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19057

DP/ID/SER.A/1492
18 July 1991
ORIGINAL: ENGLISH

RESTRICTED

ASSISTANCE TO THE
ZAMBIA INDUSTRIAL AND MINING CORPORATION LTD. (ZIMCO)
RESEARCH, DEVELOPMENT AND INNOVATION (RDI) UNIT
DP/ZAM/90/010
REPUBLIC OF ZAMBIA

Technical report: Chemical technology subsector*

Prepared for the Government of Zambia
by the United Nations Industrial Development Organization,
acting as executing agency for the
United Nations Development Programme

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*This document has not been edited

V.91-27286

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0.0 ABSTRACT

Personal author: Ludek VODICKA
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Title: Technical Report "C": Chemical
Technology Subsector
Project title: Assistance to ZIMCO RDI (Research,
Development and Innovations)
Project number: DP/ZAM/90/010

The purpose and the long term objective of the project was to set up at ZIMCO Directorate for Research a coordination and information unit oriented mainly on the company's R & D activities.

The Research, Development and Innovation Liaising and Coordinating Unit (RDU) is aiming primarily at liaising and coordinating RDI activities between ZIMCO subsidiaries and other research institutions. This Unit will help discover new possibilities of utilizing local raw materials and wastes, build a system of industrial information exchange between ZIMCO/INDECO subsidiaries, and set up a complete data bank of new materials, byproducts, and wastes in selected sectors.

The Unit will also coordinate the activities of ongoing projects, propose new perspective projects and help subsidiaries to solve the problems of environmental protection.

This Technical Report is a part of Terminal Report "Assistance to ZIMCO RDI" DP/ZAM/90/010 and is oriented especially on R & D activities in the chemical subsector and also covers various aspects of environmental protection. It contains an analysis of present situation within the Zambian chemical industry, the main links of chemical subsector to the other sectors, an analysis of ongoing and potential development programs in chemical industry, and recommendations to ZIMCO/INDECO, its subsidiaries, and the Zambian Government on how to improve the present situation in the chemical sector.

The proposed organization of the R & D Unit and its activities in the sphere of chemical technology are also described.

1.0 INTRODUCTION

Zambia belongs to the group of African developing countries which depend on a narrow range of primary commodities for exports and have weak financial and infrastructural base. High population growth still aggravates the economic problems.

In the present time Zambia faces a formidable challenge in its efforts to restore economic stability, restructure the economy and achieve the objectives of positive per capita GDP growth with increased employment and incomes. This challenge is made particularly difficult by the extremely tight resource constraints presently confronting the economy. The main elements of the strategy to meet this challenge include a major effort at domestic resource mobilization and expenditure restructuring. This process also encompasses manufacturing in general and the chemical technology subsector in particular.

GRZ recognizes that the manufacturing sector must play a significantly larger role within the national economy in the future. The background of the present project was the awareness of GRZ that under changing economic conditions due primarily to increase in world oil prices and decrease of copper prices, rapid economic diversification became vital for the growth of Zambian industrial potential.

The manufacturing sector needs to be fundamentally restructured. Import dependence should be reduced and the expansion of the sector should be based more on an increasing processing of natural resources. The different ways of substituting domestic foreign industrial inputs and for increasing capacity utilization should be studied.

The Government also recognizes the need for building up adequate information facilities at the national level as an essential prerequisite for rapid and planned economic growth. Industrial information on chemical technologies exists in enormous quantities and is needed by industry and its infrastructural organizations. However, the required industrial information can only be available if effective information services are available. GRZ asked for support to built up these facilities.

Previously an industrial assistance project was already implemented (PD/ZAM/88/028 - ZIMCO Technology Audit). This project was funded by UNDP and executed in 1989 by UNIDO.

ZIMCO Technology Audit helped to discover new possibilities of utilization of local raw materials, byproducts, and wastes. During the UNIDO mission to Zambia (April/May, 1989), more than 50 ZIMCO subsidiaries and other institutions were visited. It was

found that there was no organized R & D at most of the subsidiaries, although a number of subsidiaries did engage in development activities. Some of them were not able to undertake R & D themselves but they were able to collaborate on some R & D projects or could benefit from R & D conducted at other subsidiaries or associate companies.

The lack of sufficiently complete information on the products or byproducts available in one subsidiary (or one sector) often is responsible for an unwelcome situation where other subsidiaries or sectors use imported products instead of using local, Zambian materials and products.

The Technology Audit project identified an urgent need of a Research, Development and Innovations (RDI) Liaising and Coordinating Unit under the ZIMCO R & D Directorate aiming primarily at liaising and coordinating activities between ZIMCO subsidiaries, at the subsidiary/HQ interface, and between ZIMCO and other research institutions etc.

This report is oriented mainly on the R & D potential and activities in the sector of chemical technology and also covers selected aspects of environmental protection. It integrates the results of the first mission to Zambia in 1989 (under the ZIMCO Technology Audit project) and the findings of the second mission (April/May 1991) carried out under the present project.

The findings of this report are geared to the general objective of the present project which is to establish a RDI Liaising and Coordinating Unit capable of performing the following tasks and providing the following services to the ZIMCO Group of companies:

- coordination of RDI activities within the ZIMCO Group;
- stimulation of RDI activities in the ZIMCO companies;
- information services to support and backstop the RDI activities.

The objectives of the project in the chemical subsector were attained.

2.0 ANALYSIS OF PRESENT SITUATION IN CHEMICAL INDUSTRY AND RELATED SUBSECTORS

This Chapter provides a brief outline of the situation in Zambia's industry and especially within the ZIMCO/INDECO Groups. The situation is analyzed on the basis of technology audits and RDI information from individual subsidiaries.

2.1 Zambia

Most of Zambia's current manufacturing enterprises were established during the time when the country was generating adequate foreign exchange from its copper exports. Most manufacturing plants were therefore mainly designed to process imported raw materials. The decline of copper prices has resulted in a shortage of foreign exchange for importing raw materials and spare parts in all industrial subsectors.

The chemical industry also continues to heavily depend on imported raw materials, spares, and other inputs and therefore is very sensitive to fluctuations in the availability of foreign exchange.

There is considerable scope of chemical production in the parastatal ZIMCO/INDECO. Even with the recent privatization efforts gaining momentum, the chemical enterprises which now are parastatal will continue to play a major role in the supply of inputs to agriculture, mining, industry, food processing, and the other sectors of national economy. This is why links to all the other sectors are so important.

As industry grows, environment is getting polluted. Chemical industry ranks among important polluters, together with mining and power generation. At the same time, it is the responsibility of the chemical subsector, due to its very nature, to help monitor and mitigate pollution.

Zambia's environment will have depreciated drastically by the year 2000 if measures are not taken to prevent the increase of pollution.

Atmospheric pollution is high in the mining areas (Copperbelt) and crops grown here have been affected by pollutants such as copper nitrate. Lead and cadmium are found in vegetables grown near the Kabwe zinc smelter. Other areas suffering excessive pollution include Kafue (fertilizer factory), Maamba (coal), Lusaka (automobile exhausts, industrial area oil spills and untreated effluents), and also Mt. Makulu where pollution by

cement thwarts research on crops.

