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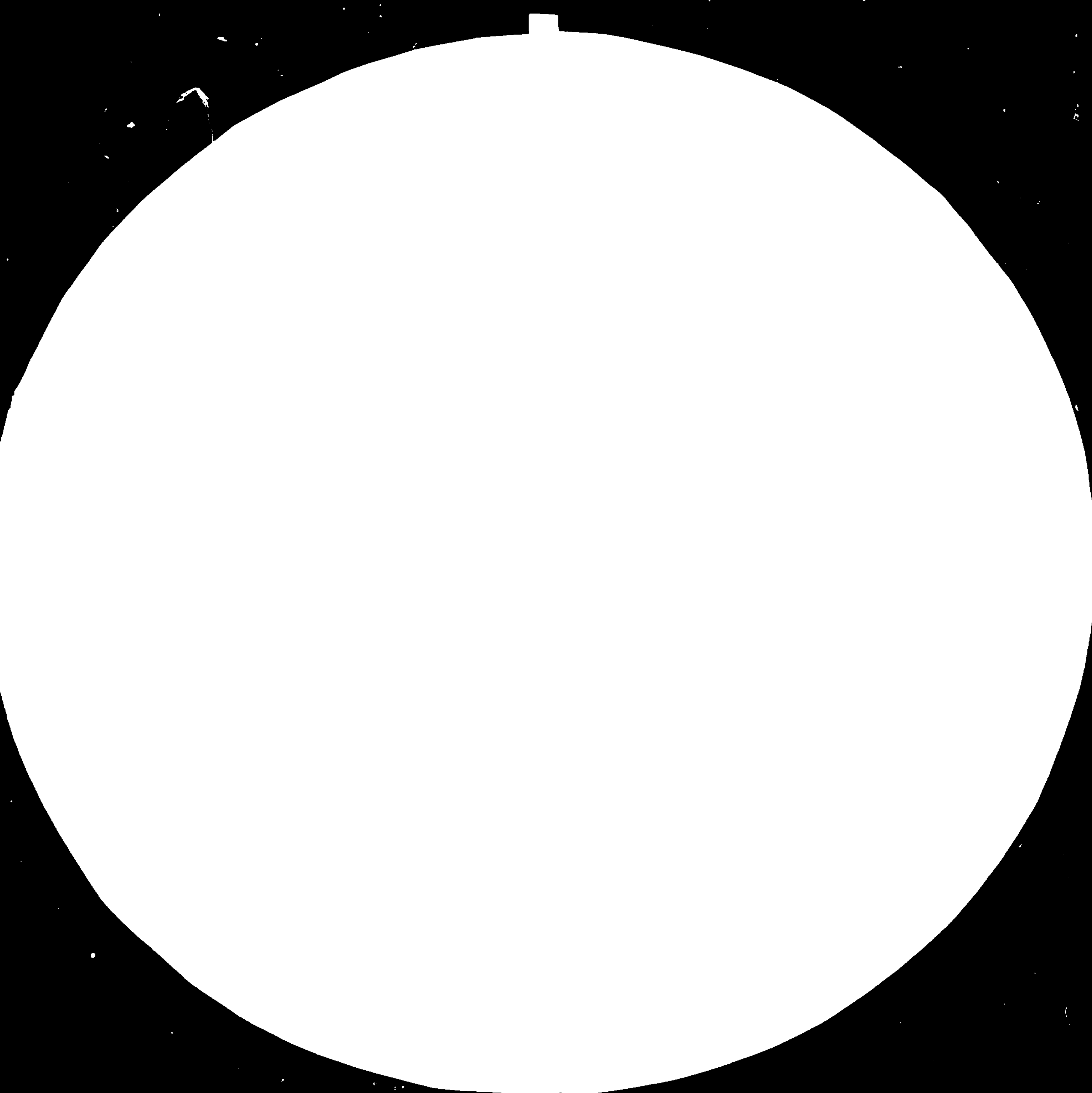
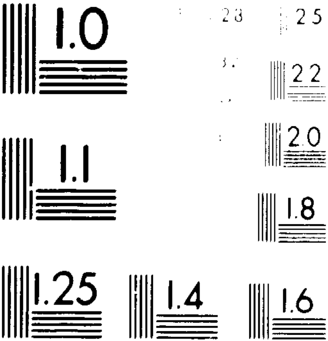




MICROCOPY RESOLUTION TEST CHART

Contract No T 81 91
United Nations Industrial Development Organization
(UNIDO)

13266

India.

Techno-economic evaluation for construction of experimental-demonstration unit for production of aluminium-silicon alloys in orissa state (India)

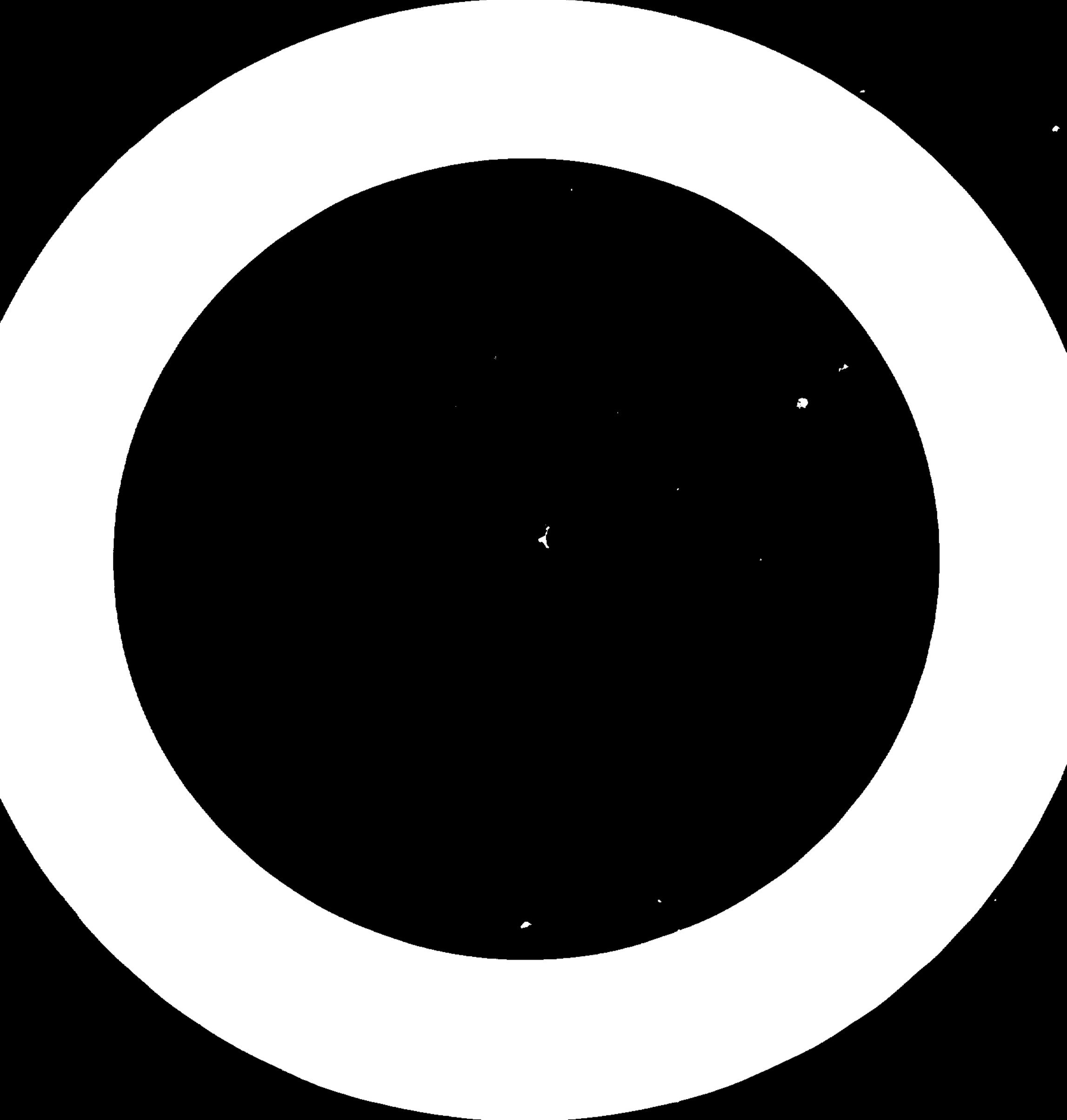
Project No DP IND 81 015
(Supplement)

General Explanatory Note

VAMI

V O TSVETMETPROMEXPORT

LENINGRAD
1983



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1. EXECUTIVE SUMMARY (RESUME)

1.1. Project Background (Chapter 2)

The project initiator for construction of the experimental demonstration unit (EDU) for production of aluminium-silicon alloys from sillimanite concentrate in Orissa (India) is the Industrial Promotion and Investment Corporation of Orissa Limited, IPICOL (IPICOL House, Janpath, Bhubaneswar 751007). IPICOL is the State's Government development bank and management consultancy for medium and large-scale industries of the State of Orissa.

This Feasibility Report for construction of the EDU for production of aluminium-silicon alloys aims at conversion of sillimanite concentrate turned out by OSCOM (Orissa) as a by-product.

Implementation of this project will ensure:

- establishment of new technology in Indian conditions for production of aluminium-silicon alloys;

- training of required workforce for future expansion of production of the above alloys, with ever growing demand for alloys;

- complex conversion of sillimanite-containing sands of Orissa state;

- expansion of raw material resources of the Indian aluminium industry due to utilisation of alumosilicate ores unsuitable for production of alumina and improvement in consumption structure of primary aluminium;

- reduction in consumption of primary aluminium in manufacture of Al-Si alloys (depending on grades of alloys in average by 20%) and respective decrease in import of aluminium for this purpose, by opening a new source of production of Al with decrease in specific electric power consumption (up to 5-8%), and elimination of consumption of pure silicon.

The lab tests and pilot trials conducted in 1980 (under the UNIDO contract No. 77/65 of 8.06.78) by the VAMI Institute of the Ministry for Non-ferrous Metallurgy of the USSR proved in principle the potential of use of Indian sillimanites for production of cast aluminium alloys.

Based on the tests carried out to the order of the Indian company IRE under the contract No. T81/91 signed between UNIDO and V/O TSVETMETPROMEXPORT, the VAMI Institute of the USSR Ministry for Non-ferrous Metallurgy prepared the Feasibility Report for construction of the Silicon-aluminium alloys plant (SAAP) in the State of Orissa (India) of 90,000 tpy capacity in 1982.

The above Feasibility Report was discussed in February 1983 by IRE with participation of UNIDO and VAMI representatives and approved as a quality report.

However, due to financial limitations imposed for the near future and shortage of electric power, IRE decided to postpone construction of the SAAP and expressed a wish for consideration of the above production facility as an experimental demonstration unit with output of about 30,000 tpy of alloys. After consideration of the report on the EDU, the management of IRE assured in their readiness to assist any Indian company in implementation of the above project.

It this connection the Government of Orissa authorised the IPICOL responsible for development of the State's industries to investigate this issue in order to establish the EDU in the State of Orissa.

1.2. Market and EDU Capacity (Chapter 3)

At present demand in aluminium-silicon alloys in India is estimated to be 45-50,000 tpy. By 1985 this demand (estimated basing on analysis of development of the industry and consumption structure of primary aluminium) will reach 85,-90,000 tpy.

According to prevailing tendency in India for replacement of heavy-weight steel structures by lighter structures of aluminium and its alloys favorable preconditions exist for more dynamic development of manufacture of alloys owing to further development of such large users of aluminium alloys as car making, aircraft, railway and building industries.

Manufacture of Al-Si alloys based on traditional technology (direct alloying primary aluminium with silicon) is constrained because of shortage of aluminium, whose import increased more that 20 times for the last 10 years.

The introduction of electro-thermic metallurgical smelting of Al-Si alloys in the present demand - supply situation (70--75% of demand met) would ensure decrease in aluminium imports for alloy manufacture by 14,-18,000 tpy.

The EDU capacity in the event of conversion of sillimanite concentrate is 9,450 tpy, with 28,223 tpy of finished Al-Si alloys (depending on grade).

In future on the basis of estimated demand in range of finished alloys, and also full utilisation of sillimanite concentrate of OSCOM the annual sales of alloys could reach an estimated 90,000 t, provided that EDU is expanded by addition of two direct ore reduction furnaces.

1.3. Materials and Inputs (Chapter 4)

The following is to be used for production of Al-Si alloys:

- raw materials for electrosmelting: sillimanite concentrate, kaolin (dry cleaned), alumina, coal, petroleum coke, quartzite, electrode paste;

- additives for finished alloy production: aluminium copper, manganese, nickel, magnesium;

- auxiliary materials (molasses, cryolite, etc), and utilities (power, water, compressed air, fuel oil, steam).

Nearly all materials and inputs required for alloy manufacture are available in Orissa. Average radius of supply of these materials to the plant amounts to 400 km max.

The annual demand of the EDU:

- sillimanite concentrate	- 11,350 t
- molten aluminium	- 19,740 t
- fuel oil	- 9,120 t
- power	- 5,650 MWh

1.4. Location of EDU (Chapter 5)

Location of the EDU was considered in the region of the towns of Hirakud and Talcher, as recommended by the EPICOL, in the north-western developed industrial section of the State of Orissa with available electric power and coal resources.

Besides, the INDAL's aluminium smelter operates in the region of Herakud and the NALCO's aluminium smelter is being built in the region of Talcher.

Availability of the aluminium smelters in this region will ensure supplies of liquid aluminium metal required for production of finished aluminium-silicon alloys.

Area requirements for siting the EDU are estimated at 12 hectars.

1.5. Plant Organisation, Overheads and Other Costs (Chapter 7)

Taking into consideration that the EDU is proposed to be located in vicinity of aluminium smelter situated in region of Talcher or Hirakud, the economic calculation were worked out in view of cooperation of EDU with one of above mentioned smelters.

The problems related to manning the EDU, organisation of maintenance and repairs, transport services and others were solved in the context of the above statement.

Overheads include factory, and indirect costs related to marketing and sales of finished products, that is charges related to manufacture and sales of Al-Si alloys.

1.6. Manpower (Chapter 8)

Total manpower for the EDU is estimated basing on full capacity of the plant in number of 240 persons, with 154 production workers, 53 indirect labour, 6 maintenance workers and 27 engineers or technicians.

It was assumed that planning and functional management of the EDU is effected in the framework of the smelter.

1.7. Project Implementation Schedule (Chapter 9)

The following EDU project implementation programme was assumed for the present Techno-economic evaluation:

- before the start-up of construction - the preparation of the Feasibility Report, geo-technical survey, site development, and detailed engineering, release of final specifications;

- construction period of EDU - 1.5-2.0 years;

- equipment supply and erection - 1.5 years starting with the last quarter of the first year of construction;

- commissioning of production capacities and start-up of production - the third year, and attaining the full capacity of the EDU producing commercial Al-Si alloys- the fifth year from beginning of construction.

The Feasibility Report considers additionally the variant of EDU construction in the region of aluminium smelter in Hirakud. The evaluation is based on comparison of raw materials transport charges.

The calculations revealed that the location of the EDU in Hirakud determines (with other conditions equal) the decrease of annual profit due to increase of transport charges by more than Rs. 970 thous. as compared with its location in Talcher.

1.8. Financial and economic evaluation of project is based on price/cost levels of 1982 up-dated in June 1983 in Orissa State Government, not considering escalation.

Foreign currency component is determined on the basis of rupee equivalent of 1 rouble = Rs 10 adopted according to agreement between the USSR and India for industrial construction.

1.8.1. Total investment costs

Total initial investment costs for EDU construction amount to Rs. 212.8 mln.

The distribution of this amount by major items is shown below:

Item	Expenditure category	Amount Rs.Mln
1	Site preparation	2.6
2	Buildings and civil works	49.4
	including housing colony	4.3
3	Technology (know-how fee including tax)	2.8
4	Equipment	
	4.1. Production equipment, including	101.2
	4.1.1. Imported from the USSR	92.5
	4.2.2. Indigenous	6.7
	4.1.3. Purchased in third countries	2.0
	4.2. Erection	11.7
	4.3. Port charges, insurance, transportation to plant site	4.6
	Total equipment	117.5
5	Preliminary expenditures (project engineering, administration recruitment, Soviet experts services etc.)	23.4
6	Current assets (100%)	17.1
	TOTAL INVESTMENT COSTS	212.8

The additional capital expenditures for gas cleaning system in amount of Rs. 31.2 mln. are also included in calculations. The construction of gas-cleaning system is assumed after the attaining the full capacity of EDU. In this connection the total capital investment costs were estimated in amount of Rs.244 mln.

The break-down of initial total capital costs by sources of finance is represented by following indicators:

Item	Source of finance	Rs.mln	Share in total volume of expenditures, %
1	Equity capital, total	69.7	32.8
	incl.: - government equity	64.8	30.5
	- margin money	4.9	2.3
2	Long-term national loan	36.4	17.1
3	Supplier's credit	94.6	44.4
4	Short-term loan on working capital	9.1	4.3
5	Current liabilities	3.0	1.4
	TOTAL	212.8	100.0

1.8.2. Project financing

According to financial scheme the expenditures of EDU construction (excluding housing colony but including 35% of working capital) would be covered by government equities and loan assets in ratio 1:2. A part of these assets in amount of supply of equipment and technology is covered by Supplier's credit, and to finance the remaining portion the local long-term loan is used. The construction of housing colony to be financed completely by equities.

65% of working capital total requirements is to be financed through short-term loan, and other 35% of working capital is to be covered by margin money.

1.8.3. Total production costs

The total production costs computed as annual total amount of expenditures on production of Al-Si alloys after reaching the full EDU capacity make Rs. 585.3 mln.

By cost items this amount is distributed as follows

Item	Cost item	Amount Rs.mln
1	Factory costs, including	552.9
	1.1. Raw materials, utilities and inputs	546.2
	1.2. Wages and salaries of direct manpower	2.2
	1.3. Factory overhead costs	4.5
2	Finished product sales and marketing costs	16.2
	Total operating costs	569.1
3	Financial costs (average for the total operating period)	5.2
4	Depreciation (average for the total operating period)	
	TOTAL production costs	5[illegible].3

1.8.4. Financial evaluation

The financial evaluation is based on following prices: alloy - Rs 23,000/t, aluminium (primary liquid) - Rs 19,600/t, fuel oil - Rs.3,000/t, and electric power - Rs. 37.1/1000 kWH.

For determination of financial impacts of EDU project implementation the calculation of cash-flow, net-income statement and projected balance sheet were carried out.

On the basis of these calculations the indicators of project profitability and economic efficiency were determined. These indicators are summarised in following table:

Item	Description	Unit	Value
1	Internal rate of return:		
1.1	On total investment	%	24.8
1.2	On equity capital	%	24.8
2	Pay-back period	year	5
3	Break-even point	%	46.4

According to UNIDO recommendation several ratios proving the economic viability of the project are shown below:

- project profitability, determined as net profit after tax as a percentage of sales, makes about 3-5% for the total calculated operational period (15 years);

- the ratio of generated cash and amount of debt repayment (interest and debt service), characterising the level of cash generated for its coverage for total calculated operational period makes about 2 : 1 which is in satisfactory margin as per the UNIDO guidelines.

1.8.5. Conclusions

The Techno-Economic Evaluation of EDU construction in India (Talcher) carried out allows the following conclusions to be made:

1. The implementation of EDU project to produce aluminium-silicon alloys by electrosmelting method ensures for India:

- the complex processing of sillimanite-bearing sands of Orissa state and the establishment at this basis the wasteless production;

- the enlargement of raw material base of Indian aluminium industry due to the processing of alumosilicate ores unsuitable for alumina production and the balancing at this account of the demand structure of electrolytic aluminium;

- the reduction of primary aluminium consumption for aluminium-silicon alloys production (in average by 20% and the respective reduction in its improts for this purpose), the reduction of electric power consumption (by 5-8%) and the complete elimination of pure silicon utilisation;

- the industrial-scale mastering of the technology of electrothermal method of alloys production;

- training of labour, technicals and engineers.

2. As the calculations worked out had shown, the location of EDU in vicinity of aluminium smelter in Talcher from the economic point of view is more viable as compared with its location adjacently with the source of the major raw material (OSCOM site, Chatrapur) due to the reduction of aluminium cost by more than 8% at the expense of its utilisation in liquid state and thus the reduction of losses.

The comparative indicators by these sites are as follows:

	Talcher	OSCOM
1. Internal rate of return, %		
on investment	24.8	16.3
on equities	23.9	15.6
2. Pay-back period, years	5.0	6.0
3. Break-even point, %	46.4	76.2

3. The present Techno-Economic Evaluation is prepared in full volume in accordance with "Manual for the Preparation of Industrial Feasibility Studies" (United Nations, New-York, 1978) and in full compliance with UNIDO requirements.

Financial evaluation of the project including sensitivity analysis has been carried out with the use of computer and set of programmes developed in VAMI.

2. PROJECT BACKGROUND

2.1. Background

2.1.1. Aim of Project

The Project aims at establishment of the experimental demonstration unit in the State of Orissa to produce aluminium-silicon alloys from sillimanite concentrate containing upto 62% of aluminium oxide and 37% of silicon oxide turned out as a by-product at the OSCOM (Orissa). The above unit will ensure establishment of a new technology for production of aluminium-silicon alloys in Indian conditions and training of labour required for future expansion of production of the above alloys, with ever growing demand for the alloys.

2.1.2. The project is aimed at carrying out the production of Al-Si alloys from the sillimanite concentrate using a new process, by a reduction smelting of the concentrate in the electric-arc reduction furnaces followed by dilution of an alloy with aluminium.

The new production process allows to simplify an equipment flowsheet, reduce the capital costs, considerably expand a raw material base of the Indian aluminium industry by the use of the alumosilicate ores (the Indian sillimanite and other similar materials) not suitable for the alumina production, to decrease a consumption of the electrolytical aluminium by 20% and that of power - by 8%, to completely exclude the use of pure silicon and to partially use secondary aluminium for dilution.

When employing the new process along with the sillimanite concentrate the following raw materials will be used: kaolin, alumina, coal and petroleum coke. The materials to be proportioned in a powder form, mixed with a binder, briquetted, dried and then transferred for a reduction smelting in the electric-arc reduction furnaces. To produce silumin or other commercial Al-Si alloys, a primary alloy obtained in the electric-arc reduction furnaces after refining will be diluted with required quantity of aluminium.

2.1.3. Type of products and product mix

The technology proposed allows to produce the alloys of the following applications according to the Indian Standard for aluminium alloys (Indian Standard Specification for aluminium and aluminium alloy ingots and castings for general engineering purposes, Indian Standards Institution, New Delhi 1975) 4420, 4520, 4600, 4600A.

