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UNITED NATIONS INDUSTRIAL
DEVELOPMENT ORGANIZATION

ASSISTANCE TO THE SOCIALIST REPUBLIC OF VIET-NAM (SRVN) 1/ IN ESTABLISHING A DDT PROJECT (DICHLORO DIPHENYL TRICHLOROETHANE)

(TS/RVN/76/001)

Report of a UNIDO/WHO Mission

by

United Nations Industrial Development Organization (UNIDO)
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and

World Health Organization (WHO)
W. Van Dijk, Medical Doctor

September 1976

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5 "The place of pesticides in public health programmes" by H.A. Rafatjah - WHO

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GENERAL INFORMATION

President of SRVN Mr. Ton Duc Thang

Premier of SRVN Mr. Pham Van Dong

Population of SRVN North 25.5 million
South 23.5 million

Area North 159,000 km2
South 173,300 km2

Hotels (Hanoi)

Hotel Democrat (Phieu Thy) in the
Hotel Unity (old Metropole) city

Hotel Victory (Hotel Thang Loi) about 6 km from city
(most modern A category; minimum room charge 50 Dhongs/day)

Currency rates

1 US$ = 2.93 Dhongs
1 US$ = 2.93 + 50% for tourists
1.465
4.395 Dhongs

Where to get visa

Paris)
Moscow)
New York) for Hanoi
East Berlin)
New Delhi)

Air lines

1 East Berlin to Hanoi Mondays and
Interflug (IF) Wednesdays

2 Moscow to Hanoi
Aeroflot (AF) Mondays, Tuesdays and Fridays
Tranship from jets to propellor plane at Vientiane (Laos)

3 Bangkok to Vientiane
Thai Air Lines

Climate

May to October	hot rainy season - 30°C
November to April	cool dry season - 18-20°C

Main crops

Rice production	7.6 million tons
Rice requirements	8.8 million tons

Area under cultivation

6 million hectares
0.16 hectare per capita

Industry

Consumer products
Food preservation
Fishery products
Pharmaceuticals
Pulp and paper
Basic chemicals (sulfuric acid, caustic/chlorine)
Fertilizers (super phosphates)
Pesticides (BHC)
Petrochemicals (PVC)
Construction industries
Engineering industries
Building materials
Iron and steel
Coal mining
Zinc smelting

Ministries concerned

Ministry of Heavy Industry
Ministry of Light Industry
General Service of Chemistry

2. INTRODUCTION

The Ministry of Health of the Socialist Republic of Viet-Nam (SRVN) requested by cable an urgent mission consisting of experts from UNIDO and WHO to explore possibilities of establishing a DDT production unit utilizing chlorine from an existing caustic-chlorine plant. The DDT is to be used exclusively for malaria control purposes and not for agriculture.

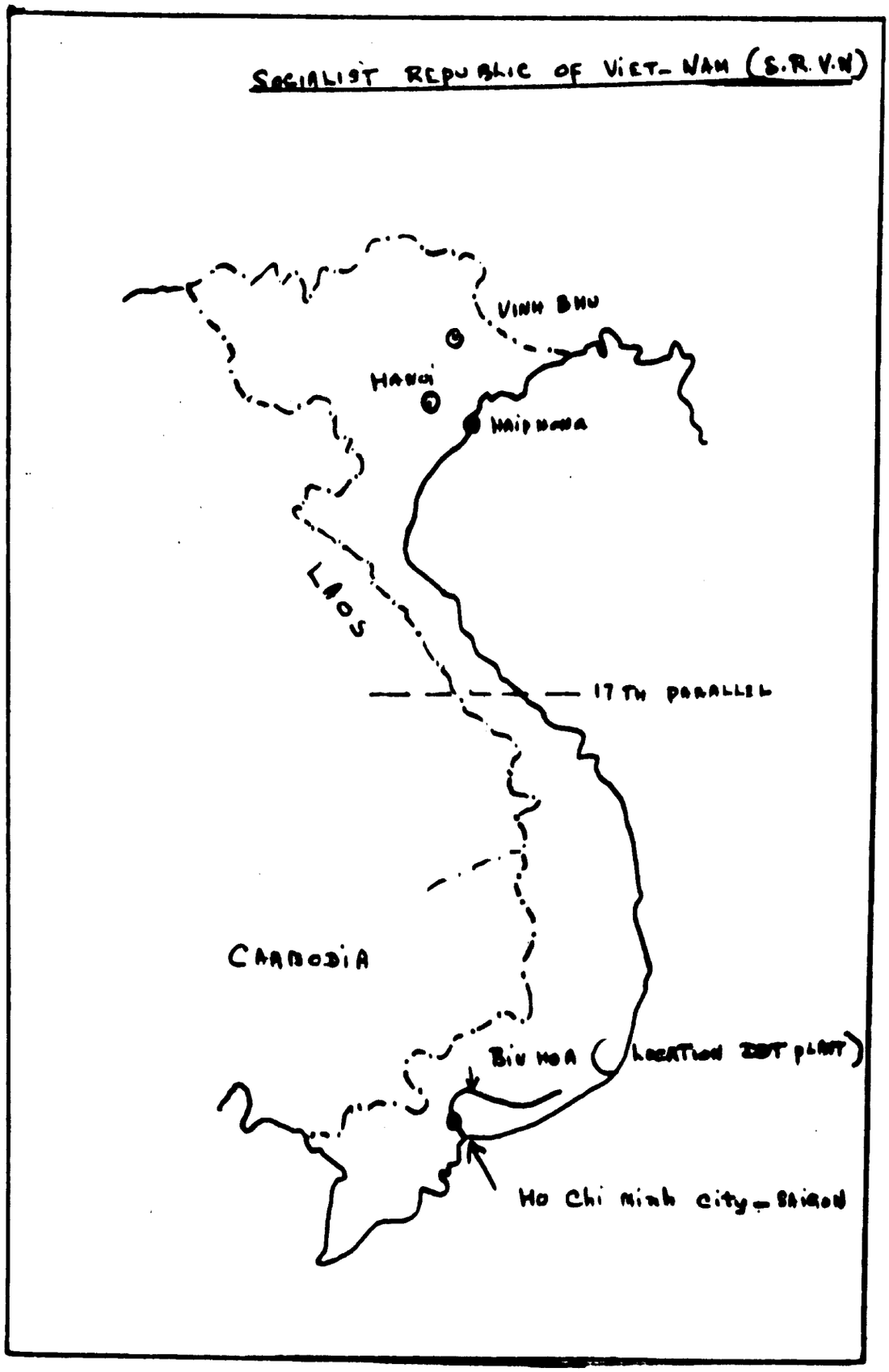
The mission was carried out between 28 August and 11 September 1976 by two senior staff members of UNIDO and WHO. They held several discussions with officials of the Ministry of Health, the General Services of Chemistry and the Foreign Ministry in addition to visits to a caustic-chlorine plant and the Institute for Malaria and a Field Malaria Centre.

