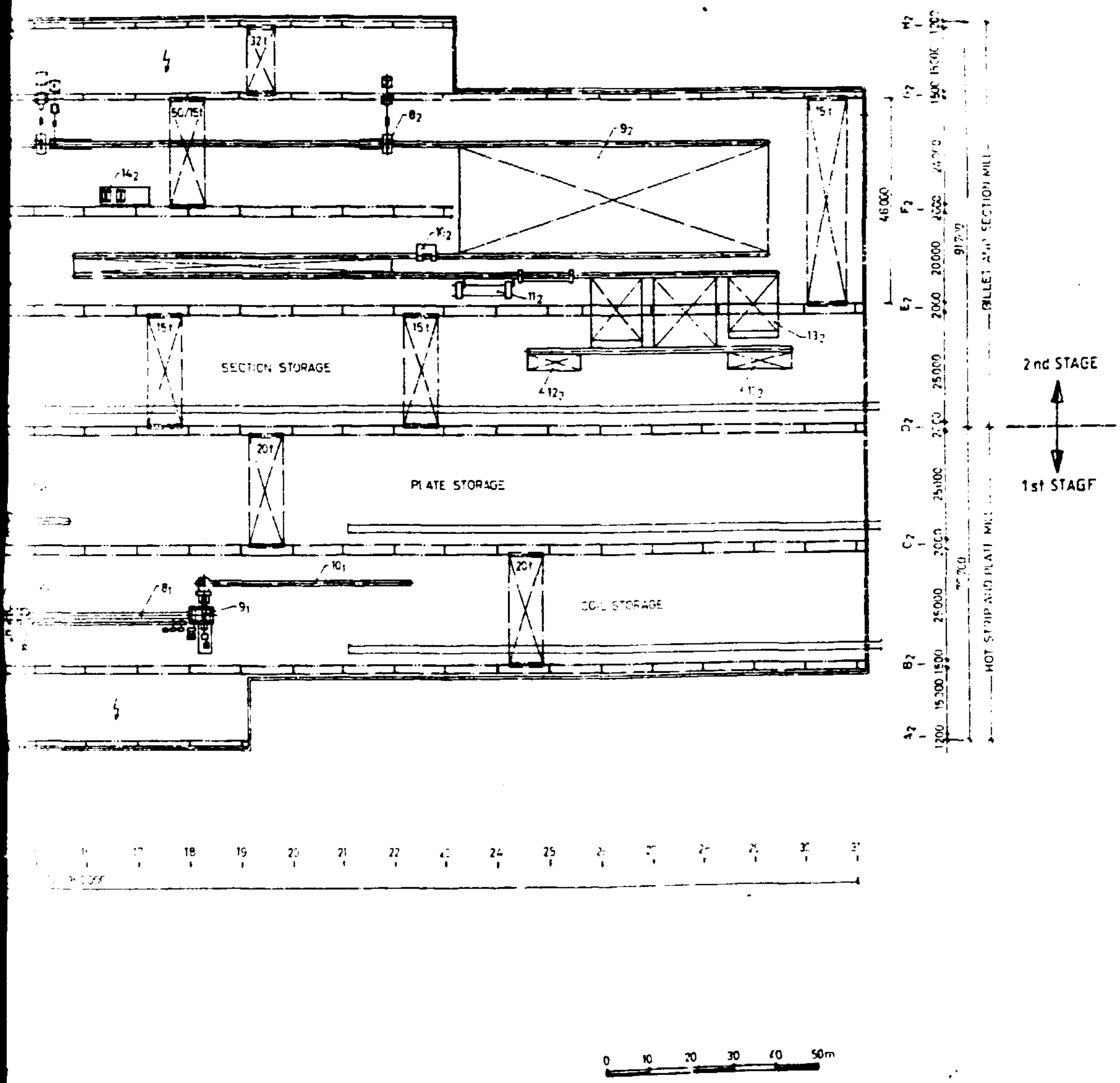
STANDARD REFERENCE MATERIAL

TEST CHART



50t
32t
50/15t
15t
ROLL SHOP
BILLET STORAGE
SECTION STORAGE
20t
PLATE STORAGE
50/15t
50t
30 x 12000 = 360 000

SECTION 1



BILLET AND SECTION MILL

- 1_2 REHEATING FURNACE
- 2_2 NO 1 BREAKDOWN MILL
- 3_2 NO 2 BREAKDOWN MILL
- 4_2 CROP SAW
- 5_2 BILLET SHEAR
- 6_2 BILLET COOLING BED
- 7_2 UNIVERSAL BEAM ROUGHING MILL WITH FLANGE EDGER
- 8_2 UNIVERSAL FINISHING MILL
- 9_2 SECTION COOLING BED
- 10_2 ROLLER STRAIGHTENER
- 11_2 COLD SAW GROUP
- 12_2 LOADING BEDS
- 13_2 SHORT END COLLECTING BED
- 14_2 2-HI CHANGE STANDS