Beside these main alloys used in India, special alloys can also be produced (4525, 4636, 4652).

For the proposed experimental demonstration unit made up of one direct ore reduction furnace with power rating of 17 MW a narrow range of alloys (grades 4600, 4600A and 4652) is suggested, as these alloys are the most common at present in India.

For the purpose of calculations of the production programme of the EDU it is assumed that 40% of refined aluminium-silicon alloy produced in the direct ore reduction furnace is used for manufacture of alloy grade 4600, 30% - for alloy grade 4600A and 30% - for alloy grade 4652.

2.1.4. Field of application

The above alloys depending on a content of chemical components in them will be used in the following:

- in the cylinder heads with air and water cooling and in the pistons of the internal combustion engines;
- in the crane bodies;
- for the parts of scooters, planing boats and fans;
- in the building structures.

2.1.5. Capacity of the EDU and its location.

The capacity of the proposed experimental demonstration unit is determined by the direct ore reduction furnace with power rating of 17 MW.

On this basis the design capacity of the EDU will be 9,540 tpy of crude aluminium-silicon alloy or 28,223 tpy of finished alloys.

According to the exploration data, the sillimanite deposit in Orissa allows future increase in production of the sillimanite concentrate at OSCOM up to 60 thous.t/year which, in turn, will permit, if necessary, 5 to 6-fold increase in the production of Al-Si alloys. through expansion of the EDU by addition of three or more similar direct-ore reduction furnaces for production of aluminium-silicon alloys.

Siting of the experimental demonstration unit was recommended by the IPICOL in the region of the NALCO's smelter which is being built in Talcher.

As an alternative site for location of the EDU the region of the operating smelter in Hirakud is considered.

These towns are located in the north-western developed industrial area of the State of Orissa. Area requirements for siting the EDU are estimated at about 12 ha.

2.1.6. Orientation of EDU

As shown above the major task of the experimental demonstration unit is to establish a new technology for production of aluminium-silicon alloys in Indian conditions and training the workforce required for future expansion of alloys production, with steady growth of demand.

According to the data supplied by Indian Rare Earths Ltd (IRE) the annual production of Al-Si alloys by synthetic method in India for 1980-1981 was about 30 thous.t/y, and the required quantity is estimated to be 50 thous.t/y with a projected rise to 80-85 thous.t/y in 1985.

At present the demand for Al-Si alloys is met through production at small plants by melting the indigenous and imported aluminium and silicon.

The major consumers of Al-Si alloys in India are ASHOK Leyland, Madras, India Pistons, Madras, HMT Ltd.Bangalore and EAL Bangalore which have their own facilities for producing these alloys.

On the basis of an analysis in the rise of consumption of Al-Si alloys in the Indian industry it can be assumed that by 1990 a demand for these alloys will be about 120-130 thous.t/year.

2.1.7. Project implementation schedule

From an experience in construction and commissioning of similar plants in the USSR a complete implementation of the EDU for production of Al-Si alloys in the quantities stated above is planned for 6 years taking into account the reaching of the design capacity.

The construction of the EDU is proposed to carry out in one phase commissioning one electric-arc reduction furnace.

2.1.8. Socio-economic importance of setting up production of Al-Si alloys in India

As has been noted above, the organisation of production of Al-Si alloys from sillimanite concentrate in India will permit in future to completely meet its demand for these alloys and to export a part of them.

As has been noted above, the project is to be built in Orissa state which is one of the backward states economically. As it was indicated in 1980, for a population of 26.7 mln there are only 1.350-1.530 industrial enterprises with capital investments of Rs. 7,709 mln which is only 3% of the total investment in the industry for the whole country.

It follows that construction of such a project as the EDU, employing 240 workers will be a positive factor for the state, where the unemployement rate among the active population is 10.82%.

2.1.9. Comparison of EDU capacity with similar facilities in India and abroad

As has been noted above, an annual production of Al-Si alloys at various plants in India by the conventional method during 1980-1981 was 30 thous.t. Hence the setting up of Al-Si alloys production at the proposed EDU at the rate of 28,223 t/y will increase the production of Al-Si alloys in the country two fold after expansion.

There are no similar plants for the production of Al-Si alloys any where in the world using the proposed process, exept in the USSR.

2.2. Project Promoter

2.2.1. Project Initiator

The project initiator of the experimental demonstration unit for production of aluminium-silicon alloys in the State of Orissa is IPICOL, the Industrial Promotion and Investment Corporation of Orissa Limited (IPICOL House, Janpath, Bhubaneswar 751007).

IPICOL is the development bank and management consultancy for medium and large-scale industries of the State of Orissa.

IPICOL in cooperation with other State's organisations and the Government of India promotes development of new industries in the private and public sectors aimed at utilisation of vast industrial resources of the State of Orissa.

2.2.2. IPICOL role in EDU project implementation

IPICOL showed a great interest in construction of the EDU in Orissa and was active in providing a number of basic data and recommendations for siting this unit in the region of the towns of Talcher and Hirakud, next to the aluminium smelters.

According to IPICOL's information it was granted a license from the Government of India for construction of a single-furnace experimental demonstration unit in the State of Orissa.

2.3. Project history

2.3.1. Historical development of project

On behalf of Indian Government the Indian Rare Earths Ltd (IRE), requested in 1978 UNIDO to carry out preliminary studies of possibilities to produce aluminium-silicon alloys basing on sillimanite concentrates.

In this connection and in accordance with contract No.77/65 dated 8 june 1978 between United Nations Industrial Development Organisation (UNIDO) and V/O Tsvetmetpromexport the institute VAMI of Ministry for non-ferrous metals of USSR carried out laboratory studies and trial tests in 1980 on Indian sillimanite concentrates supplied by IRE.

Studies and technological trials proved the possibility of using Indian sillimanites for electrothermic production of silicon-aluminium alloys.

Alloy produced from sillimanite was treated to obtain casting aluminium alloys, grades 4600 and 4525 (according to Indian standards), used in automobile industry.

The Report on studies carried out was examined and approved by representatives of UNIDO and IRE.

Based on the performed tests to the order by IRE under the contract No. T81/91 signed between UNIDO and V/O Tsvetmetpromexport the VAMI Institute of the USSR Ministry for Non-ferrous Metallurgy has prepared the Feasibility Report for construction of the silicon-aluminium alloy plant (SAAP) in India (Project No.DP/IND/81/015).

The above Feasibility Report proves expediency of establishment of the facility for processing a co-product of the OSCOM - sillimanite concentrate - to produce aluminium-silicon alloys by building on its territory a special plant with the following major techno-economics:

1. Capacity:

- crude alloy	28,600 tpy
- finished alloys	90,000 tpy

2. Capital investment Rs. 935.4 million
3. Men on roll 700 persons
4. Internal rate of return 22.3%
5. Overall profitability 22.2%
6. Breakeven point 64.8%

This Feasibility Report was reviewed in February 1983 with participation of the experts of IRE, UNIDO and VAMI.

It was disclosed later, that the IRE Board of Directors during the meeting in the second half of June took the decision not to proceed with implementation of this project (even the single-furnace demonstration unit) because of constraints and limitations connected with commissioning OSCOM in 1983/84. However, IRE is prepared to cooperate with other Indian companies capable of implementating the project.

In this connection the Government of the State of Orissa authorised IPICOL responsible for promotion and financing industries of Orissa to study this issue with the view of establishing in the State of Orissa the facility for processing OSCOM sillimanite concentrate, first by construction of the experimental demonstration unit (in the region of Talcher or Hirakud towns).

Based on the above statements the Feasibility Report for construction of the experimantal demonstration unit for production of aluminium-silicon alloys has been prepared in accordance with the afore -mentioned contract No. T81/91 (Project DP/IND/81/015) with siting the unit as recommended by IPICOL in the region of Talcher or Hirakud towns nearly the aluminium smelters.

2.4. Techno-economic Evaluation

2.4.1. Designer

This techno-economic evaluation for construction in the State of Orissa for production of aluminium-silicon alloys from sillimanite concentrate by a new method was prepared by VAMI Institute of the USSR Ministry for Non-ferrous Metallurgy as a follow-up of the contract No. T81/91 between UNIDO and V/O Tsvetmetpromexport under which VAMI Institute prepared in 1982 the Feasibility Report for construction of the silicon-aluminium alloy plant (SAAP) for processing sillimanite concentrates on the territory of IRE's OSCOM facility (Orissa).

2.4.2. Client - United Nations Industrial Development Organisation (UNIDO), Vienne, Austria.

From the Indian side assistance to the EDU project is rendered by the IPICOL of the State of Orissa, the promoter of industries in Orissa.

3. MARKET AND PLANT CAPACITY

3.1. Alloy Demand and Production

Analysis of production and consumption trends of aluminium-silicon alloys in India carried out by VAMI on the basis of demand assessment and review of the world production of primary aluminium metal and its consumption structure showed that India has a great potential in market for aluminium-silicon alloys. The market includes such large spheres of economy as transport (car-making, aircraft, railway industries), manufacture of household durables, electrical appliances, electric motors and diesel engines.

Demand of India for aluminium-silicon alloys is estimated at 85, to 90,000 tpy for 1985.

The proposed production technology of aluminium-silicon alloys by a new electrothermic method ensures, as compared with the conventional synthetic method (direct melting and mixing of aluminium and silicon metals), savings in primary aluminium upto 150-200 kg/t of alloys, which is critical for the Indian economy as the major trend in aluminium consumption in this country is the power engineering industry (50% of total consumption), where aluminium is used to replace more expensive and scarce copper, and shortage of aluminium in other industrial fields is covered by import.

3.2. Product Sales

This Feasibility Report assumes that the resulting aluminium-silicon alloys will be totally marketed in India.

According to the Basic Data (adjusted in 1983) the average price of aluminium-silicon alloys is Rs.22 to 27 thousand/tonne depending on the grade, and regions of location of producers and users.

For the purpose of calculations the average price of the alloy grades considered (to be produced at the EDU) is Rs.23 thousand per tonne. Effect of the alloy price fluctuation on profitability of the EDU project is shown below in Section 10 "Finance and economic analysis".

Schedule 3.1 shows calculations of sales revenue based on the assumed price and production programme of the EDU.

Schedule 3.1

Calculations of Sales Revenue

S/N	Alloy grade	Unit price Rs/t	Years from the start-up					
			Year 1		Year 2		Year 3 and following	
			Q-ties to be sold	Sales revenues Rs thous	Q-ties to be sold	Sales revenues Rs thous	Q-ties to be sold	Sales revenues Rs thous
1	4600	23000	4193	96439	6290	144670	10483	241109
2	4600A	"	3397	78131	5096	117208	8493	195339
3	4652	"	3699	85077	5548	127604	9247	212681
	Total		11289	259647	16934	389482	28223	649129

Sales revenue is shown with sales charges of 2.5% of total sales revenue (according to IRE data). Calculations of expenses is given in Schedule 3.2.

Schedule 3.2

Value	Unit	Cost item	Local	Amount	Charges, Rs.000 foreign	local	total
2.5	% of sales	Sales expenses	Rs.000	649129	–	16228	16228

3.3. Production Programme

The proposed technology allows production of a wide range of finished aluminium-silicon alloys to Indian Standard (IS:617-1975).

For the purpose of calculation of production of finished alloys at the EDU are taken two common grades 4600 and 4600A, and special grade 4652.

Depending on the level of production capacity of the major process equipment (direct-ore reduction furnace) for manufacture of refined primary alloy and its consumption for manufacture of the finished aluminium-silicon alloys of the above range Schedule 3.3 determines the production programme of the EDU.

Schedule 3.3

Production Programme

Al-Si alloy grade	At 100% capacity	Years from the start-up: 1st		2nd		3d and following	
		capacity %	quantity t	capacity %	quantity t	capacity %	quantity t
4600	10483	40	4193	60	6290	100	10483

Al-Si alloy grade	At 100% capacity	Years from the start-up					
		1st		2nd		3d and following	
		capacity %	quantity t	capacity %	quantity t	capacity %	quantity t
4600A	8493	40	3397	60	5096	100	8493
4652	9247	"	3699	"	5548	"	9247
Total	28223		11289		16934		28223

The following breakdown of ratios of finished aluminium-silicon alloys was determined based on the above figures:

grade 4600 - 37%

grade 4600A - 30%

grade 4652 - 33%

The above production programme is governed by the output of refined primary alloy depending on availability of the direct-ore reduction furnace capacity.

3.4. EDU Capacity

The design production capacity of the proposed unit is governed by the amount of finished aluminium-silicon alloys which can be produced on the basis of refined primary alloy with 60% Al and over 37% Si produced in the direct-ore reduction furnace.

Normal attainable capacity of the EDU in terms of the primary alloy (9540 tpy) is governed by the process capacity of the direct-ore reduction furnace.

Production output of finished aluminium-silicon alloys is also determined by the grades of alloys manufactured which require different amounts of refined primary alloy. So with the same output of the direct-ore reduction furnace, amounts of alloys produced may differ depending on the market. According to the proposed range of aluminium-silicon alloys, the level of their output may range from 26.2 to 30.8 thousand tpy.

Based on the proposed breakdown of finished alloys the normal attainable capacity of the EDU is 28223 t of aluminium-silicon alloy per annum.

4. MATERIALS AND INPUTS

4.1. Characteristics of materials and inputs

4.1.1. Material classification

The following are used for production of Al-Si alloys:

- raw materials: sillimanite concentrate, kaolin (dry cleaned), alumina, coal, pet.coke and quartzite;
- processed industrial materials: molten aluminium, electrode paste, manganese, copper, nickel, magnesium;
- auxiliary materials: molasses, common salt, cryolite, potassium chloride, sodium fluoride, refractories.
- utilities: electric power, water, fuel oil, steam, compressed air.

4.1.2. Specifications for raw and other materials

To produce primary Al-Si alloy of optimum composition with 60-65% Al sillimanite concentrate, kaolin of high alumina content is required. This will help reduce addition of alumina to the feed.

Harmful impurities include iron, titanium and zirconium oxides. Metals of these oxides pass to the melt in full quantity and their separation as intermetalloids in the process of finished casting Al-Si alloy production results in lower recovery of products and extra costs. This is why content of iron oxides in the feed is not to exceed 0.7% and the sum of titanium and zirconium oxide - 0.4%.

Resistivity of electrode paste is to be 87 ohm.mm^2/m max, with ash content of 7% and volatiles of 12-20%. Specifications for electrode paste are based on necessity to maintain certain process parameters during smelting in the electric arc reduction furnaces. Coal used as a reductant in the process is to have high reactivity, which increases with higher volatiles and lower ash content. Content of iron oxide is to be in agreement with the general requirements for its content in the feed.

Pet .coke is to contain minimum amount of sulfur, basing on environment protection requirements and corrosion of equipment.

On this basis the following specifications are to be met by chemical analysis of raw materials:

- Sillimanite concentrate to contain at least 56% Al_2O_3 and not over 0.6% iron and titanium oxides each, and 0.5% zirconium oxide;

- Dry cleaned kaolin to contain 36% min Al_2O_3 and 0.6% max of iron and titanium oxides each;

- Alumina to contain 94% min Al_2O_3 and 0.1% max of iron oxide;

- Quartzite to contain 98.5% min SiO_2 and 0.2% max of iron oxide;

- Coal to contain 30% min of volatiles and 0.8% max of iron oxide;

- Pet.coke to contain 7-12% of volatiles, 85-90% of fixed carbon, 1.5% max of sulfur, 0.1% max of iron oxide.

In order to secure a possible production of finished casting Al-Si alloys of grades 4600, 4600A and 4652 with iron content from 0.6 to 1.3% (according to the Indian standard) the following iron content in raw materials used for production of the above grades of alloys is specified: 0.2% in aluminium, 2.3% in manganese in master alloys (copper, nickel, magnesium) - 0.6% each.

To ensure required strength and heat stability of briquetted feed some binder is to be added to the feed along with kaolin which has some cementing ability. As a binder the use may be made of magnesium lignosulfonate in the form of lye or powder, and molasses - waste of sugar cane processing. Binding ability of molasses depends on sugar and ash content. Ash can be a source of harmful impurities of iron, calcium, phosphorus. On this ground molasses are to contain 62% sugar, 8% max ash, including 1.5% CaO, 0.2% Fe_2O_3, 0.2% P_2O_5. Common salt, potassium chloride, cryolite and sodium fluoride used as fluxes are to contain 0.5% moisture (from point of view of safe operation).

- Electric power. Voltage 415/230 V, 50 Hz. Current rating depends on characteristics of each particular power user.

Water used for make-up losses of the water recycle system of the shop and for cooling the fire boxes in the reductant grinding section, and also for cooling certain elements of the electric arc reduction furnace, transformers and pneumatic screw feeders is to meet the following specifications:

- total hardness of 3 mg.equiv./l max;
- carbonate hardness of 2.5 mg.equiv./1 max;
- suspended solids of 20 mg/l max;
- iron salts of 0.1 mg/l max;
- total dissolved solids of 100 mg/l max;
- pH of 6.5-8.5;
- temperature of 30°C.

Fuel oil used for process needs is to contain 1.5% max of sulfur, calorific value 9500 kcal/kg min.

Steam to be used for fighting accidental fires in coal bunkers of the feed preparation room and raw material store is to be saturated and have pressure of 0.3-0.7 MPa at entry point to these units.

4.1.3. Selection and Specifications for Raw and Other Materials and Production Factors

Basing on data furnished by a number of Indian firms the following raw materials, supplies, etc. were taken for calculations in the Feasibility report:

- production of crude Al-Si alloys:

sillimanite concentrate, alumina, kaolin, coal, pet.coke, quartzite, molasses, electrode paste;

- production of finished casting Al-Si alloys:

molten primary aluminium, secondary aluminium in pigs, manganese metal for manufacture of alloy grades 4600 with iron content of 0.6%, and alloying metals (copper, nickel and magnesium for alloy grade 4652).

Also for refining crude Al-Si alloys and manufacture of finished casting alloys are used common salt, cryolite, potassium chloride and sodium fluoride.

Specifications for the above materials and supplies are shown in Tables below.

Sillimanite concentrate

S/N	Description	Unit	Average value
1	Al_2O_3	%	61.5
2	SiO_2	"	37.0
3	Fe_2O_3	"	0.1
4	TiO_2	"	0.1
5	ZrO_2	"	0.3
6	CaO + MgO	"	0.2
7	Moisture	"	0.5
8	Bulk weight	g/cm^3	1.95
9	Mean particle size	micron	-500+100

Alumina

S/N	Description	Unit	Average value
1	Al_2O_3	%	99.5
2	L.O.I.	"	1.0
3	SiO_2	"	0.03
4	Fe_2O_3	"	0.02
5	Na_2O	"	0.4
6	Bulk weight	g/cm^3	0.93-1.04
7	Angle of repose	deg.	31-32
8	Mean particle size	micron	+45 mcm-85-88% -45 mcm-12-15%

Dry cleaned kaolin

S/N	Description	Unit	Average value
1	Al_2O_3	%	38.0
2	SiO_2	"	44.0
3	Fe_2O_3	"	0.5
4	TiO_2	"	0.45
5	CaO + MgO	"	1.0
6	Moisture	"	2.0
7	L.O.I.	"	15.5
8	Bulk weight	g/cm^3	0.35
9	Mean particle size	micron	-2 mcm - 68%, +2-10 mcm - 27%, +10 mcm - 5%

Coal

S/N	Description	Unit	Average value
1	Ash	%	22.92
2	Fe_2O_3 in ash	"	8.62
3	Fe_2O_3 in coal	"	1.98
4	Volatiles	"	31.43
5	Moisture	"	5.03
6	Sulfur in coal	"	0.44
7	Fixed carbon	"	40.55
8	Bulk weight	g/cm^3	0.7-0.8
9	Size	mm	200 max

Pet.coke

S/N	Description	Unit	Average value
1	Ash	%	0.2-0.3
2	Fe_2O_3 in ash	"	NA*)
3	Fe_2O_3 in coke	"	-"-
4	Volatiles	"	0.2
5	Moisture	"	6-15
6	Sulfur in coke	"	0.8
7	Fixed carbon	"	88.0
8	Bulk weight	g/cm^3	0.7-0.8
9	Size	mm	+250 - 1%; -250+150 - 5%, -150 - 94%

*) - not available

Quartzite

S/N	Description	Unit	Average value
1	SiO_2	%	99.5
2	Al_2C_3	"	0.2 total
3	Fe_2O_3	"	Al_2O_3+Fe_2O_3
4	Bulk weight	g/cm^3	1,5
5	Size	mm	10-70

Molasses

S/N	Description	Unit	Average value
1	Organic matter	%	72.0
2	incl. sucrose	"	32.0
	glucose	"	14.0
	fructose	"	16.0
	non-sugar matter	"	10.0
3	Inorganic matter (ash)	"	8.0
4	Moisture	"	20.0
5	Specific weight	g/cm^3	1.5
6	Viscosity	cp	20000

Electrode paste

S/N	Description	Unit	Average value
1	Ash	%	2.0
2	Volatiles	"	12.0
3	Fixed carbon	"	86.0
4	Resistivity	$\frac{ohm.mm^2}{m}$	75.0
5	Apparent density		
	- green	g/cm^3	1.58
	- baked	"	1.4
6	Porocity	%	30.0
7	Compression strength	kg/cm^2	150-250

Molten primary aluminium

S/N	Description	Unit	Average value
1	Fe	%	0.2
2	Si	"	not specified

Manganese metal

S/N	Description	Unit	Average value
1	Mn	%	99.5-99.8
2	S	"	0.028
3	C	"	0.01
4	Si	"	0.001
5	O_2	"	0.18-0.39
6	H_2	"	0.0006-0.018
7	Fe	"	NA
8	Lump size	mm	powder

Chemical analysis of copper, nickel and magnesium used for manufacture of finished casting alloys as alloying elements is assumed on the basis of Indian Standards.

Chemical analysis of a flux also corresponds to an Indian standard, except that moisture content is limited by 0.5%.

Fuel oil to be used as a process fuel has a heat capacity of 9700 kcal/kg. Industrial and potable water supply will be from the regional water supply network. Water supply is from the operating aluminium smelter near which the EDU is sited.

4.2. Supply programme

4.2.1. Fundamental data

The product mix of the Al-Si alloys to be produced at the EDU and specified in p.4.2.1.1 is adopted for establishing the programme of raw materials and other inputs.

Alloy grades are selected in accordance with the Indian standard "Specification for aluminium and aluminium alloy ingots and castings institution", New Delhi, 1975, taking into consideration their demand, optimum technical and economic performances and composition of the located raw materials.