In 1990, about 200,000 tons of sulfur dioxide was released into the air in Zambia.¹

An Environmental Protection and Pollution Control act (EPPC) was passed in 1990 but most industries fail to comply, mainly because of financial constraints.

2.2 ZIMCO and INDECO

Most ZIMCO companies in the Industrial Sector fall under the INDECO Group. At present there are 39 subsidiaries operating under INDECO umbrella.

According to the public enterprise restructuring program (completed in 1989 under the Industrial Reorientation Project), 13 of INDECO's 36 enterprises were subjected to efficiency audits. These subsidiaries were financially and organizationally restructured and some product lines were discontinued.

The performance of INDECO Group, measured in terms of turnover and pretax profits, remained in 1990 below the planned targets. However, there was a marked improvement when compared to achievement during the same period of the previous year. Out of 40 companies (in 1990), eight showed losses as at 30 June 1990. Loss making companies are being closely monitored by INDECO with a view to improve their performance, and were paid primary attention by the UNIDO mission.

2.2.1 Analysis of ZIMCO/INDECO subsidiaries within the chemical industry subsector

There are 3 INDECO subsidiaries engaged in the production of chemicals and drugs: Kafironda Explosives Limited, Zambia Oxygen Limited (ZAMOX) and General Pharmaceuticals Limited.

Outside of INDECO Group there are in Zambia some other companies which produce or use various chemicals and influence the total consumption or availability of chemicals at the domestic market. One of the largest chemicals producers is Nitrogen Chemicals of Zambia Limited in Kafue, a ZIMCO subsidiary.

¹Zambia Daily Mail, 27 April 1991.

Chemical technologies and/or chemical products are also used to various extent in several other subsectors of manufacturing, for example, in textiles production and in agro-based industries (production of sugar, beer, soft-drinks, edible oils, soap, etc.). Chemicals are also necessary for the production of glass and ceramics. Oil refineries need various chemicals for fuels and oils production.

Agriculture is one of the largest consumers of chemicals (such as fertilizers, insecticides, herbicides, additives to stockfeeds).

The complete list of ZIMCO/INDECO subsidiaries and associate companies involved in the chemical industry sector together with their respective principal products and/or services can be found in Annex C-1. The list also includes a number of companies which basically are not chemical but do border on chemistry through some of their products, raw materials, trading, etc.

In the Chemicals, Rubber and Plastic Products group the average capacity utilization increased from 40 per cent in 1989 to 47 per cent in 1990.

In the Food Chemistry and Technology group (treated in detail in Technical Report "F") mealie-meal, sugar, and edible oils are three prominent products.

The average capacity utilization for the food, beverage, and tobacco subsector was 52 per cent in 1990 compared to 56 per cent achieved in 1989. The production of cooking oil dropped by 16 per cent and the production of sugar increased by 3 per cent in 1990. The increased production of beer (by 12 per cent) is mainly due to the rehabilitation program completed recently.

The Silicate Chemistry group is represented by the production of glass, cement, lime, ceramics, etc. On the whole, the average capacity utilization in the nonmetallic mineral products group was 49 per cent in 1990.

In the Textiles and Clothing Production group, comprising the production of textiles, polypropylene and polyethylene bags, jute, fish nets, cotton twine, nylon twine, and ropes, the average capacity utilization was 78 per cent in 1990 compared to 96 per cent achieved in 1989.

In the Petrochemistry group, the major company, Indeni Refinery, is jointly owned by ZIMCO (50%) and AGIP Petroli SpA of Italy (a member of ENI).

The feedstock is spiked crude oil pumped through Tazama pipeline. The design processing capacity is 1.1 mln tpy of crude. The

products include

- LPG
- automobile gasolines
- A-1 jet fuel
- illuminating kerosene
- gasoils
- fuel oils
- MC-30 cutback
- bitumen.

Indeni Refinery, the sole producer of all these products in Zambia, ranks among the strategically most important facilities of the country. Supplies of gasoline and diesel throughout the country suffer from recurring shortages resulting from both production and distribution problems. Indeni has no ongoing rehabilitation project right now and is seeking donor assistance for the construction of a new cracking unit.

There are two categories of chemicals which are used in the various subsectors of manufacturing and in the other sectors. The chemicals which are produced and consumed in mass quantities (i.e., caustic soda, sulfuric acid, etc.) belong to the first category. They are relatively cheaper than the chemical products of the second category comprising chemicals which are produced in smaller amounts. Efforts to expand and modernize the plants producing the chemicals of the first category are continuing vigorously (for example the project of caustic soda production, fertilizer industry restructuring project, glycerine recovery project, etc.).

On the other hand there were no proposals so far which could help the diversification of the production of chemicals belonging to the second category. A lack of these chemicals is very often one of the constraints of production in various subsectors of manufacturing. Almost all such chemicals are imported, but some of them could be produced in Zambia relatively easily in a plant with universal equipment (distillation columns, evaporators, crystallizers, filtration and sublimation equipment, etc.).

Total needs of chemicals in all sectors should be estimated by comprehensive analysis of all subsidiaries' inputs. This information is not presently available and is to become part of the RDU's activities (cf. Chapter 5.3).

2.2.2 Review of technology audits

During the first mission to Zambia by the UNIDO team (cf. DP/ZAM/88/028, April/May 1989), the following subsidiaries were visited (including companies which are not formally in the chemical subsector but have chemical or related operations):

- Kafironda Explosives Limited
- General Pharmaceuticals Limited
- Nitrogen Chemicals of Zambia Limited
- Tazama Pipelines Limited
- Maamba Collieries Limited
- Kapiri Glass Products Limited
- Norgroup Plastics Limited
- Zambia Ceramics Limited
- Premium Oil Industries Limited
- ROP (1975) Limited.

During the present mission to Zambia (April/May 1991) the following subsidiaries were visited:

- General Pharmaceutical Limited
- Consolidated Tyre Services Limited
- Premium Oil Industries Limited
- Kafue Textiles of Zambia Limited.

As a rule, the specific problems of above subsidiaries were discussed at each plant with several executives during the visits. The interview proceeded on the basis of a systematic questionnaire prepared by the UNIDO team. Conclusions and recommendations were oriented principally on the production constraints, R & D activities, and innovations.

A short description of company problems and essential conclusions on RDI is given below.

Kafironda Explosives Limited was originally a plant producing simple ammonium nitrate/fuel oil explosives (ANFO), now is a major explosives factory supplying mainly the mining industry with nitroglycerine based explosives, blasting accessories, and ANFO.

At present the production of nitroglycerine explosives declined by 17 per cent while production of ANFO dropped by 12 per cent against their planned targets. The production was reduced in line with the demand from the mining industry. In order to optimize production levels, the company is looking for export markets and has made some progress in this regard.

The company has substituted some raw materials by local

materials. However, a major quantity of inputs (about 80%) is imported. In the effort to substitute imported materials, glycerine from ROP (1975) Ltd. could be possible substitution. A cost/benefit study on in-house production of pertinent blasting accessories at Kafironda is needed.

In 1991, Kafironda has introduced the non-electric shock-tube detonator, a new product to be used by ZCCM.

