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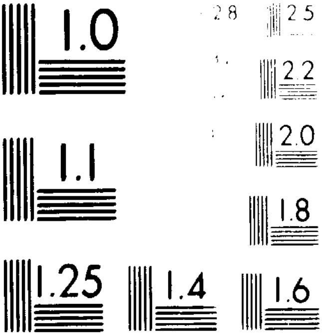
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Final Report

United Nations Industrial Development Organisation

PDR YEMEN.

Detailed Project Report for Establishment of a Mini Steel Plant in People's Democratic Republic of Yemen

SI/PDY/81/801

April 1983

922

Dastur Engineering International GmbH
Consulting Engineers
Düsseldorf

Final Report

United Nations Industrial Development Organisation

Detailed Project Report
for
Establishment of a Mini Steel Plant
in
People's Democratic Republic of Yemen

April 1983

Dastur Engineering International GmbH
Consulting Engineers
Düsseldorf

DASTUR ENGINEERING INTERNATIONAL GMBH

Consulting Engineers

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Mr D. Gardellin
Officer-in-charge
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AUSTRIA

Re: UNIDO Project SI/PDY/81/801
Contract No. 82/22

Techno-economic appraisal of the establishment of a steel scrap processing industry in People's Democratic Republic of Yemen

Dear Sir,

In accordance with the terms of the above contract, we have pleasure in submitting herewith thirty (30) copies of the Final Report in English on the establishment of a steel scrap processing industry in PDRY.

In compiling this Final Report, the Consulting Engineers have given due consideration to the comments received from UNIDO on the Draft Final Report submitted to UNIDO in December 1982.

PDRY is a developing economy with ambitious economic and industrial plans. Demand for steel by the construction as well as light and medium engineering industries sector has been progressively increasing. The country currently is meeting its steel requirement by imports costing about US$ 6 million in foreign exchange each year. Steel being the back-bone of any industrial development effort, as well as a commodity which is inevitable for the growth of any other economic or social sector, the Government has rightly recognised the importance of initiating work on the establishment of a modest steel nucleus within the country in order to be able to produce, to start with, the relatively simple construction steel.

Successive improvements in the recent past in steelmaking, continuous casting and rolling technologies have made it possible that viable small capacity mini steel plant installations could be planned and designed. While economies of scale of operation might favour installation of large units, it is not unusual today that smaller units for production of capacities in the range of 25 000 tons to 50 000 tons per year could be conceived and implemented. Such mini steel installations normally use scrap as feed material; alternatively direct reduced iron (DRI) is also used solely or together with varied proportions of scrap. The choice between these two feed materials is influenced essentially by the price at which scrap or DRI could be made available to the mini steel plant installations.

In the case of PDRY, it has been established that large quantities of scrap are available within the country which could be collected for supply to the proposed mini steel plant. This ready availability of scrap in the country does indeed set the correct background for initiating action towards the goal of implementing a steel producing unit.

It is in this context that United Nations Industrial Development Organisation (UNIDO), on behalf of Government of People's Democratic Republic of Yemen (PDRY), has entrusted Dastur Engineering International GmbH (DEI), with the preparation of techno-economic appraisal of the establishment of a mini steel complex which would operate for as long a period as possible with the internal scrap arising as the basic raw material.

As stipulated in the terms of reference contained in the contract between DEI and UNIDO, a three-member team undertook field investigations in the Project Area in the period 16th July to 3rd August 1982, subsequent to a two-day ''briefing'' session in Vienna. During the field survey by CONSULTING ENGINEERS' team, a number of selected concerned agencies (such as Ministry of Planning, National Corporation for Petroleum Exploration, National Bank of Yemen, Companies involved in the import and sale of iron and steel products in PDRY, National Company for Shipping, Public Corporation for Water, National Company for Foreign Trade and municipalities and customs authorities) were contacted and necessary information and statistics required for compilation of the techno-economic appraisal collected. The field team also made visits to selected locations where the mini steel complex could possibly be installed; also, a few of the important scrap dumps in PDRY were visited for the purpose of determining the quantum and quality of scrap that would be available for sustaining the operations of the proposed mini steel mill.

The enclosed single-volume report documents the findings of the CONSULTING ENGINEERS in connection with the implementation of a scrap-based mini steel plant in PDRY. For the type of products and the capacity visualized to be produced at the mini steel complex, a suitable project concept has been evolved and discussed in the report. The major findings as elaborated in greater details in respective chapters of the enclosed report, are as follows:

1. Though end-use method would enable a more realistic demand projection for iron and steel products, adoption of this methodology in the context of this study, has been rendered difficult for want of meaningful data and statistics, and therefore macro end-use approach has been adopted for determining the sectional demand based on their projected contributions to GDP. Also methodologies such as time trend analysis, regression analysis and per capita analogy have been adopted and their results cross checked with cement consumption.

   On this basis the projected demand for non-flat products for the years 1985, 1990 and 1992 has been estimated at 16 000, 24 000 and 27 000 tons respectively, 90 per cent of which will be required as bars, rods and sections. The envisaged finished steel production at the proposed PDRY steel complex is 20 000 tpy comprising the following:

	Size mm	tons/year
Reinforcing bars and rods	10-25	18 000
Flat bars	18-50	1 000
Angles	50x50(max)	1 000
Total		20 000

2. The local scrap available is of high quality heavy melting type. Assuming a conservative scrap collection efficiency, 75-80 per cent of the already existing scrap could be collected. Thus, the net scrap that would be available for the proposed mini steel plant is of the order of 135 000 tons. Of the scrap that would be generated in the country in the future years, it is estimated that an average of about 6 000 tpy for the year 1983-86 and 7 000 tpy for the year 1987-89 would be available and could be earmarked for supporting the operations of the mini steel complex. On this basis, the plant operation could be sustained without resorting to import of scrap over a period of atleast 10 years.

3. Of the major raw materials required for the plant operation, limestone will be locally available. Iron ore, ferro-silicon, ferro-manganese, aluminium and fluorspar have to be imported. The quantities of these materials to be imported for the proposed production of 20 000tpy of finished products are not very significant and therefore import of these is not expected to pose any problem.

4. The process route recommended is electric arc furnace-continuous casting-rolling. The increasing use of electric arc furnace steelmaking would be evident from the fact that in 1981 a production of 151 million tons of liquid steel has been achieved only through use of electric furnace steelmaking. For PDRY project, arc furnaces with relatively higher transformer ratings than those employed for "regular power" operations have been suggested. The continuously cast billets are proposed to be rolled by a single strand semi-continuous cross country mill.

5. Based on a detailed review of the various factors affecting the location of industrial projects of national importance such as steel, the area near Aden has been recommended for the location of the mini steel complex. The proposed site in the Aden area which has been earmarked for the purpose of the steel plant in consultation with the Ministry of Industry and Ministry of Construction is shown in Drawing 10020-6-2.

6. Keeping in view the volume of construction work, the lead time required for the procurement of the type of equipment proposed etc, the total time required for the project implementation activities has been estimated to be 28 months from placement of orders. This also includes 4 months for trial runs and commissioning. It is estimated that the project preliminaries such as soil investigation, site survey, construction facilities, issue of enquiries for major equipment and civil and structural work upto placement of order will take about 12 months from the time a firm policy decision is taken to implement the project.

7. It is estimated that a total work-force of 250 people will be required for the operation of the mini steel plant. Details of various categories of personnel required (in managerial, supervisory, skilled and unskilled disciplines) have been indicated.

8. The total capital requirement for the project is estimated at YD 9.1 million. This includes YD 0.55 million towards working capital. It is estimated that almost 90 per cent of the total fixed investment would have to be incurred in foreign exchange.

9. The production cost per ton of rolled product has been estimated to be of the order of YD 109.759. To this, adding the proportionate cost per ton in respect of fixed charges, administration and sales expenses of YD 49.30, the total cost of per ton of rolled product amounts to about YD 159.

10. Evaluation of various financial statements presented in Chapter 14 reveals that:

    (a) Sufficient funds would be available from 3rd year of operation for repayment of long-term loan in phased instalments.

    (b) The net cash surplus at the end of the 15th year of operation is about YD 14.53 million.

    (c) The break-even chart prepared for the second year of operation reveals that the project will break-even at about 75% of rated capacity.

    (d) Assuming "present value" trial rates at 11% and 12%, the ratios of out-flows to in-flows have been computed and on the basis of this analysis the internal rate of return has been estimated to be of the order of 11.5%.

    (f) Based on the various assumptions elaborated in the chapter on Financial Analysis, the pay-back period for the project is estimated to be about 8 years.

In the interest of implementing a project of this nature with minimum delay, it is suggested that urgent advance action be initiated in respect of the following major aspects:

Project authority: A separate organisation charged with the task of taking all necessary steps towards implementing the mini steel complex needs to be urgently set up. Such an organisation - as the Project Authority - will liaise with Government bodies, arrange finance and place orders on various agencies involved in the implementation of the project.

Finance: Policy decision will need to be taken for arranging adequate finance for the project so that the construction work could be taken on hand. Such decision will need to be expeditiously implemented and the source and method of financing the project frozen, so that the suggested construction schedule could be adhered to.

Consulting services: An independent professional consulting engineering organisation has to be appointed for providing the design and engineering services for the project.

Land acquisition: Based on the evaluation of alternative sites presented in this report, a decision on the final site for the steel plant has to be taken and arrangements made for acquiring the land for installation of the steel plant.

Construction materials: There will be considerable need for participation of local agencies for providing materials and services for the proposed mini steel complex.

The Project Authorities will have to identify the possible agencies who will have a role to play in the implementation of the project and give them adequate advance notice on the type and volume of construction and other efforts required for the project so that these agencies could get themselves organised to meet the project requirements. This will also help augment the share of indigenous supply and consequently reduce foreign exchange expenditure on the project.

We believe that the proposed mini steel plant project in PDRY is an essential pre-requisite for further economic development and industrialisation. We recommend that this project should be accorded a high priority in the overall national plan and expeditious steps should be taken towards implementing the project without delay.

We take this opportunity to express our gratitude to UNIDO, UNDP-Aden and the officials of the Government, for the cooperation extended to us during the course of work on this assignment.

Respectfully submitted
DASTUR ENGINEERING INTERNATIONAL GmbH

S.P. Neogi, Geschaeftsfuehrer

SPN:rv

Encl: As stated

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1 - INTRODUCTION

People's Democratic Republic of Yemen (PDRY) is located in the South-Western corner of the Arabian peninsula and occupies an area of 338 000 sq km; the country extends nearly 7 400 km along the Gulf of Aden. The mid-78 population of PDRY was around 1.8 million, the majority of them living in the narrow coastal plain along the Gulf. About one third of PDRY's population can be considered urban. Administratively, PDRY is divided into six Governorates or provinces.

The political leadership of PDRY has been making increasing use of comprehensive economic and social planning as a principal tool for development. Since formal planning started, PDRY has completed a three year plan by April 1974 and the First Five Year Plan by the end of 1978. Currently the Second Five Year Plan is in progress covering the period 1979-83. The overall strategy visualises development within the context of a socialist society.

The Government of PDRY (hereinafter referred to as GOVERNMENT) have declared that the principal objectives of developmental programmes planned would be:

a) to satisfy the basic needs of the population for food, essential consumer goods, shelter, employment, health care and other social services

b) to develop the production capacity of the economy, especially in agriculture, fisheries, industry, construction and minerals

c) to strengthen the infrastructure sectors, i.e. transport, power and telecommunications

d) to raise education standards, emphasising technical and higher education, and

e) to increase exports of domestic products

1 - Introduction (cont'd)

The overall growth target of Second Five Year Plan is 11 per cent per annum. Despite limited natural resources, PDRY is said to have performed well in the past and has a promise for faster growth in the future.

<u>Steel requirements in PDRY</u>

PDRY is a developing country with ambitious economic and insutrial development programmes. The country has been witnessing increasing requirements of steel specially in the construction and light and medium engineering industries sector. Steel is currently being imported, costing PDRY's exchequer of about US $ 6 million per year. Steel is a crucial engineering material and its availability locally would result in considerable chain of activities in various other sectors resulting in overall growth of economy. The socio-economic benefits arising out of the development of the steel industry could generally be summarised as follows:

i) the steel industry provides greater opportunities for the formation of technical and organisational skills in a wide range of disciplines

ii) it is well known that for every job in the steel plant, twenty or more new jobs are created in other steel-based manufacturing industries as well as in non-manufacturing industries like construction, transportation etc. Because of this multiplier effect, investment in steel is paid back many times over by its contribution to industrial development and economic growth

iii) due to its high backward and forward linkages, the establishment of steel industry stimulates rapid growth of steel consuming industries using its outputs and of feeder industries supplying the inputs and services

1 - Introduction (cont'd)

iv) it will also put into economic use a number of by-products from other industries such as residual fuel oil from the refineries, acids from the chemical complexes, automotive and industrial scrap etc. Viewed against this background, the backward linkage effect of the energy-intensive steel industry could be considered sizeable

v) the productions of the steel industry in PDRY will find extensive use in other industries such as building and construction, galvanizing units, wire drawing units, light and medium engineering industry, foundries for castings etc.

The annual drain on meagre foreign exchange resources points to the need to pursue atleast a modest programme of steel development, capitalising on PDRY's favourable raw material situation (availability of local scrap) but immediately motivated by the compelling necessity of import substitution. It has been seen that foreign exchange (a scarce resource in PDRY's conditions) spent in creating indigenous steel capacity can be recouped in a few years, after which the net savings should be very substantial indeed.

The arguments in favour of indigenous manufacture resulting in import substitution are reinforced by the spread effects that steel development has on the rest of the economy. Assured availability of steel encourages the establishment of fabricating and processing industries, widening the range of import substitution and generating larger income and employment. The point may be noted that steel transforming and processing industries have a capital-output ratio 50 to 75 percent lower than primary metallurgical industries. A developing country trying to achieve a satisfactory capital-output ratio over the economy as a whole has, therefore, a strong incentive to combine primary iron and steelmaking with metal-working industries.

1 - Introduction (cont'd)

The comparison of the costs of small-scale domestic production vis-a-vis cheaper imports is not necessarily meaningful. The choice for a developing country must be conditioned by larger considerations such as the availability of foreign exchange for the country's other strategic needs. In any case, import prices do not always reflect true costs. In periods of shortage, import prices tend to shoot up as in the immediate post-war years when the world as a whole was short of steel. In periods of ample supplies, when a large proportion of the capacity of well developed steel industries is under-utilized, imports tend to be made at marginal prices or at times even below works costs. But developing countries are not usually in a position to profit from these low prices since their own export earnings are sharply reduced in periods when recession renders steel capacity idle in the industrially advanced nations. Therefore, cost comparisons are not necessarily valid, when one judges in terms of prices quoted for exports at any particular time.

The present demand for construction of steel in PDRY is expected to increase manifold in the years to come with the various developmental programmes the GOVERNMENT is planning to implement. The important considerations which speak for the installation of a mini steel plant are:

i) fewer locational constraints; a unit to produce about 25 000 tons of steel products could be located in close proximity to raw material sources as well as major consuming sectors, thus resulting in optimum transportation costs

ii) the capacity of the facilities could be tailor-made so that utilisation factor is relatively high

iii) relatively shorter construction time as well as simpler technical/management skills required with the advantage that the production build-up upto the optimum level is faster

iv) the plant can also start with production of finished products i.e. rolling from imported or locally procured billets and thus enabling finished products to reach market in a shorter time

v) minimum requirement of infrastructure facilities at the initial stage

1 - Introduction (cont'd)

Considering these factors, GOVERNMENT has taken a decision to install a nucleus for production of steel which will make the country in course of time free of imports of such a basic material like steel.

With the above background in mind, United Nations Industrial Development Organisation, hereinafter referred to as UNIDO, commissioned Dastur Engineering International GmbH, hereinafter referred to as CONSULTING ENGINEERS, in end-May 1982 to prepare a techno-economic appraisal of the establishment of a steel scrap processing industry in PDRY.

Authorisation

CONSULTING ENGINEERS commenced work in accordance with telex authorisation No. MK 34072 dated 26th May 1982 from UNIDO, which was followed by a formal contract. An extract of the Terms of Reference forming part of UNIDO's contract is presented in Appendix 1-1.

CONSULTING ENGINEERS' representative was at UNIDO, Vienna, in the middle of June 1982 for a "briefing" meeting with the concerned substative officer. Following this a three-member team of CONSULTING ENGINEERS reached Aden on 16/17th July 1982 for field investigations.

During the period of CONSULTING ENGINEERS' stay in the Project area (between 16th July and 3rd August 1982) a number of organisations were met and relevant information/ statistics for compilation of the study collected. Also a visit to the selected plant sites was made to help determine the comparative merits and demerits of these locations. In accordance with the Terms of Reference copies of Draft Final Report were submitted to UNIDO on which substantive comments were made by UNIDO vide their letter No. MK/rb dated 17th February 1983 which have been taken into account in finalising this Final document.

1 - Introduction (cont'd)

Structure of the report

This techno-economic appraisal is being submitted to UNIDO in accordance with the requirements stipulated in the contract between CONSULTING ENGINEERS and UNIDO.

The report is presented in one volume with 14 chapters duly supported with tables, drawings, figures and appendices.

Following this introduction, Chapter 2 reviews the economic profile of PDRY and the present demand for bars and rods for a 10-year period. Based on the analysis of the demand figures, a suitable product-mix has been evolved for the proposed production capacity. The country's availability of scrap has been discussed in Chapter 3. The review presented therein is based on the various discussions with authorities in PDRY as well as visits to scrap dumps. Chapter 3 also reviews the scrap situation quantitatively vis-a-vis the requirements of scrap by the mini steel plant as feed material. It is expected that after a period of ten years, the plant would be required to support its operations with imported scrap, for which suitable sources have been broadly indicated.

The requirements of basic raw materials for production of the visualised quantity of steel are reviewed in Chapter 4 and their possible locations have been identified.

The proposed production route of electric steelmaking - continuous casting - rolling is reviewed in Chapter 5. Chapter 6 presents a brief discussion of the overriding factors which influence the location of a basic industry like steel, discusses the merits and demerits of a few selected locations in PDRY so as to enable GOVERNMENT to take a decision on the ultimate site for the mini steel plant. Also this chapter presents a suitable layout for the plant. The layout has been so developed as to enable smooth operation of the plant facilities as well as possible future expansion when required.

1 - Introduction (cont'd)

Technical parameters for steelmelt shop and rolling mill for the proposed production capacity are reviewed in Chapter 7 while Chapter 8 is devoted to a review of aspects on plant electrics, lignting, instrumentation and communication.

Water is a scarce commodity in PDRY. The availability quantitatively and qualitatively and sources of water in PDRY in relation to the requirement of the proposed mini steel plant is discussed in Chapter 9. Chapter 10 reviews the construction effort needed in terms of volume of construction, schedule of construction etc. Also this chapter lists a few important areas on wich GOVERNMENT would do well to initiate advance action so that once the implementation decision is taken, the construction effort proceeds in an uninterrupted manner.

Manpower and training requirements for an efficient operation of the plant facilities are discussed in Chapter 11. This chapter also discusses the present human resources position in PDRY and includes a suitable training programme which would enable the gradual take-over of the operation and maintenance of the plant facilities by local personnel.

Chapter 12 is devoted to a discussion of the capital costs required for the installation of the proposed mini steel plant and this chapter also provides an indication of the fund required in foreign exchange. The possible financing pattern and sources of fund are also reviewed. Based on a discussion of manufacturing expenses, the actual operating cost as well as cost of production per ton of product have been computed and presented in Chapter 13.

1 - Introduction (cont'd)

Chapter 14 reviews the possible mode of financing the project. A profit and loss statement is presented for the plant operations over a period of 15 years taking into account the expected sales realisation, annual manufacturing, administration, sales expenses, interest and depreciation charges etc. Other financial statements such as cash flow, break-even chart etc are also presented in this chapter together with an indication of the Internal Rate of Return and Pay-Back period for the plant operations.

ACKNOWLEDGEMENT

CONSULTING ENGINEERS gratefully acknowledge the cooperation and assistance extended by the various officials of UNDP-Aden, UNIDO-Vienna, GOVERNMENT as well as the various Government and private agencies in Aden, Hiswa and other places. CONSULTING ENGINEERS also wish to record their thanks to the counterpart team nominated by the GOVERNMENT, especially the valuable help rendered by Mrs Aziz and Mr Ezzadin in arranging various meetings, discussions, and in collecting various data by the field team of CONSULTING ENGINEERS during investigations in the Project area.

2 - STEEL DEMAND AND PRODUCT-MIX

Steel is a basic commodity closely linked to industrial progress. Engineering industries are not the only sector where steel plays a paramount role, but in the creation and development of all other industries, it is used in buildings and structures, machinery, equipment and tools. A major factor influencing steel demand in a country is not only its industrial development at a given time, but also the emphasis the country places on further development of industrial base.

For assessing the prospects of development of the steel industry in PDRY, it would be relevant to review briefly the economy and the steps that have already been taken by the Government of PDRY for industrialisation of the country.

ECONOMIC PROFILE OF PDRY

Based on the programme of the GOVERNMENT and the major indicators of the modified Second-Five Year Plan (SFYP) as laid down in April 1980 and taking into account the economic potentials and constraints, the major objectives for the 1980s could be summarised as follows:

i) Raising the living standard of the population by at least doubling the per capita real income

ii) Achieving sustained economic growth by expanding the material and technological base of the economy, particularly in agriculture, fisheries and manufacturing

iii) Improving the efficiency and productivity of labour force

iv) Broadening the role of State and Cooperative sectors as the leading sectors in the economy

2 - Steel demand and product-mix (cont'd)

v) Achieving equitable distribution of income

vi) Realising balanced sectoral and regional growth

vii) Improving the balance of payments and realizing a higher degree of mobilization of internal resources for development

viii) Achieving a higher degree of food-self- sufficiency

ix) Exploration and utilization of natural resources with emphasis on energy and mineral resources

x) Improving the physical infrastructure of the country

xi) Improving standards of education, health, housing and other social services

Given the objectives and strategies for 1980s as outlined above, the major thrust of the investment programme will be on expansion and strengthening the productive capacity of the economy.

Sectoral Contribution to GDP

The sectoral contributions to GDP in pre-SFYP and in SFYP as well as for five year period upto 1990 is given in Table 2-1.

Industry

The industrial sector including manufacturing, mining and quarrying, electricity and water supply, is expected to grow at the rate of approximately 14 per cent during the period 1980-85 and at 12 per cent for the next five year period. The contribution of the mining and quarrying to GDP is negligible at present. However, in near future with the development of 'Cement' industry, and discovery of oil wells, it is likely to grow gradually.

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iv) Broadening the role of State and Cooperative sectors as the leading sectors in the economy

TABLE 2-1 - SECTORAL CONTRIBUTION TO GDP AND GROWTH RATES
(At 1980 constant price)

Sl. No.	Sector	Pre-SFYP Period 1975 YDm	1980 YDm	1980 % of GDP	1975/80 G.Rate	Second 5 Year Plan SFYP 1985 YDm	1985 % of GDP	1980/85 G.Rate	Projection for 1980-90 1990 YDm	1990 % of GDP	1985/90 G.R.%	1980/90 G.R.%
1.	Industry ..	11.2	19.0	8.7	11.1	36.4	10.3	13.9	64.1	11.1	12.0	12.9
2.	(Manufacturing) ..	(10.0)	(16.1)	(7.3)	10.0	(30.8)	(8.7)	13.9	(52.5)	(9.0)	11.3	12.5
3.	Others (1) ..	(1.2)	(2.9)	(1.4)	19.0	(5.6)	(1.6)	14.0	(11.6)	(2.1)	15.6	23.0
4.	Fisheries ..	10.4	12.6	5.7	3.9	19.1	5.4	8.7	28.7	4.9	8.5	8.6
5.	Agriculture ..	16.1	17.4	7.9	1.6	26.9	7.6	9.1	35.2	6.1	5.5	7.3
6.	Construction (2) ..	7.4	24.9	11.4	27.0	40.8	11.5	8.1	65.5	11.3	10.0	9.1
7.	Transport and communication ..	12.8	27.6	12.6	16.6	54.4	15.3	14.5	95.9	16.5	12.0	13.3
8.	Trade, restaurants, hotels & others	28.5	30.2	13.8	1.1	48.7	13.7	10.0	78.6	13.6	10.0	10.0
	Sub-total of above	86.4	131.7	60.1	8.84	226.3	63.8	11.2	368.5	63.6	10.2	10.8
9.	Net excise tax and customs ..	6.6	31.9	14.5	37.0	46.2	13.1	7.7	74.4	12.8	10.0	8.84
	Sub-total upto 9 ..	93.0	163.6	74.6	12.0	272.5	76.9	10.7	442.9	76.4	10.2	10.50
10.	Directly prod. sec. (2, 4, 5 and 8) ..	65.0	76.3	34.8	3.3	125.5	35.4	10.5	195.0	33.6	9.2	9.8
11.	Physical infrastruc. (3, 6 and 7) ..	21.4	55.4	25.3	21.0	100.8	28.4	12.7	173.0	29.8	11.4	12.0
12.	Services(social infrastruc.)(3) ..	31.2	55.7	25.4	12.3	82.0	23.1	8.0	136.9	23.6	10.8	9.4
	TOTAL (GDP at Mrg. price) ..	124.0	219.3	100.0	12.1	354.5	100.0	10.0	579.8	100.0	10.34	10.2

NOTES:
(1) Industry includes manufacturing and petroleum & mineral resources, electricity and water
(2) Construction includes roads and buildings in various sectors
(3) Services include Government, finance, insurance real estates and others

DASTUR ENGINEERING INTERNATIONAL GmbH
DUSSELDORF

2 - Steel demand and product-mix (cont'd)

Manufacturing: The plan envisages to raise the share of manufacturing in GDP from 7.3 per cent in 1980 to 8.7 per cent in 1985, reflecting an average rate of growth of 13.8 per cent annually, the highest among the directly productive sectors. PDRY Government has already decided to set-up a cement factory with a capacity of 250 000 tons during the current Plan period.

Petroleum and Mineral Resources: This sub-sector is planned to receive investment of YD 31.4 million (at 1980 prices) during the Plan period. This investment is intended to explore the country's oil and gas potentials, both on-shore and off-shore.

Electricity: The contribution of this sub-sector to GDP wil increase from YD 1.5 million at present to YD 2.7 million in 1985. Electric power generation and distribution plays a vital role in the economic and social development. During SFYP it is planned to increase the availability of electricity supply to the directly productive sectors, 90 per cent in agriculture, 60 per cent in industry and 200 per cent in construction. This programme calls for an additional generating capacity of 194 MWH, bringing the total capacity to around 250 MWH.

Water Supply: Since potable water supply is unsatisfactory in PDRY, schemes of water supply in the SFYP are given special importance. The Plan contains about 20 water supply schemes distributed throughout the country including the rural areas.

Fisheries

PDRY's coast is one of the richest fishing grounds in the world. Moreover, this sector constitutes the bulk of the country's commodity exports. Its contribution to GDP is planned to rise from YD 12.6 million in 1980 to about YD 19.1 million in 1985.

2 - Steel demand and product-mix (cont'd)

Agriculture

The major goal of agricultural programme is to attain self-sufficiency in food and also to cover the needs of the domestic textile industry and expand the country's export capacity. The Plan aims at raising the contribution of agriculture to GDP from YD 17.4 million in 1980 to YD 26.9 million in 1985.

Construction

In any developing economy the contribution to GDP by the construction sector is quite significant because of the inevitable role this sector plays in the implementation of projects in all the rest of the economic and social sectors. In PDRY, its contribution to GDP in 1980 was estimated at about YD 24.9 million or 11.4 per cent and SFYP target is to raise it to YD 40.8 million or 11.5 per cent of GDP by 1985.

The road development programme in PDRY is included under construction sector. The SFYP's road programme includes the completion of asphalted Al-Mukalla-Seiyur (Hadramout Governorate) road, Aden-Taiz road and Shugrah-Ahwar road (Abyan-Governorate) and starting the construction of Nigabah-Baihan road and Nobat-Dubiem-Dhala (Abyan Governorate).

Transport and Communications

This sector, which contributed to GDP about YD 27.6 million in 1980, is planned to rise to YD 54.4 million by 1985, or 15.3 per cent of GDP, indicating the highest growth rate (14.5 per cent) among all sectors.

Social Services

This includes education, housing, health, tourism, labour welfare etc. In education, the programme covers 55 projects; most of them are construction of buildings of schools and improvement of Aden University with construction of a medical college annexed to it, and a college for higher education in Mukalla.

2 - Steel demand and product-mix (cont'd)

The housing problem in the urban areas has become more acute recently, specially in Aden. To solve this problem, the housing investment programme has been given high priority in the Plan and an amount of YD 86.3 million is appropriated for this purpose. The target is to build about 5 900 apartments during the Plan period of which about 5 370 apartments will be in Aden district, 224 in Al-Hotah (Lahej Governorate), 180 in Abyan, 20 in Shabwah and 102 in Hadramout.

The health programme of GOVERNMENT includes about 38 projects; a few of these health centres, hospitals etc are already nearing completion and a few others are under construction.

STEEL CLASSIFICATION

Steel is defined as an iron-based alloy, malleable in some temperature range as initially cast, containing carbon, manganese and other alloying elements. Steel may be broadly classified into two categories, ordinary (or tonnage) steel and alloy and special steels. For this report only ordinary or tonnage steel is considered relevant.

Ordinary Steel

Ordinary steels constitute a greater portion of steel produced. Their applications are so wide and diverse that it would be impossible to make a complete list of their uses. These steels are produced in many rolled shapes like bars (rounds, squares, flats etc), wire rods, plates, sheets and strips, structural sections (beams, channels, angles, tees etc), and in forged extruded or drawn conditions like axles, tubes, wires etc.

Ordinary steel has achieved its predominant position as the best engineering material because it has adequate strength for most constructional and engineering uses.

2 - Steel demand and product-mix (cont'd)

The commercial forms and qualities of steel associated with each product and its principal applications are listed in Appendix 2-1. The steel products can be grouped under two principal heads - non-flat products and flat products:

Non-flat Products

1. Bars and rods	..	Round bars, wire rods and flat bars
2. Structurals	..	Angles, channels, tees and beams
3. Railway materials	..	Rails, other railway materials such as fishplates, dogspikes, fish bolts, wheels, tyres and axles
4. Pipes and tubes	..	Seamless
5. Others	..	Seamless and welded pipes and tubes, wires, bars and rods

Flat Products

1. Sheets and strips	..	Hot rolled sheets/strips, cold rolled sheets/strips
2. Plates	..	Plates
3. Coated products	..	Tin plates, galvanised sheets, other coated products
4. Pipes and tubes	..	Welded, spiral and longitudinal

Past Steel Consumption

The apparent consumption of steel in any country can be inferred from the amount of steel produced indigenously plus imports, less exports, neglecting variations in stock. In PDRY so far there has been no primary steel production and the entire steel requirements of the country have been met through imports. As such the quantity of steel imported can be taken to represent the apparent consumption of steel in the country.

2 - Steel demand and product-mix (cont'd)

Available information from Central Statistical Organisation (CSO), Ministry of Planning on the past imports of iron and steel products by PDRY for the years 1974 to 1981 are given in Table 2-2. It is noted that the past imports are fluctuating in nature. In view of this, it is inferred that yearly import may not represent the actual consumption for that year. It is likely that sudden drop in imports was compensated by the previous year's stock.

In order to ascertain the pattern of consumption vis-a-vis pattern of imports, supply of bars and rods to domestic market for the last 4 years were collected and are given below:

Year		Supply of bars and rods tons	According to Import Statistics(1) tons
1978	..	4 357	4 107
1979	..	6 306	6 152
1980	..	4 944	8 149
1981	..	6 390	3 002
TOTAL	..	21 997	21 410

NOTE:
(1) Including wire rods

2 - Steel demand and product-mix (cont'd)

TABLE 2-2 - PAST IMPORTS OF IRON AND STEEL

Product Category	1974 tons	1975 tons	1976 tons	1977 tons	1978 tons	1979 tons	1980 tons	1981 tons
1. Bars and rods	6365	2622	6995	6386	4082	4117	1968	1012
2. Wire rods	199	493	219	229	20	2035	6181	1990
Sub-total	6564	3115	7214	6615	4102	6152	8149	3002
3. Wires	..	..	..	27	562	62	2	319
Sub-total	6564	3115	7214	6642	4664	6214	8151	3321
4. Angles, shapes and sections	..	..	..	..	302	168	1275	697
5. Seamless tubes	..	..	..	..	80	1432	7616	1243
Sub-total(4+5)	-	-	-	-	382	1600	8891	1940
Sub-total(1-5)	6564	3115	7214	6642	5046	7814	17042	5261
6. Sheets and plates	671	771	1365	1292	927	4556	6009	2464
7. Steel pipes and tubes	..	..	..	..	1439	767	14	11
Sub-total(6+7)	671	771	1365	1292	2366	5323	6023	2475
8. Cast iron pipes and tubes	2067	994	1993	..	2102	4743	1591	746
TOTAL (1-8)	9302	4880	10572	7934	9514	17880	24656	8482

It is observed that the consumption of bars and rods according to the information furnished by National Company for Home Trade follows a pattern, while those collected from CSO, Ministry of Planning shows an inexplicable drastic drop in 1981. Thus it may be concluded that though over the years (1978-81) the total aggregate quantity of bars and rods consumed is more or less same (21 410 tons against 21 997 tons), the pattern of consumption is more realistically reflected by the Home Trade statistics. Therefore, for an analysis of the past consumption trend for bars and rods these are adopted.

2 - Steel demand and product-mix (cont'd)

The consumption of bars and rods, however, for the years 1974 to 1977 were not available from Home Trade. As such, the likely trend for these years are determined indirectly by corelating with cement consumption.

The imports of cement from 1974 to 1977 are given in Table 2-3.

TABLE 2-3 - IMPORTS OF CEMENT

Year	Import tons
1974	95 053
1975	46 640
1976	49 593
1977	41 948

Note: On the basis of information collected from CSO, Ministry of Planning

The average steel consumption per ton of cement as observed in other developing countries is of the order of 85 kg. From the consumption of cement and bars and rods for the years 1978 to 1981, it is also seen that about 83 kg of steel was used per ton of cement as shown in Table 2-4.

TABLE 2-4 - SPECIFIC CONSUMPTION OF STEEL PER TON OF CEMENT

Year	Consumption		Specific consumption of steel/ton of cement
	Cement tons	Bars and rods tons	kg
1978	53807	4357	81
1979	70907	6306	89
1980	58331	4944	85
1981	82347	6390	78
	265392	21997	83

On the basis of 83 kg of steel per ton of cement, the requirements of cement for 1974 to 1977 have been estimated and compared with corresponding imports in Table 2-5.

2 - Steel demand and product-mix (cont'd)

TABLE 2-5 - ESTIMATED CONSUMPTION OF BARS AND RODS

Year	Import of bars and rods(1) tons	Requirement of cement(2)(3) tons	Import of cement(3) tons
1974	6564	79100	95100
1975	3115	37500	46600
1976	7214	86900	59600
1977	6615	79700	42000
TOTAL	23508	283200	243300

NOTES:
(1) Including wire rods
(2) On the basis of 83 kg consumption
(3) Rounded off

The aggregate imports of cement accounts for about 86% of requirements estimated on the basis of specific consumption norms of steel per ton of cement. In view of this, the quantities of bars and rods shown in the import statistics have been taken as the consumption for the years 1974 to 1977.

In regard to pipes and tubes, it is observed from Table 2-1 that entire imports are shown against cast iron pipes and tubes for the period 1974 to 1978.

From the import statistics it is noted that cast iron pipes accounted for about 80% of the total pipes and tubes (excluding seamless) as shown below:

Year	Cast iron pipes tons	Steel pipes and tubes tons	Total pipes and tubes tons	Share of cast iron pipes %
1978	2102	1439	3541	59
1979	4743	767	5510	86
1980	1591	14	1605	99
1981	746	11	757	99
TOTAL	9182	2231	11413	80

2 - Steel demand and product-mix (cont'd)

Assuming that the share of cast iron pipes during 1974 to 1977 was also on an average 80% of the total pipes, the quantity of cast iron pipes has been estimated as follows:

Year	Pipes and tubes tons	Estimated cast iron pipes (1) tons	Steel pipes tons
1974	2067	1654	413
1975	994	795	199
1976	1993	1594	399
1977	1700(2)	1360	340

NOTES:
(1) On the basis of 80% of total pipes and tubes
(2) Not indicated in import statistics. The average for the year 1974 to 1976 is assumed

Keeping in view the above, the adjusted category-wise consumption of steel for the period 1974 to 1981 are given in Appendix 2-2 and summarised in Table 2-6.

TABLE 2-6 - ADJUSTED IMPORTS OF STEEL

Year	Nonflat tons	Flat tons	Total tons
1974	6564	1084	7648
1975	3115	970	4085
1976	7214	1764	8978
1977	6642	1632	8274
1978	5301	2366	7667
1979	7968	5323	13291
1980	13837	6023	19860
1981	8649	2475	11124

DEMAND PROJECTIONS

Forecasting Techniques

There are various methods which could be applied for projecting the future demand, depending on the information that could be collected, nature of projections and the time horizon. The various forecasting techniques are detailed in Appendix 2-3.

2 - Steel demand and product-mix (cont'd)

Selection of Techniques

Historical analogy: The historical analogy method is essentially based on the stages of economic development which can be compared with those of other countries having similar economy. The divergent economic structures prevailing in different developing countries make it difficult to select suitable countries for meaningful comparison. In view of this, the historical analogy method is not considered suitable for forecasting steel demand in PDRY.

Trend analysis: For estimating steel demand, trend analysis is generally applicable when reliable time series data for a reasonably long period (say 7/8 years) are available. Moreover, the trend analysis which is based on the past trends to project future levels of consumption is more realistic for established economy showing steady trend. In view of the above this method is used as one of the projection methods for arriving at the likely average demands.

Regression analysis: Instead of relating the steel consumption on time intervals, the regression method correlates the consumption with reliable macro-economic indicator/indicators. Here again, similar to the trend analysis, this method is applied as one of the forecasting techniques for the determination of average demands.

End-use: The end-use approach is basically a derivative approach and starts with an analysis of current demand for an industrial product by major consuming sectors in terms of the product types and categories. On the basis of the projections of the growth of major user industries and sectors as well as technical norms of consumption, the future pattern and quantum of demand are estimated.

2 - Steel demand and product-mix (cont'd)

The end-use method is the most appropriate method for forecasting the demand by product category and sizes in a developing economy. However considering the limited data available on past consumption, future plan programmes etc, the end-use technique is not directly applicable for projections of demands in PDRY. In view of the above, sectoral demands based on their projected contributions to the economy have been estimated by adopting macro-end use approach.

Technological forecasting: The technological forecasting method such as Delphi, Scenario and Pattern are mainly oriented towards finding the technological levels that can be achieved by progressively adopting certain procedures. The Delphi model was applied to estimate population levels in some countries. The Delphi model being essentially an interactive technique, it is difficult to adopt this technique for estimating the demand for steel. The reason is that the application of this technique calls for brainstorming sessions with a number of experts in different branches of technology which is impracticable in a developing country where the number of experts are generally limited. The other techniques such as Scenario and Pattern are aimed at forecasting technological levels of development that can be attained rather than the demand for the products. Hence, these techniques are not suitable for estimating the future steel demand in PDRY.

Adopted techniques: On the basis of the above analysis the future demands of steel in PDRY for the years 1985, 1990 and 1992 have been projected by the following techniques:

i) Macro end-use approach
ii) Time trend analysis
iii) Regression analysis and
iv) Per capita analogy

In addition to the above, demands of bars and rods derived from the total steel demands projected by the above mentioned methods have been cross-checked with estimates made on the basis of correlation with cement consumption.

2 - Steel demand and product-mix (cont'd)

Estimates of GDP

It is to be pointed out that the most significant macro economic indicator of development used in the above forecasting techniques (except time trend analysis) is GDP. The GDP values at 1977 constant price for the years 1973 to 1980 are given in Table 2-7.

TABLE 2-7 - GDP (AT 1977 CONSTANT PRICE) BY MAJOR SECTORS
(million YD)

Sector	1973	1974	1975	1976	1977	1978	1979	1980(1)
Industry(2)	10.3	10.3	9.9	12.5	15.9	18.5	17.0	20.0
Construction (3)	5.1	5.6	7.9	8.8	12.1	21.6	22.0	26.3
Transport and communication	9.7	9.1	9.2	13.2	16.2	17.7	19.1	20.6
Agriculture	13.0	14.5	14.8	14.4	14.4	14.2	13.1	14.5
Fisheries	5.7	6.7	6.2	11.3	10.0	3.9	4.1	7.5
Tertiary(4)	59.6	53.0	55.5	63.6	79.9	74.6	89.0	101.7
TOTAL ..	103.4	99.2	103.5	123.8	148.5	150.5	164.3	190.6

NOTES:
(1) Estimates are tentative
(2) Includes petroleum, mining, water and electricity
(3) Includes building in various sectors
(4) Includes trade, hotels, net income tax etc.

From Table 2-7, the GDP growth rates for the five-year periods starting from 1973 are calculated as follows:

Period	Growth rate %
1973-78	8.0
1974-79	10.7
1975-80	12.7

The growth rates of GDP (at 1980 cement price) for the periods 1980-85 and 1985-1990 envisaged by the Ministry of Planning are as follows:

2 - Steel demand and product-mix (cont'd)

Period	Growth rates planned %
1980-85	10.0
1985-90	10.2

It is generally observed that the growth rates show a declining trend with progressive time lapse. On such a conservative basis, the following growth rates have been assumed for projecting GDP till the year 1992.

Period	Planned	Adopted growth rates %
1980-85	10.00	10.00
1985-90	10.20	8.00
1990-95	-	7.00

On the basis of the above growth rates, the projected GDP levels are indicated below:

Year	Growth rate %	GDP(1)	
		Million YD	Million US$ (2)
1985	10.0	306.9	890
1990	8.0	450.9	1310
1992	7.0	516.2	1500

NOTES:
(1) The GDP values being at 1977 constant prices
(2) On the basis of exchange rate of US $ 1 = YD 0.345 (figures rounded off)

Macro end-use approach

In macro-end-use approach, the aggregate demands are projected from sectoral GDP and corresponding steel input coefficients. The percentage shares of the major sectors in total GDP as furnished by Ministry of Planning have been adopted. For 1992 the likely percentage shares are assumed based on the trend upto the year 1990. The contributions of major sectors to GDP for the years 1985, 1990 and 1992 are given in Table 2-8.

2 - Steel demand and product-mix (cont'd)

TABLE 2-8 - SECTORAL CONTRIBUTION TO GDP AT 1977 CONSTANT PRICE

Sector	1985 Contribution		1990 Contribution		1982 Contribution	
	%	mill " $	%	mill US$	%	mill US$
Industry	10.3	91	11.1	146	11.4	171
Manufacturing	8.7	77	9.0	118	9.1	137
Others(1)	1.6	14	2.1	28	2.3	34
Construction(2)	11.5	102	11.3	148	11.2	168
Transport and communications	15.3	136	16.5	216	17.0	255
Agriculture	7.6	68	6.1	80	6.0	90
Fisheries	5.4	48	4.9	64	4.7	71
Tertiary	39.6	354	39.0	510	38.3	575
	100.0	890	100.0	1 310	100.0	1 500

NOTES:
(1) Includes petroleum, mining, electricity and water.
(2) Includes buildings in various sectors.

The sector-wise steel consumptions have been estimated by applying the corresponding steel input coefficients which have been ascertained based on the norms observed in other countries. These are given below:

Sector	Input coefficients tons/mill US$
Industry	
Manufacturing ..	65
Others ..	30(1)
Construction(2) ..	200
Transport and communication	10
Agriculture ..	40
Fisheries(3) ..	10

NOTES:
(1) Combined norms for petroleum, mining, electricity and water.
(2) Including the construction of tertiary sector
(3) Excluding construction of cold storage, warehouse etc which are included in construction sector.

On the basis of above steel input coefficients, the estimated requirements of steel as derived by macro end-use approach for the years 1985, 1990 and 1992 are given in Table 2-9.

2 - Steel demand and product-mix (cont'd)

TABLE 2-9 - FINISHED STEEL REQUIREMENTS BY SECTORS
(thousand tons)

Sector		1985	1990	1992
Industry	..	5.4	8.5	9.9
Manufacturing	..	5.0	7.7	8.9
Others	..	0.4	0.8	1.0
Construction(2)	..	20.4	29.6	33.6
Transport and communication		1.4	2.2	2.5
Agriculture	..	2.7	3.2	3.6
Fisheries	..	0.5	0.6	0.7
TOTAL	..	30.4	44.1	50.3

NOTE:
(1) Including the construction of tertiary sectors.

Time-trend Analysis

The past imports of steel in PDRY for the period 1974 to 1981 are given in Table 2-6. From Table 2-6, it is noted that the imports reached about 20 000 tons in 1980 from a level of about 8 000 tons in 1974 and dropped drastically to 11 000 tons in 1981. In the absence of information on changes in inventory, the imports are considered to reflect the apparent consumption. Therefore, in adopting the time trend analysis, in order to minimise the effects of fluctuations, it would be rational to take moving averages. The analysis has been made on the basis of annual, 2-year moving average.

The least square equation of the trend for 2-year moving average is $Y = 10.24 + 1.81\ t$, with the base year 1978. The correlation coefficient obtained is 0.88. On the basis of the above equation, the finished steel demand for the selected years are as follows:

STEEL DEMAND BY TIME-TREND ANALYSIS

Year		t	1.81t	Projected demand: Finished steel '000 tons	Projected demand: Say '000 tons
1985	..	7	12.7	22.94	23
1990	..	12	21.7	31.94	32
1992	..	11	25.31	35.54	36

2 - Steel demand and product-mix (cont'd)

Regression Analysis

In the regression analysis, the past consumption of steel has been correlated with available past data of GDP at 1977 constant price. The simple regression equation obtained using GDP as independent variable is $Y = 6.44 + 0.107 X$. The correlation coefficient obtained is 0.9. The projected steel demands on the basis of above equation are follows:

STEEL DEMAND BY REGRESSION ANALYSIS

Year	GDP(1) mill YD	0.107X '000 tons	Projected demand: Finished steel '000 tons	Projected demand: Rounded off '000 tons
1985	307	32.85	26.41	26
1990	451	48.26	41.82	42
1992	516	55.21	48.77	49

NOTE:
(1) At 1977 constant price.

Per capita Analogy

It is established that there is a correlation between per capita GDP and per capita steel consumption levels. However, if GDP is accrued mainly from non-manufacturing sector, the per capita consumption is low compared to those countries having the same order of per capita GDP but at the same time have higher contribution to GDP by manufacturing sector.

With the gradual industrialisation it is expected that per capita consumption levels will gradually rise in PDRY. The projected per capita GDP at 1977 constant price for PDRY are given below:

Year	Population mill No.	GDP(1) million US$	Per capita GDP US$	Per capita GDP Say US$
1985	2.164	890	411	410
1990	2.460	1 310	532	530
1992	2.590	1 500	579	580

NOTE;
(1) At 1977 constant price.

2 - Steel demand and product-mix (cont'd)

For arriving at the likely level of per capita steel consumptions in PDRY for the years 1985, 1990 and 1992, the consumption levels of countries with similar economy are analysed. Based on the economic structure in terms of contribution to GDP by major steel consuming sectors such as manufacturing and construction, the following countries are considered economically comparable with PDRY.

Country selected	Contribution to GDP: Manufacture per cent	Construction per cent
PDRY (1985)	8.7	11.5
(1990)	9.0	11.3
(1992)	9.1	11.2
Zambia (1970)	10.0	7.0
Liberia (1977)	8.0	6.0
Morocco (1975)	17.0	7.0
(1977)	17.0	9.0
Philippines (1978)	25.0	7.0
Tunisia (1978)	10.0	7.0

The per capita consumption levels of the selected countries corresponding to the levels of per capita GDP similar to those projected for PDRY are analysed. The range of per capita consumption and the estimated per capita GDP of PDRY are as follows:

LIKELY PER CAPITA CONSUMPTION

Year	PDRY Per capita GDP(1) US$	Per capita steel consumption(2) Lowest kg	Highest kg	Average kg
1985	410	14	22	18
1990	530	17	28	23
1992	580	17	33	25

NOTES;
(1) At 1977 constant price
(2) In terms of crude steel.

2 - Steel demand and product-mix (cont'd)

It is observed that for different levels of per capita GDP, there are different values of per capita steel consumption. Therefore, the average between the lowest and the highest per capita GDP is taken as the guideline for adopting likely per capita steel consumption levels in PDRY for the years under study.

Keeping in view the average per capita consumption of about 10 kg during the period 1979 to 1981, the future level of likely per capita consumption assumed is given below. It is to be pointed out that the adopted per capita consumption in this method need not necessarily agree with the per capita consumption figure which has been derived from the steel demand given in Table 2-10 as this is an average of four different projections.

Year	Per capita consumption Average kg	Adopted kg
1985	18	15
1990	23	20
1992	25	22

On the basis of these values of the probable per capita consumption, the likely steel requirements are given below:

STEEL REQUIREMENTS - BY PER CAPITA CONSUMPTION ANALOGY

Year	Population million	Steel requirements		
		Crude '000 tons	Finished(1) '000 tons	Say '000 tons
1985	2.164	32.5	25.0	25
1990	2.460	49.2	37.8	38
1992	2.590	57.0	43.8	44

NOTE:
(1) Calculated on the basis of 1.3 conversion factor from crude steel to finished steel.

The steel demands for the years 1985, 1990 and 1992 obtained by the various projection techniques are given in Table 2-10 and graphically shown in Fig 2-1.

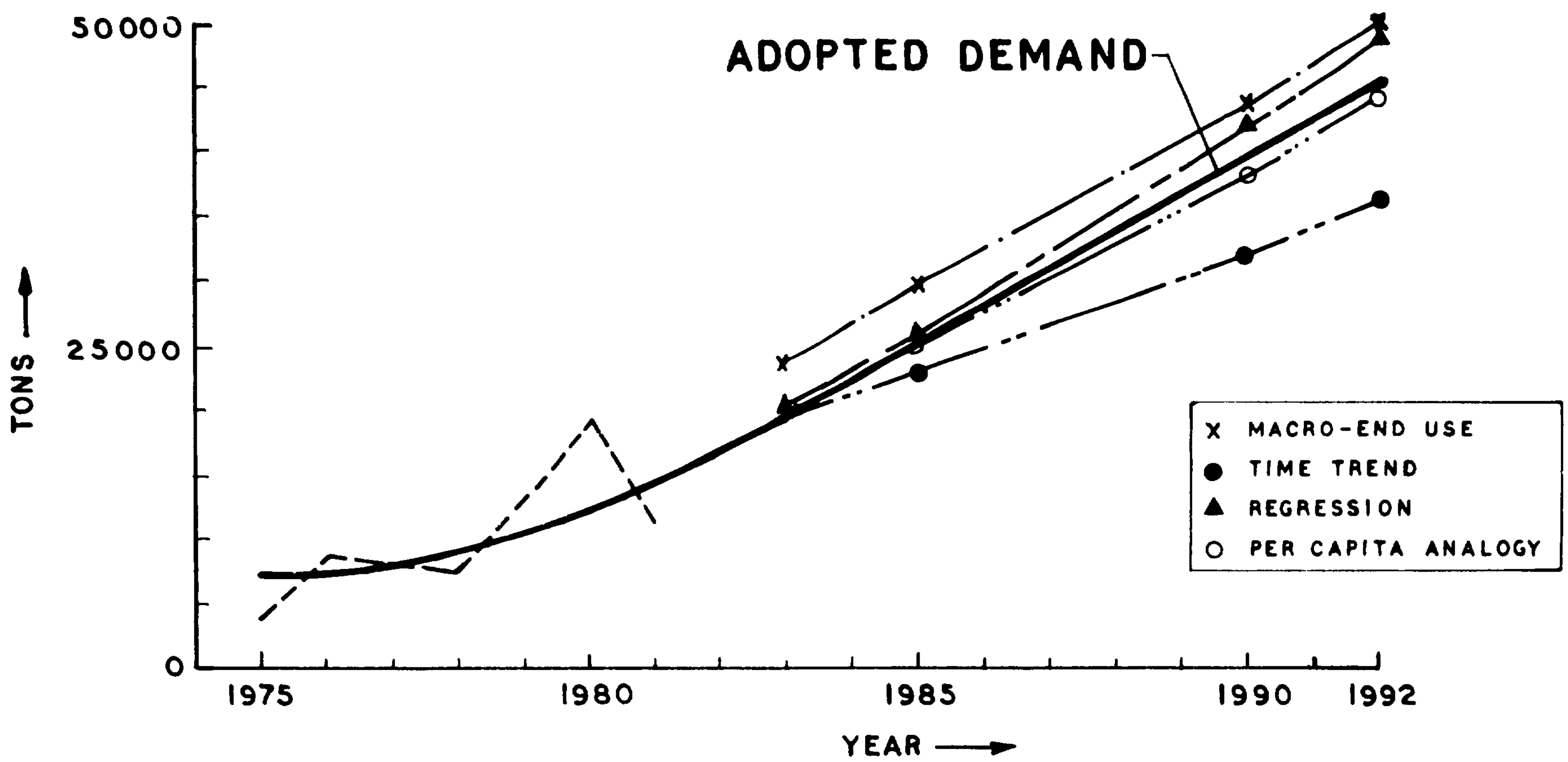


FIG. 2-1. STEEL DEMAND BY DIFFERENT METHODOLOGIES

2 - Steel demand and product-mix (cont'd)

TABLE 2-10 - FINISHED STEEL DEMAND FORECASTS

Methodology	1985 '000 tons	1990 '000 tons	1992 '000 tons
Macro end-use	30.0	44.0	50.0
Time-trend	23.0	32.0	36.0
Regression	26.0	42.0	49.0
Per capita analogy	25.0	38.0	44.0
	104.0	156.0	179.0
Average	26.0	39.0	44.8
Adopted	25.0	40.0	45.0

Category-wise Consumption

The past domestic steel consumptions have been broken down in two broad categories, non-flat and flat as shown in Table 2-6. The pattern of category-wise past consumption of steel for the period is shown graphically in Fig 2-2. From the Fig 2-2 it is observed that share of non-flat products, though declining in nature, was more than 70 per cent except for the years 1978 and 1979. The major share of non-flat products was undoubtedly due to extensive construction activity.