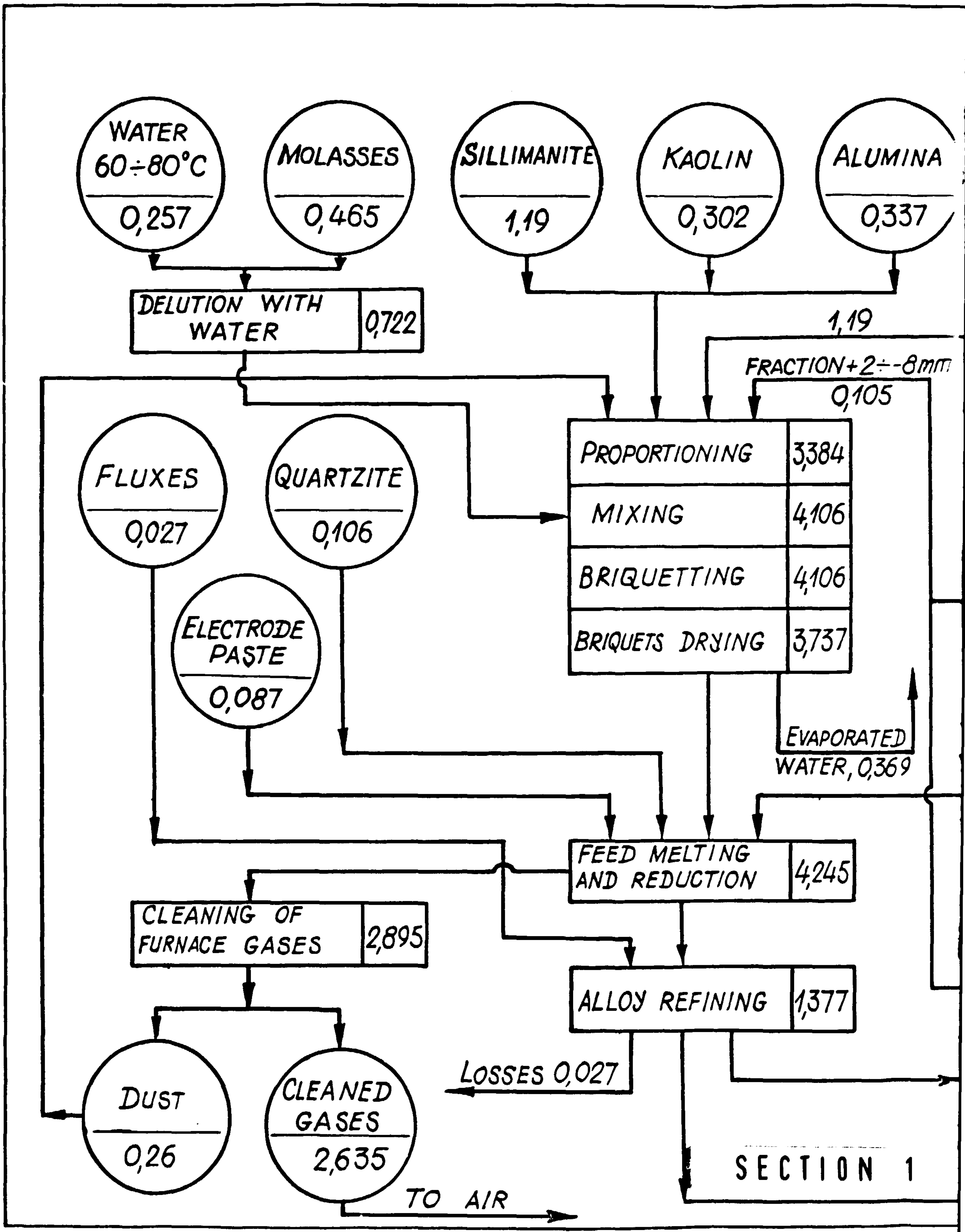
The specific consumptions of raw and other materials and power for production of primary refined and casting alloys are indicated below in pp. 4.2.1.2 and 4.2.1.3. Annual volume of production by alloy grades is indicated in p.4.2.1.4.

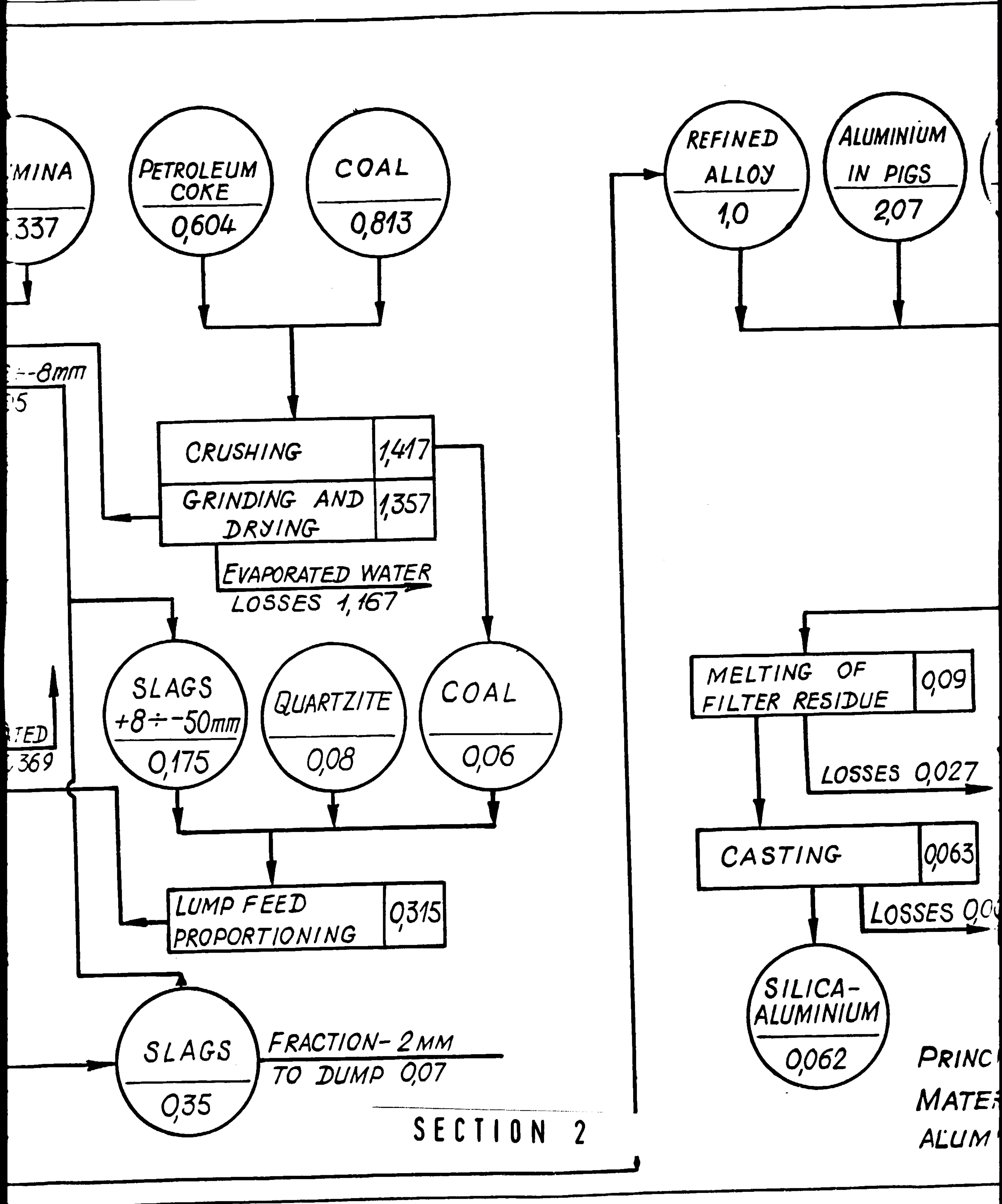
4.2.1.1. Composition of alloys to be produced in EDU

	Grade by IS	Composition, % (the rest in aluminium)											
		silicon		manganese		copper assumed		nickel		magnesium		iron	
		by standard	for calculation	by standard	for calculation	by standard	for calculation	by standard	for calculation	by standard	for calculation	by standard	for calculation
1	4600	10.0-13.0	12.5	0.5	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.6	0.6
2	4600A	10.0-13.0	12.5	0.5	0.5	0.4	0.4	0.1	0.1	0.2	0.2	1.0	1.0
3	4652	10.0-12.0	11.5	0.5	0.5	0.7-1.5	1.0	0.7-1.5	1.0	0.8-1.5	1.0	1.0	1.0

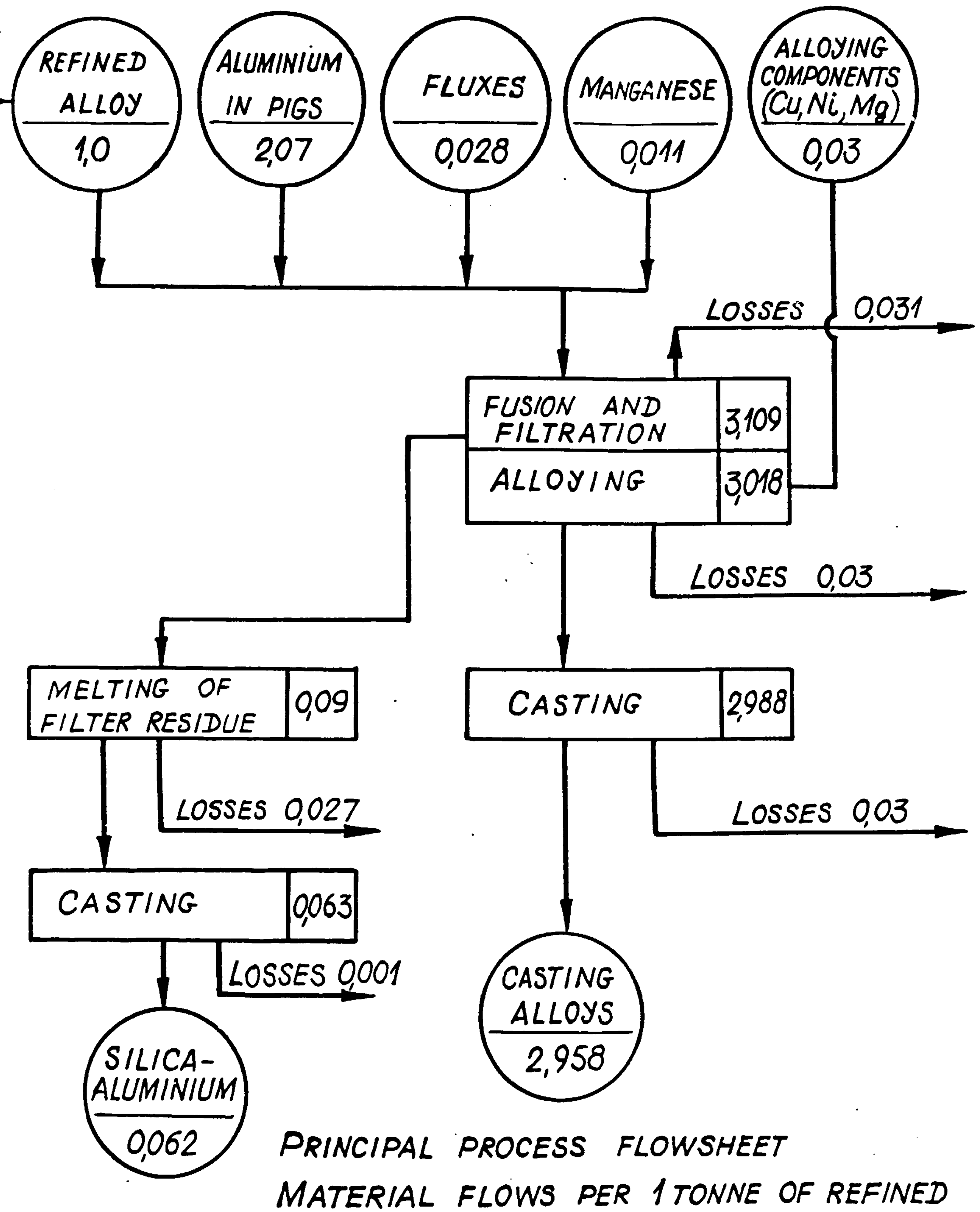
4.2.1.2. Specific consumption for production of primary refined Al-Si alloys

	Consumption article	Unit of measure	Specific consumption with losses and moisture
1	Sillimanite concentrate	t/t	1.19
2	Dry treated kaolin	"	0.302
3	Alumina	"	0.337
4	Coal	"	0.813
5	Petroleum coke	"	0.604
6	Molasses	"	0.465
7	Electrode paste	"	0.087
8	Quartzite	"	0.186
9	Common salt	"	0.0170
10	Cryolite	"	0.005
11	Potassium chloride	"	0.005
12	Electrode casing	"	0.0035
13	Graphitised electrodes	"	0.0035
14	Process power	1000 KWH/t	13.0
15	Power		
	- for gas cleaning	-"-	0.94
	- other uses	-"-	0.966
16	Fuel oil	t/t	0.14
17	Recycled water	m^3/t	780
18	Compressed air	nm^3/t	850
19	Spare parts	t/t	0.004
20	Refractories	t/t	0.02


WATER 60÷80°C
0,257
MOLASSES
0,465
SILLIMANITE
1,19
KAOLIN
0,302
ALUMINA
0,337
DELUTION WITH WATER
0,722
1,19
FRACTION+2÷-8mm
0,105
PROPORTIONING
3,384
MIXING
4,106
BRIQUETTING
4,106
BRIQUETS DRYING
3,737
FLUXES
0,027
QUARTZITE
0,106
ELECTRODE PASTE
0,087
EVAPORATED WATER, 0,369
FEED MELTING AND REDUCTION
4,245
CLEANING OF FURNACE GASES
2,895
ALLOY REFINING
1,377
LOSSES 0,027
DUST
0,26
CLEANED GASES
2,635
TO AIR
SECTION 1



MINA
.337
PETROLEUM COKE
0,604
COAL
0,813
REFINED ALLOY
1,0
ALUMINIUM IN PIGS
2,07
-8mm
5
CRUSHING
1,417
GRINDING AND DRYING
1,357
EVAPORATED WATER LOSSES 1,167
MELTING OF FILTER RESIDUE
0,09
SLAGS +8÷-50mm
0,175
QUARTZITE
0,08
COAL
0,06
TED
369
LOSSES 0,027
CASTING
0,063
LUMP FEED PROPORTIONING
0,315
LOSSES 0,0
SILICA-ALUMINIUM
0,062
SLAGS
0,35
FRACTION- 2MM TO DUMP 0,07
SECTION 2
PRINC
MATE
ALUM



PRINCIPAL PROCESS FLOWSHEET
MATERIAL FLOWS PER 1 TONNE OF REFINED ALUMINIUM - SILICON ALLOY

SECTION 3

Формат А4×3

4.2.1.3. Specific consumptions for production of casting alloys

	Consumption articles	Units of measure	Alloys 4600	4600A	4652
1	Molten aluminium	t/t	0.73	0.683	0.68
2	Refined alloy	-"-	0.364	0.337	0.3095
3	Manganese	kg/t	9.65	-	-
4	Copper	-"-	-	-	10.2
5	Nickel	-"-	-	-	10.2
6	Magnesium	-"-	-	-	10.2
7	Cryolite	-"-	0.6	0.5	0.5
8	Common salt	-"-	5.0	3.0	3.0
9	Potassium chloride	-"-	5.0	3.5	3.5
10	Sodium fluoride	-"-	1.5	1.0	1.0
11	Quartzite (grit)	-"-	5.0	5.0	5.0
12	Pig iron	-"-	1.0	1.0	1.0
13	El.power	KWH/t	200	200	200
14	Fuel oil	t/t	0.075	0.075	0.075
15	Water	m^3/t	14	14	14
16	Compressed air	nm^3/t	55	55	55
17	Spare parts	t/t	0.001	0.001	0.001
18	Refractories	-"-	0.003	0.003	0.003

4.2.1.4. Annual quantity of production by alloy grades

	Alloy grade	Annual quantity of production in tonnes
1	4600	10483.5
2	4600A	8492.5
3	4652	9247
	TOTAL:	28223

4.3. Selection of supply programme

4.3.1. The selection of supply programme is determined by the consumption of materials in production, by the continuity of production, by the availability of storage capacities, by the uniformity of utilisation of transport equipment and employment of personnel attached to the handling operations.

4.3.2. The consumptions of raw and other materials by the years of running of the plant are specified in p.p.4.3.2.1 and 4.3.2.2 according to the capacity of the reduction arc furnace achieved by the end of the first year of operation to 40%, the second year - to 60% and the third year - 100% of the design capacity.

4.3.2.1. Annual demand of raw and other materials and power for the production of the refined Al-Si alloy

	Raw and other materials, power sources	Unit of measure	Years from the start-up		
			1st	2nd	3d
1	Sillimanite concentrate	t	4541	6812	11353
2	Dry treated kaolin	t	1152	1729	2881
3	Alumina	t	1236	1929	3215
4	Coal	t	3102	4654	7756
5	Petroleum coke	t	2305	3457	5762
6	Molasses	t	1774	2662	4436
7	Electrode paste	t	332	498	830
8	Quartzite	t	710	1065	1775
9	Fluxes:				
	- common salt	t	65	97	162
	- cryolite	t	19	29	48
	- potassium chloride	t	19	29	48
10	Power	10^6 kW hour	57	86	142.2
11	Fuel oil	t	534	802	1336
12	Recycled water	10^6 m^3	3.0	4.5	7.44
13	Compressed air	10^6 Nm^3	3.2	4.9	8.1

4.3.2.2. Annual demand of raw and other materials and power for production of casting Al-Si alloys

	Raw and other materials, power sources	Unit of measure	Years from the start-up		
			1st	2nd	3d
1	Molten aluminium	t	7900	11845	19741
2	Refined Al-Si alloy	t	3816	5724	9540
3	Manganese	t	40.5	61	101.2
4	Copper	t	38.0	57	94.3
5	Nickel	"	38.0	57	94.3
6	Magnesium	"	38.0	57	94.3
7	Fluxes:				
	- cryolithe	t	6.1	9.1	15.2
	- common salt	t	42.25	63.4	105.6
	- potassium chloride	t	45.8	68.7	114.5
	- sodium fluoride	t	13.4	20.1	33.5
8	Quartzite	t	56.5	85	141.1
9	Power	10^6 kW hour	2.26	3.4	5.65
10	Fuel oil	t	846.7	1270	2116.7
11	Water	10^6 m^3	0.16	0.24	0.4
12	Compressed air	10^6 Nm^3	0.62	0.93	1.55

4.4. Cost Estimate

The estimate of production expenses for materials and utilities for the EDU is shown in summary Schedule 4.1 and 4.2.

The calculations are based on annual requirements for materials and utilities as estimated on the basis of the consumption figures and proposed production programme, and prices of the materials and utilities as specified by the Government of the State of Orissa in June 1983.

Estimate of Production Expenses

Materials and Utilities

Project: EDU			Product: Refined primary alloy					
S/N	Q-ty	Unit	Cost item	Local	Unit price	Expenses, Rs. 000		
						Foreign	Local	Total
1			Raw, main and intermediate industrial products					
1.1	11353	t	Sillimanite concentrate	Rs.	1000	-	11353	11353
1.2	2881	t	Dry cleaned kaolin	Rs	2200	-	6338	6338
1.3	3215	t	Alumina	Rs	2810	-	9034	9034
1.4	7756	t	Coal	Rs	300	-	2327	2327
1.5	5762	t	Pet.coke	Rs	6000	-	34572	34572
1.6	4436	t	Mollases	Rs	95	-	421	421
1.7	830	t	Electrode paste	Rs	7810	-	6482	6482
1.8	1775	t	Quartzite	Rs	200	-	355	355
			Total of 1		-	-	70882	70882
2			Auxiliary materials					
2.1	162	t	Common salt	Rs	300	-	49	49
2.2	48	t	Cryolite	Rs	17000	-	816	816
2.3	48	t	Potassium chloride	Rs	4000	-	192	192
2.4	34	t	Graphitised electrodes	Rs	44170	-	1502	1502
			Total of 2				2559	2559
3			Recoverable waste					
3.1	2671	t	Slag					
3.2	2480	t	Entrapped dust					

Estimate of Production Expenses

Materials and Utilities

Project: EDU			Product: Refined primary alloy					
S/N	Q-ty	Unit	Cost item	Local	Unit price	Expenses, Rs. 000 Foreign	Local	Total
4			Fuel					
4.1	1336	t	Fuel oil	Rs	3000	-	4008	4008
5			Utilities					
5.1	142203	kWh 000	Electric power, with:	Rs	371	-	52757	52757
5.1.1	124020	do	Process	Rs	371	-	46011	46011
5.1.2	18183	do	Auxiliary	Rs	371	-	6746	6746
5.2	7441	m^3 000	Industrial water	Rs	300	-	2232	2232
5.3	8109	Nm^3 000	Compressed air	Rs	16	-	130	130
			Total of 5				55119	55119
			Grand Total				132568	132568

Estimate of Production Expenses

Materials and Utilities

Project: EDU

Product: Finished Al-Si alloys

S/N	Qty	Unit	Cost item	Local	Unit price	Expenses, Rs. 000 Foreign	Local	Total
1			Main materials and intermediate industrial products					
1.1	9540	t	Primary Al-Si alloy	Rs			132568	132568
1.2	19741	t	Molten primary aluminium	Rs	19600		386924	386924
			Total of 1				519492	519492
2			Industrial materials					
2.1	101.2	t	Manganese	Rs	26000		2631	2631
2.2	94.3	t	Copper	Rs	30000		2829	2829
2.3	94.3	t	Nickel	Rs	90000		8487	8487
2.4	94.3	t	Magnesium	Rs	22000		2074	2074
			Total of 2				16021	16021
3			Auxiliary materials					
3.1	105.6	t	Common salt	Rs	300		32	32
3.2	15.2	t	Cryolite	Rs	17000		258	258
3.3	148	t	Potassium chloride and sodium fluoride	Rs	4000		592	592
3.4	141.1	t	Quartzite	Rs	200		28	28
			Total of 3				910	910
4			Fuel					
4.1	2116.7		Fuel oil	Rs	3000		6350	6350

Estimate of Production Expenses

Materials and Utilities

Project: EDU

Product: Finished Al-Si alloys

S/N	Q-ty	Unit	Cost item	Local	Unit price	Expenses, Rs. 000 Foreign	Local	Total
5			<u>Utilities</u>					
5.1	5644.6	kWh 000	Electric power	Rs	371		2094	2094
5.2	395.2	m^3 000	Water	Rs	300		1317	1317
5.3	1552.3	Nm^3 000	Compressed air	Rs	16		25	25
			Total of 5				3436	3436
			Grand Total				546209	546209
			Less cost of primary alloy				413641	413641

5. SITE LOCATION

5.1. Location

Region and state of EDU location was chosen according to the recommendations of IPICOL taking into consideration the following factors:

- availability and location of raw materials and utilities;
- state government public policy;
- infrastructure availability;
- recommendations of company-initiator of the project.

