No. 25

FEASIBILITY STUDY REPORT
ON
THE REHABILITATION OF
NITROGENOUS FERTILIZER PLANT
THE REPUBLIC OF ZAMBIA

MARCH, 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of Zambia, the Government of Japan decided to conduct a feasibility study on the rehabilitation of the Nitrogen Chemicals of Zambia, Ltd. and entrusted the study to the Japan Internanional Cooperation Agency (JICA). The JICA sent to Zambia a survey team headed by Mr. K. Adachi from February 2 to March 21, and from October 2 to November 5, 1981.

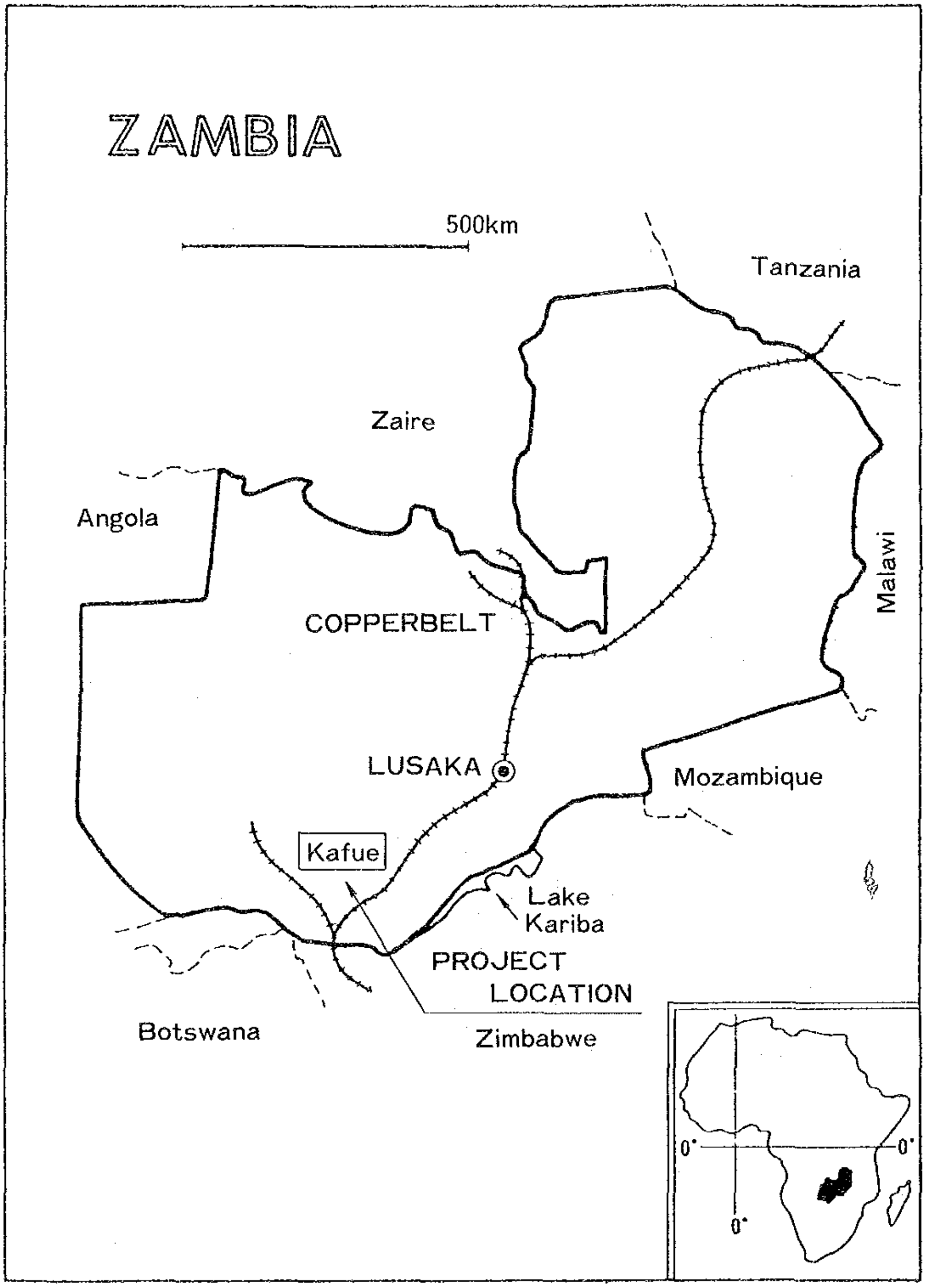
The team had discussions with the officials concerned of the Government of Zambia and conducted field surveys. After the team returned to Japan, further studies were made and the present report has been made.

I hope that this report will serve for the reconstruction of the Nitrogen Chemicals of Zambia, Ltd. and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Zambia for their close cooperation extended to the team.

March, 1982

Keisuke Arita
President
Japan International Cooperation Agency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ABBREVIATIONS

NCDP	National Commission for Development Planning
ZIMCO	Zambia Industrial and Mining Corporation
NAM Board	National Agricultural Marketing Board of Zambia
INDECO	INDECO Limited
ZESCO	Zambia Electric Supply Corporation
NCZ	Nitrogen Chemicals of Zambia Limited
GDP	Gross Domestic Product
GNP	Gross National Product
IRR	Interal Rate of Return
Y	Year
M	Month
D	Day
H	Hour
Min	Minute
Sec	Second
km	Kilometer
m	Meter
mm	Millimeter
m^2	Square Meter
m^3	Cubic Meter
l	Liter
T	Metric Ton
Kg	Kilogramme
g	Gramme
kg/cm^2G	Kilogramme Per Square Centimeter Gauge

KV	Kilovolt
V	Volt
KVA	Kilovolt Ampere
KW	Kilowatt
KWh	Kilowatt–hour
Hz	Hertz(Frequency)
℃	Degree Centigrade
%	Percent
wt %	Weight Percent
vol. %	Volume Percent
ppm	Parts Per Million
AN	Ammonium Nitrate
AS	Ammonium Sulphate
ANBA	Ammonium Nitrate for Blasting Agent
CF	Compound Fertilizer
K	Kwacha
¥	Yen

Summary, Conclusion and Recommendation

Summary, Conclusion and Recommendation

1. Background and Purpose of Study

A fertilizer plant designed for production of 30,000 T/Y of ammonia, 50,000 T/Y of nitric acid and 60,000 T/Y of ammonium nitrate was constructed in Kafue about 50 Km to the south of Lusaka, the capital of Zambia, aiming at self-sufficiency in the fertilizer field, and it was commissioned in 1970.

In addition, an expansion plant with the capacity of 66,000 T/Y of ammonia, 70,000 T/Y of nitric acid, 80,000 T/Y of ammonium nitrate, 50,000 T/Y of ammonium sulphate and 141,000 T/Y of compound fertilizers was constructed to promote self-sufficiency and commercial operation started in 1982.

Now that more than ten years have passed since the plant was commissioned, the facilities have been deteriorated and the producion rate has dropped to nearly 70% of the capacity. Unless some action is taken, it is expected that production will drop further and this will greatly affect self-sufficiency program of fertilizer.

A request for a feasibility study on plant rehabilitation was made to the Government of Japan by the Government of Zambia.

Then, at the request of the Government of Japan, the Japan International Cooperation Agency undertook this feasibility study.

The purpose of this study is to clarify the causes of the decline in production, to formulate a draft plan for rehabilitation to ensure stable operation of the plant within the originally designed capacity, and to evaluate the financial and economic effects.

2. Scope and Contents of the Study

The Study consists of the following activities ;

(1) Surveys on the economic situation and supply-demand situation for fertilizers in the Republic of Zambia

(2) Surveys on the current situation and the causes of decline of production in the fertilizer plant

(3) Inspection of deteriorated equipment and survey of the extent of deterioration

(4) Formulation of Rehabilitation plan

(5) Total capital requirement and financial plan

(6) Financial analysis and economic evaluation of the plan

The first survey team visited the fertilizer plant of NCZ in Zambia for 30 days from Feb. 20, to March 21, 1981. The team investigated Zambia's economic situation and its supply demand situation of fertilizers, the current state of the plant and the causes of decline in production, and selected machinery and equipment for check/inspection to be done in the second field survey. Following this, the survey team made another field survey at NCZ for 35 days from Oct. 2 to Nov. 5, 1981 when the operation of the plant was suspended for annual overhauling, and examined each item of machinery and equipment in order to determine the extent of deterioration.

3. Supply–demand Situation of Fertilizers in Zambia

(1) The country's self–sufficiency in food is now 50%, and the import of food influences its foreign exchange.

(2) The 3rd national development plan gives the first priority to the attainment of self–sufficiency in food. Some agricultural projects are being planned, and it is expected that self–sufficiency in food will be attained by 1983. In order to achieve the objectives of the Plan, it is essential to secure the supply of fertilizers.

(3) NCZ is the only fertilizer manufacturer in Zambia. NAM Board imports fertilizers and

monopolizes the sale of both imported and homemade fertilizers.

(4) NCZ at present manufactures 40,000 T/Y of ammonium nitrate, of which 20,000 T/Y are used for mining explosives and 20,000 T/Y for fertilizers. It plans to increase production of ammonium nitrate by 80,000 T/Y and compound fertilizers by 141,000 T/Y from 1982 by the expansion plant.
According to the supply-demand plans of NAM Board, however, even with the production increase at NCZ, nitrogenous fertilizers will remain in short supply and a large amount of urea fertilizer will have to be imported.

(5) In this respect, the capacity decrease of the existing plant is a big bottleneck. The plant, therefore, needs to be rehabilitated.

4. Outline of NCZ

The outline of NCZ is as follows :

(1) Capital : K 12,880,000

(2) Location : Kafue (50 Km south of Lusaka, the capital of Zambia)

(3) Number of Employees : 1,000, planned to be increased to 1,500 after the expansion plant is completed.

(4)	Existing Plant Rated Capacity : (Commissioned in 1970)	Ammonia	30,000T/Y
		Nitric Acid	50,000T/Y
		Ammonium Nitrate	60,000T/Y
(5)	Expansion Plant Rated Capacity : (Commisioned in 1982)	Ammonia	66,000T/Y
		(Raw gas)	90,000T/Y)
		Nitric Acid	70,000T/Y
		Ammonium Nitrate	80,000T/Y
		Ammonium Sulphate	50,000T/Y
		Compound Fertilizers	141,000T/Y

Ammonia production section has an excess capacity to the downstream section.

(6) Production and Sales from the Start-up

	Ammonia (T/Y)	Nitric Acid (T/Y)	Ammonium Nitrate(T/Y)
1971	15,000	25,400	32,500
1972	14,300	24,500	29,300
1973	26,400	48,400	53,400
1974	26,100	47,600	52,100
1975	22,400	40,300	44,200
1976	24,400	44,800	49,100
1977	24,000	44,100	47,500
1978	24,800	44,700	48,800
1979	23,900	43,700	47,000
1980	19,540	35,510	36,413

	Sales (K1,000)	Profit before Tax (K1,000)
1970	4,800	54
1971	11,400	(−)3,017
1972	7,500	(−)3,371
1973	5,000	(−) 268
1974	10,700	1,071
1975	9,400	689
1976	11,100	1,141
1977	13,700	3,332
1978	14,300	1,450
1979	17,336	3,275

The annual production quantity has been decreasing from 1974, and is expected to drop more rapidly.

5. Technical Problems of the Existing Plant

(1) Capacity of Each Section

Capacity of each section is as follows as a result of the first survey.

Section \ Capacity	Design Capacity	Present Capacity	Expected Capacity
Coal Handling Coal T/H (as ammonia T/D)	6.6 (95.3)	8 (85)	8 (85)
Gasification gas Nm^3/H (as ammonia T/D)	10,600 (95.3)	8,500 (85)	8,500 (85)
H_2S Removal gas Nm^3/H (H_2S ppm)	10,600 (3)	8,500 (800)	10,600 (3)
Gas Purification Ammonia Synthesis T/D	95.3	79	95.3
Nitric Acid T/D	172.4	150－160	172.4
Ammonium Nitrate T/D explosive fertilizer	205 39 166	205	205

Note :

Design capacity : original capacity
Present capacity : present production capacity
Expected capacity : capacity expected when there is no external disturbances and troubles etc.

The present low capacities of Coal Handling and Gasification are not only due to a decline in efficiency as a result of deterioration of equipment but also due to a shift to low quality coal from the high quality coal planned to be used at the time of designing. Recovery to the original design capacities, therefore, will not be possible unless the design is altered and modification of the plant is made. It will be possible to recover the design capacity by making rehabilitation as far as H_2S Removal and its downstream are concerned.

(2) Results of Check/Inspection

The survey team inspected 336 items of machinery and equipment during the second field survey, the results of which are as follows :

(a) Complete replacement 81 items (24%)

(b) Replacement of parts 117 items (35%)

(c) No rehabilitation 138 items (41%)

(3) Operation rate in case of no rehabilitation work

The survey team estimates that the operation rate of the plant will decline as shown in the following table and that the maintenance expenses will increase year after year, without rehabilitation.

Year	*1 Number of operation days per year	*2 Operation rate (%)	*3 Production rate (%)
1982	285	86.3	73.1
1983	260	78.8	66.7
1984	260	78.8	66.7
1985	240	72.7	61.6
1986	240	72.7	61.6
1987	210	63.6	53.9

*1 Operation days a year : 330days

*2 Operation days per year/330 days

*3 Operation rate x (72/85)

NCZ's production plan of ammonia for 1982 : 72 T/D

(4) The survey team presumes that the following are the major causes for the deterioration of machinery and equipment.

(a) Due to the shortage of foreign exchange, necessary spare parts and chemicals could not be imported. As a result,

1) The plant was kept running without proper maintenance,which resulted in acceleration of deterioration.

2) As corrosion inhibitors and other additives as specified were not added, deterioration was accelerated.

3) Inadequate maintenance of instruments resulted in blind operation partly, which promoted corrosion of machinery and equipment.

(b) Operation of machinery and equipment with defects promoted deterioration.

(c) Inadequate maintenance causes deterioration.

6. Draft Plan for the Rehabilitation

(1) In making up the draft plan, the following points were set forth as premises.

(a) The production capacity should be kept within the capacity as originally designed.

(b) No large scale repair works will be required to maintain stable operation for some years after rehabilitation, provided it is properly maintained.

(c) To ensure maximum investment effect with minimum capital.

(2) Selection of Optimum Plan

The following three plans were studied.

(a) To recover the annual production of 30,000 tons of ammonia, and 60,000 tons of ammonium nitrate which were the capacities in the original design : A change of design and large−scale modification of the Raw Gas section will be necessary.

(b) Restoration of the Raw Gas section to the capacity presently expected.

(c) The Raw Gas section which is most deteriorated should be rahabilitated to a state where operation is possible only in emergency ; at other times, it should be kept as a standby. For this purpose, raw gas (24,000 T/Y in terms of ammonia) and ammonia (4,300 T/Y) should be supplied by the expansion plant, while the Nitric Acid and Ammonium Nitrate Plants should be rehabilitated completely so that they could produce the same amounts as specified in the original design.

The expansion plant at NCZ has the capacity of 90,000 T/Y of raw gas (in terms of ammonia) and 66,000 T/Y of ammonia, which are more than the requirements of the downstream sections. Therefore, it can supply raw gas and ammonia to the existing plant. In conclusion, the plan (c) is the optimum in that it needs the lowest investment, the production of ammonium nitrate remains the same, and it can utilize surplus capacity of the expansion plant.

(3) The scope of rehabilitation works is as follows :

(a) The project should be executed on a turn−key basis including design, procurement of machinery and equipment, transportation, and construction.

(b) Commissioning of the plant should be made by NCZ, and supervisors should be provided by the contractor in order to make smooth commissioning.

(c) Overseas training should be included for better maintenance of NCZ.

(d) Consulting shoud be limited to the review of drawings and documents, and the inspection of machinery and equipment manufactured outside Zambia.

(4) Proposed Time Schedule of the Rehabilitation

March 31, 1982	Presentation of the report on the feasibility study
March 31, 1983	The Government of Zambia will make a decision on the execution of the project
September 30,1983	Conclusion of the contract agreement
March, 1985	Commencement of the field works
August, 1985	Completion of field works
September, 1985	Completion of the test run

(5) It is recommended that a management team be organized by NCZ for the execution of the project.

7. Capital Requirements

(1) The capital required was estimated based on the following premises.

(a) The rehabilitation works at NCZ will be completed by August 1985 and the test run by September 1985.

(b) The scope of rehabilitation works is as shown in 6−(3).

(c) The currency exchange rate : K1.00=¥266=SDR1.01227

(d) The time of the cost estimation : as of December 1981

(e) Physical contingency

(f) Price contingency (inflation)

	(e)	(f)
Foreign currency	8%	7% (annual)
Local currency	10%	12% (annual)

(2) The capital requirements are estimated as follows :

Capital Requirements (1,000)

Items	Foreign		Local	Total
	¥	K	K	K
Engineering Fee	274,700	1,033		1,033
Machinery & Equipement (FOB)	3,125,300	11,749		11,749
Construction Equipment & Materials	190,300	715	169	884
Ocean Freight & Insurance	196,100	737	48	785
Inland Transport & Handling Charge	150,500	566	48	614
Erection			641	641
Supervising	216,300	813	306	1,119
Training	25,700	97		97
Consultant Fee	70,000	263		263
Base Project Cost	4,248,900	15,973	1,212	17,185
Physical Contingency	339,900	1,278	121	1,399
Price Contingency	792,700	2,980	499	3,479
Total Project Cost	5,381,500	20,231	1,832	22,063
Interest During Construction Interest Rate				
Foreign 10%, Local 10%		2,461	92	2,553
Foreign 7%, Local 10%		1,705	92	1,797
Foreign 4%, Local 10%		964	92	1,056

(3) The allocation of capital is planned as follows :

(K1,000)

	1983	1984	1985	Total
Foreign Currency Local Currency	3,957	15,761	513 1,832	20,231 1,832
Total	3,957	15,761	2,345	22,063

(4) The capital requirements shall be by a long-term loan under the terms as follows :

	Foreign currency	Local currency
Term of repayment	10 years	10years
Interest rate (%)	10,7,4,	10

For the financial evaluation, 10% interest rate on foreign currency is used as a basis.

8. Financial Evaluation

(1) Financial evaluation is made in the following manner.

(a) Profit and loss was estimated for the case that no rehabilitation works would be made to the existing plant.

(b) Profit and loss was estimated for the case that rehabilitation works would be made to the existing plant, and internal rate of return (IRR) was calculated.

(c) Assuming the difference in profit and loss between the cases with and without rehabilitation works as the return on investment in the rehabilitation works, the internal rate of return (IRR) was calculated.

(d) Profit and loss of NCZ as a whole was estimated assuming that the rehabilitation works would be made.

(2) Data provided by NCZ were examined and analyzed to provide the basis for evaluation.

(3) Evaluation was made for the period from 1982 to 1994. The life of the project is 9.5 years.

(4) Evaluation was made based on 1982 prices. As for the costs required for this project, the amount excluding the price contingency was the object of evaluation as the cost required in 1982.

(5) Sales plan was based on the plans provided by NCZ.

(6) In the existing plant, although both ammonia and nitric acid will be produced, they should be used as materials for ammonium nitrate, and ammonium nitrate alone should be manufactured and sold.

(7) The production at the existing plant will go on declining until the rehabilitation works are completed.

(8) As for working capital, it was estimated to be an amount corresponding to 2 month's production of ammonium nitrate for the existing plant, and 2 month's production of compound fertilizers for the expansion plant.

(9) Unit consumption of raw materials at existing plant is expected to improve after completion of the rehabilitation works.

(10) Maintenance cost for the existing plant is considered to increase with the number of days of suspension of operation, but to remain stable at a certain level after the completion of the rehabilitation works.

(11) The capital requirement and financial sources for the existing and the expansion plants are as follows :

(K1,000)

	Existing plant 1982	Expansion plant 1982	Rehabilitation Works
Investment			
Machinery	6,180	274,400	18,584
Building		20,000	
Working capital	6,700	4,560	2,165*
Loans	10,000	180,760	20,749
Equity capital	12,880	118,200	
Internal reserves	(−)10,000		

*Interest during construction

(12) (a) Depreciation : Straight Line Method

Machinery	7.5% p. a.
Buildings	2.0% p. a.

(b) Income Tax 50%

○ Tax Holiday	5 years
○ Carryover of Losses	5 years

(13) NCZ's fertilizers are marketed through NAM Board which is also a national corporation like NCZ, and the prices of fertilizers are determined by the Government every yerar. NCZ's expansion plant goes into commercial operation in January 1982. The new prices of fertilizers are, therefore, being examined by the organizations concerned. As the new prices are determined based on the cost of production, the survey team calculated the production cost of each product from the total production cost of existing and expansion plants.

Financial analysis was made with the assumed selling prices based on these figures. Assumed selling prices of products were set as follows :

Ammonia		751 (K/T)
Nitric Acid		295
Ammonium Nitrate		507
Ammonium Sulphate		471
Compound Fertilizer	C	519
〃	D	531
〃	R	557
〃	X	565

(14) Financial prospect of the existing plant

If no rehabilitation works were made, the plant would suffer from deficit every year after 1985 due to the decline in production. However, it would turn to the surplus in the profit and loss accounts from 1986, if the rehabilitation works were executed.