It is generally observed that with progressive development of the country, the proportion of flat products (including pipes and tubes) tends to increase over a period of time and depending on the type of economy, it stabilises at a level of 55 to 60 per cent of the total steel consumption. Keeping in view the above and the nature of trend shown in Fig 2-2, the proportion of non-flat and flat products in future steel demand in PDRY has been assumed as given below:

Year	Share in total demand	
	Non-flat per cent	Flat per cent
1985	65	35
1990	60	40
1992	60	40

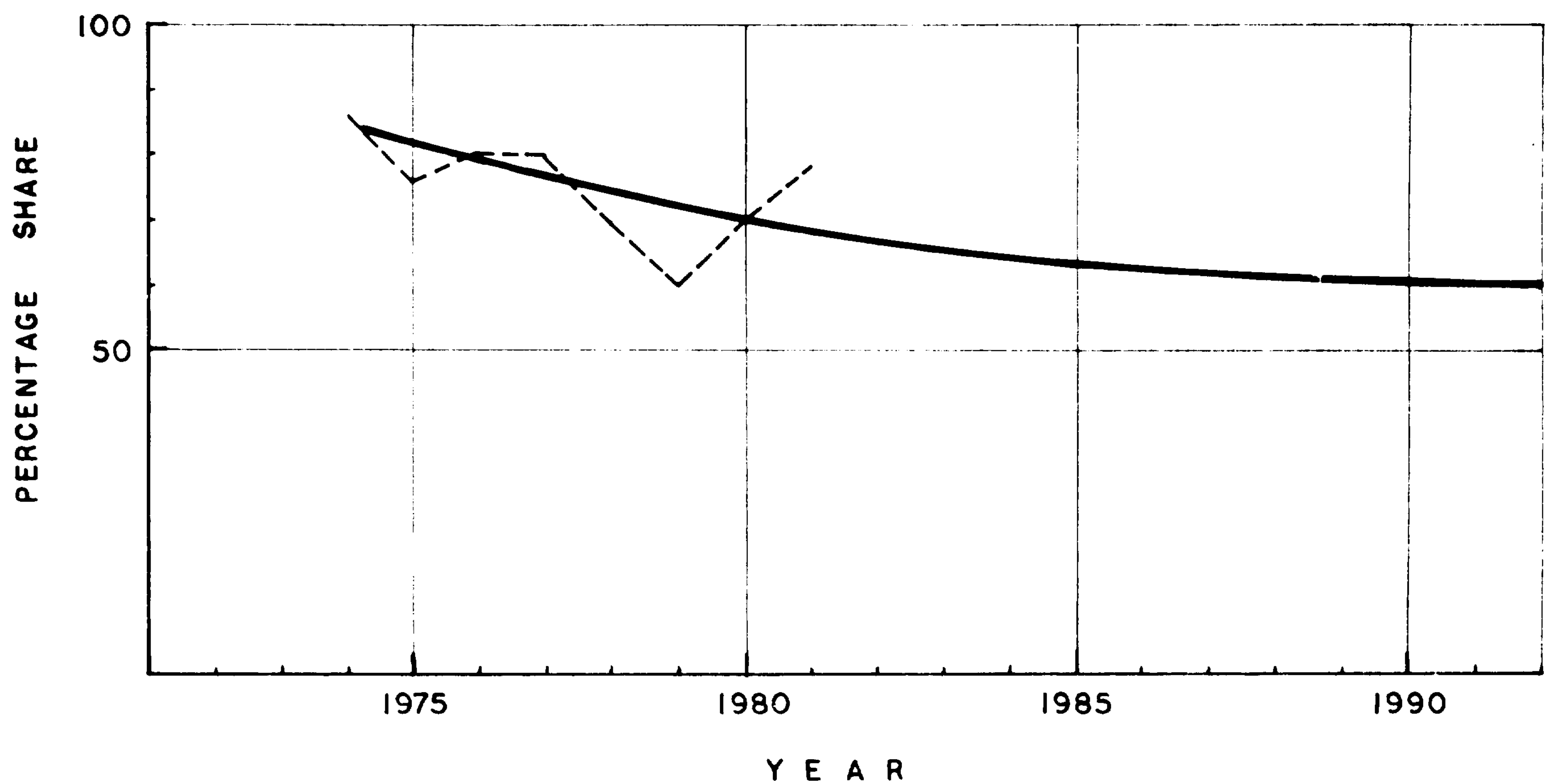


FIG. 2-2. SHARE OF NON-FLAT PRODUCTS IN TOTAL STEEL

2 - Steel demand and product-mix (cont'd)

Based on the above percentage shares, demand of non-flat products in PDRY for the years 1985, 1990 and 1992 are estimated as follows:

Year	Share in total demand per cent	Total demand '000 tons	Demand of non-flat '000 tons
1985	65	25	16
1990	60	40	24
1992	60	45	27

Demand of bars and rods: The non-flat products include bars and rods, wire rods, structurals, wires and seamless tubes. Generally, the demand of wire accounts for about 3 per cent and seamless tubes account for about 5 per cent in non-oil rich countries and the share of bars and rods including sections may account for 90 per cent of total non-flat demand. The quantity of bars and rods and sections estimated on the above basis are given in Table 2-11.

TABLE 2-11 - DEMAND OF BARS, RODS AND SECTIONS

Year	Total of demand '000 tons	Percentage share per cent	Demand '000 tons
1985	16	90	14.4
1990	24	90	21.6
1992	27	90	24.3

Of the total demand given above, about 10 per cent may be considered as section products. Thus the demand of total bars and rods (including wire rods) will be of the order of 13 000 tons, 19 500 tons and 22 000 tons for the year 1985, 1990 and 1992 respectively. The demand of bars and rods thus estimated are also cross checked with requirements projected on the basis of correlation with cement companies.

2 - Steel demand and product-mix (cont'd)

Correlation with cement consumption: The past imports of cement in PDRY for the years 1978 to 1981 have been collected from National Company for Home Trade, and have been presented in Table 2-3 earlier. From the consumption of bars and rods for the same period (1978 to 1981) it has been estimated that about 83 kg of steel was used per ton of cement. Keeping in view the gradual shift towards the heavier section of bars and rods in future due to increased emphasis on construction of high-rise buildings, it is assumed that about 90 kg of bars and rods will be required per tonne of cement till 1985 and 100 kg per ton of cement beyond 1985.

At present the cement consumption is of the order of 82 000 tons. In the Plan Document it is envisaged that the construction section will grow at about 9 per cent for the period 1980 to 1990. Assuming the same growth rate of 9 per cent till 1992 the projected cement consumption are indicated below:

Year	Cement consumption '000 tons
1985	125
1990	195
1992	210

The requirements of bars and rods on the basis of assumed consumption norms are estimated as follows:

Year	Specific consumption of bars and rods kg/ton of cement	Cement consumption '000 tons	Requirement of bars and rods
1985	90	125	11.3
1990	100	195	19.5
1992	100	210	21.0

The demand for bars and rods estimated above on the basis of co-relation with cement consumption agree fairly well with those discussed under "Demand of Bars and Rods" in page 2-24.

2 - Steel demand and product-mix (cont'd)

Bars and rods: Size-wise break-down of past consumption of bars and rods for the years 1979, 1980 and 1981 are given in Table 2-12.

TABLE 2-12 - SIZE-WISE CONSUMPTION OF BARS AND RODS

Size range	1979		1980		1981	
mm	tons	%	tons	%	tons	%
6-8	602	9.5	611	12.4	1 003	15.7
10	750	11.9	485	9.8	1 069	16.7
12-25	4 954	78.6	3 848	77.8	4 318	67.6
	6 306	100.0	4 944	100.0	6 390	100.0

It is expected that in future there will be more and more high-rise buildings and as such the proportion of 6-8 mm will grdually go down with respect to 1980/1981. In view of the above, the likely size-wise distribution of demand of bars and rods for the years 1985, 1990 and 1995 are assumed as given below:

Size range	1985	1990	1992
mm	%	%	%
6 - 8	12	10	10
10 -25	88	90	90
	100	100	100

It is assumed that the entire flat bar demand in PDRY will be within 50 mm wide.

The section products include angles, channels, tees and beams. In PDRY, mainly small angles (upto 50x50 mm) are used and will continue to be used. It is assumed that angles (upto 50x50 mm) will account for 10 per cent of total requirement of sections.

Based on the above analysis, the break-down of demand of non-flat products into size ranges is given in Table 2-13.

2 - Steel demand and product-mix (cont'd)

TABLE 2-13 - BREAK-DOWN OF DEMAND OF NON-FLAT PRODUCTS

	Size mm	Demand (tons) 1985	1990	1992
Bars and rods				
i) Round bars	6 - 8	1 500	1 900	2 100
incl wire rods	10 -25	11 000	17 100	18 800
		12 500	19 000	20 900
ii) Flat bars	upto 50	500	1 000	1 100
		13 000	20 000	22 000
Sections				
i) Angles	upto50x50	900	1 100	1 400
ii) Others		500	500	900
		1 400	1 600	2 300
TOTAL		14 400	21 600	24 300

Regional Distribution of Demand

Bars and rods: Almost the entire requirement of bars and rods in PDRY is for costruction purposes. The regional distribution of round bars and cement by Governorates for the years 1979, 1980 and 1981 are given in Table 2-14.

TABLE 2-14 - GOVERNORATE-WISE CONSUMPTION OF BARS, RODS AND CEMENT

	1979				1980				1981			
	Round bars		Cement		Round bars		Cement		Round bars		Cement	
Governorate	tons	%	tons	%	tons	%	tons	%	tons	%	tons	%
Aden	3043	48	28347	40	3081	62	36804	63	4996	78	48361	59
Lahej	330	5	21979	31	428	9	9747	17	299	5	11771	14
Abyan	764	12	14578	21	623	13	10569	18	446	7	11398	14
Shabwa	913	15	5189	7	552	11	756	1	516	8	1907	2
Hadramout	1256	20	813	1	260	5	455	1	133	2	8910	11
TOTAL	6306	100	70906	100	4944	100	58331	100	6390	100	82347	100

From the above it is seen that Aden and Lahej account for more than 70 per cent of the total consumption of bars and rods as well as cement.

2 - Steel demand and product-mix (cont'd)

Others: The consumption of other steel in terms of pieces as furnished by National Company for Home Trade for the years 1979 to 1981 are given in Table 2-15. It is assumed that the average weight per piece is more or less equal for all the Governorates.

TABLE 2-15 - GOVERNORATE-WISE CONSUMPTION OF OTHER STEEL

Governorate	1979 Others '000 pcs	1979 Others %	1980 Others '000 pcs	1980 Others %	1981 Others '000 pcs	1981 Others %
Aden ..	43.5	91	120.2	86	144.9	82
Lahej ..	1.5	3	4.8	3	3.2	2
Abyan ..	1.1	2	4.5	3	7.3	4
Shabwa ..	0.7	2	8.1	6	13.4	8
Hadramout	1.0	2	2.1	2	6.4	4
	47.8	100	139.7	100	176.0	100

Based on Table 2-14 and 2-15, it is concluded that bulk of the steel is consumed in Aden Governorate and together with the two adjacent Governorates (Lahej and Abyan) account for about 90 per cent of bars and rods as well as in terms of other steel. With the increased emphasis in development of other Governorates, however, the pattern may change my in future. The likely distribution pattern of steel in PDRY is given in Table 2-16.

TABLE 2-16 - LIKELY DISTRIBUTION PATTERN OF STEEL

Area	1985 '000 tons	1990 '000 tons	1992 '000 tons
Aden and Lahej	80	75	72
Abyan	8	10	10
Shabwa	8	10	12
Hadramout	4	5	6
	100	100	100

2 - Steel demand and product-mix (cont'd)

EXPORT POSSIBILITIES

It is to be emphasised that the proposed steel nucleus in PDRY is being conceived with the overriding objective of meeting demands of PDRY. Also, the steel unit to be installed in PDRY will be of such a small size, that it can hardly expect to have surplus quantities for export. If at all there is going to be an exportable surplus, then, it will be prudent to examine the export possibilities only to those close neighbouring countries which are largely dependent on imports. For this purpose the following countries in the region could be considered.

i) Oman and North Yemen
ii) Ethiopia
iii) Madagascar
iv) Mozambique

The total imports of finished and semi-finished steel by the above countries have been steadily going up over the years, as given in Table 2-17.

TABLE 2-17 - IMPORTS OF STEEL BY SELECTED COUNTRIES
('000 tons)

Country	1975	1976	1977	1978	1979	1980
Oman and N. Yemen	45.1	75.7	95.0	84.4	86.6	151.5
Ethiopia	22.8	24.0	39.8	16.5	37.9	45.1
Madagascar	29.6	24.9	34.3	34.0	52.3	52.5
Mozambique	21.2	18.3	14.4	37.5	4.2	5.1

Source: Statistics of World Trade in Steel, United Nations.

Again it is important to note that the eventual export to these countries would be relevant only in respect of the finished products which are included in the product mix of the proposed steel complex. For this purpose imports of the relevant selected finished products by the above countries, who might be the prospective buyers of steel from PDRY are given in Table 2-18.

2 - Steel demand and product-mix (cont'd)

While Table 2-18 clearly shows that the above selected countries do need to import their requirements of the different categories of steel, the question whether PDRY could be the possible exporter is something which cannot be answered with any certainty. Success of PDRY in exporting even small quantities to these countries would depend on several major considerations such as

(a) the competitiveness of PDRY steel in the export market

(b) the level of domestic demand and

(c) the production capability of the plant and equipment installed.

TABLE 2-18 - IMPORTS OF NON-FLAT STEEL BY SELECTED COUNTRIES
('000 tons)

	1978			1979			1980		
	Heavy(1) sections	Light sections	Wire rods	Heavy(1) sections	Light sections	Wire rods	Heavy(1) sections	Light sections	Wire rods
Oman and N. Yemen	56.17	10.60	8.27	42.92	22.50	8.30	63.76	15.69	10.60
Ethiopia	0.73	0.79	-	0.66	2.58	2.18	0.26	5.66	4.17
Madagascar	1.76	7.40	0.03	3.54	18.03	0.44	1.52	10.95	0.32
Mozambique	12.10	23.88	6.31	0.04	0.09	-	0.05	0.01	-
TOTAL..	70.76	42.67	14.61	47.16	43.20	10.92	65.59	32.31	15.10

NOTE:
(1) Includes bars and rods

Source: Statistics of World Trade in Steel, United Nations.

2 - Steel demand and product-mix (cont'd)

PLANT CAPACITY

The evolution of the plant capacity depends on the selected product-mix. For this purpose it will be appropriate to examine the domestic demand pattern in PDRY for the period upto 1990/1992 as the construction and gestation period for a steel plant, particularly in a developing country, is rather long. Further, in selecting the product-mix and plant capacity, the export possibilities as well as maximum utilisation of the various equipment and facilities are also to be taken into consideration.

Selection of Product-mix

The domestic demand for bars and rods as well sections by major size ranges in 1985, 1990 and 1992 are given in Table 2-16.

It is not possible to roll the entire range of products and sizes in a single mill. Considering that the major demand is for bars and rods for reinforcement, and taking into account the limited size of the market, it is proposed to install a semi-continuous bar and rod mill. On this basis, the suggested product-mix is given in Table 2-19.

TABLE 2-19 - SUGGESTED PRODUCT-MIX

Product	Size mm	Quantity tons
Reinforcing bars and rods	10-25	18 000
Flat bars	18-50(1)	1 000
Angles	50x50(max)	1 000
		20 000

NOTE;
(1) Maximum thickness assumed is 10 mm.

2 - Steel demand and product-mix (cont'd)

Annual Production

For the suggested product-mix given in Table 2-18 and the recommended production process, discussed hereinafter, the annual production requirements and the respective yields are as given below:

Finished steel production	..	20 000 tons/year
Yield of finished products from billets	..	92%
Requirement of billets	..	21 700 tons/year
Yield of billets from liquid steel	..	94%
Requirement of liquid steel	..	23 000 tons/year

3 - SCRAP AVAILABILITY

The basic raw materials for production of steel in the electric arc furnace is steel scrap. The total scrap requirement for the plant visualised at PDRY is estimated at 24 600 tons per annum. Approximately 10 per cent of the total requirements will be met from return scrap generated within the plant. The balance quantity of about 22 000 tons will have to be procured either from domestic sources or imported.

DOMESTIC SCRAP AVAILABILITY

Domestic scrap generation may be classified into three categories according to the mode of generation, namely:

i) Circulating scrap - produced in the steel plant during the process of steel production and consumed within the plant itself.

ii) Process scrap - generated by the steel processing and metal working industries

iii) Capital scrap - resulting from demolished steel structures, obsolete/damaged equipment and machinery, rejected automobiles etc.

Circulating scrap is consumed within the steel plant and is not available for sale. Since the industrial sector of PDRY is still in its formative stages and there are hardly any steel processing or metal working industries, generation of process scrap is considered to be negligible. The predominant source of scrap in PDRY is capital scrap.

Capital scrap in PDRY is mainly in the form of discarded passenger cars and other road transport equipment. Some quantity of capital scrap is also available as damaged construction machinery, metal products, furniture etc.

3 - Scrap availability (cont'd)

Estimates of Accumulated Scrap

Existing Scrap Dumps

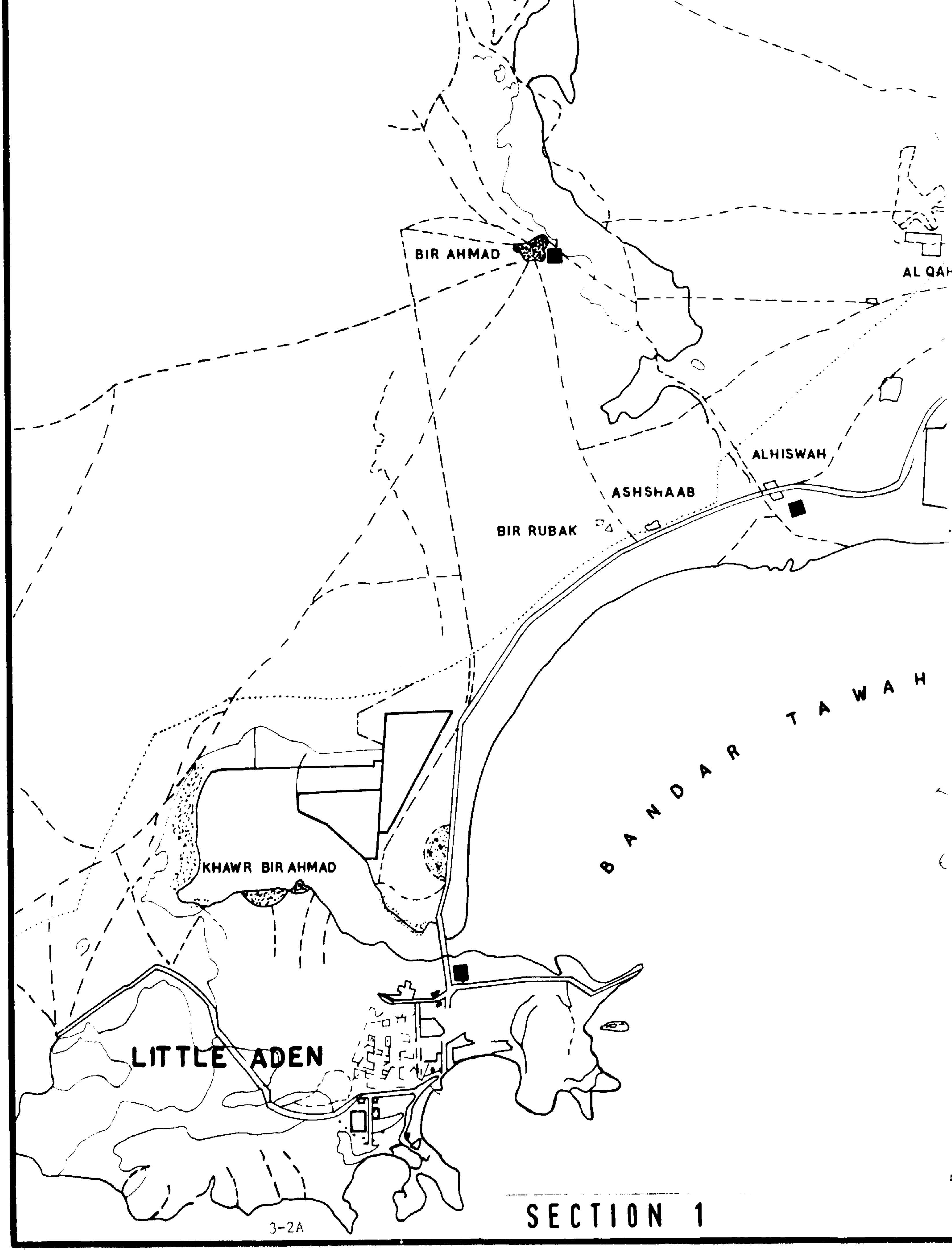
During the field survey investigations were carried out with the object of determining the quantum of scrap available in PDRY. These revealed that - there are about 20 scrap dumps in PDRY, scattered around the main cities/towns - majority of the scrapdumps are in and around Aden - The scrap dump around Aden is considered to represent about 6C to 70 per cent of the total scrap quantity accumulated in the country over the years.

The major scrap dumps in and around Aden are shown in Drawing 10020-3-1.

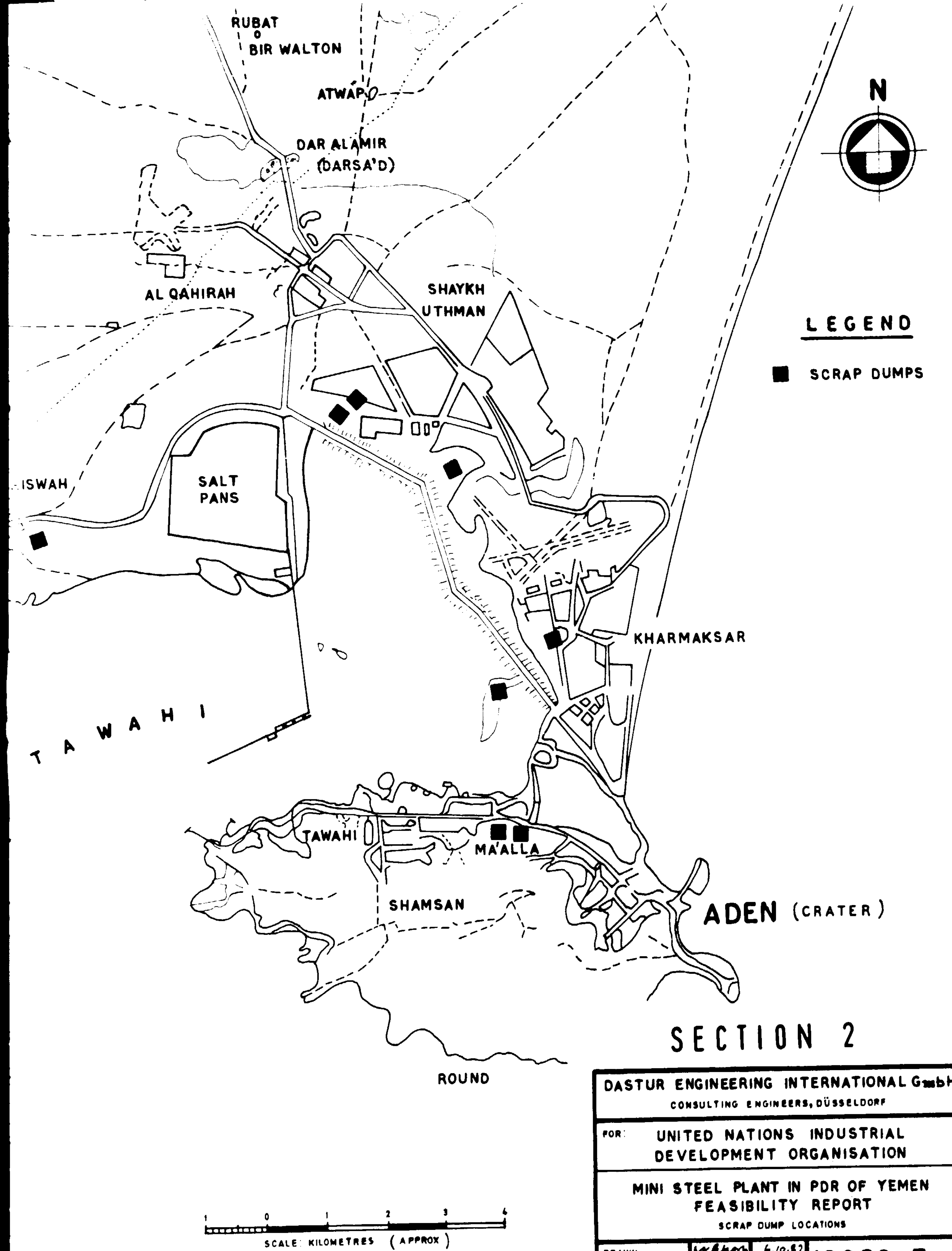
Visit to scrap dumps: It is understood that there are about 10 major scrap dumps in and around Aden. The following seven scrap dumps were visited during the field survey:

Location	No. of drums	Distance from Aden harbour km
Near airport	1	7
Duran	2	15
Malla	2	1
		6
Little Aden	1	37
Labour Island	1	6

From the scrap dumps visited, it is noted that in general they are mostly automobiles scrap. The scrap is generally of high quality, heavy melting type and do not contain turnings, borings and cuttings, obviously because of absence of any processing industries. Apart from these, the dumps also include in small quantities some machinery parts and domestic furniture.


BIR AHMAD
AL QAH
ALHISWAH
ASHSHAAB
BIR RUBAK
BANDAR TAWAH
KHAWR BIR AHMAD
LITTLE ADEN

SECTION 1



SECTION 2

DASTUR ENGINEERING INTERNATIONAL GmbH
CONSULTING ENGINEERS, DÜSSELDORF

FOR: UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

MINI STEEL PLANT IN PDR OF YEMEN
FEASIBILITY REPORT
SCRAP DUMP LOCATIONS

DRAWN	[illegible]	6.10.82	10020-3-1
APPROVED	[illegible]	8.10.82	

3 - Scrap availability (cont'd)

Visual assessment: From approximate area and average height covered by scrap, a preliminary assessment of quantity was made. It is assumed, on the basis of visual examination, that about 0.5 tons per cu m of volume may be considered as the average bulk density of scrap. On the above basis, the estimate of the scrap quantity for the seven scrap dumps visited are given in Table 3-1.

TABLE 3-1 - ESTIMATES OF SCRAP IN THE SCRAP DUMPS VISITED DURING FIELD SURVEY

Location	No.of dumps	Approx. area	Average height	Estimated volume	Approx. quantity
		sq m	m	cu m	tons
Near airport	1	60 000	1	60 000	30 000
Duran	2	65 000	1,5	100 000	50 000
Malla	2	6 000	1,5	9 000	4 500
Little Aden	1	-	-	-	325(1)
Labour Island	1	-	-	-	18 000(2)
					102 825
				Say	103 000

NOTE:

(1) Comprises only buses. Number of discarded buses is 125 equivalent to 325 tons of steel on the basis of 2.6 tons of scrap norm per bus.

(2) Comprises only small ships. Number of ships is about 69, equivalent to about 1 800 tons.

In this first quarter of 1982 a team of experts from Ethiopia surveyed various scrap dumps in and around Aden. On the basis of this survey, it is seen that aggregate quantity of scrap available in the seven dumps (also visited by the CONSULTING ENGINEERS) was estimated at 100 900 tons. As the the estimates indicated in Table 3-1 and those by the Ethiopians are very close, it is assumed that total steel scrap available in and around Aden is of the order of 110 000 tons, including defence scrap.

3 - Scrap availability (cont'd)

Total Scrap in PDRY

The scrap available in and around Aden is estimated at about 110 000 tons. Assuming the Aden covers about 60-70 per cent of the total scrap in the country, the gross availability in PDRY from the accumulated scrap dumps may be placed at about 180 000 tons.

The entire quantity of the scrap cannot be recovered. Assuming that at least 75 to 80 per cent can be recovered from the scrap dumps, the net-scrap, that will be available for the proposed mini steel plant, is of the order of 135 000 tons.

ESTIMATES OF FUTURE GENERATION

It is envisaged that by end-1986 the plant will go into operation. Therefore likely generation of scrap from 1983 to 1986 and beyond are relevant. As explained earlier the main source of scrap is automobiles and will continue to be so, till such time the processing industries are developed. The generation of automobile scrap is normally estimated from the automobile population in various years and the number of new automobiles added in the corresponding years. However, in the absence of such information in PDRY, an attempt has been made to estimate the generation of automobile scrap in PDRY based on yearly imports of various types of vehicles. The import of a particular type of vehicle is assumed equal to the number of new vehicles registered in a particular year. Available information on registration of new vehicles in the past are given in Table 3-2.

3 - Scrap availability (cont'd)

TABLE 3-2 - REGISTRATION OF NEW VEHICLES IN PDRY

Types of vehicles	1975	1976	1977	1978	1979
Private transport ..	9 529	9 573	9 869	10 327	11 730
Taxi ..	1 902	1 944	2 143	2 229	2 482
Bus ..	229	402	534	586	708
Trucks ..	8 476	9 137	10 799	11 182	13 912
Motor cycle ..	5 608	5 705	6 020	4 281	7 140
Tractor and mobile cranes	916	1 006	1 256	1 523	1 895

Source: Statistical Year Book, Central Statistical Organisation, Ministry of Planning, PDRY.

An average life of 12 years is assumed for private transport, taxis and motor cycles and 8 years for buses, trucks, tractors and cranes. Hence, in the case of 12 years useful life, those vehicles imported in 1975 can be considered as sources of scrap in 1987. In the case of 7 years useful life, the corresponding year of import will be 1979. On this basis, the theoretical quantity of automobile scrap in the year 1987 is estimated in Table 3-3.

TABLE 3-3 - THEORETICAL QUANTITY OF AUTOMOBILE SCRAP GENERATED IN 1987

Type of vehicles	Ref.year	Number	Scrap norm kg/unit	Total scrap tons
Private transport	1975	9 529	800	7 623
Taxi ..	1975	1 902	800	1 522
Bus ..	1979	708	2 500	1 770
Trucks ..	1979	13 912	1 500	20 868
Motor cycle ..	1975	5 608	50	280
Tractor and mobile cranes(1)	1979	1 895	2 000	3 790
TOTAL ..				35 853

Note:
(1) Combined norm for tractors and cranes.

3 - Scrap availability (cont'd)

Although the theoretical generation of automobile scrap is estimated at about 36 000 tons, the actual amount that will be available will be much less. For instance, even in a highly industrialised country like France, with a well developed and organised scrap collection and processing industry, the efficiency of scrap collection is only about 50 per cent. In PDRY there is no scrap collection/ processing agency. Therefore even assuming that the Government decides to take the initiative in developing the scrap processing industry in time to feed the proposed steel plant with domestic scrap, the scrap collection efficiency by 1987 is not likely to exceed 20 per cent. Hence, actual domestic scrap availability in PDRY by 1987 could be around 7 000 tons. On similar basis, the scrap availability for 1988 and 1989 are estimated as follows:

Type of vehicle	1988 tons	1989 tons
Private transport ..	7 658	7 895
Taxi ..	1 555	1 714
Bus ..	2 000(1)	2 250(1)
Trucks ..	22 500(1)	24 000(1)
Motor cycles ..	285	301
Tractors and mobile cranes ..	4 000(1)	4 500(1)
	37 999	40 660
Say	38 000	41 000
Net scrap available @20%	7 600	8 200

Note:

(1) These numbers are estimated on the basis of the yearly increase observed for the period 1975 to 1979. Number of buses, trucks, tractors and mobile cranes for the years 1980 and 1981 are not available.

3 - Scrap availability (cont'd)

Same approach could be adopted for estimating likely scrap generation for the period 1983-86 provided similar data, as given in Table 3-2, were also available. However as this type of data is not available, the estimate of scrap for the period 1983-86 has been made by extrapolation of the generation rate projected for the period 1987-89. It is estimated that average scrap generation for the period 1987 to 1989 will be about 38 000 tons. Therefore on a conservative basis, it may be assumed that at least 30 000 tons will be the average scrap generation for the period 1983-86. On the basis of 20% scrap collection efficiency, the likely availability per year, on an average, may be taken as 6 000 tons. Thus, by end 1986, in addition to 135 000 tons available from the existing scrap dumps, about 24 000 tons of scrap will also be available. Thus the total amount available to the mini steel plant, before operation starts, is of the order of 159 000 tons. Based on the above analysis, the scrap availability upto the end of 1989 are given below:

Source	tons
Existing scrap dumps(as of 1982)	135 000
Fresh generation:	
Period 1983-86 @ 6 000 t/yr ..	24 000
Period 1987-89 @ 7 000 t/yr ..	21 000
	180 000

Duration of Scrap supply from Existing Dumps

Of the total requirements of scrap of 24 600 tons, plant return scrap will be about 2 300 tons and therefore 22 300 tons will have to be made available from the existing scrap dumps, till such time they are exhausted. The estimated accumulated scrap of about 135 000 tons will enable operation for about 6 years at the full rated capacity production. Taking into consideration the build-up period as 2 years to achieve the full production level, the existing scrap of 135 000 tons will last for about 7 years. During this period of about 7 years, there will be fresh accumulations perhaps even more than the estimated 135 000 tons.

3 - Scrap availability (cont'd)

Duration of Scrap Supply from freshly Accumulated Scrap for the Period 1983-1986

Net scrap available to the mini steel plant from the total generation during 1983 to 1986 has been estimated above as 24 000 tons. This will be adequate for more than one year operation at the rate of 22 300 tons of purchased scrap.

Availability Beyond 1989

For the purpose of scrap balance, it may be assumed that yearly generation of scrap beyond 1989 will be about 8 000 tons and will increase by 1 000 tons for each period of 5 years from 1989. On this basis, the total scrap available for the plant, till the existing dumps are consumed, are estimated below:

Number of operating years with the existing scrap ..	7 (1987-1993)
Rate of generation for 1987-1989	7 000 tons
Total generation from 1987-1989	21 000 tons
Rate of generation from 1990-1993	8 000 tons
Total generation from 1990-1993	32 000 tons
Aggregate generation from 1987-1993	53 000 tons

Estimated quantity of 53 000 tons will last for more than 2 years at the rate of 22 300 tons annual requirement of purchased scrap. Thus the plant will be able to operate at least for a period of 10 years without any import.

Scrap supply Scenario

Sources of scrap supply and the quantity to be procured from local and imported for the 15 years of operation of the plant is given in Table 3-4.

TABLE 3-4 - SCENARIO OF SCRAP SUPPLY
('000 tons)

Sources of supply	Impl. period 1	2	3	4	Operating period 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A. EXISTING DUMPS - 135.000 TONS																			
i) Supply to mini steel plant					13.4	22.3	22.3	22.3	22.3	22.3	10.1	-	-	-	-	-	-	-	-
ii) Cumulative					13.4	35.7	58.0	80.3	102.6	124.9	135.0	-	-	-	-	-	-	-	-
B. FRESH ACCUMULATION																			
i) Rate of net accumulation	6.0	6.0	6.0	6.0	7.0	7.0	7.0	8.0	8.0	8.0	8.0	8.0	9.0	9.0	9.0	9.0	9.0	10.0	10.0
ii) Cumulative	6.0	12.0	18.0	24.0	31.0	38.0	45.0	53.0	61.0	69.0	77.0	85.0	94.0	103.0	112.0	121.0	130.0	140.0	150.0
iii) Supply to mini steel plant	-	-	-	-	-	-	-	-	-	-	12.2	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3
iv) Cumulative	-	-	-	-	-	-	-	-	-	-	12.2	34.5	56.8	79.1	101.4	123.7	146.0	168.3	190.6
C. SURPLUS/DEFICIT																			
i) Cumulative	6.0	12.0	18.0	24.0	31.0	38.0	45.0	53.0	61.0	69.0	64.8	50.5	37.2	23.9	10.6	-2.7	-16.0	-28.3	-40.6
ii) Net imports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.7	13.3	12.3	12.3

3 - Scrap availability (cont'd)

POSSIBILITY OF SCRAP IMPORTS

The world consumption of scrap in 1975 was around 290 million tons as against a world crude steel production of 652 million tons. In view of the trend in the share of electric arc furnace steel in the world steel production, the scrap consumption for steelmaking will continue to rise. As domestic supplies of scrap are inadequate to meet the melting stock requirements in many countries, these will have to be augmented by imports from scrap trading countries.

The pattern of scrap trade during the five years 1970 to 1974 reveals that USA is the largest exporter of scrap. For instance out of a total of about 19 million tons traded by selected countries in 1974, scrap exports from USA accounted for about 8 million tons. Other major exporters are EEC, USSR and Poland. Scrap-deficient countries are principally Italy, Spain and Japan, which account for over 60 per cent of the total scrap imports of all countries.

Based on a review of the world scrap situation and trade, the possible sources of scrap supplies to PDRY are USA, EEC, USSR and Poland which are the major exporting countries. The European sources will have an ocean freight advantage over USA.

Price of Scrap

As there are no steelmaking units in PDRY at present, there is no prevailing price for available domestic scrap. With the establishment of an arc furnace based steel plant there should be enough incentive for local entrepreneurs to collect, process and supply domestic scrap to the steel plant.

3 - Scrap availability (cont'd)

International scrap prices during the past decade have been characterised by frequent fluctuations owing to changes in demand caused by either a boom or a recession in global steel production. For instance, the price of heavy melting scrap in USA showed a downward trend till 1968, when it was US$ 25,86 per ton; it started moving up gradually reaching a peak in 1974 to US$ 108,51 per ton. There was fall in 1975 to US$ 70,90 per ton, but the prices rose again in the first half of 1976. Subsequently, the prices commenced falling and in December 1976, it came down to US$ 67,50 per ton. From Early 1978, however, the price showed an upward trend and in January 1980 it touched US$ 100 per ton. Subsequently, the price has steadily declined and by the middle of 1982 the price was around US$ 56 per ton. The corresponding price of No. 2 Bundles was US$ 42 per ton.

In view of the fast fluctuating trend in prices covering even short periods of time and the fact that scrap is conventionally traded on spot/short-term contract basis, the price at which scrap can be procured cannot be predicted with any degree of certainty. It will depend on the global conditions prevailing at the time of procurement. However, based on the price levels of scrap prevailing in the second quarter of 1982, the average f.o.b. price of scrap considering 50 per cent heavy melting scrap and 50 per cent No. 2 bundles is assumed as US$ 50 per ton. The landed price in PDRY is expected to be about US$ 60 per ton i.e. YD 20 per ton.

4 - RAW MATERIALS SITUATION

In Chapter 3, scrap situation in PDRY has been discussed. This chapter deals with the other major raw materials and examines the availability of these raw materials in respect of their possible sources, quantities and qualities. For those raw materials which are not available in PDRY and would have to be imported, the international market for such raw materials are reviewed. The likely unit prices for the raw materials are also estimated.

ANNUAL RAW MATERIALS REQUIREMENT

The annual production of 23 000 tons of liquid steel (20 000 tons finished products) by the scrap-based electric arc furnace route, the major raw materials required other than scrap and their approximate quantities are given in Table 4-1.

TABLE 4-1 - MAJOR RAW MATERIALS REQUIREMENT

Raw material	Use	Annual requirement tons
Limestone ..	As flux	1 700
Iron ore ..	As a decarburiser	230
Ferro-silicon	As a deoxidiser	80
Ferro-manganese	As an additive	160
Aluminium ..	As a deoxidiser	10
Fluorspar ..	As a thinner	50
Petroleum coke	As a carburiser	60

LIMESTONE

It is reported that in PDRY, a number of limestone deposits are available. Near Aden, there is a vast deposit of good grade limestone suitable for steelmaking. This deposit is situated at Batis in Abyan Province, about 90 km from Aden. Out of this distance of 90 km a distance

4 - Raw materials situation (cont'd)

of 80 km is metal road (Gaur-AL-Husan-Batis) and the rest 10 km is sand-graval-rock road. Considering this deposit as the main source of raw materials, a cement plant of 250 000 tons annual capacity has been planned. It is envisaged that by 1985 the cement plant will be implemented. The Batis limestone deposit was visited by the CONSULTING ENGINEERS' Field Team.

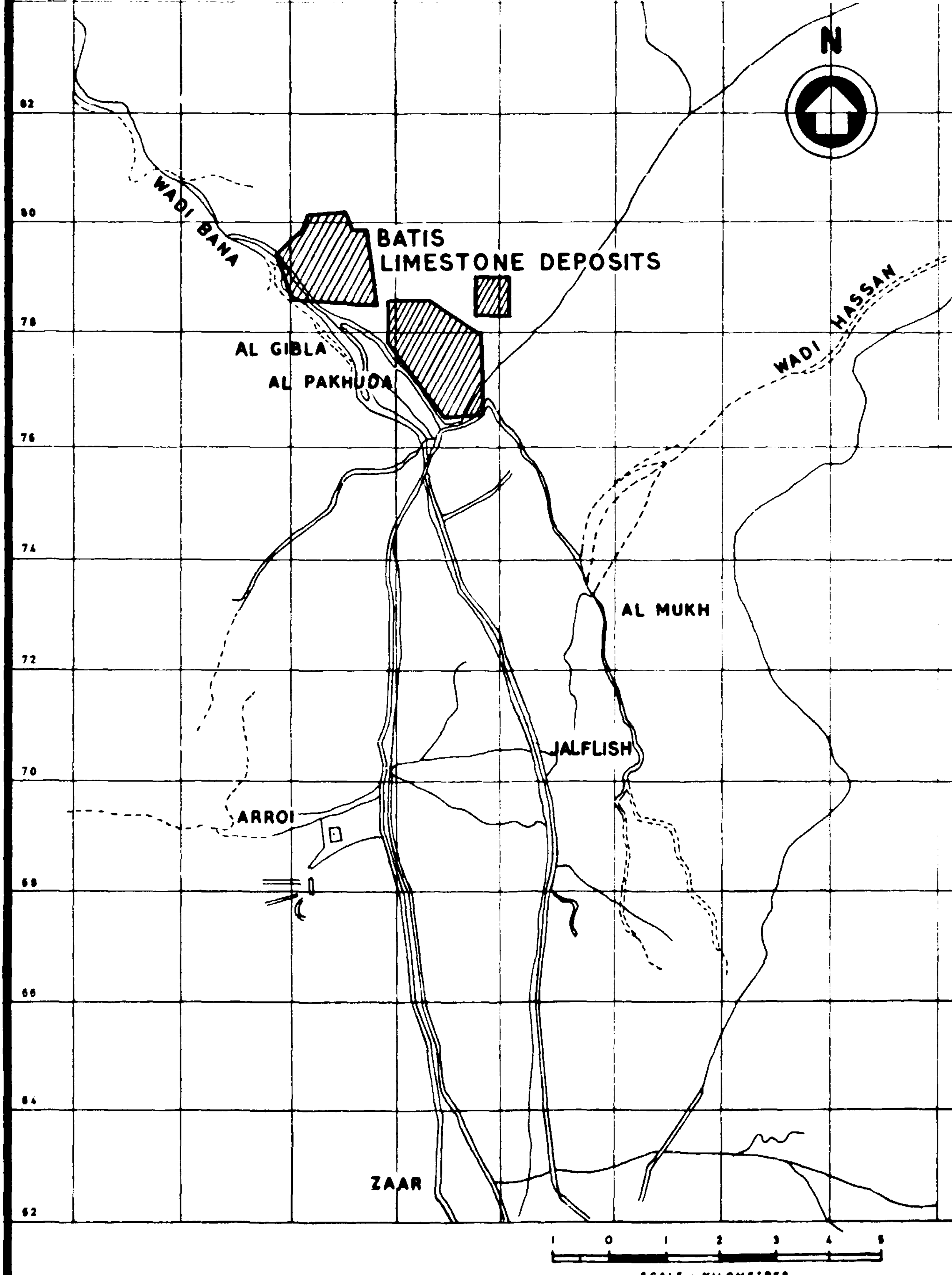
The location of the Batis deposit is shown in Drg 10020-4-1. The total area of the deposit is approximately 0.54 sq km. The total reserve is estimated at about 104 million tons as shown below:

Zone	Reserve million tons
A	7.5
B	16.6
C1	65.1
C2	14.7
	103.9

The deposit is entirely exposed and the overburden is practically absent. The typical analysis of limestone is as follows:

Constituent		%
CaO	..	53.09
MgO	..	1.16
SiO2	..	1.43
Al2O3	..	0.34
Fe2O3	..	0.27
LOI	..	42.99
R2O	..	0.21
TiO2	..	0.02
SO3	..	0.15
P2O5	..	0.02

It is expected that limestone of the required quality will be available from this deposit. The cost of limestone is indicated to be YD 0.89 per ton.



SOURCE:
REPORT ON DETAILED EXPLORATION OF BATIS LIMESTONE DEPOSIT BY DEPARTMENT OF ZEOLOGY AND MINERAL EXPLORATION, PDRY AND USSR GEOLOGICAL TEAM

4-2A

DASTUR ENGINEERING INTERNATIONAL GmbH
CONSULTING ENGINEERS, DÜSSELDORF

FOR: UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

MINI STEEL PLANT IN PDR OF YEMEN
FEASIBILITY REPORT
LIMESTONE DEPOSITS AT BATIS

DRAWN	[signature]	14.10.82	10020-4-1
APPROVED	[signature]	20.10.82	

4 - Raw materials situation (cont'd)

IRON ORE

So far no occurrances of iron ore are reported in PDRY. However, very little geological investigations have so far been undertaken to ascertain any existance of this raw material. Hence, for the proposed plant the requirement of iron ore will have to be imported. India can be considered as the most likely source of import. The prevailing f.o.b. price of iron ore is US$ 17 per ton with 64 to 65 per cent Fe. The landed price is adopted as US$ 22 per ton, which is equivalent to YD 6.5 per ton.

FERRO-ALLOYS

Ferro-manganese and ferro-silicon are the principal ferro-alloys required. The requirements of ferro-alloys would have to be met through imports.

Production and Export of Major Exporting Countries

There are over fifteen countries (excluding South Africa) exporting ferro-manganese and ferro-silicon. Of these, the major exporters are Norway, France, USSR, Japan, Belgium and Yugoslavia. The production and export of these countries in 1978 are given in Table 4-2.

TABLE 4-2 - PRODUCTION AND EXPORT OF FERRO-MANGANESE (Fe-Mn) AND FERRO-SILICON (Fe-Si) IN 1980

Country	Production ('000 tons)			Export ('000 tons)		
	Fe-Mn	Fe-Si	Total	Fe-Mn	Fe-Si	Total
Beligum ..	91.0(1)	-	91.0(1)	34.0	-	34.0
W. Germany	-	-	339.0	28.0	18.0	46.0
India ..	-	-	278	29.0	8.0	37.0
France ..	250.0	270.0	520.0	288.0(2)	80.0	368.0
Norway ..	-	-	610.0	246.0	269.0	515.0

Note:
(1) Figures given are for 1979, as no data for 1980 is available.
(2) The export is more than production and obviously the build up stock for previous years was used.

Source: Metal Bulletin Hand Book, 1981.

4 - Raw materials situation (cont'd)

Possible Sources of Supply

Considering the small quantities of ferro-alloys required for the proposed steel plant, it may be pointed out that procurement of ferro-alloys will not pose any problem.

In addition to the countries mentioned in Table 4-2, USSR, Spain, Sweden, Canada and Brazil may also be considered as possible sources of supply for ferro-alloys.

Price of Ferro-alloys

The iron and steel industry accounts for about 95 per cent of manganese consumption, as manganese is an essential constituent of virtually all steels and has no satisfactory substitute. The demand of ferro-manganese has also been fluctuating, as the requirement for manganese in the world market is a direct function of the level of world steel production.

USA, the leading importer of ferro-manganese, procured about 612 000 tons of ferro-manganese in 1978 from a number of countries spread all over the world, namely South Africa, Mexico, Australia, Norway, Brazil and Canada at prices ranging between US$ 300 and US$ 400 per ton. The 1979 purchase contracts were mostly settled by January 1979 at the 1978 price level. In the first quarter of 1980, the average price per ton of ferro-manganese (Mn 78 per cent) ranged between US$ 488 and US$ 511 and ferro-silicon (Si 75 per cent) between US$ 755 and US$ 833. During the whole of 1981 ferro-manganese prices have remained generally stable. During this period the European prices ranged between US$ 410 and US$ 450 per ton ferro-manganese and decreased to US$ 360 in mid-1982 and touched a level of US$ 344 in October 1982. The price of ferro-silicon dropped from about US$ 800 per ton in early 1981 to US$ 635 per ton in mid-1982 and reached as low as US$ 532 in October 1982.

4 - Raw materials situation (cont'd)

In view of the fluctuating nature of international prices of ferro-alloys, as well as the fact that transactions are done on a half-yearly basis, it is difficult to predict precisely the prices at which the two ferro-alloys could be procured. However, based on mid-1982 price levels, the average landed prices for ferro-manganese (78 per cent Mn and 7.5 per cent C) and ferro-silicon (75 per cent Si) can be considered as US$ 380 and US$ 665 respectively. This works out to YD 131 per ton ferro-manganese and YD 230 per ton ferro-silicon.

ALUMINIUM

Aluminium is produced in many countries and the world production in 1980 amounted to 15 million tons. Canada is the largest exporter (785 000 tons) followed by USA (648 000 tons) Norway, Netherland, Germany and UK. The small quantity required for the PDRY steel plant may also be obtained from neighbouring countries like India. In 1980 India produced about 185 000 tons of aluminium.

FLUORSPAR

Fluorspar is produced in many countries and the world production has been about 8 million tons in 1981. The largest producer and exporter is Mexico. Based on the export statistics, Mexico, Thailand, Spain, France and Italy may be the potential sources of fluorspar for supply to the steel plant.

PETROLEUM COKE

Petroleum coke may be available from Aden refinery. However, no information on the present production, quality and costs are available.

USA is the largest producer of petroleum coke in the world; other countries such as Argentina, Canada, Federal Republic of Germany, Rumania and India also produce petroleum coke. The requirement of PDRY can be met by imports. If available from Aden Refinery, fluorspar need not be imported.

5 - SELECTION OF PRODUCTION PROCESS

SELECTION OF STEELMAKING PROCESS

Two major considerations influence the choice of steelmaking process: (i) the type of raw materials to be used and (ii) the grades of steel to be made. In the context of PDRY, the charge material for steelmaking will be steel scrap as there are no known reserves of iron ore or metallurgical coal of suitable quality or quantity required for use in ironmaking. Some quantity of direct reduced iron (DRI) could also be used depending upon the availability and price. The steel grades envisaged to be produced include only mild steel which does not necessarily call for use of DRI as charge material which in current day market trend does not have a price advantage in comparison with scrap. The electric arc furace is the most suitable steelmaking unit for melting scrap or DRI. However for the initial years of operation at least scrap-based electric arc furnace steelmaking is recommended for adoption. Later on in the future if the then prevailing prices of DRI and quality of steel to be produced justify, use of DRI should be no problem.

Electric Arc Furnace Steelmkaing

The operations of the proposed plant will be based on electric arc furnace steelmaking. With the recent developments in electric furnace technology and the advent of continuous casting, electric furnace-cum-continuous casting machine combinations have become more attractive and have made the installations of small steel plants economically more viable.

The electric arc furnace in its early stages was mainly used for alloy and special steels production. However, during the last decade, it has also become a major tonnage steel producer, mainly because of the development of large arc furnaces, improvement in furnace design and adoption of high power and ultra high power systems.

5 - Selection of production process (cont'd)

Arc furnace power: The most significant development in electric arc furnace steelmaking technology in recent years has been the phenomenal rise in power inputs to the furnace to reduce melting time and increase furnace productivity. Modern practice generally distinguishes between regular power (RP) operation and ultra high power (UHP) operation. As may be noted from Figure 5-1, there is no precise demarcation between the two operations.

With RP, the meltdown time will be two hours or more, while with UHP this is not likely to exceed one hour. With intermediate power inputs, meltdown times of 1 to 2 hours are achieved.

High power operations are not only characterised by high power levels during meltdown, but also by high power level of the average integrated power over the total power-on time of the entire heat. In UHP, this ratio should be over 0.7. Generally, UHP is used for the manufacture of tonnage commercial steels, where full advantage of quick melting can be taken as the refining periods are short.

Keeping the above trends in view, the installations of arc furnaces with higher transformer ratings than those employed for 'Regular Power' operation is considered for PDRY.

Preheating of scrap: Another technique employed to increase electric arc furnace productivity is preheating of scrap. A 10 per cent increase in production and about 10 per cent decrease in power consumption have been achieved with a preheat temperature of about 350 Deg C. The benefits will be greater with higher preheat temperature. Scrap preheating requires special type of charging buckets and additional investment on preheating installations. This also adds to shop scheduling problems. In view of this, scrap preheating has not been considered for the proposed plant.

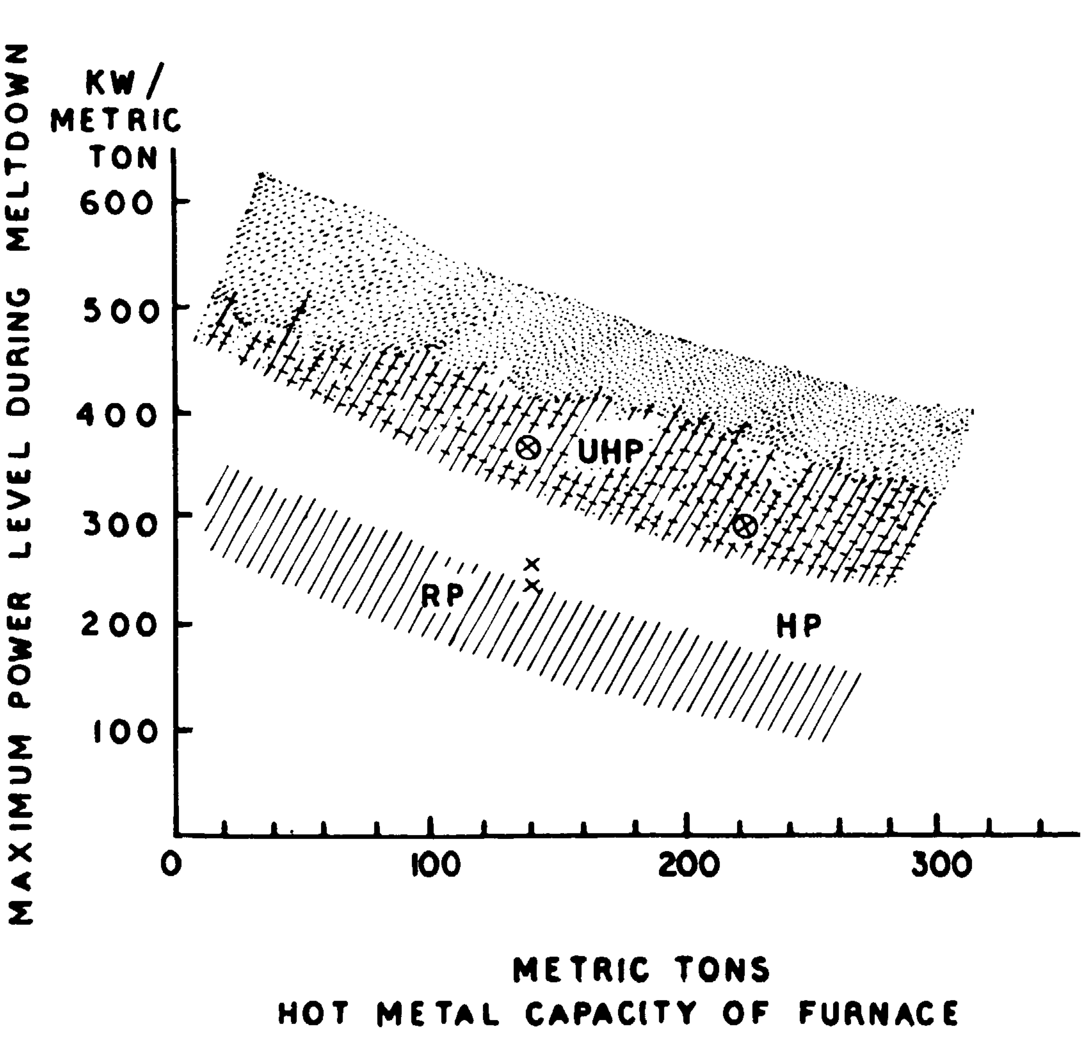


FIG.5 -1. RANGE OF SPECIFIC POWER LEVELS OF ARC FURNACES

5 - Selection of production process (cont'd)

Use of DRI in Electric Steelmaking

The ability of the arc furnace to melt sponge iron will give further fillip to its growth. This is because of the world-wide trend towards increasing use of sponge iron following the global shortage of scrap which was the basic raw material for the electric arc furnace operation at its early stages. Also the favourable economics of the direct reduction-electric furnace route for smaller scale of production affords an opportunity to many developing countries with limited finances and small market to make a start on integrated steelmaking. In recent years a number of mini steel plant have been installed all over the world and some of them have integrated direct reduction facilities. At present about 16 million tons of steel capacity has been installed based on DR-EF route.