On the basis of the above factors IPICOL has recommended for a techno-economic assessment to locate the EDU in Orissa state situated in an eastern part of India. This state has possibilities to supply the EDU with raw materials, materials and power to produce Al-Si alloys.

Orissa state is the main state of the country in mining, supplying a total amount of chromite in the country, more than one third of manganese ore and quartzite. Mining of coal, iron ores, limestone, fireclays and kaolin is also of great importance.

The tests revealed that from above raw materials coal, quartzite and kaolin can be used for production of Al-Si alloys.

Regarding a raw material of the aluminium industry it should be noted that India has one of the largest reserves of bauxite in the world. As per data at the beginning of 1982 the reserves of this raw material is estimated to be 2,592 mln.t., which makes 8,3% of world reserves. From the above amount of bauxite Orissa state share is 1,416.31 mln.t, which makes 55% of the national reserves.

5.2. Site for the EDU

For a purpose of this evaluation a site for the EDU to be located, as recommended by IPICOL, adjacent to the aluminium plant being built by NALCO in the vicinity of Talcher. As an alternative, the siting of the EDU is considered close to the INDAL aluminium smelter located in the neighbourhood of Hirakud.

An area required for the EDU's site is about 12 hectares.

5.3. Sources of raw materials, materials and utilities supply

At present IRE, initiator of this project, in region of Chatrapur, Orissa state, is setting up an industrial complex, namely OSCOM, intended to co-produce up to 30,000 tpy of sillimanite concentrate which is the main raw material for production of Al-Si alloys. According to IRE data the above complex is likely to be commissioned in early 1984.

In this state National Aluminium Company (NALCO) in vicinity of Talcher and Koraput is constructing a large aluminium complex (capacity: 800,000 tpy of alumina and 218,000 tpy of aluminium) which ensures supply of alumina and aluminium for the EDU. Capacities of alumina production are projected to be commissioned in 1985, and of aluminium production in 1986.

Coal should be delivered from Talcher Coal Mines, quartzite-from Koraput region, electrode paste - from Hirakud. In future there is a possibility to supply kaolin from deposits of Sambalpur and Hirakud region.

In Orissa state exists a developed network of power transmission lines and important capacities generating electric power totaling at present to about 1,000 MW, with an expected increase up to 1,600 MW by the end of 1985.

According to the tentative data the EDU's requirement in power will be 163.65 mln.kW.hours per year, to be supplied from the Talcher power system.

The supply sources planned and annual requirements of the main types of raw materials and materials for production of Al-Si alloys.

	Description	Location	Annual requirement t	Talcher site, distance km	Hirakud site, distance km
1	Sillimanite concentrate	Chatrapur, OSCOM	11.352	300	650
2	Kaolin	Trivandram Kerala	2.881	2.050	1.950
3	Coal	Talcher	7.756	-	180
4	Petroleum coke	Baraumi, Assam	5.762	1.860	1.450
5	Quartzite	Orissa	1.775	300	650
6	Cryolite, fluorides	Bombay	48	1.780	1.250
7	Alumina	Karaput	3.215	625	580
8	Electrode paste	Bhubaneshvar	830	130	260
9	Fuel oil	Visakhapatnam	1.336	600	450
10	Liquid aluminium	Talcher	19741	-	-

5.4. Local conditions

Due to the fact that a specific site for this stage of the Feasibility Study has not been selected yet, a general description of the Orissa state is given below.

5.4.1. Climate

The climate of Orissa is a hot and humid one. During all the year the variations of the temperature is in the range of 25 to 28°C, an average maximum reaches 47°C and an average minimum - 5°C. The climate in Orissa is influenced by the monsoon air masses moving from the Bay of Bengal. An annual rainfall is about 1,500 to 2,000 mm with 80% of it for a period from the middle of June to the end of September. During the monsoon period there are heavy storms and cyclones on the Orissa's coast and almost every year there are floods.

Agriculture and Industry

Orissa has the largest amount of forests in India. They occupy 42% of the total state's area. This state forms a part of the Great Rice Belt stretching alont the eastern coast of the Indostan peninsula. Rice occupies about 80% of the state's sown area. Usually after rice other grain and bean crops follow. Batata, sugar cane, ground nuts, sesamum, as well as chili and tobacco are also of importance.

The most important industrial crop is jute, it occupies the Kataka region where a network of irrigation channels is provided for.

Orissa is one of the main mining states in India. It supplies almost all chromite and graphite mined in the country, over 1/3 of the manganese ore, quartzite and dolomite. Of a major importance is the mining of the iron ore (containing up to 60% Fe), coal, limestone, refractory clay, kaolin and bauxite.

The first major project of the state implemented in 1948-1957 was the Hirakud hydroengineering complex built on the Mahanadi river. As a result a water storage was created to supply water for about 250,000 hectares of farmland. An installed capacity of the complex was 270 MW.

On the basis of power from the Hirakud complex and of the Talcher coal an iron and steel plant in Rourkela was brought into service. Then two ferromanganese plants were built, along with the Paradip port in the Mahanadi river mouth and some other projects. The aluminium industry of the state is represented by two small aluminium smelters in the vicinity of Hirakud and Sambalpur and also by a major aluminium smelter close to Talcher and a big alumina plant near Karaput being built by NALCO.

5.5. Environmental impact

The EDU's impact on a regional infrastructure will no be significant due to the fact that it will use an already established and mainly built infrastructure of the aluminium smelters located near Talcher and Hirakud.

The EDU's influence on the region's ecology will manifest itself in some pollution of the atmosphere by dust and gases produced in the course of the process. An amount of the dust and gases after the gas cleaning stage is expressed as follows: dust - 98 kg/hr, SO_2 - 46 kg/hr.

The maximum concentration of these pollutants in a surface layer under the most unfavourable meteorological conditions, as has been shown by the preliminary calculations of dispersion, at the boundary of a one kilometer zone will be as follows: dust - 0.17 mg/m^3, sulphur dioxide - 0.030 mg/m^3. These figures are less than the maximum permissible concentrations for populated areas according to the current sanitary norms of the Soviet Union.

5.6. Estimated costs

The estimates for construction of the EDU were prepared for the unit to be located on a site of the plant being built. Due to this they do not include a land acquisition cost as well as costs connected with the site's use.

The costs connected with preparation of the site for construction are included into an estimate of the investment costs for the buildings and structures, section 6.

6. TECHNOLOGY

6.1. Kinds of technologies for aluminium-silicon alloys

Casting aluminium-silicon alloys are generally produced by the synthetic method which involves melting of electrolytic aluminium and crystalline silicon.

The Soviet Union has developed and is successfully using on a commercial scale an electrothermic metallurgical process for production of silicon-aluminium alloys based on a direct reduction of aluminium and silicon from natural alumosilicates and other silica - containing aluminium ores in electric arc reduction furnaces.

In the electrothermic process raw materials in a powder form (sillimanite, kaolin, alumina, coal and petroleum coke) are proportioned, mixed with a binder additive, briquetted, dried and transported to an electric arc furnace for reduction melting. For silumin and other aluminium-silicon casting alloys a primary alloy produced in the furnaces is diluted after refining with a corresponding quantity of an electrolytic or secondary aluminium and also with copper, nickel and magnesium depending on a grade to be produced.

One of the main advantages of the electrothermic process of Al-Si alloys production is the possibility of using low-modulus alumosilicate raw materials, such as kyanite, sillimanite, kaolins, low-iron bauxites and others which can not be efficiently treated to produce alumina and electrolytic aluminium.

Besides the above-mentioned electrothermal method in comparison with the synthetic one has the following advantages:

- reduction of the capital costs;
- reduction of the power consumption;
- no crystalline silicon used;
- lowering of the total electrolytic aluminium consumption by 20-25%;
- usage of the major process unit of a substantially higher power rating (active power rating of the electric arc reduction furnaces used is 17000 kW while 175 kA electrolytic cells' power rating is 750 kW, i.e. 22 times less);
- low electrode material consumption due to replacement of an expensive anode paste by cheaper reductants-coal and petroleum coke (an anode paste consumption is 565 kg per tonne of the electrolytic aluminium, an electrode paste consumption is 87 kg per tonne of the refined Al-Si alloy, or 145 kg per tonne of aluminium in the alloy);
- low cryolite consumption (8 kg instead of 34 kg per tonne of aluminium produced by the electrolytic method) and no aluminium fluoride used;
- lowering of fluoride emissions into the atmosphere;
- the use of cheaper alternate current in place of direct current and consequently, elimination of the capital costs for installation of rectifying devices and also of the operation costs for a current transformation.

Capital costs calculations and calculations of an electric power consumption for silumin and other Al-Si casting alloys based on operation data of a number of plants in the USSR conditions show that silumin and other Al-Si casting alloys production by the electrothermal method in comparison with the synthetic method results in reduction of the capital costs to 10% and a decrease in consumption of electric power by 4-8%.

6.2. Process selection. Major process parameters

Sillimanite is a quality raw material (Al_2O_5 - 61.5%, SiO_2 - 37%, Fe_2O_3 - 0.1%) for Al-Si alloys production by the electrothermal method. Thus for a sillimanite concentrate treatment on an industrial scale the only process for Al-Si alloys production is the electrothermic process which consists in a reduction melting of the feed to produce primary Al-Si alloy. To produce sillumin and other casting Al-Si alloys, the primary alloy after refining is diluted with a corresponding quantity of electrolytic and secondary aluminium and alloying metals (copper, nickel, magnesium) depending upon the grade.

6.3. Principal process flow-sheet of Al-Si alloys production

Carbon materials-lump coal and petroleum coke - used as reductants are received at the raw material storage and, when necessary, crushed in the jaw and roller crushers. Coal and coke crushed up to -30 mm are transported by belt conveyors and an elevator to the shaft-type mill for grinding. Coal and coke ground up to -1 mm are then transferred by the pneumatic conveyor into hoppers in the feed preparation room.

At the raw materials storage there is a device for treating the slag wastes. These wastes are separated into three fractions: a fine fraction is sent to dump, a medium fraction - to the feed preparation room hoppers, a coarse fraction mixed with lump coal and quartzite is returned to the electric arc furnace for melting.

The powdered sillimanite, alumina, kaolin are also fed into the hoppers of the feed preparation room. There are also hoppers there in which dust from the gas cleaning plant and a medium fraction of the waste slag are gathered. All powder components of the feed are metered by continuous weighers and by screw conveyors are sent to a blade mixer. A binder-molasses solution is added to the mixer. A mixed raw feed is transported to the roller presses. Raw briquettes with the help of vibration feeders are fed into a conveyor drier where they are dried and consolidated. The finished briquettes via a system of the vibration feeders and belt conveyors are transported to the furnace for melting.

A primary Al-Si alloy produced in the furnace is subjected to high-temperature refining and cast into ladles which are then transported to a low-temperature refining unit.

The furnace off-gases are fed into a gas cleaning system from which the cleaned gases are discharged into the atmosphere and a collected dust is returned to the process.

Refined alloy is cast into holding furnaces where liquid aluminium and manganese are added. When the melt reaches a certain temperature an excess iron, titanium and zirconium are filtered out.

Filtered alloy is received in a collector of the filtering furnace where it's alloyed with copper, nickel, magnesium and other components, depending on grades of Al-Si casting alloys to be produced. After mixing and blending the alloy is analysed and cast on a casting conveyor. Filtration residues are recovered from the filtering furnaces funnels and transferred to an induction furnace for remelting to produce a commercial alloy - silicoaluminium with a rather higher content of iron, manganese, titanium and zirconium.

A chemical analysis of silicoaluminium , %:
Si - 14-24; impurities, not more than: Fe - 4.5; Mn - 3.5; Ti - 2.0; Zr - 2.0; Al - the rest.

Such alloy can be used in the iron and steel industry as a complex steel deoxidizer. The using of silicoaluminium instead of a separate utilization of aluminium and ferrosilicon makes it possible to produce more pure steel with a lower non-metal impurities content. Silicoaluminium can also be used a reductant for ferroalloys production and a complex inoculant.

For determination of optimal alternative of gas-cleaning for electric arc reduction furnace the following methods of gas-cleaning have been examined:

- dry gas-cleaning (in bag filters and electrostatic precipitators), ensuring dust recycle into the process;
- wet gas-cleaning (in Ventury scrubbers), with this method the captured dust is removed to the dump.

Analysis of calculations and techno-economic parameters show that the dry gas-cleaning in electrostatic precipitators is the optimal alternative.

6.4. Brief description of major process equipment

The major process equipment of the EDU is listed bellow:

in the feed preparation room:

- a conveyer drying oven - 1pce;

in the alloy production and furnace room:

- an electric arc reduction furnace - 1 pce;
- a tilting rotary holding furnace with an agitator - 2 pcs;
- a filtration furnace with an agitator - 2 pcs;

- an induction electric furnace - 2 crucibles with 1 set of electrical equipment.

Conveyer drying oven

The drying oven is used for drying briquetts. The oven consists of a heat-insulated casing divided into 16 chambers, a metal perforated belt made of movable jointed box-shaped sections, fans supplying the drying agent separately to each chamber excluding three last chambers used for briquetts cooling, an exhaust fan ensuring gas movement along the oven and its removal throughout a dust separator to the atmosphere.

A center-to-center distance of the driving shaft of a belt motor is 37.4 m; a belt width is 1.5 m. The casing dimensions: length - 31.2 m, width - 3.3 m; height - 3.9 m.

Drying oven specifications

Parameters	Unit of measure	Value	Remark
1. Capacity	t/hr	5-6	
2. Residual moisture content of briquetts	%	1-2	
3. Fuel oil consumption for firing	kg/hr	130-150	
4. Power rating of installed motors	kW	93	

Electric arc reduction furnace

The electric arc reduction furnace is used for primary Al-Si alloy melting from a briquetted feed. The furnace consists of an open round lined bath, three self-baking electrodes with a steel casing, an exhaust hood with lifting curtains, an electrode suspension and adjustment mechanism, a current lead mechanism and an electric equipment including furnace transformers, control pannels and boards, an automatic controller, the equipment of a transformer cooling system, a pump-and-accumulator station.

Each electric furnace is powered from 3 single-phase furnace transformers ЭОЦНК-21000/II , each with a power rating of 8,333 kVa, operating voltage of 11,000/230-140 V, oil-water cooling, with a built-in on-load tap changer on the secondary side.

Buswork is delta-wired on the electrodes.

To compensate a reactive power of the furnace circuit and increase the power factor the furnace transformers include a special booster transformer for connection of corrective capacitors. To bring the power factor of the unit to 0.9 the 11 kV buswork is connected to a capacitor bank of power factor correction. Electrical parameters of the furnace are automatically controlled by a power controllers of type APP-1 by means of an electrode movement.

Taphole opening is controlled by the stinger device connected to the phases of a secondary voltage of the transformer.

Protection of the furnace transformers and their control is achieved by means of HV circuit breakers of type BЭM-10, located in PY-11 kV rooms in a separate building.

Current supply from the furnace transformers to the electrodes is via the copper buswork consisting of 8 tubes of 220 mm O.D. and 20 mm wall thickness and flexible copper strips, moving current-carrying system of electrode holders and contact plates pressed to the electrodes. A buswork current density is 0.85 A/mm^2 at an electrode operating current of 85 kA.

The moving current-carrying system consists of two parts. The lower part includes contact plates with a pressure ring. The plates are housed in a cylindrical water-cooled split casing acting as a seal for the contact device of the system at the point of entry through the cover of the exhaust hood and protects the system from heat radiation from the furnace top. The current-carrying tubes of the lower system lead to the current-collecting part of the upper system suspended from the load-bearing casing of the hydraulic lifting device. Suspension and slipping of the electrode is by means of spring-loaded hydraulic devices consisting of two pressure rings mounted on the support frames of the hydraulic lifting device. Slipping is performed by hydraulic cylinders fitted between the pressure rings of the device.

Cables near the furnace are laid in tubes, and openly in the electrical rooms. Power and control cables up to 1000 V are of grade BPБ and KBBГ-T.

The furnace transformers are located in a separate room not far from the furnace. The control,instrumentation and metering panels are located in the electrical rooms on the service platforms.

The common grounding circuit for the electrical equipment of all voltages is provided. As a grounding conductor provision is made for the fourth cores of the power cables and steel strips 25 x 4 mm. The table below shows specifications of the electric furnace.

Specifications of Electric Arc Reduction Furnace

Parameters	Unit of measure	Value	Remarks
1. Furnace power rating			
- total	MVA	25.0	
- active	MW	17.0	
2. Type of furnace		three-phase open	
3. Type of bath		round stationary	
4. Type of electrodes		self-baking with iron casing	
5. Number of electrodes	pc	3	
6. Electrode diameter	mm	1,400	
7. Location of electrodes in bath		at apexes of an equilateral triangle	
8. Electrode circle diameter	mm	3,100-3,300	variable at shutdown
9. Number of tapholes	pc	1	
10. Geometrical size of bath			
- depth	mm	2,450	
- diameter	m	6,800	
11. Number of furnace transformers	pce	3	
12. Off-load voltage of transformer	V	140-230	

Holding furnace

The holding furnace is designed for smelting of the refined Al-Si alloys with aluminium and discharging the alloy for filtration.

The furnace consists of a welded cylindrical casing lined with refractory bricks, an oil burner, a hydraulic lifting device and an agitator unit.

The casing is provided with a tip used for charging and discharging the alloy, a hole for the agitating unit and a hole for the burner, two annular rims supported on rollers fitted on the foundation and a lug for linking to the plunger of the hydraulic lifting device.

The agitating device is of an electromechanic type. The working members are built in heat-resistant steel.

The hydraulic lifting device consists of one plunger, oil pumpset, hydraulic equipment and controls.

Specifications

Parameters	Unit of measure	Value	Remarks
1. Maximum temperature	°C	850	
2. Holding capacity (by Al-Si alloy)	t	30	
3. Angle of rotation	degree	60	
4. Time of rotation	s	15-30	
5. Oil consumption for heating	kg/h	70-90	
6. Installed power of motors	kW	14	

Filtering furnace

The furnace is intended for filtering the alloy discharged from the holding furnace and its alloying with a master alloy, then discharging the alloy to the casting operations.

The furnace consists of a refractory-lined welded cylindrical casing, a removable cover and a motorised drive of the cover, and two oil burners. A hole is provided in the furnace casing for charging master alloys, flux and cleaning the furnace, with a cover, a hole for the filtering hopper, two holes for burners, a hole for a gas exhaust and two diametrically opposite tapholes.

Specifications

Parameters	Unit of measure	Value	Remarks
1. Maximum temperature	^{o}C	650	
2. Holding capacity (by Al-Si alloy)	t	30	
3. Fuel oil consumption	kg/h	80-100	
4. Installed power of motors	kW	1.1	

Induction furnace

The induction furnace is designed for melting a filter residue, preparation of master alloys, secondary refining of Al-Si alloy.

The furnace is of induction, crucible type, 50 Hz.

It consists of a frame, a lined crucible, a bottom, an inductor, magnetic cores, power plungers, and a cover with the cover lifting and turning device.

The inductor and bottom are of a removable type.

The crucible and furnace bottom are lined with special refractory concrete.

The inductor is of a water-cooled, cylindrical, single-layer, single-phase type made of copper tube of a specific configuration.

Power supply to the electric furnace is via the flexible water-cooled cable. The inductor is surrounded with a crown of laminated packs of magnetic cores intended for absorbing dessipated energy from the inductor. The magnetic core packs are built in special steel and isolated from the inductor by spacers of heat-resistant material.

The electric furnace is covered with a welded cover lined with refractory concrete. The cover lifting and turning device is hydraulic. Metal is poured through the tip after tilting the furnace through an angle up to 100°. Tilt of the furnace is controlled by means of limit switches. The hydraulic tilting device consists of two plungers, hydropower pack and hydraulic equipment.

The set of electrical equipment of the furnace includes: a furnace transformer, control and instrumentation panels, an automatic controller of furnace operating parameters of type APKP, a capacitor bank, a contactor panel, a hydropower pack for the furnace tilting hydrosystem, a tilt control panel, inductor lining and insulation alarms, a heater for inductor drying with a control panel.

Each furnace is powered from a single-phase transformer ЭОМН-2700/10-73У3, oil-cooled, with power rating of 1,600 kVA, voltage 1100/1054-210 V and an on-load tap changer on the secondary side of the transformer.

One set of the electrical equipment is provided for two crucibles of the furnace.

To correct a reactive power and to maintain a required power factor provision is made for the capacitor bank. Part of the bank is permanently connected and the other part is connected according to the preset operating conditions.

Protection of the furnace transformers and operation is by means of HV circuit breakers of type ВЭМ-10, located in the РУ-11 kV room. Buswork of the capacitor bank and current-carrying system of the furnace are made of flat aluminium buses on insulators. Current density in buswork is 0.5 A/mm^2.

Cables inside the electrical rooms are openly laid, wherever possible, near the furnace - in a metal tube. Power and control cables up to 1000 V are mainly of grades ВРБ and КВБГ-Т.

The induction furnaces are located on the first storey and the capacitor bank is sited in a direct vicinity of the furnaces. The control and instrumentation panels are built in to the wall recesses of the electrical rooms at the level of the service platform. The furnace tilt control panel is mounted next to the furnace, because of the necessity to observe the metal discharging operation from the furnace area.

The hydropower pack is located in a separate room under the service platform.

The furnace transformers are installed in separate rooms in conjuction with РУ-11 kV.

Specifications of the furnace are shown in Table below.

Specifications

Parameters	Unit of measure	Value	Remarks
1. Holding capacity	t	6	
2. Transformer power rating	kVA	1,600	
3. Power demand			
inductor	kW	1,030	
unit	kW	1,100	
4. Number of phases			
power supply		1	
contour circuit		1	
5. Frequency			
power supply	Hz	50	
contour circuit	Hz	50	
6. Nominal voltage			
power supply	kV	10	
contour circuit	V	1,320	
7. Power factor (Cos)			
before correction		0.109	
after correction		1	
8. Cooling water requirements	m^3/h	15.0	
9. Pressure drop of cooling water in inductor	m	29	

6.5. The electric loads and power requirements of the EDU are given in the Table below:

Ser. No	User	Power requirement, MW	Annual power requirement mln.kW-hr
1	Raw material storage with grinding department	0.3	1.05
2	Reductants grinding department	0.33	1.15
3	Feed preparation room	0.45	1.6
4	Alloy production and furnace room	19.28	138.85
5	Gas cleaning plant	1.25	9.0
6	Water recycle unit	1.0	7.5
7	Compressor station	0.75	4.5
	Total:	23.36	163.65

6.6. Estimated costs

An estimated cost of the EDU construction is determined on the basis of calculations carried out in accordance with the Initial data, which have been prepared by a group of experts of VAMI Institute of Ministry for non-ferrous metallurgy, of the USSR in collaboration with IRE, the promoter of the project.