The mission records its gratoful thanks to the Deputy Minister of Health, Dr. Hoang Dinh Cau, the Director of the External Department, Mr. Nguyen Van Trong, the Director of Hygiene and Epidemiology, Dr. Pham The who also helped as counterpart, the representative of the General Service of Chemistry, Mr. Nguymen Qui Sanh, and Miss Le Thu Ha, who helped as interpreter. But for the co-operation and assistance of all officers in SRVN, the mission could not have completed its task in so short a time.

The report of the United Nations mission to North and South Viet-Nam headed by Dr. Victor Umbricht dated March 1976 reported on Malaria control as follows in the North:

"The purpose of this campaign is to reduce the over-all incidence of malaria to its 1964 level or 0.23 per 1,000 population, that proportion being considered a basis for the complete eradication of malaria in the larger term. To that end the government has asked for an annual supply of 300 tons of DDT for five consecutive years, the estimated cost of this operation being evaluated at approximately $500,000 a year.

In view of the needs of the malaria control campaign to be waged in South Viet-Nam, it may be estimated that annual consumption of DDT will be between 1,000 and 1,500 tons for several years. Accordingly, it is important to consider whether it would be more economic to set up a DDT manufacturing plant".


SOCIALIST REPUBLIC OF VIET-NAM (S.R.V.N)
VINH BHU
HANOI
HAIPHONG
LAOS
17TH PARALLEL
CAMBODIA
BIEN HOA
(LOCATION ZBT PLANT)
Ho Chi Minh city - SAIGON

The Government of SRVN has therefore decided to set up a DDT plant in the South in the Dong Nai province (Bien Hoa) close to the VICACO - VIET-NAM chlorine and alkali company 30 km from Ho Chi Minh city on the river Dong Nai. Chlorine to the extent of 2700 tons per year is available from this factory whereas chlorine from the other existing factory at Vinh Phu 80 km from Hanoi is already being fully utilized for the production of polyvinyl chloride (PVC), benzenehexachloride (BHC), etc. Considering that chlorine is the most important and largest needed (1.8 tons chlorine per ton of technical grade DDT) it will be most economic to locate DDT production close to the chlorine source. Further, proximity of a deep water river is essential for water supply.

The conclusions and recommendations of the mission were submitted as an aide-mémoire to the Ministry of Health before the mission left Hanoi and discussed in detail with them. The agreed conclusions and recommendations are given below except for a third alternative for financing the project. When the site data on two alternative sites are received, they will be added on to this report as appendix 3.

3. ESTIMATE OF DDT REQUIREMENTS FOR MALARIA CONTROL IN SRVN

The immediate annual requirements are estimated at 300 tons DDT 75% water dispersible powder (wdp) for the North and 750 tons for the South. A more complete coverage in the country could bring the figure for the entire country to about 1500 tons DDT 75% wdp in the near future. It is also anticipated that DDT may be supplied to the malaria control programmes in Kampuchea and Laos. Although in these programmes at present virtually no DDT is used, the situation is likely to change in the near future, but it is unlikely that the DDT requirements of these programmes together will exceed 500 tons DDT 75% wdp in the foreseeable future.

The total annual requirements for the three countries is thus, for the time being, estimated at 2000 tons DDT 75% wdp or 1500 tons DDT technical grade. DDT is not used outside the Department of Health, where its use against other vector-borne diseases is prevented by DDT resistance among vectors.