Besides replacing scrap, DRI offers other important advantages. It has very low tramp elements and, therefore, is well suited for making high grade steels which call for low levels of residual copper, nickel and chromium. As DRI is of known composition, greater control can be exercised over the steelmaking operation. The continuous charging technique of feeding DRI has made possible the introduction of mechanisation and automation to a greater extent. It also enables higher average power input and reduces the flicker level on the electric power supply system. For the PDRY ministeel plant, the need for using DRI may arise after about 12 to 13 years of operation when scrap will have to be imported as shown in Table 3-4 of Chapter 3.

SELECTION OF CASTING PROCESS

Two routes can be adopted for casting liquid steel - (i) conventional ingot casting, and (ii) continuous casting.

5 - Selection of production process (cont'd)

Conventional Ingot Casting

In conventional ingot casting, liquid steel is poured into ingot moulds; the ingots are stripped, heated and then rolled in primary mills to produce semis such as blooms and slabs.

Continuous Casting

On the other hand, in continuous casting, liquid steel is directly cast into semis like blooms, billets and slabs. World-wide the installed capacity of continuous casting has risen from a mere 1 million tons in 1960 to 150 million tons by 1974 and has reached about 250 million tons by 1978. It is estimated that the share of continuous casting in the world raw steel production will rise to about 50 per cent by 1990, from about 30 per cent at present.

Advantages of continuous casting: The rapid progress of continuous casting is mainly due to the many advantages it offers over ingot casting. Continuously cast semis are usually smaller in section than the conventional ingot. They can be converted into finished products with less reduction and fewer operations on smaller and less expensive equipment than required for conventional ingots. For instance, continuous casting of blooms and billets instead of rolling them from ingots, results in the elimination of ingot casting and stripping facilities, soaking pits and primary mill. Besides possible savings in capital investments, the most important advantage arises from higher yields. The yield from liquid steel to semis in the continuous casting route varies from 94 per cent to 96 per cent, as against 81 per cent to 89 per cent by the ingot casting route. Except for some high alloy and special steels, all grades of steels may be continuously cast. A comparison of the conventional ingot practice and the continuous casting practice is drawn in Figure 5-2.

The continuous casting process has now attained such a level of development that large integrated steel plants producing tonnage carbon steels for conversion into bars and section products or flat products can be based wholly on continuous casting of steel into semis as required.

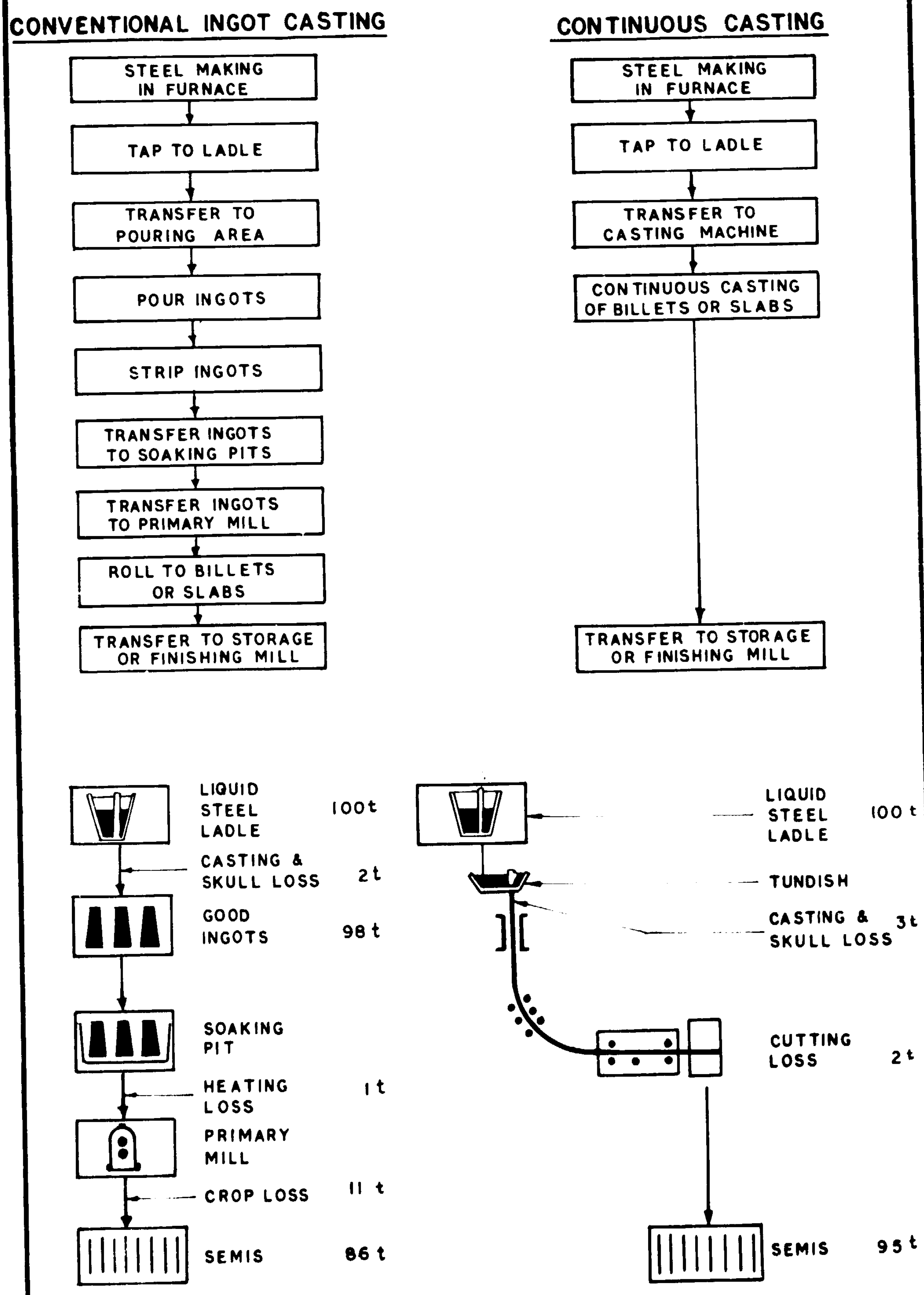


FIG. 5-2. COMPARISON BETWEEN CONVENTIONAL AND CONTINUOUS CASTING METHODS

5 - Selection of production process (cont'd)

In the case of mini-steel plants, the adoption of continuous casting enables production of good quality billets in the place of conventional pencil ingots or small size ingots. It also obviates the need for a breakdown mill for rolling the ingot to billet as well as the limitation imposed on the rolling mill due to the small weight of ingots.

From the foregoing review, it will be seen that the adoption of continuous casting technique is obviously the right solution for the proposed steel plant in PDRY and is therefore recommended.

Choice of continuous casting machine: From the early vertical type of continuous casting machine, several other types have been developed, mainly with the objective of reducing the machine height, lowering construction cost, improving operational convenience and increasing the casting rates. The four types of machines generally in use are:

i) Vertical type with vertical discharge
ii) Vertical type with bending discharge
iii) Circular arc type with straight mould, and
iv) Circular arc type with curved mould.

All the above machines are being successfully employed for casting ordinary grades of steels. Each type of machine has its own specific advantages as well as limitations, and the selection of a particular type will depend on the grades to be cast, the extent to which it has been proved and other considerations.

In the context of PDRY, taking into account the quality of steels proposed in the product-mix, the size range of billets required for the rolling mill and the overall economics, a low-head machine is considered the most appropriate and it is recommended.

5 - Selection of production process (cont'd)

SELECTION OF ROLLING FACILITIES

The product-mix envisages production of reinforcement bars and rods, as well as some quantities of flat bars and light angles. For the sizes of finished products to be rolled, the input materials will be 100 mm sq continuous cast billets.

The rolling facilities will essentially consist of billet heating furnace and a bar and rod mill.

Choice of heating furnace: For heating billets the furnace could be of the walking beam type or the pusher type. The walking beam furnace has the advantages of providing better quality product, greater flexibility of operation and lower scale losses. On the other hand, pusher furnace is lower in capital cost, simpler to operate and easier to maintain. For the type of product envisaged the quality requirements can be adequately met by a pusher type furnace. Therefore, installation of a pusher type furnace is recommended.

Choice of bar and rod mill: The choice of a bar and rod mill depends on the shape, size, quality and output of the finished products required. For the proposed plant in PDRY the ultimate annual production envisaged is 70 000 tons per year, for which the bar and rod mill can be any of the following types:

i) Open-train-cross-country
ii) Semi-continuous
iii) Continuous

The open-train-cross-country types have the strands arranged side by side in a single line and are low production units. The capacity of such units may be upto 50 000 tons per year.

5 - Selection of production process (cont'd)

Semi-continuous mills, which quite often are combination of continuous/open-train-cross-country mills, are employed where the required production is too high for an open-train-cross-country mill and low for a continuous mill.

Continuous bar and rod mill are high capacity units, the capacity ranging from about 200 000 tons to 800 000 tons per year. In these mills, the bar is reduced in a number of stands at the same time. Long billets can be used, and the temperature drop beginning to end, and between passes, is minimum. Automation of these mills enables rolling at high speeds of up to 200 metres per second and over 70 metres per second for rods.

In the context of the production envisaged for the proposed plant in PDRY a single-strand semi-continuous cross-country mill is the only type which merits consideration as this provides the necessary capacity range as well as adequate technological features to ensure a good product. The continuous mills are designed for very large capacities and as such cannot be considered.

6 - PLANT LOCATION, SITE SELECTION AND GENERAL LAYOUT

In this Chapter, major factors which influence the selection of a location for the establishment of steel plants are discussed. The important features of alternative locations evaluated in PDRY are described and the basis on which the proposed site has been recommended for selection is explained.

PLANT LOCATION

The important locational factors to be considered are the availability of adequate area of suitable land, proximity to existing transport network, sources of power and water, nearness to the developed areas of the country, which also normally are the major market centres, and avilability of construction materials.

The overriding consideration which has prompted the idea of establishing the proposed steel plant in PDRY is to utilise the accummulated steel scrap in the principal cities. As discussed in Chapter-3 the majority of scrap is accumulated in and around Aden which accounts for 60 to 70 per cent of the total accumulated scrap. In the initial stage the plant will be able to sustain its operations based on the accumulated home scrap which may last for a period of 10 to 12 years, beyond which substantial quantity of steelscrap will have to be imported. Therefore at a point of time majority of the requirements of raw materials will have to be transported by sea to the plant site. Keeping this in view, plant site would be best located on sea coast.

6 - Plant location, site selection & general layout (cont'd)

Land

Adequate area of land as required for the steel plant complex and all the infrastructure facilities should be available. Further, the shape and topography of the land should not impose constraints on the development of the most desirable layout features for the complex as a whole. The land should preferably be non-agricultural and uninhabited. The topography should be as flat as possible to reduce site development costs, but should drain well. The sub-soil conditions should be good enough to bear the loads of equipment.

Proximity to existing transport network

Considerable amount of traffic, both material and passenger, will be generated by the activities of the steel plant and the associated infrastructure. It would be ideal therefore if the location is close to the main highway which can be suitably connected to the plant by approach roads. It should also be not far away from a major airport in the country to facilitate domestic and international travel, particularly of government and management officials, expatriate employees, important visitors, etc. It would also be useful to have an airport nearby, if and when imported spare parts are to be rushed by air freight during emergency situations.

Nearness to electric power and water supply

The steel plant will need electric power and water initially for the construction activities and later on for plant operation. The requirements during the construction period will be small but will go up substantially when the plant facilities are commissioned. As there are limited sweet water sources in PDRY, the water requirements are to be met from sea water desalination plants. For these considerations, it will be of great advantage if the location is not far away from existing national electricity grid/power plant and desalinated water sources. Such a location would enable the construction work to be started without delay, by drawing the requirements from these sources.

Nearness to developed areas and major market centres

If the location is near the already developed region of the country, the steelplant will derive several benefits: it will make the steel plant more attractive for engineers, technicians, workers and expatriates. For instance, the employees can take advantage of higher education facilities for their children, avail of specialised medical services to their families and have better opportunities for academic, technical and cultural activities. Further, it will be much easier for the steel plant authorities to liaise with suppliers, consumers, local industries, local and foreign firms, government departments etc.

In most of the developing economies of the size of PDRY, generally the major market will be the capital area and its neighbourhood, where the bulk of the construction and industrial activities remain concentrated. Therefore, from the point of view of nearness to market also, it is desirable that the location of the steel plant is in proximity to the capital area in PDRY, that is Aden.

Availability of construction materials

Large quantities of construction materials such as cement, coarse and fine aggregates, etc will be required for the construction of the steel plant. Availability of these materials within a reasonable distance will be an advantage.

Coastal location

As already mentioned, because of the large import of raw materials at a point of time when the accumulated domestic scrap will be exhausted, it would be economical to locate the steel plant on the sea coast, where suitable port and harbour facilities exist. A coastal location will also facilitate the installation of power and desalination plant, if required, which will require sea water and simplify the dischage and drainage problems. Further, it will be possible to use coastal shipping for local supplies, and for despatch of products to domestic destinations on the coast.

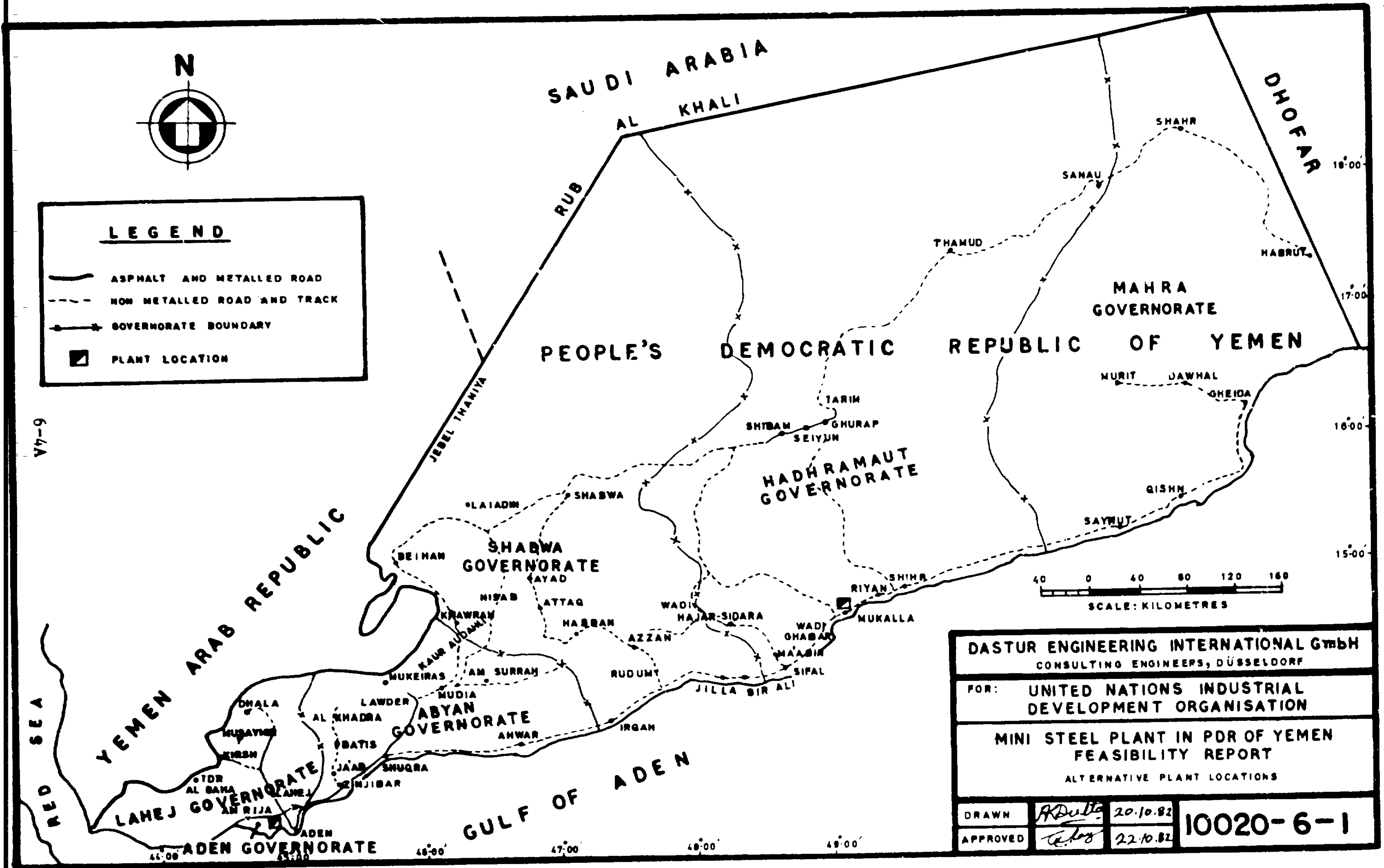
Pre-selection of alternative locations

Based on the CONSULTING ENGINEERS' field investigations, and their various discussions with government agencies, two possible areas have been preselected as possible locations for the proposed steel plant. These are Aden and Al Mukalla as shown in Drawing 10020-6-1. The reasons for preselecting these two locations are summarised below:

i) Nearness to main consuming centre: Aden is the principal steel consuming centre in PDRY. Therefore from market considerations the plant should be located near the major consuming centres, so as to reduce product distribution cost.

ii) Developed port facilities: The plant will be dependent to a considerable extent on imported scrap at a later date; also other raw materials such as ferro-alloys, aluminium, etc will have to be imported, and for this purpose availability of a port within reasonable distance from the plant site would be advantageous in reducing the cost of transporting imported raw materials. In this connection it should be noted that for the production of one ton of finished product, approximately equal quantity (1.0 ton) of raw materials would have to be imported, and in this context location of the proposed steel complex on the coast near a developed port would be of advantage. These advantages would be even more relevant when in the future scrap will have to be imported on account of local scrap resources getting fully used up.

There are only two ports at present in PDRY - Aden and Al Mukalla.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LEGEND
ASPHALT AND METALLED ROAD
NON METALLED ROAD AND TRACK
GOVERNORATE BOUNDARY
PLANT LOCATION
SAUDI ARABIA
AL KHALI
RUB
JEBEL THANIYA
DHOFAR
PEOPLE'S DEMOCRATIC REPUBLIC OF YEMEN
YEMEN ARAB REPUBLIC
RED SEA
GULF OF ADEN
MAHRA GOVERNORATE
HADHRAMAUT GOVERNORATE
SHABWA GOVERNORATE
ABYAN GOVERNORATE
LAHEJ GOVERNORATE
ADEN GOVERNORATE
SHAHR
SANAU
THAMUD
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TARIM
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SEIYUN
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QISHN
SAYHUT
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RIYAN
MUKALLA
WADI GHABAR
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SIFAL
JILLA BIR ALI
WADI HAJAR-SIDARA
AZZAN
RUDUM
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KAUR AUDAHLI
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DASTUR ENGINEERING INTERNATIONAL GmbH
CONSULTING ENGINEERS, DÜSSELDORF
FOR: UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION
MINI STEEL PLANT IN PDR OF YEMEN
FEASIBILITY REPORT
ALTERNATIVE PLANT LOCATIONS
DRAWN
APPROVED
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6 - Plant location, site selection & general layout (cont'd)

In view of the fact that Aden is not only the main consuming centre, but also enjoys the benefits of a well developed port, Al Mukalla in comparison to Aden can be evaluated only as an alternative location.

Evaluation of location

Raw materials assembly cost: The raw materials required to be assembled to produce one ton of finished product are as follows:

	kg
Scrap ..	1 115
Limestone ..	85
Iron ore, ferro-alloys,etc	29

Iron ore, ferro-alloys and additives will be imported through the ports at Aden or Al Mukalla. Limestone could be obtained from Patis in case of a plant location at Aden. In case of Al Mukalla the possible source of supply of limestone needs to be identified. It is understood that in PDRY there are adequate reserves of good grade limestone scattered all over the country. In view of this it may be assumed that it will be possible to identify a suitable limestone deposit near Al Mukalla. Assuming that the plant is to be located as near as possible to the port, the assembly costs for ferro-alloys and additives will be similar for both Aden and Al Mukalla. Therefore, the main difference in raw materials assembly cost between the two locations will be on account of domestic scrap as shown in Table 6-1.

6 - Plant location, site selection & general layout (cont'd)

TABLE 6-1 - ASSEMBLY COST OF SCRAP

	Aden location	Al Mukalla location
Source of domestic scrap	Mainly Aden area	Mainly Aden area
Distance from plant	15 (1)	520 (1)
Freight rate	YD 0.12/t km(2)	YD 0.01/t km(3)
Scrap to b ^ns-ported per ton of finished product product	1 115 kg	1 115 kg
Assembly cost per ton finished product	YD 2.007	YD 5.798

Note

(1) Weighted average distance from the existing scrap dumps in and around Aden.

(2) Transport cost is YD 35.00 for a 10/12 ton truck within Aden Governorate. Assuming average distance of transport as 30 km, the average freight rate works out to YD 0,12 per ton-km.

(3) Average charge for a 10/12 ton truck is YD 50 from Aden. On this basis, the freight rate works out to about YD 0,01 per ton-km.

Finished Product Distribution Cost

As discussed in Chapter 2, the major market for steel in PDRY is Aden. The distribution pattern for 20 000 tons of finished product is assumed to be as follows:

Governorate		Quantity '000 t	Share %
Aden/Lahej	..	14.5 to 16.0	72 to 80
Abyan/Shabowa (for Al Mukalla)	..	2.5 to 3.5	12 to 18
Others	..	1.5 to 2.0	8 to 10

6 - Plant location, site selection & general layout (cont'd)

Based on the above distribution pattern, the distribution costs per ton of finished product for the two locations are computed in Table 6-2.

TABLE 6-2 - PRODUCT DISTRIBUTION COST

	Aden location	Al Mukalla location
1. Pattern of distribution,%		
i) To Aden/Lahej ..	72 to 80	72 to 80
ii) Abyan/Shabowa (for Al Mukalla location) ..	12 to 18	12 to 18
2. Distance from plant location, km		
i) To Aden/Lahej ..	15 (1)	520 (2)
ii) Abyan/Shabowa (for Al Mukalla) ..	520	5
3. Freight rates from plant location, YD/ton-km		
i) To Aden/Lahej ..	0.12	0.01
ii) Abyan/Shabowa (for Al Mukalla) ..	0.01	0.12
4. Weighted average transport cost per ton of finished product, YD	1.130 to 1.345	2.745 to 4.235

Note

(1) Distance assumed as average figure, taking into consideration the Lahej Governorate.

(2) The distance between Al Mukalla and Aden is 516 km and an additional 4 km is taken to cover the distances of the Lahej Governorate.

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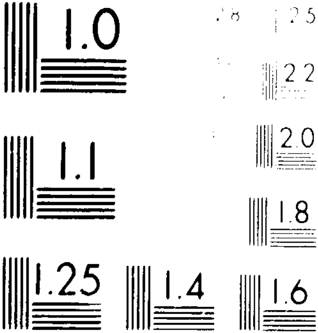

1.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

6 - Plant location, site selection & general layout (cont'd)

Availability and price of land

The total land requirement for the plant will be about 12 hectares. Adequate flat land is expected to be available in and around Aden and Al Mukalla. The CONSULTING ENGINEERS have been given to understand by the Ministry of Industry that although there may be significant difference in the land cost from location to location, for projects of national importance like the proposed steel plant, the required land would be placed at the disposal of the project authorities at no cost.

Availability of utilities and infrastructure facilities

The existing and likely power situation in PDRY has been discussed in Chapter 8. As indicated therein only one power plant of 2 x 55 MW is currently under construction. In future, a 16 MW power station may be installed at Al Mukalla. The short circuit level available with one of the TG set working will be around 650 MVA when Hiswa power plant will be in operation. This will ensure smooth operation of two 8-ton arc furnaces selected for the proposed plant. But the required short-circuit level will not be available at Al Mukalla. Therefore, from the point of view of power, Al Mukalla is not quite suitable.

Water

According to information received from the Public Corporation for Water, though the quality of bore-well water in Al Mukalla area is not as salty as that obtaining in and around Aden, any heavy industry as the proposed steel plant may not be permitted to draw water only from bore wells. In view of this, the plant, if located in Al Mukalla area, has to be located near a desalination plant. It should be emphasised however that it would be totally uneconomical to install a desalination plant as a captive unit for supply of water to the proposed steel plant. Viewed from

6 - Plant location, site selection & general layout (cont'd)

the economic considerations therefore the Al Mukalla location is handicapped, particularly because the proposed steel plant is too small to justify the installation of a desalination plant for supplying the required quantitites of water.

Road transport

Both Aden and Al Mukalla are well connected with the major cities of the PDRY by all-weather asphalted roads.

Port facilities

At present there are only two ports in PDRY as already mentioned - Aden and Al Mukalla. Coastal shipping services linking Aden and Al Mukalla are in operation in which traditional boats called "Dhow" are used.

Aden port, one of the finest natural harbours in the region, was the fourth largest bunkering port (after London, Liverpool and Rotterdam) until the closure of Suez Canal in 1968. The closure of Suez Canal adversely affected the advantageous position enjoyed by Aden.

However, with the reopening of the canal in 1975, the port of Aden gradually recaptured its position. The number of ships using Aden harbour and bunkering facilities is gradually increasing from the pre-1975 level. To improve the port facilities at Aden, the GOVERNMENT purchased a floating dry dock, with lift capacity of 12 000 tons. Berth facilities for ships unloading cargo have also been improved.

6 - Plant location, site selection & general layout (cont'd)

Currently, Aden port is suitable for ship size of 20 000 DWT. Still larger ships have to be anchored in mid- stream and lighters are to be used for transporting cargo to the quay. At present there are 88 lighters of capacity ranging from 200 tons to 400 tons. Lighter is towed to the quay where it is unloaded at the wharf. Fork lifts of 25 ton capacity and mobile cranes of also 25 ton capacity are available today at the Aden port, together with a floating crane of 26/28 tons capacity. Al Mukalla, being a smaller port and with inadequate berth draft and length, is only capable of receiving lighters. From the above brief discussion it would be seen that while Aden could be considered to have adequate handling and port facilities already, Al Mukalla's facilities have to be improved vastly to be able to meet the demands of the steel plant.

Housing and other social amenities

For the plant personnel and their families adequate housing facilities and various social facilities such as schools, colleges, medical facilities, shopping centres and entertainment facilities have to be provided. Aden being a large city and capital of PDRY, most of the above facilities will be readily available. In case of Al Mukalla, however, these amenities are yet inadequate. Creation and development of these facilities, specially in respect of living accommodation and other necessary social amenities for the plant personnel, would involve heavy additional costs.

Recommended location

Location near Aden favoured: Based on the above discussions on the merits and demerits of the two pre-selected locations, Table 6-3 below summarises the salient features:

6 - Plant location, site selection & general layout (cont'd)

TABLE 6-3 - RELATIVE MERITS AND DEMERITS OF ALTERNATIVE LOCATIONS

Criteria	Aden location	Al Mukalla location
1. Raw material assembly cost	Of the order of YD 2.007 per ton product.	Very high. Of the order of YD 5.798 per ton product.
2. Product distribution cost	Of the order of YD 1.25 per ton	Very high. Of the order of YD 7.0 per ton.
3. Availability of land	Adequate	Adequate
4. Availability of electric power	Adequate power will be available at 33 kV from Hiswa power plant.	Adequate power will be available.
5. Availability of water	Same as that for Al Mukalla	Same as that for Aden.
6. Port and road transport facilities	Bigger port with better handling facilities; good road connections	Smaller port with inadequate handling facilities; good road connections.
7. Availability of housing and social amenities	Generally available	Poor availability; additional cost involved.

From Table 6-3, it will be observed that Al Mukalla does not offer any advantage over Aden. In fact Al Mukalla location will cause a large amount of economic disadvantage in terms of material assembly and product distribution costs. In view of these, plant location near Aden is suggested.

6 - Plant location, site selection & general layout (cont'd)

Possible site at Aden

Before selecting the possible site at Aden, discussions were held with the Ministry of Industry, Ministry of Construction, Municipality of Aden Governorate, Public Corporation for Electric Power and Public Corporation for water. As explained in Chapter 8 and 9, power will have to be made available to the proposed plant from the Hiswa Power Plant now under construction. Similarly water will have to be obtained from the desalination unit of the Hiswa Power Plant. Therefore, the plant site should be preferably as near as posssible to the Hiswa Power Plant so that costs for bringing power and desalinated water could be minimised. In addition, the plant site should be reasonably away from the residential area now existing and planned in future. Also the location of effluent treatment plant which is on the main highway connecting Aden to Little Aden has to be cleared by about 1 km. In the context of above constraints, the site selected or earmarked in consultation with Ministry of Industry and Ministry of Construction for the proposed steel plant is shown in Drawing 10020-6-2.

Plant General Layout

The general layout of the steel plant has been developed keeping in view the proposed site at Hiswa and the major facilities to be installed. The main considerations taken into account while developing the layout are smooth movement of incoming, in-plant and outgoing materials and provision for rational expansion in future.

The plant general layout is shown in Drawing 10020-6-3. The total area within the plant boundary is approximately 12 hectares (120 000 sq m), of which the area covered by the buildings and storages is about 3 hectares (3 000 sq m). The total length of roads is around 2 km.

Disposition of Major Facilities

The plant is laid out almost parallel to Aden-Little Aden highway. The area of 12 hectares will be adequate for ultimate future expansion of the plant when the steelmelt shop and some of the associated facilities need to be augmented. The proposed disposition of various shops and facilities of the mini steel complex, as shown in Drawing 10020-6-3 is briefly described below.

The open scrap storage and processing yard is located adjacent to the western plant boundaries and near the plant main entrance. Adequate space provision is kept to expand this area.

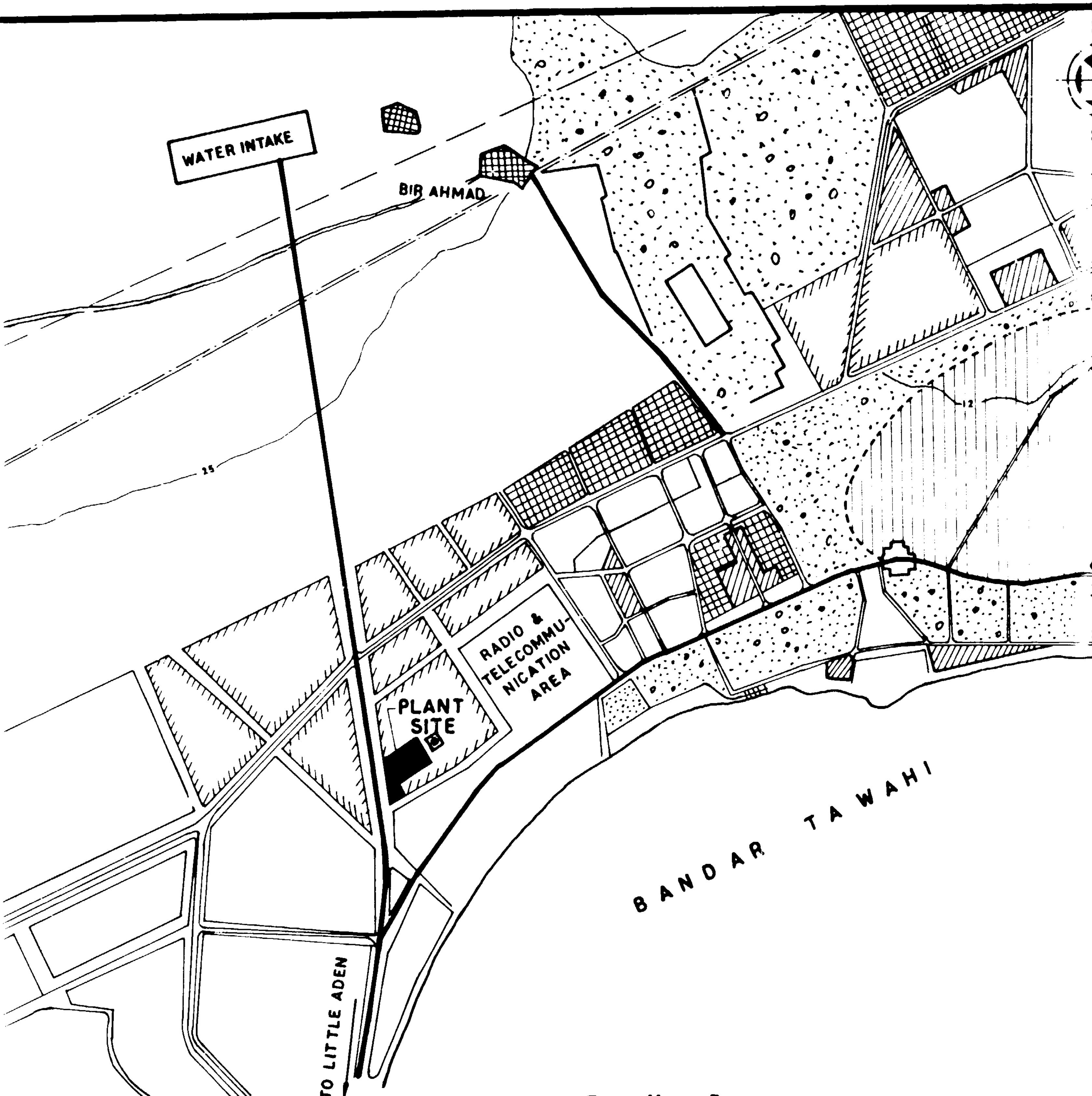
The steelmelt shop is situated to the north-east of the open scrap storage and processing yard. The rolling mill is adjacent to and immediately to the north-east of the steelmelt shop.

The main power receiving substation is to the South of the steelmelt shop and is located at middle near the road running along the southern plant boundary. The water facilities are to the south of the rolling mill. Repair and maintenance facilities, stores and fuel oil storage are situated to the north of the rolling mill and are laid out along the northern boundary of the plant.

The administrative complex housing the offices, canteen and first-aid station is located outside the plant boundary and adjacent to the plant main etrance.

Material flow Pattern and Utility Distribution

The general flow of incoming raw material, namely scrap, in-process material within the plant, and outgoing material, namely finished products, is indicated in Drawing 10020-6-4. From the pattern of material movement indicated it will be seen that the layout provides for easy flow of material.



LEGEND

IMPORTANT HIGHWAYS AND ROADS

INDUSTRY, WAREHOUSE AND ENGINEERING WORKS ZONE

RESIDENTIAL ZONES

AGRICULTURAL LAND

PUBLIC CENTRE

SEA PORT

PLANT SITE

SLAG DUMP

ENVIRONMENTAL CONTROL ZONE & WASTE WATER TREATMENT AREA

NOTE :- MAP OF REGION ADOPTED FROM GREATER ADEN DEVELOPMENT SCHEME'
PREPARED BY MINISTRY OF CONSTRUCTION-ENGINEERING DEPARTMENT, TOWN PLANNING SECTION.

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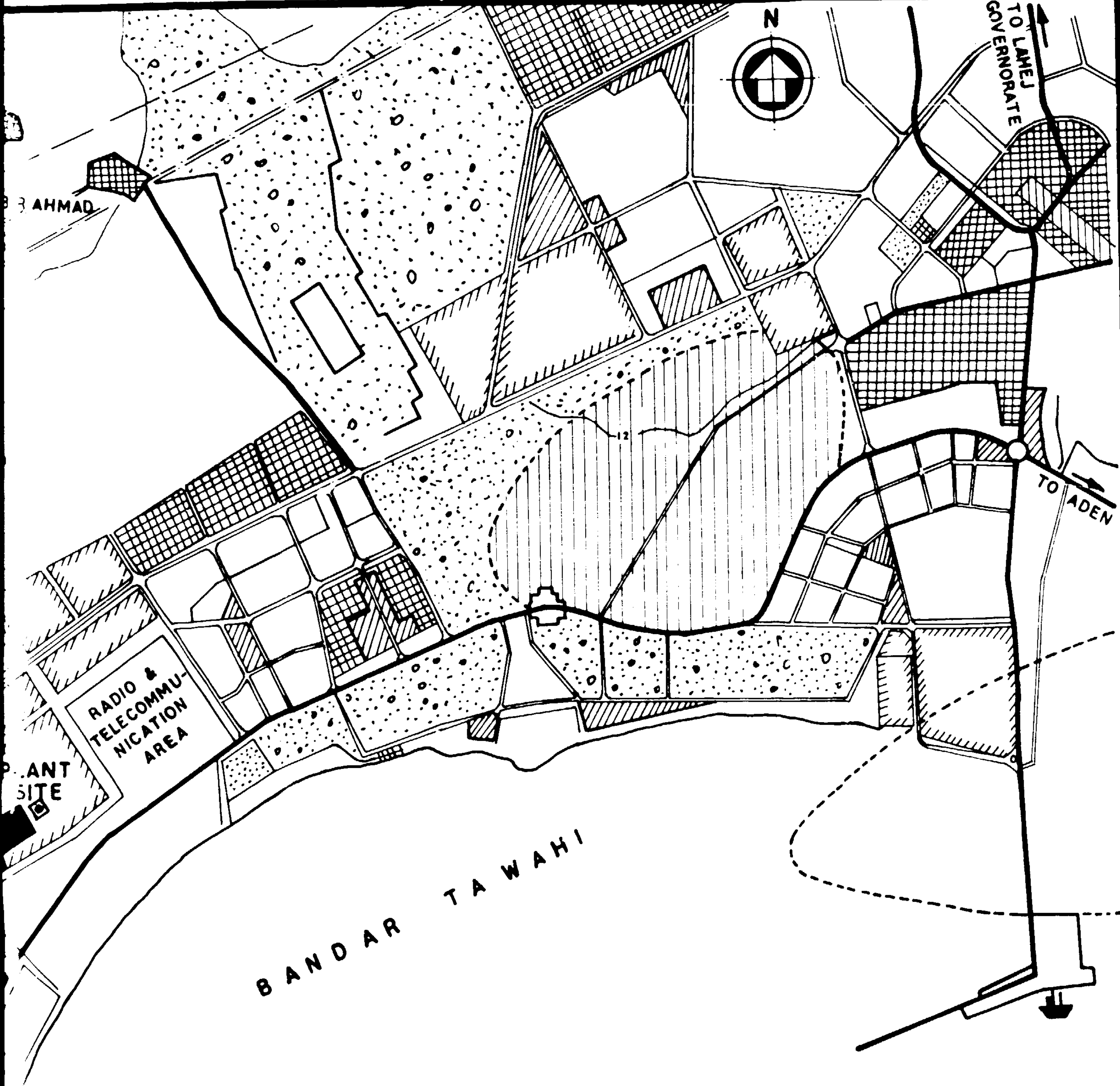
SECTION 1



SECTION 2

SCALE: KILOMETRES (1 — 0.5 — 0 — 1 — 2)

EGEND

- PUBLIC CENTRE
- SEA PORT
- PLANT SITE
- SLAG DUMP
- ENVIRONMENTAL CONTROL ZONE & WASTE WATER TREATMENT AREA

ADEN DEVELOPMENT SCHEME'
-ENGINEERING DEPARTMENT, TOWN PLANNING SECTION.

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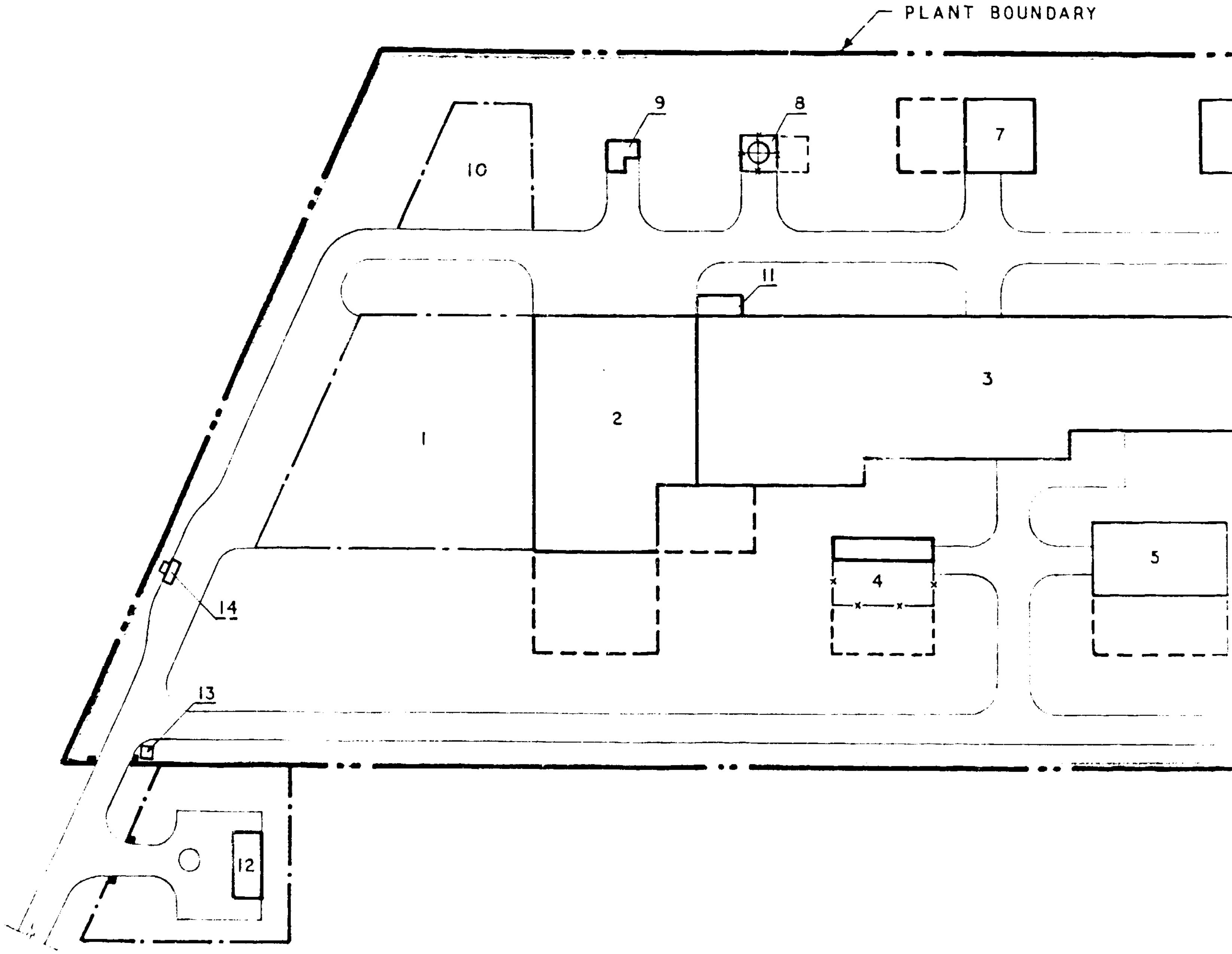
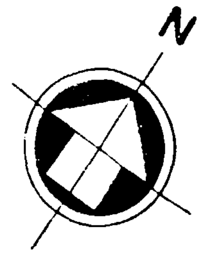
FOR: UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

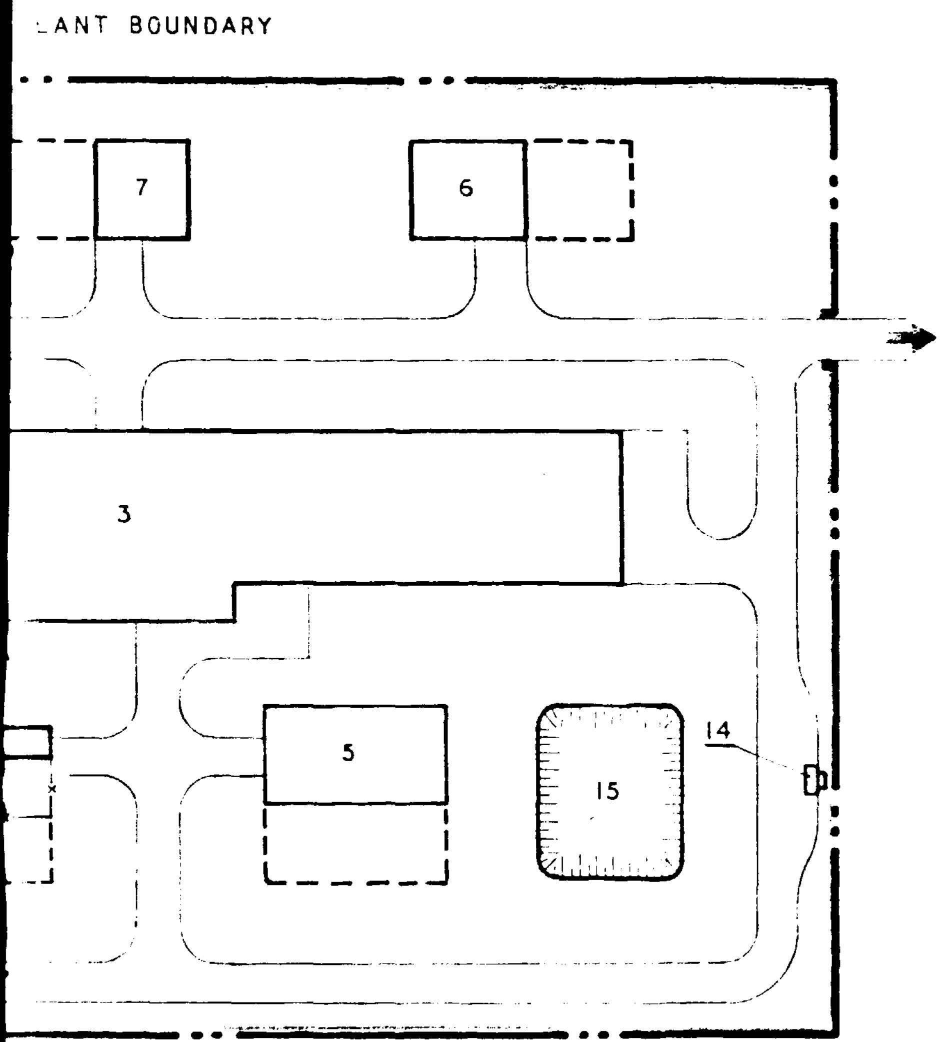
MINI STEEL PLANT IN PDR OF YEMEN
FEASIBILITY REPORT
SITE PLAN

DRAWN		6.10.82	10020-6-2
APPROVED		7.10.82	



SECTION 1





LEGEND

1 SCRAP STORAGE AND PROCESSING YARD
2 ARC FURNACE SHOP
3 BAR AND ROD MILL
4 POWER SUBSTATION
5 WATER SUPPLY FACILITIES
6 REPAIR AND MAINTENANCE SHOPS
7 GENERAL STORES
8 FUEL OIL STORAGE
9 FIRE STATION
10 MOBILE EQUIPMENT PARKING AREA
11 OFFICE AND LABORATORY
12 ADMINISTRATIVE BUILDING COMPLEX
13 GATE HOUSE
14 WEIGHBRIDGE
15 SLUDGE POND

PRESENT PLANT

FUTURE EXPANSION

50 0 50 100

SCALE: METRES

SECTION 2

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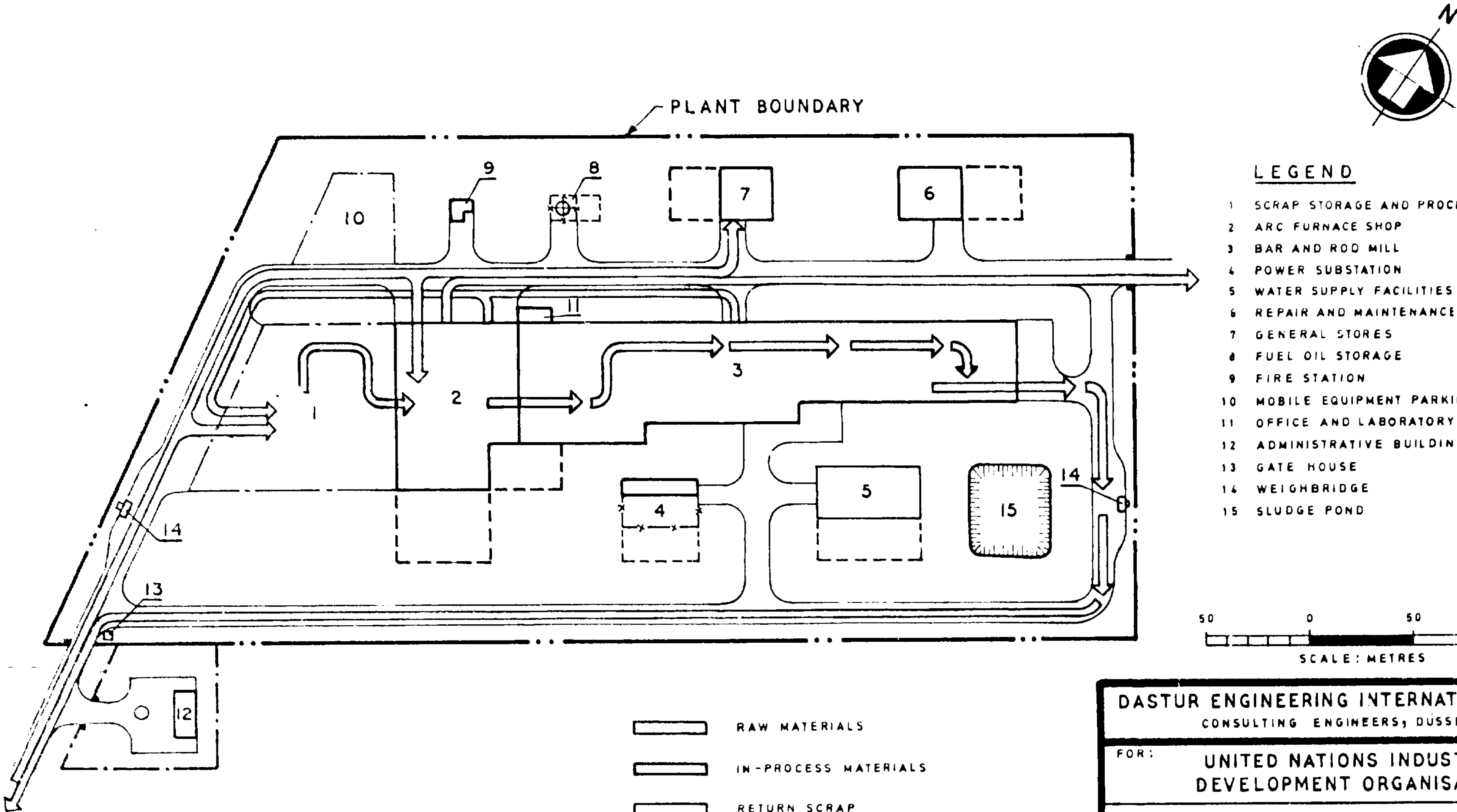
FOR UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

MINI STEEL PLANT IN PDR OF YEMEN
FEASIBILITY REPORT

DRAWN			10020-6-3
APPROVED			



LEGEND

1 SCRAP STORAGE AND PROCESSING YARD
2 ARC FURNACE SHOP
3 BAR AND ROD MILL
4 POWER SUBSTATION
5 WATER SUPPLY FACILITIES
6 REPAIR AND MAINTENANCE SHOPS
7 GENERAL STORES
8 FUEL OIL STORAGE
9 FIRE STATION
10 MOBILE EQUIPMENT PARKING AREA
11 OFFICE AND LABORATORY
12 ADMINISTRATIVE BUILDING COMPLEX
13 GATE HOUSE
14 WEIGHBRIDGE
15 SLUDGE POND

50 0 50 100
SCALE: METRES

RAW MATERIALS
IN-PROCESS MATERIALS
RETURN SCRAP
FINISHED PRODUCTS
SLAG

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MINI STEEL PLANT IN PDR OF YEMEN
FEASIBILITY REPORT
FLOW OF MAJOR MATERIALS

DRAWN	Smajhi	16.11.82	10020-6-4
APPROVED	Calog	17.11.82	

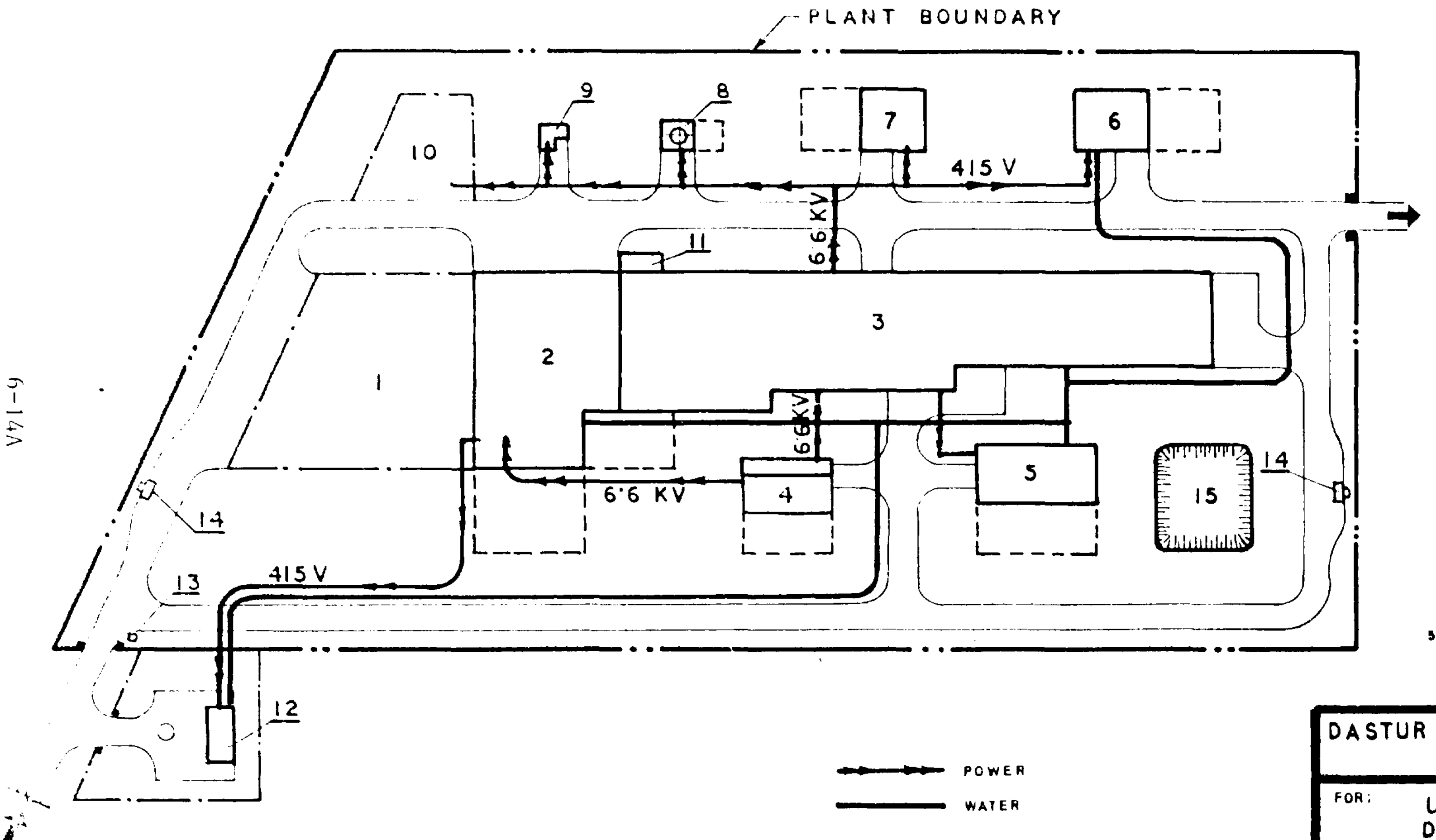
6 - Plant location, site selection & general layout (cont'd)

Preliminary routing of cable from the sub-station to the various plant departments for power distribution, and pipelines for supply of water are indicated in Drawing 10020-6-5. The routing shown are tentative and are likely to undergo major modifications during detailed engineering.