General Pharmaceuticals Limited manufactures intravenous fluids (imported technology from Vicfor S.A. of Switzerland, commissioned 1979) and oral rehydration salts (imported technology, commissioned 1986).

The output of intravenous fluids (IV fluids) declined by 26 per cent while oral rehydration salts (ORS) production increased by 4 per cent in 1990.

At present the company is looking at updating the plant and equipment for IV fluids. The rehabilitation of IV fluids plant is oriented mainly on the replacement of worn out equipment. More efficient equipment is imported from Switzerland (Vicfor S.A. and SWECO). The proposed completion date of this project is 1991, the proposed production upgrading is 20 per cent. The rehabilitation of the ORS production line (by replacing old equipment and using new semi-automatic machines) should be completed by 1992. The production after rehabilitation should be higher by 200 per cent than the present production.

A new project is in the preparation stage at General Pharmaceuticals. This project aims at switching the emphasis from human parenterals and eye drops to veterinary medicines and eye drops.

The feasibility study accomplished by UNIDO adviser R.W. Hampson in February in 1991 shows that this change of production program of General Pharmaceuticals will have an obvious benefit to Zambia in the supply of essential veterinary products and will avoid the problem of duplication of production of human parenterals in the country. Three local companies, Gamma Pharmaceuticals Limited, National Drug and Medical Stores Limited, and external suppliers will be able to cover the demand of human parenteral products on the Zambian markets.

If the agricultural development of the country progresses as planned, the demand of veterinary products will be far greater than the demand of human parenterals.

At Nitrogen Chemicals of Zambia Ltd. (NCZ) the production level showed an improvement in 1990. Due to a postponement of the major rehabilitation work on Klockner line, production of NCZ resumed.

Development of import substitute products remains a major problem.

Fertilizer stocks in Zambia have reached critically low levels in 1991 with NCZ falling short of meeting demand. There are 21 fertilizer varieties used in Zambia, demand of which for the 1991/1992 season is projected at 226,680 tpy. Less than 100,000 tpy have been available to farmers recently.

Actually, the general situation in the area of fertilizers in Zambia can be characterized as follows:

Zambia derives its fertilizers from three sources including NCZ of Kafue; the local plant is expected to play a leading role in fertilizer supply.

Plant rehabilitation is underway at NCZ to raise capacity utilization (to 80% of design capacity).

Many small-scale farmers in Zambia apply less than the recommended fertilizer rates or do not use any because of limited resources.

Commercial farmers and companies now are allowed to import their fertilizers.

"Agriculture, an economy with potential for sustained growth, must command the highest priority."² Fertilizer must be the backbone to achieve this. Zambia is well endowed with rich soils but high yields can only be obtained with good use of fertilizers.

It was found during the technology audit at NCZ that R & D projects could be oriented on the following outputs: inert gases (Xe, Kr), processing of new products by nitration and sulfonation, and methanol production/purification. Other information on NCZ can be found in Chapter 3.3.

Tazama Pipelines Ltd. Crude oil transportation is the major process of the company. The pipeline is designed to handle 1.1 mln tpy of crude oil, but the real output is 0.5 - 0.8 mln tpy. There are two principal constraints to raising output: the limited quantity of crude oil available per annum and the weakness of the line.

This company is crucial to many sectors of the national economy

²Report on fertilizer marketing seminar opened by Minister of Cooperatives; Times of Zambia, 23 April 1991.

and therefore the rehabilitation program of Tazama Pipeline is very urgent. The first phase of rehabilitation has already taken place, the Phase II (rehabilitation of the pipeline, rehabilitation of storage tanks and improvement of supporting facilities, etc.) is in progress. The proposed completion date is 1993. More details can be found in the Technical report "T".

Maamba Collieries Ltd. is the only producer of coal in the country. During the TNDP, internal reorganization and rehabilitation were undertaken and production of coal was increased to 570,000 tpy.

More funds are needed for the coal briquetting development project. Large quantities of slurry fines are generated and could be utilized. The subsidiary should consider becoming involved in the development of chemicals production from thermic degradation processes (cf. Recommendations in this report).

The production of Kapiri Glass Products Limited was improved in last two years.

As for the technology R & D, the following tasks should be solved:

- iron removal from sand (important for the production of clear bottles);
- furnaces and machines rehabilitation;
- sand plant throughout upgrading;
- sheet glass production.

Norgroup Plastics Limited. Production of bottles, jerrycans, and plastic crates at Norgroup Plastics Ltd. was 47 per cent below the target of 2,300 in 1990. This is extremely low production.

The major constraints responsible for the poor production were the plant and machinery breakdowns. Speedy rehabilitation of machinery is necessary.

The possibility of using substitute raw materials is considered as about 90 per cent of inputs are being imported. A better collection system of broken crates and their reusing is recommended as well as the recycling of the other products. Diversification of products would be very useful.

The output of tableware and sanitaryware at Zambia Ceramics Ltd. increased in 1990, the production of tiles decreased.

This is a company with considerable range of existing R & D activities aimed mainly at process and product development.

The following innovative activities are pursued at the company:

- increasing capacity utilization;
- reducing waste;
- increasing the use of local resources;
- product development (design and quality);
- improvement of packing.

At Premium Oil Industries Ltd. the solvent extraction line has been rehabilitated in the past 4 - 5 years and the laboratory has been newly equipped. The original technology applied proved to be unreliable and not safe enough.

New rehabilitation of the key product lines is now going on. At the deodorization plant the deodorizer is to be modified by introducing a new Konus Kessel Boiler and heat exchanger. The refinery cooling towers will be replaced during 1991.

Several projects are at the preparation stage:

- reconstruction of the bleaching plant;
- reconstruction of the filling room (new filling line and sachet filling machine);
- soap plant innovation (new cooling towers for soap and glycerine, new finishing line);
- modernization of margarine plant (repair and replacement of some equipment);
- condensate return/blowdown steam heat recovery.

No formal R & D unit exists in the company, but all development plans and their practical materialization are of a high professional level.

More advanced research activities should be considered after the total plant rehabilitation will have been finished.

ROP (1975) Limited belongs to the group of the most important companies producing edible oil, soaps and detergents in Zambia. The main obstacles to increased output are: irregularity of input deliveries (particularly imports), stoppages of machinery, and shortage of suitable packaging materials.

The company has a considerable potential for research and development. It is one of few subsidiaries which already have a R & D department and more extensive research facilities.

The management is supporting the research activities at the company but liaisons with the other companies or institutions in this field have yet to be set-up.

Consolidated Tyre Services Limited (CTS) is an INDECO subsidiary which is engaged mainly in retreading and relugging of tires. The company is manufacturing its own rubber and extrudates. There are other three business activities at the company: rubber lining, sales of batteries, and sales of new tires. In the manufacture of the rubber compounds, following chemicals are used: talc, China clay, whiting, barium sulfate (altogether 30 per cent of inputs) and additives as sulfur, ZnO, etc. (20 per cent of inputs).

The new company's activities in the field of rubber lining can help overcome the corrosion problems in many sectors of national economy. The rubber lining for some equipment of Zambia Sugar Company Limited and National Milling Company Limited was already provided by CTS. Rubber lining was also proposed for Tazama pipeline.

A new Quality Control Testing Laboratory has been established at the company recently.