4. CAPACITY OF DDT PLANT (300 days working per year)

From the points of view of requirements of DDT, availability of know-how and equipment immediately and availability of chlorine in SRVN, it is recommended that as phase I, a DDT plant with capacity for production of 1500 tons per year of technical grade material be put up. As phase II, another line of same capacity may be built. But even during phase I, space requirements, utilities like electric power, water and effluent treatment be designed for 3,000 TPY. After operational experience is obtained and after requirement of DDT goes up and after expansion of existing caustic/chlorine plant provides enough chlorine, the phase II can be put up.

Health Ministry officials are of the view that even in phase I

a) a continuous chloro benzene unit for a production of 3000 TPY technical DDT

b) formulation and effluent treatment for 3000 TPY

c) one line for grinding

should be set up.

Such flexibilities could be discussed with donors depending on finances available and engineering flexibility. It is agreed that in principle 4/5 of yearly technical grade DDT 1500 TPY be formulated as water dispersible powder (WDP) as 50% concentration and 1/5 of yearly production be formulated as emulsion 25% concentration incorporating 9% Lindane.

"The exact amounts to be formulated as WDP and emulsion concentrate respectively will be dependent on requirements of the moment and decided upon later." By the way, should it be 25% or 30% emulsion concentrate? Although 75% WDP is more economic for transport and 30% is most uneconomic, considering the experience in most developing countries and taking into account ease of formulation, effectiveness, quality in storage and economics, 50% WDP is most suitable.

5. RAW MATERIALS, UTILITIES AND OPERATING SUPPLIES REQUIREMENTS AND AVAILABILITY

		Per ton of technical grade DDT	For 1.500 TPY
a)	**Raw materials**		
i	Chlorine (99%)	1.77 tons	2655 tons
ii	Benzene	0.84 "	1260 "
iii	Ethyl alcohol (100% basis)	0.33 "	495 "
b)	**Utilities**		
i	Steam (10 kg/cm2)	11.0 tons	16500 tons
ii	Electricity	1000 KWH	About 300 KVA
iii	Filtered soft water	100 tons	150000 tons
c)	**Operating supplies**		
i	Oleum (20%)	1.32 tons	1980 tons
ii	Caustic soda lye (50%)	0.1 "	150 "
iii	Calcium chloride	(as required)	
d)	**For formulation**		
i	Technical grade DDT		
ii	China clay (as carrier/filler)		
iii	Hydrated calcium silicate (as anti-caking agent and absorbent)		
iv	Surface active agents		
v	Solvents (for emulsions)		
vi	Lindane (as needed)		

Out of the above raw materials, utilities and operating supplies, chlorine is available from the existing caustic/chlorine plant at Dong Nai province (Bien Hoa) called VICACO (Viet-Nam Chloride and Alkali Company) to the extent of 2500 TPY. Ethyl alcohol is available from nearby sugar factories. Only benzene has to be imported. Water supply will be from the Dong Nai River. Steam will be generated and electricity taken from the electric grid. Oleum will be obtained from nearby sulfuric acid plants as well caustic soda from VICACO. Rest of operating supplies not available in SRVN has to be imported.

6. LOCATION AND SITE

A preliminary mission was sent by SRVN to Dong Nai province in the South to study a location for the DDT plant close to the Viet-Nam chloride and Alkali Company (VICACO) which has presently 2700 TPY chlorine available. The mission had discussions with the members who inspected the site. They reported that 3-5 hectares of land are available on the other side of the road. The location is in the industrial area and on the other side are the paper and iron and zinc factory and an electrical factory. But very close to VICACO and adjacent to the site is a sugar processing factory. The river Dong Nai is on the opposite side of the road. It is felt that it would be inadvisable to locate the DDT factory close to the sugar factory. However, at a later stage this site as well as an alternate site a few kms away should be investigated. A detailed questionnaire has been submitted to the Health Ministry to collect data and information (appendix 3). After such data is received, the site near the VICACO factory and an alternate site will be examined. Even if the site is a few kms away from VICACO and the sugar factory, the chlorine can be liquified and transported by lorry in item cylinders (see location and site sketch).