Estimated Profit and Loss after Tax

(K1,000)

Year	If not Rehabilitated	If Rehabilitated
1985	(−) 647	(−)4,436
1986	(−) 582	1,870
1987	(−) 2,789	2,252
1988	(−) 2,893	2,592
1989	(−) 3,147	2,354
1990	(−) 3,425	1,569
1991	(−) 3,732	1,705
1992	(−) 4,069	1,842
1993	(−) 4,440	1,978
1994	(−) 4,848	2,115

(a) Financial prospect of the existing plant with the rehabilitation works

Interst Rate on Long−term Loan(%)	10	7	4
Cumulative Net Profit after Tax at the End of 1994 (K1,000)	7,926	10,735	12,889
Cash Balance at the End of 1994 (K1,000)	11,671	14,697	17,064
Cumulative Depreciation (K1,000)	21,337	21,337	21,337

Although loans can be duly repaid, actual internal reserves in terms of cash balance is not sufficient compared with cumulative depreciation. Such financial position will be improved by adopting 4% interest rate on long-term loans.

(b) Assuming the difference of profit and loss between the cases with and without the rehabilitation works as return from the investment, internal rate of return (IRR) is computed.

IRR (pretax profit base)	: 26.02%
IRR (after-tax profit base)	: 19.17%

Consequently, the investment for the existing plant is feasible.

Meanwhile, assuming the total of the equity capital and outstanding loans in 1982 and the investment for the rehabilitation works to be the overall investment costs for the existing plant, internal rate of return (IRR) is computed.

IRR (pretax profit base)	: 7.41%
IRR (after-tax profit base)	: 5.87%

(15) Outlook for the total profit and loss of NCZ as a whole

Net profit after tax as of the end of 1994 :		K 112,000,000
End cash balance	〃	K 223,000,000
Total amount of investment		K 313,000,000

NCZ will have surplus from 1985 on regarding net profit loss and from 1984 regarding end cash balance. So it will be able to repay the debt but amortization shall be insufficient. For sound management of NCZ, it is necessary to have the selling price improved by 5-10%.

9. Economic Benefits

(1) Saving of foreign exchange

In ten years from 1985 to 1994, K 105,414,000 of foreign exchange will be saved.

(2) Value added

An increase of K 70,000,000 in the value added (profit before tax + labour expenses + depreciation + interests) can be expected in ten years as a result of the improved production of fertilizers.

10. Conclusion

(1) Zambia will still run short of nitrogenous fertilizers and have to import urea fertilizer even after the rehabilitation is executed. The rehabilitation can be considered as feasible.

(2) For the planning of the rehabilitation, the plan to have the supply of raw gas from the expansion plant will be the best, as it requires the minimum amount of investment and achieves high economic efficiency because surplus capacity of the expansion plant is utilized.

(3) Since the rehabilitation works will be undertaken through a contract with single responsibility by an experienced contractor on a turn-key basis, there will be little technical risk.

(4) Since NCZ has more than ten years experience in operating the plant, there should be no trouble in the test run and commercial operation after the completion of rehabilitation works.

(5) In the respect of investment effect of rehabilitation, internal rate of return is very high. But the financial situation of NCZ is not necessarily sound and healthy with debts still unpaid. In the long run, although a shortage of depreciation is expected, NCZ will get the profits more than enough to repay the debts.

(6) The Republic of Zambia is suffering from a lack of foreign exchange. The rehabilitation works will help to prevent the outflow of foreign exchange from the country and contribute to the betterment of the balance of payment situation of Zambia.

(7) In short, this rehabilitation project is feasible. It contributes to the improvement of the national balance of payments and food policy, and earnings of NCZ.

Chapter 1.

Introduction

Chapter 1. Introduction

1.1 Background of the Survey

The Government of Zambia established Nitrogen Chemicals of Zambia Limited (NCZ) in 1967 under Industrial Development Corporation Limited (INDECO) in order to promote the development of industry and self-sufficiency in fertilizer production in the country. In May 1970, the first fertilizer plant was constructed in Kafue, about 50 km south of Lusaka, the capital, to manufacture ammonium nitrate for fertilizer and for mining explosives using the coal produced in the country as a major material.

But with more than ten years having passed, the facilities of the plant have deteriorated considerably and production has dropped to nearly 70% of capacity. Should it be left as it is, there is a possibility that the plant will have to be closed in several years. Now, an overall review for the rehabilitation of the plant is needed.

Under this situation, the mining project finding mission of the Japan International Cooperation Agency was requested by the Government of Zambia to make a fesibility study for the plant rehabilitation project during its visit to the country in November, 1979.

Following this, in September, 1980 the president of the Republic of Zambia visited Japan and the commencement of the feasibility study was confirmed through a joint communique by the two nations. The Government of Japan entrusted the undertaking of the project to the Japan International Cooperation Agency.

1.2 Purpose of the Survey

The purpose of the survey is to determine and rectify the causes of decline in production from various angles such as machinery, production process, management and operation in view of the above-mentioned background, to draw up a draft plan for a rehabilition project to ensure stable operation of the plant within the range of original design capacity, and to evaluate the financial and economic effects.

1.3 Scope of the Survey

The survey consisted of two field surveys ; the first one was carried out when the plant was in operation, and the second, during the shutdown of operations for the annual overhauling of the plant.

(1) The First Field Survey

(a) Surveys on the trends in the economic situation and the supply and demand of fertilizers in the Republic of Zambia.

(b) Classification of the causes of the decline in production at NCZ.

1) Examination of past performance

2) Examination of the working condition of equipment and machinery

3) Examination of material and utility situations

4) Examination of maintenance condition and the administrative systems in the plant.

(c) Survey of the financial situation of NCZ

(d) Selection of machines and equipment to be inspected

(2) The Second Field Survey

(a) Overhaul inspection of the machines and equipment selected in the first field survey.

(b) Collection of data necessary for project planning.

1.4 Method and Schedule of the Survey

In view of the special nature of the rehabilitation project, surveys were carried out twice ; once when the plant was in operation and once when it stopped operation for a regular inspection. The first survey team consisted of ten specialists and one staff member from the Agency, headed by Katsuo Adachi. It made a field survey at the NCZ plant, Zambia, for 30 days from Feb. 20 to March 21, 1981, when the plant was in operation. There, the team, in cooperation with its counterparts consisting of those concerned from INDECO, and NCZ, analyzed the factors attributing to the decline in the rate of operation such as the working condition of each process and materials which could be checked when the plant was in operation, and selected the machines and equipment to be inspected. The team also investigated economic situation, supply and demand situation of fertilizers in the country and the financial situation of NCZ.

The second survey team consisted of seven specialists and two staff members from the Government and the Agency, again headed by Katsuo Adachi. It made a field survey at the NCZ plant, too, during the shutdown of operations for 35 days from Oct. 2 to Nov. 5, 1981. Again, in cooperation with its Zambian counterparts, it made an overhaul inspection of those machines and equipment selected in the first survey and investigated the extent of damage, abrasion and wear.

(Note)
The followings are given in the Appendices of this report.

App. 1. Program of Survey and Evaluation Study
App. 2. Members of the First and Second Survey Team
App. 3. Itinerary of the First and Second Survey
App. 4. Places Visited
App. 6. Members of the Zambian Counterpart Team, NCZ

1.5 Summary of the Survey

According to the scope of the survey mentioned in sections 1.1 to 1.3 of this chapter, the main areas of this survey can be classified as follows :

(1) Investigation into the food and fertilizer situation in the Republic of Zambia

(a) Kinds and volume of grain produced in Zambia and its rate of self-sufficiency were investigated.

(b) The Government's agricultural policy in the 3rd five year plan was analyzed.

(c) Supply and demand conditions and distribution channels for fertilizers were investigated.

(d) Marketing forecast of fertilizers by the NAM Board was reviewed.

(e) Future demand for fertilizers was estimated based on the present demand, taking into account the above factors.

(2) The Current State of NCZ

(a) History and the outline of NCZ were studied.

(b) Working conditions in the existing plant were investigated.

(c) Production schedules for the new plant were studied.

(d) Production balance and the equipment investment ratio between the two plants were examined.

(3) Technical Review of the Existing Plant

(a) Problems with each process and causes for the decline in capacity were investigated.

(b) In the first survey, the machines and tools that needed overhaul inspection were identified, and during the second survey an overhaul inspection of equipment was carried out to examine the extent of deterioration.

(4) The Draft Proposal for Improving the Existing Plant

(a) Among the three proposals suggested concerning the method for improvement, the optimum proposal was identified through comparison and review.

(b) Scope, contents and problems of rehabilitation works were reviewed.

(5) The Draft Execution Plan for the Plant Rehabilitation Works.

(a) The scope of the rehabilitation works was confirmed.

(b) Procurement of equipment and materials necessary for the rehabilitation works were studied.

(c) The transportation of equipment and materials necessary for the rehabilitation works was studied.

(d) Contents of the field works were studied in detail.

(e) Schedule of the field works was studied in detail.

(f) Construction machinery and equipment to be used in the works were studied.

(g) Utilities for the works, facilities available in NCZ, sub-contractors, training, test running and consulting were studied.

(h) The schedule of the project was studied.

(6) Capital Requirements

Total cost required for the project was estimated on the basis of the optimum proposal mentioned in (4),and a financial plan was formulated.

(7) Formulation of a Draft Proposal concerning the Execution of the Project.

The organization for the execution of the project was studied after reviewing the administrative structure of NCZ.

(8) Financial Evaluation and Economic Effects

Based on (6) Capital Requirements and results of relevant studies, a financial evaluation of NCZ was made as well as the analysis of the investment effect of project.

With regard to the analysis of the investment effect, the internal rate of return was computed taking the improvements in earnings realized by the new investment in the existing plant as returns to offset that investment, and then, the investment effect was analyzed. Based on this analysis,the commercial feasibility, financial soundness and the economic effect of the project were evaluated.

Chapter 2.

Food and Fertilizer Situation in Zambia

Chapter 2. Food and Fertilizer Situation in Zambia

2.1 Food Situation

2.1.1 Production of Grain

The production of grain in fiscal 1979/1980 showed an increase of 14% for maize, which is the major grain product of the country, about 14% for rice and 7% for wheat over the previous year. But on the whole, it satisfies only 50% of the domestic demand, and the country depends for the other 50% on imports. Although the production of grain increased considerably compared with that of the previous year as mentioned above, the shortage of foreign exchange had an impact on the agriculture sector ; the import of agricultual machines, storage facilities, fertilizer, agricultural chemicals and so on has had to be limited. On the other hand, in some parts of the country, agricultural production especially in 1979, was greatly restricted because of unfavorable environmental factors of southern part of Africa. Further, the exploitation of the market for agricultural products and vocational training for those engaged in agriculture, together with lending restrictions toward farmers have had a substantial influence on the production activity. (Table 2−1)

(1) Maize

Although the output of maize in 1979/1980 increased to 4.2 million bags (90 kg per bag) from the previous year, the crop per ha. decreased.
The domestic demand for maize in the same grain fiscal year ran to about 8 million bags (90 kg per bag). Consequently, 2.3 million bags of maize were imported.

(2) Rice

Rice acreage in grain fiscal 1979/1980 increased by 65% from the previous year to 5,100 ha. In the same fiscal year, 26,300 bags (80 kg per bag) of rice were produced, but this only satisfies 50% of domestic demand.

(3) Wheat

While the output of wheat was 6,966 tons in grain fiscal 1979/1980, the domestic demand for wheat in the same year amounted to 115,000 tons.

Table 2-1 Changes in Planted Area and Marketed Production during the 1979/80 Crop Season

Crop	Unit of Output	1978/79		1979/80		Change (%)	
		Planted area (ha)	Marketed Production	Planted area (ha)	Marketed Production	Planted area (ha)	Marketed Production
Maize	Million 90kg. bags	336,000	3.7	540,000	4.2	61	14
Rice	80kg. bags	3,100	23,156	5,100	26,300	65	14
Wheat	Tonnes	2,100	6,528	2,400	6,966	14	7
Groundnuts	80kg. bags	27,487	34,213	25,552	25,000	−7	−27
Soyabeans	90kg. bags	2,607	14,387	3,700	38,000	42	164
Sunflower	50kg. bags	26,709	238,371	30,791	340,000	15	43
Cotton (seed)	Tonnes	24,146	15,000	30,300	23,000	25	53
Sorghum	90kg. bags	—	—	—	1,661	—	—
Tea	kg.	—	245,902	—	300,000	—	22
Tabacco							
(a) Virginia flue-cured	Tonnes	4,700	4,591	—	4,127	—	−10
(b) Burley	Tonnes	—	381	—	554	—	45

2.1.2 Distribution Channel

All grain products sold in the Republic of Zambia are handled by the National Agricultural Marketing Board (NAM Board) which is under the jurisdiction of the Ministry of Land and Agriculture. That means the grain crops in the country are purchased by the NAM Board, which also controls the import of grain. The NAM Board receives a Government subsidy in order to compensate for the difference between the purchase price and the selling price. In the Government's 1981 budget, about K 25 million (about ¥6,250 million) was appropriated as the subsidy to the NAM Board, which accounted for 20% of the total amount of subsidies in the budget of K 125 million.

2.1.3 Government's Policy

In the 3rd national development plan, the Government planned several grain projects, some of which have already been started.

- Kabwe-Mkushi "Maize project"
  started in 1979/1980
  K 8.6 million financed by the EEC (¥2,150 million)

- Chama "Rice Development Project"
  Started in 1979/1980

- Zam-Can "Wheat Project"
  Started with the assistance of the Government of Canada
  Zam-Can Growers Ltd.

- Mpongwe Pilot Project "Wheat"
  Pilot project with the assistance of the EEC

The Government of Zambia set a target to achieve full self-sufficiency in maize and rice and to achieve 25% self-sufficiency in domestic demand for wheat by 1983, the last year of the 3rd plan (Table 2−2). In order to realize this, it is indispensable to increase the production of fertilizers.

2.2 Fertilizer Situation

2.2.1 Home-produced Fertilizers

Since 1970 NCZ has been manufacturing ammonia, nitric acid, and ammonium nitrate (both for fertilizer and for mining explosives) as the sole fertilizer manufacturing company in Zambia. And to raise self-sufficiency of nitrogenous fertilizer, the expansion plant is starting comercial operation in 1982. The output of each product by years is shown in Chapter 3.

Table 2-2 Demand Projections and Estimates of Production for Important Agricultural Commodities in 1983

(Unit : T)

Commodity	Total Internal Demand	Estimated Prouduction
Maize	1,483,000	1,700,000
Rice	15,000	15,000
Wheat	190,000	48,000
Barley	40,000	16,000
Sweet Potatoes and Potatoes	54,000	100,000
Cassava	*	41,753
Dry Beans	21,000	30,000
Groundnuts (in shell)	93,000	94,000
Sunflower Seed	32,000	32,000
Soyabean	6,500	6,500
Tea	1,200	650
Coffee (ground)	400	400
Seed Cotton	27,000	32,000
Virginia Tobacco	+	12,000
Burley Tobacco	+	1,100
Oriental Tobacco	+	315
Beef	74,370	53,460
Pork and Bacon	8,000	12,000
Poultry Meat	26,000	33,000
Eggs	5,000	13,000
Milk (litres)	92,000	38,150

* Not available

\+ Not significant

Table 2 −3 Fertilizer Sales Volume by NAM Board
(Actual and Forecast 1972 through 1987)

	NPK Compound	NT* Fertilizer	P Fertilizer		K Fertilizer		Others
			NSP	TSP	Potassium Chloride	Potassium Sulphate	
1972	66,490	27,378	832		498		-
1973	51,081	20,216	1,226		200		-
1974	48,076	26,965	2,751		351		-
1975	74,784	33,152	1,086	386	11	316	156
1976	78,272	39,932	751	1,325	38	1	4,900
1977	90,225	44,717	130	1,480	134	35	-
1978	77,140	31,216	308	1,588	87	62	471
1979	80,136	35,858	137	1,588	140	62	2,035
1980	88,150	39,444	151	1,747	154	68	2,239
1981	96,965	43,388	165	1,921	169	75	2,462
1982	106,661	47,727	183	2,113	186	83	2,708
1983	117,327	52,499	200	2,325	205	91	2,979
1984	129,060	57,750	220	2,557	225	99	3,277
1985	141,966	63,525	242	2,813	248	110	3,605
1986	156,162	69,877	267	3,094	273	120	3,965
1987	171,779	76,865	294	3,404	200	132	4,362

Note; (1) According to achievements and projection of supply demand by NAM Board
(2) 1972 - 1973 achievements
(3) 1980 - 1987 projection by annual increase rate of 10% by NAM Board
(4) * NT Base for fertilizer, including compound fertilizers
(5) NSP; Normal Super Phosphate, TSP; Triple Super Phosphate

2.2.2 Distribution Channels for Fertilizers

As in the case of grain mentioned above, the NAM Board monopolyzes fertilizer in Zambia. It has control over every distribution channel through the purchase of all the home-produced fertilizers, and controls the import.

2.2.3 Supply and Demand Conditions for Fertilizers

Table 2−3 shows the purchase and the sales of fertilizers by the NAM Board during the period 1972-1979. Of nitrogenous fertilizer the whole quantity of ammonium nitrate (N contents : 35%) was produced by NCZ. The domestic demand is met by importing mainly urea, ammonium sulphate and compound fertilizers.

At present, NCZ has the capacity to produce 40,000 tons of ammonium nitrate a year (14,000 N T/Y). The expansion will have production capacity of 80,000 tons of ammonium nitrate, 50,000 tons of ammonium sulphate and 141,300 tons of compound fertilizer a year (38,500 tons per year on NT basis), when the expansion plant is started. It is predicted that the supply of nitrogenous fertilizer on the NT basis will be insufficient from 1984 onward, as nitrogenous fertilizer available at NCZ is 52,500 T/Y on NT basis.

Next, Table 2—4 shows the supply-demand balance in ammonium nitrate. If the urea which is mostly imported at present is replaced partly by ammonium nitrate, the supply of ammonium nitrate will run short, even though 50% of urea demand is covered by ammonium nitrate. It is, therfore, of importance to secure the supply of ammonium nitrate by rehabilitating the existing plant, as the shortage of ammonium nitrate will get worse by the deterioration of the existing plant and it has a great impact on the home-made food increase policy.

Table 2−4 Comparison between Demand and Production of NCZ for Ammonium Nitrate (1980 through 1987)

Table 2−4 Comparison between Demand and Production of NCZ for Ammonium Nitrate(1980 through 1987)

	Ammonium Nitrate 1.	AN 2.	Urea	AN 3.	AN Total	NCZ Production
1980	14,877	19,626	46,642	31,250	65,753	24,275
1981	16,241	21,589	51,306	34,375	72,205	-
1982	18,001	23,747	56,437	37,813	79,561	75,787
1983	19,790	26,122	62,001	41,540	87,452	81,349
1984	21,781	28,734	68,289	45,753	96,268	93,349
1985	23,958	31,600	75,117	50,328	105,886	88,000
1986	26,353	34,769	82,629	55,361	116,481	108,000
1987	28,989	38,246	90,092	60,361	127,596	108,000

Note : 1. Ammonium nitrate 1 : the amount of ammonium nitrate to be used for compound fertilizers

2. Ammonium nitrate 2 : the amount of ammonium nitrate to be used as mono-fertilizer

3. Urea : Expected demand for urea

4. Ammonium nitrate 3 : The amount to be used in the case where a half the demand for urea will be met by ammonium nitrate. Conversion from urea to ammonium nitrate is based on the following formula.

$$\text{Urea} = (35/47) \times \text{Ammonium nitrate}$$

5. NCZ's output is calculated based on the financial analysis (See Chapter 9). Two-third of its output is for fertilizers. The figure is premised on the assumption that the rehabilitation works will be done to the existing plant.

Chapter 3.

Present Status of NCZ

Chapter 3. Present Status of NCZ

3.1 Its Foundation

Zambia is one of the top copper producers of the world and uses huge quantities of mining explosives. The Government of Zambia made plans for domestic production of nitrogen explosives and took their first step towards this end by planning domestic production of nitric acid and ammonium nitrate. However, a prior survey indicated that production of explosives alone was not economically feasible and plants were made to promote production of fertilizers at the same time.

As a result NCZ was founded in September 1967 financed 100% by INDECO. Details of the company is as follows :

Capital	:	INDECO 100%	
Located	:	Kafue (50 km south of capital, Lusaka)	
Annual Production	:	Ammonia	30,000T
		Nitric Acid	50,000T
		Ammonium Nitrate	60,000T

3.2 Outline of NCZ

Today, NCZ has become the largest chemical company in Zambia. The outline of the company is as follows:

Capital:	K12,880,000
Sales:	K17,336,000 (1980)
Profit before tax:	K3,275,000 (1980)

Production, Sales:

	Production (T/Y)	Sales (T/Y)
Ammonia	19,540	—
Nitric Acid	35,510	7,399
Ammonium Nitrate	36,413	35,808
Liquid Carbon Dioxide	605	913

Employees 999 (After completion of expansion plant 1,509)

The outline of expansion plant to meet the increasing demand for fertilizer in Zambia is as follows :

Capital Investment : K294,400,000
Start of Production : January, 1982
Plant Capacity:

	Annual Production
Ammonia	66,000 T
Nitric Acid	70,000 T
Ammonium Nitrate	80,000 T
Ammonium Sulphate	50,000 T
Compound Fertilizers	141,000 T

Further plans to build Sulphuric Acid Plant for the production of ammonium sulphate is under way with completion targeted for May, 1983 (Annual Production 60,000 T).