The company's R & D program is fairly rich and variegated. The following main fields of R & D are pursued at CTS:

- using the waste from tire retreading for shoe soles production (for the Copperbelt Shoe Company and Zambian National Service);
- production of battery cases from waste generated in tire retreading;
- substitution of imported inputs;
- developing a pilot scheme to see if rubber can grow in Zambia;
- proving the optimal conditions for various imported rubber seeds and budwoods;
- developing new types of rubber mixtures with various physical properties;
- producing spare parts for the automotive, mining and local industries (fan belts, engine and gearbox mountings, seals and rings, conveyor belt rollers, etc.);
- latex composition and quality testing.

The R & D rubber program at CTS offers the perspective of substitution for imported rubber. Its local production could save about 1 per cent of total foreign exchange of Zambia.

Kafue Textiles of Zambia Ltd. (KTZ) has the following RDI priorities:

- to transform the company's Training Center into an Institute of Textile Technology;

- to encourage the company's scientists and technicians to venture into RDI related projects in their fields of specialization.

The above mentioned Institute shall be used as the company's center of know-how and shall assist in improving manufacturing processes which would ensure the operation of plant and machinery at optimum levels. The Institute shall plan and coordinate projects related to RDI. A highly qualified and experienced person for filling the post of R & D manager is needed.

Most of the company's byproducts are either sold or recycled. Effluents are discharged into the Council Effluent plant. This plant does not work and so from there the effluent is directly discharged into Kafue river. This serious environmental problem should be solved urgently.

There are following potential RDI projects at KTZ:

- substitution of caustic soda with ammonia for use in the process of textile production;
- widening of old narrow weaving machines;
- own import/export transport.

Substitution of imported caustic soda by locally produced ammonia (in NCZ) would bring about substantial forex savings.

In the modern world of textiles, wide fabrics are preferred to narrow ones. It has therefore become necessary to consider widening the narrow Pinacol looms.

The company has ventured into exporting its products to Europe using mainly Dar-es-Salaam port, from where is also transported most of imported inputs. KTZ has been considering acquiring their own fleet of trucks for this transport.

KTZ currently has good business links with the following companies: LINTCO, NCZ, Colgate Palmolive Ltd., and ROP.

The company is considering the possibilities of substitution of some other imported inputs: i.e. textile dyes and chemicals, starch, textile machinery spares, and other auxiliaries.

Zambia Oxygen Limited (ZAMOX) produces industrial and medicinal gases and welding electrodes. In 1981 ZAMOX embarked on two new projects, the Nitrogen Oxide and Hydrogen Gas Plants. The plants came on stream in 1981 and 1983, respectively.

In 1990 ZAMOX registered increases in the production of oxygen, acetylene, nitrous oxide, and welding electrodes. Production of

carbon dioxide has outstripped demand. The company has been looking for export opportunities and is already supplying customers in Zaire.

During last year INDECO acquired all the shares in ZAMOX previously held by British Oxygen Plc.

3.0 INPUTS AND OUTPUTS

This Chapter comprises the list of the main inputs and outputs of the major chemical plants. In some cases the outputs of one subsidiary within the chemical subsector is used as the input for other subsidiary within the same subsector (for example sulfuric acid, nitric acid, etc.).

3.1 Major inputs of subsector

In the chemical subsector there are the following principal inputs: sulfuric acid, nitric acid, glycerine, glycol, pyrite, potassium chloride, potassium sulfate, single superphosphate, diammonium superphosphate, triple superphosphate, intravenous fluids, oral rehydration salts, coal and fuel oil.

3.2 Major outputs of subsector

The chemical subsector has these principal outputs: methanol, ammonium nitrate, ammonium sulfate, carbon dioxide, sulfuric acid, nitric acid, liquid ammonia, compound fertilizers (NPK), NG explosives, blasting agents (Anfex), blasting accessories, drugs (intravenous fluids and oral rehydration salts), weld electrodes and industrial and medicinal gases: oxygen, hydrogen, nitrous oxide, acetylene.

3.3 List of major inputs and outputs for selected companies

Kafironda Explosives Ltd.

Principal inputs: glycerine (900 tpy), glycol (230 tpy), nitro cotton (90 tpy), ammonium nitrate dense (7,700 tpy), ammonium nitrate porous (18,000 tpy), kraft paper (300 tpy), nitric acid (4,800 tpy), sulfuric acid (1,500 tpy), components for construction of accessories.

Principal outputs: NG explosives (11,800 tpy), blasting agents (Anfex, 18,700 tpy), blasting accessories (7.7 mln units).

Nitrogen Chemicals of Zambia Ltd.

Principal inputs: pyrite (54,000 tpy), single superphosphate (5,675 tpy), diammonium superphosphate (19,740 tpy), triple superphosphate (12,340 tpy).

tpy), potassium chloride (878 tpy), potassium sulfate (16,600 tpy), filler for NPK (160 tpy), coating agent for ammonium nitrate (179 tpy), coating agent for NPK (525 tpy), coal (198,000 tpy), fuel oil (10,000 tpy).

Principal outputs: ammonium nitrate fertilizer grade (77,600 tpy), ammonium nitrate explosive grade (37,400 tpy), ammonium nitrate - solution of 95% concentration for NPK plant (25,220 tpy), ammonium sulfate (50,000 tpy), compound fertilizers (NPK, 142,000 tpy), liquid ammonia (91,000 tpy), methanol (1,500 tpy), nitric acid at 100% concentration (120,000 tpy), sulfuric acid (60,000 tpy), carbon dioxide (1,000 tpy).

General Pharmaceuticals Ltd.

Principal inputs: chemicals for intravenous fluids and oral rehydration salts (ca. 10 tons/month), packaging material (ca. 70 tons/month), distilled water (ca. 70 m³/month).

Principal outputs: intravenous fluids (ca. 70,000 liters per month pharmaceutical grade), oral rehydration salts (ca. 85,000 sachets per month, pharmaceutical grade).

4.0 LINKS

Out of the spectrum of possible links and liaisons involving the chemical subsector, those deserving particular attention connect chemistry with agriculture and food industry. Of course, the transport component is always present.

4.1 Links within the chemical subsector

Several strong links tie together the various ZIMCO/INDECO subsidiaries within the chemical subsector. Large quantities of chemicals produced in one ZIMCO subsidiary are the input for another chemical plant. The following cases can serve as examples:

NCZ produce ammonium nitrate which is used at Kafironda for the production of explosives; nitric acid produced at NCZ is passed on along similar links.

ROP produce glycerin which is an important starting material for the production of nitroglycerine at Kafironda Explosives.

Premium Oil and ROP have very similar production programs (edible oil, soap, etc.). This link could be strengthened by sharing experience, analytical methods and equipment, etc.

Maamba Collieries is a supplier of coal to NCZ; coal could also be used for the production of an expanded range of chemicals (possibly by cooperation of NCZ with Maamba).

The Textiles and Clothing Production group turns out polypropylene and polyethylene bags which are necessary for the packaging of fertilizers and other chemical products. On the other hand, the production of textiles requires large quantities of materials which are produced by chemical industry (caustic soda, dyestuffs, etc.).