7. PROJECT COSTS AND FINANCING METHODS

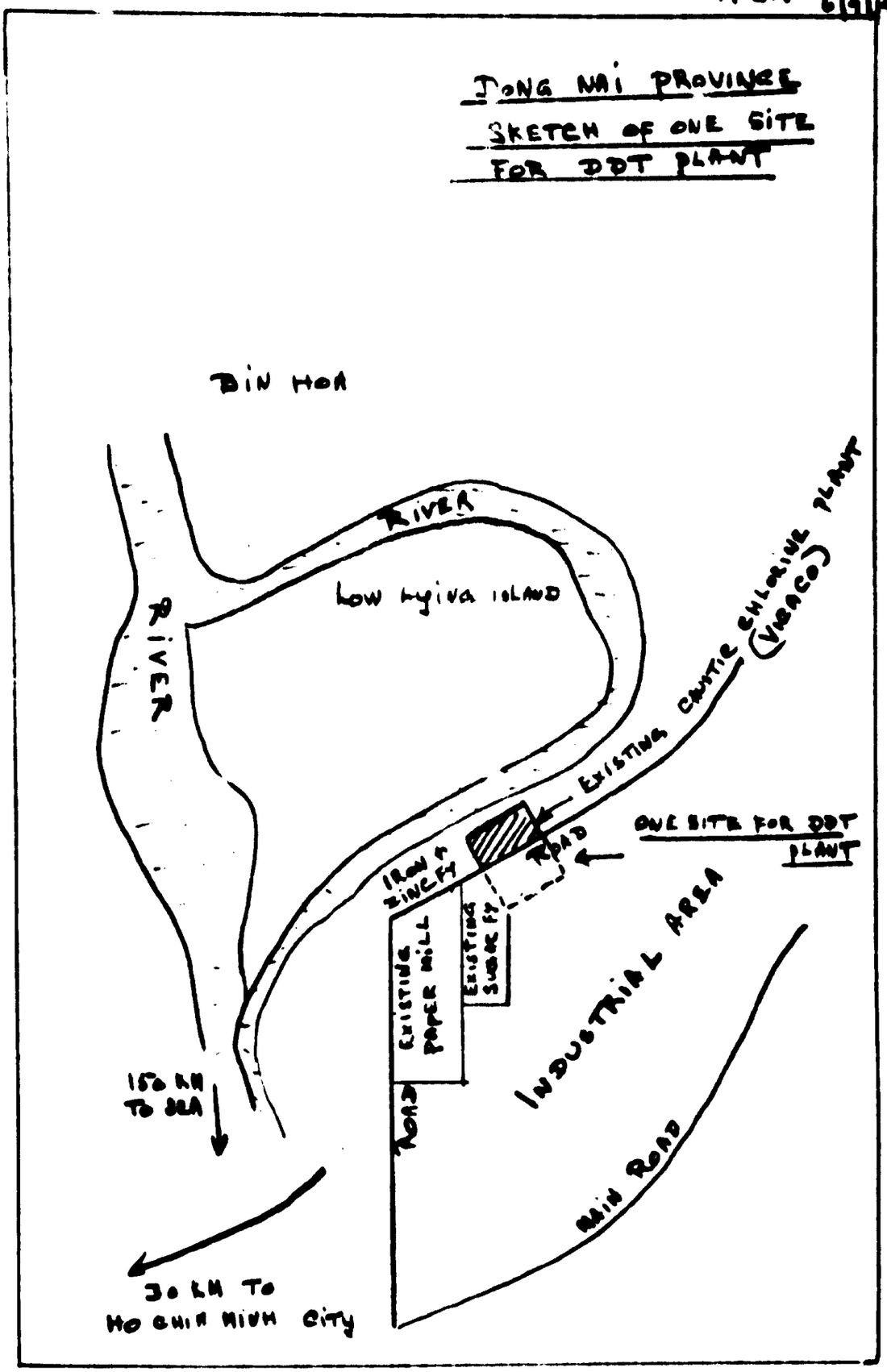
Although financing possibilities are outside the scope of the mission, the Health Ministry discussed the following possibilities:

a) United Nations Assistance within or outside the Umbricht proposals. It is suggested the SRVN submit to the Secretary General of the United Nations a request to finance the DDT project from special assistance fund to SRVN or from fund for the most seriously affected developing countries (MSA).

b) SRVN explore possibilities of bilateral aid.

c) A third alternative to be considered by SRVN is to treat their first phase of the DDT project as a pilot project and request to finance it partly with UNDP funds which, as indicative planning figure (IPF) for SRVN for the next five years, is reported to be of the order of US$ 44 million. Such assistance could be augmented by

M.C.V 6/2/1976


DONG NAI PROVINCE
SKETCH OF ONE SITE
FOR DDT PLANT
BIN HOA
RIVER
RIVER
LOW LYIVA ISLAND
EXISTING CAUSTIC CHLORINE PLANT (VINACO)
ONE SITE FOR DDT PLANT
ROAD
IRON & ZINC FY
EXISTING PAPER MILL
EXISTING SUGAR FY
INDUSTRIAL AREA
ROAD
MAIN ROAD
15 KM TO SEA
30 KM TO HO CHI MINH CITY

bilateral financial inputs as has been successfully done in the case of a project in India where at the Silk and Art Silk Manufacturers Industry Research Association (SASMIRA) for establishing a pilot plant for production and use of synthetic fibres, UNDP has put up nearly 1 million US dollars and the Federal Republic of Germany (FRG) has contributed about DM 5 million. UNIDO, together with GTZ of FRG, is executing the project.

One member of the mission visited one of the two DDT factories in India and is convinced that if bilateral aid is sought, the Hindustan Insecticides Ltd. which runs the DDT plants and which is building a third DDT factory in India has the capability in supplying a turn-key project to SRVN. It has the know-how of the process and experience in running DDT plants for the last 20 years and can design, engineer, get equipment fabricated, erect and run the project for SRVN giving necessary guarantee and allowing SRVN personnel to be trained in India. They could also guarantee supply of benzene and other raw materials for some time to come. Necessary contacts should be initiated with India, Netherlands and other suitable donor countries urgently. (Refer appendice 4)

The approximate capital investment (excluding working capital) for a completely independent "battery limit" plant of 3000 TPY technical DDT capacity will be (including a formulation unit) approximately Indian Rs. 60.0 million. Out of this the erected plant will cost Rs. 40.0 million and supporting utilities and off-sites will cost Rs. 20.0 million. This is based if the plant is to be built in a "green field" in India.