6.6.1. Technology cost

The cost of know-how of Soviet side was determined in amount of Rs. 2.0 mln. Taking into consideration the tax on know-how in amount of 40% of its cost the total sum of capital costs for technology acquisition makes Rs. 2.8 mln.

6.6.2. Equipment cost

Capital costs for acquisition and erection of the equipment include the following cost items: equipment and materials, erection works, a primary stock of spare parts. Taking into account that the unit under consideration is of an experimental-demonstration type, a custom duty on the imported equipment is not included.

In the present estimate the equipment is classified into the following types:

6.6.2.1. Production equipment including the major process equipment, handling equipment, electrical equipment, instrumentation and automation (controls), equipment for the main process operations and other units and machinery.

6.6.2.2. Auxiliary equipment including the electric power equipment, compressor station equipment, laboratory, communication and signaling equipment, in-plant sanitary engineering equipment, water supply and sewerage systems equipment and other types of the auxiliary equipment.

For calculations of the capital costs of the equipment the costs of the equipment, materials and erection are adopted as follows:

- for the equipment and materials supplied from the USSR - in accordance with V/O Tsvetmetpromexport data;

- for the equipment and materials supplied by the Indian side (ventilation equipment, pumps, process steel structures, pipes and valves of cast iron) the initial data of the OSCOM site were used. The primary stock of spare parts (4% of the equipment cost), as well as the cost of erection works are calculated in accordance with the initial data. A summary estimate of the capital costs of the equipment is given in Schedule 6.1.

Production costs of the maintenance and current repair of the equipment are assumed as a percentage of the equipment cost and included into the unit's overhead costs (Chapter 7).

6.6.3. Cost of buildings, structures and other civil works

The following cost items are included in an estimate of the civil engineering works:

- site preparation and development - levelling;

- buildings and special civil works - construction of buildings and structures, special civil works inside buildings and structures: equipment foundations, air chambers, pits and trenches, lining with refractory bricks, heat insulating works.

An estimate of the civil engineering works was calculated on the basis of conservative figures for quantities of civil works, building structural components and type of works (earthwork, foundations, roofings, frameworks etc.) and was calculated in accordance with order of magnitude unit rates of civil engineering works assumed in Initial data.

A summary estimate of the capital costs for constructing the EDU's buildings and structures is given in Schedule 6.2.

In accordance with initial data the annual expenditures on maintenance and repair of buildings and structures are assumed as the percentage of the total cost of civil engineering works and this cost has been included in composition of the unit's overhead cost (Chapter 7).

A township to be provided for the EDU's personnel with a total estimated cost of Rs.4.3 mln. This figure was arrived at in a similar way for the figure of a township for the OSCOM's personnel.

In a financial analysis of the project apart from the initial capital investment an additional expenditure is included covering construction of the gas cleaning plant (Rs. 31.2 mln.). This expenditure to be effected after the EDU has reached its total annual capacity.

Schedule 6.1

Estimate of investment costs

Equipment

Project: EDU

Ser. No.	Description	Costs, Rs.thous. foreign	including supplies from third countries	local	Total
1	Raw materials storage	4.882	-	455	5.337
2	Raw material grinding department	1.861	-	421	2.282
3	Feed preparation room	8.419	-	1.512	9.931
4	Alloy production and furnace room	63,166	2.002	1.148	64.314
5	Power supply	13.254	-	23	13.277
6	Compressor station	1.247	-	92	1.339
7	Water supply and sewerage networks	125	-	730	855
8	Lighting	225	-	2	227
	Total:	94.543	2.002	6.650	101.193
9	Erection	-	-	11.697	11.697
	Total, including erection	94.543	2.002	18.347	112.890

Schedule 6.2

Estimate of investment costs

Civil engineering works

Project: EDU

Ser. No	Description	Costs, Rs.thous. Foreign	Local	Total
1	Levelling	-	2,620	2,620
2	Buildings and structures			
2.1	Raw material storage	-	2,821	2,821
2.2	Raw material grinding department	-	755	755
2.3	Feed preparation room	-	5,486	5,486
2.4	Alloy production and furnaces room	-	30,850	30,850
2.5	Pneumatic conveyor trestle with conveyor gallery	-	1,388	1,388
2.6	Power supply	-	694	694
2.7	Compressor house	-	285	285
2.8	Motor roads	-	1.224	1,224
2.9	Water recycle unit	-	846	846
2.10	Water surply and sewerage networks	-	634	634
2.11	Site development and lighting	-	96	96
	Sub-total, item 2:	-	45,079	45,079
3	Township	-	4,290	4,290
	Total:	-	51,989	51,989

7. EDU'S STATUS, OVERHEAD AND OTHER COSTS

7.1. EDU's status

As has been mentioned above, the EDU to be located in the vicinity of the smelter being built. It was assumed that the EDU will be a part of the aluminium project, from an organizational point of view. It is also assumed that in the framework of the smelter the arrangements will be made for manning the EDU, for the running and major repairs of the equipment, buildings and structures as well as for an external transport service.

The main structural process unit of the EDU is the alloy production and furnace room. The production units providing the process needs are as follows: the raw material storage with the reductants grinding department, the compressor station, the water recycle unit, the power supply facilities.

The expenditures formed as a result of the materials and power used in the above units, are included into the production costs and are determined by the corresponding calculations in section 4.

7.2 Overhead operating costs

The overhead operating costs include the following:

- costs for the maintenance, running repair and servicing the buildings and structures at 0.5% of their cost, the same for the equipment-at 2.5% of the total equipment costs, according to the Initial data;

- costs of the wages and salaries of the non-productive workers, engineers and technicians, clerical staff and servicing personnel are in accordance with a calculation given in section 8 (manpower);

- miscellaneous costs (lighting, ventilation, air conditioning, drinking water) - at 0.5% of the overhead costs;

- indirect costs, sales expenses determined in section 3.

For a summary estimate of the overhead operating costs for the EDU see Schedule 7.1.

7.3. Depreciation

When calculating the total production cost of the manufacture of Al-Si alloys for a financial-economic evaluation of this project (section 10) the depreciation and financial charges (payment of an interest for the loans for financing the construction) are added to the operating costs.

A depreciation rate is determined on the basis of the following rates assumed from the Initial data:

- equipment - 10%
- buildings and structures - 3%
- preliminary expenses - 10%

When determining the depreciation, the capitalized interests, as well as a cost of the township and the current assets were not taken into account.

7.4. Income tax

An income tax is taken to be 57.75% of the taxed profit (55% - the income tax + 5% surcharge of the income tax were taken according to the Initial data).

If the first operating years give losses, the tax to be paid after the losses have been covered.

Schedule 7.1

Estimate of production costs

Overhead and operating costs

Project: EDU

Ser. No.	Value	Unit of measure	Description	Local costs	Amount	Costs, Rs.thous. foreign	local	total
1			Maintenance, current repair and servicing					
1.1	2.5	Percentage of equipment cost	Equipment	Rs.thous.	112,890	-	2,822	2,822
1.2	0.5	Percentage of buildings and structures cost	Buildings and structures	do	45,079	-	225	225
			Sub-total, item 1		-	-	3,047	3,047
2			Wages and salaries					
2.1			Non-productive workers	Rs.thous.	-	-	773	773
2.2			Engineers and technicians	do	-	-	521	521
2.3			Clerical staff	do	-	-	34	34
2.4			Servicing personnel	do	-	-	78	78
			Sub-total, item 2		-	-	1,406	1,406
3	0.5	Percentage of items 1 and 2	Miscellaneous unit's costs	Rs.thous.	4,453	-	22	22
			Sub-total, unit's overhead costs				4,475	4,475
4	-	-	Indirect costs	Rs.thous.	-	-	16.228	16.228
			Total:		-	-	20.703	20.703

8. MANPOWER

Based on the composition of the EDU units and the regime of operation of major process equipment the total nomber of production personnel was estimated of 240 persons, including:

- direct production workers - 154 persons
- indirect labour - 53 persons
- engineers, technicals and office staff - 27 persons
- maintenance staff - 6 persons.

The wages and salaries costs were estimated on the basis of average monthly wages by categories of labour assumed as per the earlier Feasibility Report and the projected nomber of workers.

The cost estimate is given in Schedule 8-1.

Schedule 8-1

PRODUCTION COSTS
WAGES AND SALARIES
UNIT: EDU

SN	Labour category	No of workers	Average monthly wage, Rs	Annual wage fund, Rs. thous.	Allowances, insurance, fringe benefits percentage, %	amount, Rs. thous.	Total costs, Rs. thous
1	Direct production workers	154	760	1404	60	842	2246
2	Indirect labour	53	760	483	60	290	773
	TOTAL of workers	207	-	1887	-	1132	3019
3	Engineers and technicians	25	1240	372	40	149	521
4	Office staff	2	875	21	60	13	34
5	Maintenance personnel	6	680	49	60	29	78
	TOTAL	240	-	2329	-	191	3652

9. PROJECT IMPLEMENTATION

9.1. Programme and EDU project implementation schedule

To evaluate the EDU project the following programme of EDU project implementation was selected for calculations:

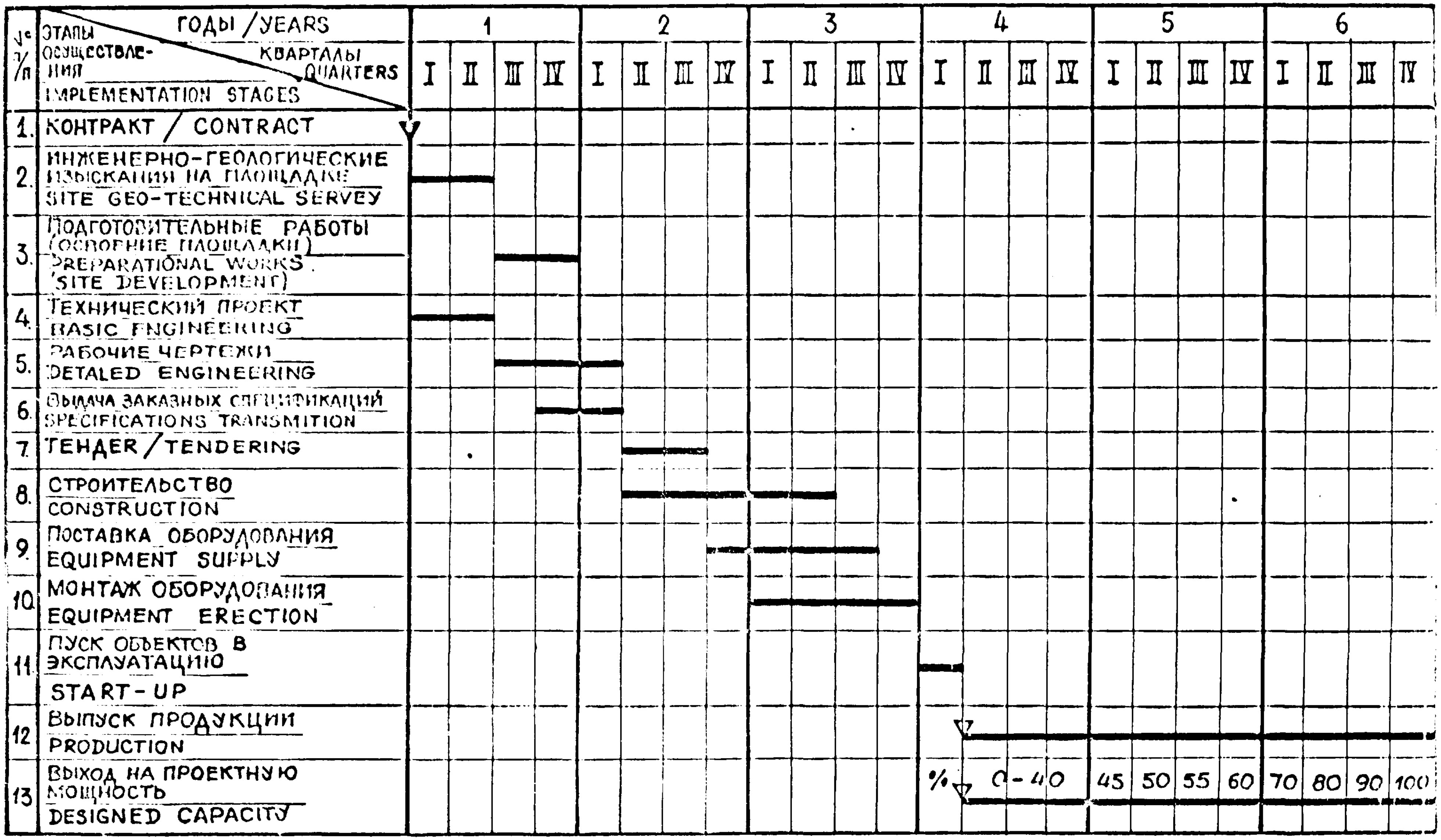
- before the beginning of construction - the geotechnical survey, site development, preparing the basic engineering for process part of the design and detailed engineering for other EDU units, issuing ordering specifications;
- before the start-up of production-construction activities for two years;
- supply and erection of the equipment for 1.5 years starting from the last quarter of the first year of construction;
- putting into operation the production facilities in the third year after starting construction comprising one electric-arc reduction furnace;
- start producing finished products also from the third year and reaching a full design capacity of the EDU in the fifth year from the beginning of construction.

The project implementation schedule prepared in conformity with this programme is given at the end of the chapter.

9.2. Evaluation of EDU location variants

Additionally the alternative variant of construction of analogue unit producing aluminium - silicon alloy in region of operating aluminium smelter in Hirakud was considered. This variant was evaluated by transport charges for raw materials as compared with the site in Talcher region.

ГРАФИК 1. ОСУЩЕСТВЛЕНИЕ ПРОЕКТА Э.Д.У.
DIAGRAM 1. IMPLEMENTATION TIME OF E.D.U.



The comparative calculation given below was carried out basing on initial data on cost of transport charges (Rs.0.4 per 1 t/km) and the sources of supply of raw materials and major materials.

Description of raw material	Source of supply	Variants: Talcher region site		Hirakud region site	
		quantities to be transported, thous. t/km	amount, Rs.	quantities to be transported, thous. t/km	amount, Rs.000
1. Sillimanite concentrate	Chatrapur, (Orissa State)	3406	1362	7379	2952
2. Kaolin	Trivandram (Kerala State)	5906	2362	5618	2247
3. Coal	Talcher	-	-	1396	558
4. Petroleum coke	Barauni(Assam State)	10717	4287	8355	3342
5. Quartzite	Orissa State	533	213	1154	462
6. Kaolin, salts	Bombay	1189	476	835	334
7. Alumina	Karaput	2009	804	1865	746
8. Electrode paste	Bhubaneshwar	108	43	216	86
9. Fuel oil	Vizaghapatnam	2072	829	1554	622
10. Liquid aluminium	Localy available	-	-	-	-
TOTAL			10376	-	11349

As it can be seen from the above calculation the EDU location at Hirakud site (with other conditions equal) determines the increase of operating costs at the expence of transport charges for raw materials by Rs. 973,000 per year or the respective decrease of the profit resulting in decrease of total profitability of EDU at this site by 0.5%.

9.3. Cost Estimate for Project Implementation

The project implementation costs formed at the stages of construction preparation, commissioning and reaching the design capacity were determined according to "Initial data".

A composition and volume of the costs are as follows:

- port charges, transport charges to the site, insurance are included in amount of 5% of imported equipment costs;

- works required for construction including temporary buildings and structures - 3% of the civil and erection works' costs;

- engineering works - 2.5% of the construction cost;

- start-up and commissioning operations - Rs. 910 thous.according to Supplier's estimate;

- administrative recruitment build-up, hiring and training the personnel, contracts on supplies and products' shipping - Rs. 1 thous/year per one expert;

- training the Indian experts in the USSR and accomodation to the Soviet experts deputied to India for construction and erection supervision, starting-up and commissioning works during an initial period and performance guarantee tests - at the rate of Rs. 740 thous. and Rs 3830 thous., respectively, was determined by the Soviet side. An income tax for services of the Soviet experts is assumed to be 40% of the foreign currency component for remuneration of the Soviet experts;

- accomodation of the management of the plant under construction - at 0.3% of the construction costs;

- control and coordination - at 1.5% of the construction cost.

Besides, the estimate includes contingencies at 10% of all the costs but cost of colony and of a part of the equipment in the alloy production & furnace room to be bought by the Indian side in the third countries.

In the estimates the preliminary period costs to be written-off during the construction period.

A summary list of the project implementation costs is given in Schedule 9-1.

Schedule 9-1

Estimate of investment costs

Project implementation

Project title - EDU

Ser. No.	Q-ty	Unit	Description	Costs, Rs. thous. foreign	indigenous	total
1	2	3	4	5	6	7
1			Port charges, transport, insurance	-	4627	4627
2			Works required for construction, including temporary buildings and structures	-	1782	1782
3			Engineering	1586	2379	3965
4			Start-up and commissioning	-	910	910
5			Administrative recruitment build-up, hiring and training the personnel	-	5	5
6			Know-how	2000	-	2000
7			Tax on know-how	-	800	800
8			Training Indian experts in the Soviet Union	955	785	1740

1	2	3	4	5	6	7
9			Accomodation of Soviet experts deputied to India for construction and erection supervision, start-up and commissioning during early operations and performance guarantee tests, collection of initial data for detailed engineering	2767	1063	3830
10			Income taxes for services of Soviet experts	-	1107	1107
11			Control, coordination, start-up & commissioning	-	2409	2409
12			Contingencies	4846	2825	7671
			TOTAL	12154	18692	30846

10. FINANCIAL AND ECONOMIC EVALUATION

In present chapter the analysis of EDU project is presented. The analysis is based on unit's full capacity (production of 28,200 tpy of aluminium-silicon alloys).

The expenditures on construction and operation of the plant were calculated at price level of 1982, up-dated in June 1983 in Orissa State government without taking into account the escalation. The foreign component of investment costs was determined on rupee equivalent of 1 rouble = 10 rupees in accordance with agreement between USSR and India for construction of industrial projects.

The analysis includes:

- calculation of cash-flow starting from the first year of construction of EDU;

- calculation of profits and losses by years of operation;
- calculation of projected balance sheet for all period of construction and operation;
- calculation of internal rate of return based on determination of net present value of EDU construction project;
- calculation of total profitability, including determination of simple rate of return on investment and equity capital;
- calculation of investment pay-back period;
- determination of break-even level of operation;
- sensitivity analysis.

Economic evaluation consists in summarized determination of requirements in capital investment costs, working capital, total current assets, production costs and sources of finance. The evaluation is based on determined capital investments in construction of buildings and civil work, site preparation, acquisition and erection of equipment, pre-production expenditures, materials and utility inputs, manpower, other overheads, as well as on data on financing, depreciation, tax regulations etc.

10.1. Total investment costs

Total investment costs in EDU construction, determined by summarizing of fixed capital (initial investments and pre-production capital costs) and current assets, make Rs. 212.8 mln, including initial investment of Rs. 172.3 mln, pre-production costs of Rs. 23.4 mln. and current assets of Rs. 17.1 mln.

Besides, the calculations include the additional capital investment for gas cleaning unit in amount of Rs. 31.2 mln. In this connection the total investment costs amount to Rs. 244.0 mln.

The investment costs and their break-down by years are summariesed in Schedules 10-5 and 10-6.

10.1.1. Fixed assets

As indicated fixed assets comprise initial investments and pre-production capital costs.

Fixed assets in amount of Rs. 195.7 mln are determined on the basis of calculations of investment costs by cost items presented in chapters 6 and 9.

These cost comprises:

- site preparation and development - Rs. 2620 thous.
- buildings and structures, - Rs. 49369 thous.
  including housing colony - Rs. 4290 tthous.
- technology (know-how incl.tax) - Rs. 2800 thous.
- equipment - Rs. 105820 thous.
  incl. indigenous - Rs. 6650 thous.
  supplied from the USSR - Rs.97168 thous.
  purchased in third countries - Rs. 2002 thous.
- equipment erection - Rs. 11697 thous.
- pre-production costs - Rs. 23419 thous.
  TOTAL - Rs. 195725 thous.

While determining the equipment cost the port and transport charges for delivery of imported equipment to the jobsite, are also included additionally in amount of Rs. 4627 thous.

The fixed capital investment by cost items are given in Schedule 10-1, and their break-down by years of construction - in Schedule 10-2*.

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* The Schedules of this section are given in the end of this Chapter

10.1.2. Working capital

Net working capital, defined as required current assets minus current liabilities, comprise inventories (raw materials, auxiliary materials and supplies, finished product), cost of alloys sent but not paid by Clients (accounts receivable) and cash.

Calculation of total amount of current assets and requirements in working capital is based on technological data on amount of inventories of raw materials and supplies expressed in days and their costs in accordance with Estimate of annual operating costs, which is determined in its turn on the basis of production costs, ennumerated in Chapters 3,4 and 7 and summarized in Schedule 10-3.

Inventory of finished product is calculated basing on operating costs, net of sales cost, in amount of one week taking into account the analysis of existing alloy supply period.

In accordance with UNIDO guidelines the sales of finished products and acquisition of materials is assumed by deferred payments (for the calculations the accounts payable are assumed for 7 days, The receivables (debtors) are determined on the basis of operating costs, and accounts payable (current liabilities) - on the basis of raw materials, production and auxiliary materials.

Cash-in-hand is determined in amount ensuring two week salaries and wages to be paid and overheads to be covered.

Calculation of working capital requirements is provided in Schedule 10-4.

10.2. Project Financing

The equity capital of the government and loaned assets in ratio 1:2 are assumed as the sources of financing of experimental demonstration unit construction (excludings the expenditures on housing colony construction, to be financed by the equity capital). The part of loan to cover the imported equipment supply and Soviet technology (Rs. 94.5 mln) is to be financed by Supplier's credit. The remaining portion of loan to be covered by long-term national loan.

65% of total requirement for working capital are covered by short-term loan at 18.5% of annual interest rate. The balanced 35% of working capital are capitalised and financed with the same terms as the fixed capital.

As said above the part of requirement in current assets is included in form of current liabilities.

10.2.1. Equity Capital

The EDU construction financing is assumed initially by government equities. Basing on above ratio the equity capital amount to Rs. 63.8 mln.

Taking into account the housing colony cost and the portion of working capital, the total amount of assets to be financed by government equities makes Rs. 69.7 mln.