Products of Indeni Refinery are used in a number of chemical factories but also in laboratories and workshops (heating oils, solvents, lubricating oils, etc.). Again, the refinery itself is using a range of chemicals to support its production processes (chemicals for selective refining, corrosion protection additives, inert gases, etc.).

4.2 Links between the Chemical subsector and Agriculture and Food Industry

Fertilizer manufacturing

There are very firm links between agriculture and chemistry. It is well known that farmers spend about equal amounts of money on seeds, fertilizers, and agrochemicals. In fact, the link between manufacturing and agriculture is seen as the backbone of any successful comprehensive R & D effort in Zambia.

The main producer of fertilizers in Zambia is Nitrogen Chemicals of Zambia Limited (NCZ). NCZ produces ammonium nitrate, ammonium sulphate, liquid ammonia and compound fertilizers (NPK).

The development of Zambian agriculture is heavily dependent on the production of NCZ. Close cooperation of the R & D Department at NCZ with the agricultural specialists is needed. Among other things, it can help to diversify fertilizer production (cf. Chapter 2.2.2).

Soil composition analysis

In 1990 the Soil Productivity Research Program and Adaptive Research Planning Team continued to carry out research on sustained utilization of the soil resources of the Northern Province.

Determination of soil composition using modern physico-chemical methods provides an important input needed to establish improved management practices (application of proper type and quantity of fertilizers) and for crop diversification.

Vegetable Oils as Diesel Extenders/Substitutes

Vegetable oils can be used as diesel extenders or substitutes. Trials of diesel engines with vegetable oils indicate that engine efficiency is similar with vegetable oils and gas oils.

Density and viscosity of vegetable oils are higher and the volumetric calorific value is lower in comparison with conventional gas oil. The high viscosity of vegetable oils can cause poor fuel atomization with a consequent increase in smoke and gaseous emissions.

The operating problems noted with vegetable oils include substantial increase in piston and injector nozzle deposition as

well as reduced life of crankcase lubricants. Most vegetable oils are completely miscible with hydrocarbon diesel fuel.

The main problem of large scale production of described alternative diesel fuels is their high price (2 - 3 times higher than crude oil product).

Straw as a source of fermentable sugar

A novel process for converting cellulose to glucose has been developed by ICI. It is a three-stage process, in the final stage of which cellulose is converted to glucose in a calcium chloride - hydrochloric acid hydrolysis. Conversions of 86 per cent of the cellulose in wheat straw was achieved.

Production of biogas from wastes

Gases are usually generated from the decomposition of agricultural wastes and largely consist of methane. Alternatively producer gas (basically carbon monoxide and hydrogen) can be made by the partial oxidation of cellulose materials such as wood or from pre-prepared charcoal. Biogas can be produced from various types of wastes, for example from piggeries, sugar production, etc.

Paper from straw

Straw for paper has been used for many years. However, the wood pulp technology is now on a high technical level and straw pulping will not be able to compete with it. In case a large paper mill will be build in Zambia it will be worthwhile to consider small straw pulping mills producing pulp from a group of farms and transporting it to a paper mill. To locate the first stage of this processing close to the resource of raw material would overcome the problems with the transport of raw materials on long distances.

The "SAICA" straw pulping process has been successfully used in Spain for 30 years. This process is based on digester with capacity of 40 tpd operated by one man. The milled straw is cooked with caustic soda at temperature less than 100°C and at atmospheric pressure.

Small satellite oil mills

Output of cooking oil in Premium Oil Industry Limited could be easily increased if local production and supply of soybeans or other seeds could be increased as well. There are two main constraints: low price of soybeans, sunflower seeds, etc. and the problems with the transport of mentioned materials for long distances. The first problem could be solved by motivating the farmers by increased prices. The transport problems can be overcome by setting up a system of small "satellite" oil mills with a simple extraction of seeds in the main production areas. The oil can be then sent more easily to the larger plant for the final treatment (refining, deodorization, etc.).

Utilization of cashew nuts oil and fruit

Cashew oil and cashew fruit are the byproduct of growing cashew nuts.

Cashew oil is burnt, providing fuel for the furnaces used for roasting the cashew nuts. As it contains phenolic compounds it can be used for the impregnation. Its impregnation properties could be quantified by tests to be run at the R & D Department at ZAFFICO or by cooperation of RDU with NCSR research laboratories.

Cashew fruit is not being utilized in Zambia. It has very good potential for the production of soft drinks (already commercialized in some South American countries).

Extraction of natural species

Natural species extracted from various plants can be used for the production of drugs, dyes, and similar additives for food products.

Extraction of caffeine from coffee is a potential project, also providing de-caffeinated coffee for export.

Some research in this field has already been done at the Tree Improvement Research Center (TIRC) in Kitwe. Utilization of the shrub "Phyllolacca dodecandra" for the eradication of the snail (a vector for schistosomiasis) was studied. At NCSR's Livestock and Pest Research Center (LPRC) at Mount Makulu some Zambian plants were screened for their potential as acaricides.

Veterinary medicines and vaccines

The Central Veterinary Research Institute (CVRI) produced five vaccines and two astringents. The vaccine production unit produced the following types of vaccines: rabies black quarts, Hemorrhagic, Septicaemia and brucella.

The department of veterinary and Tsetse Control Services undertook control measures to combat poultry diseases. With the local production of Salmonella antigen, CVRI is able to screen the major foci of the disease.

A new project on the production of veterinary medicines at General Pharmaceuticals Limited is at present in the preparation stage (cf. Chapter 2.2.2).

Analysis of toxic chemicals

Monitoring of toxic chemicals in soil, plants, and animals is very important for the health of the population and for environmental protection.

For the analyses of toxic residual impurities, modern analytical equipment such as gas and liquid chromatographs and spectrometers is necessary (cf. Chapter 5.4).

Fermentation of sugar to ethanol

Fermentable material from agricultural production can be used as raw material for the production of ethanol. Sugar cane is the dominant feedstock for ethanol production; ethanol is produced from the fermentation of sugars by micro-organisms, principally yeasts.

Large scale production of ethanol is operational in Brazil where ethanol is used as automotive fuel. Sugar cane provides a relatively pure juice containing 12 - 16 per cent sucrose together with more than enough bagasse for the process energy requirements.

Fuel ethanol based on agriculture feedstock will most probably remain uncompetitive with gasoline for the next five to ten years (fuel ethanol cost used to be 3 - 5 times higher than the price of gasoline for years but the ratio is more favorable now). However, the production of ethanol from low-value molasses can make economic sense. Taking into account the severe crude oil supply disruptions in last years, it can be recommended to the

RDU to collect continuously all information from this field. Their evaluation will be important for medium and long term strategies in this sector.

4.3 Links between the Chemical Industry subsector and the Transport sector

Gasoline, diesel fuel, oils

The refineries consume large amount of chemicals for the refining process and for the various additives as well. For example, tetraethyl lead is used as additive to gasoline, various depressants and viscosity improvers are used for diesel fuel, additives improving the lubricating properties and thermal stability of oils are used for the lubricating oils, etc.

The Indeni Petroleum Refinery Co. Ltd. in Ndola is of vital importance for all Zambian transport, as all crude oil (about 650 thousand tpy, much less than the refinery's design capacity) imported by Tazama pipeline is refined there.