It is difficult to break up these costs for phase I and phase II as envisaged in this report. In order to approach a donor country a budget figure for phase I will be Rs. 45.0 million.

Considering other sources of know-how, engineering and subcontract inputs if available, the total cost of the project may be less.

8. POSSIBLE FUTURE UNIDO AND WHO ASSISTANCE

If approached officially and considered and approved by UNIDO and if funds are available, the following could be undertaken by UNIDO if the finance for the DDT plant is found from either a United Nations aid or bilateral assistance.

a) Technical co-ordination and advising both of the pre-investment and the construction phase
b) Arrangements for training of future staff
c) Safeguarding environmental considerations
d) Assistance in running the DDT plant for the first two years.

WHO could consider assistance for the following:

a) Ensuring safety to personnel and control effluents to air, land and water.
b) The provision of additional equipment, supplies and technical assistance as required by the malaria control programme subject to availability of funds.

9. SUGGESTED IMMEDIATE UNIDO ASSISTANCE

Even before finances are secured if officially requested by SRVN, UNIDO could consider and arrange the following:

a) A SRVN mission to India lasting four weeks and consisting of three top administrators, engineers/chemists to study DDT production and malaria control.
b) After the above mission is concluded, a mission from India consisting of three top men from Ministry of Chemicals and Fertilizers and the Hindustan Insecticides Ltd. should visit SRVN to have discussions on the possible costs and to study locations for a period of two to three weeks.

A senior official of UNIDO and WHO could be associated and assist both missions. UNIDO could consider financing the missions using funds under technology transfer, co-operation between developing countries (CDC) or under special industrial services (SIS). WHO could also participate in financing. The total cost of the two missions will be about US$ 18,000.

10. ECONOMICS OF THE DDT PROJECT

The needs for malaria control should outweigh any other considerations. Especially in resettling population in the new economic zones malaria eradication will have an important role. Secondly a new industry based on available chlorine will be built as basis for future pesticide and pharmaceutical industries giving necessary training to personnel. According to Dr. Umbricht's report the cost to WHO for supplying 300 tons DDT per year and allied operations for next five years will be US$ 2.5 million. It should also be noted that availability of DDT and its prices in world market are difficult to forecast. It will become more and more difficult to obtain necessary supplies. Further if in the next 2½ years (30 months) a DDT plant can be put up and successful production is started 50% of the above sum of US$ 2.5 million can be saved.

11. PROPOSED TIME SCHEDULE

a) Collection of data on two sites as per questionnaire submitted and transmitted to mission members (four weeks - 1st week October 1976) - Health Ministry.

b) Request for financial assistance to United Nations Secretary General and bilateral donors (1st week October). Request to UNIDO/WHO for technical mission - Foreign Ministry.

c) Submission of present mission report after data on sites is received (1st week November) - UNIDO/WHO mission.

d) Technical SRVN mission to India (four weeks December 1976) parallel with seeking finances.

e) Technical India mission to SRVN (four weeks in January 1977) after finances are secured.

f) Decision to build DDT project with U.N. or bilateral financial assistance (February 1977).

g) Negotiations for signing of contract (February/March 1977), site preparations, utilities, buildings and

h) Erection of DDT plant (March 1977 to March 1979) - 24 months.

i) Training of personnel etc. (1977 and 1978) - UNIDO.

j) Start-up and trial production (March 1979 - September 1979) - 6 months.

k) Completion of project in 30 months after signing of contract (March 1977 to September 1979).

APPENDIX 1

Itinerary of the Mission

1.	Arrival of Mission member M.C. Verghese (UNIDO) in Hanoi	28 August 1976
2.	Arrival of Mission member Dr. Van Dijk (WHO) in Hanoi from Manila	1 September 1976
3.	First meeting Health Ministry	30 August 1976
4.	Second meeting Health Ministry	31 August 1976
5.	Third meeting Health Ministry	1 September 1976
6.	Participation National Day Rally	2 September 1976
7.	Fourth meeting Health Ministry	3 September 1976
8.	Visit to Chemical Factory No.1 (caustic-chlorine plant) Viet Tri (80 km north of Hanoi) M.C. Verghese	4 September 1976
9.	Visit to Malaria Institute, Dr. Van Dijk	4 September 1976
10.	Visit to Haiph Hong Harbour (100 km northeast of Hanoi) and to Vinh Ha Long (Mining District - 60 km from Haiph Hong)	5 + 6 September 1976
11.	Fifth meeting Health Ministry	7 September 1976
12.	Meeting with General Services of Chemistry	7 September 1976
13.	Meeting with Ministry of Foreign Affairs	7 September 1976
14.	Departure for Vienna - M.C. Verghese	8 September 1976
15.	Visit to Malaria Control Field Station, Dr. Van Dijk	8 September 1976
16.	Departure Dr. Van Dijk for Manila	11 September 1976