3.3 Existing Plant

3.3.1 Outline

Construction began in 1968 by Kobe Steel, Ltd. and was completed in May, 1970.

	Daily Production	Annual Production
Ammonia	95.3 T	30,000 T
Nitric Acid	172.4 T	50,000 T
Ammonium Nitrate	205 T	60,000 T

Test runs yielded products according to the original projection for plant capacity. But when the plant was put into commercial operation, low quality domestic Maamba coal was used instead of Shiankandobo Coal thus the production of ammonia decreased to a daily output of 85 T or an annual production of 25,000 T.

Furthermore, lack of the material, ammonia, lowered the annual production capacity of ammonium nitrate to 50,000 T. In order to guarantee stable operation of ammonia, in 1978, a stand-by plant of Gasification was constructed. In 1979, a carbon dioxide facility (1,000 T/Y) was constructed and production of carbon dioxide began.

50% of the ammonium nitrate is sold to Kafilonda, Ltd. for the production of explosives and the remaining 50% is sold by the NAM Board as fertilizer.

3.3.2 Results since the Start of Operation

The actual results of NCZ since the start of operaion are as follows:

Table 3-1 Production Results of NCZ (T/Y)

	Ammonia	Nitric Acid	Ammonium Nitrate
1971	15,000	25,400	32,500
1972	14,300	24,500	29,300
1973	26,400	48,400	53,400
1974	26,100	47,600	52,100
1975	22,400	40,300	44,200
1976	24,400	44,800	49,100
1977	24,000	44,100	47,500
1978	24,800	44,700	48,800
1979	23,900	43,700	47,000
1980	19,540	35,510	36,413

Table 3-2 Sales and Profit Results of NCZ

(K 1,000)

	Sales	Profit before Tax
1970	4,800	54
1971	11,400	(−)3,017
1972	7,500	(−)3,371
1973	5,000	(−)268
1974	10,700	1,071
1975	9,400	689
1976	11,100	1,141
1977	13,700	3,332
1978	14,300	1,450
1979	17,336	3,275

3.4 Expansion Plant

Expansion plant is constructed by Klockner of West Germay.

The outline is as follows:

Table 3-3 Outline of Expansion Plant

Production	Capacity T/D	Capacity T/Y	Process	
Ammonia	220	66,000	(Coal Handling)	Krupp-Koppers
			(Gasification)	Krupp-Koppers
			(H_2S Removal)	Rectisol
			(Gas Purification)	Rectisol
			(Ammonia)	Cassale
			(Air Separation)	Linde
Nitric Acid	212	70,000		Grand Paroises
Ammonium Nitrate	242	80,000		Ketioner
Ammonium Sulphate	151	50,000		Ketioner
Compound Fertilizer	427	141,000		CDF Chemie

3.5 Outline of Fertilizer Plant after the Completion of Expansion Plant

3.5.1 Relationship between Existing Plant and Expansion Plant in terms of Facilities

Facilities for producing ammonia from coal have been divided in the following manner. The production capacity of existing and new facilities for ammonia is as follows:

Projected Sectional Production Capacity of the Ammonia Plant (T/D) Section

	Existing	Expansion
Coal Handling	95	300 (150 × 2)
Gasification	〃	300 (100 × 3)
Compression	〃	330 (165 × 2)
H_2S Removal	〃	300
Gas Purification	〃	220
Synthesis Gas Compression	〃	242 (121 × 2)
Ammonia Synthesis	〃	220
Air Separation	〃	220

The expansion plant has increased production capacity in those sections covering Coal Handling to H_2S Removal to 300 T/D. The gasification section is common for the existing plant and the expansion plant, and one of four facilities is used as a stand-by.

Also if raw gas section is fully operating, the expansion plant will be able to provide raw gas to the existing plant equivalent to 80 T/D of ammonia.

Figure 3−1 indicates the relationship between Ammonia Plant of the existing plant and that of the expansion plant.

3.5.2 Product Balance between Existing Plant and Expansion Plant

The product balance of NCZ after rehabilitation works is shown in Figure 3−2.

The ammonia production capacity of the expansion plant will be 66,000T/Y. Thus when it provides ammonia to Nitric Acid, Ammonium Nitrate and Ammonium Sulphate Plants, there still remains more than 10,000 T/Y for reserve.

As has been indicated in 3.5.1, if the raw gas equivalent to 24,000 T/Y of ammonia is supplied by the expansion plant to the existing plant, and 4,300 T/Y of Ammonia is provided to the existing plant, the existing plant will be able to produce 50,000 T/Y of nitric acid and 60,000 T/Y of ammonium nitrate.

Fig. 3-1 Outline of Ammonia Plant Capacity (designed capacity: NT/Y)

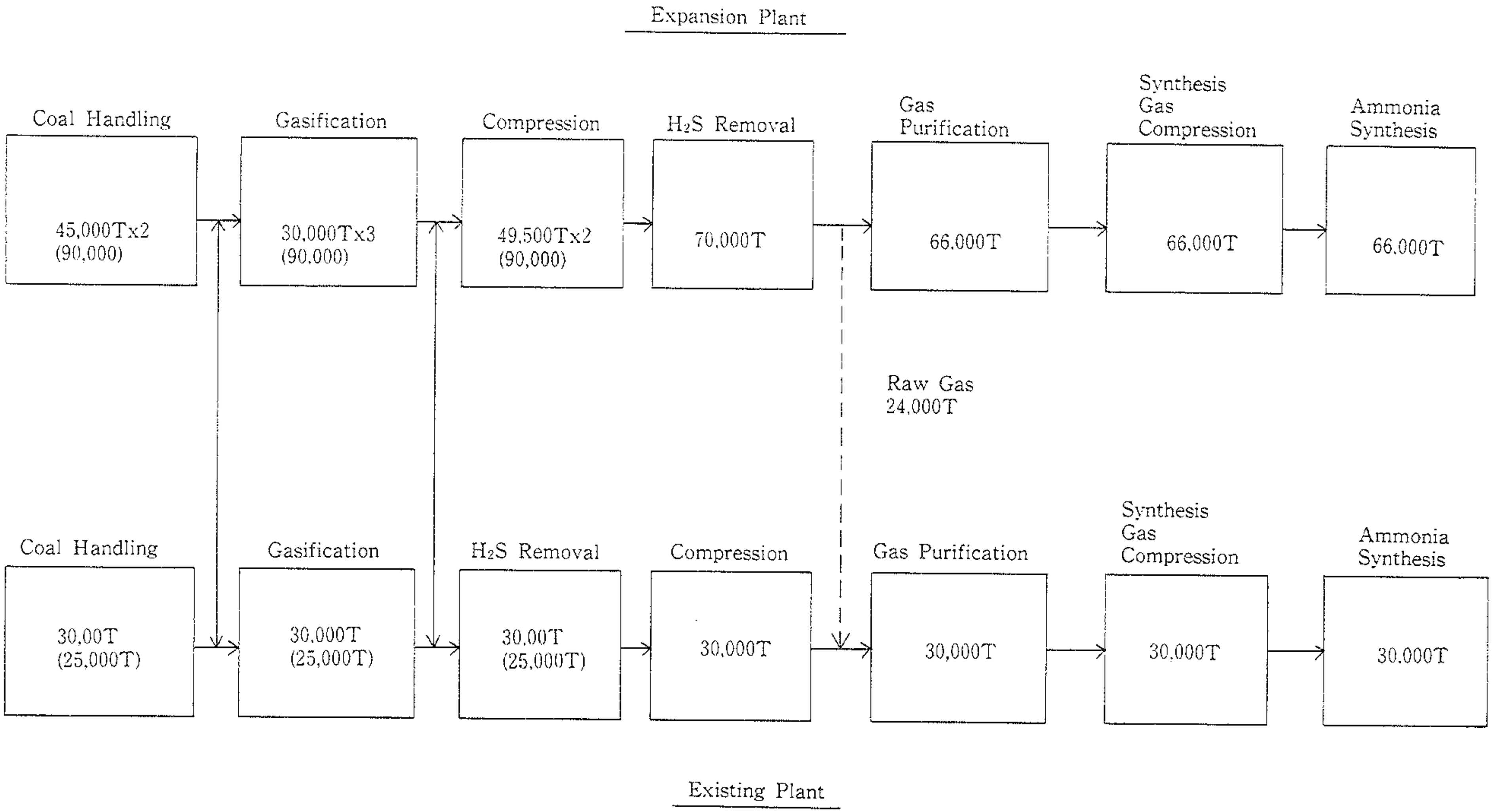
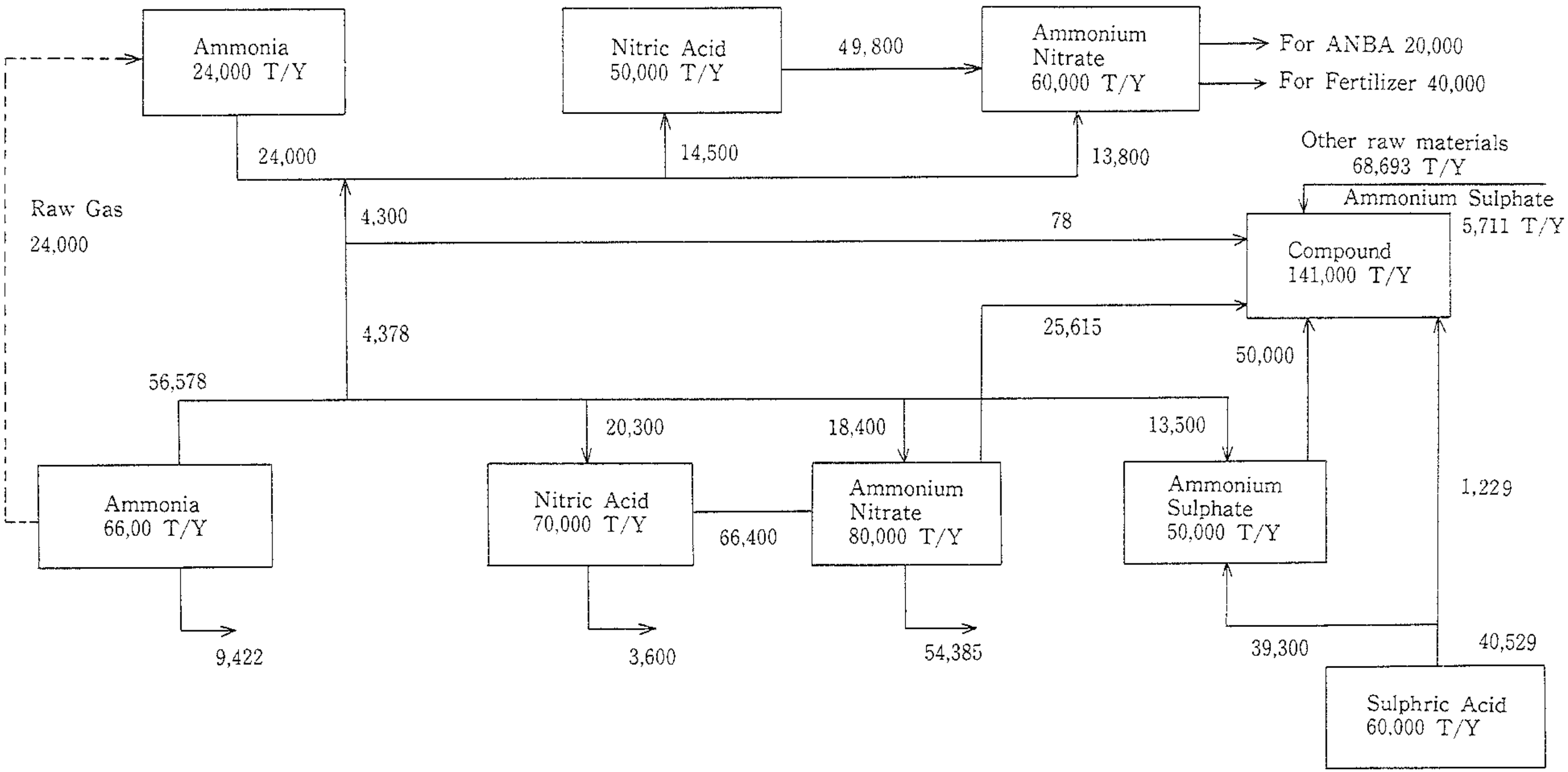


Fig. 3-2 Production Balance (as per the plan No.3)



3.6 Administrative System in NCZ

3.6.1 Organization Chart and Employee Distribution

The organization chart of NCZ is as follows. It is divided into 7 departments. Three production related departments are managed by the Works Manager and the other departments are under the direct control of the General Manager.

- General Manager (1,509)
  - Works Manager (1,297)
    - Engineering Department (516)
      Maintenance of Plant Equipment, Procurement of Spare Parts, Quality Control
    - Production Department (724)
      Operation of Ammonia, Nitric Acid, Ammonium Nitrate, Liquid Carbon Dioxide Plants
    - Technical Department (57)
      Improvement of Equipment and Chemical Process. Construction, Quality Control,Fire Fighting Facilities, Central Warehouse Safety Control
  - Personnel Department (150)
    General Office Affairs, Personnel Management, Wages, Welfare, Training, Safety Control
  - Accounting Deparment (36)
  - Purchasing Department (19)
  - Marketing Department (7)

* Projected Number of employees at the completion expansion plant

Organizational position of the technical employees are as follows:

Table 3-4 Organizational Position

	Engineering Dept.	Production Dept.	Technical Dept.	Total
Manager	1	1	1	3
Assist. Manager	1	1	1	3
Section Engineer	9	5	3	17
Engineer	39	39	5	83
Assist. Engineer	37	45	5	87
Technician Supervisor	87	98	9	194
Craftman / Operator	284	353	26	663
General Worker	58	182	7	247
Total	516	724	57	1297

Section Engineers must be university graduates with 5 or more years of experience. Engineers must be high school graduates with at least 5 years experience.

Two engineers are allocated to each of the three shifts for each section.

3.6.2 Job Specifications

Job specifications are established for each job and each position. They stipulate job description, authorities, qualifications and where that employee is to report to.

3.6.3 Operation Control

The operation groups, administration system and training system seem to be well organized. Hourly checks and data recording as well as analysis of specific sections are conducted according to regulations. But the survey team reports the following:

1) Instruments with broken gauges are not repaired.

2) All the equipment are not operated in accordance with specific operating conditions.

3) Leaking steams and water leaks are not rectified.

4) Instruments and tools are not kept in good order.

5) Rotary machines are grimy with oil, not maintained well.

6) High frequency of similar accidents.

The above points will decrease productivity, unit cost, and plant life. In order to rectify the above we recommend :

1) Each operator must be cost-conscious and report any descrepancies or irregularities.

2) Maintenance of machinery is listed under the job specification of the engineering department. However, the middle management of the production department should take more active interest in maintenance.

3) Induce better understanding of operating procedures and regulations.

4) When breakdowns or accidents occur, the engineering department should feed back the reasons for such breakdowns to the procuction department. This should prevent the occurence of similar breakdowns and accidents.

5) Every member should co-operate to keep the plant clean and orderly.

6) It is necessary for the production, maintenance and technical departments to have a closer working relationship with each other.

3.6.4 Safety Control and Training

The technical department is in charge of personnel safety and fire prevention. The personnel department is in charge of facility safety measures and education.

(1) Personnel Safety and Fire Prevention

Safety handbooks and fire prevention handbooks are handed out to individual workers. Fire training is carried out regularly and safety checks are conducted by upper management personnel.

Personnel accidents since 1970 is as follows :

Table 3-5 Statistics of NCZ Personnel Accidents

	Non-Disabling injury	Disabling injury	Total
1970	212	9	221
1971	604	21	625
1972	267	37	304
1973	90	11	101
1974	108	12	120
1975	106	13	119
1976	71	17	88
1977	77	21	98
1978	47	17	64
1979	52	13	65
1980	34	17	51

An annual improvement with a decreasing numer of accidents can be seen. But compared with similar plants in Japan (mon-disabling 0-5 cases and disabling 0−2 cases) further efforts are required.

(2) Accident Prevention Training

A training center has been set up within the personnel department to increase productivity and ensure safe operation.

New Employee Course
Beginner's Course
Intermediate Course
Senior Course
Specific Job Course

Each course has its own specific curriculum and training is given regularly. After the training session, certificate examinations are given. Examination are necessary for promotion.

3.6.5 Maintenance

The engineering department is responsible for maintenance for the entire plant. Its job responsibility is as follows :

Electrical Section	Electrical facilities of the entire plant. 3 shifts.
Instrument Section	Maintenance of instruments and quality control of entire plant. 3 shifts.
Area 1 Machines	Coal Handling, Gasification, Boiler, Water Treatment
Area 2 Machines	H_2S Removal, Compression, Purification Ammonia Synthesis and Air Separation
Area 3 Machines	Nitric Acid, Ammonium Nitrate, Bagging
Area 4 Machines	Ammonium Sulphate, Compound Fertilizers, Transportation, and Warehouse
Machine Shop	Repair of entire plant machines. 3 shifts.
Fabrication Shop	Piping, tanks, welding.
Repair Shop	Repair of instruments and Automobiles by machine tools
Construction Section	Civil construction
Clerical Section	Total management

The administration system is complete, but the following points must be considered.

(1) Inadequate communication with the operation department prevent having a good grasp of the actual conditions.

(2) Inadequate communication with the technical department, thus inadequate productivity

(3) No specific maintenance manual, therefore varying results

(4) Lack of measuring instruments and repair equipment, thus inadequate finish

(5) Breakdown gets worse and repairs are prolonged with lack of necessary parts. And many broken instruments are left as they can not be fixed.

(6) There is delay in repairing of leakage points and operator pays no attention to leakage.

(7) Well stocked with spare parts for some items but they are not properly listed in the inventory.

(8) There is a lack of the low price frequently needed spare parts. Better method for purchasing method is required.

(9) They seem to be behind in training the personnel in the maintenance department.

Lack of stable supply of spare parts due to shortage of foreign currency seems to be one of the major draw backs in maintenance. Inadequate operation administration seems to be for this reason. It is necessary to increase the stock of spare parts to solve this problem. Furthermore, in order to make the most effective use of the available foreign currency, detailed purchasing plans must be made. In order to minimize wear on the machinery, better communication must be established so that repairs can be done at the earliest possible date.

Generally speaking, the administration system is well established,but there seems to be some mismanagement due to inexperience. Especially, middle management personnel should understand the system well in order to operate it in a more integrated way.

Chapter 4.

Technical Examination of Existing Plant

Chapter 4. Technical Examination of Existing Plant

4.1 Description of the Processes at the Existing Plants

4.1.1 Outline of the Existing Plants

The existing plants consist of an Ammonia, a Nitric Acid and an Ammonium Nitrate Plant, and their auxiliary facilities, and are equipped as shown in Fig. 4−1. For reference, the projected and the present plan views of the whole plants are given in Figs. 4−2 and 4−3, respectively.

4.1.2 Ammonia Plant

Coal known as Maamba coal, the main material for the plant, is brought here by railroad from an open-air coal mine nearby.

The coal is pulverized to coal dust in th e Coal Handling Section, and then passed into the Gasification Section, where it is partially burnt with oxygen fed from the Air Separation Section to produce raw gas for ammonia synthesis. After hydrogen sulphide is removed in the H_2S Removal Section, the raw gas is sent by a raw gas compressor to the Gas Puriffication Section, in which it is puriffied into ammonia synthesis gas.

The purified ammonia synthesis gas (mainly hydrogen) is mixed with nitrogen from Air Separation Section and then pressurized by the synthesis gas compressor to feed the Ammonia Synthesis Section, where hydrogen and nitrogen react in the presence of catalysts to produce ammonia.
The capacity is 95.3 T/D and the constitution of the plant is as follows :

(1) Coal Handling

(2) Gasification

(3) H_2S Removal

(4) Gas Purification
- ○ Primary CO Conversion
- ○ Carbonate CO_2 Removal

○ Secondary CO Conversion
○ MEA CO_2 Removal
○ Methanation CO Removal

(5) Ammonia Synthesis

(6) Compression

(7) Air Separation

4.1.3 Nitric Acid Plant

In the Nitric Acid Plant, ammonia from the Ammonia Plant is mixed with air and oxidized in the presence of catalysts to form nitrogen peroxide, which is in turn absorbed in water to produce nitric acid.

The capacity is 172.4 T/D in terms of 100% nitric acid. The concentration of nitric acid formed is 55 wt%.

4.1.4 Ammonium Nitrate Plant

In the Ammonium Nitrate Plant, ammonia from the Ammonia Plant and nitric acid from the Nitric Acid Plant are combined to form ammonium nitrate solution, which is concentrated and passed into the respective prilling towers for fertilizer and ANBA. In the towers, the charges are air-cooled by their respective coolers and then coated to prevent moisture absorption for the production of prilled ammonium nitrate for use as fertilizer and ANBA. The capacity is 166 T/D for fertilizer and 39 T/D for ANBA.

4.1.5 Auxiliary Facilities

Pumps at the Water Intake Station send water obtained from the Kafue River (3km away), into the Water Treatment Section in the plant. The water is used as cooling water and after being treated, is fed to the plant to be used as process (filtered) and demineralized water.

Independent boiler and waste heat recovery boilers attached to facilities produce steam for use in the plants.

A main substation in the plant compound receives 6.6 KV-electric power distributed by ZESCO.