Used oils

Used oil is a very valuable raw material which can be relatively easily regenerated to a good quality oil by the combination of chemical and refinery processes.

Unfortunately, there is no well organized system of used oil collection in the country.

Tires

There is no tire production in Zambia. Tire retreading which is provided by Consolidated Tyre Services Limited (CTS) is a process more mechanical than chemical.

The rubber growing project (cf. Chapter 2.2.2) in which INDECO is a partner will be the appropriate place for the chemical research in future (also see Technical Report "A" and "T").

5.0 FORMULATION OF RDU IN CHEMICAL INDUSTRY

According to the new economic program, GRZ is giving high priority to scientific research and technology development.

In line with this orientation, ZIMCO/INDECO give support to the project of establishing a RDU to serve both the Group and GRZ. In this connection the problems addressed include assessment of the information needs of ZIMCO/INDECO, potential cooperation among ZIMCO/INDECO subsidiaries, setting of priorities in RDI, and resolving a range of practical regarding RDU's operation (staff, financing, equipment, etc.).

5.1 UNIDO team activities

This Chapter gives an account of the UNIDO project activities in the chemistry subsector in compliance with the work plan for the UNIDO mission. From these activities resulted the definition of objectives to be reached by the RDU (cf. Chapter 5.2) and of the RDU activities and outputs (Chapters 5.3 and 5.4, respectively).

There are two groups of activities and outputs addressed in this Technical Report. The first part was undertaken in cooperation with other members of the field team and with national counterpart staff, dealing with more general problems, i.e., the structure of the RDU, the methods of collecting and disseminating information, etc.

The second part describes the outputs and activities which are oriented at specific problems in the field of chemical technology, pharmaceuticals, and environmental protection. All outputs are referred to in the context of the activities.

5.1.1 Assessment of information needs

The assessment of industrial information needs was done by various means.

The conclusions and recommendations from the ZIMCO Technology Audit project (1989) served as a very detailed source of information. A list of chemical companies visited during the 1989 and 1991 missions is given in Annex C-1.

In some cases it was necessary to revisit several companies during the present mission (April/May 1991) to obtain more information on R & D activities and to check on changes of

orientation and priorities in this field.

Contacts were established with some companies cooperating in any aspects with the companies having the "pure" chemico-technological profile, for example with food-producing companies, spare parts producers, refineries, glass and ceramic production, etc.

During the companies' visits the following questions were asked:

- What kind of R & D activities do you have at your company and in which R & D programs of any other company do you participate?
- Which kind of R & D project can help you in any of your specific problems?
- How can the RDU established at the ZIMCO Directorate for R & D help your company?
- How can you help the RDU activities?
- Which will be the most effective way of cross-sectorial cooperation using the help of the RDU?
- What's your opinion on the form of funding the RDU?

All responses, insofar as they were received from the company managers and research officers, were taken into consideration in preparing the RDU organization proposal.

Visits were paid also to pertinent ministries (Ministry of Commerce and Industry, Ministry of Water, Lands and Natural Resources, Ministry of Agriculture, Ministry of Higher Education, Science and Technology), requesting up-to-date information on the situation in the chemical industry subsector and environmental protection, also including information on links to other sectors using chemicals or providing inputs for the chemical industry.

The discussions with scientists from the NCSR and UNZA proved also to be very useful and opened new angles regarding the possibilities of utilization of domestic raw materials, the organization of various research projects, and possibilities of cooperation of large and medium size industrial plants with small scale industry.

The annual reports of ZIMCO, INDECO and some other companies from the field of chemical technology were studied to collect data on all perspective R & D activities and to narrow down a selection suiting the INDECO and GRZ priorities.

The study of various scientific literature on chemistry and technology, and reports from national and international conferences helped the team to establish the key problems which should be preferentially solved in the production of chemicals

and in the organization of chemical technology in Zambia, for the sector to operate effectively and also assist at this stage mainly agriculture, food processing, and the transport and systems sector.

5.1.2 RDI cooperation among ZIMCO/INDECO subsidiaries

During the technology audits at chemical and food processing companies in 1989 and 1991 the potential areas of cooperation between ZIMCO/INDECO subsidiaries were identified. For example, the cooperation between Premium Oil and ROP in the production of cooking oil and soap and unification of analytical methods could be recommended. Many other similar links between the chemical and "non-chemical" companies were also found and the possibilities of participation in new projects were discussed during the company visits.

During their visits at ZIMCO/INDECO subsidiaries, the UNIDO consultants also demonstrated practical examples of the most effective ways of disseminating information.

Cooperation with companies outside ZIMCO/INDECO could provide for extended production of spare parts for chemical industry and food processing.

Possible inter-sectorial contacts and cooperation should also be established regarding chemicals for agriculture, forestry, textile industry, veterinary, etc.

The Chemical Technology Specialist of the RDU will start his work by technology auditing of those chemical and food processing subsidiaries which have not been covered by either the ZIMCO Technology Audit or the present (1991) mission.

5.2 RDU objectives

These are

- to intensify research into development of locally available materials for chemical industry;
- to pursue an integral approach in strengthening of linkages between R & D activities in chemical sub-sector and R & D activities in the other sectors;
- to utilize all results of research for increasing the capacity utilization of chemical plants and for other diversification of chemicals production;

- to use R & D potential for advising subsidiaries on environmental protection in chemical plants and on monitoring and dumping of toxic wastes;
- to set priorities on imports of RDI instrumentation for chemical analyses;
- to assist the subsidiaries in introducing new technologies for the chemical and food industry plants;
- to gather, analyze, and disseminate information on the latest RDI results from chemical industry subsector;
- to prepare an inventory of all imported chemicals and raw materials and byproducts of chemical industry in order to provide the basis for R & D on import substitution;
- to complete the ZIMCO/INDECO technology audit in all chemical and food processing subsidiaries and review the results following the methodological guidelines given by UNIDO consultants.

5.3 RDU activities

RDU activities in chemical technology are oriented mainly on the following areas of subsidiaries' cooperation:

- discovering production losses;
- utilizing wastes or byproducts;
- improving quality of chemicals;
- introducing new products;
- sharing technological or analytical equipment;
- sharing know-how;
- disseminating information on new possibilities of using chemicals in other sectors
- setting up a data bank of all chemicals used in Zambia
- training.

5.4 RDU outputs

The RDU structure and the program of its startup (Phase I) were proposed.

The job descriptions were defined for the individual RDU staff members. This job description is rather detailed in the case of the chemical technology specialist.

Equipment was also proposed for the RDU, to assist its operation

and to make it possible to alleviate somewhat the rather bleak situation persisting e.g., in the sphere of inspection of agricultural and food products as well as in analysis of harmful substance affecting the environment.

Specifically, in the area of chemical technology and chemical R & D (with impact on agriculture, food, and other sectors as well), the instrumentation package proposed is to comprise three analytical instruments:

- gas chromatograph, see Annex C-3
- liquid chromatograph, see Annex C-3
- infrared spectroscope, see Technical Report "A".