10.2.2. Long-term National Loan

Amount of long-term national loan is Rs. 36.4 mln.
The loan is applicable with 12.5% of interest rate under condition of loan repayment by equal installements for the period of 10 years starting from the next year after plant commissioning.

Interest charged on loan in costruction period is added to loan and is repaid together with initial loan sum.

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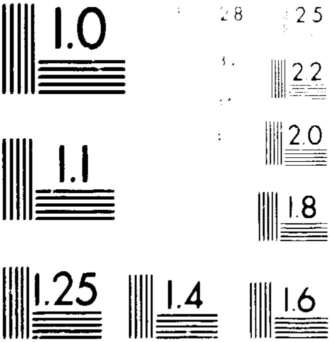

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS

10.2.3. Supplier' credit

Supplier's credit is determined in amount of Rs. 94.5 mln (or 44.4% of total amount of current assets and fixed capital) is assumed with 4% interest rate and repayment by equal instalements for 10 years starting from the next year after plant commissioning.

Capitalized interest on credit in calculations is considered in total amount of credit and repaid in period of credit repayment on the same terms.

Credit is given under separate agreement between competent organizations of Supplier and the Indian side.

While determining the credit amount the cost of imported equipment was assumed in calculations without considering the purchases from third countries to be effected by Indian side.

10.2.4. Loan on working capital

Funds for working capital at 65% of total requirement (Rs. 9.1 mln) are to be obtained in form of short-term loan at 18.5% of interest rate. This loan is not to be repaid, but at the end of plant designed operation period the loan is considered in its salvage value.

The financing of total requirements in funds by sources and the break-down of financing by years are summarized in Schedules 10-7, 10-8.

10.2.5. Period of operation

To analyse the cash inflow (in form of sources of finance and sales revenue) and cash outflow (investment costs, production costs etc.) the plant operation period is assumed for 15 years.

At the end of this period the salvage value (housing colony + working capital+cost of fixed capital net of depreciation) is considered.

10.3. Total production costs

Production costs were determined on the basis of Estimate of annual operating costs, calculation of depreciation and interest in period of construction calculated as total annual sum of alloys production costs for the total period of EDU operation. Production costs are shown by major cost items in agregated form with their break-down by years of operation in Schedule 10-9.

10.4. Financial Evaluation

To evaluate financially the implementation of construction of experimental-demonstration unit the calculations of cash-flow, of net income statement (profits and losses), projected balance sheet by years of operation for 15 years were worked out.

The financial analysis is based on the following basic prices:

1) price of aluminium-silicon alloy - Rs.23,000/t;
2) price of aluminium - Rs. 19,600/t
3) price of power - Rs. 371/1000 kWh
4) price of fuel oil - Rs. 371/1000 kWH

The calculation of viability of the EDU project include the determination of the internal rates of return on investment and equities, of the pay-back period and break-even points.

The financial analysis is worked out using the computer programmes developed by VAMI Institute. The computer printing of financial analysis results with basic prices includes the following calculations.

1. Cash-flow for financial planning (Schedule 10-10)
2. Net income statement (Schedule 10-11)
3. Projected balance sheet (Schedule 10-12)
4. Calculation of internal rate of return (Schedule 10-13)

The profitability of EDU project based on basic prices is characterised by following indicators:

- internal rate of return on investment - 24.8%
- internal rate of return on equities - 23.9%
- pay-back period - 5 years
- break-even point - 46.4%.

10.4.1.1. Internal rate of return

The internal rate of return represents the profitability factor at which the total value of projected receipts is equal to the amount of the current investment, or put another way, when the net present value is equal to zero. The internal rate of return was calculated by discounting obtained values throughout the time to their present value.

Calculated in such a way on the basis of data provided in Schedule 10-13 of net income, the internal rates of return on equities and the total invested capital make 23.9% and 24.8% respectively.

10.4.1.2. Simple rate of return

Simple rate of return characterised by the ratio of net income versus equity capital is calculated for each year of EDU operating period. The values of simple rate of return are given in Schedule 10-12 Net income Statement (Profits and losses). Additionally the ratio of sales revenues to net income is shown by years of operating period.

10.4.1.3. Pay-back period

The pay-back period of 5 years after the beginning of unit operation was determined by period required to recuperate the initial investment outlay through the profits earned by the project after tax. For pay-back period determination interest and depreciation were added to net profit.

Graphical determination of pay-back period is shown at the end of the chapter.

10.4.2. Break-even point

The break-even point determines the level of capacity utilisation, when the break-even operation would be reached or in other terms the sales revenues would be equal to production costs.

Such an operation is insured through 46.4% of the arc reduction furnace capacity utilisation (in physical quantities this value is equal to 4,430 t of primary refined alloy).

The minimum quantity of commercial Al-Si alloys produced at this level is determined at 13,100 tpy (with basic price level).

Graphical determination of break-even point is shown at the end of the chapter.

For determination of break-even point the annual financing costs and depreciation were included in fixed costs as average annual value for the total estimated operating period.

10.4.3. Sensitivity analysis

The sensitivity analysis includes the study of influence of:

- price of alloys,

- price of aluminium,
- price of power,
- price of fuel oil

on internal rate of return and break-even point.

For each price of alloys and fuel oil the sensitivity analysis was worked out to determine the influence on aluminium and power prices. The impact of each of these parameters is shown in Schedule 10-14 "Sensitivity Analysis" at the end of the chapter (For the variants which are not viable the internal rate of return has a symbol 777.7).

Influence of alloy prices

The alloy prices were considered within the range of Rs.21,000 to 27,000 per 1 tonne with an interval of Rs. 1000. The diviation from the basic price level (Rs. 23,000/t) makes - 9% to +17%.

The analysis shows that the project can be viable even with the minimum level of alloy price, but the price of aluminium used has not to exceed the level of Rs. 18,000-18,500 per 1 tonne.

Influence of aluminium prices

The aluminium prices were considered within the range of Rs. 17,000 to 22,000 per 1 tonne (with deviation from basic level of ±13%).

Its impact on viability level is significant which is conditionned by the high cost component of aluminium in total amount of operating costs (70%). The tendency prevailing at present at the world market to decrease the price of metal (considerably lower the minimum level assumed for calculations) ensures the economic viability of the project.

Influence of power prices

The power price was studied within the range of Rs. 371 (basic price) to Rs. 500 per 1000 kwH (+35% from basic variant).

The analysis shows that the project as a whole remains viable even with the price of power of Rs. 500/1000 kwH, but the aluminium price has not to exceed Rs. 20,000 per 1 tonne.

Influence of fuel oil prices

The fuel cost makes less than 2% out of the total amount of operating costs, thus the variation of fuel oil prices doesn't influence significantly the viability of the project. For the increase of fuel oil price of +10% assumed in calculations the internal rate of return decreases only by 0.4%.

The total effect of variables

The total effect of variables characterises the viability and break-even level of the EDU project in best (high alloy prices and low prices of materials and utilities used) and worst conditions (low alloy prices and high prices of materials and utilities).

In best conditions the internal rate of return on investment increases up to 62.9%, and IRR on equities - up to 63.6%, the break-even point reduces down to 17.8% of capacity utilisation (or to 1,700 t of primary refined alloy).With the low price of alloys the project viability depends on the cost of aluminium used in production of commercial aluminium-silicon alloys. With the price of metal exceeding Rs. 18,000-18,500 per 1 tonne the production of commercial Al-Si alloys is not viable, but the project as a whole is viable for the production of primary refined alloy, as the influence of other variable costs on the rate of return is less important as compared with aluminium.

The interconnection of all parameters and their influence on internal rate of return (on equities) are illustrated on the diagramme of sensitivity analysis given below at the end of the Chapter

10.5. Conclusions

The financial and economic evaluation carried out for experimental demonstration unit located at Talcher Site shows its high profitability. As compared with the evaluation of similar unit at OSCOM site, the internal rate of return on total investment as well as on its equity portion, for the present project in absolute values is higher by 8.5% with the respective reduction of break-even operation point (in physical quantities of arc reduction furnace capacity) from 7,270 t to 4,430 t of primary refined alloy.

The increase of profitability (viability) of EDU construction project by more than 40% as compared with its location at OSCOM site is mainly determined by significant reduction in annual aluminium consumption (by more than 1,800 t or by 8%) and by its utilisation in liquid state.

Schedule 10-1

Fixed investment costs

Rs.000

Item	Investment category	Foreign	Local	Total
1	Site preparation and development			
1.1	Site levelling	-	2620	2620
2	Civil works			
2.1	Buildings and structures	-	45079	45079
2.2	Housing colony	-	4290	4290
	Total of buildings and structures including housing colony	-	49369	49369
3	Technology			
3.1	Know-how	2000	-	2000
3.2	Tax on know-how	-	800	800
	Total of technology	2000	8000	2800
4	Production equipment			
4.1	Indigenous	-	6650	6650
4.2	Supplied from the USSR	92541	-	92541
4.3	Purchased from third countries	2002	-	2002
4.4	Port charges, transport, insurance	-	4627	4627
4.5	Erection	-	11697	11697
	Total of production equipment	94543	22974	117517
5	Pre-production expenditures for project implementation	10154	13265	23419
	GRAND TOTAL of fixed capital investment	106697	89028	195725
	including housing colony	-	4290	4290

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Rs.000

Period	Construction						Start-up, commissioning and operation			Total		
year / cost / cost category	1			2			3			4		
	foreign	local	total	foreign	local	total	foreign	local	total	foreign	local	total
1. Fixed investment costs	28455	33332	61787	68088	40091	108179	-	2340	2340	96543	75463	172306
1.1. Site preparation and development	-	2620	2620	-	-	-	-	-	-	-	2620	2620
1.2. Buildings and structures	-	27047	27047	-	18032	18032	-	-	-	-	45079	45079
1.3. Housing colony	-	1570	1570	-	2720	2720	-	-	-	-	4290	4290
1.4. Technology	2000	800	2800	-	-	-	-	-	-	2000	800	2800
1.5. Production equipment	26455	1295	27750	68088	9982	78070	-	-	-	94543	11277	105820
1.6. Erection works	-	-	-	-	9357	9357	-	2340	2340	-	11697	11697
2. Pre-production costs	3578	6379	9957	5652	4520	10172	924	2366	3290	10154	13265	23419
2.1. Temporary buildings and structures	-	1782	1782	-	-	-	-	-	-	-	1782	1782
2.2. Design engineering	1586	2379	3965	-	-	-	-	-	-	1586	2379	3965
2.3. Start-up and commissioning	-	-	-	-	-	-	-	910	910	-	910	910
2.4. Administration staff recruitment, training of personnel, provision for sales and supplies, management costs, control and coordination	-	440	440	-	1344	1344	-	630	630	-	2414	2414
2.5. Training of Indian specialists in the USSR	425	360	785	530	425	955	-	-	-	955	785	1740
2.6. Accomodation of Soviet experts dispatched to India for designer and erection supervision, start-up and commissioning, tax on services of Soviet exterts	230	207	437	1657	1300	2957	880	663	1543	2767	2170	4937
2.7. Contingencies	1337	1211	2548	3465	1451	4916	44	163	207	4846	2825	7671
TOTAL of items 1 and 2	32033	39711	71744	73740	44611	118351	924	4706	5630	106697	89028	195725

Schedule 10-3

Estimate of annual operating costs

Rs.000

Period	Start-up and commissioning		Full capacity operation
Year	3	4	5-th and others
Production programme, %	40	60	100
Category			
1. Raw materials	28353	42529	70882
1.1. Sillimanite concentrate	4541	6812	11353
1.2. Kaolin	2535	3803	6338
1.3. Alumina	3614	5420	9034
1.4. Quartzite	142	213	355
1.5. Coal	931	1396	2327
1.6. Petroleum coke	13829	20743	34572
1.7. Binder-molasses	168	253	421
1.8. Electrode paste	2593	3889	6482
2. Electrolytic aluminium	154770	232154	386924
3. Master alloys	6408	9613	16021
4. Auxiliary and other materials	1378	2090	3469
5. Utilities	27566	41348	68913
5.1. Electric power	21940	32911	54851
5.2. Fuel	4144	6215	10358
5.3. Others	1482	2222	2704
Total for materials and utilities	218475	327734	546209
6. Wages of direct manpower	2246	2246	2246
7. Factory overhead costs	4475	4475	4475

Period	Start-up and commissioning		Full capacity operation
Year	3	4	5-th and others
Production programme, %	40	60	100
Category			
7.1. Maintenance and repair of buildings and civil work	225	225	225
7.2. Maintenance of equipment and mechanisms	2822	2822	2822
7.3. Salaries of managerial and services staff and indirect labour	1406	1406	1406
7.4. Other factory costs	22	22	22
Total for factory production costs	225196	334455	552930
8. Other indirect costs	16228	16228	16228
8.1. Finished product sales costs	16228	16228	16228
Total operating costs	241424	350683	569153

Schedule 10-4

Calculation of working capital requirements

Rs.000

Cost category	Inventory, days of coverage	Coefficient of turnover	Start-up and commissioning years starting from beginning of construction		Full-capacity years	
			3	4	5	6-th and following years
Current assets						
1. Accounts receivable	7	51.4	86	129	218	218
2. Raw materials, materials and finished product						
2.1. Sillimanite concentrate	15	24	189	284	473	473
2.2. Kaolin	14.5	24.8	102	153	256	256
2.3. Alumina	14	25.7	141	211	352	352
2.4. Quartzite	44	8.2	17	26	43	43
2.5. Coal	29	12.4	75	113	188	188
2.6. Petroleum coke	32	11.25	1229	1844	3073	3073
2.7. Molasses	15	24	7	11	18	18
2.8. Fuel	15	24	173	259	432	432
2.9. Master alloys and auxiliary materials	7	51.4	152	228	379	379
2.10. Finished product	7	51.4	4508	6696	11073	11073
Total for raw materials, materials and finished product	-	-	6593	9825	16287	16287
3. Cash-in-hand	15	24	550	550	550	550
Total for current assets	-	-	7229	10504	17055	17055

Schedule 10-4 (Cont.)
Rs.000

Cost category	Inventory, days of coverage	Coefficient of turnover	Start-up and commissioning years starting from beginning of construction		Full-capacity years	
			3	4	5	6-th and following years
Increase in current assets	-	-	-	3275	6551	0
4. To be excluded:						
4.1. Current liabilities (accounts payable)	7	51.4	1211	1816	3027	3027
Total for net working capital	-	-	6018	8688	14028	14028
Increase in working capital	-	-	-	2670	5340	0

Schedule 10-5

Total investment costs

Rs.000

Item	Investment category	Foreign	Local	Total
1	Fixed investment costs	96543	106963	203506
1.1.	Initial capital investment	96543	75763	172306
1.2.	Gas-cleaning plant	-	31200	31200
2	Pre-production capital expenditures	10154	13265	23419
3	Current assets	-	17055	17055
	including:			
3.1.	Working capital	-	14028	14028
3.2.	Current liabilities (accounts payable)	-	3027	3027
	TOTAL investment costs	106697	137283	243980

Break-down of total investment costs by

Period / Year / Costs Category	1 foreign	1 local	1 total	2 foreign	2 local	2 total	3 foreign	3 local	3 total	4 foreign	4 local
							C o n s t r u c t				
1. Fixed investment costs	28455	33332	61787	68088	40091	108179	-	2340	2340	-	-
1.1. Initial capital investment	28455	33332	61787	68088	40091	108179	-	2340	2340	-	-
1.2. Gas-cleaning plant	-	-	-	-	-	-	-	-	-	-	-
2. Pre-production costs	3578	6379	9957	5652	4520	10172	924	2366	3290	-	-
3. Current assets increase	-	-	-	-	-	-	-	7229	7229	-	3275
including:											
3.1. Working capital	-	-	-	-	-	-	-	6018	6018	-	2670
3.2. Current liabilities	-	-	-	-	-	-	-	1211	1211	-	605
TOTAL investment costs	32033	39711	71744	73740	44611	118351	924	11935	12859	-	3275

SECTION 1

Schedule 10-6

investment costs by years

Rs.000

Construction

	4			5			6			Total		
total	fore-ign	local	total	fore-ign	local	total	fore-ign	local	total	fore-ign	local	total
2340	-	-	-	-	-	-	-	31200	31200	96543	106963	203506
2340	-	-	-	-	-	-	-	-	-	96543	75763	172306
-	-	-	-	-	-	-	-	31200	31200	-	31200	31200
3290	-	-	-	-	-	-	-	-	-	10154	13265	23419
7229	-	3275	3275	-	6551	6551	-	-	-	-	17055	17055
6018	-	2670	2670	-	5340	5340	-	-	-	-		14028
1211	-	605	605	-	1211	1211	-	-	-	-	027	3027
1285[illegible]	-	3275	3275	-	6551	6551	-	31200	31200	106697	137283	243980

SECTION 2

Schedule 10-7

Sources of financing of initial investment costs

Rs.000

Item	Sources of finance	Foreign	Local	Total
1	Equity capital			
1.1	Government equities	-	64828	64828
1.2	Margin money (35% of working capital)	-	4910	4910
	TOTAL equity capital	-	69738	69738
2	Long-term national loan (12.5% rate of interest)	-	36356	36356
3	Short-term loan on working capital (18.5% rate of interest)	-	9118	9118
4	Supplier's credit	94541	-	94541
	including			
4.1	Equipment supply	92541	-	92541
4.2	Technology	2000	-	2000
5	Current liabilities	-	3027	3027
	TOTAL	94541	118239	212780

Break-down of financing sources by yea

Period	Construction						Start-up and commis			
Years	1			2			3			
costs / cost category	fore-ign	local	total	fore-ign	local	total	fore-ign	local	total	f i
1. Equity capital	-	43289	43289	-	26449	26449	-	-	-	
2. Long-term national loan	-	-	-	-	25816	25816	-	10540	10540	
3. Short-term loan on working capital	-	-	-	-	-	-	-	1108	1108	
4. Supplier's credit	28455	-	28455	66086	-	66086	-	-	-	
5. Current liabilities	-	-	-	-	-	-	-	1211	1211	
TOTAL	28455	43289	71744	66086	52265	118351	-	12859	12859	

SECTION 1

Schedule 10-8

inancing sources by years

Rs.000

	Start-up and commissioning						Full capacity operation			Total		
	3			4			5					
	foreign	local	total	foreign	local	total	foreign	local	total	foreign	local	total
)	-	-	-	-	-	-	-	-	-	-	6-739	69738
	-	10540	10540	-	-	-	-	-	-	-	36356	36356
	-	1108	1108	-	2670	2670	-	5340	5340	-	9118	9118
	-	-	-	-	-	-	-	-	-	94541	-	94541
	-	1211	1211	-	605	605	-	1211	1211	-	3027	3027
51	-	12859	12859	-	3275	3275	-	6551	6551	94541	118239	212730

SECTION 2

Production costs

Period	Start-up and commissioning		Full capaci-					
Year	3	4	5	6	7	8	9	10
Production programme, %	40	60	100	100	100	100	100	100
1. Cost of raw materials and utilities	218475	327734	546209	546209	546209	546209	546209	5462
2. Cost of wages of direct production workers	2246	2246	2246	2246	2246	2246	2246	2246
3. Factory overhead costs	4475	4475	4475	4475	4475	4475	4475	4475
4. TOTAL factory production costs	225196	334455	552930	552930	552930	552930	552930	5529
4. Indirect costs								
5. Product sales costs	16228	16228	16228	16228	16228	16228	16228	1622
TOTAL operating costs	241424	350683	569158	569158	569158	569158	569158	5691
6. Interest	8093	9101	8977	8606	7741	6876	6011	5146
7. Depreciation	15805	15805	15805	15805	15805	15805	15805	158
TOTAL production costs	265322	375589	593940	593569	592704	591839	590974	5901

SECTION 1

Schedule 10-9

..uction costs

Rs.000

Full capacity operation

	8	9	10	11	12	13	14	15	16	17
	100	100	100	100	100	100	100	100	100	100
:09	546209	546209	546209	546209	546209	546209	546209	546209	546209	546209
	2246	2246	2246	2246	2246	2246	2246	2246	2246	2246
	4475	4475	4475	4475	4475	4475	4475	4475	4475	4475
:0	552930	552930	552930	552930	552930	552930	552930	552930	552930	552930
	16228	16228	16228	16228	16228	16228	16228	16228	16228	16228
8	569158	569158	569158	569158	569158	569158	569158	569158	569158	569158
	6876	6011	5146	4281	3416	2551	1686	1686	1686	1686
	15805	15805	15805	15805	15805	1431	1431	1431	1431	1431
4	591839	590974	590109	589244	588379	573140	572275	572275	572275	572275

SECTION 2

SCHEDULE IC-IO. CASH FLOW TABLE FOR FINANCIAL PLANNI

PERIOD	CONSTRUCTION		START-UP	
YEAR	1	2	3	4
PRODUCTION PROGRAMME	0	0	40	60
A. CASH INFLOW	71744	118351	272510	392752
1. FINANCIAL RESOURCES TOTAL	71744	118351	12859	3275
2. SALES REVENUE	0	0	259651	389477
3. BANK OVERDRAFTS	0	0	0	0
B. CASH OUTFLOW	71744	118351	262376	381360
1. TOTAL ASSETS INCLUDING REPLACEMENTS	71744	118351	12859	3275
2. OPERATING COSTS	0	0	241424	350683
3. DEBT SERVICE (TOTAL)	0	0	8093	22657
3.1. INTEREST :	0	0	8093	9101
3.1.1. SUPPLIERS' CREDITS	0	0	3903	3903
3.1.2. BANK TERM LOANS	0	0	4097	4746
3.1.3. WORKING CAPITAL LOAN	0	0	102	451
3.1.4. BANK OVERDRAFTS	0	0	0	0
3.2. REPAYMENTS :	0	0	0	13556
3.2.1. SUPPLIERS' CREDITS	0	0	0	9759
3.2.2. BANK TERM LOANS	0	0	0	3796
3.2.3. BANK OVERDRAFTS	0	0	0	0
4. CORPORATE TAX	0	0	0	4745
5. DIVIDENDS	0	0	0	0
C. SURPLUS / DEFICIT	0	0	10134	11392
D. CUMULATIVE CASH BALANCE	0	0	10134	21526