HOT STRIP AND PLATE MILL

- 1_1 REHEATING FURNACE
- 2_1 DESCALING DEVICE
- 3_1 ROUGHING MILL WITH VERTICAL EDGER
- 4_1 TURNING WORK ROLLER TABLE
- 5_1 CROP SHEAR
- 6_1 REFLER FURNACE
- 7_1 FINISHING MILL
- 8_1 RUN-OUT COOLING ROLLER TABLE
- 9_1 DOWN COILER
- 10_1 COIL CONVEYOR
- 11_1 PLATE COOLING BED
- 12_1 PLATE LEVELLER
- 13_1 SIDE TRIMMING SHEAR
- 14_1 DIVIDING SHEAR
- 15_1 PLATE TORCH CUTTING

SECTION 2

6312

MANNESMANN 0 4 1 6 0 8 3 2 0

LURGI

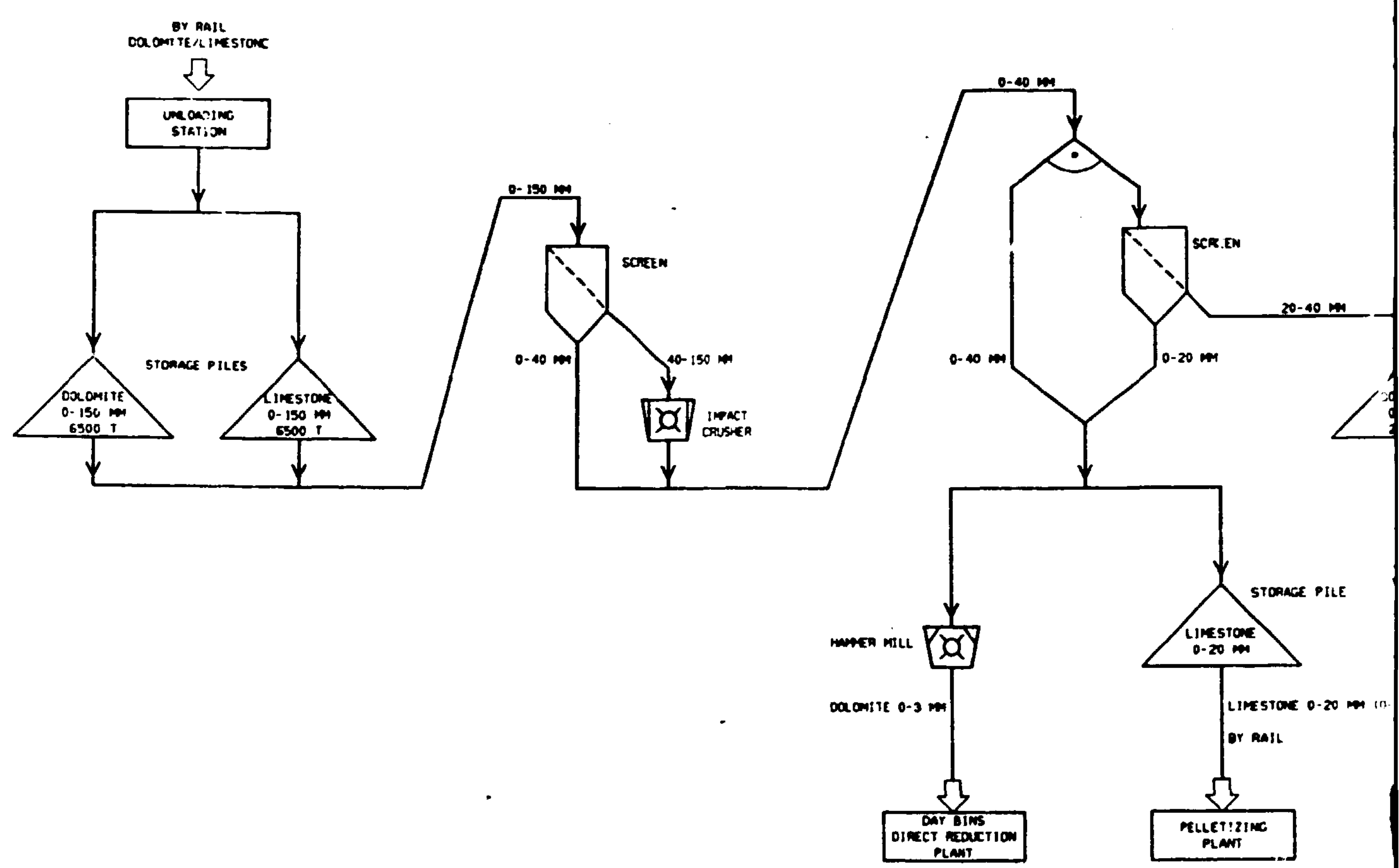