These instruments will find application primarily in inspection, supervisory, and arbitration analyses. This will be controlled and administered by the RDU. As for the location of these instruments (either in a central laboratory or separately) and method of operation (analysis on contract, loan agreements, hiring out to subsidiaries, etc.), this will be decided in conformity with experience and with immediate needs of ZIMCO and INDECO.

TRAINING

In the chemical sector, training should focus on the following topics:

- analytical inspection of product quality;
- handling and reuse of wastes;
- monitoring of noxious substance in environment;
- implementation of computers to evaluating the effectiveness of processes and technology; and
- principles of modern marketing and company management.

In addition, the RDU should be active in organizing seminars and workshops for the subsidiaries, aiming at selected issues (e.g., edible oil upgrading, rationalization of the production of charcoal).

The RDU should also make suggestions regarding study trips of technologies to foreign countries.

6.0 RECOMMENDATIONS IN THE CHEMICAL SUBSECTOR

In this Chapter the recommendations are ranked in order of decreasing priority.

- (1) Special attention should be paid to diversified, small-to-medium scale, production of chemicals which are used in agriculture, food production, and other subsectors. To set up a new plant with the universal equipment for the production of various types of pure and technical chemicals should be considered by ZIMCO/INDECO. A comprehensive analysis of the present needs of chemicals in all sectors of Zambian economy should be an important prerequisite to the final decision on launching this new investment program.
- (2) In line with previous recommendations, it is recommended to ZIMCO/INDECO to work towards outlining a pre-feasibility study into the commercialization of low grade mineral deposits; the phosphate deposits should be used for the needs of agriculture as soon as possible. It is recommended to the Phosphate Utilization Committee to start with small scale production of simple fertilizers (mixture of low-grade phosphates, inorganic acids, and some material containing peat, fossil wood, or plants from the local deposits).
- (3) To improve the situation in the supply of basic chemicals for various sectors, it is recommended to INDECO to research the potential of building a new plant for sodium chloride electrolysis. The production of larger amounts of caustic soda and chlorine is the prerequisite for the manufacture of many chemicals and other products (detergents, chlorinated solvents, washing agents, etc.). This recommendation is valid in spite of the existence of an ongoing expansion project, inasmuch as the country can absorb even larger quantities of caustic soda. Attention must however be paid to utilization of the relative surplus of chlorine.
- (4) As for the technology research at Kapiri Glass Products Limited, it is recommended to address preferentially these tasks:
 - iron removal from the raw material (important for the production of clear glass);
 - diversification in bottle and containers production for food industry (containers of various shape and size);
 - sheet glass production (foreign experts and technology transfer needed).
- (5) It is recommended to ZIMCO/INDECO to prepare, with UNIDO technical assistance and in cooperation with MCI, a proposal with on how to set up a Regional Center for the Promotion of

- Technologies and Methods on the Minimization, Recovery, and Recycling of Waste Residues (W.M.R.C.) in Zambia.
- (6) It is recommended that chemists and geologists of ZIMCO and GRZ on the one hand and agriculture specialists on the other hand work in close cooperation on an ad-hoc committee towards solving the problems of high soil acidity in the some provinces; it is recommended to the NCDP to involve this problem into development plans for near future.
 - (7) It is recommended to ZIMCO/INDECO and NCSR to study the project of introducing new extraction technology where carbon dioxide under supercritical conditions is used for the production of caffeine-free coffee and for the extraction of natural substances (medical drugs, natural colorants for food industry) from Zambian plants.
 - (8) It is recommended that ZIMCO/INDECO should promote, and ZIMCO/INDECO subsidiaries should participate in, an effective system of collection and utilization of selected wastes:
 - used oils should be returned, regenerated, and reused;
 - used chlorinated solvents from dry cleaners should be regenerated by distillation;
 - silver from photography processing should be regenerated chemically;
 - waste paper should be collected for re-processing or for export;
 - charcoal fines could be briquetted and sold as carbonaceous material, e.g., to metallurgical industry;
 - a system of collection of iron scrap should be devised and, at a more remote horizon commensurate with the recommendations of the FNDP, the scrap should be processed for re-sale or even for consumption in a local foundry or a local steel mill once the steelmaking project takes off.
 - (9) ZIMCO/INDECO should consider the project of a small tannery, combined with a facility for processing animal residues (for example, glue production from animal skins, horns, and hoofs); cf. Technical Report "F".
 - (10) It is recommended to ZIMCO/INDECO and RDU to investigate the availability of brick making materials (clay pits) around urban and suburban areas and to identify suitable brick making. The bricks could be dried and fired using local low grade coal as fuel.
 - (11) It is recommended to ZIMCO/INDECO subsidiaries active in the building trade to agree on measures whereby cement should be

used mainly for the concrete constructions and not so much for family houses. For plasters and for brick-joining mortar, lime should be used instead of cement.

- (12) It is recommended to ZIMCO/INDECO to infuse environmental consideration into the planning, implementation and review of new major development projects.
- (13) It is recommended to ZIMCO/INDECO and the Ministry of Commerce and Industry to study the possibilities for launching the paint and pigment industry. The availability of raw materials such as lime, barite, gypsum, manganese, mica, clay, etc. is a good prerequisite for such a proposal. The various colorants such as yellow (ochre), rust (hematite), black (manganese), green (malachite), blue (azurite), titanium oxide, etc. for the paint industry are also available locally.
- (14) It is recommended to ZIMCO/INDECO and the Ministry of Mines to utilize locally produced graphite and calcium fluoride of very high purity (97 - 98 per cent) for the production of polyfluorinated graphite, known as a very effective lubricant for high temperatures. The high quality graphite could be also used for the production of graphite electrodes, molds, and other special products well suited for exports.
- (15) With a view to the modest output of Mansa Batteries, it is recommended to Mansa Batteries Ltd. and ZIMCO/INDECO to optimize the resources for the production of batteries (locally available manganese, zinc, lead, and graphite).
- (16) It is recommended to ZIMCO/INDECO to promote at Norgroup Plastics Limited new technology for the production of granulated polypropylene regenerate from used polypropylene bags. Other diversification of the production should also be considered (bottoms for home shower baths and other household plastware).
- (17) It is recommended to ZIMCO/INDECO and the Ministry of Commerce and Industry to utilize local raw materials as talcum, cyanite, mica, clay, etc. for the production of insulators, spark plugs, and current resistors.
- (18) It is recommended to RDU, NCSR, and the Ministry of Mines to launch an economic study into utilization of Zambian sulfide ores for the production of sulfuric acid which is in short supply in the country.

- (19) It is recommended that ZIMCO/INDECO and the Ministry of Mines consider utilizing high grade fluorspar for the production of hydrofluoric acid and fluorine.
- (20) It is recommended that ZIMCO/INDECO and the Ministry of Mines intensify efforts to re-examine the feasibility of a mini-steel plant for the production of medium quality structural steel. Availability of numerous deposits of good quality iron ore throughout Zambia and of low cost energy are good prerequisites for this project.
- (21) It is recommended to ZIMCO/INDECO, Maamba Collieries, and/or NCZ to utilize coal for the production of chemicals by applying thermic degradation processes - for example, coal gasification. Aromatic hydrocarbons, phenols, etc. could be produced by this route.
- (22) It is recommended to ZIMCO/INDECO and Ministry of Mines to set up an ad-hoc team to study the possibilities of evaluating of gemstones for various use, including the possibility of tapping local talent for larger-scale processing to semi-products and even finished jewellery.
- (23) On a more remote horizon, it is recommended that ZIMCO/INDECO also reviews the other potential development and/or improvement projects listed in Chapters 4.1 and 4.2.