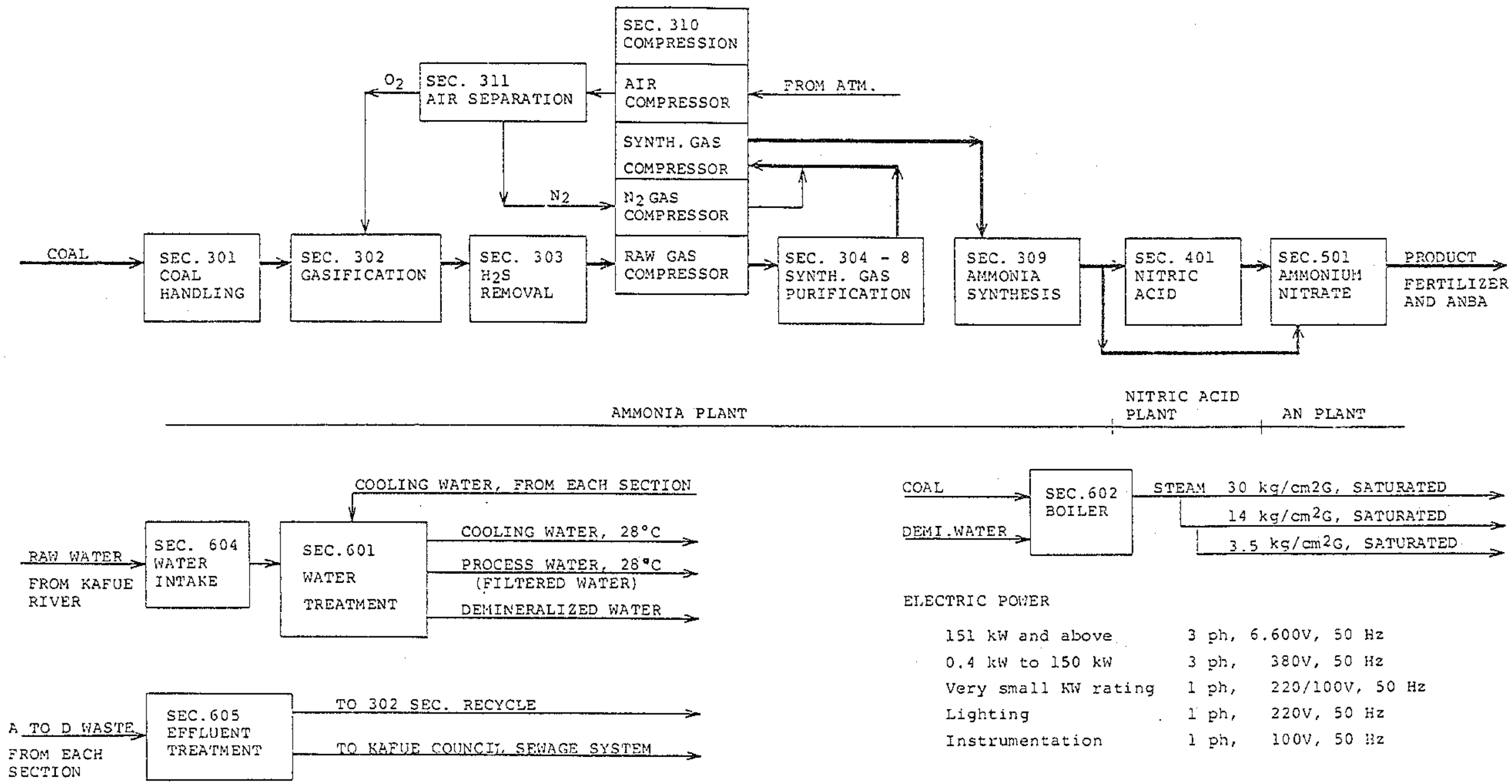
General specifications of the auxiliary facilities are ;

(1)	Water Intake Station	500m^3/H
(2)	Water Treatment	
	○ Capacity	500m^3/H
	○ Cooling Tower	3,400m^3/H
	○ Demineralized Water	40m^3/H
(3)	Boiler	32kg/cm^2G, 13T/H
(4)	Effluent Treatment	
	○ Capacity	630m^3/H
(5)	Electricals and Instrumentation	as required
(6)	Emergency Power	375KVA, diesel engine generated
(7)	Laboratory	
(8)	Workshop	

(Detail process description)
Refer to Appendix 7.

Fig. 4-1 NITROGEN CHEMICALS OF ZAMBIA Ltd.

GENERAL BLOCK DIAGRAM



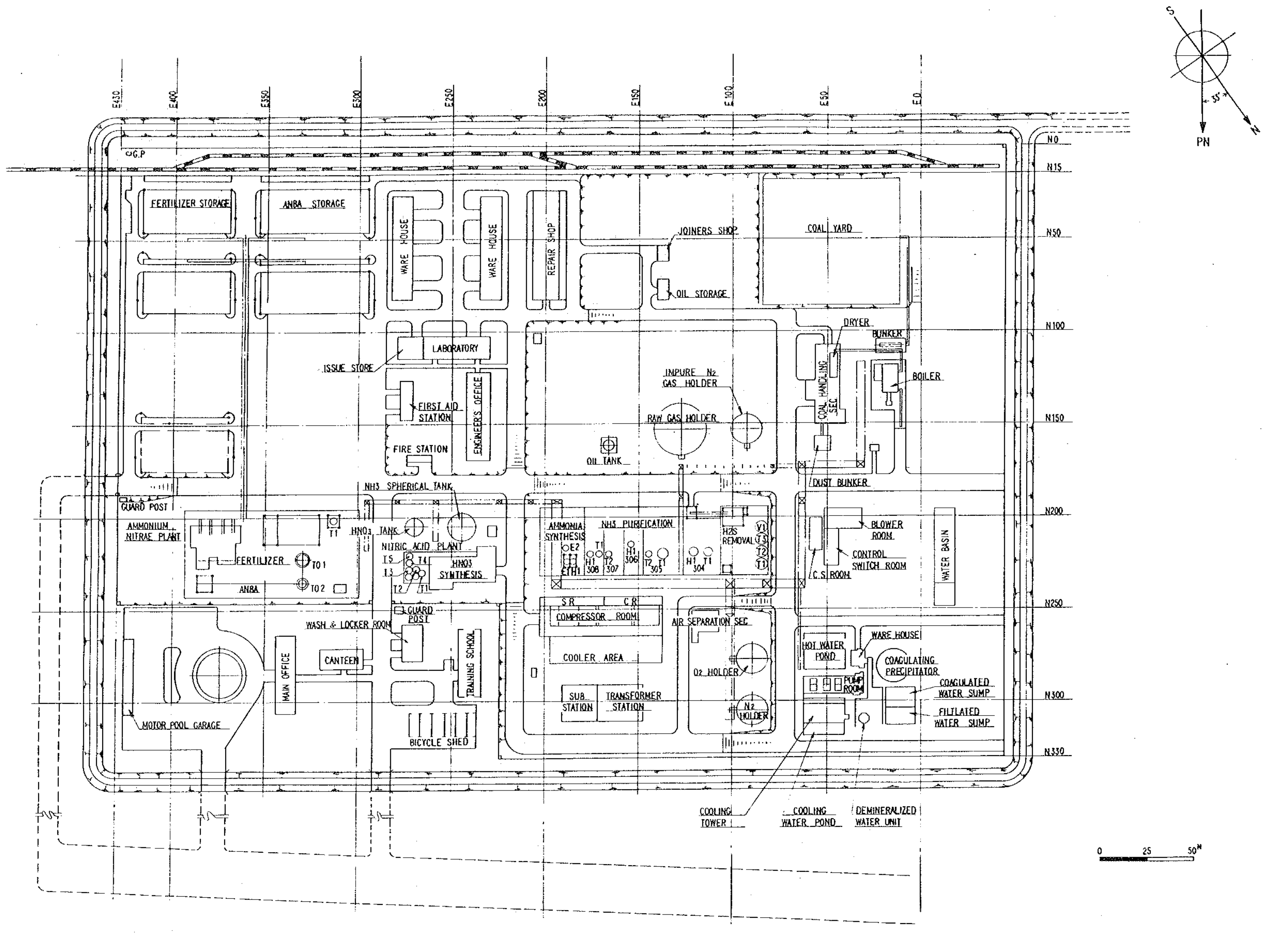
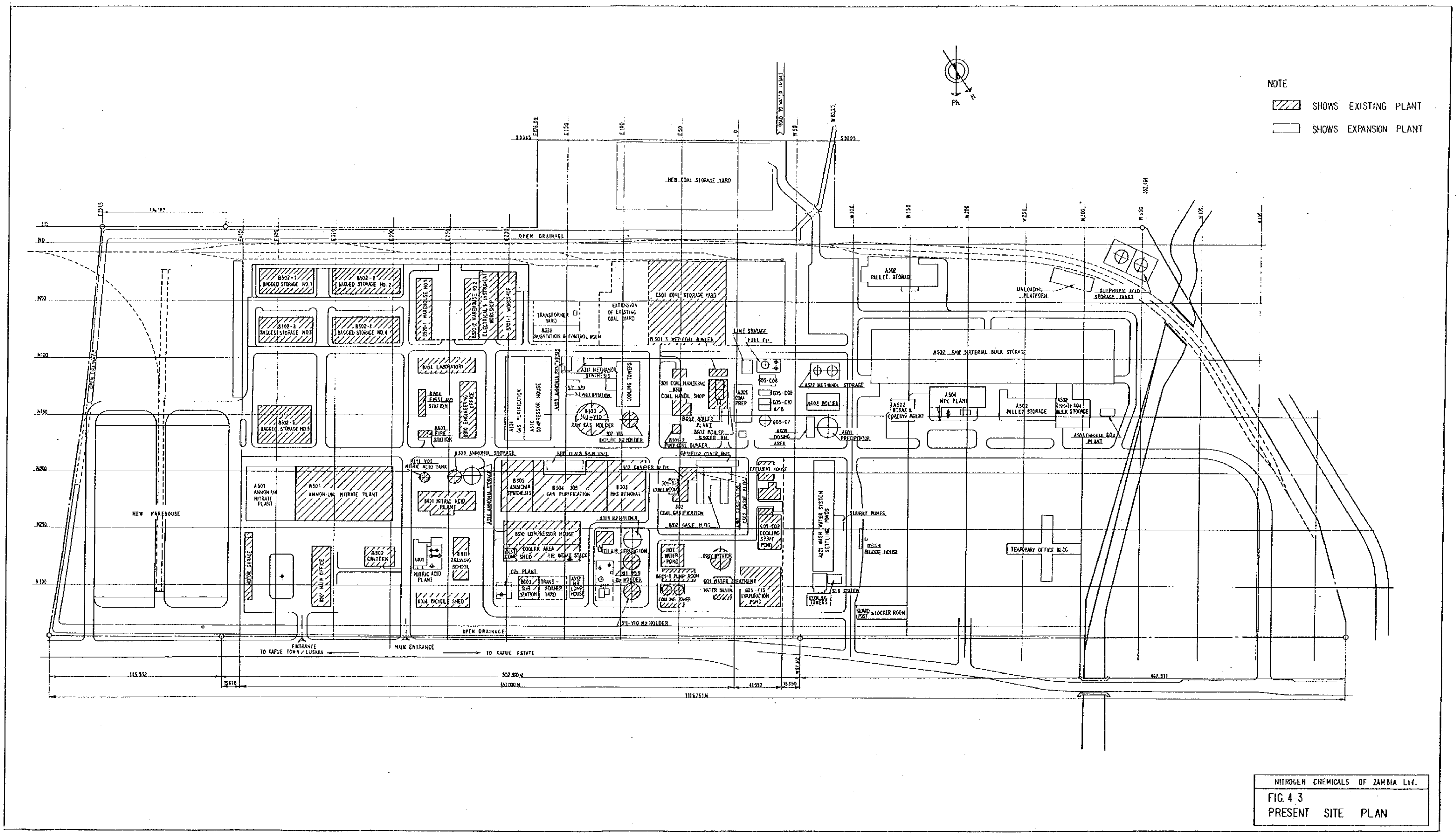


FIG . 4-2
GENERAL LAYOUT OF NCZ



NITROGEN CHEMICALS OF ZAMBIA Ltd.

FIG. 4-3
PRESENT SITE PLAN

4.2 Present Conditions and Problems of the Existing Plants

4.2.1 Outline

Ten years have passed since the start of operations in 1970. Some pieces of equipment are as much deteriorated as expected from that period of usage and others considerably more. The Coal Handling Section and H_2S Removal Section in the Ammonia Plant are heavily deteriorated. The Nitric Acid Plant and Ammonium Nitrate Plant are heavily corroded.

The Nitric Acid Plant is expected to pose a safety problem and requires careful operation at all time and repairs in the immediate future.

The plants, viewed as a whole, may continue to be used for another four to five years if they are repaired partly every year, but the later the repairs take place, the more time and materials it will need.

As shown in Table 4－1, the quantity of ammonium nitrate produced for the fiscal year 1979 decreased to about 47,000 tons or 78% of the design capacity because of a lowered plant operation rate brought about by the deteriorated equipment and because of a degradation of coal used. The annual production has been downward each year since 1973 when the peak was reached at 53,400 tons and is expected to experience rapid decline from now on.

The present conditions of facilities and their problems are detailed in the following section. For reference, Table 4－2 outlines :

(1) Design Capacity

(2) Present Capacity

(3) Expected Capacity

(4) Operation Rate

(5) Problems

Table 4-1 Nitrogen Chemicals of Zambia Limited

Statement of Production

(Figure in T.)

Financial Year Quarter	Ammonia	Nitric Acid	Fertilizer	Dense	Porous	Total Ammonium Nitrate
TOTAL FOR THE YR. 1971-1972	15,000	25,400				32,500
TOTAL FOR THE YR. 1972-1973	14,300	24,500				29,300
TOTAL FOR THE YR. 1973-1974	26,400	48,400				53,400
April 1974-March 1975						
1st Qtr.	6,038	10,667	5,651	2,451	3,779	11,881
2nd Qtr.	7,420	13,570	8,820	3,763	2,714	15,297
3rd Qtr.	6,727	12,372	3,415	4,335	5,797	13,547
4th Qtr.	5,913	11,016	5,259	300	5,827	11,386
TOTAL FOR THE YR.	26,098	47,625	23,145	10,849	18,117	52,111
April 1975-March 1976						
1st Qtr.	3,492	6,367	426	2,597	3,575	6,598
2nd Qtr.	6,459	11,491	8,163	2,176	2,303	12,642
3rd Qtr.	6,323	11,507	4,098	3,223	5,544	12,865
4th Qtr.	6,116	10,969	4,431	2,515	5,177	12,123
TOTAL FOR THE YR.	22,390	40,334	17,118	10,511	16,599	44,228
April 1976-March 1977						
1st Qtr.	3,448	6,697	826	2,713	3,248	6,787
2nd Qtr.	7,670	14,126	8,813	3,571	3,519	15,903
3rd Qtr.	6,826	12,378	4,665	2,485	6,322	13,472
4th Qtr.	6,439	11,631	8,559	1,344	3,025	12,928
TOTAL FOR THE YR.	24,383	44,832	22,863	10,113	16,114	49,090

Financial Year Quarter	Ammonia	Nitric Acid	Fertilizer	Dense	Porous	Total Ammonium Nitrate
April 1977-March 1978						
1st Qtr.	5,395	9,735	4,268	2,085	4,042	10,395
2nd Qtr.	6,335	11,900	7,857	2,756	2,371	12,984
3rd Qtr.	5,841	10,651	6,590	2,356	2,410	11,356
4th Qtr.	6,383	11,829	4,630	3,585	4,547	12,762
TOTAL FOR THE YR.	23,954	44,115	23,345	10,782	13,370	47,497
April 1978-March 1979						
1st Qtr.	4,815	8,924	3,550	2,357	3,579	9,486
2nd Qtr.	7,126	12,565	9,059	1,962	2,877	13,898
3rd Qtr.	6,401	11,470	8,432	1,826	2,701	12,959
4th Qtr.	6,428	11,711	8,391	1,560	2,506	12,457
TOTAL FOR THE YR.	24,770	44,675	29,432	7,705	11,663	48,800
April 1979-March 1980						
1st Qtr.	6,680	11,920	5,970	4,210	3,508	13,688
2nd Qtr.	4,027	7,988	6,005		1,693	7,698
3rd Qtr.	6,846	12,371	5,363	4,621	3,485	13,469
4th Qtr.	6,326	11,414	8,964		3,161	12,125
TOTAL FOR THE YR.	23,879	43,693	26,302	8,831	11,847	46,980
April 1980-Dec. 1980						
1st Qtr.	5,921	11,105	2,614	5,283	3,575	11,472
2nd Qtr.	2,149	3,744	2,691		928	3,619
3rd Qtr.	5,757	10,651	4,319	2,360	4,109	10,788
TOTAL FOR NINE MTHS.	13,827	25,500	9,624	7,643	8,612	25,879

Table 4-2 Present Conditions of Facilities

*1 Capacity : Represented by production per day

*2 Operation rate : Actual operating days/planned operating days (%)=(planned operating days−nonoperating days due to trouble)/planned operating days (%), derived from the performance over the past one to two years.

*3 Expected capacity : Capacity expected if external causes, machine trouble, etc. are eliminated.

Facilities	Design Capacity	Present Capacity	Expected Capacity	Operation Rate	Problems
Coal Handling	Coal 6.6 T/H	Coal 8 T/H	Coal 8 T/H	92%	1) A change in coal specification has made the handling capacity in sufficient. As designed (Shiankandobo coal) / As is (Maamba coal) Carbon (elemental analysis): 85.90% / 69.4% Volatile component (proximate analysis): 20.00% / 21.7% Ash (proximate analysis): 16.95% / 17.1% 2) All the instruments are in faulty condition and the dryer is operating insufficiently. This makes the raw coal high in water content and of unstable quality, resulting in a lot of carbon burnt imperfectly in the Gasification. 3) Leaked fine coal accumulates on the moving portions of the equipment, which is a cause of wear there.
Gasification	Gas 10,600 Nm^3/H (NH_3 95.3 T/D)	Gas 8,500 Nm^3/H (NH_3 85 T/D)	Gas 8,500 Nm^3/H (NH_3 85 T/D)	97%	1) Lowered quality of raw coal and its higher moisture content produce more accompanying clinker from the ash, which accumulates in the gas line and finally closes it. This increases the pressure inside the furnace and makes it inoperable.

Facilities	Design Capacity	Present Capacity	Expected Capacity	Operation Rate	Problems
Gasification (Continued)					2) Operation at gas flow of 9,000 to 9,500 Nm^3/H increases the furnace internal pressure to the point at which operation is no longer possible. 3) A standby furnace is available and used alternately realizing a high operation rate of the Gasification.
H_2S Removal	Gas 10,600 Nm^3/H H_2S at outlet 3 ppm	Gas 8,500 Nm^3/H H_2S at outlet 800 ppm	Gas 10,600 Nm^3/H H_2S at outlet 3 ppm		1) Faulty preparation of desulphurizing and absorbing solutions contributed to ineffective desulphurization. Setting / Present $NaVO_3$ 1.5g/l / 0.5g/l ADA 5.0g/l / 1.5g/l 2) The circulating solution containing a lot of H_2S has corroded the equipment very much. 3) The deteriorated filtering equipment is not capable of fully recovering the sulphur content of the circulating solution and the free sulphur blocks the absorbing tower packings.
Gas Purification and Ammonia Synthesis	NH_3 95.3 T/D	NH_3 79 T/D	NH_3 95.3 T/D	85%	1) The operation rate is low because of power failure and trouble on the upstream facilities. 2) The catalyst bed of the primary shift converter is clogged and produces a great differential pressure, lowering capacity. Design capacity can be realized again if the catalyst is repl aced and raw gas is fed in sufficient quantities. 3) The potassium carbonate regenerator tower is operated in a faulty condition and the equipment is in an advanced state of corrosion. 4) The instruments have deteriorated and can not show the correct operating condition.

Facilities	Design Capacity	Present Capacity	Expected Capacity	Operation Rate	Problems
Nitric Acid Plant	HNO_3 172.4 T/D	HNO_3 150-160 T/D	HNO_3 172.4 T/D	98%	1) Because of shortage of raw ammonia, the production capacity is reduced. 2) The cooler is corroded and clogged, which reduces the plant capacity and make it impossible to maintain set operating conditions. 3)The eqipment is corroded to a considerable degree.
Ammonium Nitrate Plant	For ANBA 39 T/D For Fertilizer 166T/D Total 205T/D	AN 205 T/D	AN 205 T/D	every day stopped due to minor troubles.	1) Given an adequate supply of raw material, the plant can be operated at its design capacity. 2) Bagging and weighing machines are broken. 3) The mother liquor line filter has been removed. This causes frequent clogging of the prilling nozzles. 4) Crystals adhere to the prilling tower bottom. 5) The troubles above are corrected by resorting exclusively to abundant manpower. 6) The equipment is corroded in a considerable extent.

4.2.2 Ammonia plant

4.2.2.1 301Coal Handling

(1) Production and Capacity

The plant is now operated at the rate of around 8 T/H (design : 6.6 T/H) wet coal containing 8% or so of water. This is not adequate to the original rated capacity because of a degradation of coal used, but it is regarded as having a capacity capable of meeting the present level (85 T/D) of ammonia production.

(2) Operation Rate

The operation rate averaged 91.8% for the period from the fourth quarter of 1978 to the third quarter of 1980 ; out of 15,408 hours available excluding periodic repair periods, 14,152 hours were actually used.