APPENDIX 2

Names and Addresses of Persons met

1. Ministry of Health - No.138A, Gianguo Street
   Hanoi - SRVN
   Cable: HEALTH MINISTRY HANOI
   Telephone: 52036, 52035
2. Dr. Vu Van Can - Minister of Health
3. Dr. Hoang Dinh Cau - Deputy Minister, Training and External Relations
4. Dr. Nguyen Van Tin - Deputy Minister, General Health
5. Mr. Vu Cong Thuyet - Deputy Minister, Pharmacy
6. Mr. Nguyen Van Trong- Head, External Relations, Ministry of Health
7. Dr. Pham The - Head, Hygiene and Epidemiology(counterpart officer)
8. Dr. Nguyen Qui Sanh - Expert of Chemisty, General Services of Chemistry
9. Mr. Le Van Phuong - External Relations
10. Miss Le Thu Ha - Interpreter
11. Mr. Tran-Ky - Director, Chemical Factory No.1 - Viet Tri
12. Mme Phan Thi Minh - Director Adjoint
    - International organization, Ministry of Foreign Affairs
13. Mr. Hoang Huu Binh - General Services of Chemistry
14. H.E. Mr. C.R. Gharekhan - Ambassador of India to SRVN
15. Mr. Ian G. Hopwood - Programme Officer, UNICEF

APPENDIX 3

Data to be collected

(Questionnaire on site data to be collected by Health Ministry SRVN)

(Capacity of proposed factory ultimately 3,000 tonnes per year of technical grade D.D.T. and formulated products for Malaria Control Capacity to start with 1500 tonnes per year)

I. Location and Site Data (based on availability of Chlorine by pipe line)

1. Name of place(within the land of the existing caustic-chlorine plant)
   at Biên Hoa 30 kms from Hồ Chi Minh (Saigon) city

2. Address ..

3. Available land in hectares or square metres which can be fenced in without obstructions under ground or above ground with access to Road/River/Railroad/Harbour

4. Longitude and latitude

5. Elevation above Mean Sea Level in metres and barometric pressure

6. Distances
   a) from sea
   b) from river Đồng Nai
   c) from Saigon harbour
   d) from nearest railroad
   e) from nearest highway
   f) from nearest town/village/housing colony/factory

7. Average humidity month by month

8. Maximum and minimum temperature and average temperature month by month

9. Rainfall — Maximum, Minimum, Average } per month and per year

10. Wind directions — Summer, Winter, Month by month if obtainable

11. Soil and land conditions
    a) Clay, sandy, lateritic or rocky;
    b) Load bearing capacity kg/cm^2
    c) Depth of underground water from surface in summer during rainy season
    d) Gradient and slope
    e) Is land clear and vacant.

12. Site plan showing land boundaries and gradients to be fenced and marking existing caustic-chlorine plant

13. Plan or map of region showing the approach road, railroad, river harbour, etc.

14. River level - flood water level from site ground level
low water level from site ground level

II. Utilities

1. Electric power above 440 volts about 1000 KVA

a) voltage
b) cycles
c) A.C/D.C
d) distance from boundary fence

2. River water (non-saline)

a) flow summer and rainy season
b) analyses of water during summer and rainy season
pH
turbidity
total solids
suspended solids
dissolved solids
total hardness
temporary hardness
B.O.D.
etc.

3. Steam (to be produced in plant)

4. Compressed air (to be produced in plant)

5. Refrigeration (to be produced in plant)

6. Nitrogen (to be bought in cylinders)

III. Raw materials availability

1. Chlorine - from existing caustic-chlorine plant quantity now produced as hydrochloric acid or dry chlorine gas available for DDT production.Can chlorine be supplied to DDT plant as dry gas at a pressure of 2 kg/cm^2 by pipe line? Purity - not less than 98%.

2. Benzene - to be imported (Thiophene free and nitration grade)
a) Specific gravity at 27/27°C 0.866 to 0.873
b) Distillation range - the difference between the temperature (running points) at which 1 and 96% of the volume taken have been collected shall not exceed 0.6°C when a heated sample is tested by a STD method.
This range shall include the temperature of 80.1°C.

3. Alcohol - from existing distilleries - Distance?

   a) Specific gravity at 15.6°C max. 0.817
   b) Ethanol content
      i) per cent by volume at 15.6°C - Min. 94.68
      ii) degree overproof - Min. 66

IV. Operating supplies

1. Oleum (20%) from existing sulphuric acid plant, distance?

   a) specific gravity at 25°C - Min. 1.90
   b) total sulphur trioxide (SO_3)
      per cent by weight - Min. 85.1
   c) Free sulphur trioxide (SO_3)
      per cent by weight - Min. 20 ± 1

2. Caustic soda
   Caustic soda lye (50%)

3. Calcium chloride - commercial grade - fused

V. Raw materials for formulation of 50% - wettable powder of DDT

1. Technical grade DDT

2. Carriers/fillers
   China clay
   i) Moisture content % by weight, Max. 1.5%
   ii) Material weight passing through 200 mesh B.S. % by weight, Max.1.5%
   iii) pH - 5.50 - 8.0
   iv) Suspensibility, Min. 60% by method similar to wettable powder testing

3. Anti caking agent/adsorbent
   Hydrated calcium silicate
   Oil absorption value 400% Min.
   Adsorbents sold under brand names such as "Hi-sil", "micro-cell" etc. are also suitable

4. Surface active agents (surfactants) for improving physical properties such as wettability, dispersability and suspensibility of wettable power formulations

VI. By - products disposal

1. Hydrochloric acid normally 30 - 33% strength
   1.7 tonnes of 30% HCl/tonne of DDT should be bought back by existing caustic/chlorine plant

2. Sulphuric acid

   If an auxiliary plant for the hydrolysis of spent sulphuric acid is put up, the economics of DDT manufacture can be improved.
   Spent sulphuric acid about 1 tonne of 65-78% strength is obtained for every tonne of DDT produced. It can be used for ammonium sulphate or superphosphate manufacture.