7.0 CONCLUSION

The following conclusion can be drawn as a result of observations during the ZIMCO Technology Audit and findings from the discussions on RDI activities at ZIMCO/INDECO chemical and related subsidiaries.

- 1 Shortage of chemicals (not just special chemicals but even of common ones) and incomplete information on the actual needs represent one of the constraints which hinder a full development of industrial and agricultural companies in Zambia.
- 2 Valuable domestic raw materials (and some intermediates) cannot be fully utilized unless there is better coordination among the companies and among various sectors of the national economy. Another adverse factor is weak communication links and lack of information on the companies' production programs and the application range of their products.

These drawbacks should be eliminated by the activity of the coordination unit (RDU) at ZIMCO/INDECO, equipped with up-to-date technology and staffed with experienced, enthusiastic technologists.

- 3 Ranking among the major factors which can positively influence the operations of the Unit is a careful selection of the RDU staff.

Specialists in their respective professions must also have organizational and coordinating capabilities. Adequate funding of the RDU and sufficient salaries of its staff are important in this respect.

- 4 Development of manpower for industrial information (including sustained retraining of the RDU staff) should take advantage of cooperation with international specialists in the respective fields.
- 5 Major problems posing a challenge to the national economy in the area of technology and R & D should be tackled by "ad hoc" teams nominated so as to cover those professions which are required to solve the problem in question. RDU should be active both in the selection of these specialists and in the operation of the teams.

ANNEX C-1

**ZIMCO subsidiaries and associate companies
involved in the chemical industry sector**

| Company | Bordering on sector(s) | Principal products/services |
|------------------------------------|------------------------------|--|
| Agip (Zambia) Ltd. | T | gasoline & petroleum products (retail) |
| BP (Zambia) Ltd. | T | gasoline & petroleum products (retail) |
| Consolidated Tyre Services Ltd. | T | tire retreading |
| General Pharmaceuticals Ltd. | | intravenous fluids, oral rehydration salts |
| Indeni Petroleum Refinery Co. Ltd. | | fuels & petroleum products |
| Industrial Development Corp. Ltd. | A, F, T | mixed |
| Kafironda Explosives Ltd. | | mining explosives |
| Kapiri Glass Products Ltd. | | glass bottles |
| Lublend Ltd. | | lubricating oils |
| Maamba Collieries Ltd. | | stone coal |
| Mansa Batteries Ltd. | | dry cell batteries |
| National Drug Co. Ltd. | | pharmaceuticals (retail & manufacture) |
| Ndola Lime Co. | A | lime |
| NIEC Agencies Ltd. | F | food, consumer goods & pharmaceuticals (wholesale) |
| Nitrogen Chemicals of Zambia Ltd. | | fertilizers & sulfuric acid |
| Norgroup Plastics Ltd. | | plastic containers |
| Premium Oil Industries Ltd. | F | hard soaps & detergents, edible oils & fats |
| ROP (1975) Ltd. | F | hard soaps & detergents, edible oils & fats |
| Tazama Pipelines Ltd. | T | transport of crude petroleum |
| Zambia Ceramics Ltd. | | ceramic products |
| Zambia Clay Industries Ltd. | | brick making |
| Zambia Oxygen Ltd. | | industrial gases |
| Zamlube Refiners Ltd. | | lubricating oils |

| | | |
|-------------------------------|-------|-----------------|
| Zimco Institute of Management | A,F,T | training |
| ZIMOIL | T | import of crude |

Note: **A** = agronomy sector
 F = food processing sector
 T = transport & systems sector

ANNEX C-2

Job description for chemical industry specialist

Post title: Chemical Technology Specialist

Qualifications: Chemical Engineer (university graduate).
Experience in research and/or industry is desirable.

Duties:

- To participate, under the general direction of the RDU Head and in close cooperation with the other staff members, in the startup and routine work of the RDU.
- To closely monitor all RDI activities in the chemical industry sector.

The specialist will be expected to perform the following activities:

- review the results of the "ZIMCO Technology Audit" in given professional area
- generate and update lists of all inputs and outputs (incl. wastes) of all subsidiaries and associate companies within the chemical technology sector
- generate and update a list of all chemicals used in all other sectors, mainly in agronomy, food processing, and the transport and systems sector
- convert above lists to data bank input format
- assist companies in accelerating existing R & D projects
- identify RDI problems to be analyzed and potential new RDI projects to be launched
- make efforts to initiate the utilization of wastes from the chemical industry and look for economical, effective, and environmentally harmless waste disposal methods

- advise companies on environmental pollution and control; initiate preventative measures
- take an active part in the dissemination of information on R & D, technology upgrading, and modern know-how in the chemical industry sector
- write a list of R & D contact persons at the companies who can maintain links in the area of R & D to other sectors
- mediate company-to-company links
- advise RDU Head on participation by professionals from his sector in the work of ad hoc teams on cross-sectorial or multi-sectorial RDI projects
- provide help to subsidiaries in their efforts to establish, expand, or re-orient their R & D departments
- establish and maintain linkage between NCSR, UNZA, Copperbelt University, and the RDU in the area of chemical technology
- look for natural species which can be used for the production of chemicals and drugs
- prepare a list of chemical analysis instruments and techniques at the subsidiaries; work toward their unification and standardization; advise on their optimum use and sharing in R & D, environmental monitoring, and inspection
- operate the ZIMCO pool of analytical and testing instruments
- train companies' RDI staff in methods of effective work with professional chemical literature and in literature searching techniques
- assist the scale-up of R & D results to pilot and full-scale production of chemicals and drugs
- identify and quantify production constraints and technology related losses.

ANNEX C-3

Analytical equipment for analyses of chemicals,
food products, and environment

(1) Gas Chromatograph 5890A (Series II) Hewlett-Packard

- HP 5890A - Mainframe (for capillary columns)
- Single Flame Ionization Detector with make-up gas
- Single Electron Capture Detector with electronics
- Data Station (or single integrator)
- Fused silica capillary columns (0.25 - 0.35 mm i.d., 20 - 30 m length), with nonpolar stationary phase (OV-101) and with polar stationary phase (e.g. Carbowax 20 M).

(2) Liquid Chromatograph 1090 (Series L) Hewlett-Packard (HPLC)
(with manual injection)

- Diode-array detection system (HP 1040 M)
- differential refractometer OPTILAB (Sweden)
- HPLC ChemStation (HP 9000 Series) with printer
- Selected software
- HPLC columns:
 - (1) with 5 microns silica gel
 - (2) 5 microns silica gel with reverse phase (C₈, C₁₈) and other various chemically bonded phases.

Note: The first instrument is regarded as indispensable and its cost is included in the budget of the international (UNIDO) assistance project envisaged for upscaling the RDU (cf. Annex 7 of the main Terminal Report). The second instrument is equally important, but it is suggested that because of its price, ZIMCO/INDECO take care of financing in this case.