Principal causes of suspended operation include power failure, cleaning of coal dust, breakdown of weighing feeder and conveyor, and clogging of coal dust line.

(3) Present Operating Conditions

A lot of dust accumulates throughout the plant. Most of that dust is coal dust and originates mainly from :

(a) Inlet of the ball mill

(b) Inlet of the rotary dryer

(c) Inlet of the lime supply

(d) Inlet of the fuel coal to the dryer

The dust contaminates the working area and also causes the moving portions of machines to be worn with the result of shortened useful machine life. Besides, it may cause fires.

The dust can be prevented from spreading by installing a dust collector for local dust removal at each of the sources above. The capacity recommended is around 100m³/min for these points.

The instruments on the control room panel are in bad shape, and it is no exaggeration to say that they are almost totally unreliable. The present manual control needs to be replaced by the former automatic control by instruments.

To assure a more stable operation of this plant, stable operation of the dryer is the first requisite, which in turn requires the instruments above to be repaired.

4.2.2.2 302 Gasification

(1) Production and Capacity

The Gasification, making raw gas from coal for the production of 95.3T/D ammonia, was originally planned and built on the design assumption that it used Shiankandobo coal with the composition ; 85.90% carbon, 20.00% volatile matter and 16.95% ash. However, Shiankandobo coal was found to be difficult to obtain and Wankie coal of about the same quality was used instead for the guarantee test. This test showed that the plant produced 10,000Nm³/H raw gas using an average of 6,600kg/H coal (when dry) for the subsequent production of 100 T/D ammonia.

In the follwing commercial operation, the plant has been using Maamba coal mined in Zambia.
Compared with Wankie coal, it contains 20% less carbon and has contributed to lowering the plant's gasifiication efficiency to approximately 66%.

Judging from the past ten years of operating performance at NCZ, it is possible to operate the plant at the rate of 9,000 to 9,500Nm³/H raw gas for seven to ten days. However, this rate of operation requires a supply of coal at the rate of about 9 T/H or nearly at the upper limit of the coal feeding screw conveyor capacity. Besides, it will result in ash clinker blocking the gas passage, the gasification furnace internal pressure rising and eventually the eguipment having to be stopped.

For the reason, from the point of view a long-range operation, it is advisable to operate the plant at the rates ; 8,500Nm³/H of raw gas formed and about 8 T/H of coal fed, namely,85 T/D in terms of ammonia produced.

(2) Operation Rate

The present operation is at around 8, 000Nm³/H ; of 5,136 hours available in the period from September, 1979 to March, 1980, 5,010 hours were actually utilized for a very good operation rate of 97.6%.

The standby gasifier, constructed in 1978, is contributing to a stabilized operation of the plant.

(3) Present Condition of Equipment

Cooling washer and Water separator have been repaired by NCZ and pose no problem. Water leaked from Gasifier through its water jacket but this was solved by changing the jacket material from SB to SUS and installing an expansion joint. Repairs or replacements are necessary for the connection between Radiation Boiler and Tubular Boiler, and for Tubular boiler and for Theisen Washer.

(4) Operation

The gasification plant capacity is closely related to its raw material handling capacity or the Coal Handling capacity.

As a result of a substantially deteriorated unit consumption of coal due to the use of Maamba coal, the gasification plant stays low in its production, although the Coal Handling is operated beyond its specified handling capacity of 6.6 T/H. This overload operation of the Coal Handling of a long duration makes the particle sizes of the coal dust coarser, thus not only aggravating the gasification efficiency, but also lowering the Gasification operation rate through increased unburnt coal dust and having serious adverse effects on the subsequent processes. All these unfavorable factors combine to decrease the output of ammonia.

According to the Gas Plant Efficiency Test Run Report of the test conducted by NCZ in October, 1973, the gasification plant was capable of producing 8, 400 to 9,280 Nm³/H raw gas for ammonia synthesis, and the ammonia output and the unit consumption of coal were 77.9 to 86.97 T/D and 1.790 to 1.889 coal T/NH_3T, respectively.

To improve this plant performance and increase its operation flexibility, NCZ commissioned the standby Gasifier in January, 1978. Intended for the use of Maamba coal as the raw material, this standby Gasifier was naturally designed to have a coal consumption larger than that of the original Gasifier. However, since it also depnends on the Coal Handling capacity for its own capacity and is forced to operate with coal supplies inferior than are specified, it is incapable of full efficiency. On the other hand, the Coal Handling is required to operate under overload conditions, and this makes the grain sizes of the coal dust coarser and still worsens the gasification efficiency of the standby Gasifier.

Fortunately, a new Coal Handling commissioned by NCZ will start operation soon. When the coal dust made by this expansion plant is fed to the original and the standby Gasifier and when the overload conditions of the existing Coal Handling are removed, the operating conditions of the Gasification are expected to be improved considerably.

(5) Stable Operation

As a general rule, it is hard to have a uniform quality of low-grade coals including Maamba coal. In operating Gasifier, therefore, it is necessary to have a full understanding of the manipulating variables and change them as required by the quality of the coal used, namely, to establish the operating know-how.

As things stand now, the standby Gasifier, built in 1978, is contributory to stabilized operation of the Gasification as a whole, but in times of tuouble, many instances apparently have been experienced where the switch to the standby Gasifier was not smooth enough, which worked to the detriment of stable operation of the succeedng Gas Purification and Ammonia Synthesis.

As indicated in Table 4−4, the major causes of stoppage of the Gasification Section is the clogging of its lines with slag and fly ash. It is extremely difficult to completely prevent this clogging but as a countermeasure, maintenance must be provided where slag and fly ash are apt to accumulate, so that the number of suspended operations due to clogging and wear can be reduced.

(6) Joint between E01 and E02

The gas line joint between Radiation Boiler (E01) and Tubular Boiler (E02)and the surface of the tubular boiler tubesheet have been eroded by fly ash severely. Discussions were held to take some measures, but considering that removing the problem thoroughly will necessitate changing the flow line and reducing the fluid velocity and thus remodeling on a large scale, the problem should be taken care of later on, separately from the context of the present rehabilitation plan.

The gas flow straightening vanes now are removed but should be replaced immediately since the removal has probably aggravated the corrosion. Inciedntally, the vanes should be considered consumable spare parts.

(7) Instruments

The instruments have all become deteriorated and need replacing. Their irregularity and unreliability prevent the operators from establishing the operating know-how and operating the plant with care. Unless replaced, they would reduce operation rate as well as plant safety.

4.2.2.3 303 H_2S Removal

(1) Production and Capacity

The H_2S Removal was designed and built to handle 10,600 Nm^3/H of raw gas with 0.92% H_2S content and bring down H_2S to 3 ppm at its outlet.

In the guarantee test, the H_2S conentration was 0.36 to 0.6% at the inlet and was as designed at the outlet. Since then, the plant has been operated for ten odd years, but the composition of the desulphurizing solution is not well adjusted and this causes HS^{-1} to remain in the solution and results in poor desulphurization rate ; exceeding 800 ppm at the outlet.

What is more, because of the circulating solution still having sulphur in it, sulphur adheres to the wood grids of the absorbing towers and blocks the towers. Also,HS^{-1} in the solution has corroded the piping and the equipment severely throughout the section.

Keeping the solution compostion correct will alleviate the corrosion.

(2) Operation and its Rate

As mentioned above, the composition of the solution is far diverted from the design figures particularly, about 0.5 g/l against the design value 1.5 g/l for sodium vanadate and about 1.5 g/l against the design value 5.0 g/l for ADA. This prevents V^{+5} in the solution from promoting the reaction $H_2S \rightarrow HS \rightarrow S$ and leads to operation with HS^{-1} remaining in the solution. At pH 8.2, if HS^{-1} is 5.5 ppm, H_2S won't fall below 100 ppm.

The operation rate of this plant is very high as it is stopped only when it goes through the periodic maintenance, and cleaning of the wood grids once-a-year.

(3) Present Condition of Equipment

Because operation is going on in the severely corroded conditions as mentioned above, the absorbing towers have been corroded and their wood grates clogged excessively.

To remove sulphur in the solution, a filter press is used but the solution leaks.

Overall, considerable measures have been taken but belatedly in every case. Because of this, the equipment are damaged. They need to be repaired on a large scale.

4.2.2.4 304 through 309 Gas Purification and Ammonia Synthesis

(1) Production and Capacity

The present load of this plant is about 79 T/D ammonia. The reason for this low load is the deteriorated catalysts in the primary shift converter ; the differential pressure on the catalyst bed at the third stage of the converter has reached 0.5 to 0.6 kg/cm^2, exceeding the design upper limit of $0.5 kg/cm^2$ and making it impossible to increase the load on the plant any further. Replacing this catalyst with a proper one will restore the plant capacity to the original design.

(2) Operation and its Rate

Hot insulation is poor and the pipe fittings are very much deteriorated. The instruments are considerably deteriorated and given insufficient daily maintenance. Since many of the instruments are considered giving faulty readings, the operating condition can not be grasped.

Steam is leaking at many points and the cooling water discharge is not under quantitative control. This suggests a lack of interest in manufacturing costs.

Second Carbonate Reboiler and Preheater A (306) are operated outside the range of the set conditions, and thus the tubes and the piping adjacent to them are corroded.

Operation is liable to be suspended due to power failure and equipment troubles ; in 1980, suspension took place for 43 days because of such external factors as trouble on the upstream side of the plant and power failure, and for 3.5 days owing to internal factors related to piping, equipment failure, etc. , thus for a total of 46.5 days for an operation rate of about 85%.

(3) Present Condition of Equipment

Insulation material is deteriorated on many equipment. Corrosion and discoloration of outer casings are conspicuous. Degradation of cast-iron and steel equipment is particularly noticeable. Many of the instruments, carbon steel pipes, piping supports are degraded. Steam traps which function satisfactorily are few. Deterioration such as excessive corrosion is promoted by faulty control of the cooling water quality, unattended deviation in operating conditions from the set values, etc.

(4) Operation

Table 4−3 sums up the actual ammonia output for the year ended December 31, 1980 on the basis of the NCZ log sheets.

(Annual Production) Estimating the annual ammonia production from this table,

$$\left.\begin{array}{r}192 \text{ days} \times 80.2 \\ 98 \text{ days} \times 44.9 \\ 12 \text{ days} \times 56.8\end{array}\right\} \quad 20{,}480.2 \text{ T/Y} + \text{shipments in cylinder} \rightarrow \text{about } 20{,}500\text{T/Y}$$

(Operation rate)

The numbers of days contributing to lowered operation rate by factors are :

Due to external factors :

$$98 \text{ days} \times (80.2-44.9) \div 80.2 = 43\text{days}$$

Due to internal factors :

$$12 \text{ days} \times (80.2-56.8) \div 80.2 = 3.5\text{days}$$

These add up to 46.5 days for an operation rate of

$(1-46.5/300) \times 100 \fallingdotseq 85\%$.

Table 4-3 Operation Data of Gas Purification and Ammonia Synthesis Section

(1980)

Month	Normal Operation			Stoppage due to External Factor			Stoppage due to Internal Factor			Remarks
	Days	Av. Daily Product	Max. Daily Product	Times	Days	AV. Daily Product	Times	Days	Av. Daily Product	
Jan	28	82.3	84	2	3	58.9	0	0	—	
Feb	15	*	*	10	14	*	0	0	—	
Mar	20	79.2	81	7	11	48.3	0	0	—	
Apr	19	79.9	86	8	11	42.7	0	0	—	
May	20	84.3	88	7	11	43.3	0	0	—	
Jun	15	83.7	85	5	5	74.1	0	0	—	
Jul	Annual shut-down (total 66 days)									
Aug	4	*	*	2	3	*	0	0	—	
Sept	21	74.5	80	9	9	41.0	1	1	69.3	
Oct	17	80.2	81	5	7	35.4	6	7	46.9	
Nov	14	80.9	84	10	15	49.8	1	1	73.8	
Dec	19	77.2	80	6	9	27.9	3	3	70.2	
	192	80.2	88	71	98	44.9	11	12	56.8	

Note (1) * The output is unknown due to faulty weighing equipment and the average annual production is substituted for calculation.

(2) That part of the NH_3 which was shipped in cylinders by the NCZ was drawn on the upstream side of the measuring equipment and thus was not included in the production above. The quantity shipped this way would stand at an average of 0.1 T/D or less over a year.

(3) The number of days on which shutdown occurred owing to external and internal factors represents the number of days when output was affected.

(4) Production : T/D

(5) Stabilized Operation

The following three factors account for about 80% of the troubles in the Gas Purification and Ammonia Synthesis as shown in Table 4−4. :

(a) Gasification troubles (58%)

(b) Power failures (12%)

(c) Raw gas compressor troubles (8%)

Therefore, if the Gas Purification and Ammonia Synthesis is to be operated stably, the troubles in the Gasification should be remedied immediately. For remedial measures, refer to chapter 4, paragraph 4.2.2.2.

Power failures, often caused by thunderbolts in the rainy season, should be dealt with by the public power utility, etc. because they are beyond the NCZ's control.

To reduce the number of troubles in the raw gas compressor, it is important to overhaul it at regular intervals. The NCZ performed a periodic overhaul every year until it was unable to provide enough maintenance because of spare parts shortages in the past two to three years. It is necessary to get the spare parts and to overhaul.

(6) Raschig Rings on the Saturator (304−T01)

The Raschig rings are frequently replaced ; some in six months on one extreme and others in two and a half years on the other extreme. The water analysis this time found PH 7.55. Even if the water quality is fully checked before purchase, ordinary ceramic rings cannot be expected to withstand use in the presence of high-temperature water for an extended period of time. Judging from the frequency of replacement, stainless steel rings should be substituted. In deciding on the specification for the substitute stainless ring, the saturator performance must be considered.

Table 4-4 Causes of Stoppage (Gas Purification and Ammonia Synthesis Section)

	Cause of Stoppage		Frequency
Gasification	Ash Extractor clogging		13
	Pressure rise on blow pipe		17
	Tubular Boiler clogging		2
	Gasifier internal pressure rise		11
	Others		5
		SUM	48 (57.8%)
Ammonia Synthesis	Synthesis Gas Compressor Valve leakage		4
	Pump trouble		1
	Water Pipe leakage		1
	Heat Exchanger leakage		1
	Instrument trouble		3
	Operational trouble		1
		SUM	11 (13.3%)
Other Facilities	Coal Handling section trouble		1
	Raw Gas Compressor trouble		7
	H_2S Removal section trouble		1
	N_2 purity drop		1
	Raw Gas Holder repair		1
	Cooling Water short		2
	Boiler stop		1
	Electric Failure		10
		SUM	24 (28.9%)
	TOTAL		83 (100%)

(7) Raschig Rings on the Carbonate CO_2 Removal and the MEA CO_2 Removal

The present frequency of replacement is considered unavoidable except for the bottom bed of Carbonate Absorber. As a general rule, ceramic rings last between four and eight years in this type of plant. Because of this, resin rings have often been adopted recently in Japanese—built plants of the same kind. The Raschig Rings for the bottom bed of Carbonate Absorber have been replaced every year, presumably because of the slags accumulating on them that are formed by equipment corrosion.

Use of anticorrosives and solution filters is imperative.

(8) Carbonate CO_2 Removal Section Corrosion

Corrosion is conspicuous on the carbon steel devices, and Nos. 1 and 2 Reboilers in this section. The major reson is no use of anticorrosives starting May, 1974.

Applicable anticorrosives include vanadium, arsenic and chromium but vanadium is most suitable in view of the public hazard problem. If no anticorrosive is used, every wet portion should be constructed of stainless steel instead.

The reason why NO.2 Reboiler, which is designed for less severe operating conditions than NO.1 Reboiler, has been damaged is assumed to lie in overloads ; probably, it has been corroded by raised temperatures (concentrations) of the solution ascribable to more supplies of steam than is required by the design.

The solution here is of such a characteristic that its corrosiveness increases with its concentration. At the time of the first field survey, the temperature was higher by about 5°C on the outer surface of NO.2 Reboiler than on NO.1 Reboiler.

The CO_2 concentration at the outlet of the absorber in this section was designed for 0.8% to 1.0% but stood at an abnormaly low value of 0.55% on February 24, 1981, according to the log sheet. This is probably because of the overloads on the reboiler.

NO.2 Reboiler was provided with a lot of plugs in 1979 to stop leakage from holes due to corrosion on the tubes, and was operated in this way until the tubes were replaced with new ones several months later.

Despite this replacement, new tube bundles were substituted in 1980 and 1981, too. The original tubes lasted about ten years while NCZ-made replacements lasted only several months. The reason probably lies in a faulty selection of material.

(9) Secondary Shift Preheater A Tube Corrosion (306-E01)

The low operating temperatures are assumed to have caused condensates on the tube surface to corrode it. Considering many instances of trouble on the upstream side, very low load operation and short stop-restart time, the tubes should be made of stainless steel.

(10) Catalysts

All of the CO conversion, methanation, ammonia synthesis catalysts become deteriorated in a short time compared with their performance in Japan, probably because of a lack of steady plant operation. Abnormally high frequencies of plant shutdown, variation in the quantity handled during operation, etc. will cause the catalyst beds to change in temperature and pressure and deteriorate catalyst performance considerably. Furthermore, they will become more prone to cause entrainment from the proceeding process and promote pollution of catalysts and lower their strength.

The primary CO converter experienced a sharp rise in the differential pressure in the catalyst bed between 12 : 00 and 14 : 00 hours of October 14, 1980, according to log sheet. Since the log sheet mentioned no other abnormalities than the increased differential pressure, the reason can not be pinpointed. Nevertheless, the field survey this time produced the results as shown in Table 4-5 ; the differential pressure on the third catalyst bed was 0.5 to 0.6 kg/cm^2, exceeding the design upper limit of 0.5 kg/cm^2 and making it impossible to increase the load on the converter any further.

The NCZ record shows that the catalysts were all replaced simultaneously on the first, second and third beds. Generally speaking, catalysts for a converter of this kind become deteriorated most early on the first bed operating under the most severe conditions and those on the second and third beds lasts about twice as long, unless the converter is subject to some serious, faulty operation.

The sharply increased differential pressure on the third bed suggests that the converter has been in some abnormal condition or subject to some serious, faulty operation.

The possible reasons are :

(a) Wrong readings on faulty differential pressure instruments

(b) Broken catalyst support

(c) Foreign matter mixing with the thirdbed catalyst

(d) Deterioration of catalyst due to contaminating condensates

(e) Blocked second desuperheater

It is necessary to check the converter for these possible faults with care. For the purpose of preventing catalysts from deteriorating, stable operation of the plant as a whole is most important, and this in turn makes it essential to operate it according to the operation manual and minimize the number of plant shutdown. In any case, 80 odd shutdowns a year must be reduced by all means.

Table 4-5 Differential Pressure of Primary Shift Converter

kg/cm^2

	1st Run	2nd Run
1st Bed	0.21	0.19
2nd Bed	0.29	0.31
3rd Bed	0.50	0.60
Total	1.00	1.10

Note 1) Date: March 4, 1981
2) Raw Gas Flow: 9,600Nm^3/H
3) Steam Flow: 6,960kg/H

(11) Devices inside the Ammonia Synthesis Converter

At the time of the field survey, the operating conditions were : The temperature at the catalyst bed inlet varied widely and in a totally irregular manner in the 350 to 500°C range, the catalyst bed temperature fluctuated considerably on the first bed, and temperatures in other points, loop pressures, quantities of raw gas received, etc., were also unstable.

The internal devices now in use were installed in May, 1976. The catalysts charged at that time consisted of TOPSO new, BASF leftovers from those charged in 1973 and BASF second hands. After being used until July 1980, they were replaced with BASF new catalysts. Therefore, at the time of the field survey, the converter consisted of ; the internal devices which had been used since May, 1976 and the catalysts since July, 1980.

For reference, Table 4-6 gives four operating data ; at the time of the commission, before and after the catalyst replacement in July, 1980, and at the time of the 1st field survey in February, 1981. The reason for the temperature variation could not be pinpointed at the 1st field survey because many instruments were faulty and the readings on the functioning instruments were not totally reliable. However, the major probable reasons are largely twofold : (a) and (b)

(a) Short Passes inside the Synthesis Converter

Expected short passes are subdivided into two : 1) and 2)

1) Short passes of shell cooling gas from the hot insulation cover sheet to the catalyst bed inlet, in which case the operational values will be affected in the following way.

① The catalyst bed temperatures vary, the bed inlet temperature in particular being greatly affected.
② The tight-pressure barrel surface temperature is affected if leakages are great.
③ The gas flow rate is affected if leakages are great.

According to the operational values and data obtained at the 1st field survey, phenomenon ① was conspicuous; sometime the catalyst inlet temperature varied by 50 to 100°C. Also, phenomena ② and ③ were indicated but without wide variations. If phenomenon ① is attributable solely to leaks from the hot insultation cover, it will be accompanied by phenomena ② and ③ considering the heat balance involved.

2) Short passes from outside the catalyst pipes to the inside.

Leakage from the catalyst pipe connection at each stage and from the internal heat exchanger connection is expected. If that occurs, the operational data will indicate ;

① The catalyst bed temperature fluctuates.
② The synthesis converter performance lowers. Apparent catalyst deterioration advances quickly.
③ It become difficult to keep the first-stage hot spot under control, because the first-stage SV becomes smaller.