PERIOD	PACITY			
YEAR	10	11	12	13
PRODUCTION PROGRAMME	100	100	100	100
A. CASH INFLOW	649129	649129	649129	649129
1. FINANCIAL RESOURCES TOTAL	0	0	0	0
2. SALES REVENUE	649129	649129	649129	649129
3. BANK OVERDRAFTS	0	0	0	0
B. CASH OUTFLOW	621943	621578	621212	629148
1. TOTAL ASSETS INCLUDING REPLACEMENTS	0	0	0	0
2. OPERATING COSTS	569158	569158	569158	569158
3. DEBT SERVICE (TOTAL)	18702	17837	16972	16108
3.1. INTEREST :	5146	4281	3416	2551
3.1.1. SUPPLIERS' CREDITS	1561	1171	780	390
3.1.2. BANK TERM LOANS	1898	1423	949	474
3.1.3. WORKING CAPITAL LOAN	1686	1686	1686	1686
3.1.4. BANK OVERDRAFTS	0	0	0	0
3.2. REPAYMENTS :	13556	13556	13556	13557
3.2.1. SUPPLIERS' CREDITS	9759	9759	9759	9759
3.2.2. BANK TERM LOANS	3796	3796	3796	3797
3.2.3. BANK OVERDRAFTS	0	0	0	0
4. CORPORATE TAX	34083	34583	35082	43882
5. DIVIDENDS	0	0	0	0
C. SURPLUS / DEFICIT	27186	27551	27917	19981
D. CUMULATIVE CASH BALANCE	148169	175720	203637	223618

SECTION 1

…LOW TABLE FOR FINANCIAL PLANNING

000 DS

…TION	START-UP			FULL CA…			
2	3	4	5	6	7	8	9
0	40	60	100	100	100	100	100
18351	272519	392752	655680	649129	649129	649129	649129
18351	12859	3275	6551	0	0	0	0
0	259651	389477	649129	649129	649129	649129	649129
0	0	0	0	0	0	0	0
18351	262376	381360	630113	654605	623039	622674	622308
18351	12859	3275	6551	31220	0	0	0
0	241424	350683	569158	569158	569158	569158	569158
0	8093	22657	22533	22162	21297	20432	19567
0	8093	9131	8977	8606	7741	6876	6011
0	3903	3903	3513	3122	2732	2342	1951
0	4097	4746	4271	3796	3322	2847	2373
0	192	451	1192	1686	1686	1686	1686
0	0	0	0	0	0	0	0
0	0	13556	13556	13556	13555	13556	13556
0	0	9759	9759	9759	9759	9759	9759
0	0	3796	3796	3796	3796	3796	3796
0	0	0	0	0	0	0	0
0	0	4745	31871	32005	32584	33094	33593
0	0	0	0	0	0	0	0
0	10134	11392	25967	-5476	26090	26455	26821
0	10134	21526	47093	41617	67707	94162	120983

			FULL CAPACITY				SALVAGE VALUE IN LAST YEAR	TOTAL
	12	13	14	15	16	17		
	100	100	100	100	100	100		
…9	649129	649129	649129	649129	649129	649129	0	9390585
…0	0	0	0	0	0	0	0	212780
…9	649129	649129	649129	649129	649129	649129	0	9087805
…0	0	0	0	0	0	0	0	0
…8	621212	629148	615226	615226	615226	615226	-50465	8590890
…0	0	0	0	0	0	0	-50465	193515
…58	569158	569158	569158	569158	569158	569158	0	1138316
…37	15972	16108	1686	1686	1686	1686	0	213104
…51	3416	2551	1686	1686	1686	1686	0	77543
…71	780	390	0	0	0	0	0	25368
…23	949	474	0	0	0	0	0	30186
…35	1686	1686	1686	1686	1686	1686	0	21977
…0	0	0	0	0	0	0	0	0
…76	13556	13557	0	0	0	0	0	135561
…9	9759	9759	0	0	0	0	0	97590
…76	3796	3797	0	0	0	0	0	37961
…0	0	0	0	0	0	0	0	0
…3	35082	43882	44382	44382	44382	44382	0	493110
…0	0	0	0	0	0	0	0	0
…1	27917	19981	33903	33903	33903	33903	50465	409695
…0	203637	223618	257521	291424	325327	359230	0	0

SECTION 2

SCHEDULE 10-II. NET INCOME STATEMENT

PERIOD	CONSTRUCTION		START-UP		
YEAR	1	2	3	4	
PRODUCTION PROGRAMME	0	0	40	60	1
1. SALES	0	0	259651	389477	649
2. PRODUCTION COSTS	0	0	265322	375589	593
3. GROSS OR TAXABLE PROFIT	0	0	-5671	13888	55
4. TAX	0	0	0	4745	31
5. NET PROFIT	0	0	-5671	9142	23
6. DIVIDENDS	0	0	0	0	
7. UNDISTRIBUTED PROFITS	0	0	-5671	0	
8. ACCUMULATED UNDISTRIBUTED PROFITS	0	0	-5671	-5671	-5
9. ACCUMULATED NET PROFIT	0	0	-5671	3471	26
RATIOS					
10. NET PROFIT : SALES (P.C.)	0	0	-.2	2	
11. NET PROFIT : EQUITY(P.C.)	0	0	-.8	13	

PERIOD	PACITY				
YEAR	10	11	12	13	
PRODUCTION PROGRAMME	100	100	100	100	1
1. SALES	649129	649129	649129	649129	64
2. PRODUCTION COSTS	590109	589244	588379	573140	57
3. GROSS OR TAXABLE PROFIT	59019	59884	60749	75987	7
4. TAX	34083	34583	35082	43882	4
5. NET PROFIT	24935	25301	25666	32104	3
6. DIVIDENDS	0	0	0	0	
7. UNDISTRIBUTED PROFITS	0	0	0	0	
8. ACCUMULATED UNDISTRIBUTED PROFITS	-5671	-5671	-5671	-5671	-
9. ACCUMULATED NET PROFIT	147808	173109	198775	230879	26
RATIOS					
10. NET PROFIT : SALES (P.C.)	3	3	3	4	
11. NET PROFIT : EQUITY(P.C.)	35	36	36	46	

SECTION 1

IC-II. NET INCOME STATEMENT

000 RS

TRUCTION	START-UP			FULL CA			
2	3	4	5	6	7	8	9
0	40	60	100	100	100	100	100
0	259651	389477	649129	649129	649129	649129	649129
0	265322	375589	593940	593569	592704	591839	590974
0	-5671	13888	55188	55559	56424	57289	58154
0	0	4745	31871	32085	32584	33084	33583
0	-5671	9142	23316	23473	23839	24204	24570
0	0	0	0	0	0	0	0
0	-5671	0	0	0	0	0	0
0	-5671	-5671	-5671	-5671	-5671	-5671	-5671
0	-5671	3471	26787	53260	74099	98303	122873
0	-2	2	3	3	3	3	3
0	-8	13	33	33	34	34	35

			FULL CAPACITY			
11	12	13	14	15	16	17
100	100	100	100	100	100	100
649129	649129	649129	649129	649129	649129	649129
589244	588379	573140	572275	572275	572275	572275
59884	60749	75987	76852	76852	76852	76852
34583	35082	43882	44382	44382	44382	44382
25301	25666	32104	32470	32470	32470	32470
0	0	0	0	0	0	0
0	0	0	0	0	0	0
-5671	-5671	-5671	-5671	-5671	-5671	-5671
173109	198775	230879	263349	295819	328289	360759
3	3	4	5	5	5	5
36	36	46	46	46	46	46

SECTION 2

SCHEDULE 10-12. PROJECTED BALANCE SHEET

PERIOD	CONSTRUCTION		START-UP		
YEAR	1	2	3	4	[illegible]
PRODUCTION PROGRAMME	0	0	40	60	1[illegible]
A. ASSETS (TOTAL)	72313	194759	213239	200807	2171[illegible]
1. CAPITALIZED INTEREST	569	4665	4665	4665	46[illegible]
2. CASH BALANCE	0	0	10134	21526	470[illegible]
3. CURRENT ASSETS	0	0	2319	5594	121[illegible]
4. FIXED ASSETS (NET OF DEPRECIATION)	71744	190094	190520	169022	1532[illegible]
5. LOSSES	0	0	5671	0	
B. LIABILITIES (TOTAL)	72313	194759	207618	200807	2171[illegible]
1. CURRENT LIABILITY	0	0	1211	1816	30[illegible]
2. SUPPLIER'S CREDIT	29024	97592	97592	87834	780[illegible]
3. LONG TERM LOANS	0	27429	37969	34174	303[illegible]
4. EQUITY CAPITAL	43239	69738	69738	69738	697[illegible]
5. WORKING CAPITAL LOAN	0	0	1108	3778	91[illegible]
6. SHORT-TERM LOAN	0	0	0	0	
7. RESERVES	0	0	0	3471	267[illegible]

PERIOD	[illegible]PACITY				
YEAR	10	11	12	13	1[illegible]
PRODUCTION PROGRAMME	100	100	100	100	1[illegible]
A. ASSETS (TOTAL)	270353	282097	294206	312754	345[illegible]
1. CAPITALIZED INTEREST	4665	4665	4665	4665	46[illegible]
2. CASH BALANCE	148169	175720	203637	223618	257[illegible]
3. CURRENT ASSETS	12145	12145	12145	12145	12[illegible]
4. FIXED ASSETS (NET OF DEPRECIATION)	105374	89567	73759	72326	72[illegible]
5. LOSSES	0	0	0	0	
B. LIABILITIES (TOTAL)	270353	282097	294206	312754	345[illegible]
1. CURRENT LIABILITY	3027	3027	3027	3027	3[illegible]
2. SUPPLIER'S CREDIT	29272	19512	9752	-7	
3. LONG TERM LOANS	11390	7593	3796	-1	
4. EQUITY CAPITAL	69738	69738	69738	69738	69[illegible]
5. WORKING CAPITAL LOAN	9118	9118	9118	9118	9[illegible]
6. SHORT-TERM LOAN	0	0	0	0	
7. RESERVES	147808	173109	198775	230879	263[illegible]

SECTION 1

PROJECTED BALANCE SHEET

000 RS

	START-UP						FULL CA
2	3	4	5	6	7	8	9
0	40	60	100	100	100	100	100
759	213239	200807	217117	227033	237315	247962	258975
665	4665	4665	4665	4665	4665	4665	4665
0	10134	21526	47093	41617	67707	94162	120933
0	2319	5594	12145	12145	12145	12145	12145
094	190530	160022	153214	168606	152798	136990	121182
0	5671	0	0	0	0	0	0
759	207618	200807	217117	227033	237315	247962	258975
0	1211	1816	3027	3027	3027	3027	3027
592	97592	87832	78072	68312	58552	48792	39032
429	37969	34172	30375	26578	22781	18984	15187
738	69738	69738	69738	69738	69738	69738	69738
0	1198	3778	9118	9118	9118	9118	9118
0	0	0	0	0	0	0	0
0	0	3471	26787	50260	74099	98303	122873

			FULL CAPACITY			
11	12	13	14	15	16	17
00	100	100	100	100	100	100
097	294206	312754	345224	377694	410164	442634
665	4665	4665	4665	4665	4665	4665
720	203637	223618	257521	291424	325327	359230
145	12145	12145	12145	12145	12145	12145
567	73759	72326	70893	69460	68027	66594
0	0	0	0	0	0	0
097	294206	312754	345224	377694	410164	442634
027	3027	3027	3027	3027	3027	3027
512	9752	-7	-7	-7	-7	-7
093	3796	-1	-1	-1	-1	-1
738	69738	69738	69738	69738	69738	69738
118	9118	9118	9118	9118	9118	9118
0	0	0	0	0	0	0
109	198775	230879	263349	295819	328289	360759

SECTION 2

SHEDULE IC-I3. CALCULATION OF INTERNAL RATES OF RETURN

DESCRIPTION	YEARS FROM THE BEGINNING OF THE CONSTRUCTION 1	2	3	4	5	6	
1. CAPITAL COST INVESTMENT	71744.0	118351.0	11751.0	605.0	1211.0	31200.0	
2. EQUITY CAPITAL	43289.0	26449.0	0.0	0.0	0.0	0.0	
3. WORKING CAPITAL	0.0	0.0	1108.0	2670.0	5340.0	0.0	
4. GROSS PROFIT	0.0	0.0	19227.0	38794.4	79970.4	79970.4	79[illegible]
5. DEPTS REPAYMENT	0.0	0.0	0.0	13556.1	13556.1	13556.1	135[illegible]
6. INTEREST PAYMENTS	0.0	0.0	9093.6	9101.9	8977.8	8606.8	7[illegible]
7. RESIDUAL VALUE	0.0	0.0	0.0	0.0	0.0	0.0	
8. INCOME TAX	0.0	0.0	0.0	4745.3	31871.1	32085.4	32[illegible]
9. THE RETURN ON INVESTMENT	-71744.0	-118351.0	6368.0	35519.4	73419.4	48770.4	79[illegible]
10. THE RETURN ON EQUITY	-43289.0	-26449.0	9025.4	8721.2	20225.4	25722.1	26[illegible]

DESCRIPTION	YEARS FROM THE BEGINNING OF THE CONSTRUCTION 11	12	13	14	15	16	
1. CAPITAL COST INVESTMENT	0.0	0.0	0.0	0.0	0.0	0.0	
2. EQUITY CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	
3. WORKING CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	
4. GROSS PROFIT	79970.4	79970.4	79970.4	79970.4	79970.4	79970.4	79[illegible]
5. DEPTS REPAYMENT	13556.1	13556.1	13557.4	0.0	0.0	0.0	
6. INTEREST PAYMENTS	4281.9	3416.9	2551.8	1686.8	1686.8	1686.8	16[illegible]
7. RESIDUAL VALUE	0.0	0.0	0.0	0.0	0.0	0.0	50[illegible]
8. INCOME TAX	34583.0	35082.6	43882.9	44382.4	44382.4	44382.4	44[illegible]
9. THE RETURN ON INVESTMENT	79970.4	79970.4	79970.4	79970.4	79970.4	79970.4	79[illegible]
10. THE RETURN ON EQUITY	27549.4	27914.9	19978.3	33901.2	33901.2	33901.2	33[illegible]

INTERNAL RATE OF RETURN ON INVESTMENT : 24.79 P.C.
INTERNAL RATE OF RETURN ON EQUITY : 23.92 P.C.

OTAAKA INORI, KOHEI, 12,10

SECTION 1

...CULATION OF INTERNAL RATES OF RETURN

000.Rs

...INING

3	4	5	6	7	8	9	10
1751.0	605.0	1211.0	31200.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1108.0	2670.0	5340.0	0.0	0.0	0.0	0.0	0.0
9227.0	38794.4	79970.4	79970.4	79970.4	79970.4	79970.4	79970.4
0.0	13556.1	13556.1	13556.1	13556.1	13556.1	13556.1	13556.1
9003.6	9101.9	8977.8	8506.8	7741.8	6876.8	6011.8	5146.8
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	4745.3	31871.1	32085.4	32584.9	33084.5	33534.0	34083.5
5368.0	35519.4	73419.4	48770.4	79970.4	79970.4	79970.4	79970.4
9025.4	8721.2	20225.4	25722.1	26087.6	26453.0	26818.5	27434.0

...ING

13	14	15	16	17
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0
[illegible]970.4	79970.4	79970.4	79970.4	79970.4
[illegible]557.4	0.0	0.0	0.0	0.0
551.8	1686.8	1686.8	1686.8	1686.8
0.0	0.0	0.0	0.0	50465.0
382.9	44382.4	44382.4	44382.4	44382.4
970.4	79970.4	79970.4	79970.4	79970.4
778.3	33901.2	33901.2	33901.2	33901.2

RATE OF RETURN ON INVESTMENT : 24.79 P.C.
RATE OF RETURN ON EQUITY : 23.92 P.C.

SECTION 2

SHEDULE 10-14/1. SENSITIVITY ANALYSIS

PRICE OF SI-AL ALLOY : RS 21000 PER TON
PRICE OF FUEL OIL : RS2700 PER TON

NN	ALUMINIUM PRICE, RS/T		ELECTRIC POWER PRICE, RS/KW*H		
			371	435	500
1.	17000.	IRRI, P.C.	23.6	21.4	19.3
		IRRA, P.C.	22.6	20.1	17.1
		BEP, P.C.	48.3	51.2	54.9
2.	19600.	IRRI, P.C.	4.7	777.7	777.7
		IRRA, P.C.	777.7	777.7	777.7
		BEP, P.C.	114.5	157.3	229.8
3.	20000.	IRRI, P.C.	0.7	777.7	777.7
		IRRA, P.C.	777.7	777.7	777.7
		BEP, P.C.	143.9	207.2	331.0
4.	22000.	IRRI, P.C.	777.7	777.7	777.7
		IRRA, P.C.	777.7	777.7	777.7
		BEP, P.C.	53613.4	-810.6	-428.6
5.	*********.	IRRI, P.C.	0.0	0.0	0.0
		IRRA, P.C.	0.0	0.0	0.0
		BEP, P.C.	0.0	0.0	0.0
6.	*********.	IRRI, P.C.	0.0	0.0	0.0
		IRRA, P.C.	0.0	0.0	0.0
		BEP, P.C.	0.0	0.0	0.0

SHEDULE10-14/2. SENSITIVITY ANALYSIS

PRICE OF SI-AL ALLOY : RS 21000 PER TON
PRICE OF FUEL OIL : RS3000 PER TON

NN	ALUMINIUM PRICE, RS/T		ELECTRIC POWER PRICE, RS/KW*H		
			371	435	500
1.	17000.	IRRI, P.C.	23.2	21.1	18.9
		IRRA, P.C.	22.2	19.[illegible]	16.7
		BEP, P.C.	48.8	51.8	55.8
2.	19600.	IRRI, P.C.	4.2	777.7	777.7
		IRRA, P.C.	777.7	777.7	777.7
		BEP, P.C.	117.8	162.6	239.8
3.	20000.	IRRI, P.C.	0.1	777.7	777.7
		IRRA, P.C.	777.7	777.7	777.7
		BEP, P.C.	148.7	215.7	350.3
4.	22000.	IRRI, P.C.	777.7	777.7	777.7
		IRRA, P.C.	777.7	777.7	777.7
		BEP, P.C.	-7703.0	-733.1	-408.1
5.	********.	IRRI, P.C.	0.0	0.0	0.0
		IRRA, P.C.	0.0	0.0	0.0
		BEP, P.C.	0.0	0.0	0.0
6.	********.	IRRI, P.C.	0.0	0.0	0.0
		IRRA, P.C.	0.0	0.0	0.0
		BEP, P.C.	0.0	0.0	0.0

SHEDULE 10-14/3. SENSITIVITY ANALYSIS

PRICE OF SI-AL ALLOY : RS 21000 PER TON
PRICE OF FUEL OIL : RS3300 PER TON

NN	ALUMINIUM PRICE, RS/T		ELECTRIC POWER PRICE, RS/KW*H		
			371	435	500
1.	17000.	IRRI, P.C.	22.9	20.8	18.6
		IRRA, P.C.	21.9	19.4	16.2
		BEP, P.C.	49.3	52.4	56.8
2.	19600.	IRRI, P.C.	3.7	777.7	777.7
		IRRA, P.C.	777.7	777.7	777.7
		BEP, P.C.	121.2	168.2	250.5
3.	20000.	IRRI, P.C.	777.7	777.7	777.7
		IRRA, P.C.	777.7	777.7	777.7
		BEP, P.C.	153.7	224.9	371.9
4.	22000.	IRRI, P.C.	777.7	777.7	777.7
		IRRA, P.C.	777.7	777.7	777.7
		BEP, P.C.	-3651.5	-669.5	-389.7
5.	********.	IRRI, P.C.	0.0	0.0	0.0
		IRRA, P.C.	0.0	0.0	0.0
		BEP, P.C.	0.0	0.0	0.0
6.	********.	IRRI, P.C.	0.0	0.0	0.0
		IRRA, P.C.	0.0	0.0	0.0
		BEP, P.C.	0.0	0.0	0.0

SHEDULE 10-14/4. SENSITIVITY ANALYSIS

PRICE OF SI-AL ALLOY : RS 23000 PER TON
PRICE OF FUEL OIL : RS2700 PER TON

NN	ALUMINIUM PRICE, RS/T		ELECTRIC POWER PRICE, RS/KW*H		
			371	435	500
1.	17000.	IRRI, P.C.	38,8	36,9	35.0
		IRRA, P.C.	39,0	37,0	35.0
		BEP, P.C.	30,7	31,9	33.2
2.	19600.	IRRI, P.C.	25,1	21,6	18.0
		IRRA, P.C.	24,3	20,2	14.2
		BEP, P.C.	45,9	50,5	59.1
3.	20000.	IRRI, P.C.	22,7	19,1	15.4
		IRRA, P.C.	21,6	17,1	9.7
		BEP, P.C.	49,7	55,1	67.4
4.	22000.	IRRI, P.C.	8,7	4,1	777.7
		IRRA, P.C.	777,7	777,7	777.7
		BEP, P.C.	90,8	120,6	166.2
5.	*********.	IRRI, P.C.	0,0	0,0	0.0
		IRRA, P.C.	0,0	0,0	0.0
		BEP, P.C.	0,0	0,0	0.0
6.	*********.	IRRI, P.C.	0,0	0,0	0.0
		IRRA, P.C.	0,0	0,0	0.0
		BEP, P.C.	0,0	0,0	0.0

SHEDULE 10-14/5. SENSITIVITY ANALYSIS

PRICE OF SI-AL ALLOY : RS 23000 PER TON
PRICE OF FUEL OIL : RS3000 PER TON

NN	ALUMINIUM PRICE, RS/T		ELECTRIC POWER PRICE, RS/KW*H		
			371	435	500
1.	17000.	IRRI, P.C.	38.5	36.7	34.8
		IRRA, P.C.	38.7	36.8	34.8
		BEP, P.C.	30.9	32.1	33.4
2.	19500.	IRRI, P.C.	24.8	21.3	17.7
		IRRA, P.C.	23.9	19.9	13.7
		BEP, P.C.	46.4	51.1	60.1
3.	20000.	IRRI, P.C.	22.4	18.6	15.0
		IRRA, P.C.	21.3	16.7	9.0
		BEP, P.C.	50.2	56.0	68.6
4.	22000.	IRRI, P.C.	8.3	3.6	777.7
		IRRA, P.C.	777.7	777.7	777.7
		BEP, P.C.	93.1	124.0	171.9
5.	********.	IRRI, P.C.	0.0	0.0	0.0
		IRRA, P.C.	0.0	0.0	0.0
		BEP, P.C.	0.0	0.0	0.0
6.	********.	IRRI, P.C.	0.0	0.0	0.0
		IRRA, P.C.	0.0	0.0	0.0
		BEP, P.C.	0.0	0.0	0.0