VII. Man-power Availability

1. Engineers - chemical
   mechanical
   electrical
   civil

2. Chemists

3. Skilled workmen -
   i. mechanics
   ii. operators
   iii. electricians
   iv. instrument mechanics
   v. lab. technicians/analysts
   vi. plumbers
   brick layers
   vii. surveyors and draftmen
   viii. workshop men

VIII. Estimated costs

Approximate costs of land, utilities, raw materials, operating supplies, raw materials for formulation packing bags and drums, by-products prices and wages for various categories of skilled workers, engineers, chemists, etc.

APPENDIX 4

DDT TECHNICAL

Prepared by Hindustan Insecticides Ltd.

INTRODUCTION

"DDT" is the familiar term denoting the product Dichloro Diphenyl Trichloroethane (generically 2,2-bis-(p-chlorophenyl) 1,1,1-trichloroethane.) Its outstanding merit as an insecticide was discovered in 1939 by Dr. Paul Muller of J.R. Geigy AG in Switzerland. DDT Technical grade produced by industrial processes contains 70-odd percent of the isomer p,p'-DDT and about 20% of the isomer o-p'-DDT. DDT has proved to be one of the most useful and versatile insecticide ever synthesised by man. Extremely effective not only as a contact poison but also as stomach poison, it has remarkable residual effect against such pests as flies, aphids, mosquito larvae, beetles, ants, cockroaches, bedbugs, silverfish and the body louse.

First used over 30 years ago in Public Health programmes against the malarial mosquito and the typhus louse, DDT is still the most effective and widely used insecticide at man's disposal to fight the vectors of these dreaded diseases. It has also found wide application in plant protection. If applied according to recommendations, any residues at harvest will meet acceptable tolerances and will present no hazard to the consumers.

SPECIFICATIONS

The Indian Standard Specifications for DDT Technical are given below:

Sl.No.	Characteristic	Requirement
i.	p-p' isomer content percent by mass. Min.	70.0
ii.	Setting point, ^{o}C, Min.	89.0
iii.	Melting point of separated p-p' isomer ^{o}C, Min.	104.0
iv.	Total organic chlorine content, percent by mass.	49.0 to 51.0
v.	Hydrolysable chlorine content, percent by mass.	9.5 to 11.0
vi.	Matter insoluble in acetone percent by mass, Max.	1.0
vii.	Acidity (as H_2SO_4) percent by mass, Max.	0.3
viii.	Moisture, percent by mass, Max.	1.0

FORMULATIONS

Technical DDT is not in a form suitable for direct utilisation in insect control. It has to be formulated by mixing with inert compounds such as fillers or solvents to enable full realisation of its potential as an economic insecticide. The common formulations of DDT are -

1. 5% and 10% Dust
2. 25% Emulsifiable concentrate - used in wood industry
3. 50% and 75% wettable powder. - NDP - Malaria Control

Note: The figures indicate the concentration of DDT Technical in the formulation.

The choice of formulation is governed by the pest or pests to be controlled, the crops or areas to be treated, the equipment to be used, and the method, conditions and practices of application and economic factors such as cost of application.

The National Malaria Eradication Programme of India has accepted the 50% wettable powder formulation of DDT as the most effective and economic formulation in its successful fight against the mosquito menace. The 75% wettable powder, although equally effective is found to be less economic since its formulation requires expensive and high quality carriers and adsorbents.

PROCESS DESCRIPTION

The three basic steps in the manufacture of DDT starting with the raw materials chlorine, benzene and alcohol are -

Step I The chlorination of benzene to form monochlorobenzene

$$C_6H_6 + Cl_2 \longrightarrow C_6H_5Cl + HCl$$

Step II The chlorination of alcohol to form chloral

$$2C_2H_5(OH) + 4Cl_2 \longrightarrow CCl_3CHO(OH)C_2H_5 + 5HCl$$

$$\xrightarrow{\text{Oleum}} \underset{\text{(Chloral)}}{CCl_3CHO}$$

Step III The condensation reaction of monochlorobenzene with chloral in the presence of oleum to form DDT.

$$2C_6H_5Cl + CCl_3CHO \longrightarrow Cl\text{-}C_6H_4\text{-}\underset{CCl_3}{\overset{H}{C}}\text{-}C_6H_4\text{-}Cl + H_2O$$

MANUFACTURE OF MONOCHLOROBENZENE:

Benzene is dehydrated by azeotropic distillation and the dry benzene is fed into the chlorinator where it reacts with dry chlorine vapour under controlled conditions. A mixture of monochlorobenzene and benzene containing a small percentage of byproduct dichlorobenzenes is withdrawn continuously from the reactor. The unreacted benzene is flashed off and recycled to the chlorinator. The solution of monochlorobenzene and dichlorobenzene is neutralised and then subjected to batch distillation to obtain pure monochlorobenzene. The crude dichlorobenzenes obtained as byproduct can be separated into the ortho and para isomers of DCB in an auxillary unit. The overall yield of monochlorobenzene is over 90% and process efficiencies are high.