Provision for Future Expansion

From the demand projections made in Chapter 2, it will be seen that the demand for bars, rod and sections will be about 24 000 tons by 1992 and will increase further in future. Hence, the present plant should be so designed as to enable expansion in line with the growing domestic demand.

It would be possible in future to increase the annual liquid steel production from the two arc furnaces by increasing the number of heats from 5 to 7/8. The steelmelt shop production can be further increased by installing another arc furnace when an additional single s[illegible] bil[illegible] caster is to be provided. The capacity of the bar and rod mill is adequate to cater to the increased production. However, certain facilities need to be incorporated. It is expected that by this process the plant capacity can be increased to about 40 000/50 000 tons per annum.



LEGEND

1. SCRAP STORAGE AND PROCESSING YARD
2. ARC FURNACE SHOP
3. BAR AND ROD MILL
4. POWER SUBSTATION
5. WATER SUPPLY FACILITIES
6. REPAIR AND MAINTENANCE SHOPS
7. GENERAL STORES
8. FUEL OIL STORAGE
9. FIRE STATION
10. MOBILE EQUIPMENT PARKING AREA
11. OFFICE AND LABORATORY
12. ADMINISTRATIVE BUILDING COMPLEX
13. GATE HOUSE
14. WEIGHBRIDGE
15. SLUDGE POND

50 0 50 100

SCALE : METRES

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MINI STEEL PLANT IN PDR OF YEMEN
FEASIBILITY REPORT
DISTRIBUTION ROUTING OF MAJOR UTILITIES

DRAWN	NKGhosh	15.10.82	10020-6-5
APPROVED	[illegible]	20.10.82	

7 - STEELMELT SHOP AND ROLLING MILL

STEELMELT SHOP

Design basis

Based on the analysis of future steel demand in PDRY and the suggestd plant capacity, as well as the possible limitations with regard to availability of electric power as discussed in Chapter 8, it is suggested that the initial plant capacity should be around 23 000 tons per year liquid steel, which would correspond to about 21 700 tons of continuous cast billets per annum at 94 per cent yield from liquid steel to continuous cast billets.

The bar and rod mill will roll 100 mm square billets in lengths of upto 2 m for rolling the various type of products envisaged. The continuous casting facilities will be capable of producing billets from 90 mm to 120 mm square billets.

Selection of arc furnace

The most significant development in electric steelmaking in recent years is the phenomenal increase in the furnace power input to reduce the melting time and to increase productivity. The melting time is less than one hour for furnaces with ultra-high transformer. These ultra-high power transformers are normally rated at 600 KVA per ton and above. For the purpose of the proposed mini plant in PDRY however such high-power transformers would not be commensurate with the small capcity production that is being planned. Moreover high power furnaces are specifically suited for sponge iron charge; in the initial years of plant operation it is believed that the PDRY mini plant would have to use scrap only as feed material mainly for reasons that the plant economics would be severely affected if expensive DRI is used. In the future when scrap prices position improves, or when attractive supply terms could be agreed upon for scrap from neighbouring Arab countries, higher power furnace could be adopted. Keeping these considerations in view, the arc furnace and its transformer will be selected for high power and not for ultra-high power operation.

Furnace availability

The arc furnace availability may be taken at about 305 days per year as shown below:

		Days
Calendar days in the year	..	365
Annual shutdown of the steelmelt shop for major repairs	..	10
Scheduled maintenance including patch repairs, relining at 1 shift per week	..	17
Unscheduled delays 5 per cent of available 338 working days	..	17
Provision for important national holidays	..	14

However for the purpose of selection of furnace size an annual availability of 300 days has been assumed.

7 - Steelmelt shop and rolling mill (cont'd)

Heat time

The heat cycle time is estimated as follows:

		Duration minutes
Furnace fettling, repair and electrode changing, etc	..	20
Furnace charging (1 to 2 charges)	..	10
Melting time	..	105
Refining, slagging and finishing time	..	65
Tapping	..	5
Provision for delays	..	15
TOTAL	..	220

The average number of heats per day, based on the above heat cycle time, works out to about 6.5. It may be noted that the number of heats per day could be increased to about 8, provided the qualitv of charge material is consistently good and with excellent · ory performance, better furnace operations and improved power ava ; as well as well-coordinated shop scheduling and operation. Sucn levels of performance are generally obtained in highly developed countries where all the above mentioned factors along with a substantial degree of automation and vast experience in operation are readily present. However, in developing countries, particularly in countries such as PDRY where the industry is being established for the first time, it is prudent to assume more conservative levels of productivity and efficiency of operations. For the initial years of operation till the plant personnel gain considerable experience it is assumed that atleast 5 heats per furnace per day will be easily achieved. The plant design will, however, be flexible to enable increased production through better efficiency and higher productivity. It is estimated that the two 8-ton furnace will be adequate to produce about 38 000 tons of liquid steel on the basis of 8 heats per day per furnace. Provision is also kept to install in future a third furnace of 8-ton capacity when the production can be easily augmented to 57 000 tons of liquid steel per year.

Scrap preheating not considered

Scrap preheating aims at reducing the operating cost by shifting some of the energy input from electricity to cheaper forms of fuel. About 20 per cent of the arc power required for melting and refining can be shifted to a preheater. Cost savings as a result of preheating can be significant, because benefits can arise from fuel economy, reduction in electrode consumption and shortened heat time.

A major prerequisite for adoption of scrap preheating is the availability of cheap alternative fuels such as natural gas or oil. In the case of PDRY this precondition is not satisfied as there are hardly any domestic resources of natural gas, oil or any other form of energy and the country has to import these.

In view of the above considerations additional investment towards scrap preheating facilities is not economical and as such scrap heating has not been considered for the proposed plant.

Furnace size

For the stipulated production of 23 000 tons per year liquid steel, the daily production requirement, considering 300 days annual availability, is 77 tons. This production can be achieved either from single furnace or from two smaller furnaces.

The relative economics of single furnace and two furnace operations with respect to capital and operating costs of continuous cast billets are illustrated in Fig. 7-1. It will be seen that operation with a single furnace will always be more economical. On the basis of 5 heats per day, the size of a single furnace works out to 16 tons per heat.

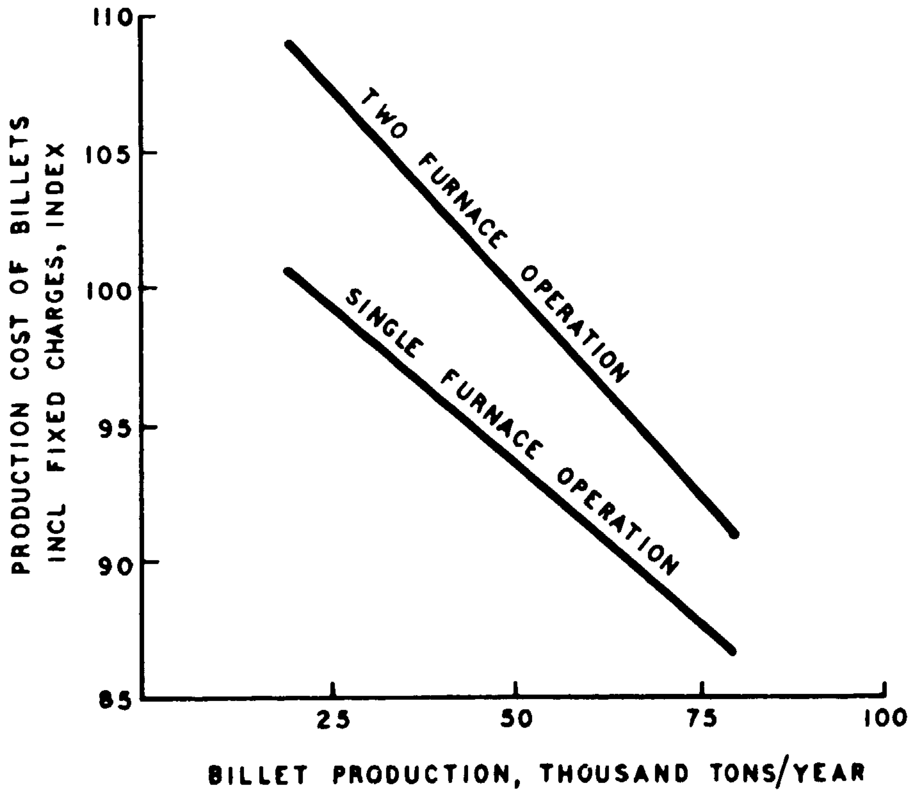


FIG.7-1. RELATIVE ECONOMICS OF OPERATION WITH ONE AND TWO ARC FURNACES

7 - Steelmelt shop and rolling mill (cont'd)

But while selecting the furnace sizes, due consideration has also to be given to the available power supply system. As discussed in Chapter 8 "Electric Power System", arc furnace is a fluctuating power consumer which imposes both reactive power fluctuations as well as active power variations on the system supplying power to the furnace. Hence the power supply system vis-a-vis the power generating plants connected to it should be able to take the electrical and mechanical stresses arising out of repeated shock loading imposed by the arc furnace without abnormal voltage and frequency disturbances.

As discussed in Chapter 8, the active power variations imposed by the arc furnace will, in effect, have to be taken care of by the Hiswa steam power station. It is equipped with two 55 MW TG sets, which can withstand sudden active load variations to the tune of 10 per cent of its operating load at the time, without undue stresses and frequency dip. Hence, considering one TG set not in operation (for maintenance purposes) and even if the other TG set runs at its full rated capacity, the maximum sudden active power variation which the Hiswa station can take will be about 5.5 MW.

As regards the reactive power fluctuations as discussed in Chapter 8, the higher the short-circuit level at the point of common coupling of the arc furnace with other loads, the lower will be the voltage disturbance on the system. During the discussion with the Public Corporation of Electric Power, the CONSULTING ENGINEERS were given to understand that short-circuit level at Hiswa steam station 33 kV bus, from where power supply to the steel plant is proposed, will be about 1 000 MVA when two 55 MW TG sets are running. However, considering one TG set down for maintenance, the short-circuit level at the 33 kV bus of Hiswa Steam station is expected to be about 650 MVA.

7 - Steelmelt shop and rolling mill (cont'd)

Though, with the above short-circuit level, operation of single 16 ton furnace having 8 MVA transformer will not pose voltage fluctuation problem, it will not be possible for Hiswa Steam station to withstand the active power variations if and when only one TG set is in operation. On the other hand, if two 8-ton furnaces each having 4 MVA transformer are selected, and their operations are staggered, the active and reactive power variations will be within tolerable limits. In addition, it will improve the plant electrical load factor.

Selection of continuous casting (CC) machine

For casting 8-ton heat into 100 mm sq billets, a single strand continuous casting machine will be adequate. The number of strands has been determined on the following basis:

Heat size, tons of liquid steel	..	8
Gross weight of liquid steel poured into mould, tons (1)	..	7.84
Billet size, mm sq	..	100
Billet weight, kg/m	..	78
Total billet length cast, m	..	101
Casting rate, m/min	..	2.5
Casting time, min	..	40.5
Permissible casting time, min	..	50
No. of strands required	..	1.0

Note

(1) At 98 per cent yield from liquid steel allowing for only ladle skull and tundish skull loss.

7 - Steelmelt shop and rolling mill (cont'd)

The estimated cycle time for casting machine is given below:

Particulars		1-strand machine
Heat size, tons of liquid steel	..	8
Billet size, mm sq	..	100
Casting time, min	..	40.5
Provision for slow start and stop, min	..	5
Provision for delays, min	..	15
Machine setting time, min	..	35
Casting cycle time, min	..	95.5
Say		96 minutes

From the above, it will be observed that the casting cycle time for the 1-strand machine is about 96 minutes. On this basis, the CC machine has a theoretical capacity to cast 15 heats per day, whereas it will be required to handle initially only 10 heats for two arc furnaces per day on batch casting basis. The casting machine utilisation will improve with higher productivity from the arc furnace in future, and will be adequate for 15 heats per day, that is 50 per cent more production.

CC machine availability

The continuous casting machine availability works out to about 305 days as shown below:

		Days
Calendar days in the year	..	365
Annual shutdown of the steelmelt shop for major repairs	..	10
Scheduled maintenance at 1-shift per week	..	17
Unscheduled down time at 5 per cent of available 338 (365-27) working days	..	17
Provision for important national holiday.		14

7 - Steelmelt shop and rolling mill (cont'd)

Major facilities and shop layout

The major facilities provided include storage and preparation of an open scrap bay, two 8-ton arc furnaces complete with electrics, facilities for handling and charging scrap, limestone, iron ore, ferro-alloys and additives to the arc furnace, liquid steel and slag handling facilities, one single strand continuous casting machine, ladle and tundish preparation facilities etc.

The 8-ton electric arc furnace is of the direct, arc tilting type, provided with three automatically adjustable vertical electrodes and a removable swing roof with multi- voltage high power transformer. The main design features will be as follows:

Furnace shell dia	..	3.05 m
Nominal capacity	..	8.5/10 tons
Transformer rating	..	4 MVA with 20 per cent overload
Metallic charge	..	Steel scrap
Method of charging scrap	..	Top
Electrode dia	..	305 mm

The furnace will be equipped with a fume extraction system including cooling device, flue duct, exhaust fan and chimney. The fume will be extracted from the furnace through a hole in the furnace roof. It will be cooled by water in the jacketed duct and then by convection and radiation, and finally by dilution with atmospheric air to bring down its temperature to about 130 Deg C before the exhaust fan. Gas cleaning fcilities may be added later, if required.

The single strand continuous billet casting machine proposed is of the low head design, either curved mould type or straight mould type. The main design particulars are given below:

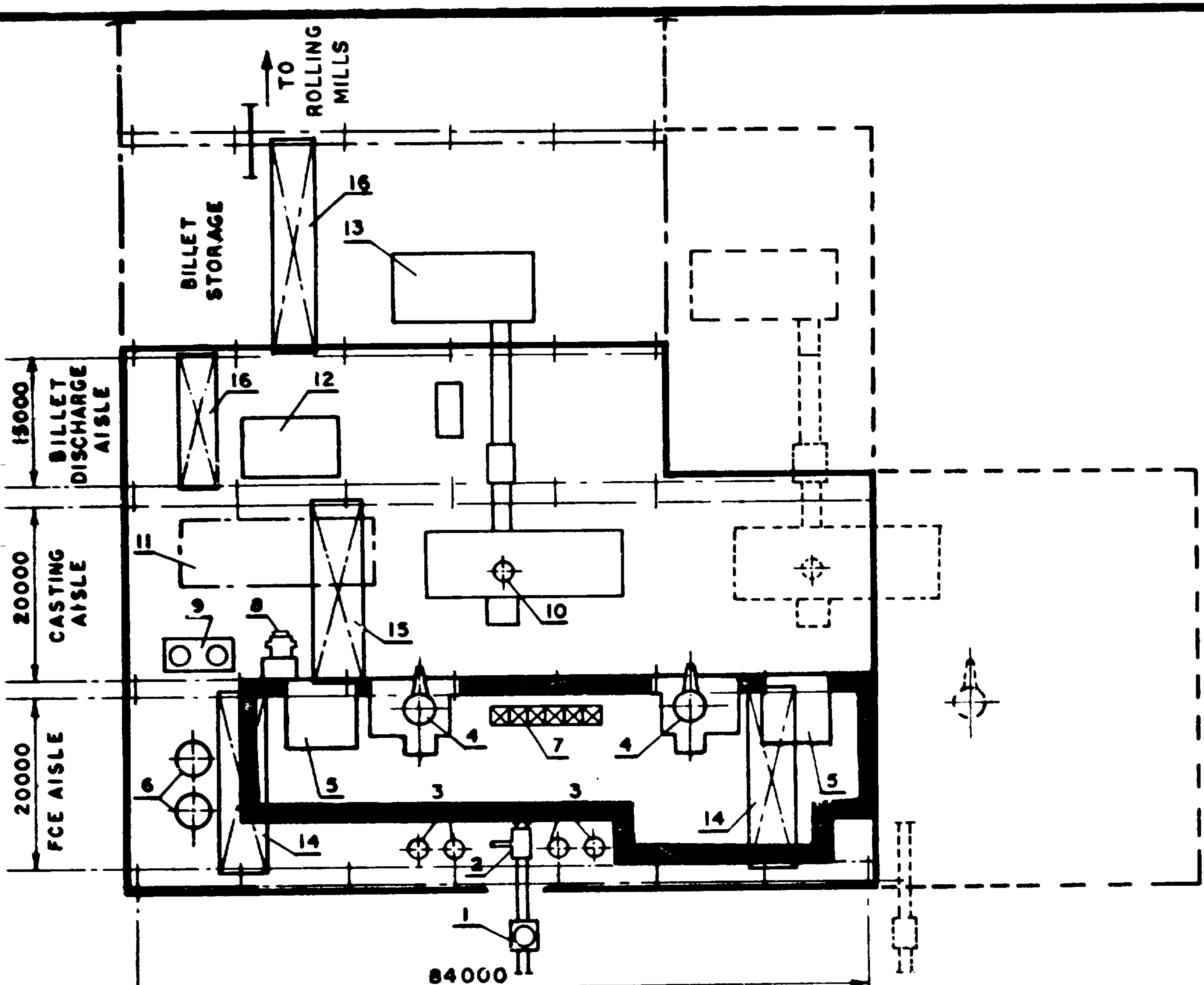
7 - Steelmelt shop and rolling mill (cont'd)

No. of strands	..	1
Steel grades to be cast	..	Plain carbon
Casting radius	..	5 m
Ladle capacity	..	10 tons (nominal heat size 8 tons)
Type of ladle	..	Bottom pouring with stopper
Design range of cast sections	..	80 to 130 mm sq
Machine equipped to cast	..	100 mm sq
Length of billet	..	2 m (min 1.5 m and max 3.0 m)
Type of cutting device	..	Manual gas torches
Method of discharge	..	On horizontal roller tables to cooling bed

The continuous casting machine will be complete with steel structures, mechanical and electrical equipment, instruments and controls, automatic control for steel level in the mould, tundishes, strand cut-off equipment, discharge roller tables and cooling bed.

The layout of the steelmelt shop is shown in Drawing 10020-7-1. A list of the major equipment to be installed for the steelmaking facilities is given in Appendix 7-1. Brief specifications for the electric arc furnace and the continuous casting machine are given in Appendices 7-2 and 7-3.

The steelmelt shop building would comprise a three parallel and adjacent aisles namely the furnae aisle, casting aisle and billet discharge aisle. Steel scrap is proposed to be received in trucks and will be stored in the scrap yard for use in electric furnaces. The billet storage aisle is proposed to be located adjacent to the billet discharge aisle and the rolling mill.



LEGEND

1 SCRAP TRANSFER
2 WEIGHBRIDGE
3 SCRAP BUCKETS
4 8^T ARC FURNACES
5 TRANSFORMER ROOM
6 ROOF RELINING AREA
7 ADDITIONS BINS
8 LADLE HEATER
9 LADLE RELINING PIT
10 CONTINUOUS CASTING M/C
11 TUNDISH RELINING AREA
12 CC MACHINE REPAIR AREA
13 BILLET COOLING BED
14 10/5-TON EOT CRANE
15 20/10-TON EOT CRANE
16 5-TON EOT CRANE

10 0 10 20 30
SCALE: METRES

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FOR: UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

MINI STEEL PLANT IN PDR OF YEMEN
FEASIBILITY REPORT
STEELMELT SHOP LAYOUT

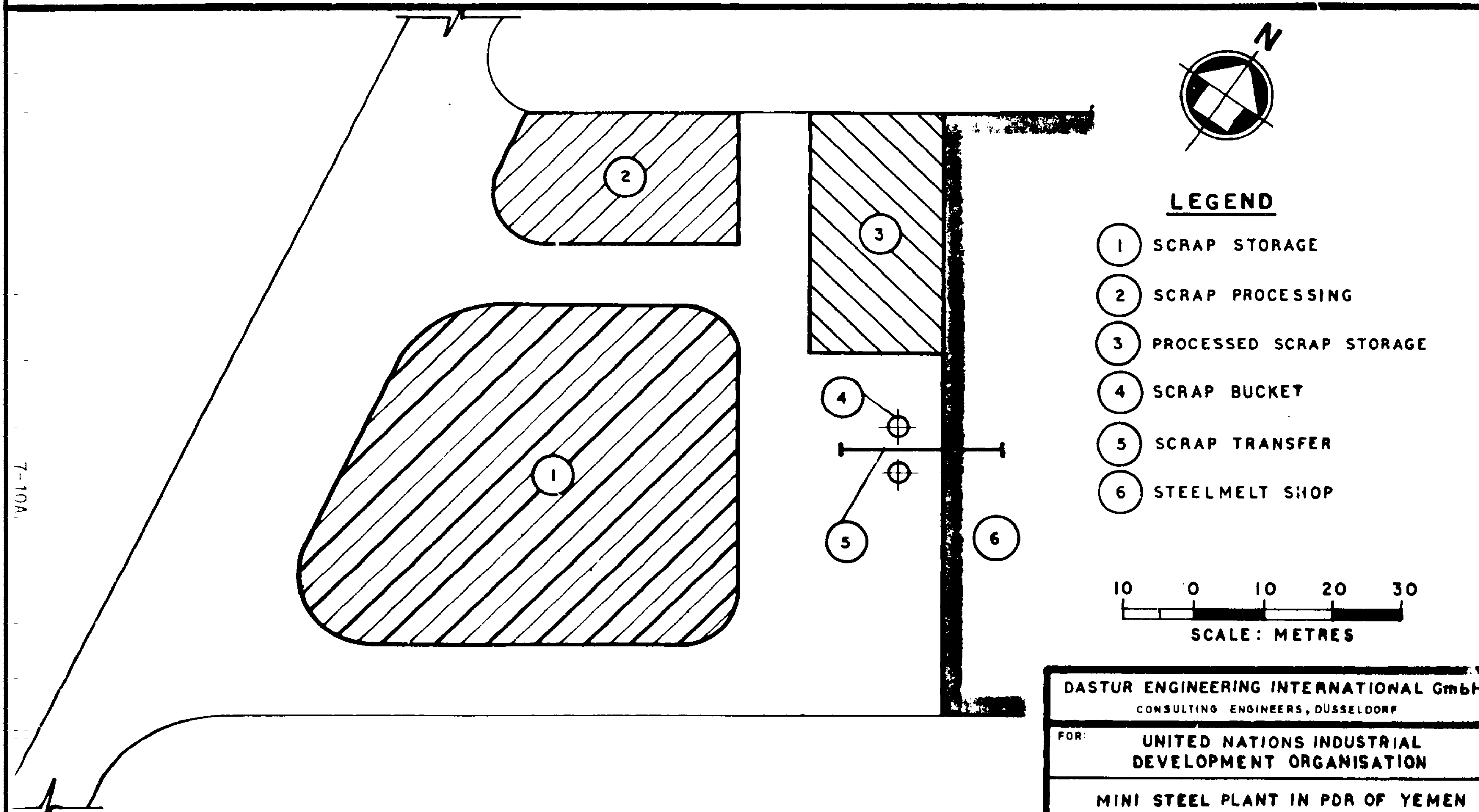
DRAWN	[signature]	10.9.82	10020-7-1
APPROVED	[signature]	14.9.82	

7 - Steelmelt shop and rolling mill (cont'd)

Scrap storage and processing yard: The scrap storage and processing yard measures approximately 90 m by 70 m and can stock about 2 months' requirement of scrap. The scrap preparation facilities proposed include (i) bailing press (ii) a shearing machine and (iii) oxy-acetylene torches for cutting oversize scrap. Two 10-ton crawler cranes with magnet is to be provided for loading the scrap into buckets and placing the bucket in the transfer device to transport to the furnace aisle. Area is provided for storing processed scrap as well as filled-in and empty buckets. The filled-in bucket will be placed by the crawler crane on the transfer car for taking it into the furnace charging aisle. The layout of open storage and processing yard is given in Drawing 10020-7-2.

Furnace aisle: The furnace aisle is 84 m long and 20 m wide between the crane rails. The arc furnace is proposed to be installed at an elevated platform of about 5.5 m above the shop floor level. EOT crane of 10/5 ton capacity has been provided for charging scrap into arc furnaces and for handling roof, slag pot etc. The heat will be tapped into a ladle held by EOT crane of 20/10 ton capacity in the adjacent casting aisle. At one end of the furnace aisle facilities are provided for relining the roof on the ground floor. Front flush slag will be received in a pot and the pot will be transported into one end of the furnace aisle by the EOT crane. After cooling, the slag from the pot will be dumped into a dump truck for disposal. Storage bins for limestone and ferro-alloys are also provided in this aisle in the space between the two furnaces. The flux and additives will be charged in the furnace manually with the help of shovels. Fettling of the furnaces will be done manually by shovels.

Casting aisle: Casting aisle is also 84 m long and 20 m wide between the crane rails. Two 20/10 ton EOT crane have been provided for handling the steel laddle. After tapping, the steel laddle will be picked up by this crane and placed on the continuous casting machine. Tundish



7-10A

DASTUR ENGINEERING INTERNATIONAL GmbH
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FOR: UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

MINI STEEL PLANT IN PDR OF YEMEN
FEASIBILITY REPORT
SCRAP STORAGE & PROCESSING YARD LAYOUT

DRAWN	McGhee	17.9.82	10020-7-2
APPROVED	[illegible]	20.9.82	

car and tundish heating facilities are provided on the continuous casting machine platform. Laddle preparation and heat facilities, tundish relining and preparation facilities and area for deskulling are provided in this aisle.

Billet discharge aisle: The billet discharge aisle is 48 m long and 15 m wide between the crane rails. This aisle is served by a 5-ton EOT crane. The aisle accommodates the withdrawal and straightening machine, the billet cutting device, the dummy bar system and the electrical and hydraulic rooms of the continuous casting machine. The maintenance of continuous casting machine parts, such as moulds aprons will also be carried out in this aisle.

ROLLING MILL

Design basis

A bar and rod mill is required to produce 20 000 tons per year of bars, rods, flats and light sections with a provision for expansion to produce about 40 000/50 000 tons in future. The input material will be continuous cast billets (100 mm sq) received from steelmelt shop. The length of the billet will be about 2 m long which will give a billet weight of about 156 kg. This billet size has been preferred since it would facilitate the rolling of proper quality of bars and rods, and permit the use of smaller size roughing stand rolls.

7 - Steelmelt shop and rolling mill (cont'd)

The material balance of the rolling mills based on 92 per cent yield is given below:

		Tons/year
Input		
Continuous cast billets	..	21 700
Output		
Finished products	..	20 000
Scrap	..	1 300
Scale	..	200
Swarf, slag etc	..	200
Total	..	21 700

The annual production capability of a mill depends mainly on:

i) the rolling rate after allowing for yield and the time gap between billets, and

ii) mill availability after allowing for delays and roll changing time as required by the rolling programme.

The mill will operate 2 shifts a day, 12 shifts per week and 48 weeks a year i.e. about 4 600 hours a year. The yield is taken at 92 per cent and the time gap between billets has been assumed as 5 seconds. Roll changing time depends on the rolling programme as well as on the changing facilities provided, while the delays are a function of the quality of equipment; both depend significantly on the men who operate and maintain the mill. The semi-continuous type of mills, roll changing time and delays account for about 30 to 35 per cent of the mill operating time, which gives an availability of 70 to 65 per cent. Based on CONSULTING ENGINEER'S experience on several similar projects in the developing countries, an availability of 65 per cent has been adopted; that is, the mill will be available for rolling approximately 3 000 (4 600 x 0.65) hours per year.

7 - Steelmelt shop and rolling mill (cont'd)

Table 7-1 shows the production capability of the mill, indicating the rolling rates for the various sizes of bars and rods and the annual rolling time needed to achieve the required production. The rolling efficiency, that is, the ratio of the annual rolling time required to the rolling hours available, works out to about 95 per cent.

TABLE 7-1 - PRODUCTION CAPABILITY

Product	Size	Production	Rolling rate(1)	Rolling time	Rolling efficiency(2)
	mm	tons/yr	tons/hr	hrs/yr	%
Bars and rods	10.25	18 000	7	2 571	
Flat bars	18.50	1 000	7	143	95.23
Angles	50x50 (max)	1 000	7	143	
				2 857	

NOTE:

(1) Assuming 5/6 m/sec rolling speed for 10 mm dia bars in straight length.

(2) $\frac{\text{Actual rolling time of 2 857 hours}}{\text{Available rolling time of 3 000 hours}} \times 100 = 95.23\%$

Even though the mill is capable of increased rolling rate of 10 tons/hour with finishing speed of 7 m/sec i.e. an annual production of about 40 000 to 50 000 tons of finished products, considering the possible requirement in PDRY, it is unlikely that a demand of even 40 000 tons will be needed by 2000 AD. In view of this, expansion of the plant capacity to 40 000 tons will assume reasonable importance only after 2000 AD. In such an event three 8-hour shift operation could be adopted. Taking 300 operation days in a year this would amount to 7200 hours of plant operation. Each of the 8 ton furnaces will be capable of making 7 to 8 heats per day per furnace. With corresponding increase in the number of operating hours for the rolling mill, 7200 hours of operation per annum could be achieved adopting three 8-hour shifts.

7 - Steelmelt shop and rolling mill (cont'd)

As explained earlier, annual availability of 300 working days has been envisaged for the steelmelt shop to produce 23 000 tons of liquid steel with 2 furnaces of 8 ton capacity each and 5 heats per furnace per day. The number of hours required for the rolling mill to roll 21 700 tons of billets (cast from 23 000 tons of liquid steel) is 4600 hours, which, on a two-shift basis, amounts to 12 shifts per week and 48 weeks in a year. In terms of operating days, this works out to 280.

The inbuilt capacity of the steelmelt shop is about 35 700 tons of concast billets, when suitable quality processed scrap, uninterrupted power supply etc could be ensured. For augmenting the production to about 40 000 tons of finished steel only the steelmelt shop and the associated facilities have to be suitably expanded. The preliminary estimates of the order of investment for finally expanded plant is about US $ 27 million. The order of production cost on the basis of unit prices and costs indicated in Chapter 13 is estimated at US $ 250 (YD 86) per ton of rolled products.

In future the proposed bar and rod mill shall be operated on three 8-hour shifts per day and 300 days in a year, that is 7 200 hours per year. The mill is capable of increased rolling rate of 10-tons/hour with machine speed of 7 m/sec and on this basis the yearly production of about 40 000 to 50 000 tons of finished product can be achieved. Thus even with the third furnace, the rolling mill need not be expanded and minor modification may be required to improve the rolling rate like increased storage capacity etc.

Major facilities and layout

The single strand bar and rod mill selected is designed to roll at a speed of 5/6 m per second when rolling rounds of 10 mm dia on the cooling bed. The mill stands are divided into three groups - i) two-stand roughing, (ii) three-stand intermediate and (iii) four-stand finishing. The proposed number and type of stands as well as roll sizes are given below:

7 - Steelmelt shop and rolling mill (cont'd)

Stand No.	Type	Roll dia mm	Roll barrel mm
Roughing stands			
Nos. 1 to 2	3-high	480	1 500
Intermediate stands			
Nos. 3 to 5	Alternate 2-high	360	800
Finishing stands			
Nos. 6 to 9	Alternate 2-high	330	700

The semi-continuous roughing train consists of two 3-high stands, fitted with anti-friction roll neck bearings. The stands will be provided with manual screwdown, tilting tables and repeaters. The stands will be of open-top housing type with arrangement to remove the rolls together with the chocks from the top. Roll changing will be carried out with the help of an EOT crane.

The intermediate and finishing trains consist of seven stands. The intermediate stands are all of closed-top and Alternate 2-high type. The finishing stands are Alternate 2-high type. The stands are fitted with manual screwdown and anti-friction roll neck bearings. Rolls in the stands will be changed with the help of an EOT crane.

The rolled bars and sections coming from the last stand of the finishing group are cut on a rotary dividing shear to cooling bed lengths. A rake and shuffle bar type cooling bed will be provided. After cooling on the bed, the products are cut to ordered lengths on a 250-ton cold shear, suitable for gang cutting. After the shear, collecting cradles will be provided where the cut length will be collected for bundling manually.

7 - Steelmelt shop and rolling mill (cont'd)

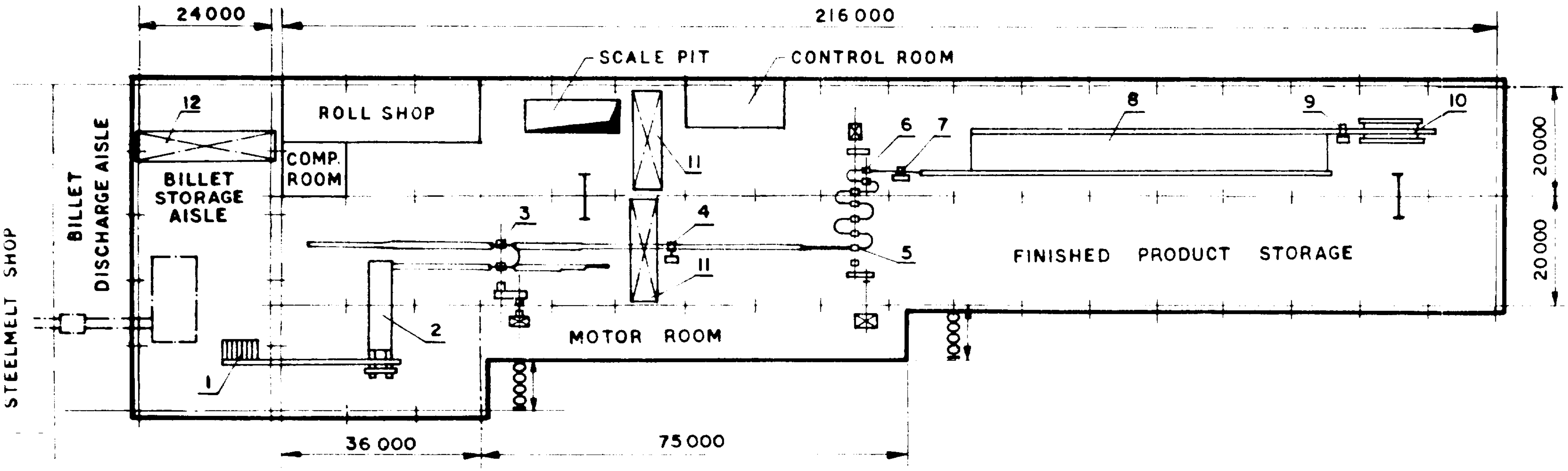
The mill will be served by one top fired, continuous pusher type billet heating furnace with a capacity of 10 tons per hour and shall be charged with two rows of billets. The furnace will have the capacity to accommodate 10 per cent overload and will be designed for a maximum operating temperature of about 1250 Deg C. The furnace will be of the end-charge and end-discharge type, and will be equipped with a billet charging grid, an automatic weighing and recording device, and two pushers. The furnace will be fired with fuel oil.

The layout of the rolling mill facilities is given in Drawing 10020-7-3. A list of major equipment of the bar and rod mill is given in Appendix 7-4, and the brief specification is given in Appendix 7-5.

Continuous cast billets are proposed to be received on the billet cooling table and stored in the billet storage area with the help of a 5-ton EOT crane. The area provided can store about 15 days billet stock. The billets will be inspected individually in the billet storage area. The defective or belt billets will be removed with the help of crane. The prime billets will be transferred to the sorted billet storage area.

The sorted billets will be placed on the charging grid of the heating furnace by means of the 5-ton EOT crane. The heating furnace discharges the billets into the rolling mill aisle. The finished products are handled by a 10/5 ton EOT crane and loaded into trailers for despatch. The roll shop and scale pit are located in the mill bus in such a way that they are in easily approachable distances from the mill stands. The 10/5 ton EOT crane mill also serves these area. The motor room is located adjacent to the drives of roughing and intermediate stands. For services in the motor room a 2-ton hoist is provided.

The roll shop is scheduled to operate 300 days in a year, working one shift per day. The roll shop will have facilities for the following:



10 0 10 20 30 40 50
SCALE: METRES

L E G E N D

1	CHARGING GRID	7	DIVIDING SHEAR
2	HEATING FURNACE	8	COOLING BED
3	ROUGHING MILL	9	COLD SHEAR
4	CROP SHEAR	10	COLLECTING CRADLE
5	INTERMEDIATE STAND	11	10/5T - EOT CRANE
6	FINISHING STAND	12	5T - EOT CRANE

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FOR: UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

MINI STEEL PLANT IN PDR OF YEMEN
FEASIBILITY REPORT
BAR AND ROD MILL LAYOUT

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7 - Steelmelt shop and rolling mill (cont'd)

i) Turning and dressing of rolls
ii) Maintenance of bearings and chocks
iii) Assembly of rolls with bearings, chocks and other fittings, ready for use in the mill
iv) Guide and template making facilities
v) Mechanical and electrical work shop facilities for minor repairs
vi) Stores
vii) Roll storage

A transfer track is provided for movement of rolls and mill equipment between the roll shop and the mill aisle.

ELECTRICAL SYSTEM

The electrical distribution scheme adopted for the steelmelt shop (SMS) and rolling mill are discussed in detail in Chapter 8 and is summarised below.

Steel Melt Shop

Source of supply: Power will be supplied to the arc furnace at 6.6 kV from MRSS and to other auxiliary loads of the shop at 415 V from the rolling mill substation.

Arc furnace power supply: In view of the high power requirement, supply to the arc furnace is taken directly from the 6.6 kV bus of MRSS over individual underground cable feeders.

Power supply for auxiliary loads: Power supply to the furnace auxiliaries, continuous casting machine and services in the SMS will be supplied over 415 V load-centre substations, located in the rolling mill.

7 - Steelmelt shop and rolling mill (cont'd)

Transformer rating: For the 8-ton arc furnace, the continuous rating of the transformer selected is 4 MVA. The furnace transformer will be capable of operating at 20 per cent overload for a period of two hours to permit increased power inputs during the melt-down period, if required. This overload condition, however, would be followed by a period of reduced load and no-load conditions. The transformer will be of the OFWF type. For minimising interruptions in operations, on-load tap-changer will be provided for varying the power input to the furnace.

Furnace circuit-breaker: The furnace circuit-breaker will be selected to withstand frequent switching operations with minimum maintenance.

Motors and controls: Controls for 380 V AC auxiliary motors associated with major equipment will be grouped into motor control centres (MCCs). DC motors, wherever specially required will have their own conversion and controlling equipment. The primary supply to conversion equipment will however be taken from available AC source.

Rolling Mill

Motors for mill stands: The main mill drives will be of speciall mill duty design. The motors will have Class F insulation and will be of the enclosed ventilated type with grease lubricated end-shield ball/roller bearings.

The ratings of main drive motors proposed for various mill stands are indicated in Table 7-2.

TABLE 7-2 - MAIN MILL DRIVE MOTORS

Mill Stands	Motors Rating kW	Motors Speed rpm	Motors Voltage, AC V
Roughing stands 1 to 2	800	500 (syn)	6 600
Intermediate stands 3 to 5	800	500 (syn)	6 600
Bar finishing stands 6 to 9	800	500 (syn)	6 600

Controls for mill drive: Power supply to the mill will be fed from 6.6 kV supply over vacuum contactor.

Auxiliary motors and controls: The cooling bed run-in roller tables will be provided with AC motors. Auxiliaries, will generally be driven by totally enclosed AC motors of squirrel-cage or slip-ring type as per duty requirements. The controls of AC motors will be suitably grouped to form motor control centres (MCC).

Mill power distribution system: Power to the main mill drives will be made available at 6.6 kV from the plant main receiving and stepdown substation over individual cable feeders. 6.6 kV/380 V AC load-centre substations required for 380 V AC consumers as well as the lighting loads of the mill will also be fed from MRSS at 6.6 kV.

Service and utilities

Road access will be provided to the various aisles of the mill building. The mill will be provided with two-way loudspeaker intercommunication system and telephones at different locations as needed. The requirements of water for the various mills are indicated in Chapter 9. The requirements of other utilities, such as fuel oil, compressed air, oxygen etc are discussed in Chapter 9.

8 - PLANT ELECTRICS, LIGHTING, INSTRUMENTATION AND COMMUNICATION

In this chapter the estimated electric power requirements of the plant, characteristics of plant loads, source of power as well as the power distribution proposed for the plant are discussed. The major electrical equipment such as transformers, switchgear, motors, controls and EOT cranes as well as the plant lighting, instrumentation and communication systems are also discussed.

PLANT ELECTRICS

Plant power requirements

The estimated power requirements of the plant including utility and auxiliary facilities are given in Table 8-1. The elctrical distribution system losses as well as diversity have been taken into account in estimating the total power requirements.

TABLE 8-1 - PLANT POWER REQUIREMENTS

Department	Annual energy consumption	15-minute maximum demand	1-minute peak demand
	kWh 10	MW	MW
Steelmaking and continuous casting ..	13.9	4.5	5.4
Bar mill	2.0	0.7	0.8
Utilities & auxiliaries	3.5	0.5	0.6
Plant total requirement with system losses and diversity	19.7	5.6	6.0

8 - Plant electrics, lighting, instrn & commn (cont'd)

The above estimate does not include the power requirements for residential housing or any other facilities that may be provided outside the plant boundary.

Characteristics of plant load

The bulk of the plant load will be accounted for by the arc furnaces. The direct arc furnaces are fluctuating power consumers. The initial scrap melting cycle of an arc furnace is characterised by heavy fluctuations of current at low power factor. The current surges impose reactive power swings on the electrical power system, which tend to cause voltage fluctuations in the system. Such fluctuations get reflected in the supplies of other consumers fed from the same system and depending upon how intensive these fluctuations are, they could be a source of inconvenience to other consumers.

Maximum amount of current is drawn by an arc furnace when the three electrodes get short-circuited over the metal charge. Hence, the maximum possible current swing occurs when the furnace changes from open circuit to short-circuit condition of the electrodes and vice versa. The maximum system voltage fluctuations are therefore correspondingly caused by the furnace when such changes occur. For a particular furnace application, the higher the short-circuit power actually available at the point of common coupling (PCC) between the arc furnace and other consumers, the lower will be the intensity of voltage fluctuations. As a corollary, the maximum size of the arc furnace for a particular power system with a definite short circuit level is therefore determined by the level at which the furnace can be operated without creating voltage fluctuations.

8 - Plant electrics, lighting, instrn & commn (cont'd)

Apart from causing reactive power swings, an arc furnace also imposes considerable amount of active power variations on the system. An arc furnace constitutes a heavy single block of active load particularly during the scrap melting period. When the furnace is switched on or off, such a block of load is suddenly thrown in or off the system. Therefore, it has to be ensured that the power system supplying power to an arc furnace is capable of stable operation without abnormal voltage and frequency disturbances when sudden active load changes take place. The power generating plants connected to the supply system must also be able to take the electrical and mechanical stresses arising out of repeated shock loading imposed by an arc furnace. For such requirements steam turbine generators are most suitable.

Source of power

The generation and distribution of electric power in PDRY is controlled and managed by Public Corporation for Electric Power (PCEP). The entire power requirement of the steel plant will have to be met by PCEP from its power system in Aden area where the steel plant is proposed to be established.

The growth of electric power supply in Aden area in the past has followed the need-based pattern of setting up individual small power stations to cater to specific blocks of loads. Formation of an interconnected power supply network in the area with reinforcements as required is now in progress.

The power generating capacity connected to the Aden system at present and also the capacities proposed to be retired as well as added in future are shown in Table 8-2.

8 - Plant electrics, lighting, instrn & commn (cont'd)

All the existing power stations are interconnected over a 33 kV network and the future Hiswa station will also be connected to the same system. Hiswa power station will be the only steam power station of a reasonably big capacity, which will be 2 x 55 MW by 1986 and 3 x 55 MW by 1990.

TABLE 8-2 - EXISTING AND FUTURE POWER STATIONS IN ADEN

	Location	Type	No.& size of units	Total installed capacity (MW)
1.Existing	Headjuff station 'B'	Steam	2 x 5 MW	10
	Headjuff station 'B'	Steam	1 x 5 MW	5
	Headjuff station 'B'	Gas turbine	2 x 7 MW	14
	Khormaksar, Station 'E'	Diesel	5 x 5 MW	25
	Al.Mansoura	Diesel	8 x 8 MW	64
Sub-total of (1)..				118
2.Proposed to be retired	Headjuff station 'B'	Steam	2 x 5 MW	10
	Headjuff station 'B'	Steam	1 x 5 MW	5
Sub-total of (2)..				15
3.Effective after retirement (1)-(2)				103
4.Future upto 1986	Hiswa	Steam	2 x 55 MW	110
Total installed up to 1986 (3) + (4)				213
5.Future by 1990	Hiswa	Steam	1 x 55 MW	55
Total of (4) + (5)				268

8 - Plant electrics, lighting, instrn & commn (cont'd)

During discussion with PCEP, the CONSULTING ENGINEERS were given to understand that power supply to the steel plant will be established from the 33 kV bus at Hiswa power station. The generators at Hiswa will be the only units which will make any significant contribution towards power supply to the steel plant. Hence, before the steel plant is established and put into operation, it has to be ensured that the 2 x 55 MW sets at Hiswa are installed and commissioned.

Plant power distribution system

Basic scheme: The basic power distribution system proposed for the plant is represented in single-line diagram shown in Drawing 10020-8-1 and is discussed below:

i) Power will be received from PCEP at the plant main receiving and step-down substation (MRSS) over two 33 kV cable feeders, each feeder capable of carrying 12.5 MVA of power. Though the power demand of the plant is initially estiamted at about 7 to 8 MVA, in the incoming feeders additional capacity is proposed to be provided at marginal cost to cover possible future power requirement when the plant expands. Duplicate full capacity feeders are proposed for ensuring a firm power supply to the plant.

ii) At the MRSS, 33 kV power will be stepped down to 6.6 kV over two 10/12.5 MVA power transformers for primary power distribution in the plant. In this case also provision has been kept for an additional in-built capacity in the transformer at a marginal cost for catering to future expansion of the plant. Two number transformers are proposed so that plant operation can be continued even when one transformer becomes inoperative for any reason.

iii) The 6.6 kV bus at the MRSS will be sectionalised over a normally open bus-tie circuit-breaker, the arc furnace being supplied from one section and the other plant loads from other sections.

iv) From one section of the 6.6 kV bus, two feeders will be taken to the two 8 T, 4 MVA arc furnaces and from the other section the rolling mill motors will be fed. From the second section, feeders will also be taken to 6.6 kV/0.433 kV load-centre substations.

8 - Plant electrics, lighting, instrn & commn (cont'd)

v) Two load-centre substations will be formed, one with a 1 600 kVA transformer and the other with a 1000 kVA transformer, for supplying power to general plant loads and lighting.

vi) All the 6.6 kV and 415 V feeders will be taken over cables.

Main receiving and step-down substation (MRSS): The equipment arrangement at the MRSS is represented in single-line diagram shown in Drawing 10020-8-1. Each of the two 33 kV incoming feeders from Hiswa power station will be connected to the 10/12.5 MVA transformer over 33 kV circuit-breakers.

The 33 kV circuit-breakers will be indoor, metal-encloed, draw-out type having interrupting rating of 1500 MVA, symmetrical. The breakers are proposed to be of MOCB type.

The 33/6.6 kV transformers will have 10 MVA ONAN rating and 12.5 MVA ONAF rating. The windings shall be delta-connected on the primary side and star-conducted on the secondary side, the secondary neutral points being earthed over resistors with a view to limit the earth fault current on the 6.6 kV system, where rortating machines will be connected. The 6.6 kV switchgear will al be indoor metal-enclosed, draw-out type having short-circuit interrupting rating of 250 MVA, symmetrical.

Load-centre substations: For supplying medium and low voltage loads as well as lighting power, two 6.6/0.433 kV load-centre substations will be located at the load-centres of such loads. The transformers will be delta-star type, with secondary neutral solidly earthed. The secondary side power supply systems will be 415-240 V, 3-phase, 4-wire and the distribution boards will be indoor cubicle type with air circuit-breakers of draw-out design housed in tier formation.

8 - Plant electrics, lighting, instrn & commn (cont'd)

Selection of voltages: The voltage of incoming power supply to the plant viz. 33 kV is decided as PCEP will supply power at 33 kV only from their Hiswa power station.

For distributing power inside the plant, adoption of a lower voltage viz. 11 kV or 6.6 kV could be an economically justifiable proposition. For arc furnace power supply as well as primary power supply to load-centre substations, either 11 kV or 6.6 kV can be adopted. However, for the 500 kW main drive motors of the bar mill, 415 V supply would be too low and 11 kV would be too high. For this size of motors, 6.6 kV supply can be adopted, though 3.3 kV could have a few additional advantages. However, 3.3 kV is not considered suitable for primary power distribution in the plant including power supply to the arc furnaces of the size in question. Hence 6.6 kV has been selected for high voltage power distribution in the plant, as this will meet all the requirements stated above.

For supplying power to the medium and low voltage consumers, 415-240 V, 3-phase, 4-wire AC distribution system is proposed to be adopted.

System short-circuit ratings: For the 33 kV system of the steel plant, 1500 MVA symmetrical short-circuit level has been adopted in line with the recommendation of PCEP.

Considering the above short-circuit level at 33 kV, the number and sizes of 33/6.6 kV transformers and contributions from motors operating on the system, a short-circuit rating of 250 MVA is proposed for the 6.6 kV system of the steel plant.

Motors and controls: The drive systems provided for the plant can be basically classifed into two categories. One category will be the motors used for powering the main mill stands of the bar mill and the second category will be the motors used for driving the vaious other plant equipment, pumps, blowers, compressors etc.

8 - Plant electrics, lighting, instrn & commn (cont'd)

The rolling mill stands will have to be powdered by special motors of robust construction, designed for large overload capability to meet the peak torque demands of the mill stands and give operational reliability under severe rolling mill operating conditions. The proposed basic features of these drives are described in Chapter 7.

All the auxiliary motors will have Class B/F insulation. For continuous duty, it is proposed to adopt general purpose industrial type, squirrel-cage induction motors of totally enclosed, fan-cooled design. In case of intermittent operation, totally enclosed, slipring induction motors suitable for mill duty operation are proposed to be adopted. Special motors such as flame-proof, increased safety or of weather-proof design will need to be also provided, as required.

All 415 V AC motors should be provided with magnetic contactor starters. For individual motors, combination starter housed in sheet steel boxes are to be provided. Where a group of motors are associated with a certain process, group control in the form of factory-assembled and wired motor control centre (MCC) should be adopted. The MCC should be of multi-tier compartmental arrangement with modular construction.

<u>Power and control cables:</u> The entire electrical power distribution within the plant is proposed to be over underground cables. The selection of sizes and types of cables will be based on feeder loadings, system short-circuit levels, locations, ambient temperatures and installation conditions.

Cables with special types of insulation and protective sheathing should be installed in locations having high ambient temperature.

<u>Earthing and lightning protection:</u> All non-current carrying metallic parts of various electrical equipment including cables, ducts, trays, racks, structures etc should be earthed effectively and efficiently.

8 - Plant electrics, lighting, instrn & commn (cont'd)

For effective earthing, requisite number of earth stations should be provided, both for system earthing as well as equipment earthing. Earthing conductors should be provided between these earthing stations and the equipment to be earthed.

The transformer at MRSS outdoor yard shoud be protected against direct lightning strokes by provision of overhead shielding wires. Lightning protection systems will have to be provided for plant buildings, tall structures, overhead tanks etc as required.

System relaying and protection: Adequate rated and quick acting circuit-breakers, aided by liable and selective relaying is proposed to be provided in all parts of the power system for quick isolation of faults to protect the equipment and ensure system stability.

Protection against overcurrent and earth-faults will have to be provided with proper discrimination. The overcurrent and earth-fault protection will have inverse time characteristics with definite minimum time. All feeders are generally provided with non-directional type overcurrent and earth-fault relays. Provision will have to be made also for instantaneous tripping on the occurrence of heavy short-ciruits, where required.

For high voltage motor circuits, special relays should be provided to operate on sustained overloads and short-circuits. The relay characteristics should be so selected as to closely match the thermal image of the protected motor. For the protection of motors against sustained system undervoltage conditions, time-lag undervoltage relays should also be provided.