1:500

ROLLING MILL
STAGE I AND II
PLOT PLAN

TANZANIA

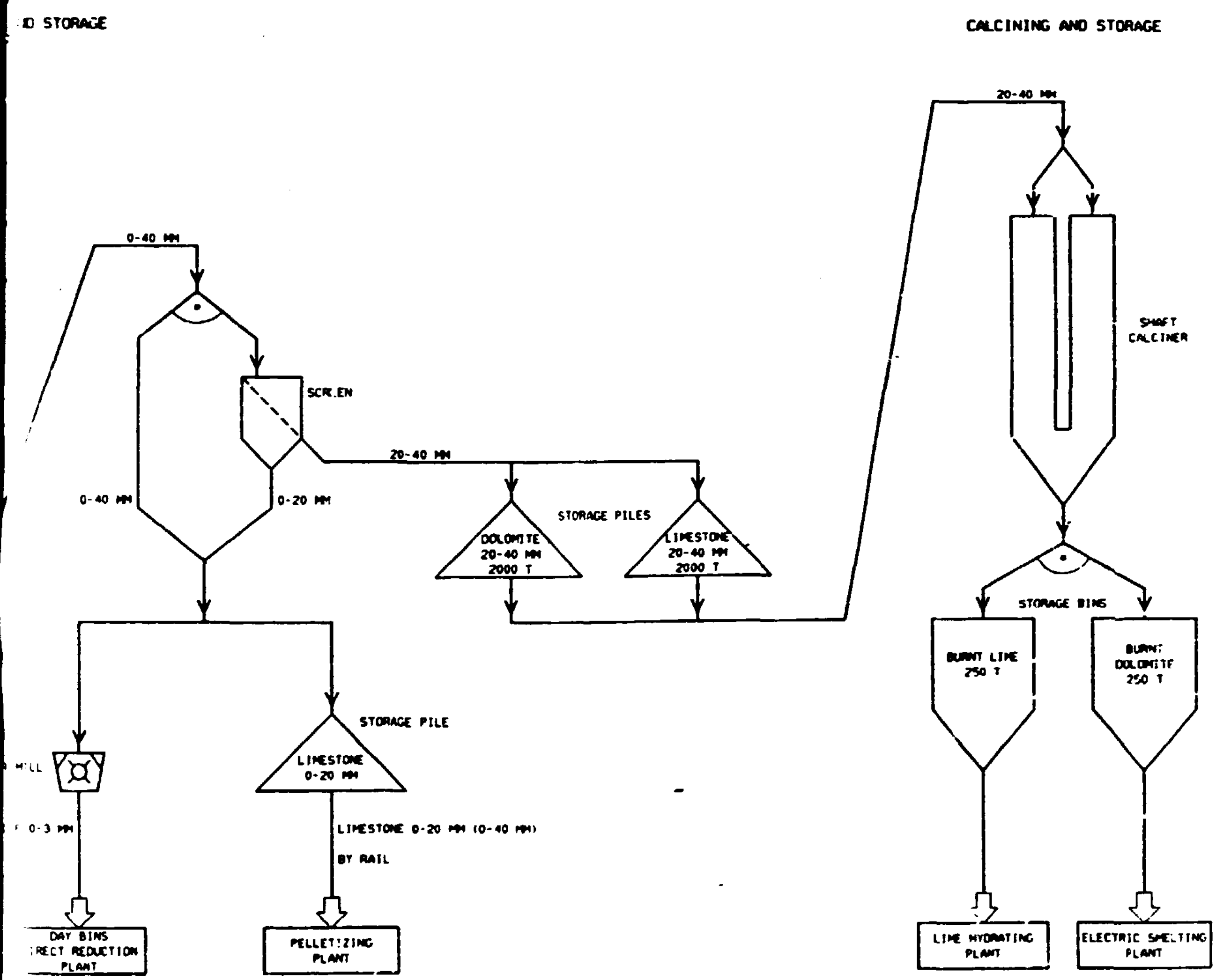
F0A0322380003 1

SCREENING, CRUSHING AND STORAGE



[202.012]A2238V001.DGN / SMST 09.01.85

SECTION 1



SECTION 2

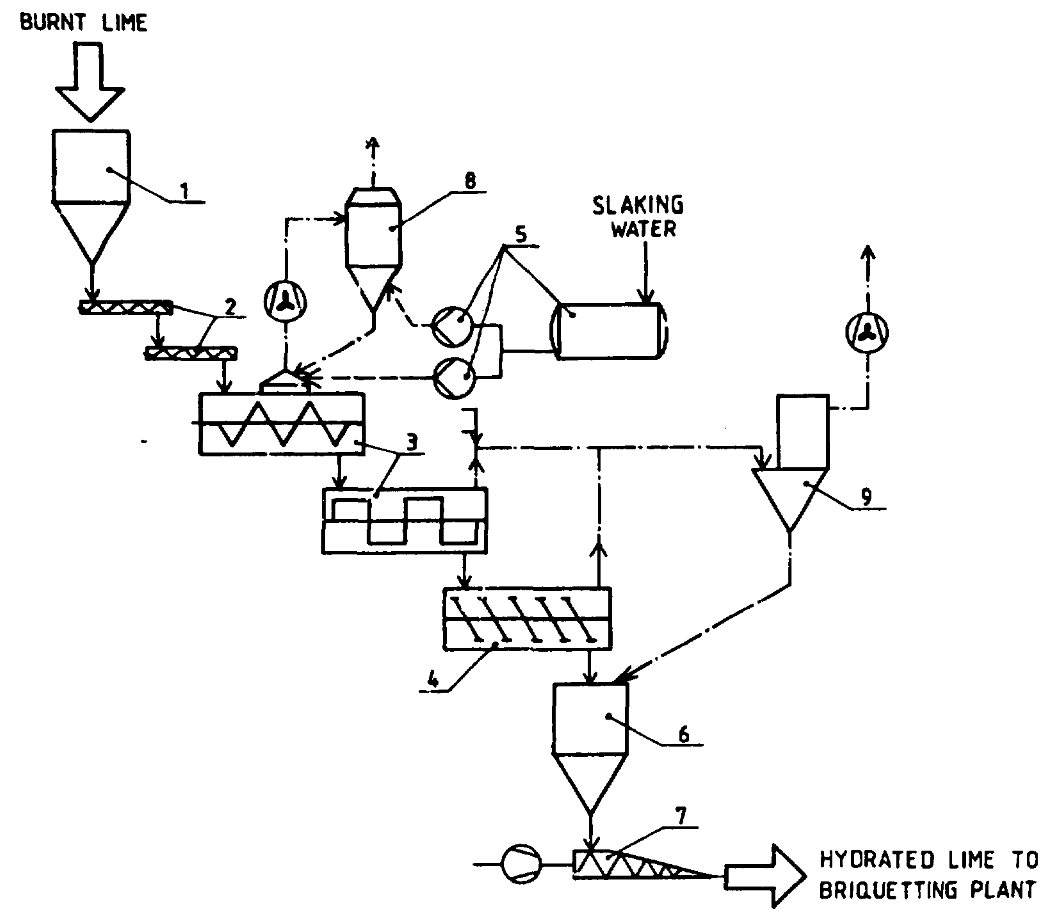
LURGI Lurgi Chemie und Hüttentechnik GmbH

LIMESTONE/DOLOMITE FACILITIES
MAHANJE
FLOW DIAGRAM

203

HRE 032238 TANZANIA

L 1A0322380002



1. STORAGE BIN FOR BURNT LIME
2. PROPORTIONING SCREW CONVEYORS
3. DUPLEX LIME HYDRATING MACHINE WITH SEASONING CHAMBER
4. MOLEKULATOR MILL
5. SLAKING WATER CONTROL
6. STORAGE BIN FOR HYDRATED LIME
7. PNEUMATIC CONVEYOR
8. WET SCRUBBER
9. PLANT DEDUSTING

	Date	Name	LURGI Lurgi Chemie und Hüttentechnik GmbH
Prepared	21.12.83	TNR	
Checked	[illegible]	[signature]	
Original Scale: ./.	Title / Characteristic Features: LIME HYDRATING PLANT MAHANJE		
Standard	Drawing Type: 205		
Process: HRE	Job or Project No.: 0 3 2 2 3 8	Job: TANZANIA	
Drawing No.: L 3 A 0 3 2 2 3 8 0 0 0 3 3	Rev	Ref Dwg	Original Size: A3