The operation data for February and March, 1981 shows that the synthesis converter performance fell exessively below the level justifiable for the catalysts replaced in July, 1980 and put into use during the last ten days of August that year. Also all phenomena ①, ② and ③ are indicated ; fluctuations in catalyst bed temperatures and abnormally high temperatures at the first stage hot spot.

(b) Variation in Operating Conditions

Particularly, variation in the quantity of raw gas received leads to temperature fluctuations in the synthesis converter. On the other hand, the variation is caused, among other things, by the current method of operation in which the quantity of gas received is controlled by pressure alone.

The synthesis converter temperature variation is considered to be due to the two factors above combined.

The short passes inside the converter are probably due to the abnormally frequent converter shutdowns. The number of shutdowns must be minimized because shutdown causes pressure and temperature variations that are possible hazards damaging the internal devices

Although in a lesser degree than shutdowns, the temperature and pressure variation due to the fluctuating quantity of raw gas received is frequent enough to have adverse effects on the internal devices. Incidentally, in the case of synthesis converters of the same kind operating in Japan under normal conditions, catalysts last five years or more, and internal devices ten years or more.

When it comes to remedial action for the temperature variation, it is necessary to replace the internal devices with a new set. It is difficult to repair them because of their structure and the materials are deteriorated (in an advanced state of nitriding and hydrogenation). At the same time, the hot insulation cover should be replaced with the welded type. Thermal stresses in the internal manifold on the startup heater line can be mitigated with or without (as now) expansion joints. If used, however, the expansion joints have to be of thin thickness, and, given their operating conditions, they may be broken because of deteriorated material. Further, no expansion joints are used for that purpose in synthesis converters of the same kind operating in Japan. For these two reasons, no expansion joints should be adopted.

Table 4-6 Operation Date for Ammonia Converter

Items \ Time		Commissioning	Before change July, 1980	After change July, 1980	1st Survey Feb., 1981
Flow Rate (Nm^3/H)	Circulation Gas	47,500	45,500	46,000	44,300
	Shell Cooling	4,750	5,000	5,000	4,500
	Bottom Gas	20,000	29,000	29,000	26,400
	1st Quench	13,600	—	6,400	(2,200)
	2nd Quench	3,500	4,500	3,200	3,300
	3rd Quench	3,400	3,500	—	3,100
	4th Quench	6,600	—	—	(1,600)
	BFW	4,000	3,500	3,500	3,250
	Purge Gas	550	700	610	620
	Flash Gas	170	54	162	out of order
Pressure (kg/cm^2)	NH_3 Cold Condenser	2.72	1.4	1.4	1.5
	Steam Drum	6.0	6.6	6.0	5.4
	Gas Condenser Outlet	279	315	300	303
	Gas Circulator $\triangle p$	14.2	17.1	15.7	16.5
	NH_3 Condenser $\triangle p$	4.0	—	—	out of order
Concentration (%)	Circulating Gas H_2	66.5	—	63	61.5 (70.3)
	Converted Gas NH_3	23.0	—	—	—
	Purge Gas CH_4	5.6	—	—	— (4.1)
	Purge Gas Ar	9.0	—	—	— (9.98)
	Circulating Gas NH_3	2.5	—	—	— (4.10)
Temperature (°C)	NH_3 Cooled Cond. Gas outlet	0	−4	−11	−1
	Catalyst Tube inlet	440/429	452/455	— /455	455/450
	1st above	548/532	545/570	562/567	540/560
	Circulator outlet	29	40	30	38
	Quench Gas	150	138	130	126
	Converted Gas NH_3	332	234	209	199
Liquid NH_3 Production (T/D)		98.18	85.8	80.9	79

4.2.2.5 310 Compression

The four compressors constituting the Compression are disassembled and checked at the periodic repair time every year and are operated without any major problems. The condition of each compressor is as follows :

(1) **Raw Gas Compressor (310−K01)**

Compared with the first-stage discharge temperature, the second and third stage discharge temperatures are somewhat high, and a regular check is necessary for the cooler and the drain separator at each stage.

The inlet filter is operated with the packing removed, because the packing in place is blocked by carbon dust. However, the packing should be restored to its original place.

As a measure against blocking of the dischrge silencer due to carbon dust, oil is now fed into gas on the first-stage suction side. To prevent the oil from adversely affecting the Gas Purification, it is necessary to install an oil separator on 4th-stage discharge side.

(2) **Nitrogen Gas Compressor (310−K02)**

The compressor operates in good condition but vibrates to a somewhat large extent, which, it is claimed, started after the regular repair time last year. Since the compressor will be adversely affected if it is allowed to operate this way for a long period, it needs to be readjusted. Since the foundation is often the reason for this kind of vibration, it should be observed and confirmed for appropriate action, if necessary.

(3) **Synthesis Gas Compressor (310−K03)**

Suction temperatures are higher at the second and third stages. The cooler at each stage needs to be checked at regular intervals.

(4) **Air Compressor (310−K04)**

Operation is in good condition.

4.2.2.6 311 Air Separation

(1) Production and Capacity

In the guarantee test, the planned capacity was demonstrated at ; 3,800 Nm^3/ H of 98.0% oxygen, 2, 850Nm^3/H of 99.99% nitrogen and 5,000 Nm^3/H of 93% nitrogen. For about ten years , Air Separation has been operated without trouble except that the reversing heat exchanger and the check valve were replaced in April, 1976.

(2) Operation and its Rate

Air separation is now operated in a somewhat excessively cooled condition compared with when it was put into operation for the first time, thus dropping the lower - tower pressure somewhat and lowering the purity of oxygen to a level a little lower than the initial value but within the guarantee value of 98% oxygen.

(3) Overhaul of the Devices inside the Cold Box

For ten odd years, these devices have been operated without any overhaul and trouble at all. The reason for no overhaul is probably that it was difficult to stop the devices even at regular repair times. The major reasons behind such a difficulty include :

(a) It is necessary to keep sealing nitrogen for the purpose of protecting catalyst for Ammonia Synthesis Converter, etc.

(b) Nitrogen is required to blow dangerous gases before the devices in the other sections are overhauled. This delays the devices in the cold box for ten days at least before they are stopped.

(c) It takes three to five days to pre-treat (heat) the devices before stopping.

(d) It takes two to three days to attain the normal output after devices are started.

(e) The devices must start to be operated about seven days earlier than those in the other sections.

(f) A regular repair is of one month duration. Given items b) through e), available time for check and repair is only a short period of about five to eight days, barely enough for repairing and cleaning the outside of the cold box.

Incidentally, in the case of the same kind of devices in Japan, pressure and tightness tests are conducted from outside the cold box at the time of regular repair once a year, based on the High Pressure Gas Control Laws. The cold box is opened every two to three years and the internal devices are overhauled.

At the time of regular repair, therefore, the devices inside the cold box should by all means be overhauled, for the purpose of grasping their remaining life and safety.

4.2.3 Nitric Acid Plant

(1) Past and Present

The present plant was designed and constructed as a plant which would produce nitric acid amounting to 172.4 T/D (55%, 310 T/D) by conversion into 100% pure nitric acid. By the data of the porformance guarantee test opreation, it was demonstrated that the production of 100% pure nitric acid 174−175 T/D would be possible, with a unit consumption of 0.2808−0.2815, exceeding ammonia 0.285 T/nitric acid T (100% conversion) of the specification.

Since then, the plant has been in operation for 10 odd years, but, as shown in Table 4−7, no decline has been seen in its performance.However, here and there in the plant severely corroded parts have appeared; the detachment of trays, and leakages from cooling coils and heat exchanger tubes have become noticeable. So it is likely that continued operation under such conditions will result before long not only in a decline in performance but in paralysation of the plant's operation.

(2) Production and Capacity

The nitric acid plant is at present not 100% operational. This is because of the restriction imposed on operations in response to the decreased production of raw ammonia.

By way of illustration, against the specification of 100% pure nitric acid 172.4 T/D, production continues to be 150−160 T/D making an 87−93% operation rate. But even under such restricted production, there are periods, though short, during which the plant is nearly in full operation corresponding to the consumption of nitric acid in the ammonium nitrate plant. The production and consumption shown in Table 4−7 are the data available from log sheets between February 28 and March 2, 1981. If the measured values are correct, the production of 100% conversion nitric acid 58.82 T/H = 176.46 T/D in the 10-6 shift on February 28 supports, though the period was short, that 100% operation is possible.

(3) Stabilized Operation

Table 4−8 shows the time and causes of stoppages occurring in the past one year in the nitric acid plant excluding those attributable to external factors ; the rate of stoppage is 4.88%, or a rate of operation of 95.12%. The causes of stoppage are broadly classified into those due to catalyst change and those due to mechanical trouble. The former took up 235 hours and 25 minutes while the latter 106 hours and 20 minutes. When stoppages due to catalyst changes which are unavoidable for the function of the plant are excluded, the rates of stoppage and operation are respectively 1.5% and 98.5%, representing an extremely favourable condition.

The catalyst is changed around every 4.5 months when output reached 18,000T (100% conversion).

Table 4-7 Nitric Acid Production and Ammonia Consumption

Date	Item		10−6 Shift	6−2 Shift	2−10 Shift	TOTAL
28th Feb. 1981	55% Nitric Acid Production	T	106.95	94.38	100.33	301.66
	Concentration of Nitric Acid	%	55	55	56	
	100% Nitric Acid Production	T	58.82	51.91	56.18	166.91
	Ammonia Consumption	T	16.19	14.53	15.45	46.17
	NH_3^T/HNO_3^T (as 100%)					0.2766
1st March 1981	55% Nitric Acid Production	T	92.70	100.65	99.31	292.66
	Concentration of Nitric Acid	%	55	55	54	
	100% Nitric Acid Production	T	50.99	55.36	53.62	159.97
	Ammonia Consumption	T	14.32	15.50	15.32	45.14
	NH_3^T/HNO_3^T (as 100%)					0.2822
2nd March 1981	55% Nitric Acid Production	T	101.20	97.78	94.92	293.90
	Concentration of Nitric Acid	%	56	57	56	
	100% Nitric Acid Production	T	56.67	55.73	53.16	165.56
	Ammonia Consumption	T	15.58	15.09	14.62	45.29
	NH_3^T/HNO_3^T (as100%)					0.2736

(4) **Present Operating Conditions**

In a comparison with conditions seen at the time of the performance guarantee operation test, the following differences have been noted :

(Rise in the temperature of demineralized water in Demineralized Water Tank)

This is due to the following reason; as the volume of condensate in Economizer is considerable, steam is poured into Demineralized Water Tank, the temperature of demineralized water in Economizer inlet is raised to 60°C to 80°C, and the temperature of the gas in Economizer outlet is raised from the conventional 65°C to 95°C aiming at decreasing the quantity of condensate. A tank for recovery of the condensate has been newly fitted to the outlet of Economizer, and it gathers the condensate as weak acid of about 18% concentration. This condensate is transferred to Absorption Tower together with another weak acid of 34 to 37% concentration belonging to another system.

Table 4-8 Time and Causes of Stoppage (Nitric Acid Plant)

Year, Month		Cause of Stoppage	Total
1981	Jan	Due to PO 1A&B Pumps	29.20
		(Main fuse on Electrical panel blown)	
1980	Dec		0
〃	Nov	Due to change of catalyst	13.00
〃	Oct	Due to Burner jacketing	22.00
		Due to catalyst change and Ammonia limitation	97.00
〃	Sep	Due to steam leak from the burner dome	30.00
		Jacketing pipe because of cracks	
		Due to steam leak from 15kg/㎠ steam	25.00
		export header safety valve flange	
〃	Aug	Annual Shut-down	
〃	Jul	Annual Shut-down	
〃	Jun		0
〃	May		0
〃	Apr	Due to change of the catalyst	125.25
〃	Mar		0
〃	Feb		0
			$341^{H}45^{M}$
		Total	$=341.75^{H}$
		Normal Operation Days : $292=7008^{H}$	
		Rate of Stoppage	
		$\frac{341.75}{7008}=0.0488=4.88\%$	

To prevent the high temperature gas being transferred into the oxidation tower, gas is cooled by the cooling coil wound around the liquid separator fitted to the outlet of the cooler, and the temperature is maintained at around 60°C as before.

(Rise in the operation temperature of the oxidation and absorption tower systems)

While the inlet temperature of Oxidation Tower is roughly the same as before, the temperature in the subsequent process rises by 5°C to 10°C or more, and the temperature of the product nitric acid rises from the conventional 24 °C to 34°C. Even if the influence of atmospheric temperature is taken into consideration, cooling is definitely inadequate.

By way of illustration, the cooling coils on the first and second steps of First Absorption Tower are not cooled at all on account of all of them having been blinded to prevent acid leaks, resulting in a rise in temperature by about 5°C above the conventional temperature. As the lower the temperature is, the greater the efficiency of the absorption tower is, step should immediately be taken to maintain the inlet temperature of each tower between 25°C and 30°C.

(Installation of Tail Gas Preheater)

Around 1975 the flange connecting Tail Gas Heater (401－E04) and Economizer (401－E05) was severely corroded by condensate leading to gas leaks. NCZ installed a tail gas preheater on the tail gas inlet side of Tail Gas Heater which should reduce the condensate and conducted remodelling so that the tail gas at 30－35°C is heated by steam to 60－65°C before entering Tail Gas Heater.

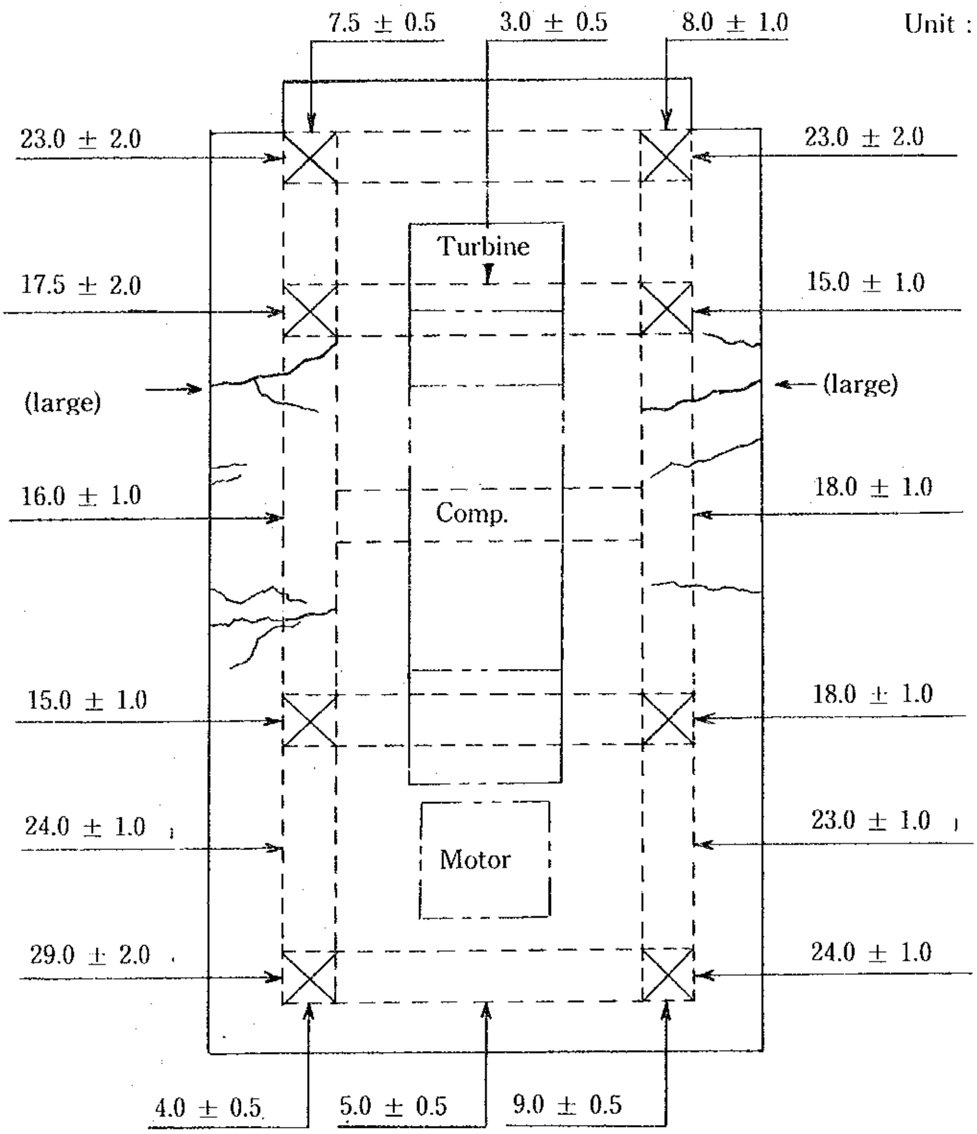
As a result, the advance of corrosion of the connection flange has been slowed down, but gas leaks are still seen to some extent because repairs cannot yet be made. It should be repaired immediately. As it is not desirable for the process for condensate to be generated between Tail Gas Heater and Economizer, the above remodelling is signigicant with respect to decreasing the condensate, little affecting the process adversely. So it is recommended to continue this remodelling after rehabilitation.

(Exhaust gas)

Analysis of $NO+NO_2$ contained in the exhaust gas without being absorbed produced a value of 1,000－1,200 ppm. As this value is about one half of the design value of 2,100 ppm and the favourable condition is now maintained, there are no problems in particular concerning the exhuast gas.

(5) **Foundation of K01 Air Compressor**

The following is the condition of vibrations and the occurrence of cracks detected in the concrete foundation by the first field survey.



As shown above, vibrations were large, registering 29μ at the maximum(the usual allowable value is around 10μ), and as a number of cracks were seen in the part where the compressor is installed, reinforcement of the foundation will be required.

4.2.4 Ammonium Nitrate Plant

(1) Production and Consumption

The total production of ammonium nitrate has been stabilized for these 5 years, remaining at the level of 47,000 T/Y, but a sharp drop was noticed in 1980 because of the stoppage of operation for about two months of the whole factory for periodic repair and linking up with the expansion plant. Relatively stabilized production is seen in ANBA in comparison with fertilizer.

(Unit consumption of nitric acid)
When the nitric acid consumption is simply divided by the production, the unit consumption is increasing year by year. Usually losses in nitric acid consist of loss in handling and loss as ammonium nitrate, and a drastic increase in the unit consumption is unthinkable. As a problem is suspected to exist in the measuring instruments concerning this matter, periodic inspection of flow meters and correction by the actual flow tests should be performed.

(Unit consumption of ammonia)
Ammonia is measured as liquid ammonia and is believed to have been measured accurately, but unit consumption is high as compared with the design value. This is due to the loss of ammonia from the ammonium nitrate solution neutralization and evaporation facilities; the facilities mentioned below are the main sources of such loss :

V03 Adjuster Tank
E09 Preliminary Surface Condenser
E10 Falling Film Evaporator

V03 was supplied with excessive ammonia because of malfunction of the pH meter, and ammonia has been gushing out from the manhole, contaminating the area around the tank.

The pH meter should be repaired or replaced. Also a large quantity of ammonia is lost from E09 as aqueous ammonia.

(Unit consumption of Nuflo−10)
As daily measurement is not carried out, this is not known, but log sheets in June and October, 1980 say that the rate of addition was 0.17−0.18% and was normal. Nuflo−10 involves few problems in connection with its solidification.

(2) **Production Capacity**

The following table shows production conditions :

Table 4-9 Production Conditions of Ammonium Nitrate Plant

T/D

	Design values	Average in Oct., 1980	Average in June, 1980	Instant on Mar.1 1981	Instant on Mar.2 1981
ANBA	39	53	60	15	120
Ferti-lizer	166	93	105	261	186
Total	205	146	165	276	306

A marked increase far above the design value 39 T/D is noted in the production of ANBA, registering 120 T/D (moment) at the maximum. But judging from the operating conditions the temperature of the product is not controlled and the temperature of the cooling air exceeds 32°C. As naturally the temperature of the product is supposed to leave the transition point of 32°C as it was, the above can hardly be said to be correct as the production capacity.

As for fertilizer, production momentarily achieved the design value of 166 T/D on certain days, but a marked decline is observed. This is attributed to the emphasis placed on production of ANBA and suspension of prilling for many hours due to mechanical troubles. Almost everyday the operation is suspended.

Production of the prilling volume as design value of 166 T/D is possible if more than 5 of the 6 prilling nozzles installed can be used, but the record of the use of prilling nozzles in October, 1980 shows that 6 nozzles were used on 5 days, 5 on 2 days 4 on 9 days and on not a few days only 3 nozzles were used. As it is natural that the target volume of production cannot be achieved with three nozzles, steps should be taken to make it possible to use more than 5 nozzles all the time.

(3) **Operation Rate**

(Fertilizer)

Failure to achieve the production target is partly attributable to the low rate of operation.

The log sheets in October, 1980 rarely show a record of suspension of prilling, but judging from the use of prilling nozzles and the records of Falling Film Evaporator (E10), suspension of the plant took place every day.

In the period from October 1 to 20, prilling had been suspended for more than 200 hours.

Records on the causes of prilling suspension and its time are not satisfactorily available, but the following three points are given as the causes of suspension :

(a) Washing out clogging of prilling nozzles

(b) Sticking of AN crystals at the bottom of the prilling tower, and washing to remove them.

(c) Clogging of hopper

The most important problem, in view of increasing the operation rate too, is to wash the clogged prilling nozzles. At present one opeator is stationed constantly to be responsible for washing the prilling nozzel mounted on the top of the prilling tower, but removing the causes of clogging is a matter calling for prior settlement. The cause of clogging is removal of the filter of the ammonium nitrate mother liquor, which should be restored.