For the protection of 33/6.6 kV power transformers, stabilised high speed differential protection should be provided.

8 - Plant electrics, lighting, instrn & commn (cont'd)

Relays for other specific applications are to be selected, with stable characteristics to perform their protective functions effectively. All relays should be properly graded for selective tripping of the faulty section.

Metering and instrumentation: For the measurement of the electrical parameters like voltage, current, reactive volt-ampere, energy, power etc at different points of the power system, indicating, integrating and recording type instruments will be provided.

Electric overhead travelling cranes

All the cranes should be suitable for operation on AC system with AC motors and AC controls. The recent developments in AC crane control technology (using static stepless speed control circuits) has contributed to dependability and better performance of AC cranes; and thus its performance standard has been brought on part with DC cranes. The power supply to the cranes is proposed to be made available from the 415 V load-centre substations.

Emergency power supply

In order to meet any exigency of total power failure in the plant, provision is proposed to be made for emergency power supply to vital consumers. This is proposed to be achieved with batteries of adequate ampere-hour capacity installed at required locations. It is envisaged that emergency water requirements in the event of power failure will be met from water stores in overhead tanks and also by running diesel pump when required.

8 - Plant electrics, lighting, instrn & commn (cont'd)

PLANT LIGHTING SYSTEM

The plant lighting system is to be planned to cater to the quantitative and qualitative illumination requirement for different plant units. In substations and motor rooms, in addition to general illumination, emergency lighting from the storage batteries are to be provided. The illumination levels in various departments will be in accordance with standards accepted for steel plants, suitably modified to meet the local conditions.

In large buildings such as steelmelt shop, rolling mills, etc highbay type of fittings are proposed, using sodium vapour lamps. Fittings used for general lighting in lowbay areas should be of direct or semi direct type with fluorescent lamps in most cases; in some cases there will be incandescent lamps.

For illumination of scrap yard, floodlights with sodium vapour lamps erected on the adjacent building structures or on poles erected for the purpose are proposed. The roadways should be illuminated by using high pressure sodium vapour lamps with suitable fittings having a symmetrical distribution giving maximum light on the road surface.

The lighting power supply will be taken from the 415/240 V, AC, 3-phase, 4-wire distribution system in various departments.

INSTRUMENTATION AND CONTROLS

Instrumentation and control system included should be sufficient to monitor and control the various significant variables of each prodution unit in accordance with the process requirement, to provide all operating requirements and necessary safety controls including alarms for off normal conditions.

8 - Plant electrics, lighting, instrn & commn (cont'd)

To keep pace with the modern trend, electronic analog control instrumentation with 4 to 20 mA DC signal output has been considered for adoption. Miniature instruments should be employed in the control panels to indicate record and control of the process parameters. Controllers should be generally of proportional and reset action type. Solid state, plug-in type flashing audio-visual alarm system is to be provided. All field mounted instruments will have weather-proof and dust-tight casings suitable for use under the ambient conditions prevalent in the specific areas. Major production units will have facility for centralised control effected from control panels located in air-conditioned or pressurised control rooms. Adequate space will be set apart in the control room to facilitate maintenance activities.

PLANT COMMUNICATION SYSTEM

Rapid and reliable communication facilities play an important role in achieving inter-departmental coordination and management of the plant. The following communication systems have been envisaged for the plant:

Private automatic branch exchange (PABX): For automatic communication within the plant as well as external communication outside, a PABX system is proposed. This PABX will be linked with adequate tie line connections to the local government exchange.

Loudspeaker inter-communication systems: Two-way loud-speaker inter-communication systems will be provided in the steelmelt shop and the bar mill to ensure quick exchange of operating instructions at the shop level.

Telex service: It is suggested that post and telegraph authority should provide on rental basis a telex machine, which will be located in the telephone operator's room at the administrative building.

9 - WATER AND OTHEP UTILITIES

WATER

Water is required in the steel plant mainly for equipment cooling, gas cooling, collecting and conveying scales, for drinking and sanitation purposes and for miscellaneous uses. It is understood that water from desalination plant located at Hiswa will be available for use in the proposed steel plant. The water requirements and the water system for the steel plant are discussed in the following paragraphs.

Water requirements of the plant units

The water requirement for the various plant units on once-through basis is indicated in Table 9-1.

TABLE 9-1 - WATER REQUIREMENTS FOR THE PLANT UNITS

Consumers	Requirement on once-through basis cu m / hour
Industrial water	
(i) Steelmaking including continuous casting:	
Arc furnace, gas cooling and transformer	250
Concast mould	100
Concast apron spray and machinery	80
	430
(ii) Rolling mill:	
Furnace, machinery, oil cooling and others ..	200
Rolls, mill stands and other equipment cooling ..	250
	450
(iii) Compressors and miscellaneous ..	25
(iv) Potable water ..	10
TOTAL ..	915

9 - Water and other utilities (cont'd)

Source of water

There are no rivers or lakes in PDRY and the water requirements of the entire country are met from underground sources. For instance, the requirement of Aden City is met from bore wells. The only desalination plant in the country is a captive unit at the Hiswa power plant now under construction.

The Public Corporation for Water (PCW) is making concerted efforts at locating additional reserves of underground water in the country. For this purpose extensive hydrogeological surveys are being conducted in various areas. Analyses of water samples taken from various sources in PDRY are given in Table 9-2.

The water resources in and around Aden has been over-exploited: for this reason the salinity has been considerably increased. In view of this the water system for Aden is to be connected to Abyan wells and bring the water over a distance of 60 km. The present level of salt in bore well water around Aden and those in Bir Ahmed area is of the order of 2500-5000 ppm, as shown in Drawing 10020-9-1.

Availability of Water

Water is a scarce commodity in PDRY and the GOVERNMENT is keen to ensure that adequate underground water reserves are maintained for meeting the domestic requirements. In the light of this consideration PCW is not in a position to supply water to the plant from bore wells.

During the discussion with PCW, the CONSULTING ENGINEERS were given to understand that water may be made available from the desalination plant now under construction at Hiswa. The capacity of the desalinated plant is adequate and it is envisaged that required water should be available from this unit.

TABLE [illegible] - ANALYSIS OF WATER SAMPLES FROM [illegible]

Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Tolerable max. [illegible]
Temperature [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Colour mg.Pt/l	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
pH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hardness [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] mg/l	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chloride mg/l	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nitrate mg/l	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sulphate mg/l	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Iron mg/l	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Manganese mg/l	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Calcium mg/l	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Magnesium mg/l	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mg^{++}+Na [illegible] mg/l	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fluoride mg/l	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NOTE:
Sources of water samples are given below:

Number	Source	Number	Source	Number	Source
1.	Ibail Bawadir Spring	[illegible]	[illegible]	[illegible]	[illegible]
2.	As-Chihir [illegible]	[illegible]	[illegible] water spring [illegible]	[illegible]	[illegible]
3.	As-Chihir [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4.	Hami [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5.	Hami [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]

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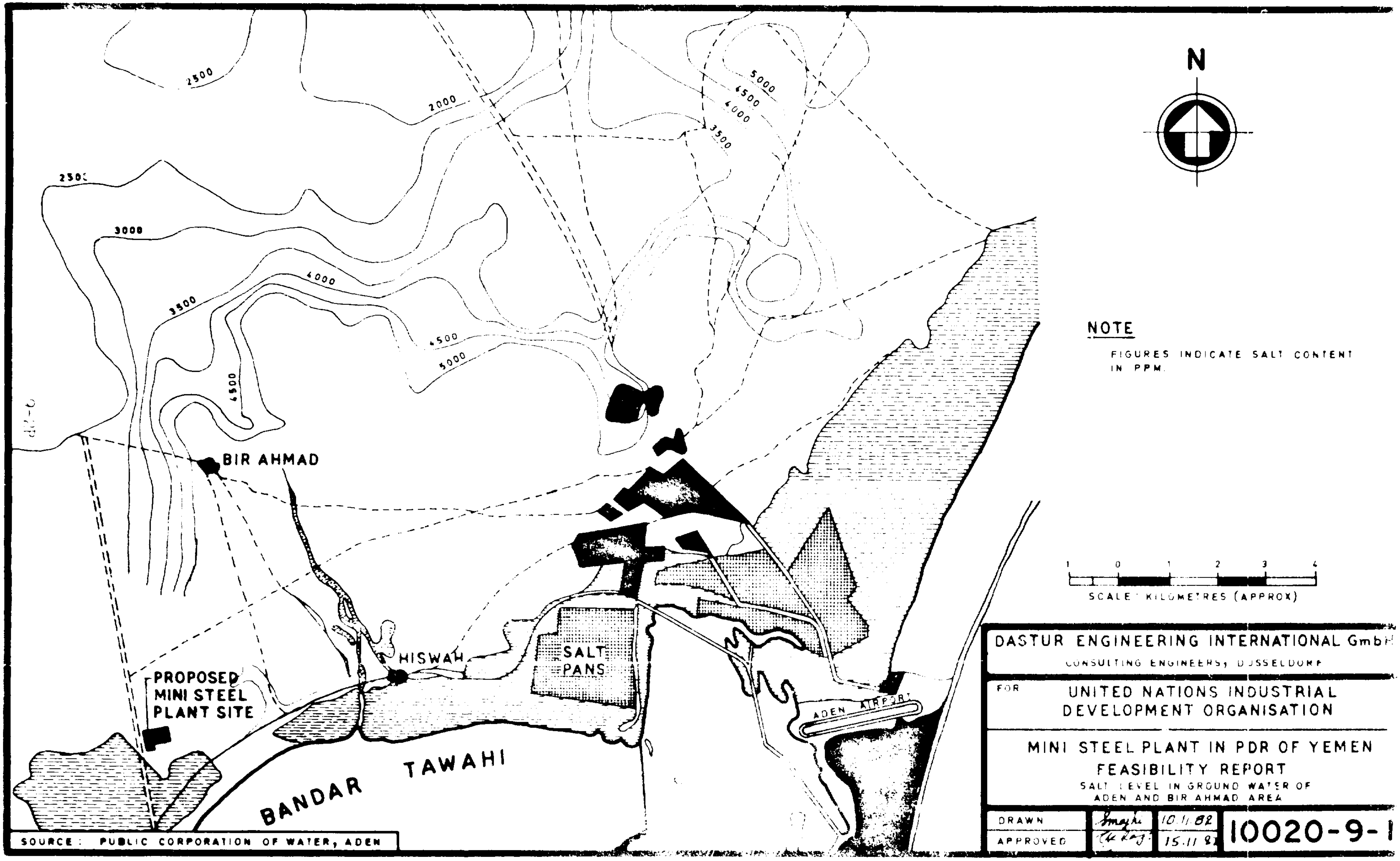

N
2500
2000
5000
4500
4000
3500
3000
4000
3500
4500
5000
4500
NOTE
FIGURES INDICATE SALT CONTENT IN PPM.
BIR AHMAD
HISWAH
SALT PANS
PROPOSED MINI STEEL PLANT SITE
BANDAR TAWAHI
ADEN AIRPORT
1 0 1 2 3 4
SCALE: KILOMETRES (APPROX)
SOURCE: PUBLIC CORPORATION OF WATER, ADEN
DASTUR ENGINEERING INTERNATIONAL GmbH
CONSULTING ENGINEERS, DUSSELDORF
FOR
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION
MINI STEEL PLANT IN PDR OF YEMEN
FEASIBILITY REPORT
SALT LEVEL IN GROUND WATER OF ADEN AND BIR AHMAD AREA
DRAWN
APPROVED
10.11.82
15.11.8
10020-9-1

9 - Water and other utilities (cont'd)

As the ministeel plant is proposed to be located close to the sea, sea water which is available in abundance can be used where permissible. In view of the corrosive action of sea water on equipment, the present trend, even at locations where sweet water is scarce as in the case of PDRY, is to use sweet water in preference to sea water even if this involves some effort. This is attempted at by adopting, for instance, intensive water conservation measures to minimise the consumption of sweet water. Therefore, the use of sea water for primary cooling of steel plant equipment is not proposed, but its use has been considered only for secondary cooling in heat exchangers. Except for direct use of sea water, the entire quantity of water required by the plant has to be supplied as desalinated water from the desalination unit of the Hiswa Power Plant.

Plant water system

To minimise the requirement of desalinated water, it is proposed to adopt recirculating water system with appropriate conservation measures, such as:

i) successive reuse of water in a temperature cascade system (for example, water used for motor cooling in the rolling mill is reused for billet heating furnace cooling before it is returned to the heat exchangers of the cooling system)

ii) successive reuse of water in a quality cascade system (for example, the supernatant water from the rolling mill scale pit is used for scale flushing in the mill flumes).

Based on the climatological data and proposed coastal location of the steel plant, water-to-water heat exchanger has been selected for cooling the recirculated water, instead of selecting other cooling equipment, such as evaporative cooling tower and air to water heat exchangers.

Data on sea water temperature at different depths and at different times of the year is not availabe. In view of this the maximum sea water temperature recorded, namely 27 degree centigrade has been adopted.

9 - Water and other utilities (cont'd)

Overall water requirements of the steel plant

The schematic water flow diagram is shown in Draw' g 10020-9-2. The overall requirements of water for make-up and other uses are summarised in Table 9-3.

TABLE 9-3 - OVERALL WATER REQUIREMENTS FOR THE STEEL PLANT

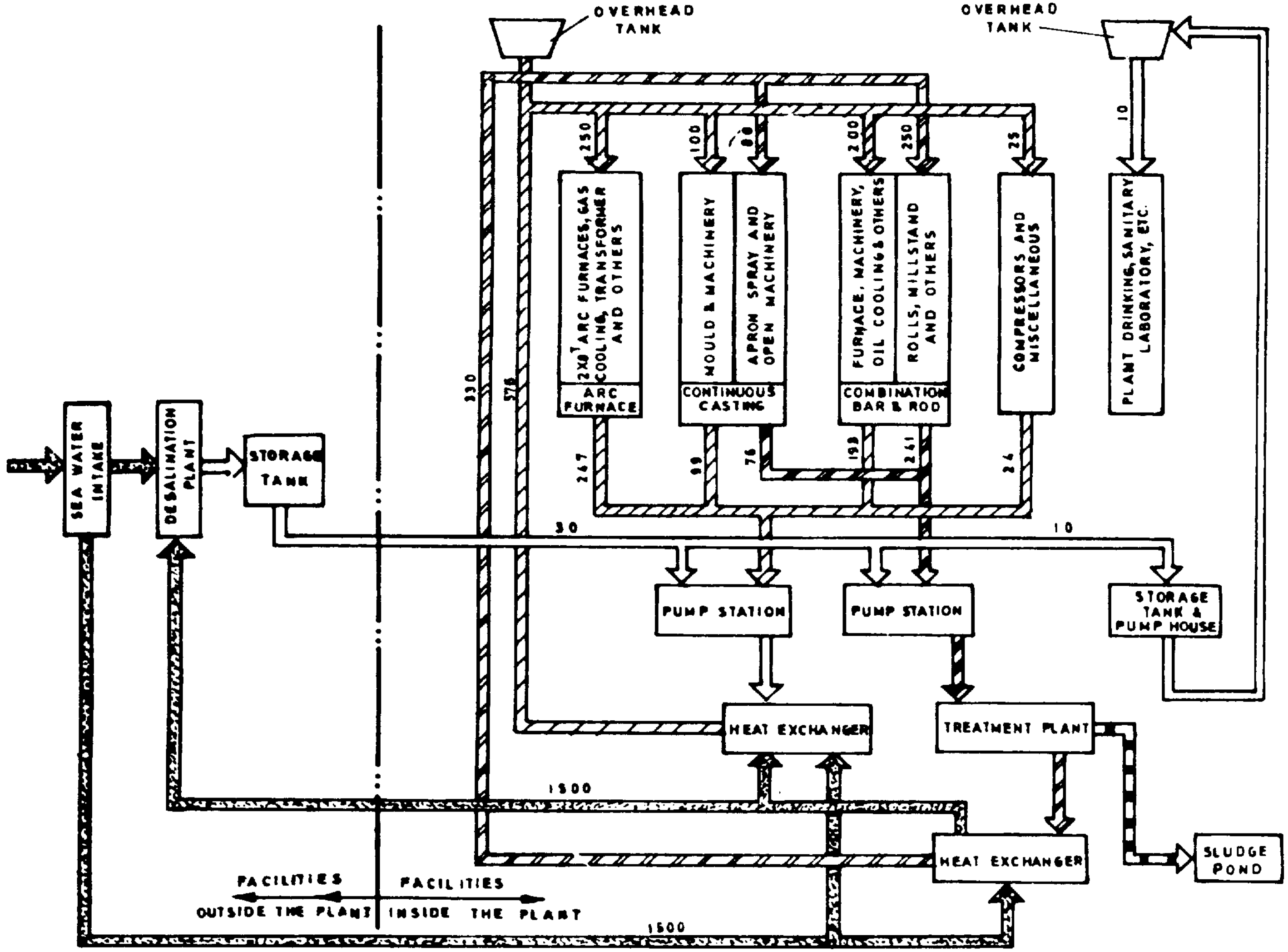
Desalinated Water	Requirements cu m/hr
Make-up water for steel plant	20
Potable water for steel plant	10
	30
Sea water	
Heat exchanger cooling	1 500

Distribution system

The plant industrial water recirculating system comprises mainly (i) indirect cooling water cycle in which the water is used to remove only the heat from the equipment and (ii) direct cooling water cycle in which the cooling water is also contaminated with scales, oil, etc which must be removed before reuse.

The basic scheme is to supply water both for indirect cooling and direct cooling of the plant and equipment from a central water station where the heat exchangers and the secondary treatment units for the direct cooling water cycle are proposed to be located. From the central water station water will be supplied at a pressure of about 4 kg/cm sq at the ground level of the various shops.

Indirect cooling water cycle: Water used for indirect cooling in the different shops is generally returned by gravity to the central water station, where it is pumped through heat exchangers and then sent back for



LEGEND

- INDIRECT COOLING WATER (SUPPLY & RETURN)
- DIRECT COOLING WATER (SUPPLY)
- DIRECT COOLING WATER (RETURN)
- DESALINATED WATER
- SEA WATER (SUPPLY & RETURN)
- SLUDGE

NOTE:

FIGURES INDICATE RATE OF FLOW IN CUBIC METRE PER HOUR.

DASTUR ENGINEERING INTERNATIONAL GmbH CONSULTING ENGINEERS, DÜSSELDORF	
FOR: UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION	
MINI STEEL PLANT IN PDR OF YEMEN FEASIBILITY REPORT PLANT WATER SYSTEM SCHEMATIC FLOW DIAGRAM	
DRAWN: McGlon 8.11.82	10020-9-2
APPROVED: Cakoz 15.11.82	

9 - Water and other utilities (cont'd)

recirculation. The total quantity of indirect cooling water in circulation is about 575 cu m per hour (see Drawing 10020-9-2). For pumping this quantity of water, two punps are proposed, one operating and one stand-by in the central water station.

A separate booster pump will be installed in the steelmelt shop for supply of indirect cooling water at high pressure for cooling the moulds of the continuous casting machine.

Direct cooling cycle: Contaminated water supply mostly containing scales and oils from the continuous casting machine and the rolling mill is collected in local scale pits. Scale pits of RCC construction with two compartments and necessary baffle arrangement are to b provided. Heavier scales would settle in the primary chamber, whereas the supernatant water would be collected in the pump chamber, from where a part would be pumped fpr flushing the scale in the mill flumes and the remaining quantity would be returned to the central water station. Necessary oil traps and skimming arrangement are to be provided in the scale pits.

After the above preliminary treatment in the scale pits to remove part of the scale and oil, the water is returned to the central water station, where it is pumped through pressure filters to remove the remaining scale and oil and then cooled in heat exchangers and sent back for recirculation. The total quantity of direct cooling water in circulation is about 330 cu m per hour (see Drawing 10020-9-2) and for pumping this quantity of water, two pumps, including one stand-by are provided in the central water station.

The pressure filters are of the vertical type. The sludge from the filtration unit will be pumped to a sludge pond.

A separate booster pump is provided in the steelmelt shop for supply of direct cooling water at high pressure for apron cooling and the machinery of the continuous casting machines.

9 - Water and other utilities (cont'd)

Central water station

The location of the central water station is shown in Drawing 10020-6-1. The central water station proposed would include an outdoor pump station, heat exchangers and treatment units with a central control room. The pump station includes sumps of RCC construction and vertical pumps which are installed on the slabs covering the sumps.

A list of the major equipment proposed to be provided for the water system is given in Appendix 9-1.

Emergency water sypply

It is essential that supply of water to the vital units such as arc furnace, reheating furnace, mould cooling section of the continuous casting machines etc is continued even in an emergency to prevent serious damage to equipment. For this purpose, one 70 cu m capacity overhead tank floating on the indirect cooling water system will be provided. The overhead tank capacity has been fixed to ensure water supply to the vital units for a duration of about 15 minutes, in the event of pump stoppage due to power failure. Besides, a diesel engine driven pump has been considered for purpose of continuing supply of emergency water. Motor control centres in the pumphouse will also be fed with electric power over two independent feeders to minimise the chances of total power failure in the pumphouse.

For mould cooling section of the continuous casting machines, a thermo-symphonic tank has been provided so that in case of power failure, water will be in circulation automatically by thermo-symphonic action.

Drinking water system

Underground water will be supplied by PCW as potable water for plant drinking and sanitary requirements. A separate tank of 50 cu m capacity for supply of water to the plant buildings will be provided. Potable water will also be supplied for laboratory and other miscellaneous uses.

9 - Water and other utilities (cont'd)

Fire-fighting system

The fire-fighting system envisages installation of stand-post type fire hydrants at regular intervals on one of the drinking water mains laid along side the shops and buildings. For this purpose, two pumps will be provided, one electrically operated adjoining the ground storage tank which would supply water for fire-fighting through the drinking water pipeline, by-passing the overhead tank.

AUXILIARY FACILITIES

Materials handling and transport

As there is no railway system in PDRY, all material movement to and from the plant will have to be by road. Local scrap will be transported from the scrap dumps to the open storage and preparation yard in the plant by road dumpers or trucks. Other materials such as limestone, iron-ore, ferro-alloys, refractories etc will be brought by truck and unloaded in the store provided in the kitchen floor of steelmelt shop. The outgoing traffic will comprise finished rolled products. All movement outside the plant boundary will be done in contractors' vehicles.

All material within the plant will also be moved by road. For this purpose truck forklift and dumper are provided. A list of major equipment for handling in-plant materials is given in Appendix 9-2.

Maintenance facilities and stores

For smooth operation of the plant, facilities need to be provided for carrying out repair and maintenance work. It is not proposed to manufacture spare parts in the plant. A small maintenance shop is proposed with facilities for carrying out minor repairs, replacement and other activities of routine nature. It may also be possible to take help from the Revolutionary Spare Parts Factory for some of the general type of repairs and maintenance shops.

9 - Water and other utilities (cont'd)

Spare parts,consumables, refractories, electrodes etc will be kept in the general store provided in the plant.

A list of major facilities proposed for the maintenance shop and stores is given in Appendix 9-3.

Laboratory

The laboratory provides the basic facilities for exercising control over the plant process and the quality of the finished products. The facilities relate to chemical analysis and testing of raw materials, in-process materials and finished products. Taking into account the location and requirements of the steelmelt shop and the rolling mill, one common laboratory is proposed. This laboratory will be located next to the steelmelt shop. The list of major facilities in the laboratory is given in Appendix 9-4.

Fuel oil storage

Fuel oil will be required for preheating of ladles in the steelmelt shop and for the reheating furnace in rolling mills. Furnace oil having a calorific value of about 10 000 kcal/kg is proposed to be used for this purpose. The estimated requirement of fuel oil is given below:

	Tons/year
Ladle heating, tundish heating, etc	300
Reheating furnace ...	1000
Total	1300

Fuel oil may be brought to the plant in road tankers and stored in storage tanks from where the oil will be distributed to the consumers. Possibility of obtaining fuel oil from Aden refinery will have to be examined during detailed engineering. At present, about 1 000 tons of heavy oil (Mazout) is produced in Aden Refinery.

9 - Water and other utilities (cont'd)

Compressed air

Compressed air is required for general services in the plant and for breaking of refractory lining etc. For this purpose, two (2) water cooled reciprocating air compressors of 250 Ncu m/hr each are proposed to be provided in the steel melt shop.

Administrative building, canteen and first-aid station

The administrative building, canteen and first-aid station are grouped in an administrative complex, located near the main entry to the plant. The complex will be isolated from the steel plant and will have access only from the outside. A prayer hall is provided in the administrative complex for use by the plant personnel.

10 - PLANT CONSTRUCTION

The proposed steel plant to be established at Hiswa is designed to produce initially 20 000 tons per year of bars, rods and light section. The major production facilities are a steelmelt shop with two 8-ton furnaces and a single-strand billet caster, and a bar and rod mill.

The total work for the plant construction will involve the following:

Construction facilities and preliminary works

- Construction power system
- Construction water system
- Site survey and levelling
- Construction offices
- Consturctor's area

Production units

- Steelmelt shop
- Bar and rod mill

Auxiliary and ancillary units

- Administrative building complex
- Repair and maintenance shop and stores
- Gate house, weighbridge etc.

Utilities

- Power system
- Water system
- Fuel oil storage and distribution system
- Compressor room
- Piping, cabling, roads, sewerage and drainage

This chapter deals with the type and volume of construction work to be handled and presents a construction schedule for the project. The implementation procedure as well as the areas where advance action needs to be taken are also outlined.

10 - Plant construction (cont'd)

TYPE OF CONSTRUCTION IN STEEL PLANT

Foundations and civil work

The proposed plant site is away from the sea coast and above the mean sea level. In view of this, it is proposed to keep the site formation level at 0.5 m above sea level.

The production and auxiliary facilities will largely be located on level ground. The bearing capacity of the soil as informed by Ministry of Construction is 1.5 kg/sq cm. Hence the building column foundations and foundations for major equipment in the steelmelt shop and the bar and rod mill may be supported by piles. However, this has to be examined in detail during engineering. The foundations for ar[illegible]ary buildings and other auxiliary facilities, such as the stores, r[illegible] and maintenance shops, will be on normal foundations of reinforced concrete. In view of the high water table within 1.5 to 2 m depth and the water quantity being highly brackish in nature, all underground structures will have to be waterproofed and given necessary anti-corrosive treatment.

In general, ground floors of most of the buildings are proposed to be made of reinforced concrete slab laid over boulder or gravel soiling. In production shops, floor should be of reinforced concrete supported on structural steel framework or simple gravel floor as the circumstances may demand.

Steel structures

The production units, repair and maintenance shops, stores, service and utility buildings etc are proposed to be of welded structural steel construction. Provision for expansion will be kept on certain sides by providing bolted connections. Due allowance will also be made in the design of members to take care of corrosion effects.

10 - Plant construction (cont'd)

The roof and side cladding in all production units, repair and maintenance shops, stores and utility and service buildings will be with galvanised steel sheets. Natural lighting will be provided by glazing on the sides, and suitable ventilation features will be incorporated in the building designs.

The building structures will be provided with expansion joints at intervals to accommodate thermal expansion. Heat shields and column encasements will be provided to protect the steelwork in areas of intense heat. Necessary access provisions for maintenance of cranes, lighting, roof drainage will be provided. For roof drainage, slopping gutters and downpipes will be provided with suitable access to the roof.

Utility networks

All underground cable feeders will be laid in the ground. Overhead pipelines will be carried on steel trestles. Underground pipelines will be protected by corrosion-resistant treatment.

Volume of construction

The approximate quantities of major items of work for the construction of the proposed steel plant are given in Table 10-1.

TABLE 10-1 - APPROXIMATE QUANTITIES OF WORK FOR MAJOR ITEMS FOR CONSTRUCTION

Major items of work	Unit	Approximate quantity
Excavation in foundations ..	cu m	58 000
Concrete of all grades ..	cu m	18 500
Shuttering	sq m	50 500
Reinforcement	tons	1 300
Structural steelworks ..	tons	1 700
Roof and side cladding ..	sq m	27 000
Glazing	sq m	1 350
Roads	meter	1 800(1)
Equipment	tons	3 000

Note:

(1) Within plant boundary and including access to the administration building.

10 - Plant construction (cont'd)

These estimates are based on preliminary design, and the type of equipment proposed for the plant, and are only indicative of the magnitude of the work involved. The actual quantities might [illegible] during the actual plant construction, depending upon the final plant site, the equipment finally selected, their design, layout finally adopted, results of soil investigations, etc.

The distribution of the major items of work such as concrete, structural steelwork and equipment erection in the various [illegible] given in Table 10-2.

TABLE 10-2 - DISTRIBUTION OF MAJOR ITEMS OF WORK

Facility	Concrete cu m	Structural steelwork tons	Equipment erection tons
Steelmelt shop ..	[illegible] 700	750	[illegible]
Bar and rod mill ..	[illegible] 400	[illegible]	[illegible]
Electric power system	500	50	100
Water system ..	1 500	-	350
Other utilities ..	[illegible]	[illegible]	[illegible]
Auxiliary units ..	1 500	[illegible]	[illegible]
Ancillary buildings ..			
and miscellaneous	[illegible] 500	-	
	[illegible] 500	[illegible]	[illegible]

Based on the quantum of work indicated in [illegible], the approximate requirements of major construction materials for the steel plant are shown in Table 10-3.

TABLE 10-3 - APPROXIMATE REQUIREMENTS OF MAJOR CONSTRUCTION MATERIALS

Materials	Unit	Approximate quantity
Cement ..	tons	9 000
Coarse aggregate ..	cu m	17 000
Fine aggregate ..	cu m	12 000
Reinforcing steel ..	tons	1 300
Structural steel ..	tons	1 800
Sheeting materials ..	sq m	30 000
Glazing ..	sq m	1 500

10 - Plant construction (cont'd)

Construction schedule

A tentative construction schedule showing the commencement, duration and completion of various activities is given in Drawing 10020-10-1. In order to meet this schedule, it is necessary that the construction/erection, once started, proceeds without a break. Any break in these activities is likely to have a chain reaction with ultimate delay in the commissioning of the plant. To be able to adhere to the schedule closely, the critical path method (CPM) will have to be adopted to determine likely bottlenecks, so that remedial steps in advance could be taken.

It is estimated that the preliminaries such as soil investigation, site survey, construction facilities, issue of enquiries for major equipment, civil and structural work, and placement of orders will take about 12 months from the time a firm decision is taken to go-ahead with the project.

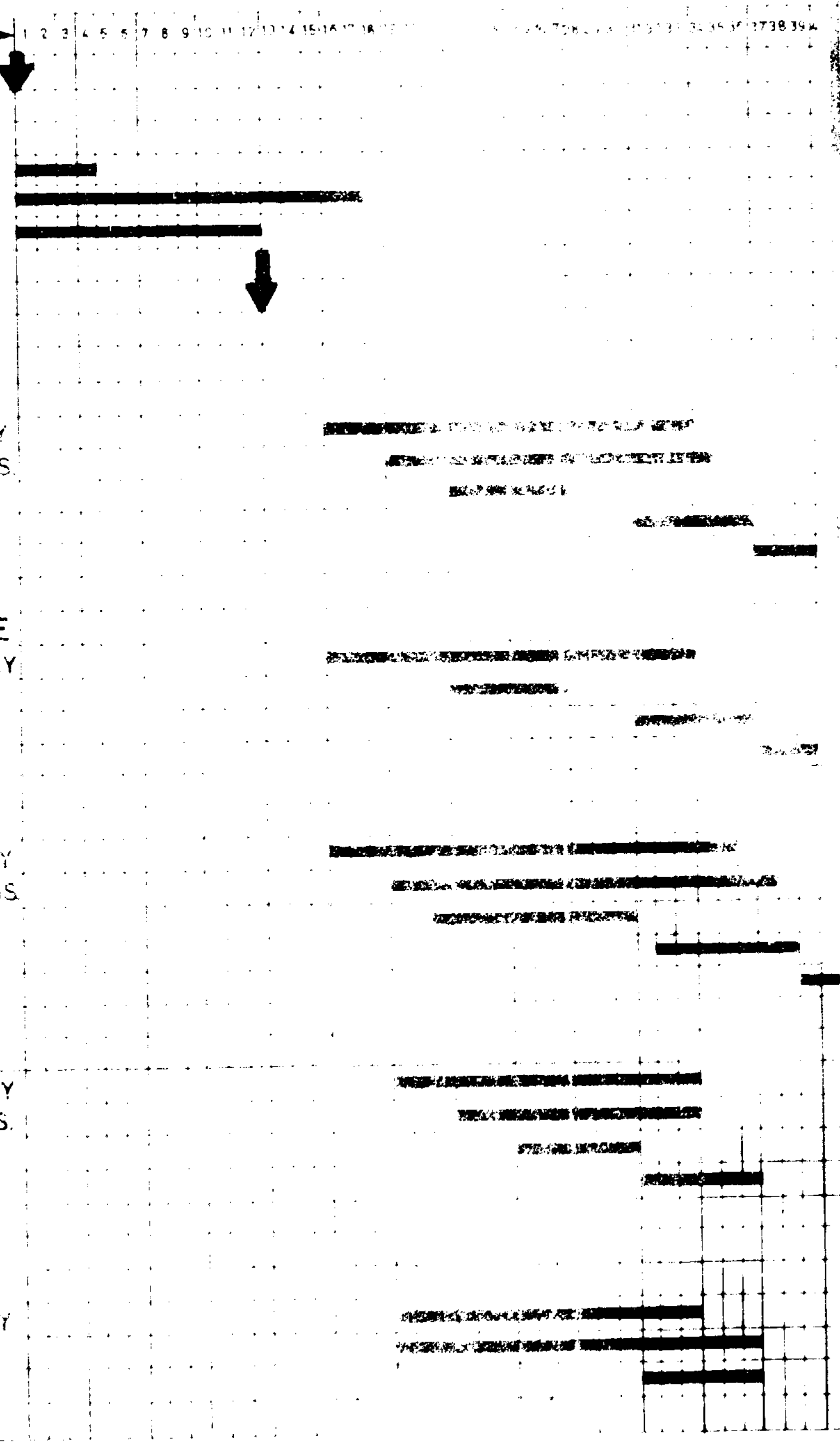
Keeping in view the volume of work, the lead time required for procurement of the type of equipment proposed, etc the total time for project implementation activity is estimated at 28 months, from the placement of orders inclduing four months for trial runs and commissioning. It is to be noted that the timely implementation of the project will call for a coordinated effort on the part of a number of agencies. The interrelationship between the different activities is brought out in the form of a precedence diagram in Drawing 10020-10-2. The various activities are briefly described below.

Pre-engineering activities

Site investigation, site levelling, etc: This activity comprises soil investigation work, finalization of plant general layout, site survey and provision of construction facilities such as water and electric power at site. Because of the nearness of the proposed plant site to the sea,

CONSTRUCTION SCHEDULE

MONTHS →



GO AHEAD

PRELIMINARY ENGINEERING
- i) SOIL INVESTIGATION & SITE SURVEY
- ii) CONSTRUCTION FACILITIES
- iii) PREPN. OF SPEC, ISSUE OF TENDERS & TENDER EVALUATION

PLACEMENT OF ORDER

PROJECT IMPLEMENTATION

i) ELECTRIC ARC FURNACE
- A) EQUIPMENT MANUFACTURE & DELIVERY
- B) CIVIL & STRUCTURAL WORK FOR BLDGS.
- C) CIVIL WORK FOR EQUIPMENT
- D) EQUIPMENT ERECTION & TESTING
- E) TRIAL RUNS & COMMISSIONING

ii) CONTINUOUS CASTING MACHINE
- A) EQUIPMENT MANUFACTURE & DELIVERY
- B) CIVIL & STRUCTURAL WORK
- C) EQUIPMENT ERECTION & TESTING
- D) TRAIL RUNS & COMMISSIONING

iii) BAR AND ROD MILL
- A) EQUIPMENT MANUFACTURE & DELIVERY
- B) CIVIL & STRUCTURAL WORK FOR BLDGS.
- C) CIVIL WORK FOR EQUIPMENT
- D) EQUIPMENT ERECTION & TESTING
- E) TRIAL RUNS & COMMISSIONING

iv) POWER SYSTEM
- A) EQUIPMENT MANUFACTURE & DELIVERY
- B) CIVIL & STRUCTURAL WORK FOR BLDGS.
- C) CIVIL WORK FOR EQUIPMENT
- D) EQUIPMENT ERECTION & TESTING

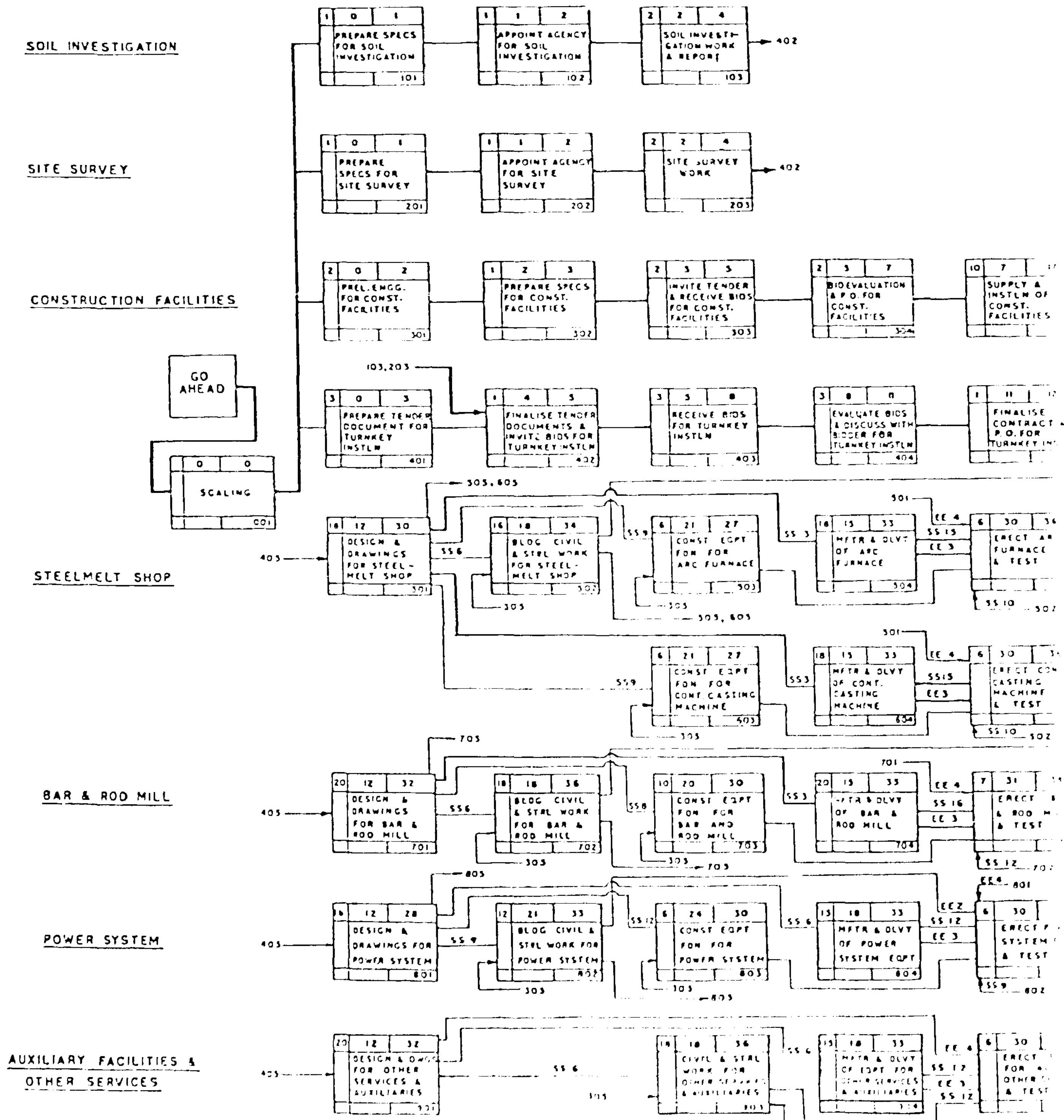
V) AUXILIARY FACILITIES AND OTHER SERVICES
- A) EQUIPMENT MANUFACTURE & DELIVERY
- B) CIVIL & STRUCTURAL WORK
- C) EQUIPMENT ERECTION & TESTING

DASTUR ENGINEERING INTERNATIONAL GmbH
CONSULTING ENGINEERS, DUSSELDORF

FOR: UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

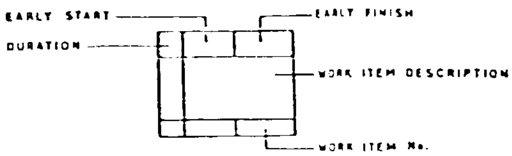
MINI STEEL PLANT IN PDR OF YEMEN
FEASIBILITY REPORT
CONSTRUCTION SCHEDULE

DRAWN		15.11.82	10020-10-1
APPROVED		16.11.82	


SOIL INVESTIGATION
SITE SURVEY
CONSTRUCTION FACILITIES
STEELMELT SHOP
BAR & ROD MILL
POWER SYSTEM
AUXILIARY FACILITIES & OTHER SERVICES
GO AHEAD
SCALING
PREPARE SPECS FOR SOIL INVESTIGATION
APPOINT AGENCY FOR SOIL INVESTIGATION
SOIL INVESTIGATION WORK & REPORT
PREPARE SPECS FOR SITE SURVEY
APPOINT AGENCY FOR SITE SURVEY
SITE SURVEY WORK
PREL. ENGG. FOR CONST. FACILITIES
PREPARE SPECS FOR CONST. FACILITIES
INVITE TENDER & RECEIVE BIDS FOR CONST. FACILITIES
BID EVALUATION & P.O. FOR CONST. FACILITIES
SUPPLY & INSTLN OF CONST. FACILITIES
PREPARE TENDER DOCUMENT FOR TURNKEY INSTLN
FINALISE TENDER DOCUMENTS & INVITE BIDS FOR TURNKEY INSTLN
RECEIVE BIDS FOR TURNKEY INSTLN
EVALUATE BIDS & DISCUSS WITH BIDDER FOR TURNKEY INSTLN
FINALISE CONTRACT & P.O. FOR TURNKEY INSTLN
DESIGN & DRAWINGS FOR STEELMELT SHOP
BLDG CIVIL & STRL WORK FOR STEELMELT SHOP
CONST EQPT FOR FOR ARC FURNACE
MFTR & DLVY OF ARC FURNACE
ERECT ARC FURNACE & TEST
CONST EQPT FOR FOR CONT CASTING MACHINE
MFTR & DLVY OF CONT. CASTING MACHINE
ERECT CON CASTING MACHINE & TEST
DESIGN & DRAWINGS FOR BAR & ROD MILL
BLDG CIVIL & STRL WORK FOR BAR & ROD MILL
CONST EQPT FOR FOR BAR AND ROD MILL
MFTR & DLVY OF BAR & ROD MILL
DESIGN & DRAWINGS FOR POWER SYSTEM
BLDG CIVIL & STRL WORK FOR POWER SYSTEM
CONST EQPT FOR FOR POWER SYSTEM
MFTR & DLVY OF POWER SYSTEM EQPT
DESIGN & DWGS FOR OTHER SERVICES & AUXILIARIES
CIVIL & STRL WORK FOR OTHER SERVICES & AUXILIARIES
MFTR & DLVY OF EQPT FOR OTHER SERVICES & AUXILIARIES

SECTION 1

LEGEND

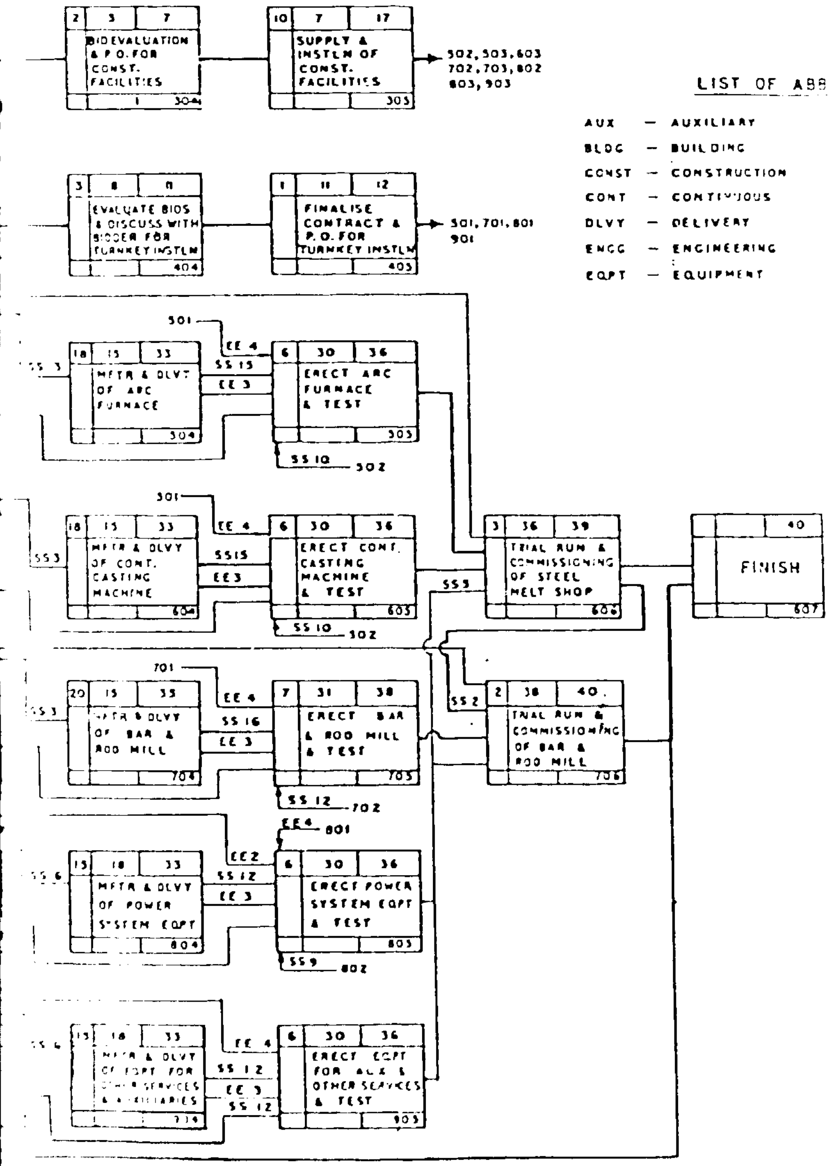


NOTE

1. SS – START TO START
2. EE – END TO END
3. CRITICAL PATH SHOWN THUS ———
4. ALL DURATIONS ARE IN MONTHS

LIST OF ABBREVIATIONS

AUX	– AUXILIARY	FDN	– FOUNDATION
BLDG	– BUILDING	INSTLN	– INSTALLATION
CONST	– CONSTRUCTION	MFTR	– MANUFACTURE
CONT	– CONTINUOUS	P.O.	– PLACEMENT OF ORDER
DLVY	– DELIVERY	PREL	– PRELIMINARY
ENGG	– ENGINEERING	SPECS	– SPECIFICATIONS
EQPT	– EQUIPMENT	STRL	– STRUCTURAL



SECTION 2

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FOR: UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

MINI STEEL PLANT IN PDR OF YEMEN
FEASIBILITY REPORT
PRECEDENCE DIAGRAM

DRAWN	R Dutt	20.11.82	10020-10-2
APPROVED	[signature]	22.11.82	

10 - Plant construction (cont'd)

sub-soil water level variations and salt content of the sub-soil water must be carefully investigated, in the context of their likely effect on concrete structures. Simultaneously with the receipt of this data, the plant general layout will be finalised.

Equipment procurement: Global tenders are proposed to be invited for bulk of the equipment.

The following major plant and equipment involve relatively long delivery periods:

Arc furnace

Continuous casting machine

Rolling mill equipment

The project implementation can be taken up only on final placement of order for these with a view to ensure uninterrupted construction and early commissioning. It is, therefore, essential to complete the work on tender prepartion for the above equipment, tender evaluation and placement of orders by the end of the 12th month from the go-ahead.

Project implementation

The project implementation activity will commence from the time orders for major equipment are placed. Orders for other ancillary equipment and utilities will also be finalised by the end of the 12th month so as to ensure that these facilities are installed and are ready, in line with the commissioning schedule which envisages completion of all facilities in 24 months from the time project implementation is taken up.

Civil work: Civil work for the main plant building and ancillary and auxiliary buildings is planned to commence from the 19th month. Arrangement will have to be made to ensure regular supply of construction material such as cement, aggregate, reinforcement etc. Civil work is

10 - Plant construction (cont'd)

expected to continue over a period of about 12 months. However, construction of structural column footings would have to be completed on a priority basis to facilitate the commencement of structural erection work.

Structural steelwork: It is estimated that about 1 700 tons of fabricated structural steelwork would be required for the project. A progressive, properly sequenced and well-coordinated fabrication and delivery schedule will permit uninterrupted erection work. Erection will be completed by the 36th month.

Equipment installation: The first major equipment to be received and erected at site will be EOT cranes for the furnace and casting aisle. Erection of the cranes is expected to be completed before the commencement of furnace erection. This is to facilitate the handling of heavy components of the furnace. The furnace is scheduled for trial runs in the 37th month. The erection of the continuous casting machine and other ancillary equipment, as well as the installation of electrical and piping utilities is so planned as to be completed to enable trial runs being taken up from the 37th month onwards. The erection of the rolling mill equipment and reheating furnace is exp cted to be completed by the end of the 38th month and the mill commissioned by the 41st month.

ACTION POINTS

The smooth implementation of a project involves coordinated efforts by various agencies such as the Project Authority, the Consulting Engineers, Government bodies and the Contracting Agencies.

The action points that need to be initiated immeidately for the implementation of the project are summarised below:

Project authority: Set up the Project Authority at the earliest to liaise with Government bodies, arrange finance and place orders on various agencies involved in the implementation of the project.

10 - Plant construction (cont'd)

Finance: Arrange in advance adequate finance for the project, to take up the construction work according to the schedule.

Consulting services: Appoint an independent professional consultant for providing the design and engineering services for the project.

Land acquisition: Based on the evaluation of the alternative location possibilities, select the site for the steel plant and acquire the land for installation of the steel plant.

Construction materials: Inform the local suppliers of construction materials in advance regarding the order of magnitude of the various requirements for the steel plant, so that they can gear themselves up to meet the additional demand.

11 - MANPOWER AND TRAINING REQUIREMENTS

This chapter presents the preliminary estimates of manpower requirements for administration, operation and maintenance of the proposed steel plant. The main purpose of this exercise is to indicate the order of manpower requirement, derive the labour component of production cost and provide guidelines to initiate action on recruitment and training.

ORGANISATION STRUCTURES

The organisation structure proposed for the management of the steel plant is presented in Figure 11-1. However, it is only indicative, as it may have to be modified at an appropriate time to suit the actual working requirements and administrative procedure that may be adopted by the steel plant authorities. The organisation chart indicates the top management as well as departmental supervisory personnel.

The organisation structure conceived by the Consulting Engineers visualises that it will be headed by a General Manager, who will be the Chief Executive responsible for the efficient working of the entire organisation. He will be assisted by two Assistant General Managers: one responsible for Production/Technical aspects and the other for Administration and Finance. The Assistant General Manager, Administration and Finance will be responsible for the general administration, personnel and welfare functions, industrial relations, security, finance and commercial functions. The Assistant General Manager (Production/Technical) will be responsible for the satisfactory operation of the plant in respect of production, maintenance, quality, cost and safety. The Assistant General Manager (Technical/Production) will be aided by

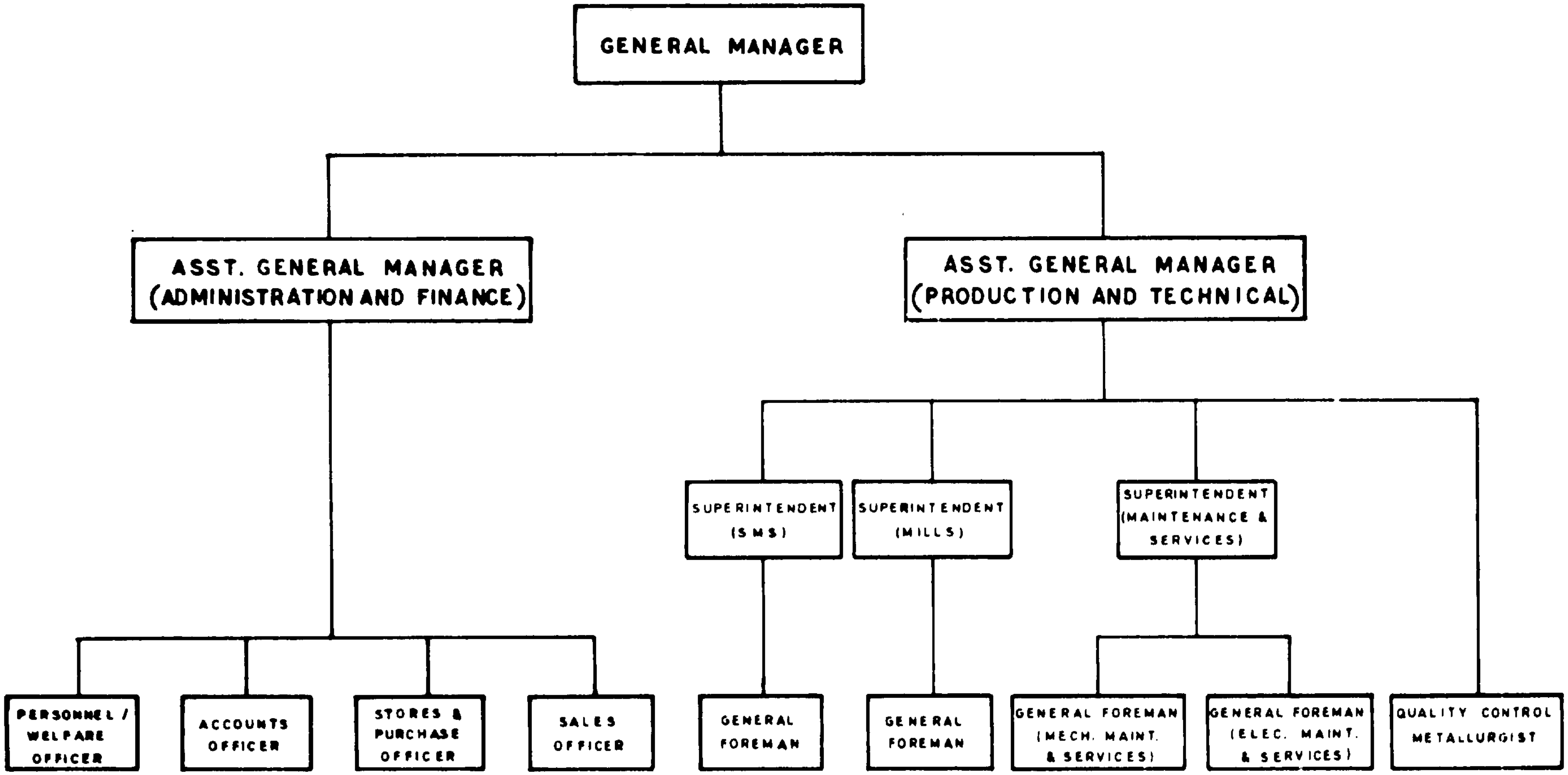


FIG. 11-1. ORGANISATION CHART

NOTE: THIS IS NOT A STATUS CHART

superintendents - one in charge of steelmelt shop, one for the rolling mills, and the third for maintenance and services. In order to inculcate quality consciousness in production, it is proposed to have a metallurgist with expertise on quality control aspects; he will report directly to the Assistant General Manager (Technical/ Production).