SHEDULE 10-14/6. SENSITIVITY ANALYSIS

PRICE OF SI-AL ALLOY : RS 23000 PER TON
PRICE OF FUEL OIL : RS3300 PER TON

NN	ALUMINIUM PRICE, RS/T		ELECTRIC POWER PRICE, RS/KW.H		
			371	435	500
1.	17000.	IRRI, P.C.	38,3	36.4	34.5
		IRRE, P.C.	38,4	36.5	34.5
		BEP, P.C.	31,2	32.4	33.7
2.	19600.	IRRI, P.C.	24,5	21.0	17.3
		IRRE, P.C.	23,6	19.5	13.0
		BEP, P.C.	46,8	51.6	61.2
3.	20000.	IRRI, P.C.	22,1	18.5	14.7
		IRRE, P.C.	20,9	16.3	8.7
		BEP, P.C.	50,8	57.0	66.8
4.	22000.	IRRI, P.C.	7,8	3,1	777.7
		IRRE, P.C.	777,7	777.7	777.7
		BEP, P.C.	95,5	127.7	177.9
5.	*********.	IRRI, P.C.	0,0	0,0	0.0
		IRRE, P.C.	0,0	0,0	0.0
		BEP, P.C.	0,0	0,0	0.0
6.	*********.	IRRI, P.C.	0,0	0,0	0.0
		IRRE, P.C.	0,0	0,0	0.0
		BEP, P.C.	0,0	0,0	0.0

SHEDULE 10-14/7. SENSITIVITY ANALYSIS

PRICE OF SI-AL ALLOY : RS 25000 PER TON
PRICE OF FUEL OIL : RS2700 PER TON

NN	ALUMINIUM PRICE, RS/T		ELECTRIC POWER PRICE, RS/KW.H		
			371	435	500
1.	17000.	IRRI, P.C.	51,6	49.9	48.1
		IRRA, P.C.	52,2	50.4	48.7
		BEP, P.C.	22,5	23.2	23.8
2.	19600.	IRRI, P.C.	40,0	36.9	33.8
		IRRA, P.C.	40,3	37.1	33.7
		BEP, P.C.	29,8	31.0	33.8
3.	20000.	IRRI, P.C.	38,1	35.0	31.8
		IRRA, P.C.	38,3	35.0	31.5
		BEP, P.C.	31,3	33.4	35.8
4.	22000.	IRRI, P.C.	27,7	24.5	20.8
		IRRA, P.C.	27,2	23.3	18.5
		BEP, P.C.	42,2	46.1	51.4
5.	********.	IRRI, P.C.	0,0	0,0	0.0
		IRRA, P.C.	0,0	0,0	0.0
		BEP, P.C.	0,0	0,0	0.0
6.	********.	IRRI, P.C.	0,0	0,0	0.0
		IRRA, P.C.	0,0	0,0	0.0
		BEP, P.C.	0,0	0,0	0.0

SHEDULE 10-14/8. SENSITIVITY ANALYSIS

PRICE OF SI-AL ALLOY : RS 25000 PER TON
PRICE OF FUEL OIL : RS3000 PER TON

NN	ALUMINIUM PRICE, RS/T		ELECTRIC POWER PRICE, RS/KW*H		
			371	435	500
1.	17000.	IRRI, P.C.	51,3	49.6	47.9
		IRRA, P.C.	52,0	50.2	48.4
		BEP, P.C.	22,7	23.3	24.0
2.	19600.	IRRI, P.C.	39,8	36.7	33.6
		IRRA, P.C.	40,0	36.8	33.4
		BEP, P.C.	30,0	31.6	34.0
3.	20000.	IRRI, P.C.	37,8	34.7	31.6
		IRRA, P.C.	38,0	34.7	31.2
		BEP, P.C.	31,5	33.6	36.1
4.	22000.	IRRI, P.C.	27,4	24.0	20.5
		IRRA, P.C.	26,8	23.0	18.1
		BEP, P.C.	42,6	46.6	52.2
5.	*********.	IRRI, P.C.	0,0	0.0	0.0
		IRRA, P.C.	0,0	0.0	0.0
		BEP, P.C.	0,0	0.0	0.0
6.	*********.	IRRI, P.C.	0,0	0.0	0.0
		IRRA, P.C.	0,0	0.0	0.0
		BEP, P.C.	0,0	0.0	0.0

SHEDULE 10-14/9. SENSITIVITY ANALYSIS

PRICE OF SI-AL ALLOY : RS 25000 PER TON
PRICE OF FUEL OIL : RS3300 PER TON

NN	ALUMINIUM PRICE, RS/T		ELECTRIC POWER PRICE, RS/KWH		
			371	435	500
1.	17000.	IRRI, P.C.	51,1	49.4	47.7
		IRRA, P.C.	51,7	50.0	48.2
		BEP, P.C.	22,8	23.4	24.1
2.	19600.	IRRI, P.C.	39,5	36.4	33.3
		IRRA, P.C.	39,8	36.5	33.1
		BEP, P.C.	30,1	32.1	34.3
3.	20000.	IRRI, P.C.	37,6	34.5	31.3
		IRRA, P.C.	37,7	34.4	30.9
		BEP, P.C.	31,7	33.9	36.3
4.	22000.	IRRI, P.C.	27,1	23.7	20.2
		IRRA, P.C.	26,5	22.6	17.6
		BEP, P.C.	43,0	47.0	53.0
5.	*********.	IRRI, P.C.	0,0	0.0	0.0
		IRRA, P.C.	0,0	0.0	0.0
		BEP, P.C.	0,0	0.0	0.0
6.	*********.	IRRI, P.C.	0,0	0.0	0.0
		IRRA, P.C.	0,0	0.0	0.0
		BEP, P.C.	0,0	0.0	0.0

SHEDULE 10-14/10.SENSITIVITY ANALYSIS

PRICE OF SI-AL ALLOY : RS 27000 PER TON
PRICE OF FUEL OIL : RS2700 PER TON

NN	ALUMINIUM PRICE,RS/T		ELECTRIC POWER PRICE,RS/KW*H		
			371	435	500
1.	17000.	IRRI,P.C.	62.9	61.3	59.7
		IRRA,P.C.	63.6	62.0	60.3
		BEP, P.C.	17.8	18.2	18.6
2.	19600.	IRRI,P.C.	52.6	49.8	46.9
		IRRA,P.C.	53.3	50.4	47.4
		BEP, P.C.	22.0	23.0	24.1
3.	20000.	IRRI,P.C.	51.0	48.1	45.2
		IRRA,P.C.	51.6	48.7	45.7
		BEP, P.C.	22.8	23.9	25.1
4.	22000.	IRRI,P.C.	42.2	39.1	36.1
		IRRA,P.C.	42.5	39.4	36.1
		BEP, P.C.	28.2	29.8	31.7
5.	********.	IRRI,P.C.	0.0	0.0	0.0
		IRRA,P.C.	0.0	0.0	0.0
		BEP, P.C.	0.0	0.0	0.0
6.	********.	IRRI,P.C.	0.0	0.0	0.0
		IRRA,P.C.	0.0	0.0	0.0
		BEP, P.C.	0.0	0.0	0.0

SHEDULE 10-14/11. SENSITIVITY ANALYSIS

PRICE OF SI-AL ALLOY : RS 27000 PER TON
PRICE OF FUEL OIL : RS3000 PER TON

NN	ALUMINIUM PRICE, RS/T		ELECTRIC POWER PRICE, RS/KW.H 371	435	500
1.	17000.	IRRI, P.C.	62,7	61,1	59.5
		IRRA, P.C.	63,4	61,8	60.1
		BEP, P.C.	17,9	18,3	18.7
2.	19600.	IRRI, P.C.	52,4	49,6	46.7
		IRRA, P.C.	53,1	50,2	47.2
		BEP, P.C.	22,1	23,1	24.3
3.	20000.	IRRI, P.C.	50,7	47,9	45.0
		IRRA, P.C.	51,4	48,4	45.4
		BEP, P.C.	23,0	24,1	25.3
4.	22000.	IRRI, P.C.	41,9	38,9	35.8
		IRRA, P.C.	42,3	39,1	35.9
		BEP, P.C.	28,3	30,0	32.0
5.	********.	IRRI, P.C.	0,0	0,0	0.0
		IRRA, P.C.	0,0	0,0	0.0
		BEP, P.C.	0,0	0,0	0.0
6.	********.	IRRI, P.C.	0,0	0,0	0.0
		IRRA, P.C.	0,0	0,0	0.0
		BEP, P.C.	0,0	0,0	0.0

SHEDULE 10-14/12. SENSITIVITY ANALYSIS

PRICE OF SI-AL ALLOY : RS 27000 PER TON
PRICE OF FUEL OIL : RS3300 PER TON

NN	ALUMINIUM PRICE, RS/T		ELECTRIC POWER PRICE, RS/KW*H		
			371	435	500
1.	17000.	IRRI, P.C.	62.5	60.9	59.3
		IRRA, P.C.	63.2	61.6	59.9
		BEP, P.C.	17.9	18.3	18.7
2.	19600.	IRRI, P.C.	52.2	49.4	46.5
		IRRA, P.C.	52.8	49.9	47.0
		BEP, P.C.	22.2	23.2	24.4
3.	20000.	IRRI, P.C.	50.5	47.7	44.7
		IRRA, P.C.	51.1	48.2	45.2
		BEP, P.C.	23.1	24.2	25.4
4.	22000.	IRRI, P.C.	41.7	38.6	35.6
		IRRA, P.C.	42.0	38.9	35.6
		BEP, P.C.	28.5	30.2	32.2
5.	********.	IRRI, P.C.	0.0	0.0	0.0
		IRRA, P.C.	0.0	0.0	0.0
		BEP, P.C.	0.0	0.0	0.0
6.	********.	IRRI, P.C.	0.0	0.0	0.0
		IRRA, P.C.	0.0	0.0	0.0
		BEP, P.C.	0.0	0.0	0.0

ГРАФИК 2. ПЕРИОД ОКУПАЕМОСТИ

DIAGRAM 2. PAY-BACK PERIOD

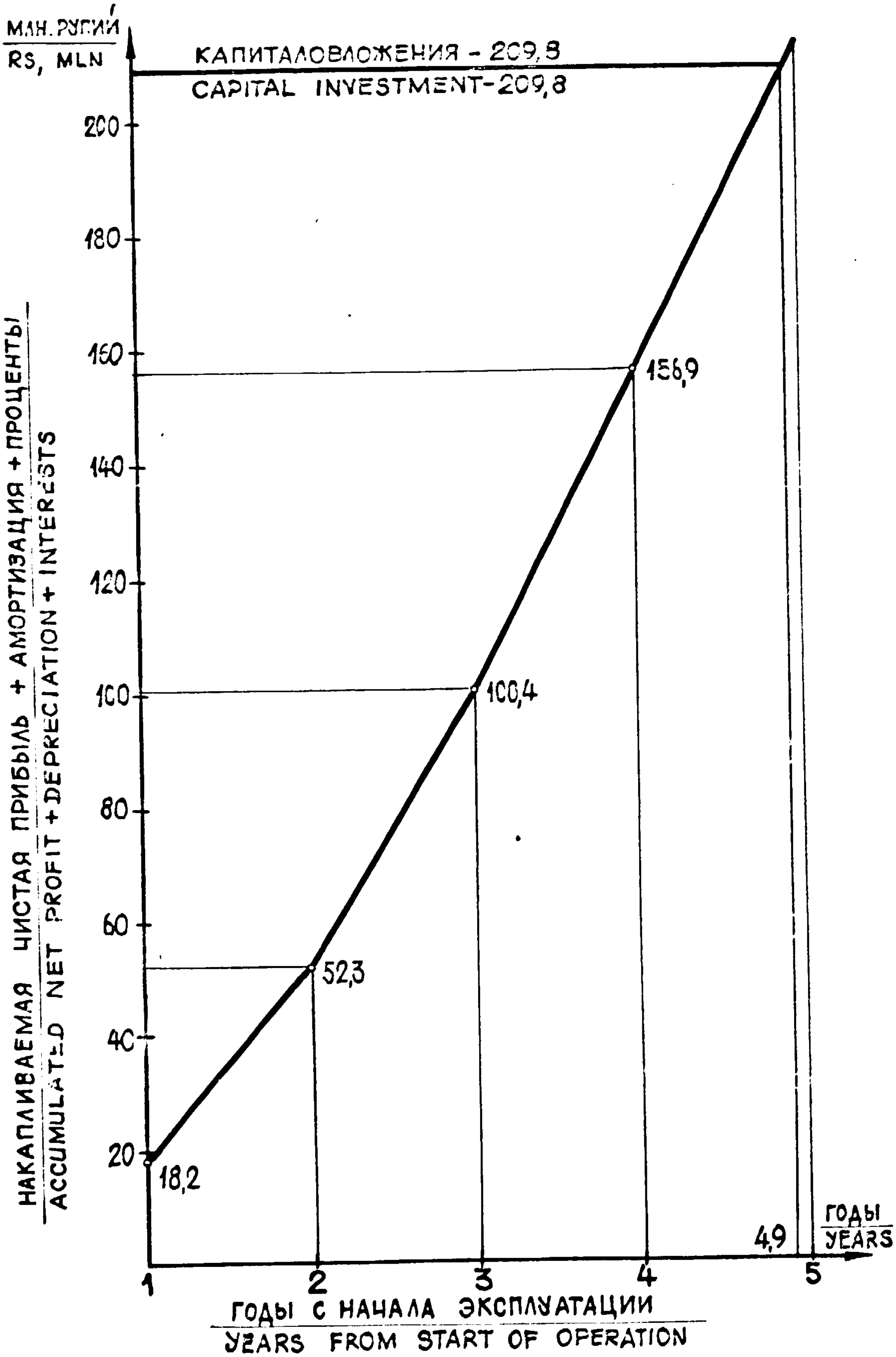

ГРАФИК 3. СРЕДНЕГОДОВОЙ УРОВЕНЬ БЕЗУБЫТОЧНОСТИ
(В БАЗОВОМ УРОВНЕ ЦЕН)

DIAGRAM 3. AVERAGE YEARLY BREAK-EVEN POINT
(AT THE BASIC LEVEL OF PRICE)

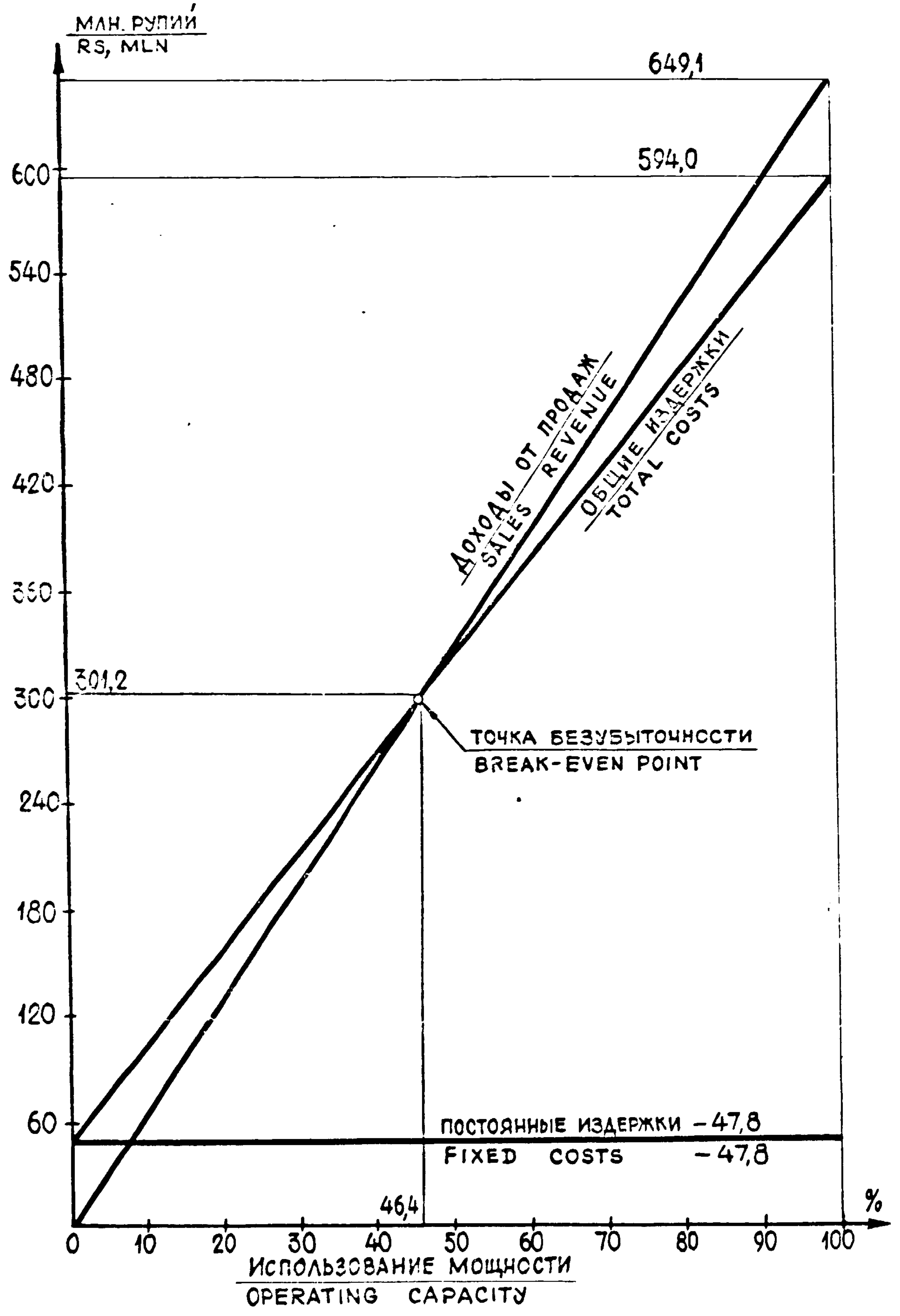

ГРАФИК 4. ЗАВИСИМОСТЬ ВНПК ОТ УРОВНЯ ЦЕН
DIAGRAM 4. EFFECT OF PRICE LEVEL ON IRRI

БАЗОВЫЕ ЦЕНЫ: / BASE PRICES:		
	- СПЛАВОВ / - ALLOY	- 23000 рупий/т / -Rs 23000/T
	- АЛЮМИНИЯ / - ALUMINIUM	-19600 рупий/т / - RS 19600/T
	- ЭЛЕКТРОЭНЕРГИИ / - POWER	- 371 рупий/1000 квт-ч. / -RS 371/1000 KWH
	- МАЗУТА / - FUEL OIL	- 3000 рупий/т / - RS 3000/T

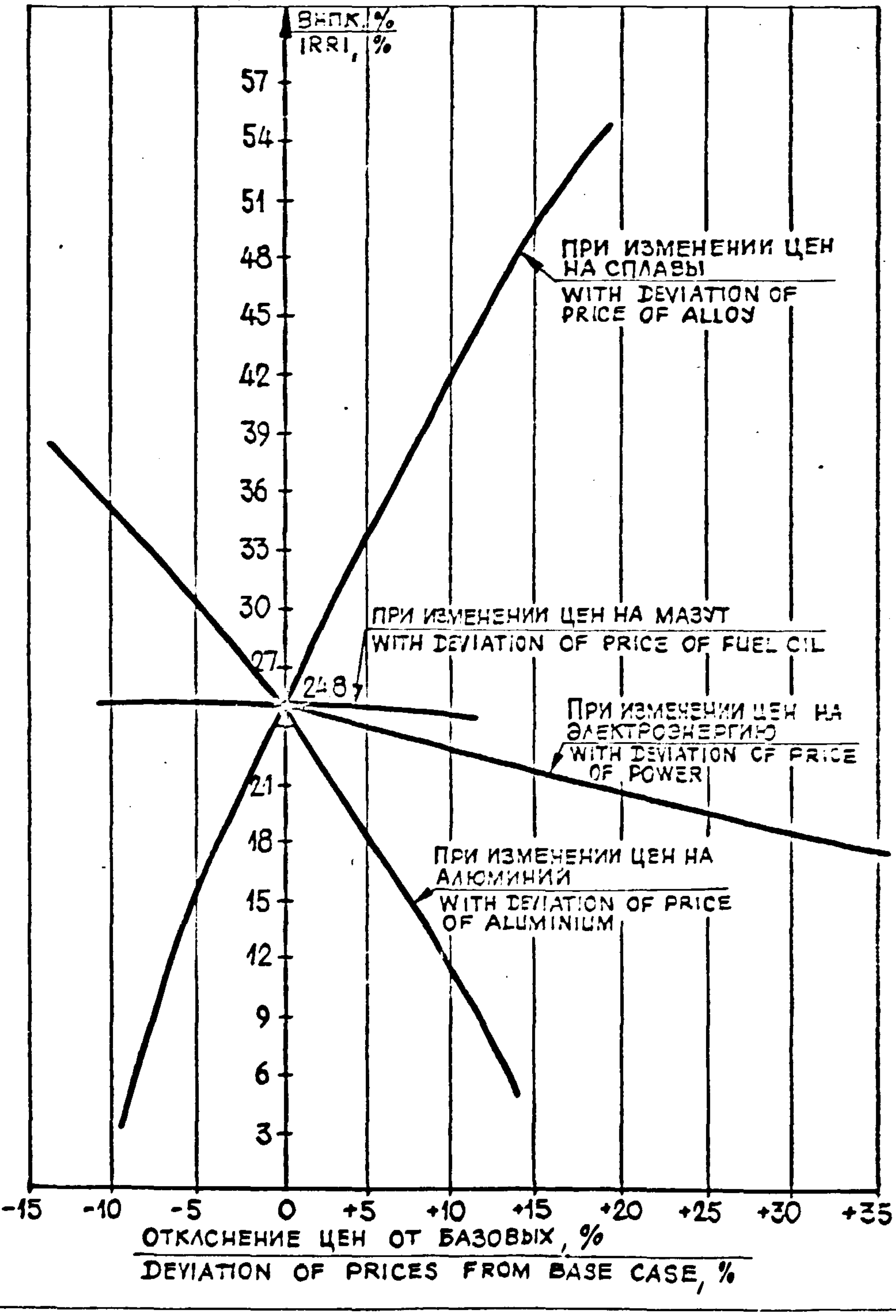

ГРАФИК 5. ЗАВИСИМОСТЬ ВНПА ОТ УРОВНЯ ЦЕН
DIAGRAM 5. EFFECT OF PRICE LEVEL ON IRRE

БАЗОВЫЕ ЦЕНЫ: / BASE PRICES:	- СПЛАВОВ / - ALLOY	- 23000 РУПИЙ/Т / - RS 23000/T
	- АЛЮМИНИЯ / - ALUMINIUM	- 19600 РУПИЙ/Т / - RS 19600/T
	- ЭЛЕКТРОЭНЕРГИИ / - POWER	- 371 РУПИИ/1000 КВТ-Ч / - RS 371/1000 KWH
	- МАЗУТА / - FUEL OIL	- 3000 РУПИЙ/Т / - RS 3000/T