(ANBA)

The operation rate of ANBA is almost the same as fertilizer.

(4) **Prilling Nozzles**

The diameter of the prilling nozzles has been enlarged as a result of frequent removal of clogging and washing of them which has further resulted in enlargement of the diameter of the prills of ammonium nitrate for fertilizer and ANBA use. Thus a considerable quantity is not included in the output on account of those prills having become off-grade at the stage of grading of the product with the vibrating screen. Renewal of the prilling nozzles is required.

(5) **Quality**

Study was made of the quality of ammonium nitrate based on the analytical data available from October 2 to 6, 1980 (Table 4-10).

(Sampling)

The process has not been stabilized, resulting in changes in the sampling conditions, but at present sampling is performed at the rate of once for each shift. Analysis is carried out in the analysis room in the factory, and filing and control of the analytical data are frequently done.

(Results of study of analytical data)

(a) ANBA

The rate of oil absorption, the most important point, registers an extremely high value, representing a favourable condition.

The product is well dried at a moisture level of 0.1%. The bulk density (B.D.) is 0.77 −0.78 g/cc, representing a desirable condition. Other analytical values also show good conditions without any particular problems.

(b) Fertilizer

Moisture registers 0.2%, representing a favourable condition.
Sometimes low values are displayed in the pH value, which is a problem. Steps should be taken so as to maintain the pH value at 4.8 or above constantly.

(c) Hardness Index (H.I.)

The same values are shown in the hardness index by both fertilizer and ANBA, suggesting something abnormal. Also, usually a higher value (harder) is shown in this index by fertilizer than ANBA, but these analytical data give the reverse results. As this is thought to be attributable to a wrong method of measurement, correction should be effected immediately.

(6) **Quality Control**

The analysis room is fairly well controlled and the analytical data are also kept in good order which is a good condition. But importance should be attached to operation control rather than control of the analysis room so far as quality control is concerned. In view of the results of the last surveys, attention should be directed particularly to the following aspects concerning operation :

(a) Effecting at the producing area the control of moisture contained in the product.

(b) Making all personnel including those of operator rank fully aware of the extremely high hygroscopicity of ammonium nitrate.

(c) Effecting product temperature control at the producing area. (This is useful for preventing solidification and clogging to keep the product temperature below the transition point of 32°C. The air inlet temperature of the product cooler should be kept at around 15°C.)

Table 4-10 Analysis Data of Ammonium Nitrate

Year 1980

	Date	Moisture (%)	Insoluble Matter (%)	pH	B.D. (g/cc)	Oil Absorption	Size (%)				H.I.
							+8	+10	+14	−14	
ANBA	2, Oct.	0.06	0.35	6.4	0.769	10.8	0.1	10.5	74.3	15.1	—
ANBA	4, Oct.	0.14	0.07	4.9	0.794	12.6	—	14.2	81.4	4.4	99.8
ANBA	6, Oct.	0.10	0.06	4.9	0.781	10.8	—	9.1	86.0	4.9	99.8
Fertilizer	2, Oct.	0.11	0.46	6.4	0.943	—	3.3	16.6	61.6	18.5	99.2
Fertilizer	4, Oct.	0.16	0.05	5.2	0.962	—	—	2.0	27.4	70.6	99.3
Fertilizer	6, Oct.	0.25	0.03	4.0	0.943	—	0.2	8.2	64.7	26.9	98.6

4.2.5 Auxiliary Facilities

4.2.5.1 601 Water Treatment

The Water Treatment consists of the coagulation unit, filtration unit, demineralization unit and cooling tower. The coagulation unit and filtration unit function for the intake of raw water, the demineralization unit for the production of demineralized water for the boiler and the cooling tower for cooling the circulating cooling water.

(1) **Coagulation Unit and Filtration Unit**

The filtration unit was open for repair of the adequate strainer plate, but its capacity is believed to be full. Against its design value of 500 m^3/H, the precipitator of the coagulation unit is used at 200−500 m^3/H. Though it has sufficient capacity, no guarantee is available for feeding in of the chemicals in a correct concentration due to damage of the chemical feed pump and the level gauge of the chemicals adjustment tank. But viewed from the analytical values, it is thought that better effects may be obtained if aluminum sulphate is increased from the current level of 30−40 ppm to 50 ppm and auxiliary coagulant is added by 0.1 −0.2 ppm.

(2) **Demineralization Unit**

Against the design flow rate of 40 m^3/H, the operaction is at present continuing at the rate of 45−50m^3/H, but no problems have occurred practically.

However, it is recommended to increase the time for slow rinse in both the cation and anion towers from the present 2 and 5 minutes to 6 and 20 minutes. As a big delay is seen in the response of the currently used conductivity meter, it should be replaced.

(3) **Cooling Tower**

Against the design values of the quantity of circulating water of 3,400 m^3/H and the quantity of water for replenishment of 153m^3/H, they are actually 3,500m^3/H and 180 m^3/H respectively. The quantity of blow-off is almost null against the design value 95.2m^3/H. This is because any quantity greater than the quantity in the case of blow-off is lost in the course of circulation.

This loss should be reduced and blow-off correctly performed. Though chlorine feeding is performed, only loose control such as 2 tons/2 months is effected. It should be tried to maintain the residual chlorine of 0.5 ppm for 4−6 hours every day. As slime has appeared in the circulation line, an inhibitor should be used.

4.2.5.2 604 Water Intake Station

The Water Intake Station for the expansion plant is in operation, and operation of the same facility for the existing plant was suspended, but it is in a condition ready for immediate use.

4.2.5.3 605 Effluent Treatment

B-effluent from Gasifier, the most harmful among the various kinds of effluents, is transported through pipes to a special lagoon without being discharged into the sewerage. In this lagoon there are small fish swimming, and no problems have arisen.

4.2.5.4 602 Boiler

(1) Out put and Capacity

In the beginning coal was used as fuel, but now the boiler has been remodelled to the coal dust burning system in which oil is partly used. Capacity is 32 kg/㎠G and it is operated usually at 12 T/H, and at 13 T/H at the maximum.

(2) Operation and its Rate

Coal dust is supplied by the facility in which a hammer crusher and a blower are combined. There are two pairs of main burners, 4 in all,and inside the main burners, sub-oil-burners for ignition and auxiliary burning are also installed. Apart from these burners, two other burners are installed one each on the left and right for auxiliary burning. The consumption of coal is not measured and is not known. It is sheduled to stop the boiler for 48 hours every two months and remove clinker attached to the outer surface of tubes as well as coal dust, soot, etc. attached to Economizer. Even during stoppage of the boiler, nothing affects the operation of the plant because an oil-burning rapid start boiler (rated operation available within 30−60 minutes) is used then.

(3) Wear and Tear of the Equipment

Ten tubes of the main body of the boiler were replaced in June, 1978, and no trouble has occurred since then. Supposedly on account of a large quantity of coal dust existing in the burning gas, the impeller of the induced draft fan is badly abraded. After a careful study of material it should be replaced with a new impeller.

4.2.5.5 Instrumentation

(1) General

In the equipment industry, the reliability of the instruments is extremely important for stabilized production and safety of equipment. But in this factory the maintenance and control of instruments are not necessarily satisfactory, and are thought to have shortened the life not only of the instruments, but also of the equipment themselves. It is desired to improve and establish various respects in relation to the maintenance system which is necessary for maintaining a high degree of reliability in the measuring devices.

(a) Management of the Test Instruments

The existence of errors in test instruments which are necessary for adjusting the instruments, sometimes makes the condition of the repaired instrument worse than it was before repair.

The list of test instruments currently owned by NCZ factory is shown in attached Table 4−11. Among these about 30% are thought to be defective, and the environment in which they are stored is not good. There are no reference instruments or standard instruments by which each test instrument could be corrected. No system of controlling weights and measures has been established.

For management of the test instruments, it is necessary to use the method of QC and QA, and to start with the establishment of a system for managing the reference instruments or standard instruments.

(b) Shortage of Tools

There are many defective tools, and there are insufficient tools specifically used for instruments of the Foxboro type.
Under such conditions, it is difficult to conduct perfect repairs and to raise the good results of maintenance. Check/inspection and adjustment of sets of tools should be executed at an early date.

The test instruments and tools which are recommended for keeping are listed in Appendix 8.

(c) Drawing up Work Criteria

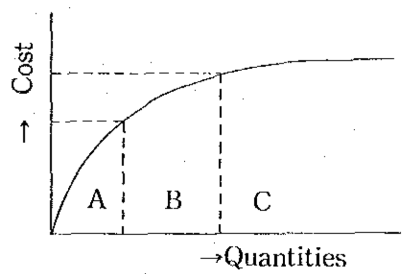
Though maintenance and repair are performed with great enthusiasm, the desired results have not been obtained. It is necessary to prepare a manual in which the order and criteria of work are shown, to familiarise each labourer with it so that they do their work checking the process according to the manual. Works for instruments, however small it may be, contain some very important points, and basic operation, judgement of environmental conditions and experience are rquired. Repairs and adjustments will be performed very smoothly if workers are accumstomed to the correct order of their work.

(d) Training of Trainer

As handling of instruments is the charge of specialists only, it is necessary to train trainers within the company so that training may be given to repair workers and operators.

(e) Stock Control of Spare Parts

Proper stock control is required for the parts necessary for doing repairs. Classification control should be effected by dividing the parts in stock into consumable parts used in large quantities and those parts which are expensive and important. To do so, the method of ABC control is available :



A. Those used in small quantities but are expensive.

B. Those used in quantities greater than the above, but are less expensive.

C. Those used in very large quantities, but the unit value is very low.

As for A and B, prepare a ledger and perform control in the warehouse and the instrument sections.

As for C, a ledger is not necessary. The instrument section accepts and controls them.

The procurement section should estimate the quantity to be consumed in a specific period, and replenish the stock so as not to have a shortage of parts.

At present the control and maintenance of spare parts in stock, and careful arrangement of shelf labels are not satisfactorily performed. Grasp of the correct quantities by means of periodic stock-taking, checking of ledgers and others is essential.

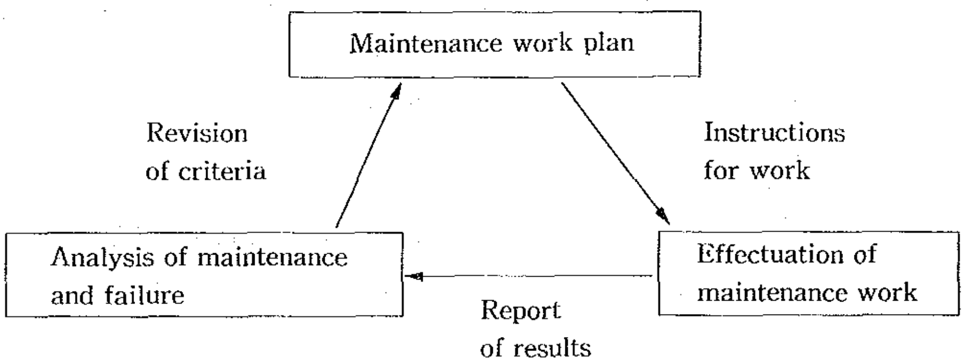
It is necessary to examine shipments strictly upon arrival in the presence of the person responsible for instruments and to keep the records of inspection carefully.

(f) Improvement of Sectionalism

Closely exchange technical information all the time among the operation, machine, electrical and instrument sections. Prepare a maintenance work plan and perform it helping each section. It is necessary to solidify a system of cooperation, in which if any abnormality is found by an operator in any of the meters, instruments or electricals in operation, the conidtion is reported in detail to the section in charge so that proper steps may be taken. If no steps are taken against faults, it will result in the occurrence of a serious accident.

(g) Establishment of a Facility Maintenance Cycle

At present no analytical data about maintenance and failures of not only the instruments but machinery and equipment are available. Neither the form for reporting maintenance work (parts for replacement, method of inspection, etc.) nor the criteria for maintenance, (e.g. items for inspection, the period of inspection, etc.) has been made up. A minute record of maintenance work gives the next maintenance plan reliability.



(2) **Instrumentation**

(a) Panel Instruments

The panel instruments which are vital to operation of the facility are unreliable. What is particularly noticeable is the loss of capability of recording in many recorders due to defects in the recording mechanisms in them. Needless to say, recorders are important instruments which constantly record the conditions of the plant every moment, and provide the data necessary for clarifying the cause at the time of any trouble occurring.

Defects in recording mechanisms of recorders are not due to the ink-introducing system itself and others, but due to wrong handling.

It is urgently urged to train the operators to follow the correct handling process of recorders.

Breakages were found in many of the ink covers of the YEW (Yokogawa Electric Works, Ltd.) Model 54 among panel meters.

This is supposed due to wrong handling when ink is replaced or meters are drawn out.

Many parts of bellows of YEW Models 54 and 52 for use in sections 302, 303−309 are rusty and require replacement.

(b) Model Changes in YEW Instruments

The panel instruments in the NCZ factory are mostly made by YEW, but progress in industrial instruments has made these instruments out of date.

By way of illustration, the NCZ still use some types of instruments, production of which has already been discontinued and parts for which are not available in stock (such as Models 54, 52, 44 and EIH, etc.), or type of which is expected to be discontinued in the near future (in 1984 such as ERB, TIH, etc.).

For defective instruments it has become necessary to replace drastically the currently used instruments with new models for maintenance in the future.

It must be tried to utilize the parts of the instruments replaced as far as possible as spare parts. Taking into consideration the above-mentioned damage and the circumstances necessitating model changes, we are of the opinion that the panel and panel instruments shall inevitably be replaced entirely in each section.

(c) Local Meters

Through periodic inspection, replacement of the gaskets in d/p cell type transmitters, cleaning and adjustment of relays, check of the floats and torque tubes in the displacer type level meters, cleaning of the inside of level meter chambers and calibration of the middle range of level meters are required.

(d) Control Valve

Maintenance is not well performed generally, and many cases of leaks and poor response capability were found.

Disassembling and repair of the valves are performed without trouble, but due to the lack of spares for gland packing and gaskets, the defective ones are reassembled without being replaced. For such reasons, leaks occurring during operation are inevitable.

(e) Local Panels

The panels installed in each section are in the conditions described below :

For	301G03	Should be replaced.
	301Y14	Should be replaced by a dust proof one.
	303F01	Should be replaced.
	309K01	Should be painted.
	309K03 A/B	Should partly be repaired.
	310K01	In good condition.
	310K02	〃
	310K03	〃
	310K04	〃
	401K01	〃

(f) Pneumatic Signal Piping

There are many cases of leaks from the valve gland. On account of the large quantity of drain in instrument air pipes, endeavour should always be made in the terminal sections (501, 601 and 602) to draw off the drainage to prevent failure in the instruments.

Three types of joints of 6/4 copper pipes are used, but they shold be unified into one type. The tool of a bender should be used to bend copper tubes at instrumentation work.

(g) Electric Signal Cable

There are many defects in the flexible tubes used in the terminal of cables. Insulation resistance in the electrical system should be checked periodically.

(3) Instruments Air Dryer

As for the air dryer for instruments, air not sufficiently dehumidified is being supplied on account of insufficient regeneration capability due to damage to the heater.

Therefore water droplets flow out when open−inspection is conducted of the instruments. As this is a fundamental problem which may shorten the life of the instruments in general, it should promptly be attempted to restore sufficient capacity of regeneration to the equipment.

Table 4-11 NCZ-Owned Test Instrument

No.	Item	Model No.	Maker	
1	Multimeter	PM24121/ 01	PHILIPS	
2	Multimeter	PM24121/ 02	PHILIPS	
3	Digital Multimeter	PM 2513	PHILIPS	
4	AVO Meter	8 MK IV	AVO LTD.	
5	Multimeter	JP−8D	SANWA	(Japan)
6	Multimeter	JP−8D	SANWA	(Japan)
7	Multimeter	JP−8D	SANWA	(Japan)
8	Multimeter	JP−8D	SANWA	(Japan)
9	Multimeter	JP−8D	SANWA	(Japan)
10	Digital Multimeter	464	B.B.C METRAWATT	
11	A.C Meter	SP FB	YOKOGAWA	
12	D.C Meter	2012	YOKOGAWA	
13	Metra Pont R.L.C	RLC 2	METRAWATT	
14	Clip-on Ammeter	FE251104	GOER ELECTRO	
15	Megger (500 V)	L−5	YOKOGAWA	
16	Megger (500 V)		YOKOGAWA	
17	Megger	40050	E & V	
18	Current Calibrator	0110	DELRISTOR	
19	Current Calibrator	0110	DELRISTOR	
20	Current Calibrator	0110	DELRISTOR	
21	Potentiometer	44228	CAMBRIDGE INST	
22	Potentiometer	44228	CAMBRIDGE INST	
23	Potentiometer	PP 321	FOSTER CAMBRIDGE	
24	Potentiometer	PP 321	FOSTER CAMBRIDGE	
25	D.C Potentiometer	P 31	YOKOGAWA	
26	A.C, D.C Decade Resistor		CAMBRIDGE	
27	A.C, D.C Decade Resistor		CAMBRIDGE	

No.	Item	Model No.	Maker	
28	A.C, D.C Decade Resistor		CAMBRIDGE	
29	A.C, D.C Decade Resistor		CAMBRIDGE	
30	Decade Resistor	RP−51L	YOKOGAWA	
31	Decade Resistor	32370	ELECTROFACT	
32	Wheatston Bridge	43379	CAMBRIDGE INST	
33	Wheatston Bridge	L−3C	YOKOGAWA	
34	PH Meter Checker	Y−J260	YOKOGAWA	
35	Amplifier Tester	E9128WA	YOKOGAWA	
36	Thickness Detector	KM−1	KRAUTKRAMER	
37	Thickness Detector	UTM−20	TOKYO KEIKI	
38	Hand Digital Tachometer	HT−330	ONO SOKKI	
39	PH Calibration	77B	ELECTRONIC & INSTRUMENTS	
40	Xenon Storoboscope		EDWARD SCIENTIFIC INTERNATIONAL	
41	Pneumatoe Calibrator	FA−145	WALLACE & TIERNAN	
42	Pneumatoe Calibrator	FA−145	WALLACE & TIERNAN	
43	Dead Weight Tester	FIG−280H	BUDENBURG	
44	Dead Weight Tester	P−5	NAGANO KEIKI	High range 100kg/cm²
45	Dead Weight Tester	P−1	NAGANO KEIKI	Low range 25kg/cm²
46	Pressure Comparator	TA−1000	CELLA	
47	Pressure Comparator	TA−1000	CELLA	
48	Mercury Manometer	YJ285H	YOKOGAWA	
49	Water Manometer	YJ285A	YOKOGAWA	
50	Mercury Manometer	MCH−316	CELLA	
51	Water Manometer	MCA−316	CELLA	
52	Set of STD. Gauges		CELLA	
53	Standard Thermometer		TOSHIBA	
54	Fluidised Bath	FB−07	(England)	

4.2.5.6 Electricals

(1) **General**

Currently the power consumption is around 280,000 KWH/D. The operation data for the main motors (Mar. 3, 1980) are shown in Table 4−12. Since what we described in the chapter 'Instrumentation' can be applied to various problems concerning the electrical system maintenance, it is omitted in this chapter. There are many high tension panel units which require overhaul inspection and replacement of parts such as oil circuit breakers (OCB or TCB) and protection relays.

There are also many low tension panel units which require overhaul inspection and replacement of parts such as magnetic contactors and no-fuse breakers (NFB). As for the transformer, overhaul inspection and replacement of oil and silica gel are needed.

For local switches and motors, descriptions will be made of each section in the following paragraph.

(2) **301 Section**

The motor for Compeb Mill (280 KW) underwent an internal overhaul in July, 1980 about 10 years after commissioning, and its starter should undergo an overhaul inspection. In general, the inside of the low tension panel is maintained in good condition.

There are many equipment such as conveyors, operations of which are suspended and motors of which are shifted to other equipment to be used. It is necessary to restore the original condition.

Only slight damage was found among the local switches. However, they should always be cleaned enough to prevent a short or ground caused by coal dust fouling.

(3) **302 Section**

Generally all is in good condition. But the bearings in about 12 motors are supposed to be defective and are in a condition calling for replacement in the next periodical repair. There are some defective local switches. Under the present condition, they need replacement of parts such as lids of outer cases, push-button switches and amperemeters.

(4) **303−311 Sections**

The local switches in 303 section are mostly defective and their replacements are needed. Severe corrosion is observed on the motors.

The motor for Carbonate Pump (340 KW × 2) underwent an overhaul in July, 1980, but spare bearing metals were not available. As a result, the motor was re-assembled without replacement of the bearing metals. The present condition makes it necessary to purchase the above parts for replacement.

But it is regarded as a proper step to replace the motor entirely if the overall repair plan is to be carried out several years hence.

Low tension panels and low tension motors are kept in good condition except those in 303 section.

(5) **310 Section Large Sized Motor**

In October, 1981 a disassembling inspection was conducted for the motors below listed :

310K01—M1	Motor for Raw Gas Compressor (2400 KW)
310K02—M1	Motor for Nitrogen Gas Compressor (530 KW)
310K03—M1	Motor for Synthesis Gas Compressor (1750 KW)
310K04—M1	Motor for Raw Air Compressor (2300 KW)

Some of them were re-assembled without replacement of defective parts because spare parts were not available. The problems against which immediate steps should be taken are as follows :

K01 Adjustment of the centering.
Installation of device to drain off water standing in ventilation duct. Check on the effect caused by the magnet center not being correctly located.