MANPOWER REQUIREMENT

The estimate of the manpower requirements presented in this chapter is tentative. It will be necessary to review the manpower requirement at the time of engineering the project, keeping in view the final plant layout, the equipment selected and personnel policies adopted. Detailed manpower studies will have to be made at the time of commissioning and operation of the plant, using systematic work study.

The efficient operation of a steel plant is determined to a large extent by the skills possessed by the work force. A wide range of skills is involved, as the operations carried out in a steel plant are many and complex. The work force in a steel plant can be broadly grouped into the following categories of personnel according to the characteristic skill for carrying out their respective tasks:

i) Managerial

ii) Supervisory

iii) Highly skilled such as steel making, continuous casting, rolling, maintenance of electrical and mechanical equipment etc.

iv) Skilled like masons, welders, crane operators, control panel operators etc.

v) Semi-skilled as typefied by the work of conveyor attendants, oilers, packers, loaders etc.

11 - Manpower and training requirements (cont'd)

vi) Unskilled such as those required for cleaning, handling materials, messengers, janitors etc.

vii) Office staff carrying out works such as secretarial, typing, filing etc.

Keeping the above factors in view, manpower estimates have been prepared for different departments; the total is estimated at 250. The department-wise manpower estimates are presented in Appendices 11-1 to 11-5 and are summarised in Table 11-1.

TABLE 11-1 - TOTAL MANPOWER REQUIREMENT

Department	Shifts Genl	I	II	III	Total per weekday	Total on payroll
I. Administration Dept	19	2	2	2	25	27
II. Works Departments						
Assistant General Manager (Technical/ Production) including quality control and laboratory	5	1	1	1	8	9
Steelmelt shop	6	24	23	21	74	91
Bar and rod mill	17	25	25	-	67	86
Maintenance and plant services	28	19	19	14	80	93
Total (II)	56	69	68	36	229	279
GRAND TOTAL	75	71	70	38	254	306

11 - Manpower and training requirements (cont'd)

Basis of manpower estimates

The manpower estimates are based on the production processes, equipment and facilities envisaged in different departments; also these estimates have been arrived at taking into account, as far as possible, the prevailing practices of manning in the steel plants. Wherever direct manning is involved, the positions have been tentatively identified on the basis of the layout, technology, equipment, location, job affinity etc. Where a crew is required for a particular operation, the crew size has been determined generally in line with normal practices and taking into account the proposed facilities. In addition, manpower has been provided to meet other requirements such as handling, shop cleaning, and miscellaneous work.

A centralised maintenance system has been proposed, keeping in view the size of the plant. The merits of centralised system are: efficient co-ordination and monitoring of the maintenance activities, better utilisation of maintenance manpower, standardisation of spares and maintenance procedures.

Concept of working with multi-skill worker has also been incorporated to reduce the work force. The multi-skill concept will assist in developing the skill of operational personnel for carrying out minor repairs and inspection of the equipment, and assisting the maintenance crew in carrying out capital repairs and break-downs.

11 - Manpower and training requirements (cont'd)

Provision for weekly off, leave etc

Manpower requirement for each department is shown under four shifts. The total of these shifts, entitled 'Total per weekday' gives the estimated number of men required on any working day. It also includes relief personnel for jobs involving continuous proximity to high temperatures. As the plant is scheduled to work only 6 days a week, allowances for only leave and absenteeism have been added to arrive at the 'Total on Payroll'.

Provision for leave reserve has been made on the basis of 38 days leave entitlement.

The holidays/leave entitlement of 38 days is about one quarter month in a year. Plant will remain shut down for 52 days corresponding to 52 weeks in a year. Therefore, no weekly off is to be additionally provided. In view of this, a provision of about 17 per cent has been made to cover holidays and leave. These additional men have been provided generally at appropriate lower levels, so that they can gather experience during acting periods in the higher positions and thus equip themselves for future promotion.

Break-down of manpower requirement by qualification and category

The qualification-wise and category-wise summary of the plant manpower requirements is given in Tables 11-2 and 11-3 respectively to highlight the skills and extent of qualification necessary at different levels.

11 - Manpower and training requirements (cont'd)

TABLE 11-2 - QUALIFICATION-WISE SUMMARY OF MANPOWER

Qualification/Trade		Qualification code	Total
Engineering Graduates			
Metallurgical Engineer	..	Met	7
Mechanical Engineer	..	Mech	2
Electrical Engineer	..	Elec	1
Sub-total	..		10
University Graduates			
Graduates in Science	..	B.Sc	4
Other Graduates (1)	..	Grad	5
Sub-total	..		9
Technicians			
Metallurgical	..	T.Met	16
Mechanical	..	T.Mech	20
Electrical	..	T.Elec	8
Civil	..	T.Civil	1
Sub-total	..		45
Trades			
Engineering trade	..	VTE	126
Commercial trades	..	VTC	21
Sub-total	..		147
School Certificate			
Secondary school	..	SS	8
Primary school	..	Pr.S	60
Sub-total	..		68
Others			
Drivers	..	Driver	15
Literate	..	Lit	12
Sub-total	..		27
TOTAL	..		306

Notes:

(1) 'Other Graduates' means university graduates in arts, commerce etc.

(2) Commercial trade includes store keeping, accounting, secretarial work, cooks etc.

11 - Manpower and training requirements (cont'd)

TABLE 11-3 - CATEGORY-WISE SUMMARY OF MANPOWER

Category	Administration	Assistant General Manager's Office	Steel-melt shop	Rolling mills	Maintenance and plant services	Total
Managerial	2	1	1	1	1	6
Supervisory	4	5	9	5	10	33
Highly skilled	-	-	8	6	11	25
Skilled	1	1	50	56	40	148
Semi-skilled & unskilled	9	1	22	12	29	73
Office staff	11	1	1	6	2	21
TOTAL	27	9	91	86	93	306

ANNUAL WAGE BILL

The annual wage bill comprises the basic salaries and wages and other benefits payable to the plant personnel. The resultant gross emoluments for the different categories of personnel are given in Table 11-4. It is to be noted that the salaries/wages given are indicative values and are primarily intended for estimating the magnitude of the annual wage bill to be included in the plant operating expenses.

TABLE 11-4 - ANNUAL SALARIES AND WAGES
(YD/Year)

Category		Gross emoluments
Managerial	..	1 200
Supervisory	..	960
Highly skilled	..	780
Skilled	..	600
Semi and unskilled	..	450
Office staff	..	720

Based on the total plant manpower requirement estimated earlier and the annual salaries/wages given in Table 11-4, the annual wage bill for the plant is computed in Table 11-5.

11 - Manpower and training requirements (cont'd)

TABLE 11-5 - ANNUAL WAGE BILL

Category	Number	Gross emoluments YD/Year	Annual bill YD	Provision for expatriates YD	Total bill YD
Managerial	6	1 200	7 200	550	7 750
Supervisory	33	960	31 680	2 370	34 050
Highly skilled	25	780	19 500	1 480	20 980
Skilled	148	600	88 800	-	88 800
Semi & unskilled	73	450	32 850	-	32 850
Office staff	21	720	15 120	-	15 120
TOTAL	306		195 150	4 400	199 550
				Say	200 000

In computing the total wage bill 25 per cent expatriates have been considered in managerial, supervisory and highly skilled categories. The gross emoluments for the expatriates h been taken at 30 per cent more than their Yemeni counterparts. The annual wage bill is YD 0.2 million.

MANPOWER AVAILABILITY IN PDRY

Present situation

As already mentioned a considerable number of PDRY work force works in neighbouring countries including some in industries. This is evident from the fact that the most important item in the service account are the workers' remittances. The remittances have significantly increased from US$ 41 million in 1977 to US$ 258 million in 1979.

The education/training attainment profile of the labour force is reported to have improved during the past few years. A number of training institutes have started operating in the country and enrollments in the primary level of education, as well as other levels, are increasing.

11 - Manpower and training requirements (cont'd)

In order to meet the shortage of adequately trained and skilled manpower, PDRY has had to employ expatriate workers.

TRAINING

Trained manpower is one of the essential pre-requisites for the successful maintenance and operation of the proposed steel plant. The education and training of industrial manpower takes considerable time. As recruitment and training of work force is time consuming, it is imperative to initiate comprehensive manpower planning well in advance so that the required number of qualified and trained personnel are available during commissioning and operation of the steel plant. The objective of such a plan should not be limited to merely listing out the requisite number of men and their qualifications and training needs, but should also provide for adequate opportunities to the workmen for development of additional skills and for advancement. Manpower planning should therefore, embody the following aspects:

i) Manning schedule

ii) Job specification and qualification for recruitment

iii) Organisation planning, span of control, functional responsibilities, reporting relationship and delegation of power.

iv) Wage and salary scales

v) Lines of promotion and age matrix

vi) Job description, and

vii) Recruitment, training and placement programme

In the interest of PDRY's development and sustained growth, the training policies and programmes will have to be necessarily oriented towards ensuring maximum participation by the Yemini personnel. With this end in view, and without unduly compromising on the time period required for bringing up the plant to a stable level of operation, the following broad scheme of training is suggested.

11 - Manpower and training requirements (cont'd)

The training of Yemeni personnel can be mainly divided into following three categories:

i) Training in trades for which basic facilities are already available in PDRY

ii) Training in skills and jobs outside PDRY in plants with facilities similar to those being proposed for installation

iii) Training at the equipment suppliers' works in order to familiarise the presonnel with the design, operation and maintenance requirements of the equipment being supplied.

Besides the above, it will be necessary to provide on-the-spot training at PDRY itself during the erection, commissioning and operation of the plant. In order to achieve this, it is proposed that the initial operation of the plant be placed in charge of expatriates/a specialised agency who will provide the services of necessary management and key technical personnel, extending over a period of about three to five years. In addition to the normal responsibility of plant operation and maintenance, this group of expatriates will also have the responsibility of training Yemini counterparts at different levels according to a training programme for ensuring transfer of expertise and responsibility and enable smooth phasing out of expatriates.

Based on the experience in developing countries, an indicative training period abroad in plants with similar facilities and at equipment suppliers' works for different categories of Yemini personnel outlining the educational qualification is given in Table 11-6.

11 - Manpower and training requirements (cont'd)

TABLE 11-6 - INDICATIVE TRAINING PERIOD FOR YEMINI PERSONNEL

Category	Number	Basic intake qualification	Training period months
1. Superintendent and General Foreman	5	University degree in Engineering	18
2. Shift Foreman and highly skilled staff	8	Technicians	18
3. Skilled staff in operation department	7	Vocational training Institute Graduate (Engineering Trades)	12
4. Skilled staff in maintenance and service departments	3	Vocational training Institute Graduate (Engineering Trades)	18

Semi-skilled staff will be trained at the plant itself during trial runs and commissioning.

The total cost of training will depend on the training charges per man-month, the living and out-of-pocket expenses of the trainees and their travelling expenses. For the purpose of this report, a provision of YD 7 million is considered adequate to cover training expenses. It is assumed that this cost will be borne by the PDRY Government for overall development of manpower skill.

12 - CAPITAL COSTS

The 'plant cost' covers all costs associated with the actual construction of the steel plant and includes the costs of site preparation, production and auxiliary departments, utilities and services, ancillary buildings, engineering and administration charges during construction, as well as contingencies. The costs to be incurred on capital spares, preliminary and promotional expenses, start-up expenses, construction facilities and interest during construction are added to the plant cost to arrive at the 'fixed investment'.

The capital cost estimate has been prepared only for the steel plant proper. The costs of township and other infrastructure facilities outside the plant boundary are not included, as these will have to be set up by the concerned authorities.

Plant cost

The plant cost estimate is prepared on the basis of prices of equipment and materials prevailing during middle half of 1982.

The plant cost includes the costs of site preparation, civil and structural work and equipment as erected. It also includes the expenses on administration during construction and charges for design, engineering and supervision of construction.

It needs to be pointed out that the site preparation and civil work costs have been estimated on the basis of information available during the field survey.

12 - Capital costs (cont'd)

The plant cost is estiamted at YD 8.1 million as given in Table 12-1. Details of the cost estimate are given in Appendices 12-1 to 12-6. The plant cost does not include the cost of land, since it is assumed that required land at Hiswa site will be made available free of cost.

TABLE 12-1 - PLANT COST SUMMARY

Item		Thousand YD
Soil investigation, site survey and preparation	..	100
Steelmelt shop	..	2 747
Bar and rod mill	..	4 032
Electrical power system	..	706
Water and other utilities	..	288
Repair shop and stores	..	54
Ancillary buildings and auxiliary facilities	..	135
Boundary wall, roads, drainage and sewerage	..	22
		8 084

Cost of structural steelwork: The cost estimates for structural steelwork are generally based on prevailing unit rates of steelwork as compiled by the Ministry of Construction. For certain items of work, for which unit rates are not available, the unit rates have been derived based on the cost of material and by making necessary provisions for labour, equipment and consumables, losses in fabrication and erection. The quantity of steelwork in buildings has been estimated based on preliminary design concept.

Cost of civil work: The cost of civil work has also been derived on similar basis as that indicated for structural steelwork. The approximate quantum of civil work in terms of concrete quantity has ben broadly estimated based on the preliminary layouts of the major departments, the covered area, the area of ancillary buildings, length of roads, drainage and sewerage facilities etc. Provision has been made in the estimate for soil investigation and site surveys. It is emphasized

12 - Capital costs (cont'd)

that the cost of civil work have been estimated on the basis of general information on the site conditions in Hiswa area collected by the Consulting Engineers' field team. However, these will have to be reviewed after detailed soil investigations are made on the selected site to establish the exact nature and type of foundations necessary. Similarly, the work involved on site preparation will also have to be established on the basis of contour surveys of the proposed site and the optimum plant level in keeping with the site contour.

Equipment cost: The cost of equipment has been estimated based on the type of facilities proposed, their preliminary layout and arrangement, and costs of comparable equipment available with the Consulting Engineers' data bank for projects being currently engineered by them. For arriving at the landed cost of equipment at site, a provision of 5 per cent of the f.o.b. cost of equipment has been added to cover the ocean freight, insurance, port clearance and handling charges and inland transportation to site. No provision has been made towards import duty as it has been indicated that the equipment for the project will be exempted from import duty.

Other costs: Based on the Consulting Engineers' experience, an average provision of about 20 per cent of the equipment cost has been made to cover the erection cost of the equipment.

A provision of about 10 per cent of the total cost of civil and structural work, and equipment as erected has been made to cover costs of design, engineering and construction supervision. Contingencies are provided at 10 per cent.

The capital cost of YD 8.0 million is equivalent to US $ 23 million taking into consideration the actual inbuilt capacity of the plant as indicated in Chapter 7, the Capital costs per annual ton liquid steel capacity and finished steel capacity are indicated below:

12 - Capital costs (cont'd)

	Capacity Tons	Investment per annual ton US $
Liquid steel	38 000	605
Billet	35 700	644
Rolled products	32 800	701

Fixed investment

The costs incurred on capital spares, preliminary and promotional expenses, construction facilities, start-up expenses, training expenses and interest on long-term loan during construction are added to the plant cost to arrive at the fixed investment.

Spares: To cover capital spares to be purchased with the equipment, a provision of 5 per cent of the equipment cost has been made. The estimated amount on this basis is YD 155 000.

Preliminary expenses: A provision of YD 5 000 is made to cover the initial expenses towards registration of company etc.

Training expenses: As discussed in Chapter 11, a number of Yemeni personnel will have to be trained in other countries, either in similar plants or at the equipment suppliers' works. For this purpose a preliminary provision of YD 700 000 is indicated in Chapter 11. It is assumed, however, that training expenses will be met by PDRY Government as a part of overall development of manpower skill.

Start-up expenses: The start-up expenses have been estimated as equivalent to about one and a half week's manufacturing cost at full production level and it works to approximately YD 60 000.

Construction facilities: During the construction, certain temporary facilities such as construction site office, construction power, construction water etc will be required. A provision of YD 20 000 has been made on this account.

12 - Capital costs (cont'd)

Interest on loan during costruction: The interest on long-term loan has been calculated considering a construction period of 40 months, as discussed in Chapter 10. The yearly phasing of capital expenditure, which will be financed through long-term loan and equity in the ratio of 1:1, is expected to be as follows:

Year		'000 YD		
		Capital expenditure	Equity	Loan
I year	..	1 664	1 664	-
II year	..	2 500	2 500	-
III year	..	3 330	-	3 330
IV year	..	830	-	830

The prevailing interest rate on long-term loans in PDRY is 8.0 per cent. However, it was understood that for a special major project like the steel plant, the interest may come down to 6 per cent. Based on anticipated phasing of capital expenditure and taking long-term interest rate as 8 per cent per annum the total interest on loan during construction works out to YD 228 000.

The total fixed investment is estimated at about YD 8.6 million as given in Table 12-2.

TABLE 12-2 - ESTIMATES OF FIXED INVESTMENT
('000 YD)

Plant cost	..	8 084
Spares	..	155
Preliminary expenses	..	5
Start-up expenses	..	60
Construction facilities	..	20
Interest during construction		228
Total	..	8 552

Total capital requirement

The total capital requirement is estimated at about YD 9.1 million. This includes YD 0.55 million towards working capital requirement, which is taken as equivalent to three months' manufacturing expenses and administrative and sales expenditure.

12 - Capital costs (cont'd)

Foreign exchange requirement

The requirement of foreign exchange will be mainly for the plant and machinery, spares, training expenses, start-up expenses and interest during construction. Foreign exchange expenditure for procuring construction facilities will depend on the extent to which similar facilities are available and can be modified for this project. A tentative break-down of the fixed investment in terms of the local currency component and the foreign exchange equivalent is given in Table 12-3.

TABLE 12-3 - LOCAL CURRENCY AND FOREIGN EXCHANGE REQUIREMENT
(in '000 YD)

	Local currency	Foreign exchange	Total
Plant cost ..	1 000	7 084	8 084
Spares ..	-	155	155
Preliminary expenses ..	5	-	5
Start-up expenses ..	15	45	60
Construction facilities	10	10	20
Interest during construction	25	203	228
Total ..	1 055	7 497	8 552

From the above table it is seen that the foreign exchange component is likely to constitute almost 90 per cent of the total fixed investment. This is based on the assumption that by the time plant construction will start, the proposed cement plant will be in production and a portion of the requirement of cement will be met from local supply.

Financing pattern and sources of funds

As has been discussed above, the total capital requirement for the project is estimated at about YD 9 million. The debt and equity components are expected to be as follows:

12 - Capital costs (cont'd)

		'000 YD		
		Loan	Equity	Total
Fixed investment excl interest on loan during construction	..	4 030	4 294	8 324
Interest on loans during construction	..	228	-	228
Working capital requirement	..	550		550
Total	..	4 808	4 294	9 102

From the above it would be seen that borrowed capital would account for about 53 per cent of the total capital requirement and equity capital for the balance 47 per cent.

It is expected that a major portion of the equity capital may be obtained through friendly Arab countries, as well as from Financial Institutions of PDRY. In keeping with the recent trend for turn-key contracts awarded in other developing countries, the Contractor/Supplier could also be asked to participate in the equity capital.

Long-term loans could be obtained from international and regional financing agencies such as the International Bank for Reconstruction and Development (IBRD),International Development Bank, the Arab Development Fund etc, as well as through bilateral credits and suppliers' credit. For example, for the Rashtriya Ispat Nigam Ltd, Visakhapatnam, USSR has extended their financial help at a nominal interest rate on the repayment term of 20 years. For sponge iron/billet making plant now under construction at Trengganu, Malaysia, Nipon Steel Corporation, Japan have entered into equity participation with Malaysian authorities. It may be possible for PDRY to attract soft-term loan from USSR, East European countries and from Japan for implementing the project. Preference for obtaining loans from a particular agency/source would have to be evaluated on the basis of various terms and conditions offered by different financing sources such as the interest rate charged, grace period allowed before loan repayment is to commence and the stipulated loan repayment schedule.

13 - OPERATING COST

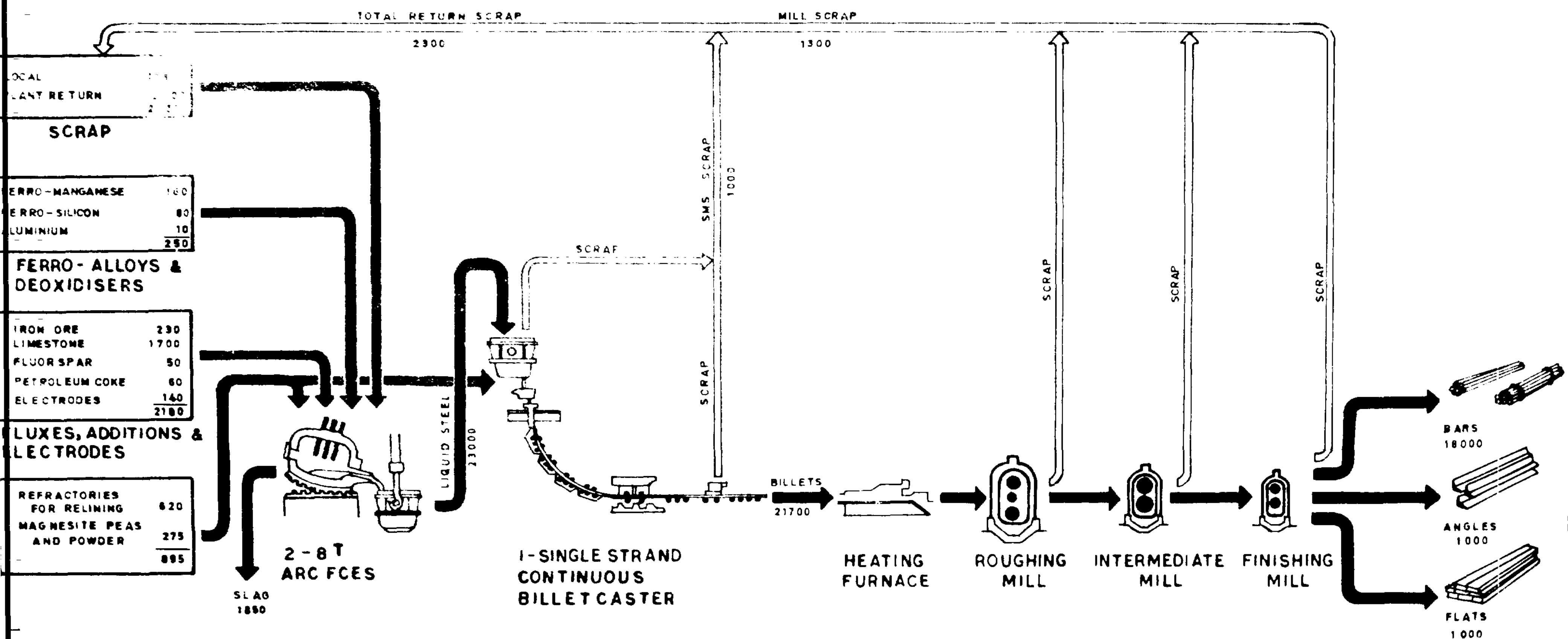
The annual operating cost comprises the manufacturing and other expenses. The manufacturing expenses cover all costs associated with the actual production and include the cost of raw materials and conversion cost including the cost of labour and supervision. The other expenses include administration and sales expenses, interest on long-term loan, interest on short-term loan required for working capital, depreciation and amortisation of deferred charges.

Manufacturing expenses

The plant flowsheet indicating the requirements of various raw materials for the annual production of 20 000 tons bars, rods and sections are given in Drawing 10020-13-1. The material and utility flowsheet for the production departments is given in Figure 13-1. Based on these flowsheets, the annual manufacturing expenses have been worked out and are given in Table 13-1. The foreign exchange costs and costs in local currency in the annual manufacturing cost are indicated in Table 13-2. The percentage share of the foreign currency in the total annual manufacturing expenses are as follows:

	YEAR OF OPERATION				
	1	2-11	12	13	14-15
	%	%	%	%	%
FC	25.76	29.52	31.79	40.51	39.71
LC	74.24	70.48	68.21	59.49	60.29
Total	100.00	100.00	100.00	100.00	100.00

From the above, it is seen that upto the 11th year of operation foreign currency accounts for about 30 per cent and in the later years when accumulated domestic scrap will be depleted the percentage share of foreign currency will be of the order of 40 per cent.



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FOR: UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

MINI STEEL PLANT IN PDR OF YEMEN
FEASIBILITY REPORT
PLANT FLOW SHEET

NOTE: QUANTITIES IN TONS PER YEAR

DRAWN		3.9.82	10020-13-1
APPROVED			

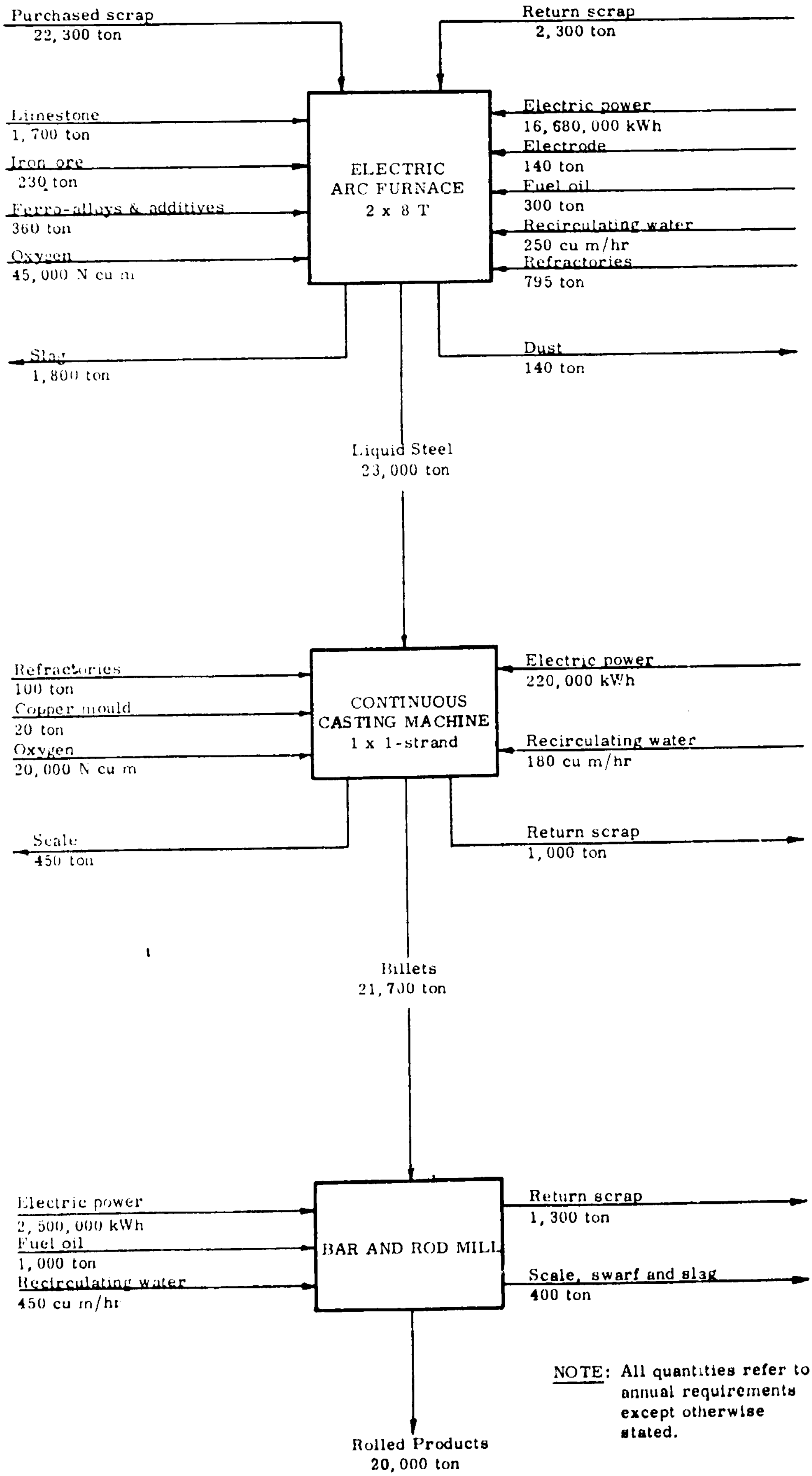

FIG. 13-1. MATERIAL AND UTILITY FLOW SHEET

TABLE 13-1 - ANNUAL MANUFACTURING EXPENSES

	Unit	Price YD	Year 1 Quantity '000 tons	Year 1 Cost '000 YD	Years 2-11 Quantity '000 tons	Years 2-11 Cost '000 YD	Year 12 Quantity '000 tons	Year 12 Cost '000 YD	Year 13 Quantity '000 tons	Year 13 Cost '000 YD	Years 14-15 Quantity '000 tons	Years 14-15 Cost '000 YD
A. COST OF MATERIALS												
Domestic scrap	ton	19.333	13.40	[illegible]	22.30	431.126	19.60	378.[illegible]	9.00	173.997	10.00	193.330
Imported scrap	ton	23.148	-	-	-	-	2.70	62.[illegible]	13.30	[illegible]	12.30	284.720
Limestone	ton	3.779	1.02	3.855	1.70	6.424	1.70	6.424	1.70	6.424	1.70	6.424
Iron ore	ton	13.228	0.138	1.825	0.230	3.042	0.230	3.042	0.230	3.042	0.230	3.042
Ferro-manganese	ton	122.001	0.096	11.712	0.160	19.520	0.160	19.520	0.160	19.520	0.160	19.520
Ferro-silicon	ton	187.187	0.048	8.[illegible]	0.080	14.975	0.080	14.975	0.080	14.975	0.080	14.975
Aluminium	ton	337.750	0.006	[illegible].027	0.010	3.378	0.010	3.378	0.010	3.378	0.010	3.378
Fluorspar	ton	[illegible].593	0.030	2.778	0.050	4.630	0.050	4.630	0.0[illegible]	4.630	0.050	4.630
Petroleum coke	ton	166.667	0.036	6.000	0.060	10.000	0.060	10.000	0.060	10.000	0.060	10.000
Sub-total				[illegible]		[illegible]		[illegible]		[illegible]		540.019
B. CONVERSION COST												
Labour and supervision				182.781		182.781		182.781		182.781		182.781
Electrode	ton	1000.000	0.074	74.000	0.140	140.000	0.140	140.000	0.140	140.000	0.140	140.000
Electric power	'000 kWh	37.000	13400	496.000	19700	728.890	19700	728.890	19700	728.890	19700	728.890
Other utilities				114.360		166.553		166.553		166.553		166.553
Repair and maintenance consumables, refractories etc				258.640		446.150		446.150		446.150		446.150
Works general expenses				34.438		34.438		34.438		34.438		34.438
Sub-total				1160.771		1698.812		1698.812		1698.81[illegible]		1698.812
TOTAL				[illegible]		[illegible]		[illegible]		[illegible]		2238.831

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TABLE 13-2 - FOREIGN AND LOCAL CURRENCY IN ANNUAL MANUFACTURING COSTS

	Year of operation														
	1			2-11			12			13			14-15		
	FC '000 YD	LC '000 YD	Total '000 YD	FC '000 YD	LC '000 YD	Total '000 YD	FC '000 YD	LC '000 YD	Total '000 YD	FC '000 YD	LC '000 YD	Total '000 YD	FC '000 YD	LC '000 YD	Total '000 YD
A. COST OF MATERIALS															
Domestic scrap ..	-	259.062	259.062	-	431.126	431.126	-	378.927	378.927	-	173.997	173.997	-	193.330	193.330
Imported scrap ..	-	-	-	-	-	-	53.095	9.404	62.499	261.544	46.324	307.868	241.880	42.840	284.720
Limestone ..	-	3.855	3.855	-	6.424	6.424	-	6.424	6.424	-	6.424	6.424	-	6.424	6.424
Iron ore ..	1.345	0.480	1.825	2.241	0.801	3.042	2.241	0.801	3.042	2.241	0.801	3.042	2.241	0.801	3.042
Ferro-manganese ..	11.377	0.335	11.712	18.963	0.557	19.520	18.963	0.557	19.520	18.963	0.557	19.520	18.963	0.557	19.520
Ferro-silicon ..	8.818	0.167	8.985	14.696	0.279	14.975	14.696	0.279	14.975	14.696	0.279	14.975	14.696	0.279	14.975
Aluminium ..	2.006	0.021	2.027	3.343	0.035	3.378	3.343	0.035	3.378	3.343	0.035	3.378	3.343	0.035	3.378
Fluorspar ..	2.673	0.105	2.778	4.456	0.174	4.630	4.456	0.174	4.630	4.456	0.174	4.630	4.456	0.174	4.630
Petroleum coke ..	5.875	0.125	6.000	9.791	0.209	10.000	9.791	0.209	10.000	9.791	0.209	10.000	9.791	0.209	10.000
Sub-total ..	32.094	264.150	296.244	53.490	439.605	493.095	106.585	396.810	503.395	315.034	228.800	543.834	295.370	244.649	540.019
B. CONVERSION COST															
Labour and supervision ..	4.4	178.381	182.781	4.4	178.381	182.781	4.4	178.381	182.781	4.4	178.381	182.781	4.4	178.381	182.781
Electrode ..	73.690	0.310	74.000	139.414	0.586	140.000	139.414	0.586	140.000	139.414	0.586	140.000	139.414	0.586	140.000
Electric power ..	-	496.000	496.000	-	728.890	728.890	-	728.890	728.890	-	728.890	728.890	-	728.890	728.890
Other utilities ..	-	114.362	114.362	-	166.553	166.553	-	166.553	166.553	-	166.553	166.553	-	166.553	166.553
Repair and maintenance consumables, refractories etc ..	254.810	3.880	258.690	439.458	6.692	446.150	439.458	6.692	446.150	439.458	6.692	446.150	439.458	6.692	446.150
Works general expenses ..	10.331	24.107	34.438	10.331	24.107	34.438	10.331	24.107	34.438	10.331	24.107	34.438	10.331	24.107	34.438
Sub-total ..	343.231	817.540	1160.771	593.603	1105.209	1698.812	593.603	1105.209	1698.812	593.603	1105.209	1698.812	593.603	1105.209	1698.812
TOTAL ..	375.225	1081.690	1457.015	647.093	1544.814	2191.907	700.188	1502.019	2202.207	908.637	1334.009	2242.646	888.973	1349.858	2238.831

NOTES:

1. FC = Foreign currency
2. LC = Local currency

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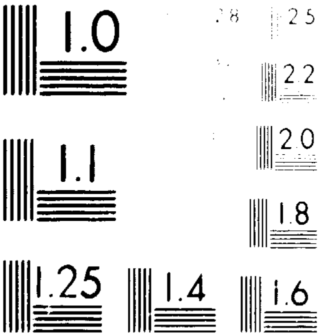
1.0
2.8
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2.0
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1.25
1.4
1.6

13 - Operating cost (cont'd)

The comparatively low level of foreign exchange requirements is likely to pave the way for favourably considering the establishment of the proposed steel plant.

Raw materials: The annual requirements of raw materials are shown in Table 3-4 and 4-1 of Chapter 3 and 4 respecively. The unit costs of various raw materials are discussed in Chapter 3 and 4. The unit price of materials are given in Table 13-3. Based on the annual requirements and the unit costs, the annual cost of raw materials is estimated.

TABLE 13-3 - UNIT PRICES OF RAW MATERIALS
(YD per ton)

Material		Sources	Base price(1)	Port and other charges	Total
Domestic scrap	..	scrap dumps	17.250	2.083	19.333
Imported scrap	..	Imported	19.665	3.483	23.148
Limestone	..	Local	0.890	2.889	3.779
Iron ore	..	Imported	9.745	3.483	13.228
Ferro-silicon	..	Imported	118.518	3.483	122.001
Ferro-manganese	..	Imported	183.704	3.483	187.187
Aluminium	..	Imported	334.267	3.483	337.750
Fluorspar	..	Imported	-	-	92.593
Petroleum coke	..	Imported	-	-	166.667

NOTE:
(1) c.i.f. price Aden port in case of imported materials and price at source for domestic material.

Labour and supervision: The requirement of Works Personnel has been estimated as 279 in Chapter 11. Based on the salaries and wages for different categories of personnel, as given in Chapter 11, the annual wage bill for the Works Personnel is computed as YD 182 781.

Electrode: The annual requirement of graphite electrode for arc furnace operation is estimated at 140 tons. Based on the international price the unit cost of electrode at Hiswa site works out to about YD 1 000 per ton. On this basis the annual cost of electrode works out to YD 140 000.

13 - Operating cost (cont'd)

Electric power: The electric power requirements of the steel plant will be supplied by PCEP from the Hiswa Power Station now under construction near the recommended plant site. The prevailing rate of electric power charged to industry is 37 phills per kWh, irrespective of quantum of consumption. The same rate has been adopted in this Study for computing the cost of electric power. It may, however, be pointed out that for heavy industries like steel plants, power is generally supplied at concessional rates in many countries. For example, in India the average power rate for domestic consumption is almost double compared to that levied for heavy industries like steel plant. The steel plant authorities should take up this matter with PCEP and secure concessional rate for electric power to improve the project viability.

Based on the annual consumption of 19.7 million kWh of electrical energy, the annual cost of purchased electric power is estimated at YD 728 890.

Other utilities: Other utilities include water, fuel oil, oxygen and compressed air. Desalinated water for the steel plant will be supplied by PCW from the desalination plant of Hiswa Power Station now under construction. As indicated by PCW, the cost of desalinated water has been taken at 200 phills per cu m. Compressed air will be available from the compressor units within the plant, the costs associated with the operation and maintenance of these facilities have been included under other items of conversion cost such as labour and supervision, electric power and repair and maintenance. The price of fuel oil has been taken at YD 61.410 per ton and that of oxygen in cylinders as YD 2.5 per N cu m as indicated by the Ministry of Industry.

Repair and maintenance: A provision of about 3.0 per cent of the cost of equipment has been made towards repair and maintenance expenses to cover the materials cost. The salaries and wages for the maintenance personnel have already been included under labour and supervision.

13 - Operating cost (cont'd)

Consumables and supplies: Provision has been made towards expenses for consumables and supplies to cover the cost of refractories, copper moulds, rolls, lubricants, chemicals etc.

Works general expenses: The provision made towards works general expenses includes works transport cost, laboratory expenses and other miscellaneous items of cost.

Annual operating cost

The annual operating cost comprises the manufacturing and other expenses namely administration and sales expenses, interest on long-term loan, interest on short-term loan required for working capital, depreciation and amortisation of deferred charges. The annual operating cost in the second year of operation, when the plant is expected to reach its rated capacity production is given in Table 13-4.

TABLE 13-4 - ANNUAL OPERATING COST

	Thousand YD
1. Manufacturing expenses	
Raw materials cost	493
Labour and supervision	183
Other conversion costs	1 482
Sub-total	2 158
2. Other expenses	
Administrative and sales expenses ..	34
Interest on long-term loan ..	341
Interest on short-term loan ..	55
Depreciation and amortisation ..	590
Sub-total	1 020
Total	3 178

13 - Operating cost (cont'd)

Administrative and sales expenses: The administrative and sales expenses comprise the salaries of the personnel of the administration and commercial departments, as well as the overhead expenses to be incurred on items such as stationery, postage, telephone, telex, travel etc. The total expenses are estimated at YD 34 000.

Interest on long-term loan: Assuming a loan-equity ratio of 1:1 and an interest rate of 8 per cent per annum on long-term loan, the incidence of interest charges on the long-term loan works out to YD 341 000.

Interest on short-term loan: The working capital requirement is estimated at about YD 550 000 equivalent to 3 months' manufacturing, administration and sales expenses. Allowing for the cash that would become available towards working capital from the steel plant operations, the short-term loan for working capital to be secured in the first year of operation will be about YD 365 000. The annual interest on this working capital loan at the rate of 15 per cent per annum works out to YD 55 000.

Depreciation and amortisation: The plant cost excluding the cost to be incurred for soil investigations and site surveys, roads, drainage and sewerage, and engineering and administration during construction works out to YD 7.3 million. This amount has been considered for depreciation over 15 years on straight line basis.

The expenses to be incurred on engineering and administration during construction, preliminary expenses, start-up expenses, cost of construction facilities and interest on long-term loan during construction amount to YD 1.0 million. This amount has been amortised over a period of 15 years.

13 - Operating cost (cont'd)

Production cost per ton

The two production units in the steel plant are the steelmelt shop and the rolling mill. The production costs per ton of billet and rolled product have been estimated separately, and are shown in Appendices 13-1 and 13-2 respectively.

The production cost includes the cost of materials and the conversion cost. It will be seen that under the materials cost, credit for scrap arising is shown. This is only notional for computing the departmental production cost, as ultimately the cost of the plant return scrap charged to the consuming unit cancels the credit given to the scrap generating unit.

From Appendices 13-1 and 13-2, it will be seen that the production costs per ton of billet and rolled product are as follows:

		Billet YD/ton	Rolled product YD/ton
Material cost	..	23.461	91.445
Conversion cost	..	61.401	18.314
Production cost	..	84.862	109.759

To the production cost of the rolled product, the fixed charges (interest on long-term loan, interest on short-term loan, depreciation and amortisation of deferred charges) as well as the administrative and sales expenses should be added to arrive at the total cost per ton of rolled

13 - Operating cost (cont'd)

product. As indicated in Table 13-4, these expenses and charges together amount to YD 986 000, which works out to YD 49.30 per ton rolled product. Thus the total cost per ton of rolled product works out to YD 159 as shown below:

	YD/ton
Production cost of rolled product ..	109.759
Fixed charges and administrative and sales expenses ..	49.300
Total cost of rolled product	159.059
	Say YD 159 per ton

14 - FINANCIAL ANALYSIS

Based on the estimated capital cost, annual production cost, other charges and sales realisation, the financial aspects of the project for 15 years of operation covering profit and loss statement, cash-flow statement, break-even point, internal rate of return and pay-back period are discussed in this chapter.

Mode of financing the project

The total fixed investment, including the capitalised interest during construction, is estimated at about YD 8.55 million as indicated in Chapter 12. The loan-equity ratio assumed for the project is 1:1 and it is envisaged that YD 4.29 million will be obtained as equity while about YD 4.26 million will be obtained in the form of long-term loan.

Sales realisation

At present the entire requirement of reinforcing bars and rods and light section products is imported by PDRY mainly from European countries. Therefore, for determining the likely selling prices of products to be rolled in the proposed steel plant, the present levels of fob prices for similar products exported by the ECSC countries have been examined.

The average fob prices of reinforcing rounds and section (upto 600 mm) exported by ECSC member countries to third countries, from 1979 till the middle of 1982, are given in Table 14-1.

14 - Financial analysis (cont'd)

TABLE 14-1 - EXPORT PRICES OF ECSC COUNTRIES FOR SELECTED STEEL PRODUCTS
(US $ per ton, fob)

Year	Reinforcing rounds	Sections
1979		
Jan	280	300
Jun	325	315
Dec	330	325
1980		
Jan	325	325
Jun	310	325
Dec	300	325
1981		
Jan	235	320
Jun	225	315
Dec	240	320
1982		
Jan	240	320
Feb	240	320
Mar	235	320
Jun	215	300

Source: Metal Bulletin, various issues.

It is seen from the Table 14-1 that there was sharp fall in ECSC export price of reinforcing rounds and sections in June 1982. This declining trend is due to severe recession that world steel industry is currently passing through and it is undoubtedly a temporary phase. Thus the average price observed from 1979 to 1981 should form the basis for deriving the likely sales prices of the products in PDRY. For this purpose a comparison of the average ECSC export prices and the corresponding landed costs per ton of imported rolled products at Aden port is made. Imports and the corresponding values given in annual statistics have been used for computing the landed cost as shown below:

14 - Financial analysis (cont'd)

Year	Reinforcing rounds				Sections			
	Imports		Cost per ton		Imports		Cost per ton	
	tons	value '000 YD	YD	US $(1)	tons	value '000 YD	YD	US $(1)
1979	4117	544	132.1	383	168	28	167	484
1980	1968	292	148.4	430	1275	237	186	539
1981	1012	215	212.5	616	697	115	115	478

NOTE:
(1) On the basis of exchange rate of YD 0.345 to 1 US $.

The landed cost of steel as computed above for the period 1979 to 1981 are compared with corresponding export prices as shown in Table 14-2.

TABLE 14-2 - COMPARISON OF ECSC EXPORT PRICES AND LANDED COSTS IN PDRY

Year	Reinforcing rounds			Sections		
	ECSC export price(1) US $ ton	Landed cost in PDRY(2) US $ ton	Landed cost/fob price %	ECSC export price(1) US $ ton fob	Landed cost in PDRY(2) US $ ton	Landed cost/fob price %
1979	310	383	124	315	483	153
1980	310	428	138	325	537	165
1981	235	615	262	310	479	155

NOTES:
(1) Average price for the whole year.
(2) Equivalent cost in US$ calculated from Foreign Trade Statistics.

From the Table 14-2 it is seen that the landed cost of reinforcing rounds in 1981 was about US $ 615 per ton and US $ 497 for sections. From the information furnished by National Company for Home Trade it is seen that the average selling price of reinforcing round of 10 to 12 mm dia is also of the order of US $ 650 per ton. Therefore. in the case of the proposed plant it would be reasonable to compute the selling prices on the basis of the corresponding landed costs of imported steel

14 - Financial analysis (cont'd)

a nominal profit margin of 10 per cent. However, keeping in view the objective of supplying steel at a cheaper price than the present day market price in PDRY, the landed cost of steel has been derived based on the average ratio between landed cost and f.o.b price observed for the period 1979 to 1981. The average ratio works out to about 175 and 155 per cent for reinforcing rounds and sections respectively.

In computing the selling prices the incidence of port charges and applicable import duties (15 per cent for reinforcing rounds and 20 per cent for sections) have been taken into consideration. A profit margin of 10 per cent has also been added.

	ECSC fob price YD/ton	Landed cost in PDRY YD/ton	Port charges YD/ton	Import duties YD/ton	Total cost in PDRY YD/ton	Adopted selling price(6) YD/ton
Reinforcing bars & rods, flat bars	81.08(1)	141.89(3)	3.48	21.28(5)	166.65	183.00
Sections	103.40(2)	160.43(4)	3.48	32.09(6)	196.00	215.00

NOTES;

(1) Equivalent to US $ 235 per ton
(2) Equivalent to US $ 300 per ton
(3) Assuming landed cost is 75 per cent higher than fob price.
(4) Assuming landed cost is 55 per cent higher than fob price.
(5) At 15 per cent of landed cost
(6) At 20 per cent of landed cost.

Based on the above mentioned selling prices for the various categories of steel products, the estimated annual sales realisation from the second year of operation (when the plant is expected to attain its full rated capacity) amounts to YD 3.692 million, as shown in Table 14-3. In the first year of operation when the plant is expected to achieve effectively about 60 per cent of its rated capacity, the estimate of annual sales realisation is YD 2.228 million.

14 - Financial analysis (cont'd)

TABLE 14-3 - ANNUAL SALES REALISATION

Product	Annual production tons	Sales price YD/ton	Sales realisation '000 YD
Reinforcing rounds and flat bars ..	19 000	183	3 477
Sections ..	1 000	215	215
	20 000		3 692

Annual manufacturing expenses

Manufacturing expenses cover cost of raw materials and conversion costs including labour and supervision as discussed in Chapter 13.

The plant is expected to operate at full rated capacity from the second year of operation and the annual manufacturing expenses at rated capacity are estimated at about YD 2.158 million. For the first year of operation when the effective production is expected to be abcut 60 per cent of the rated capacity, the annual manufacturing expenses excluding administration and sales expenses are estimated at about YD 1.42 million.

Administrative and sales expenses

The annual administrative and sales expenses are estimated to be YD 34 000. This will cover salaries and benefits of administrative staff, other office expenses such as postage, telegram, telex, telephone, printing, stationary, advertisement, travel etc.

Interest on long-term and short-term loans

Interest rates on long-term and short-term loans have been assumed as 8 per cent per annum and 15 per cent per annum respectively.

14 - Financial analysis (cont'd)

Depreciation and amortisation

The depreciation and amortisation has been calculated at 7 per cent per annum. On this basis the annual depreciation and amortisation works out to about YD 590 000.

Profit and loss statement

Based on the estimates and assumptions stated above, the profit and loss statement is presented in Table 14-4. It will be observed that the net profit increases progressively as the sales realisation increases and interest charges decline from the fourth year of operation. In the 12th and 13th year the net profit decline from the previous year and goes up again in 14th year. The temporary decline in net profit is due to the increase in the manufacturing expenses from 12th year as could be seen in Table 14-4.

The entire amount of long-term loan is expected to be repaid by the tenth year of operation and the net profit in the eleventh year of operation would be of the order of YD 0.9 million.

The cumulative net profit over 15 years of operation amounts to about YD 11 million yielding an average annual net profit of about Y 0.7 million on an equity capital of YD 4.29 million.

Cash-flow statement

Estimated figures of cash-flow generated by the project over a period of 15 years are presented in Table 14-5. It will be seen from the table that sufficient funds are available from the third year of operation for repayment of long-term loan in phased instalments. The net cash surplus at the end of the 15th year of operation is about YD 14.53 million.

TABLE 14-4 - PROFIT AND LOSS STATEMENT
('000 YD)

	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year	11th year	12th year	13th year	14th year	15th year
A. INCOME															
Sales realisation ..	2228	3640	3692	3692	3692	3692	3692	3692	3692	3692	3692	3692	3692	3692	3692
B. MANUFACTURING EXPENSES ..	1423	2158	2158	2158	2158	2158	2158	2158	2158	2158	2158	2168	2208	2205	2205
C. GROSS PROFIT (A-B) ..	805	1534	1534	1534	1534	1534	1534	1534	1534	1534	1534	1524	1484	1487	1487
D. OTHER EXPENSES															
Administrative & sales expenses ..	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
Interest on Long-term loan at the rate of 8% per annum ..	227	341	341	301	261	221	181	141	101	61	-	-	-	-	-
Interest on Short-term loan at the rate of 15% per annum ..	37	55	-	-	-	-	-	-	-	-	-	-	-	-	-
Depreciation and amortisation ..	390	590	590	590	590	590	590	590	590	590	590	590	590	590	337
Total (D) ..	658	1020	965	925	885	845	805	765	725	685	624	624	624	624	371
E. NET PROFIT BEFORE TAX															
Current ..	117	514	569	609	649	689	729	769	809	849	910	900	860	863	1116
Cumulative ..	117	631	1200	1809	2458	3147	3876	4645	5454	6303	7213	8113	8473	9836	10956

TABLE 14-5 - CASH FLOW STATEMENT
('000 YD)

	Construction period			Operating period														
	1st year	2nd year	3rd year	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year	11th year	12th year	13th year	14th year	15th year
A. SOURCE OF CASH																		
Opening balance ..	-	-	-	-	507	1061	1720	2419	3158	3937	4756	5615	6514	7195	8695	10185	11625	13078
Equity ..	1664	2500	130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Long-term loan ..	-	-	3328	930	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Short-term loan for working capital ..	-	-	-	365	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Net profit/loss before tax ..	-	-	-	117	514	569	609	649	689	729	769	809	849	910	900	860	863	1120
Depreciation amortisation ..	-	-	-	390	590	590	590	590	590	590	590	590	590	590	590	590	590	337
TOTAL (A) ..	1664	2500	3458	1802	1611	2220	2919	3658	4437	5256	6115	7014	7953	8695	10185	11635	13078	14535
B. DISPOSITION OF CASH																		
Capital expenditure ..	1664	2500	3330	675	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spares ..	-	-	-	155	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Interest during construction	-	-	128	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Working capital requirement	-	-	-	365	185	-	-	-	-	-	-	-	-	-	-	10	-	-
Repayment on long-term loan	-	-	-	-	-	500	500	500	500	500	500	500	758	-	-	-	-	-
Repayment on short-term loan	-	-	-	-	365	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL (B) ..	1664	2500	3458	1295	550	500	500	500	500	500	500	500	758	-	-	10	-	-
C. CASH SURPLUS (A-B) ..	-	-	-	507	1061	1720	2419	3158	3937	4756	5615	6514	7195	8695	10185	11625	13078	14535

DASTUR ENGINEERING INTERNATIONAL GmbH
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14 - Financial analysis (cont'd)

Break-even chart

The break-even chart, prepared for the 3rd year of operation and given in Figure 14-1, indicates the fixed cost, total cost and sales realisation at various levels of output. For the purpose of this exercise, the fixed costs, and the variable costs include the following:

Fixed costs		'000 YD
Labour and supervision	..	183
Other conversion costs	..	294
Administrative and sales expenses	..	21
Interest charges	..	396
Depreciation and amortisation	..	590
Total fixed costs	..	1 484
Variable costs		
Raw material	..	493
Other conversion costs	..	1 201
Total variable costs	..	1 694

The sales realisation in the second year of operation at full rated capacity is estimated at YD 3.692 million. The break-even chart prepared on the basis of the above estimates for the second year of operation reveals that the project will break-even at about 75 per cent of the rated capacity.

Internal rate of return

For working out the internal rate of return (IRR) before tax, the cash flow figures are adjusted to find out the actual cash surplus generated by the plant operation. The adjusted cash flow is given in Table 14-6.

It will be noted from the table that apart from adding back the depreciation and deferred charges, the interest charges on long-term loan and short-term loan have also been added to work out the internal rate of return on the total investment including the loan capital. In the

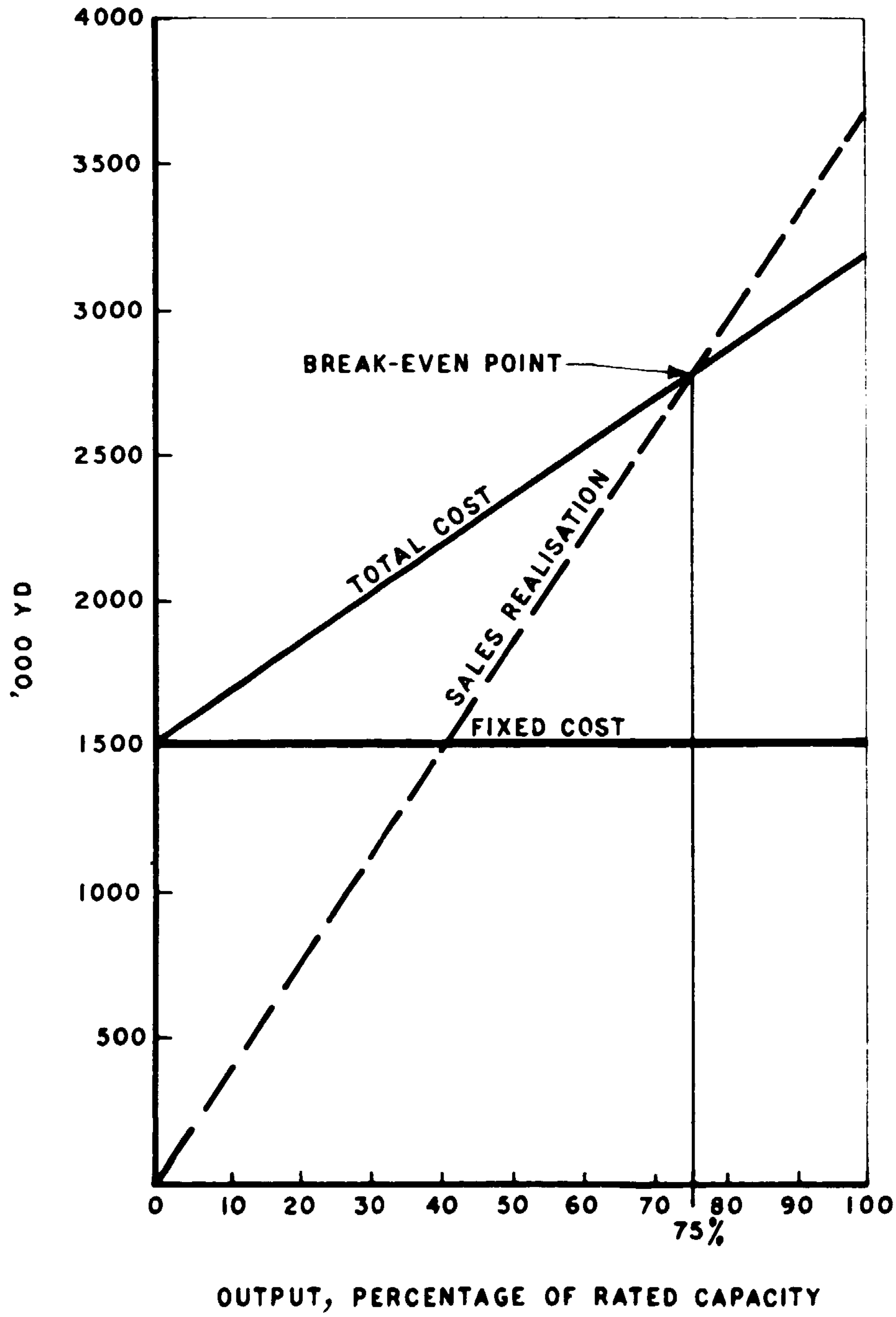


FIG. 14-1. BREAK-EVEN CHART

fifteenth year of operation the residual value of the plant is estimated at about YD 1.665 million. The working capital of YD 550 000 and YD 155 000 worth of spares are also assumed to be fully salvaged at the end of the fifteenth year.

The beginning of the first year of operation is taken as the zero point for working out the present value. All the fixed investment outflows during the construction period have been compounded.

In Table 14-7 the present values of the outflows and inflows have been arrived at by adopting two trial rates of 11 per cent and 12 per cent respectively. The ratio of out-flows to in-flows for the two trial rates are worked out and plotted on the interpolation chart given in Figure 14-2 from which it will be noted that the internal rate of return is estimated to be about 11.5 per cent.

Excess present value analysis

The analysis is given in Table 14-8. It is noted that the total value of net inflows at 8 per cent amounts to YD 12.63 million as against total present value of outflows of YD 9.97 million. The excess present value on this basis amounts to YD 2.66 million (i.e. Y^ 12.63 million minus YD 9.97 million). The present value index which is worked out as the ratio of the total present value of net inflows divided by present value of outflows is 1.27.

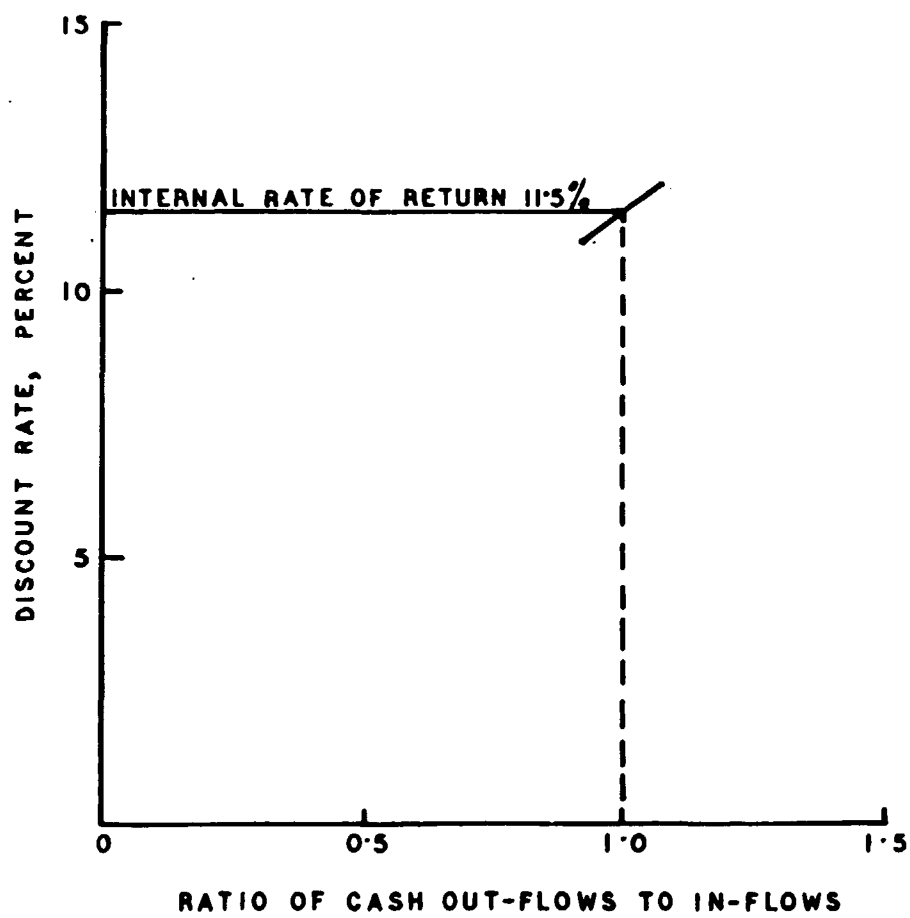


FIG. 14-2. INTERPOLATION CHART FOR INTERNAL RATE OF RETURN

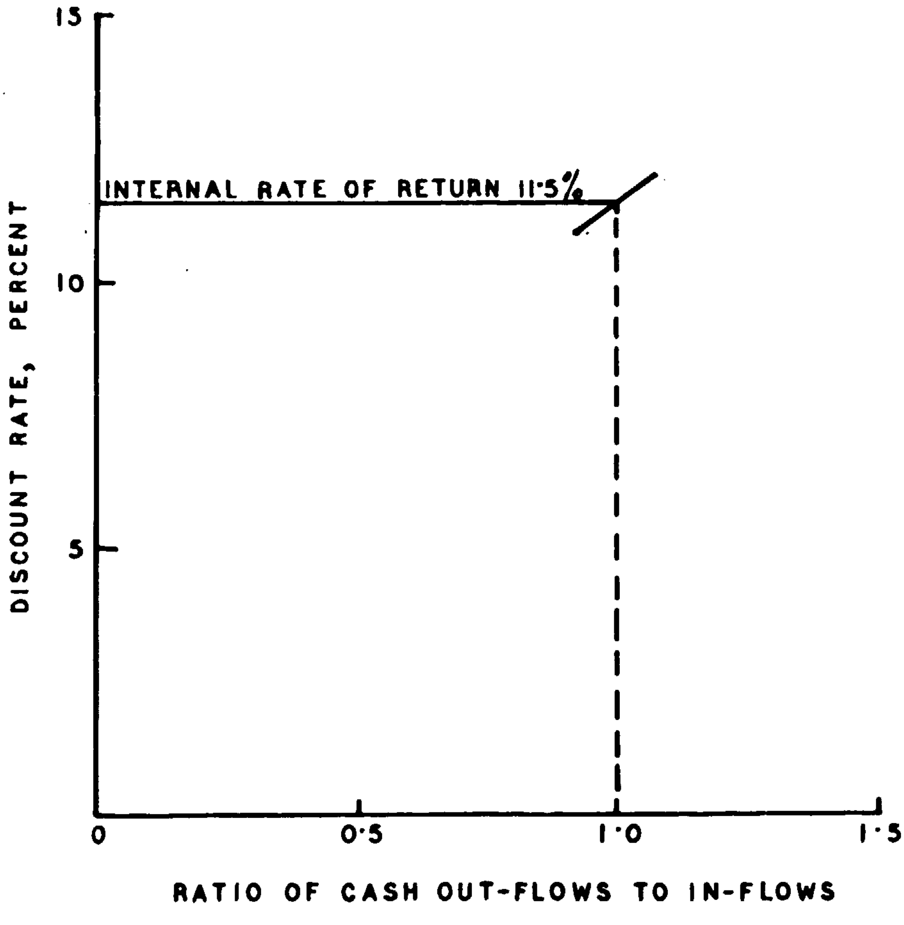


FIG. 14-2. INTERPOLATION CHART FOR INTERNAL RATE OF RETURN

14 Financial analysis (cont'd)

TABLE 14-6 ADJUSTED CASH-FLOW
('000 YD)

Year of operation	Operating surplus	Add interest on long-term loan	Add interest on short-term loan	Residual Value of eqpt and salvage value of working capital	Adjusted in-flow
1	507	227	37	-	771
2	1104	341	55	-	1500
3	1159	341	-	-	1500
4	1199	301	-	-	1500
5	1239	261	-	-	1500
6	1279	221	-	-	1500
7	1319	181	-	-	1500
8	1359	141	-	-	1500
9	1399	101	-	-	1500
10	1439	61	-	-	1500
11	1500	-	-	-	1500
12	1490	-	-	-	1490
13	1450	-	-	-	1450
14	1453	-	-	-	1453
15	1453	-	-	1665	3118

14 - Financial analysis (cont'd)

TABLE 14-7 - INTERNAL RATE OF RETURN
('000 YD)

	Fixed investment excluding capitalised interest	Working capital	Total fixed investment	Present value 11%	Present value 12%
A. CASH OUT-FLOW					
Construction period -					
year 1	1664	-	1664	2276	2338
2	2500	-	2500	3080	3136
3	3330	-	3330	3696	3730
Operation period (Zero point) 1	830	365	1195	1195	1195
2	-	185	185	151	165
				10398	10564

B. CASH IN-FLOW

	Adjusted cash surplus 11%	Adjusted cash surplus 12%	Discounted at 11%	Discounted at 12%
Year 1	771		695	688
2	1500		1351	1196
3	1500		1217	1068
4	1500		1097	953
5	1500		980	851
6	1500		890	760
7	1500		802	679
8	1500		722	606
9	1500		651	541
10	1500		586	483
11	1500		528	431
12	1490		426	382
13	1450		373	332
14	1453		337	297
15	3118		652	570
			11307	9837
Ratio A/B ..			0.92	1.07
IRR ..			11.5%	

14 - Financial analysis (cont'd)

TABLE 14-8 - EXCESS PRESENT VALUE ANALYSIS
('000 YD)

A. CASH FLOW

Years	Adjusted cash surplus	Discounted at 8%
1	771	714
2	1500	1286
3	1500	1191
4	1500	1103
5	1500	1022
6	1500	945
7	1500	875
8	1500	810
9	1500	750
10	1500	695
11	1500	642
12	1490	592
13	1450	532
14	1453	494
15	3118	982
		12633

B. CASH OUTFLOW

Year		Present value at 8%
Construction period		
1	1664	2097
2	2500	2915
3	3330	3596
Operation period		
1	1195	1195
2	185	171
		9974

EXCESS PRESENT VALUE = 12633-9974 = 2659

PRESENT VALUE INDEX = $\frac{12633}{9974}$ = 1.27

14 - Financial analysis (cont'd)

Pay-back period

In Table 14-9. the pay-back period is worked out on the traditional basis of estimated net in-flows. The pay-back period for the project is about 8 years.

TABLE 14-9 - PAY-BACK PERIOD
('000 YD)

A. CASH IN-FLOW

Year of operation		Operating surplus Current	Cumulative
1	..	507	507
2	..	1104	1611
3	..	1159	2770
4	..	1199	3969
5	..	1239	5208
6	..	1279	6487
7	..	1319	7806
8	..	1359	9165
9	..	1399	10564
10	..	1439	12003
11	..	1500	13503
12	..	1490	14993
13	..	1450	16443
14	..	1453	17896
15	..	1453	19349

B. CASH OUT-FLOW

Construction period		Estimate for the period
Year 1	..	1664
2	..	2500
3	..	3330
Operating period		
Year 1	..	675
Interest during construction		228
	Total	8397

C. PAY BACK PERIOD (Traditional method)=7.5 years

14 - Financial analysis (cont'd)

Balance sheet

The balance sheet of the project has been given in Table 14-10.

Sensitivity analysis

In order to study the effects of variations in capital and operating costs on the project, the IRRs for varying sales realisation, and power tariff have been computed and plotted in Figure 14-3.

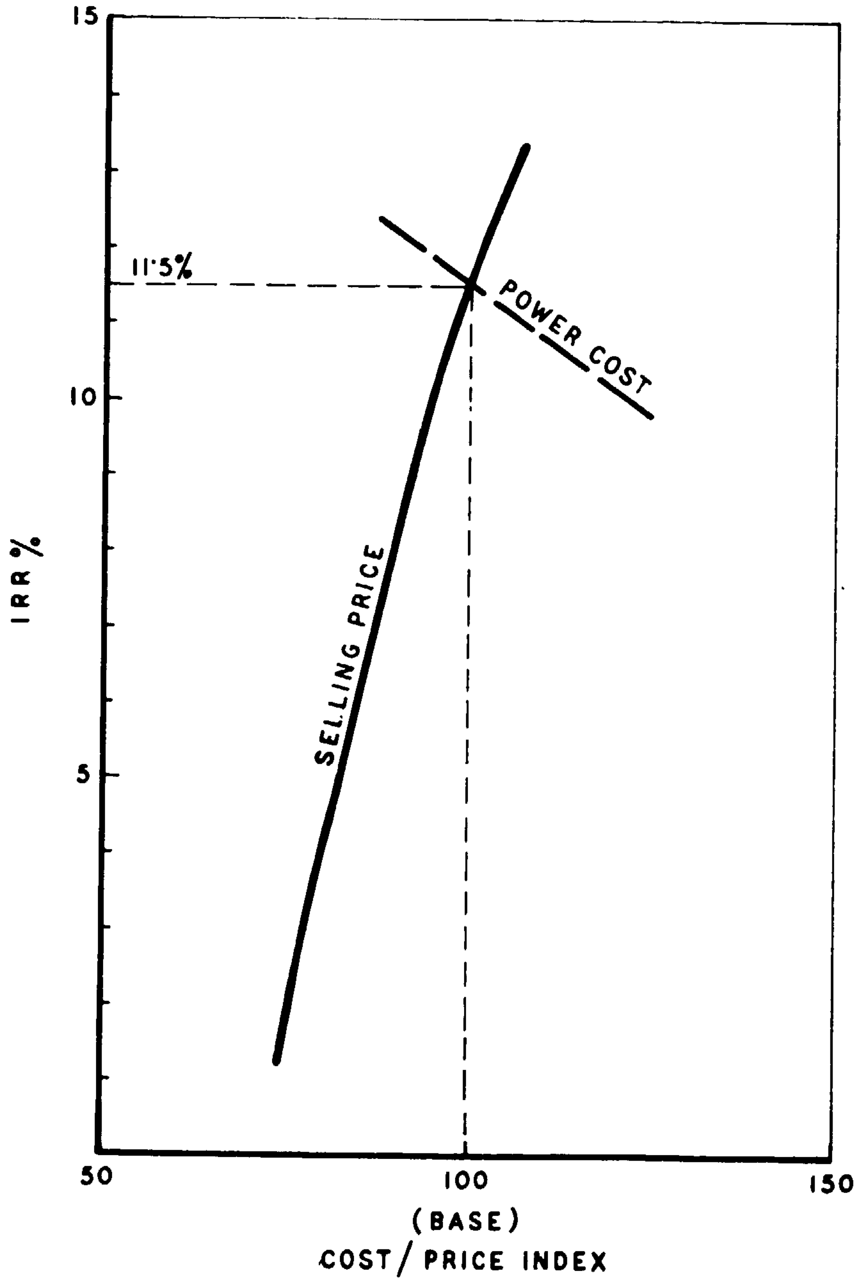
From the IRR trends indicated in Figure 14-3 the following observations emerge:

i) The IRR for the project is most sensitive to the annual sales realisation, that is the selling prices of the rolled products.

ii) IF an IRR of 10% before tax is to be achieved, the selling prices as adopted in this report may be reduced by about 5 per cent keeping all other prices and costs same, or the power cost may be increased by about 20 per cent.

TABLE 14-10 - BALANCE SHEET
('000 YD)

		Construction period			Operation period														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A. ASSETS																			
1. Cash balance	..	-	-	-	507	1 061	1 720	2 419	3 158	3 937	4 756	5 615	6 514	7 195	8 695	10 185	11 625	13 078	14 535
2. Current assets	..	-	-	-	520	705	705	705	705	705	705	705	705	705	705	705	715	715	715
3. Fixed assets (net of depreciation)	..	1 664	4 164	7 622	8 007	7 417	6 827	6 237	5 647	5 057	4 467	3 877	3 287	2 697	2 107	1 517	927	337	-
TOTAL (A)	..	1 664	4 164	7 622	9 034	9 183	9 252	9 361	9 510	9 699	9 928	10 197	10 506	10 597	11 507	12 407	13 267	14 130	15 250
B. LIABILITIES																			
1. Current liabilities	..	-	-	-	365	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Long-term loan	..	-	-	3 328	4 258	4 258	3 758	3 258	2 758	2 258	1 758	1 258	758	-	-	-	-	-	-
3. Equity	..	1 664	4 164	4 294	4 294	4 294	4 294	4 294	4 294	4 294	4 294	4 294	4 294	4 294	4 294	4 294	4 294	4 294	4 294
4. Reserves	..	-	-	-	117	631	1 200	1 809	2 458	3 147	3 876	4 645	5 454	6 303	7 213	8113	8 973	9 836	10 956
TOTAL (B)	..	1 664	4 164	7 622	9 034	9 183	9 252	9 361	9 510	9 699	9 928	10 197	10 506	10 597	11 507	12 407	13 267	14 130	15 250



NOTE:

BASE INDEX OF 100 REFERS TO UNIT PRICES AND COSTS ADOPTED FOR THE FINANCIAL ANALYSIS

FIG. 14-3. EFFECT OF VARYING COSTS / PRICES ON IRR

APPENDICES

APPENDIX - 1-1

TERMS OF REFERENCE VISUALISED IN UNIDO CONTRACT

3. TERMS OF REFERENCE

The following areas should be covered in the feasibility study:

3.1 Market and plant capacity

3.11 A survey of the present demand as well as projections for the next 10 years in all the six Governorates of the country should be made, broken down into various categories of products, and a market analysis undertaken.

3.12 An appropriate production programme should then be selected from alternatives.

3.13 A feasible normal plant capacity should be determined, based on parameters of the production programme and minimum economic equipment size.

3.2 Materials and inputs

3.21 All required raw materials and inputs should be identified qualitatively and quantitatively with potential sources and unit costs and a suitable supply programme prepared.

3.22 Likewise, all utilities required, e.g., electricity compressed air, fuel, water, effluent disposal etc., should be included under this head.

Appendix 1-1 (continued)

3.3 Location and site

The most suitable location and site should be determined after consideration of possible alternatives, based on topography, geography, availability of infrastructure, local conditions etc.

3.4 Project engineering

3.41 Optimum layouts of the equipment and facilities should be prepared for a new plant.

3.42 All new equipment to be procured should be classified into production, auxiliary and service equipment, spare parts and tools and listed with specifications and individual estimated costs. Adequate maintenance facilities and equipment should be provided.

3.43 All civil engineering work including site preparation and development buildings and special civil work, auxiliary and service facilities with estimated costs.

3.5 Manning

3.51 Detailed organisation structure and manning tables should be prepared, showing managerial, supervisory production labour and non-production labour including maintenance, services and administrative categories.

3.52 The requirements of skills and levels of training should be specified.

Appendix 1-1 (continued)

3.53 Requirements of short-term and long-term training for various levels of plant personnel, duration of training for each category and location of and arrangements for such training should be defined.

3.6 <u>Implementation scheduling</u>

3.61 An implementation programme and time schedule should be crawn up, considering technical know-how supply, detailed planning and engineering financing arrangements, and similar factors.

3.7 <u>Financial evaluation</u>

3.71 The total investment and production costs should be calculated and cash-flow tables for financial planning prepared.

3.72 The commercial profitability criteria, viz., net present value, internal rate of return, pay-back period, simple rate of return, break-even analysis and sensitivity analysis should be computed.

APPENDIX 2-1

SPECIFICATION FOR TONNAGE STEEL PRODUCTS

Indian standard specification	British standard specification	American standard specification	German standard specification	Available forms	Composition: C	Mn	Si	S	P	[illegible]	Tensile strength kg/mm²	Elongation	Principal uses
Semis													
IS2830/64	-	-	-	-	-	-	-	-	-	-	-	-	-
Gr I	-	-	-	Billets	0.10/0.1[illegible]	0.50/0.[illegible]0	-	0.0[illegible]	0.05[illegible]	[illegible]	-	-	For re-rolling into structural steel of standard quality
Gr II	-	-	-	-do-	0.17/0.[illegible]3	-do-	-	-do-	-do-	-do-	-	-	-do-
				-do-	[illegible]	-do-	-	-do-	-do-	-do-	-	-	-do-
IS 2831/64	-	-	-	-do-	0.10/0.17	0.[illegible]0/1.[illegible]	-	0.[illegible]	0.[illegible]	[illegible]	-	-	For re-rolling into structural steel of ordinary quality
				-do-	0.18/0.30	-do-	-	-do-	-do-	-do-	-	-	-
Structurals													
IS226/62	4,15, 968, 2762	-	-	Plates, sections, angles, tees, beams, channels, flats, bars and rods	0.2[illegible]	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Mainly for constructional purposes
IS1977/62 (St 32)	-	-	-	Plates, sections, angles, tees, beams, channels etc and flats	0.2[illegible]	-	-	0.0[illegible]	0.0[illegible]	[illegible]	[illegible]	[illegible]	-do-
IS1977/62 (St 44)	-	ASMA-283	-	-do-	0.[illegible]	-	-	-do-	-do-	-do-	[illegible]	[illegible]	-do-
IS2062/65	-	-	-	-do-	[illegible]	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	For structural purposes where fusion welding property is required
IS961/62 (St 58-HT)	-	-	-	-	0.27	-	-	[illegible]	[illegible]	-	[illegible]	[illegible]	Semi-killed or killed quality steel used for high tensile structural purposes

Indian standard specification	British standard specification	American standard specification	German standard specification	Available forms	Composition C %	Mn %	Si %	S %	P %	Cu %	Tensile strength kg/mm²	Elongation %	Principal uses
IS3039	-	-	-	All types of strl. steel	0.[illegible]	0.60/1.40	0.35	0.05	0.05	-	41/50	[illegible]	For ship building purposes
Flat products													
IS 2002/62	BS:1633	-	-	Plates	-	-	-	-	-	-	-	-	-
Gr I	-do-	-	1623	-do-	0.18	-	0.10/0.35	0.04	0.04	-	55	[illegible]	For boiler construction
Gr 2A	-do-	-	-	-do-	0.020	-	-do-	0.05	0.05	-	50	25	-do-
Gr 2B	-do-	-	-	-do-	0.22	-	-do-	-do-	-do-	-	[illegible]	[illegible]	-do-
IRS M 6.59	-	-	-	-do-	0.20	-	-	0.05	0.05	-	39/47	[illegible]	For locomotive boiler construction, non-flanging quality
IRS M 30.61	-	-	-	-do-	0.25	-	-	0.06	0.06	-	[illegible]	[illegible]	Flanging and pressing quality for wagons
-	BS:4/42	-	-	-do-	0.20	0.5	-	0.05	0.05	-	-	-	-
IS-[illegible] 63	BS:1449	-	-	Hot rolled sheets/strips	0.13	-	0.06	0.06	-	-	-	-	For general purposes and forming operations
ST34	-	-	-	-do-	0.15	-	0.050	0.[illegible]	-	-	34/42	[illegible]	-
ST42	-	-	-	-do-	0.20	-	-do-	-do-	-	-	42/50	[illegible]	-
ST50	-	-	-	-do-	0.30	-	0.05	0.05	-	-	50/[illegible]	[illegible]	-
ST52	-	-	-	-do-	0.22	-	0.05	0.05	-	-	[illegible]	[illegible]	-
IS513/63	BS:1449	-	-	Cold rolled sheets/strips	0.15	-	-	0.06	0.06	-	-	-	For ordinary purposes
Ordinary	-do-	-	-	-do-	-	-	-	-	-	-	-	-	-
Drawing	-do-	-	-	-do-	0.12	-	0.50	0.05	0.05	-	-	-	-
Deep drawing	-do-	-	-	-do-	0.10	-	0.50	0.[illegible]	0.04	-	-	-	-
Extra deep drawing	-do-	-	-	-do-	0.10	-	0.50	0.035	0.035	-	-	-	-
IS597/55	BS:1449	-	-	Black plates	0.14	0.5	-	0.06	0.07	-	-	-	Black plate for tinning required for deep stamping

Indian standard specifi-cation	British standard specifi-cation	American standard specifi-cation	German standard specifi-cation	Available forms	Composition C %	Mn %	Si %	S %	P %	Cu %	Tensile strength kg/mm²	Elon-gation %	Principal uses
Flat products (cont'd)													
-	-	-	-	Black plates	0.10	0.40	-	[illegible]	0.06	-	-	-	For deep drawing quality
IRS M 30/63	-	-	-	Sheets	0.15	[illegible].50	-	0.05	0.04	[illegible]	[illegible]	[illegible]	Sheets used for manufacture of integral coach
Pipes and tubes													
-	[illegible]	-	-	Tubes	0.08/0.18	0.30/0.90	0.30 max	[illegible]	[illegible]	-	-	-	Cold drawn tubes
IS1978	BS:3601	A53	-	-do-	0.20 max	0.70 max	-	[illegible]	[illegible]	-	-	-	Pipes and tubes for pressure purposes
-	BS:3602	-	-	Cold drawn seam-less tubes and welded tubes and pipes	-do-	[illegible]	-	[illegible]	[illegible]	-	-	-	For high duty applications
-	BS:3603	-	-	Seamless tubes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	For application at low temperature
IS 307-	BS:980 CDFI	-	-	Tubes	[illegible]	-	-	[illegible]	[illegible]	-	-	-	For automobiles
IS 307-	BS:980 ERWI	-	-	Welded tubes	[illegible]	[illegible]	-	[illegible]	[illegible]	-	-	-	-do-
IS [illegible]	BS:1717 CDS101	-	[illegible]	Seamless tubes	[illegible]	-	-	[illegible]	[illegible]	-	-	-	Cold drawn seamless tubes used for cycles and motor cycles
Bars and rods									max	max			
IS 2073/6	-	-	-	-	-	-	-	-	-	-	-	-	-
C 20	-	-	-	Carbon steel bars	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]	[illegible]	For production of machined parts for general engineer-ing purposes
C 40	-	-	-	-do-	0.35/0.4[illegible]	0.60/0.[illegible]	-do-	-do-	-do-	-	[illegible]	[illegible]	-do-
IRS M 4/65	-	-	-	Steel bars	[illegible]	0.7[illegible]	-	[illegible]	[illegible]		[illegible]	[illegible]	For general engineering purposes

Indian standard specification	British standard specification	American standard specification	German standard specification	Available forms	Composition C %	Mn %	Si %	S %	P %	Cu %	Tensile strength kg/mm²	Elongation %	Principal uses
Bars and rods (cont'd)								max	max				
IRS M 2[illegible].64	-	-	-	Steel bars	0.25	-	-	0.05	0.05	[illegible]	[illegible]	[illegible]	For manufacturing high tensile rivets
IS 1148-[illegible]	-	-	-	-do-	0.[illegible]0	-	-	-do-	-do-	0.[illegible]	[illegible]/[illegible]	[illegible]	For manufacturing rivets for structural purposes
IS 1149.59	-	-	-	-do-	0.[illegible]	-	-	-do-	-do-	[illegible]/[illegible]	[illegible]	[illegible]	For manufacturing high tensile rivets for structural purposes
IS 1139.[illegible]	-	-	-	Deformed bars	0.[illegible]0	-	-	0.06	0.065	-	[illegible]	[illegible]	Deformed bars for use in constructional purposes
-do-	-	-	-	do-	0.30	-	-	0.05	0.06	-	[illegible]	[illegible]	Manufacture of medium tensile deformed bars for constructional purposes
Wires													
IS 432.[illegible]	BS:[illegible]	-	-	Bars and wires	0.25	-	-	0.055	0.055	-	[illegible]	[illegible]	For use as concrete reinforcement bars
-	BS:970/55	-	-	bars	0.07/0.15	0.80/1.20	0.10 max	0.[illegible]/ 0.30	0.[illegible]	-	-	-	For forging purposes
IS 2[illegible].64	-	-	-	Wires	0.08	0.40/0.60	0.03	0.035	0.035	0.1[illegible]	-	-	For manufacture of metal arc welding electrode core wire
Railway materials													
IRS T12/60													
i) Mi.Mn	BS:9	-	-	Rails	0.55/0.60	0.95/1.25	0.07/0.30	0.06	0.06	-	[illegible]	1[illegible]	Railroad rails - medium duty purpose
ii) Plain carbon	BS:11	-	-	-do-	0.50/0.[illegible]8	0.65/0.[illegible]	0.0[illegible]/0.30	0.05	0.[illegible]	-	[illegible]	[illegible]	-do-
IRS T18 [illegible]													
i) Mi.Mn	-	-	-	-do-	0.40/0.[illegible]	0.90/1.[illegible]	0.03/0.30	[illegible]	0.0[illegible]	-	-	-	-do-
ii Plain carbon	-	-	-	-do-	0.50/0.70	0.60/0.[illegible]	0.0[illegible]/0.[illegible]	[illegible]	0.0[illegible]	-	-	-	Railroad rails for [illegible] duty purpose.

Indian standard specification	British standard specification	American standard specification	German standard specification	Available forms	Composition C %	Mn %	Si %	S % max	P % max	Cu %	Tensile strength kg/mm²	Elongation %	Principal uses
Railway materials (cont'd)													
IRS T1 [illegible]	[illegible]	-	-	Fish plates	0.30/0.35	0.80 max	0.15 max	0.06	0.06	-	[illegible]	20	Fish plates for all kinds of rails
IRS R:14 [illegible]	-	ASTM A-57	-	Wheels	0.57/0.77	0.90 max	[illegible]	[illegible]	[illegible]	-	[illegible]/77.2	-	For manufacture of wrought steel [illegible] railway carriages and wagons
IRS M-/65 Class IV	-	A 32[illegible]	-	Tyres	[illegible]	[illegible]	0.15/[illegible]	[illegible]	[illegible]	-	[illegible]	-	For wheel tyres of railway carriages and wagons
IRS-[illegible] 65	-	A [illegible]	-	Axles	[illegible]	[illegible]	0.15 min	[illegible]	[illegible]	-	[illegible]	-	Axles for railway carriages and wagons

APPENDIX - 2-2

ADJUSTED IMPORTS OF IRON AND STEEL

Product Category	1974 tons	1975 tons	1976 tons	1977 tons	1978 tons	1979 tons	1980 tons	1981 tons
Bars and rods	6365	2622	6995	6386)	4357(1)	6306(1)	4944(1)	6390(1)
				)				
Wire rods	199	493	219	229)				
	6564	3115	7214	6615	4357	6306	4944	6390
Wires	...	...	...	27	562	62	2	319
Angles shapes and sections	...	...	...	...	302	168	1275	697
Seamless tubes	...	...	...	...	80	1432	7616	1243
	...	...	...	27	944	1662	8893	2259
Sub-total(non-flat)	6564	3115	7214	6642	5301	7968	13837	8649
Sheets and plates	671	771	1365	1292	927	4556	6009	2464
Steel pipes	413	199	399	340	1439	767	14	11
Sub-total (flat)	1084	970	1764	1632	2366	5323	6023	2475
Total steel	7648	4085	8978	8274	7667	13291	19860	11124

Notes:
(1) Including wire rods, as furnished by National Company for Home Trade.

APPENDIX - 2-3

METHODOLOGY FOR DEMAND FORECASTS

The techniques of economic and technological forecasting can be divided into four major groups, namely:

i) extrapolation of past and present trends;

ii) intuitive forecasts using experts' opinions;

iii) morphological analysis which examines the possible inventions, strategies, policies and their impact on the outcome of forecasts; and

iv) heuristic (that is discovery-oriented) forecasts based on models of the dynamic process in which some causal mechanism is known or postulated.

The conventional extrapolative techniques for forecasting demand for an industrial product range from simple empirical methods like the historical analogy and the time trend analysis to the more intricate ones like the regression analysis and the end-use method. A recent addition to this list is the steel intensity method. Among the intuitive forecasts, the Delphi model developed by RAND Corporation, USA, is the most published technique. Scenario-writing and the normative relevance trees are examples of the morphological analysis techniques which have been recently evolved in the USA by the Hudson Institute and Honeywell Incorporated respectively. Heuristic forecasts involve the framing of cause/effect models. The various techniques and their suitability for projecting the demand for iron and steel products are briefly reviewed below.

Appendix 2-3 (continued)

Historical analogy method

The historical analogy method consists of examining past trends of steel consumption in countries which have reached high levels of economic development and using such trends over specific periods as a guide to projecting steel demand for the country under study. While the historical analogy gives some insight into the changing patterns of steel consumption according to economic development at different points of time, it does not take into consideration the effects of technological changes and substitution on steel consumption. Moreover, economic development attained by countries at different stages of growth may not be readily comparable, as the pattern of development could vary widely due to different political and economic systems prevailing in these countries from time to time.

Time trend

The trend method is based on linear or non-linear time series relationships that can be established on the basis of past consumption. For the use of this method, therefore, reliable time series data over a long period on the consumption of the product considered is essential. In an expanding economy starting from a low industrial base, reliable statistics on past consumption over long periods are generally not available. Though the use of time-trend method cannot be considered reliable in general for forecasting, its judicious use could be made on a limited scale for cross-checking the demand projections obtained by other methods, or for forecasting demand where the pertinent data for the application of other techniques are not available.

Regression method

The regression method correlates steel consumption to an independent variable or variables, usually macro- economic such as the national income, gross domestic product, index of industrial production etc - instead of relating the consumption (a dependent variable) to time intervals. The correlation may be simple with only one independent

Appendix 2-3 (continued)

variable, or may be multiple involving more than one independent variable. Here again, as in the trend method, a long, reliable series of past data is required to establish the relationship, or to find out the curve of best fit. This method is generally utilised to cross-check the aggregate estimates obtained by other techniques, or for forecasting demand where the pertinent data for the application of other techniques are not available.

End-use method

The end-use method is basically a derivative approach and starts with an analysis of the current demand for an industrial product by major consuming sectors in terms of the actual product types, categories and sizes. On the basis of the projections of the growth of major user industries and sectors as well as the technical norms of consumption, the future pattern and quantum of demand are estimated.

The accuracy of the forecasts by extra-polative techniques depend, among other things, on the selection of the past reference period which may be either a long interval with a fairly low rate of increase in the demand or a recent period marked either by an accelerated or a declining growth rate. This selection can be made more judiciously, when the individual end-uses are isolated as in the end-use method than in the case of the other extra-polative methods discussed earlier, where the end-uses are lumped together and treated as a single function, which does not permit the identification of the individual constituents. To be realistic, any long-term extrapolation should also include a careful examination of the major factors and influences which may be external to the model or the variable parameters considered and yet be capable of altering in the future the trends observed in the past. This can be achieved only by taking account of the foreseable structural changes in the economy on the one hand and the structural/technological changes in the end-product itself. The end-use method lends itself to such an analysis which is not possible with other extrapolative methods due to their basicaly global approach.

Appendix 2-3 (continued)

Delphi model

The techniques of Delphi model developed by the RAND Corporation, USA involves reiterative rounds of the intuitive thinking of the experts. It seeks to obtain the independent opinion of a number of experts who are asked to critically review the current situation and forecast the magnitude, time horizon and nature of future developments. The less probable results obtained from these discussions are discarded and the more probable results are subjected to the same process of 'brainstorming' in the successive rounds of reviewing. For example, an initial survey may be made seeking the opinion of experts on the tonnage and categories of demand of iron and steel products expected to develop at certain time intervals and the reasons thereof. The opinions which are wide off the averages will be discarded and further convergence of opinions will be sought in the successive iterative rounds.

This Delphi model helps in forecasting the time horizons for possible breakthrough in technology or the economy and has the advantage of controlled feedback of the information received and quantifiable response, but it is not suitable for forecasting the magnitude of demand of a product, as the latter involves multiple end-uses, each of which has its complex technology for its utilisation. Secondly, though minority opinion and deviates have often proved to be right in the history of inventions and innovation, they have the least weightage in the outcome of the Delphi exercise. Notwithstanding these limitations, this technique was employed some time back in some developed countries to forecast steel demand. However, as the exercise did not yield cogent results, it was abandoned. Further, application of this technique calls for 'brainstorming' sessions with a number of experts in different branches of technology. This is impracticable in a developing country where not enough number of experts may be available.

Appendix 2-3 (continued)

Scenario-writing

The technique of scenario-writing developed by Hudson Institute, USA, attempts to set up a logically hypothetical sequence of events in order to visualise as to how a future state might evolve step by step from the present or any other situation. These events expalin typically as to how each successive situation may come about and the alternatives that exist for each actor-event for preventing, diverting or facilitating some developments. The development of alternative futures or scenario-writing requires the choice to be finalised from the following pairs of sub-techniques:

i) extrapolative approach in which the selected existing tendencies and situations are extrapolated; or goal-seeking approach in which the future context or the goal proposed to be achieved is set up and the sequence of events that could lead to its realisation are developed;

ii) synthetic approach in which the individual aspects or themes are developed and synthesised into a whole or morphological approach in which the target is set up and the detailed issues and themes are fitted into this target; and

iii) empirical approach with ideas based on intuition and experience taken from the realities obtaining at present; or theoretical approach with abstract and theoretical concept.

The scenario-writing, therefore, provides a perspective on the kinds of decisions that may be necessary and on the crucial branching points to complete the exercise. The experience of USA in scenario-writing suggests that apart from being very time consuming, these exercises do not necessarily foresee important changes - political, economic, social as well as technological - which will influence technological opportunities and needs. Until now, most published 'scenarios' have been too global and general, to be of use in decision-making.

Appendix 2-3 (continued)

Normative relevance tree technique

The normative relevance tree techniques start with the goals and objectives. The steps or stimulations required to achieve the objectives are broken down and presented as alternative or complimentary branches and sub-branches at different levels of the technological normative horizontal and vertical trees.

Horizontal relevance tree

The graphic models for the horizontal tree are built to show at different levels the various characteristics and considerations that might influence the demand of the product. The influences considered irrelevant to the specific time-horizon of the forecasts, are sorted out and the relevance lines are established over all the pertinent influences. As for example, for steel bars and rods, the relevant considerations at different levels could be as under:

Fabrication requirements	..	weldability, amenability heat treatment, machinability
Performance characteristics	..	yield strength, corrosion resistance, thermal conductivity, toughness
Steel grades	..	high carbon, low carbon, low alloy, high alloy, stainless

Thus weldability and corrosion resistance are relevant for the stainless steel used in manufacturing vessels and containers for chemical industries and would form the relevance line in the graphic model.

Appendix 2-3 (continued)

Vertical relevance tree

A perspective of alternative or competing paths of technological advance is developed as an objective network in the graphic model of the vertical tree. The less probable paths over the time-horizon considered are rejected, to focus the forecasting effort on a limited number of relevant lines established over specific competitive paths. Thus, for example, a vertical relevance tree for the construction of urban houses in a country may be developed at different levels as shown below:

VERTICAL RELEVANCE TREE FOR URBAN HOUSE CONSTRUCTION

Levels	Relevance factors
Performance objections	A. To reduce material costs B. To reduce on-site fabrication costs C. To promote light-weight construction
Materials engineering	Reduction of on-site fabrication costs by i) improving fastening methods ii) developing new shapes Promotion of light-weight construction by i) introduction of design changes ii) evolution of new material specifications
Construction objectives	Improving fastening methods i) expediting construction time ii) maximising site labour work Evolution of new material specifications i) shortening lead time for material procurement ii) economising handling costs at site

Appendix 2-3 (continued)

The relevance line for this vertical tree may be identified to lie along the competing technologies.

It is accepted that though horizontal and vertical relevance trees help identification of the technological parameters critical to the attainment of a policy objective, they lack operational usefulness, as it is generally difficult to make the various analysis of relevance correspond to the levels of analysis of the administrative hierarchy. Their analytical worth is also diminished by the fact that the quantification of the objectives is not possible as they do not require any numerical information.

PATTERN technique

A variant of the vertical relevance tree known as PATTERN (Programme of Assessment Through Technical Evolution of Relevance Numbers) is used as a method of resource allocation. In this technique, each alternative element is weighed according to a number of criteria (for example, practicability, cost, completion time, social considerations etc). This weightage expressed as a fractional figure, therefore, measures the relative superiority as well as deficiency of each alternative vis-a-vis the other alternatives at the same level. The relevance number of each alternative in the vertical tree is the product of the weightage of the parent elements at different levels of the hierarchy. For example, the overall investment in the country can be divided at the different levels as follows:

Level	Sector/Investment
A	Overall
B	Primary, secondary and tertiary sectors
C	Primary: Agriculture, mining Secondary: Industry, construction Tertiary: Transport, commerce, services

Appendix 2-3 (continued)

With the allocation of weights to each element (sector or segment), the magnitude of investment in sector or segment could be determined, if the overall availability of capital for investment is known.

This complex system of analysis may often lead to unrealistic forecasts. Firstly, weightings at the higher levels in the hierarchy often depend on the political choices and at the lower levels on experience, judgement and intuition. Secondly, the assumptions behind these weightings are essentially subjective. Hence policy and technical judgements may become unduly biased by the relevance numbers, instead of being analysed and debated objectively.

Cause/effect models

The cause/effect models are developed from an investigation of the interaction between technological, economic, social and political factors and known causal mechanisms. For example, the private consumption expenditure of a country can be predicted from the forecasts of income from various sources - agriculture, industry, private and government investment, services etc, if the underlying interaction between these variables is known. The application of this technique has been so far limited to the improvement of the quality of decision-making. However, its application in the field of market projections has several disadvantages, namely:

i) The validity of the forecasts made by such models is not yet proven against the empirical results;

ii) While forecasts about the future development of technologies can be made with some confidence, data are generally incomplete in respect of the potential political and social impacts of the technologies;

iii) The measurement of impacts of social, economic and political changes is mostly qualitative which does not facilitate quantification of the effect.

APPENDIX - 7-1

LIST OF MAJOR EQUIPMENT - STEELMELT SHOP

SL. No.	Description	Quantity
I.	ELECTRIC ARC FURNACE AND ACCESSORIES	
1.	8-ton capacity, 3 050 mm shell dia, electric arc furnace, complete with 4 MVA transformer, electricals and controls, spare roof ring, refractories etc.	2
2.	Fume extraction system	1
3.	Scrap charging buckets, 5 cu m capacity each	12
4.	Immersion pyrometer assembly	2
5.	Slag pots, 1 cu m capacity	5
6.	Operating tools and tackles	1 set
II.	CONTINUOUS CASTING MACHINE AND ACCESSORIES	
1.	1-Stand continuous billet casting machine complete with steel structures, mechanical and electrical equipment, instruments and controls, billet cut off equipment, discharge roller tables and cooling bed, tundishes and tundish preheaters, refractories etc	1
2.	Immersion pyrometer	1
3.	Optical pyrometer	1
4.	Tundish stands	1 set

Appendix 7-1 (continued)

SL. No.	Description	Quantity
5.	Tundish tilting stand	1
6.	Tundish drying station	1
7.	Repair and assembly facilities	1 set
8.	Operating tools and tackles	1 set
III.	STORAGE AND HANDLING FACILITIES	
1.	Storage bins for limestone and ferro-alloys	6
2.	Steel teeming ladles, 10-ton capacity each, complete with refractories	7
3.	Scrap transfer car	1
4.	Tundish transfer car	1
5.	Steel boxes for additions and other materials	1 set
IV.	LADLE PREPARATION FACILITIES	
1.	Horizontal ladle drier	2
2.	Ladle stand	2
3.	Miscellaneous fabricated items	1 set
V.	EOT CRANES AND HOISTS	
1.	10/5-ton EOT magnet crane for scrap handling and charging	3
2.	15/10-ton EOT crane for liquid steel handling	1
3.	Electric hoists, pulley blocks and jib cranes	1 set
4.	Crawler crane with magnet	2

Appendix 7-1 (continued)

SL. No.	Description	Quantity
VI.	MISCELLANEOUS EQUIPMENT	
1.	15-ton scale for scrap bucket weighing	1
2.	Portable weighscales	1 set
3.	Bailing Press, shearing machine and cutting torches for scrap preparation	1 set
4.	15-ton crawler crane with magnet for scrap handling	1
5.	1-ton forklift truck	1
6.	Miscellaneous items such as pneumatic rammers, chipping hammers, brick cutting saw, mortar mixer, chains, slings etc	1 set

APPENDIX - 7-2

BRIEF SPECIFICATION FOR ELECTRIC ARC FURNACE

1.0 The 8-ton nominal capacity electric arc furnace shall be direct arc, tilting type, provided with three automatically adjustable vertical electrodes, removable swing roof, and multi-voltage power transformer. The main design features of the furnace shall be as follows:

Number of arc furnaces	..	2
Nominal capacity	..	8 tons
Maximum capacity	..	10 tons with allowance for slag
Steel inside diameter	..	3050 mm
Steel grades to be made	..	Plain carbon steels
Melting stock	..	100% steel scrap (if required sponge iron to the tune 25/30% may be bucket charged)
Transformer rating:		
- Continuous	..	4 000 kVA
- Overload for 2 hours	..	4 800 kVA
Electrode dia	..	305 mm
Method of charging scrap	..	Top
Method of furnace tilting, roof lifting and swinging	..	Hydraulic

Appendix 7-2 (continued)

Furnace forward tilt	..	45 Deg.
Furnace backward tilt	..	15 Deg.
Method of electrode control	..	Electro-mechanical

Refractories:

Roof	..	High alumina
Shell	..	Basic

The furnaces shall be of strong and robust construction throughout, designed to withstand the rigorous service conditions.

2.0 The electric arc furnace shall include, but not be limited to the following items:

a) Mechanical Equipment

One (1) set	-	Furnace shell and shell mountings
One (1) set	-	Roof lifting and swinging mechanism
One (1) set	-	Furnace tilting mechanism
One (1) set	-	Electrode holding and operating mechanism
One (1) set	-	Electrode movement and regulation system
One (1) set	-	Hydraulic pressure system with controls
One (1) set	-	Cooling and lubricating equipment
One (1) set	-	Pipes and fittings for water, compressed air and other utilities

b) Electrical Equipment

One (1)	-	6.6 kV furnace circuit breaker
One (1)	-	Furnace power transformer with on-load tap changer including accessories

Appendix 7-2 (continued)

One (1) set	-	Secondary busbars and flexible cables
One (1) set	-	Instruments and control panels
One (1) set	-	LT motor control centre and distribution boards
One (1) set	-	H.V., L.V. and control cables and earthing installations
One (1) set	-	Interlocks

c) Refractories

One (1) set	-	Hearth and side walls lining
Two (2) sets	-	Roof lining

d) Graphite Electrodes

Six (6) sets	-	18 lengths (three per phase) with graphite nipples

3.0 Mechanical Equipment

3.1 Furnace assembly: The furnace mechanical equipment covering the main sub-structures, namely the furnace chassis, shell/back structures and rockers shall be designed to give a well engineered and robust composite unit to withstand the rigorous duty conditions.

3.2 Furnace chassis: The platform type furnace chassis shall be well braced to give a rigid supporting structure to accurately support the furnace shell, to carry the back structure and roof gantry together with the roof lifting and swing mechanisms, as well as the electrode holder and rapid acting electrode movement provision on the back structure. Two sturdy tilting rockers shall be provided underneath the chassis to give a composite sturdy unit.

Appendix 7-2 (continued)

3.3 Pedestal rockers: The pedestal rockers shall be of heavy cast steel of fabricated steel construction with accurately machined teeth to correspond with those on the pedestal bases.

3.4 urnace shell: The furnace shell shall have a discharged bottom. Stiffening rings and vertical stiffeners shall ensure rigidity to withstand severe thermal and mechanical stresses and retain its shape. A water cooled bezel ring shall be provided at the top end seating the roof ring.

3.5 Pouring spout: The pouring spout shall be of fabricated steel plate construction bolted to the furnace shell for easy replacement. A platform shall be provided on either side of the spout to permit easy access for operation and maintenance.

3.6 Furnace door: One water-cooled working door shall be provided for deslagging and charging furnace additions. The door frame shall be refractory lined and water-cooled, and shall have a water-cooled lintel.

3.7 Access platform: A chequered plate platform and safety rails shall be provided on top of the furnace roof, along with an approach ladder, to permit easy access to all the electrode clamps, electrode glands and other furnace parts at the roof level.

3.8 Furnace back frame and gantry: The back frame shall be robust and accurately machined to provide firm support for true and free movement of electrode masts. The swing arrangement of the composite back frame and gantry structure along with the suspended roof, shall be designed for rigidity and smooth movement. The weight of the back frame and the gantry structure, when in stationary position or in movement, shall be taken on the chassis and not affect the furnace shell.

Appendix 7-2 (continued)

3.9 Roof lifting and swinging mechanism: The roof lifting mechanism shall be remote operated and effected in a smooth and controlled manner. Adjustment for vertical lift of the roof ring and its accurate seating over the furnace shell shall be provided. It shall be possible to hold the roof ring steady in an intermediate position of roof lift, and lock it in the lifted position.

The remote operated roof swing mechanism shall be independent of the roof lifting mechanism. The swing shall be towards the spout and operate in a smooth controlled manner. The angle of swing shall be large enough for the roof to clear the shell edge and permit unobstructed operation of the scrap charging bucket, allowing for a slight bucket swing.

3.10 Level blocks: Remote-operated pneumatic level or bumper blocks shall be provided both at the front and rear sides to keep the furnace in level position. They shall be designed for shock loads occurring during charging operations and when the furnace comes to rest on them from tilted positions.

3.11 Tilting mechanism: The tilting mechanism shall be hydraulically operated, to give smooth and jerk-free movement. The furnace shall tilt back to its normal position from all positions under its own weight, counteracted by the hydraulic pressure in the tilting cylinders. The forward stroke of the hydraulic cylinders shall be sufficient to completely empty the furnace even with a worn lining. It shall be possible for the furnace to tilt back even when on power.

3.12 Electrode holding and operating mechanism: Electrode holding arms will be rigidly bolted to the cylinder which will move up and down thereby adjusting the position of the electrode arm. The arrangement shall be very stable and rigid and the electrode arms shall not lose their adjustment even with longer use.

ppendix 7-2 (continued)

3.13 Electrode operation and control: The electrode operation system shall be phase-regulated and designed for high automatic regulating speed, both in the raising and lowering directions, consistent with mechanism stability and minimum overshoot. The system shall be designed for minimum maintenance problems. In the event of a power failure, the electrode shall be automatically lifted to the top position. The movement of each electrode arm shall be automatically regulated individually either electrically or hydraulically through a feed back system. In addition to the automatic operation, individual and group operation of the three electrodes shall be possible in the manual mode. The electrode mechanism shall be complete with electro-mechanical/equipment, lubrication system etc.

3.14 Hydraulic pressure system: A non-inflammable hydraulic pressure system with duplicate electric motor driven pumps, solenoids and control valves shall be provided for all hydraulically operated mechanism such as furnace tilting, roof lifting and swinging, electrode regulation etc. Provision shall exist for tilting the furnace atleast once to full forward position and back to level, in the event of a power failure, so that hot metal from the furnace may be emptied into the ladle. The system shall be complete with control stand, oil storage tank and pipework. The pipework shall be pickled and flushed prior to installation.

3.15 Cooling Water System

3.15.1 The individual cooling water circuits to the various parts at the furnace shall be laid out on the transformer room outer wall and permit easy identification. All return circuits shall be brought to a discharge water trough where they can be clearly seen.

3.15.2 A separate closed-circuit cooling system shall be provided for the water-cooled secondary circuit flexible cables. A separate water bosh with a glass cover shall be provided for this circuit.

Appendix 7-2 (continued)

3.16 Lubrication: Grease lubrication shall be provided for all moving parts.

4.0 Electrical Equipment

4.1 Furnace Circuit Breaker

4.1.1 The furnace circuit breaker shall preferably be of the indoor, remote-operated, draw-out, dead-front cubicle type fully interlocked for safety of operation and maintenance. The unit shall be suitable for frequent switching duty in conjunction with the furnace transformer unit having an on-load tap changer. The circuit breaker shall be preferably of vacuum break type or can be air blast type.

4.2 Furnace Transformer

4.2.1 The furnace transformer shall be of core type. It shall be of robust construction and specially designed to withstand the electro-dynamical and thermal stresses. The main features of the transformer shall be as follows:

Transformer rating:		
- Continuous	..	4 000 kVA
- Overload for 2 hours	..	4 800 kVA
Repetitive duty cycle.		120% full load for two hours, 60% full load for one hour; No load for half-an-hour
Primary voltage	..	11 kV, 3 phase, 50 Hz
Secondary voltage	..	To suit the furnace requirements. Six inter-leaved leads brought out for delta connection to be made as close to the furnace as possible

Appendix 7-2 (continued)

Tap changer	..	On-load, remote controlled with pre-set tap selection arrangement
Cooling system	..	OFWF

4.2.2 Transformer accessories: The transformer shall be equipped with all necessary accessories such as electrode control current transformer, oil conservator, winding temperature indicator, oil temperature indicating thermometer, filter press valve, oil level gauge, earthing terminals and earthing device, and other accessories considered essential by the manufacturer.