K02 Correction of vibration (to avoid serious trouble which may be caused when an adverse influence is exerted to the motor).

K03 Correction of the shaft level and replacement of the bearing.

K04 Correction of the centering.

As the life of a motor depends upon the condition of the winding wire, it is necessary to examine the insulation.

(6) **401 Section**

The motor (2,200 KW) for Air Compressor underwent an overhaul in July, 1980 and its wedge was replaced and the rotor balance corrected. When the trial operation was started in August, a short circuit occurred at the start on account of grounding of the stator coil, but the motor has been operating since then after emergency repair. (At present it is operating at about 82% of the rated amperage.)

Apart from the above problem, an increase has been noted in the frequency of starts and stops of the motor, and the decline in its insulation has been caused by secular deterioration ;

As it is almost impossible to expect a good maintenance for the motor, it may be possible to have a recurrence of the same accident, as one in July, 1980. Also in view of its being an important part in the heart of the section, it is desirable to replace the motor in the rehabilitation plan. As for the low tension motor and its local switch, replacement is thought to be necessary for those which suffer from severe corrosion. A spare parts of contacts of O.C.B. for the 401K01−M1 motor should be prepared.

(7) **501 Section**

The low tension motors and their local switches suffer from severe corrosion, calling for replacement of all of them.

(8) **601 Section**

Each of the 3 motors for Cold Wate Pumps and Hot Water Pumps underwent an overhaul in July, 1980, and there is no problem in particular. Many defects were found in the bearings in the motors of the outdoor pumps. The motors of the machinery and equipment which had not been used were dismounted and are now used for other purposes.

(9) **602 Section**

Motors are in good condition. The panel is in a condition requiring repair.

(10) **605 Section**

There are many machinery and equipment which have suspended their operations. There are also many machinery/equipment, the motors of which have been dismounted. NCZ has been executing removal of motors and change of circuits, but problems lie in the protective circuit. It is necessary to inspect it at the time of the periodical repair.

(11) **604 Section**

The dead insects found in the panel of the water intake station are so many as to exude a nasty smell. It is necessary to replace the panel with a closed one or revamp the panel room. (Near to this panel there is a new panel for the expansion plant, which is of the closed type and presents a very nice condition inside.) The motors of pumps should be overhauled.

(12) **603 Section**

Determination of insulation resistance found the main cable of 6600V system to be in good condition. But damage was found in many lids of cable pits. It is urgently necessary to replace them with new lids for protection of the cable. As for the motor control cables defective insulation was found in many cables, especially in 401 and 501 sections. An improvement in insulation is supposed to be available in 301 section if cleaning is performed.

(13) **Others**

As to the overhead travelling crane, no problem lies in any of 310 section for compressor room, and 309 section for synthesis converter and repair shop. Only slight malcontact is seen in the handling push button switch in 310. No problem is found either in the telephone exchange board or in the automatic fire alarm.

The repair of motors for a machine tool is carried on without any trouble. On account of trouble in the automatic circuit of the automatic milling machine, it is now operated manually.

Table 4-12 Operation Data of Main Motors

(1980.3.3)

Tag No.	Item	Capacity	Operated/ Rated A	%	
310K01-M1	Raw Gas Comp.	2400 KW	200/242	82.6	
310K02-M1	Nitrogen Gas Comp.	530 KW	57/64	89.1	
310K03-M1	Ammonia Synthesis Gas Comp.	1750 KW	120/179	67.0	
310K04-M1	Raw Air Comp.	2300 KW	180/238	75.6	
305P01-M1	Carbonate Pump	340 KW	32/35.5	90.1	
309K02-M1	Ammonia Refrigerator	370 KW	36/41	87.8	
301G05-M1	Compeb Mill	280 KW	26/32	81.2	
601P09A-M1	Cold Water Pump (No.1)	200 KW	21/23	91.3	
601P09B-M1	Cold Water Pump (No.2)	200 KW	21/23	91.3	
601P09C-M1	Cold Water Pump (No.3)	200 KW			
601P08A-M1	Hot Water Pump (NO.1)	100 KW	160/190	84.2	
601P08B-M1	Hot Water Pump (NO.2)	100 KW	160/190	84.2	
601P08C-M1	Hot Water Pump (NO.3)	100 KW	160/190	84.2	
401K01-M1	Air Comp.	2200 KW	180/220	81.8	

4.3 Results of Check/Inspection

4.3.1 Summary

Ten years have passed since the inauguration of operation in 1970 and a deterioration corresponding to those years of use is seen in the plant as a whole. Except for the nitric acid plant and H_2S romoval section of the ammonia plant, the towers of all the facilities were free from severe corrosion in general, representing good cnditions, but almost all of the inner parts suffered from serious deterioration, necessitating their replacement or repair. Concerning tanks, there were few devices of which comment had to be made.

On the heat exchangers, the process fluid side is severely stained and corroded. Particularly the heat exchangers fitted to the gas purification sections are badly stained with a mixture of coal dust and oil. Also carbon steel made heat exchangers suffer from severe corrosion. This is supposed to be attributable to the quality control of the cooling water. It is supposed that early deterioration has been caused because those rotary machines have been operated without the usual maintenance because of the shortage of spare parts.

The equipment/machinery checked/inspected in the second field survey totalled 336 items, and the outline of the results will be given below :

(1) Those which should be completely replaced : 81 items (24%)

(2) Those which should partly, or whose parts should be replaced : 117 items (35%)

(3) Those which were not included in the rehabilitation : 138 items (41%)

Remarks : Those which were not included in the rehabilitation items include 37 items subject to repair to be done by NCZ. For the sectionwise number of equipment/machinery to be rehabilitated, please refer to Table 4-13.

The results of a careful and thorough study concerning and including a description of the check/inspection, a forecast of machine life, the process aspect and the results of the check/inspection, are summarized in a table in Appendix 8 for your reference.

Table 4-13 Sectionwise Numbers of Equipment/Machinery to be Rehabilitated

Section	Complete Replacement	Replacement of Parts	Repair by NCZ	N/R
301	8	14	(1)	8
302	12	12	(2)	10
303	7	12	(2)	6
304−8	10	18	(6)	19
309	3	3	—	4
310	9	11	(3)	10
311	1	15	—	4
401	5	11	(6)	18
501	6	10	(13)	34
601	8	7	(4)	13
602	2	2	—	4
604	2	1	—	1
605	8	1	—	7
Total	81(24%)	117(35%)	(37) (Included in) N/R	138(41%)

N/R : not included in the rehabilitation

Grand Total 336 items

4.3.2 General Conditions at Present

4.3.2.1 301 Section : Coal Handling

Deterioration and severe stain are seen in all the machines in this section. So far, the machines which had been badly damaged but could be repaired underwent repair by NCZ, and they are used now, but complete repair cannot be made to some machines because of the shortage of spare parts.

The time has come for replacement of the shell liner of Compeb Mill (G05) and a decline in function is observed in Dust Collectors (C01, C03) and Scrubber (C02) due to severe inner corrosion. The breakage of the instruments for measurement of raw coal prevented the quantity of consumption from being checked. From Hot Air Furnace (G03) the coal feeder had been dismounted, resulting in manual feeding. The condition now observed is different from the condition seen when the machine was installed in the beginning, and no stabilized operation can be hoped for. In Dryer (D01) , almost all of the parts except the shell have to be replaced.

4.3.2.2 302 Section : Gasification

Generally speaking the high temperature parts suffer from impairment inside and severe stain outside. Especially G02 and G03 centering around Gasifier (G01. Gasification Furnace) suffer from corrosion, which spread from the part where the fire-proof bricks were detached and that portion has been welded and repaired by NCZ frequently. Also Water Separator (T02 A/B) suffers from severe corrosion and the inside support has been deformed. (In unit B the spray nozzle of the inside is missing.)

In Tubular Boiler (E02) severe erosion is seen in the tube sheet and tube. As for Ash Extractor (G06) , the original extractor having become unusable, the extractor manufactured by NCZ is used now, but because of the structural problem, smooth function cannot be attained.

In Theisen Washers (N01−1A/B, N01−2A/B, gas washer) many parts have been damaged by corrosion and erosion. It is necessary to replace them after careful examination of the material of those parts.

4.3.2.3 303 Section: H_2S Removal

(1) **Tower**

First and Second Absorbers (T01 and T02 absorption towers) were patched in a considerable number of places outside. Inside those towers the bottom has stainless steel linings, but there is a problem in the method of repair, and corrosion had been caused by a leak in that part, forcing you to take separate steps against the leak. This is specially serious in Absorber NO.1. Also the wooden grids fitted to the inside of Absorbers NO.1 to NO.3 were all severely damaged and they should be replaced.

(2) **Tank**

As a whole, tanks are conspicuously stained in their appearance. From the peeling paint, sticking of solution and neglect of the machines not in use, it can be assumed that maintenance and cleaning have not been performed sufficiently for a long time.

Particularly in Mist Separator (V06) severe corrosion can be seen in the shell. On account of clogging with carbon dust, the separator is used with the inside demister detached. Inside, the accumulated carbon dust can be seen. A search for a proper type of separator should be made.

(3) **Heat Exchanger**

In Solution Heater (E01) corrosion was seen on the tube side and the inlet of the tube was clogged with solution to a considerable extent. In Evaporator (E02) corrosion of the frame, damage to the filling materials, abrasion of each part of the fan and sticking of solution are noticeable.

(4) **Pump**

The pipe line on the suction side of the feed pump for Absorption Tower was frequently replaced or patched by NCZ. On account of a leak caused by a malfunction in the check valve on the discharge side, the solution flows in the wrong direction from time to time. The pump casing and impellers has been eroded.

(5) **Filter Press**

Air Compressor for Automatic Filtration System (K02A/B) has been removed and replaced by the air for instruments. In the future it is planned by NCZ to use the air for instruments. Flaker is not used. The steam trace on the bottom of Autoclave Remelter (V09 A/B) should be replaced because of its severe corrosion.

The driving unit of Filter Press (F01) is damaged heavily. As the devices in the automatic filtration system were mostly corroded, the automatic system does not function and is operated manually now.

4.3.2.4 304−308 Section : Gas Purification

(1) **Tower**

Generally speaking, corrosion is seen on the towers here and there, but those towers can be used for some time to come under the present condition. But corrosion and impairment are seen to a considerable extent in internal auxiliary components such as grating, distributor, support, etc.

Also it is necessary to replace the fillers such as Raschig ring, catalyst, etc. The replacement of the internal castable of Primary Shift Converter (304−H01) and the repair of the stainless steel lining at the bottom of Saturator (304−T01) should be performed early.

(2) **Tank**

Second Condensate Separator (307−V01) was originally made of carbon steel but because of corrosion, was replaced by NCZ with a tank made of stainless steel. At present it has no problem in particular. In Desuper−Heaters (304−V02, V03) severe corrosion is observed in the internal baffle plate. Also large cracks have appeared.

(3) **Heat Exchanger**

Formation of scales, pitting and corrosion, all caused by the coolng water, are seen in many parts. Also stains by carbonate solution or carbon dust contained in the process gas are noticeable. In the heat exchanger in which the cooling water flows on the side of the shell (made of carbon steel), corrosion is seen in many places on the baffle plate (made of carbon steel) of the tube bundle (made of stainless steel): In the case of the floating head type exchanger it is considerably laborious to draw out the tube bundle.

In the heat exchanger in which the cooling water flows on the side of the tube, corrosion is more severe in the area of the welding of the tube sheet and tube than inside the tube.

(4) **Pump**

There are many pumps which can be used for some time to come by supplying them with main parts or spare parts. Some pumps are operated by using parts manufactured by the NCZ machine shop due to the shortage of spare parts, but in some pumps the damage has been aggravated by the quality of the material and the unskilled machining of these parts.

(5) **Piping**

There are many pipes of carbon steel which have been replaced by NCZ with those of stainless steel. There is no problem in those pipes in particular. But as elbows and reducers were manufactured by welding pipes cut into small pieces, it is necessary to replace a part of them because of defective welding.

As some parts of the carbon steel line from 304 section to 306 section have been patched by NCZ and severe corrosion is seen inside, replacement is needed in many places.

4.3.2.5 309 Section : Ammonia Synthesis

(1) **Tower and Tank**

In accordance with the data available in the past, the ammonia converter was not included in the present check/inspection.

Steam Drum (V04) is in operation at present and a visual inspection finds no problem. But more corrosion is seen on the inside demister as compared with the past data.

(2) **Heat Exchanger**

All the condensers in this section suffer from corrosion on their cooling water side, calling for their replacement.

(3) **Pumps**

Some pumps have been replaced by NCZ and there is no problem at present. It is necessary to overhaul Gas Circulator (K01) together with the parts used inside at the time of rehabilitation.

4.3.2.6 310 Section : Compression

The body of the compressor in this section is overhauled every year at the time of the periodical repair, but the shortage of spare parts prevents such overhaul from being performed thoroughly. Accordingly, it is necessary to perform at the time of rehabilitation a complete overhaul with spare parts prepared in advance.

(1) **Low Gas Compressor (K01)**

In Inter Coolers (E1－E3), both the shell side and the tube side were replaced with those made of stainless steel by NCZ, and no corrosion is now observed, but they have marked stains caused by the mixture of carbon and oil contained in the gas. Also, in the tube on the cooling water side there are a number of cases of clogging with pieces of wood flowing from Cooling Tower (601－T04).

By-pass Cooler (E4) is made of carbon steel and suffered severely from erosion. Drain Separators (V1－V4) have been patched up in many places in the shell. Measurement of the thickness of the shell plate found a considerable decrease in the thickness due to corrosion, calling for immediate replacement of Drain Separators. In Silencers (V20, V25) the mixture of carbon and oil have gathered in a large quantity, necessitating periodical cleaning and replacement of the inside elements.

Suction Filter (F1) is now used with the inside elements removed. Also the carbon dust accumulated is considered to be related to the stains on the related devices. Seal Pumps (P2 A/B, P3 A/B), because of their low performance, should be replaced immediately.

(2) **N_2 Gas Compressor (K02)**

In Inter Coolers (E1−E3) severe corrosion was noticed on the tube side (cooling water side). Also many water weeds were attached. The tube bundle should be replaced. In spite of corrosion seen on Oil Cooler (E4), it may be used for some time to come.

(3) **Synthesis Gas Compressor (K03)**

Pitting formed on the outside of the tube in Inter Coolers (E1−E3), but under the present condition, it is not necessary to pay attention to it in particular. But as the pipes on the gas inlet suffer from corrosion which extends to a considerably wide and deep scope, an immediate replacement is needed. (Replacement was performed by NCZ during the second field survey) As the spare for Oil Cooler (E4) has been manufactured by NCZ, there is no problem with it.

(4) **Air Compressor (K04)**

On the tube side (the cooling water side) of Inter Cooler (E1A−C) and After-cooler (E2) condiderably severe corrosion is seen. Also the drain trap including the piping should be replaced. For the shell in Oil Cooler (E3), the same for 401 section (nitric acid plant) is used while the cooler manufactured by NCZ is used on the tube side. The present condition is good.

4.3.2.7 311 Section : Air Separation

The devices in the cold box were all excluded from the present field survey because of the difficulties in overhauling them. But it is necessary anyway to carry out an overhaul at the time of rehabilitation because no overhaul has been performed in the past ten years.

Replacement of the filter elements inside Air Filter (F01), Primary Filter (K01−F1A/B) and Secondary Filter (K01−F2A/B) is needed.

4.3.2.8 401 Section : Nitric Acid Plant

(1) **Tower**

Generally the lower portion of the tower suffers from severe corrosion and repair by welding was effected by NCZ for prevention of leaks. The internal tray of Oxidation and Bleaching Tower (T01) has been corroded and partial detachment is seen. Also repair is necessary for the concrete base. In Absorption Tower No.1 (T04) the cooling coil should be replaced.

(2) **Tank**

Separator (V03) has been repaired by NCZ, having no problem at present. Burner (H01) has overall corrosion in its lower part. Also severe deformation is seen in the frame to support platinum catalyst and the shell flange, and parts of them suffer from serious damage, calling for replacement of a considerably wide scope.

(3) **Heat Exchanger**

All eight heat exchangers in this section have many problems and repairs have been performed by NCZ. But they have been used to the maximum. Though they can partly be used still more, overall replacement is required in view of the problems foreseeable in performance of welding and the difficulties in works, etc. Acquisition of the tube bundle of Economizer (E05) and Gas Cooler (E03) has already been arranged by NCZ. The main parts of Produced Acid Cooler (E07), Weak Acid Cooler (E08) and Condenser (E06) have no problem in particular but the support made of carbon steel suffers from corrosion.

(4) **Pumps**

There were few pumps to which particular attention had to be paid. But Feed Water Pump (P01) should be replaced because of erosion and corrosion seen on it. Also it is necessary to overhaul Air Compressor (K01) completely at the time of rehabilitation.

(5) **Piping**

It is necessary to replace Expansion Joint (EXJ−01) at the top of Economizer (E05) because of severe corrosion.

The check valve has lost its function, allowing severe leakage due to its corrosion. The pipes from Economizer (E05) to Absorption Tower No.1 (T04) suffer from corrosion and they have been repaired in many places by patching, etc. They have been used to their maximum and their replacement is required.

4.3.2.9 501 Section : Ammonium Nitrate Plant

(1) **Tower**

The prilling nozzle at the top of the prilling tower suffers from severe deformation due to hammering caused by clogging during operation. In a part of the fillet welded part, cracks have appeared. Due to considerable degree of detachments or cracks found in the lining in the lower part of the prilling tower, overall replacement is needed. Also as it is very dangerous to leave them as they are until the rehabilitation, an urgent repair is called for. In Neutralizer (T01) only the demister should be replaced.

(2) **Heat Exchanger**

Generally speaking, severe corrosion is observed in the heat exchangers handling ammonia. As it is particularly severe in Ammonia Evaporator by Steam (E01) and Ammonia Heater (E03), it is necessary to replace the tube bundle.

(3) **Tanks**

As hammering due to clogging has greatly deformed the lower part of the product hopper, accelerating occurrence of clogging more and more, it should be replaced. Also the installation of bridge breaker or knocker, etc. should be studied. There was no problem concerning the main body of each tank, but in many of them corrosion is observed on their concrete bases.

(4) **Driving Machine**

All the lower casings of the bucket conveyor have been deformed, calling for repair. There are several conveyors which have already been repaired. Because of their severe damage and deformation, Vibrating Screens (A02, A03, A09) should be replaced. Also because of deformation of the hoods on the inlet and the outlet of Coolers (D02, D04) and Dryer (D01), those hoods have to be repaired. In Coating Drums (D03,D05) the parts related to driving (gear, roller, ring etc.) should be replaced.

(5) **Pumps**

The pumps which went out of order have been replaced with those made in the United Kingdom, and there is no problem at present.

4.3.2.10 601 Section : Water Treatment

As Cation Exchanger (T01) suffers from severe corrosion both inside and outside by sulphuric acid for regeneration and a part of rubber lining inside has been detached, overall replacement is called for. Acid Storage Tank (V05) also suffers from serious corrosion and has to be replaced. (It is scheduled to be replaced by NCZ.) Wooden drift eliminator in Cooling Tower (T04) and its fillers are damaged due to deterioration. Also small pieces of wood are found in the cooling water, causing impairment to the heat exchanger in the plant. The wooden parts should be replaced.

4.3.2.11 602 Section : Boiler

In a number of pumps, parts should be replaced. Induced Draft Fan (K03) has been replaced several times due to serious erosion. The quality of the material should be examined before replacemnt.

4.3.2.12 604 Section : Water Intake Station

Replacement of parts of impeller and wearing ring makes it possible for the pump to be used. Vacuum Pump (P02) and Drain Pump (P03) should be replaced because of their having been damaged seriously.

4.3.2.13 605 Section : Effluent Treatment

Neutralizer Mixer (B09) had an agitator for B-effluent pond but because of its shaft being too short to produce sufficient agitation, the original agitator should be restored. C-effluent Pump (P09 A/B) and D-effluent Pump (P10 A/B) should both be replaced because of severe corrosion both on the pumps proper and impellers.

4.3.2.14 Instrumentation

The first field survey on instrumentation had covered almost all the instruments with overhaul inspection or someway. In the second field survey, even if the overhaul inspection were made on each instrument again and its bad condition were found, it should be reassembled as it was for lack of the spare parts. And this might cause a larger leakage and other troubles which were not existing before overhaul.

Taking account of these situations, the second field survey had almost no overhaul inspection and only a few inspections for each part of control valves, an instrument air dehumidifier, resistance bulbs, thermocouples and level meters (displacer type).

Componentwise damage (fair or bad) in the panel instruments and control valves and whether replacement is needed or not for them as a whole are shown for each item in the table in Appendix 8.

4.3.2.15 Electricals

Overhaul inspection was not particularly carried out in the second field survey (except the inspection for large-sized motors, conducted by Fuji Electric Co.). Because like the instrument the conditions of electricals had been clarified by the first field survey as well as the surveys preceding it. Based upon the results of those surveys, the evaluations such as fair or bad, replacement required or not, replacement of parts, overhaul, etc. have been summarized as a check list concerning the high and low tension panels, local switches, motors, transformers, motor-driven-valves and other electric devices (battery chargers, batteries, a diesel engine, a generator, etc.).
This list is shown as Appendix 8.