4.3 Transformer cooling system: The transformer cooling system shall be by means of an oil-to-water heat exchanger. The heat exchanger shall be complete with oil and water pumps and selection valves. Automatic indication and alarm shall be provided to indicate failure or disturbance in the circulating system.

4.4 ‾ -selector control switch: One (1) pre-selector control switch which will permit pre-selection of any available furnace voltage shall be provided for the arc furnace. The tap changer mechanism shall automatically follow the tap selection point on the selector dial. A tap position indicator mounted on the control panel shall be included.

5.0 Instruments and Controls

5.1 A steel clad, dead-front, completely wired and tested console type of control desk with a sloping top for all the controls and a vertical portion for the instruments shall be provided. The control panel shall ˎe designed for an accessory dispersal to give clear and logical positions for control switches, signal lamps and instruments of each phase, as well as grouping of common requirements for all three phases.

Appendix 7-2 (continued)

5.2 The control functions and instruments provided for the furnace proper shall include, but not be limited to the following:

One	(1)	-	Control switch for operating the furnace breaker
One	(1)	-	Emergency furnace breaker trip switch
One	(1)	-	Preselector control switch for transformer tap changing
One	(1)	-	Transformer tap position indicator
Three	(3)	-	Rotary switches for selecting the secondary current
One	(1)	-	Change-over switch from manual to automatic operation of the furnace
One	(1)	-	Master switch to operate manually all the three electrodes simultaneously
One	(1)	-	Set of push button control switches for starting the various auxiliaries, such as hydraulic pumps, transformer cooling equipment, etc with all the necessary safety interlocks
One	(1)	-	Set of temperature indicators for furnace transformer windings
One	(1)	-	Real time clock
One	(1)	-	Voltmeter for indicating incoming voltage on the HV side
Three	(3)	-	Ammeters for indicating incoming current on the HV side
Three	(3)	-	Voltmeters for indicating the voltage between the electrodes and the furnace batch
Three	(3)	-	Ammeters for indicating the electrode current
One	(1)	-	Power factor meter
One	(1)	-	Unbalanced load, 3-phase, indicating and recording kW meter

Appendix 7-2 (continued)

One	(1)	-	Integrated kilowatt-hour meter with maximum demand indicator
One	(1)	-	Integrated kVAR-hour meter
One	(1)	-	Kilowatt-hour counter per heat with reset device
One	(1)	-	Instrument for recording and signalling of furnace batch temperature

5.3 Necessary alarm and signal annunciation panel shall be provided on the control desk, with alarm accept/ cancel facility to highlight all abnormal conditions. These shall include but not be limited to:

i) Status of the furnace circuit breaker

ii) Status of the Bending End circuit breaker at MRSS

iii) Water flow and temperature abnormal conditions in all

iv) Abnormal shell/refractory temperatures

5.4 Controls for tilting, roof lift and swing, electrode clamp, door and level block operations shall be provided at appropriate locations and suitably interlocked to prevent mal-operation.

6.0 <u>Interlocks</u>

6.1 The various operations for the furnace shall be interlocked to ensure safety and correct sequence of operation.

6.2 Suitable locking system shall be provided for holding the electrode above the metal bath in the event of breakdown in the electric movement system. The locking system shall remain effective till the defects in the electrode movement system are rectified. During normal operation, the system shall otherwise remain inactive.

Appendix 7-2 (continued)

7.0 Refractories

7.1 One (1) complete set of refractories shall be provided for the initial lining of the arc furnace. The refractory supply shall be complete with necessary mortars, insulation, formers etc and shall suit various requirements of the arc furnace. Two sets of refractories for roof shall be of high alumina bricks.

7.2 The furnace bottom shall be lined with high quality magnesite bricks with a course of insulation and a course of fire bricks laid on the bottom shell. The working hearth shall be lined with burnt magnesite bricks which are extended on the side upto the slag level, and on the top of the bottom brick lining, a ramming mass shall be rammed. The side walls of the furnace shell shall be lined with chemically-bonded, metal encased, magnesite-chrome bricks. The furnace door and the pour spout shall be lined with high quality fire bricks.

8.0 Graphite Electrode

8.1 Six (6) sets of graphite electrodes, each set consisting of three 305 mm dia high conductivity graphite electrodes shall be provided along with matching graphite nipples. The electrodes shall have tapered inside thread at both ends. The electrode should be suitable for high current density and the current carrying capacity should match the furnace design. The conical shaped graphite nipples shall have threaded ends to match with the graphite electrodes. The electrodes and nipples shall possess superior physical properties and shall have low electrical resistivity.

Appendix 7-2 (continued)

9.0 Fume Extraction System

9.1 The dust and fume evolved during operation of the furnace shall be extracted through a fourth hole in the furnace roof. The fume extraction system shall be suitable to handle the maximum volume of fume omitted during oxygen lancing.

The fume extraction system shall consist of fume collection and cooling facilities. After cooling, the fume will be exhausted through a chimney. Provision should be made for adding fume cleaning facilities in future.

10.0 Future Provisions

10.1 The furnace and accessories shall be so constructed that in future, if deemed necessary, water cooled panels/side walls and oxy fuel burner can be installed without significant changes in general arrangement of equipment and facilities.

10.2 Depending upon the power situation in PDRY and the type of scrap that will be available, it may be felt necessary to pre-heat the scrap at a later date. For this purpose suitable provision need to be kept for installing the facilities for scrap pre-heating. The type of scrap pre-heating process will, however, be selected after careful consideration of the various factors governing the overall economics.

APPENDIX - 7-3

BRIEF SPECIFICATION FOR CONTINUOUS CASTING MACHINE

1.0 One (1) single strand continuous casting machine shall be provided in the steelmelt shop. The continuous casting machine shall be of low head design with either curved mould type or straight mould type. The machine shall be complete with steel structures, mechanical and electrical equipment, instruments and controls, tundishes, billet cut off equipment etc.

The principal design particulars of the machine shall be as follows:

Number of stands	..	1
Casting radius of machine	..	5.0 m
Steelmaking unit	..	Two 8-ton electric arc furnaces
Steel grades to be cast	..	Plain carbon steels
Ladle capacity	..	10 tons (nominal heat size-8 tons)
Type of ladle	..	Bottompour with stopper
Design range of billet size	..	8 to 130 mm sq
Machine equipped to cast	..	100 mm sq
Billet cut length	..	1.5 m - 3.0 m

Appendix 7-3 (continued)

Type of cutting equipment	..	Manual gas torches
Method of discharge	..	On horizontal roller tables cooling bed

2.0 The continuous casting machine shall include, but not be limited to the following items:

One (1) set	-	Steel structure
Eight (8)	-	Tundishes
Four (4)	-	Tundish covers
Two (2)	-	Tundish cars
Two (2) sets	-	Tundish pre-heating stations
One (1) set	-	Slag buckets, intermediate launders and deflection launders
One (1) set	-	Mould assembly
One (1) set	-	mould lubrication system
One (1) set	-	Mould tables with oscillation drives
One (1) set	-	Secondary cooling equipment
One (1) set	-	Steam exhaust system for spray chamber
One (1) set	-	Withdrawal and straightening units
One (1) set	-	Billet cut off equipment
One (1) set	-	Dummy bar receiver
One (1) set	-	Dummy bar and template
One (1) set	-	Discharge roller table
One (1) set	-	Cooling bed
One (1) set	-	Hydraulic pressure system
One (1) set	-	Cooling water system
One (1) set	-	Electrical equipment
One (1) set	-	Instruments and controls
One (1) set	-	Automatic controls
One (1) set	-	Communication system
One (1) set	-	Grease lubrication system
One (1) set	-	Pipes, fittings, instrument etc for water, compressed air, oxygen and other utilities
One (1) set	-	Bucket for collection and disposal of crop-ends
One (1) set	-	Repair and assembly facilities
One (1) set	-	Tundish preparation facilities

Appendix 7-3 (continued)

3.0 Steel Structures

3.1 The steel structure supporting the mould table, secondary cooling equipment and other auxiliary items shall be independent of the building structures and shall include casting platform, intermediate platform, ladle stand, operating platform for ladleman, spray chamber, staircases, hand-rails etc. The ladle platform shall be chequered plate construction and the casting platform shall be of ordinary steel plates. The intermediate platform, walkways and the staircase treads shall be of steel gratings and the hand-rails shall preferably be of tubular construction. The ladle stand shall be of fabricated steel construction, designed for supporting the ladle with a maximum heat of 10 tons for each furnace. The design of the ladle stand shall be such that the crane movement is minimum. The casting floor shall be lined with fire clay bricks and shall include the rails for tundish cars.

3.2 The spray chamber shall be of plate construction with necessary stiffeners, and its structure shall form an integral part of the main structure. The spray chamber shall extend between ground level and the casting floor and shall be provided with necessary access doors with inspection holes. The inside surface of the spray chamber shall be coated with an anti-corrosive compound. Necessary removable type walkways made of steel gratings shall also be provided within the spray chamber around its periphery. The concrete floor of the spray chamber shall be provided with a spray water catchment basin covered with grating.

Appendix 7-3 (continued)

4.0 Mechanical Equipment

4.1 Tundishes

4.1.1 Eight (8) tundishes and four (4) sets of covers shall be supplied to serve the 1-strand casting machine. The tundishes shall be of fabricated, welded steel plate construction, suitably reinforced to withstand the thermal and mechanical stresses, and shall be designed for using calibrated nozzle and standard fire clay refractories. The tundishes shall be provided with machined trunnions for placing the tundish on the car, lifting lugs, weeping holes and overflow spout. The tundish cover shall be of welded construction suitably stiffened and shall have pouring hole, heating ports, lifting lugs, and provision for refractory lining. Alternatively cast iron tundish cover can also be used.

4.2 Tundish cars

4.2.1 The tundish shall be supported on a car for movement between the casting position and the pre-heating station. The tundish car shall move on rails fixed on the casting platform. The under-carriage of the car shall be of fabricated steel construction complete with flanged wheels fitted with anti-friction bearings. The design of the tundish cars shall be such that while the tundish car is in the casting position, it permits a good view of the liquid steel level inside the moulds, easy access to the moulds for slag skimming, and sufficient clearance between the tundish bottom and the top of the deflection launders for plugging and lancing the tundish nozzles. The tundish cars shall be provided with mechanical stops/locking device to prevent any movement of the car during casting operation and parking position.

Appendix 7-3 (continued)

4.3 Tundish pre-heating stations

4.3.1 Two (2) sets of tundish pre-heating stations shall be provided at the parking positions of tundish cars for heating the tundishes which are in service and one (1) pre-heating station at the relining area for drying the newly relined tundishes. Each pre-heating station shall consist of a vertical stand with a horizontally swivelling burner arm in welded tubular construction with height adjustment facility. Each station shall be complete with fuel oil burners, combustion air fan, and individual pressure and flow controls for fuel and air for each burner, and necessary pipework and controls.

4.4 Slag bucket, launders etc

4.4.1 A set consisting of two (2) slag buckets, one (1) set of intermediate launders and deflection launders shall be provided. The launders and slag buckets shall be fabricated from steel plates and shall be of welded construction. The intermediate launder shall have an inclined overflow spout and lifting lugs. The deflection launder shall be supported from the tundish car and shall be provided with suitable swivelling arrangement. The slag buckets and launders shall be lined with ordinary fire clay bricks.

4.5 Mould assemblies

4.5.1 The billet casting machine shall be equipped with one (1) set of mould assemblies. Each water-cooled mould assembly shall consist of a tapered chromium plated (inside surface) copper tube and shall be fitted into a fabricated steel jacket. The mould assembly shall be provided with necessary facilities to fix on the oscillating mould table. The mould assembly shall have water cooling arrangement for the copper mould tube and shall be complete with automatic connections for the cooling water.

Appendix 7-3 (continued)

4.5.2 Protection cover of fabricated steel construction shall be provided on the mould assemblies to avoid damages due to metal splash and metal overflow.

4.5.3 The design shall permit quick exchange of moulds as and when required. Each mould assembly shall be equipped with foot rollers at the bottom end of the mould. The foot rollers shall oscillate together with the moulds. The design of the mould assembly shall include arrangements for automatic control of steel level in the moulds.

4.6 Mould tables with oscillation drive

4.6.1 One (1) set of mould tables with oscillation drive shall be supplied. The mould assembly shall be fixed on to the oscillating mould tables. The mould tables shall be made of fabricated steel frame and shall contain fixing arrangement for the mould assemblies. The mould table shall be equipped with an electro-mechanical drive to ensure the required stroke and frequency of oscillation. The stroke and frequency of oscillation shall be adjustable. Facilities for lubrication of the oscillation mechanism shall be provided.

4.7 Mould lubrication system

4.7.1 The mould lubrication system shall include a storage tank of suitable capacity, pumps with floating suction, filters, relief valves, interconnecting pipework including necessary fittings and distribution block between the main unit and the lubrication points, pressure gauges, flow indicators for each strand instrumentation and controls and necessary safety devices.

Appendix 7-3 (continued)

4.8 Secondary cooling equipment

4.8.1 One (1) set of secondary cooling equipment including strand guides and supporting devices for the strand guides shall be supplied. The strand guides shall be made by assembling different segments so as to facilitate maintenance and quick changing of the billet size. Necessary handling facilities for replacement of the strand guides shall be provided.

APPENDIX - 7-4

LIST OF MAJOR EQUIPMENT - BAR AND ROD MILL

S. No.	Description	Quantity
I.	BILLET HEATING FURNACE	
1.	End-charge, end-discharge continuous pusher type furnace of capacity 10-tons per hour complete with billet pusher, blowers, recuperators, chimney, instrumentation, controls etc	1
2.	Furnace charging and discharging equipment including billet charging grid, furnace roller table, stops and manipulators in roller table, inclined chute at furnace discharge end with buffers, discharge roller table etc.	1 set
II.	MILL MECHANICAL EQUIPMENT	
1.	480 mm dia, 1 500 mm barrel length, 3-high stands of roughing train including manual screwdown, pinion stand, reducer, flywheel etc	2
2.	360 mm dia, 800 mm barrel length, 3-high stands of intermediate train including manual screwdown, pinion stands, reducer flywheel etc	3
3.	330 mm dia, 700 mm barrel length, 2-high stands of finishing train including manual screwdown, pinion stands, reducer shoe plates etc	4
4.	Cropping shear after roughing stands	1
5.	Dividing shear before cooling bed	1
6.	Rake and shuffle bar type cooling bed complete with roller tables etc	1

Appendix 7-4 (continued)

SL. No.	Description	Quantity
7.	Cold shear	1
8.	Grease lubrication system	1 set
9.	Coil lubrication system	1 set
10.	Hydraulic system	1 set
11.	Roll changing device	1 set
12.	Scrap handling system	1 set
13.	Scale handling and removal system	1 set
14.	Miscellaneous slings, hooks, tools, tackles etc	1 lot
III.	**MILL ELECTRICAL EQUIPMENT**	
1.	800 kW, 500 rpm (syn) 6.6 kV AC slipring induction motor for roughing, intermediate and finishing necessary controls, protection and monitoring equipment all accessories and associated ventilation equipment	3 sets
2.	AC auxiliary motors with accessories and motor control centres	1 lot
3.	Power distribution equipment comprising 6.6 kV switchgear distribution board, 380 V AC load centre substations, sub-distribution boards as well as necessary controls, protection equipment and accessories	1 lot
IV.	**ROLL SHOP**	
1.	Roll turning lathes	2
2.	Groove grinding machine	1
3.	Oil injection equipment	1
4.	Induction heater	1

Appendix 7-4 (continued)

SL. No.	Description	Quantity
5.	Bearing section facilities including oil bath, washing tanks, tables, plates, mechanical/hydraulic bearing extractors	1 set
6.	Tool grinding facilities including tool and and cutter grinder, pedestal grinder etc	1 set
7.	Guide and template section facilities including lathe, shaper, drill, surface grinder, "Do-all" type vertical band saw machine, benches etc	1 set
8.	One set of equipment to carry out minor mechanical and electrical repairs	1 lot
9.	Miscellaneous items including portable and small tools, measuring instruments, gauges and tools, roll racks and stands, shelves, tables, cabinet, boxes etc	1 lot
V.	**CRANES**	
1.	5-ton billet storage crane	1
2.	10/5-ton mill crane	2
VI.	**TRANSFER CAR AND OTHER MISCELLANEOUS HANDLING EQUIPMENT**	
1.	Roll transfer car	1
2.	Forklift for transferring finished products	2
3.	Grab buckets, magnets, hand trolleys etc	1 lot

APPENDIX - 7-5

BRIEF SPECIFICATION FOR BAR AND ROD MILL

1.0 GENERAL

1.1 This specification covers the major facilities and equipment proposed to be installed in the Bar and Rod Mill.

1.2 The production programme envisaged for the combination bar and rod mill is given in Chapter-2. The mill shall be designed to roll primarily plain carbon. The input material will be continuous cast billets 100 mm x 100 mm and about 2 m long weighing about 156 kg.

1.3 The mill shall be designed to work three 8-hour shifts per day and 365 days per year. For the production of 20 000 tons of finished products, the mill should be adequate to roll in a total of 4 600 hrs operation.

1.4 The bar and rod mill and allied facilities shall be capable of rolling at a maximum finishing speed of 7 m/sec for 10 mm.

2.0 EQUIPMENT AND FACILITIES

The principal equipment and facilities in the bar and rod mill shall include, but not be limited to the following:

Appendix 7 5 (continued)

Heating furnace with charging and discharging equipment:

- Pusher type heating furnace
- Furnace charging and discharging equipment

Single strand bar and rod mill:

- Semi-conditions roughing stands
- Intermediate stands
- Finishing stands
- Mill shears

Bar finishing facilities:

- Cooling bed approach and run-in roller tables
- Cooling bed
- Cold shear
- Weighing machine

Electrical equipment

Roll shop facilities:

- Roll turning lathe
- Oil injection equipment
- Induction heater
- Bearing section facilities
- Tool grinding facilities
- Guide and template section facilities
- Miscellaneous items
- Transfer car

2.1 Heating furnace with charging and discharging equipment

The billet heating facilities shall consist of an end charged and discharged type, top and bottom fired pusher furnace with associated charging and discharging equipment to heat billets to a temperature of 1250 Deg C at the rate of 10 tons per hour. The furnace shall be designed to operate at 10 per cent overload to meet the increased demand. Oil will be used as fuel.

Appendix 7-5 (continued)

2.1.1 Pusher type heating furnace

The furnace shall be complete with structural steelwork and furnace building, skids and water cooled members, refractory and insulating materials, combustion system comprising burners, combustion air fan and recuperator, flues and stack, pipework for various services, instruments and controls, control room. The furnace shall be so designed as to control furnace temperature 1250±10 Deg C and the temperature difference between the top and bottom surface of the stock shall not exceed 20 Deg C.

The furnace structure shall be designed for sturdy construction. Doors shall be of heat resisting material. In furnace lining, use of monolithic refractories shall be minimised. The combustion system shall be designed such that furnace capacity is maintained even with skid loss of about 20 per cent. Radiant roof burners are preferred. Combustion air fan shall have 100 per cent standby. The recuperator shall be provided with required safety measures.

Instruments and controls for a complete integrated system shall be provided for efficient and safe operation of the furnace. These should essentially include measurement and control of basic parameters like temperature, pressure and flow. Audio-visual alarms for abnormal conditions shall be provided. Safety interlock shall be provided for shutting-off fuel in condition which endangers the equipment and personnel safety.

2.1.2 Furnace charging and discharging equipment

The furnace charging and discharging equipment shall include but not be limited to billet charging grind, cradle for reject billet with discharge equipment, furnace roller tables, stops in roller table, billet pushers, inclined chute at furnace discharge end

Appendix 7-5 (continued)

with buffers to absorb shock of the billets sliding on to the furnace discharge roller table, mechanical support equipment including maintenance platform. Any other facility/facilities required to complete the requirements shall be included.

2.2 <u>Single strand combination bar and rod mill</u>

The single strand bar and rod mill shall be supplied complete with roughing, intermediate and finishing trains, and shears. The supply shall include 3-high mill stands complete for the roughing and 2-high mill stands complete for intermediate strand and 2-high for finishing train, roll changing equipment, one (1) set of shocks and roll neck bearings for each stand, one (1) set of rolls for each stand to cover the entire product range, all drive spindles and couplings, spindle supports and guards, main gear and pinion gear for each mill stand, one (1) complete set of roll tackles (guards and guides), tilting table, roller tables, repeaters and loopers, and special tools for dismantling and mounting of disc rolls.

2.2.1 <u>Roughing train</u>

The roughing train shall consist of three (3) 3-high stands fitted with anti-friction roll neck bearings. The roll sizes shall be as indicated on the next page. The 3-high stands shall be of open-top housing type with arrangement to remove rolls together with chocks from the top. Roll changing will be carried out with the help of EOT crane.

Top roll adjustment shall be done by a manually operated screwdown mechanism, the bottom roll shall be adjusted either by shims or by a manually operated screw-up mechanism and the middle roll shall be fixed. Top roll shall be balanced by overhead springs. The axial adjustment of rolls shall be manually operated.

Appendix 7-5 (continued)

The 3-high stands shall be complete with tilting table, repeaters and loopers, and roller tables.

All piping cables, conduits, hoses etc shall be safely guarded against damage from cobbles.

BAR AND ROD MILL STANDS AND ROLL SIZES

Stand Number		Type	Roll dia mm	Roll barrel mm
Roughing stands				
1	..	3-high	480	1 500
2	..	3-high	480	1 500
Intermediate stands				
3	..	3-high	360	800
4	..	3-high	360	800
5	..	3-high	360	800
Finishing stand				
6	..	2-high	330	700
7	..	2-high	330	700
8	..	2-high	330	700
9	..	2-high	330	700

2.2.2 Intermediate train

The intermediate train consists of three (3) 3-high stands. The stands are of closed-top type fitted with anti-friction roll neck bearings. Roll changing shall be done with the help of EOT crane. Used rolls in the stand will be replaced by complete preassembled rolls.

Top roll adjustment shall be done by a manually operated screwdown mechanism. Bottom roll shall be adjusted either by shims or by a manually operated screw-up mechanism. Top roll balancing shall be done by hydraulic cylinders.

Appendix 7-5 (continued)

Intermediate train shall include tilting table repeaters and other accessories.

All piping, cable conduits, hoses etc shall be safely guarded against damage from the cobbles.

2.2.3 Mill shears

One (1) cropping shear shall be provided after the roughing train to crop the front end of the bar or to cobble out in the event of a cobble in the mill.

One (1) shear shall be provided before the cooling bed after the finishing train. If necessary the shear shall be capable of chopping the bar into scrap lengths in case of a cobble in the finishing train.

All the shears as specified above shall be supplied complete with drives, transmission equipment and shear blades. Special consideration shall be given to easy maintenance and replacement of shear blades.

All scrap arisings at the shears are collected in scrap buckets.

2.2.4 Roller tables

The mill shall be provided with suitable roller tables and bridging troughs wherever necessary to connect the various equipment and units. The roller tables shall preferably have individually driven rollers.

2.3 Finishing facilities

The bar finishing facilities shall include cooling bed approach and run-in roller tables, rake and shuffle bar type cooling bed, run-out roller table, cold shear, collecting cradles and weighing machine.

Appendix 7-5 (continued)

2.3.1 Cooling bed approach and run-in roller tables

The cooling bed approach roller table shall be installed after the shear. The run-in roller table in front of the cooling bed shall be equipped with bar retarders, one (1) safety end-stop shall be provided at the end of the run-in roller table.

2.3.2 Cooling bed

The cooling bed shall be of rake and shuffle bar type and shall comprise of straightening grid cooling area, fixed and moving rakes and aligning devices at the end of the cooling bed for squaring ends of the rolled sections.

The cooling bed shall be capable of receiving rolled sections from the finishing train at a maximum speed of 7 m per second in appropriate cooling bed lengths.

Cooling bed shall cool down the products to a temperature of 200 Deg C or less by natural convection, that is, without the use of fans.

The cooled products shall be discharged onto the run-out roller table with the help of shuffle bars for onward transportation to the cold shear.

2.3.3 Cold shear

A cold shear shall be provided to cut the rolled sections to ordered lengths. The shear shall be of 200-ton capacity and shall be equipped with both straight and profiled blades.

2.3.4 Weighing machine

One (1) 10-ton capacity weighing scale with one (1) kg digital increment shall be provided.

Appendix 7-5 (continued)

2.4 Electrical Equipment

The equipment shall be provided complete with AC motors, motor control gear and other control devices such as brakes, limit switches, position transducers etc.

2.4.1 Main drive motors

Each mill stand shall be driven independently by motors located in the mill bay. For the roughing, intermediate and finishing stands, 800 kW 500 rpm AC motors will be provided. Power to the main mill drives will be made available at 6.6 kV from the plant MRSS.

The main mill motors shall be of special design to meet the severe rolling mill service. It shall be electrically as well as mechanically well-suited to deliver the peak demands of the mill stands.

2.4.2 Motor ventilation system

Individual motor mounted closed circuit recirculating ventilation system shall be provided for each mill motor comprising one full capacity recirculating fan for supplying cooling air requirement, air-to-water heat exchanger; make-up and recirculating dry air filters and all accessories; set of temperature indicating and automatic warning equipment including sturdy leak-proof design for housing the complete ventilation system.

2.4.3 Main drive controls

The AC main drive controls shall comprise transformer, HRC fuses, vacuum contactors, secondary resistance with thyristor controlled slip regulator, protection equipment and all accessories.

Appendix 7-5 (continued)

2.4.4 Supervisory control panels

One (1) set of panels equipped with all necessary devices including control switches, push-buttons, indicating and recording instruments etc shall be provided.

2.4.5 AC auxiliary motors and controls

All medium voltage AC motors shall be wound for a base voltage of 380 V, 3-phase, 50 Hz and all high voltage motors shall be wound for 6 600 V, 3-phase, 50 Hz. All motors shall have Class B or F insulation with temperature rise of 70 Deg or 90 Deg C respectively measured by resistance method over an ambient temperature of 50 Deg C.

For general location in shops totally enclosed motors having degree of protection IP44 shall generally be adopted. In case of hazardous locations either flame-proof or increased safety design machines shall be adopted. Weather-proof enclosures having degree of protection IPW 55 shall be adopted for outdoor locations. The motors shall generally be of fan-cooled design.

The controls for 380 V AC motors shall be by means of combination starter comprising load-break isolator, magnetic contactors, thermal overload and short-circuit protective devices. The controls for 380 V AC motors shall be grouped to form a number of motor control centres (MCC).

2.4.6 Control desks and posts

The mill shall be provided with requisite type and number of control desks for proper operation of the mill and its associated auxiliaries. The control desks/posts shall be complete with indicating lamps, selector switches, control push buttons, master switches as required and all necessary installation accessories.

Appendix 7-5 (continued)

2.4.7 6.6 kV switchboards

All 6.6 kV switchboards shall be indoor drawout type complete with current transformers, potential transformers where required, busbars, cable termination arrangement and all necessary accessories. The circuit-breakers shall be SF6/vacuum/minimum oil type. The isolators shall be manually operated air-break type.

2.4.8 Load centre substations

Load centre substations of requisite number and capacity shall be provided for feeding the 380 V power consumers of the bar and rod mill. The load centre substations shall include 11/0.433 kV power transformers, 380 V switch gear distribution board, 380 V, 3-phase bus ducts and all necessary accessories.

2.4.9 Power and control cables and accessories

All power and control cables, jointing and termination accessories, supporting steelwork, racks, trays, pipes and fittings as required for complete installation of equipment shall be provided. All outgoing feeder cables from the HT switchboard, cables from 6.6 kV isolator panel to converter transformers and from load-centres to motor control centres as well as power distribution boards shall also be provided.

2.4.10 Earthing

Earthing station, conductors and accessories required for complete system and equipment earthing shall be provided. Earthing materials shall be of copper.

Appendix 7-5 (continued)

2.5 Roll shop facilities

The roll shop shall be designed for 1 shift working. Grinding of shear blades will also be carried out in this roll shop. In addition to roll turning facilities, roll transfer facilities to the mill shall also be provided. Shop will have facilities for storing new rolls and for intermediate storage of rolls and rolls with chocks. Necessary racks for storing rolls shall be provided. Bearing shop facilities required for stripping, cleaning and assembling of bearing and chocks shall be provided.

Guide and template shop facilities provided in the shop shall include equipment for making templates and for reconditioning of guides and guards.

All equipment shall be complete with electrics and other stands and accessories, and attachment to meet the specified purposes.

APPENDIX - 9-1

LIST OF MAJOR EQUIPMENT FOR WATER SYSTEM

Sl. No.	Description	Quantity
I.	V[illegible]AL PUMPS	
	600 cu m/hr capacity	2 Nos
	350 cu m/hr capacity	2 Nos
	200 cu m/hr capacity	2 Nos
	200 cu m/hr capacity	2 Nos
	100 cu m/hr capacity	2 Nos
	100 cu m/hr capacity	2 Nos
II.	HORIZONTAL PUMPS	
	100 cu m/hr capacity	2 Nos
	160 cu m/hr capacity	3 Nos
III.	HEAT EXCHANGERS	
	Plate type heat exchangers, suitable for removing heat load of 107 kcal/hr	1 set
IV.	TREATMENT PLANT	
	Pressure filter with sludge handling pump ..	1 set

APPENDIX - 9-2

LIST OF MAJOR EQUIPMENT - IN-PLANT TRANSPORT FACILITIES

Sl. No.	Description		Quantity
1.	5-ton truck	.. ..	2
2.	5-ton dump truck	.. ..	2
3.	Diesel tractor	.. ..	1
4.	5-ton trailer	.. ..	1
5.	Payloader, 1.5 cu m	.. ..	1
6.	10-ton crawler crane	.. ..	2
7.	10-ton road weighbridge	.. ..	2

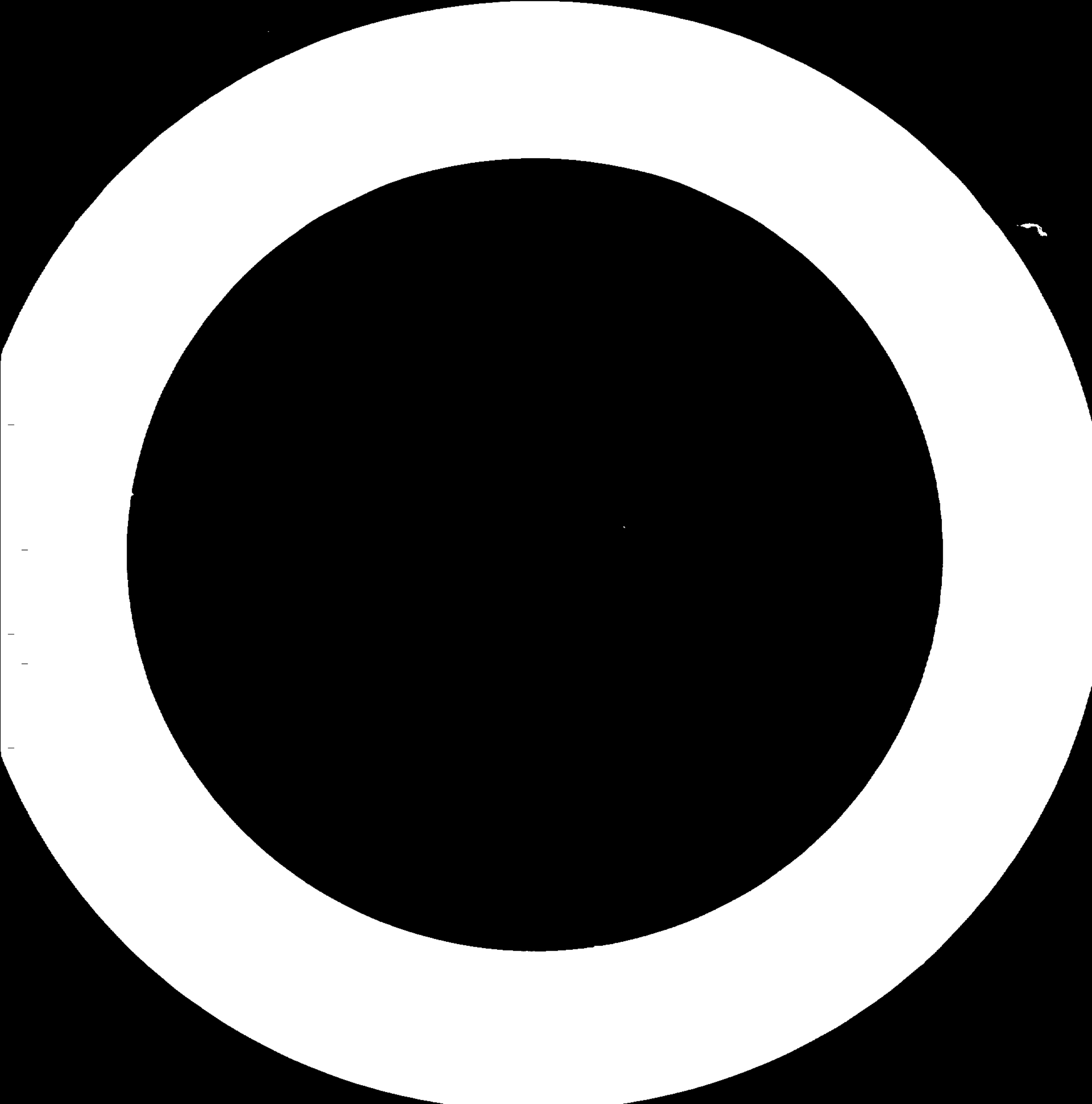
APPENDIX - 9-3

LIST OF MAJOR EQUIPMENT - AUXILIARY FACILITIES

Sl. No.	Description	Quantity
I.	MAINTENANCE SHOP	
1.	Lathe	1
2.	Radial drill	1
3.	Column drill	1
4.	Pedestal grinder	1
5.	Hack saw	1
6.	Anvil block	1
7.	Pipe cutting and threading machine ..	1
8.	Gas cutting and welding torch	1
9.	Welding set	1
10.	Surface plates	2
11.	Hoists and jib cranes	1 lot
II.	STORES	
1.	Storage racks, cupboards, steel containers and tables	1 lot
2.	Metal pellets and pellet racks	1 lot
3.	Oil storage tank	1 No
4.	Platform scale	1 No
5.	Pellet truck	1 No
6.	Forklift truck	1 No

Appendix 9-3 (continued)

Sl. No.	Description	Quantity
III.	LABORATORY EQUIPMENT	
1.	Carbon and sulphur determinator ..	1
2.	Ph meter	1
3.	Muffle furnace, maximum temperature 1100 Deg C	1
4.	Chemical balances	2
5.	Hot plates	2
6.	Drilling machine	1
7.	Sample cut off wheel	1
8.	Pestle and mortar for grinding etc ..	1
9.	Grinding and polishing (finisher) machine	1
10.	Water still, 5 lit/hour capacity ..	1
11.	Metallography microscope	1



APPENDIX - 11-1

MANPOWER ESTIMATE

ADMINISTRATION DEPARTMENT

Designation	Qualification code	Category code	Shifts Genl	I	II	III	Total per week-day	Total on pay-roll
General Manager	Met	M	1	-	-	-	1	1
Administration/ Finance	Grad	M	1	-	-	-	1	1
Personnel/Welfare Officer ..	Grad	S	1	-	-	-	1	1
Receptionist/ Telephone Operator ..	SS	OS	1	-	-	-	1	1
Security Guard	Lit	W1	-	1	1	1	3	4
Time Keeper ..	SS	OS	-	1	1	1	3	4
Janitor ..	Lit	W1	2	-	-	-	2	2
Accounts Officer	Grad	S	1	-	-	-	1	1
Accounts Assistant	VTC	OS	1	-	-	-	1	1
Purchase and Stores Officer	Grad	S	1	-	-	-	1	1
Store Keeper ..	VTC	OS	1	-	-	-	1	1
Recorder/Issuer	SS	W2	1	-	-	-	1	1
Store Helper ..	Pr.S	W1	1	-	-	-	1	1
Sales Officer..	Grad	S	1	-	-	-	1	1
Secretary ..	SS	OS	1	-	-	-	1	1
Office Assistant/ Typist ..	VTC	OS	3	-	-	-	3	3
Office Boy ..	Lit	W1	2	-	-	-	2	2
TOTAL ..	..		19	2	2	2	25	27

APPENDIX - 11-2

MANPOWER ESTIMATE

ASSISTANT GENERAL MANAGER (TECHNICAL/PRODUCTION) OFFICE INCLUDING QUALITY CONTROL AND LABORATORY

Designation	Qualification code	Category code	Shifts Genl	I	II	III	Total per week-day	Total on pay-roll
Assistant General Manager (Technical/Production)	Met	M	1	-	-	-	1	1
Quality Control Metallurgist ..	Met	S	1	-	-	-	1	1
Chemist ..	B.Sc	S	-	1	1	1	3	4
Laboratory Attendant ..	SS	W2	1	-	-	-	1	1
Office Assistant/Typist ..	VTC	OS	1	-	-	-	1	1
Office Boy ..	Lit	W1	1	-	-	-	1	1
TOTAL..	..	..	5	1	1	1	8	9

APPENDIX - 11-3

MANPOWER ESTIMATE

STEELMELT SHOP

Basis: 2x8-ton Arc furnaces) 3 shifts/day and
1x1 Strand billet caster) 7 days/week.

Designation	Qualification code	Category code	Shifts Genl	I	II	III	Total per week-day	Total on pay-roll
A. SUPERINTENDENT'S OFFICE								
Superintendent	Met	M	1	-	-	-	1	1
General Foreman	Met	S	1	-	-	-	1	1
Office Assistat/ Typist ..	VTC	OS	1	-	-	-	1	1
Office Boy..	Lit	W1	1	-	-	-	1	1
Total (A)	..	..	4				4	4
B. ARC FURNACE								
Shift Foreman	T.Met	S	-	1	1	1	3	4
B1. Scrap Storage and Preparation								
Equipment Operator..	VTE	W2	-	1	-	-	1	1
Weighbridge Operator..	VTE	W2	-	1	1	-	2	3
Sub-total(B1)	..	..		2	1		3	4
B2. Furnace								
Melter ..	T.Met	W3	-	1	1	1	3	4
First Hand..	VTE	W2	-	2	2	1	5	7
Helper ..	Pr.S	W1	-	2	2	2	6	8
Sub-total (B2)	..	..		5	5	4	14	19
Total (B)..	..	..		8	7	5	20	27

Appendix 11-3 (continued)

Designation	Qualification code	Category code	Shifts Genl	I	II	III	Total per week-day	Total on pay-roll
C. CONTINUOUS CASTING								
Shift Foreman	T.Met	S	-	1	1	1	3	4
Control Room Attendant	T.Met	W3	-	1	1	1	3	4
Casting Machine Operators	VTE	W2	-	2	2	2	6	8
Billet Stacker/ Recorder..	VTE	W2	-	1	1	1	3	4
Helper ..	Pr.S	W1	-	1	1	1	3	4
Total (C)..	..	..		6	6	6	18	24
D. CRANES								
Crawler crane Operator..	VTE	W2	2	-	-	-	2	2
Charging crane Operator..	VTE	W2	-	1	1	1	3	4
Casting crane Operator..	VTE	W2	-	1	1	1	3	4
Billet discharge aisle crane	VTE	W2	-	1	1	1	3	4
Total (D)..	..	..	2	3	3	3	11	14
E. REFRACTORY MAINTENANCE								
Ladle Deskuller	VTE	W2	-	1	1	1	3	4
Masons ..	VTE	W2	-	2	2	2	6	8
Helper ..	Pr.S	W1	-	3	3	3	9	12
Forklift Driver	Driver	W2	-	1	1	1	3	4
Total (E)..	..	..	-	7	7	7	21	28
GRAND TOTAL	..	..	6	27	25	22	70	101

APPENDIX - 11-4

MANPOWER ESTIMATE

BAR AND ROD MILL

Basis: Billet yard - 2 shifts/day and 6 days/week
One heating furnace - 2 shifts/day and 6 days/week,
one bar and rod mill - 2 shifts/day and 6 days/week
for production of 20 000 tons of finished products.

Designation	Qualification code	Category code	Shifts Genl	I	II	III	Total per week-day	Total on pay-roll
A. SUPERINTENDENT'S OFFICE								
Superintendent	Met	M	1	-	-	-	1	1
General Foreman ..	Met	S	1	-	-	-	1	1
Office Assistant/ Typist ..	VTC	OS	1	-	-	-	1	1
Office Boy..	Lit	W1	1	-	-	-	1	1
Total (A)	..	..	4				4	4
B. BILLET STORAGE AREA								
Mill Provider	VTE	W2	-	1	1	-	2	3
Charger/Painter	VTE	W2	-	1	1	-	2	3
Forklift Driver	Driver	W2	-	1	1	-	2	3
Crane Operator	VTE	W2	-	1	1	-	2	3
Total (B)	..	..		4	4		8	12
C. PRODUCTION								
Shift Foreman	T.Mech	S	-	1	1	-	2	3

Appendix 11-4 (continued)

Designation	Qualification code	Category code	Shifts Genl	I	II	III	Total per week-day	Total on pay-roll
C1.Mills								
Heater ..	VTE	W2	-	1	1	-	2	3
Furnace charging Operator..	VTE	W2	-	1	1	-	2	3
Roller ..	T.Mech	W3	-	1	1	-	2	3
Assitant Roller-cum-Guide-Setter ..	VTE	W2	-	2	2	-	4	5
Mill Operator	VTE	W2	-	3	3	-	6	7
Shear Operator	VTE	W2	-	1	1	-	2	3
Welder/Gas Cutter ..	VTE	W2	-	1	1	-	2	3
Scale Pit Attendant	VTE	W2	1	-	-	-	1	1
Crane Operator	VTE	W2	-	1	1	-	2	3
Helper ..	Pr.S	W1	-	1	1	-	2	3
Sub-total (C1) ..		..	1	12	12	-	25	34
C2.Roll Changing Crew								
Roller ..	T.Mech	W3	1	-	-	-	1	1
Assistant Roller-cum Guide Setter	VTE	W2	3	-	-	-	3	4
Sub-total (C2) ..		..	4				4	5
C3.Finishing and Shipping								
Cooling Bed Operator..	VTE	W2	-	1	1	-	2	3
Cold Shear Operator..	VTE	W2	-	1	1	-	2	2
Shipper ..	VTE	OS	-	1	1	-	2	2
Recorder ..	VTC	OS	-	1	1	-	2	3
Stencillar/Painter ..	Pr.S	W1	-	1	1	-	2	2
Crane Operator	VTE	W2	-	1	1	-	2	3
Packer/Loader	Pr.S	W1	-	2	2	-	4	5
Sub-total (C3) ..		..	-	8	8	-	16	20
Total (C) ..		..	5	21	21	-	47	63

Appendix 11-4 (continued)

Designation	Qualification code	Category code	Shifts Genl	I	II	III	Total per week-day	Total on pay-roll
D. ROLL SHOP								
Foreman ..	T.Mech	S	1	-	-	-	1	1
Roll Turner	T.Mech	W3	1	-	-	-	1	1
Roll/Tool Grinder/ Machine Tool Operator..	VTE	W2	1	-	-	-	1	1
Mechanic-I..	T.Mech	W3	1	-	-	-	1	1
Guide Maker	VTE	W2	1	-	-	-	1	1
Gauge/Template/ Tool Maker	VTE	W2	1	-	-	-	1	1
Roll Inventory Keeper ..	VTE	W2	1	-	-	-	1	1
Helper ..	Pr.S	W1	1	-	-	-	1	1
Total (D)	..	..	8	-	-	-	8	8
GRAND TOTAL	..	..	17	25	25	-	67	86

APPENDIX - 11-5

MANPOWER ESTIMATE

MAINTENANCE AND PLANT SERVICES

Designation	Qualification code	Category code	Shifts Genl	I	II	III	Total per week-days	Total on pay-roll
A. SUPERINTENDENT'S OFFICE								
Superintendent	Mech	M	1	-	-	-	1	1
Draftsman/ Planning Assistant ..	T.Mech	W3	1	-	-	-	1	1
Office Assistant/ Typist ..	VTC	OS	1	-	-	-	1	1
Office Boy ..	Lit	W1	1	-	-	-	1	1
Total (A) ..	..	..	4				4	4
B. MECHANICAL MAINTENANCE AND SERVICES								
General Foreman	Mech	S	1	-	-	-	1	1
Shift Foreman	T.Mech	S	-	1	1	1	3	4
Mechanic ..	T.Mech	W3	1	1	1	1	4	4
Hydraulic Mechanic ..	T.Mech	W3	1	-	-	-	1	1
Welder/Gas Cutter ..	VTE	W2	-	1	1	1	3	4
Rigger ..	VTE	W2	2	-	-	-	2	2
Machine Tool Operator ..	VTE	W2	3	-	-	-	3	4
Pump/Compressor Operator ..	VTE	W2	-	2	2	1	5	6
Fuel System Attendant ..	VTE	W2	-	1	1	1	3	4
Driver ..	Driver	W2	2	2	2	1	7	8
Helper ..	Pr.S	W1	2	2	2	1	7	8
Total (B) ..	..	..	12	10	10	7	39	46

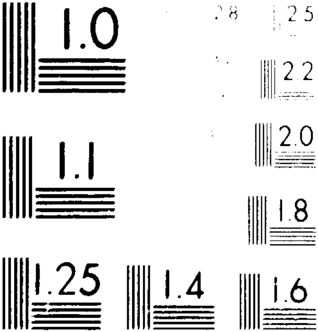
Appendix 11-5 (continued)

Designation	Qualification code	Category code	Shifts Genl	I	II	III	Total per week-days	Total on payroll
C. ELECTRICAL MAINTENANCE AND SERVICES								
General Foreman	Elec	S	1	-	-	-	1	1
Shift Foreman	T.Elec	S	-	1	1	1	3	3
Electrician	T.Elec	W3	1	1	1	1	4	4
Instrument/ Electronic Mechanic	T.Elec	W3	1	-	-	-	1	1
Sub-station Attendant ..	VTE	W2	-	1	1	1	3	4
Helper ..	Pr.S	W1	1	1	1	1	4	5
Total (C)..	..	..	4	4	4	4	16	18
D. CIVIL MAINTENANCE								
Civil Engineer	T.Civil	S	1	-	-	-	1	1
Plumber ..	VTE	W2	1	-	-	-	1	1
Electricians..	VTE	W2	1	-	-	-	1	1
Helpers/ Janitors ..	Pr.S	W1	3	-	-	-	3	4
Total (D) ..	..	..	6				6	7
E. CANTEEN								
Canteen incharge	VTC	OS	1	-	-	-	1	1
Head cook	VTE	W1	1	-	-	-	1	1
Cooks	VTC	W2	-	2	2	1	5	6
Cleaners ..	Pr.S	W1	-	3	3	2	8	10
Total (E) ..	..	..	2	5	5	3	15	18
GRAND TOTAL..	..	..	28	19	19	14	80	93

APPENDX - 12-1

CAPITAL COST ESTIMATE FOR STEELMELT SHOP

		Cost '000 YD
A. CIVIL AND STRUCTURAL	..	922
B. MECHANICAL AND ELECTRICAL EQUIPMENT		
1. Two 8-ton electric arc furnace complete with Transformer (4 MVA), electric refractories, fume extraction, ladles, pots, scrap storage and preparation etc		593
2. One single strand continuous casting machine and accessories complete with electrics and instruments	..	126
3. EOT cranes and crawler crane including bar for car	..	370
4. Building utilities	..	76
Sub-total (B)	..	1 165
C. OTHER COSTS		
1. Ocean freight and insurance, clearing and transport to site etc @ 5% of (B)	..	58
2. Equipment erection and installation work including commissioning @ 20% of (B)	..	233
Sub-total (C)	..	291
D. ENGINEERING AND ADMINISTRATION		
Provision for design and engineering charges and administration during construction @ 10% of (A+B+C)	..	238
E. CONTINGENCIES		
Provision for contingencies @ 5% of (A+B+C+D)	..	131
GRAND TOTAL (A+B+C+D+E)	..	2 747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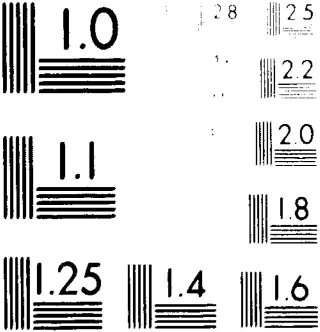
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APPENDIX - 12-2

CAPITAL COST ESTIMATE FOR ROLLING MILL

		Cost '000 YD
A. CIVIL AND STRUCTURAL	..	1 890
B. MECHANICAL AND ELECTRICAL EQUIPMENT		
1. Heating furnace complete with blower instruments controls etc	..	140
2. Mill mechanical equipment including all accessories and roll shop facilities and rolls	..	946
3. EOT cranes including billet bar for car	..	111
4. Building utilities	..	84
Sub-total (B)	..	1 281
C. OTHER COSTS		
1. Ocean freight and insurance, clearing and transport to site etc @ 5% of (B)	..	64
2. Equipment erection and installation work including commissioning @ 20% of (B)	..	256
Sub-total (C)	..	320
D. ENGINEERING AND ADMINISTRATION		
Provision for design and engineering charges and administration during construction @ 10% of (A+B+C)	..	349
E. CONTINGENCIES		
Provision for contingencies @ 5% of (A+B+C+D)	..	192
GRAND TOTAL (A+B+C+D+E)	..	4 032

APPENDIX - 12-3

CAPITAL COST ESTIMATE FOR ELECTRIC POWER SYSTEM

		Cost '000 YD
A. CIVIL AND STRUCTURAL	..	90
B. MECHANICAL AND ELECTRICAL EQUIPMENT		
Power distribution system including MRSS, transformers, switchgears, lighting and plant communication system	..	417
C. OTHER COSTS		
1. Ocean freight and insurance, clearing and transport to site etc @ 5% of (B)	..	21
2. Equipment erection and installation work including commissioning @ 20% of (B)	..	83
Sub-total (C)	..	104
D. ENGINEERING AND ADMINISTRATION		
Provision for design, engineering charges and administration during construction @ 10% of (A+B+C)	..	61
E. CONTINGENCIES		
Provision for contingencies @ 5% of (A+B+C+D)	..	34
GRAND TOTAL (A+B+C+D+E)	..	706

APPENDIX - 12-4

CAPITAL COST ESTIMATE FOR WATER AND OTHER UTILITIES

		Cost '000 YD
A. CIVIL AND STRUCTURAL	..	63
B. MECHANICAL AND ELECTRICAL EQUIPMENT		
1. Water system	..	122
2. Fuel oil system	..	12
3. Compressed air system	..	7
4. Miscellaneous	..	7
Sub-total (B)	..	148
C. OTHER COSTS		
1. Ocean freight and insurance, clearing and transport to site @ 5% of (B)	..	8
2. Equipment erection and installation work including commissioning water @ 20% of (B)	..	30
Sub-total (C)	..	38
D. ENGINEERING AND ADMINISTRATION		
Provision for design and engineeing charges and administration during construction @ 10% of (A+B+C)	..	25
E. CONTINGENCIES		
Provision for contingencies @ 5% of (A+B+C+D)	..	14
GRAND TOTAL (A+B+C+D+E)		288

APPENDIX - 12-5

CAPITAL COST ESTIMATE FOR REPAIR SHOP AND STORE

		Cost '000 YD
A. CIVIL AND STRUCTURAL	..	27
B. MECHANICAL AND ELECTRICAL EQUIPMENT		
Machine tools, handling facilities, storage equipment building utilities etc	..	15
C. OTHER COSTS		
1. Ocean freight and insurance, clearing and transport to site etc @ 5% of (B)	..	1
2. Equipment erection and installation work including commissioning @ 20% of (B)	..	3
Sub-total (C)	..	4
D. ENGINEERING AND ADMINISTRATION		
Provision for design, enginering and administration during construction @ 10% of (A+B+C)	..	5
E. CONTINGENCIES		
Provision for contingencies @ 5% of (A+B+C+D)	..	3
GRAND TOTAL (A+B+C+D+E)		54

APPENDIX - 12-6

CAPITAL COST ESTIMATE FOR ANCILLARY BUILDINGS AND ANCILLARY FACILITIES

		Cost '000 YD
A. CIVIL AND STRUCTURAL	..	68
B. MECHANICAL AND ELECTRICAL EQUIPMENT		
1. Laboratory equipment	..	10
2. Transport equipment	..	15
3. Office furniture, lighting, air-conditioning etc	..	15
Sub-total (B)	..	40
C. OTHER COSTS		
1. Ocean freight and insurance, clearing and transport to site @ 5% of (B)	..	2
2. Equipment erection and installation work including commissioning water @ 20% of (B)	..	8
Sub-total (C)	..	10
D. ENGINEERING AND ADMINISTRATION		
Provision for design and engineering charges and administration during construction @ 10% of (A+B+C)	..	11
E. CONTINGENCIES		
Provision for contingencies @ 5% of (A+B+C+D)	..	6
GRAND TOTAL (A+B+C+D+E)		135

APPENDIX - 13-1

PRODUCTION COST ESTIMATE OF BILLETS

	Unit	Unit cost YD	Unit consumption per ton billet	Cost per tons billet YD
COST OF MATERIALS				
Purchased scrap	ton	19.333	1.028	19.874
Plant return scrap ..	ton	12.000	0.106	1.272
Limestone ..	ton	3.779	0.078	0.295
Iron ore ..	ton	13.228	0.011	0.146
Fe-Mn ..	kg	0.122	7.37	0.899
Fe-Si ..	kg	0.187	3.69	0.690
Aluminium ..	kg	0.338	0.46	0.155
Fluorspar ..	kg	0.093	2.30	0.214
Pet coke ..	kg	0.167	2.80	0.468
				24.013
Less: Credit for scrap..	ton	12.000	0.046	0.552
Sub-total		..	..	23.461
CONVERSION COST				
Labour and supervision	-	-	-	4.553
Electrode ..	kg	1.00	6.45	6.450
Electric power	'000 kWh	37.00	791	29.267
Other utilities	-	-	-	3.715
Repair and maintenance, consumables, refractories etc	-	-	-	16.543
Works general expenses ..	-	-	-	0.873
Sub-total		..	..	61.401
TOTAL		..	..	84.862

Say: YD 85 per ton

APPENDIX - 13-2

PRODUCTION COST ESTIMATE OF ROLLED PRODUCTS

	Unit	Unit cost YD	Unit consumption per ton billet	Cost per ton billet YD
COST OF MATERIALS				
Billets ..	ton	85.000	1.085	92.225
Less: Credit for scrap ..	ton	12.000	0.065	0.780
Sub-total..		..	..	91.445
CONVERSION COST				
Labour and supervision ..	-	-	-	4.185
Electric power ..	'000 kWh	37.000	127	4.699
Other utilities..	-	-	-	4.297
Repair and maintenance, consumables etc	-	-	-	4.358
Works general expenses ..	-	-	-	0.775
Sub-total..		..	..	18.314
TOTAL..		..	..	109.759

Say: YD 110 per ton