MANUFACTURE OF CHLORAL:

Ethyl alcohol is chlorinated in reactors connected in series by a batch process. By carefully maintaining the optimum reacting conditions throughout the chlorination period, good yields of the intermediate chloral alcoholate are obtained. The chloral alcoholate is contacted with concentrated sulfuric acid or oleum and the chloral produced is recovered by distillation.

Note: Chloral can also be obtained by the chlorination of acetaldehyde. The alternate process starting with acetaldehyde is used in some countries where acetaldehyde is more readily available than alcohol.

MANUFACTURE OF DDT:

Measured quantities of monochlorobenzene and chloral are charged into a reactor where in the presence of oleum and at a low temperature, DDT is formed. After separation of the spent acid, the DDT with excess unreacted monochlorobenzene is washed to remove the acidity. The material is then subjected to steam distillation to drive off all the unreacted MCB which is recovered and recycled. Molten DDT from steam distillation is cast in pans or can be flaked on a belt flaker. Casting in pans gives a better product.

FORMULATION OF DDT:

The preparation of wettable powder of DDT can be divided into 3 steps.

1. Primary grinding and blending
2. Milling
3. Post blending and sieving

Technical DDT, with carriers such as clay, adsorbents and surface active agents are blended in definite proportions and ground in a primary grinder. The ground material is then allowed to cure for a few days before it is processed further. Normally a fluid energy mill with compressed air is used for the final grinding and the material is pulverised to an average particle size of 3-5 microns. After post blending and sieving the product is bagged.

RAW MATERIALS AND SPECIFICATIONS

I. RAW MATERIALS FOR DDT TECHNICAL:

Benzene: (Thiophene free nitration grade)

1) Specific gravity at 27/27°C	..	0.866 to 0.873
2) Distillation range	..	The difference between the temperature (running points) at which 1 and 96% of the volume taken have been collected shall not exceed 0.6°C when a heated sample is tested by a STD method. This range shall include the temperature of 80.1°C.

Alcohol:

1) Specific gravity at 15.6°C (60°F) Max.	..	0.817

2) Ethanol content

a) Percent by volume at 15.6°C Min.	..	94.68
b) Degree overproof Min.		66

Chlorine:

Preferably as dry gas at a pressure of 2 kgs/cm^2 approx.

Purity - not less than 98%

Liquid chlorine from cylinders can also be used but vaporisation will be necessary.

Operating Supplies:

Oleum (20%)

1. Specific gravity at 25°C min.	..	1.90
2. Total sulfur trioxide (SO_3) percent by weight min.	..	85.1
3. Free sulfur trioxide (SO_3) percent by weight min.		20 ± 1

Caustic Soda:

Caustic soda lye (50%)

Calcium chloride:

Commercial grade, fused.

II. RAW MATERIALS FOR FORMULATION OF 50% WETTABLE POWDER OF DDT:

1. Technical DDT

2. Carriers/Fillers:

China clay

Moisture content % by weight	..	1.5% max.
Material not passing through 200 mesh B.S. % by weight	..	1.5% max.
pH ..	..	5.5 - 8.0
Suspensibility ..		Min. 60% by method similar to wettable powder testing

3. Anticaking agent/adsorbent:

Hydrated calcium silicate:

Oil absorption value	.. ..	400% min.

Adsorbents sold under brand names such as "Hi-Sil", "Micro-Cell" etc. are also suitable.

4. Surface active agents:

Surface active agents (surfactants) which are added in small but definite proportions improve the vital physical properties of wetability, dispersibility and suspensibility of wettable powder formulations. Surfactants are manufactured and marketed under a wide range of brand names and the selection of the ideal combination and proportions is based on experience and/or empirical methods.

TYPICAL CONSUMPTION OF RAW MATERIALS AND UTILITIES

RAW MATERIALS:

Benzene	0.84 T/T DDT
Chlorine	1.77 T/T DDT
Ethyl alcohol (calculated on 100% basis)	0.33 T/T DDT

OPERATING SUPPLIES:

Oleum 20%	1.32 T/T DDT
Caustic soda lye (50%)	0.1 T/T DDT
Calcium chloride	15 T/year for a 10 T/Day plant.

UTILITIES:

Steam (10 kg/cm^2 at the plant) ..	11.0 T/T DDT
Electricity	1000 KWH/T
Water (filtered soft water) ..	100 T/T DDT

TYPICAL COSTS OF RAW MATERIALS AND OPERATING SUPPLIES IN INDIA (AS DELIVERED AT UDYOGAMANDAL)

Alcohol ..	Rs. 1432.85/KL
Benzene ..	Rs. 2766.85/KL
Oleum ..	Rs. 832.00/Tonne
Caustic lye ..	Rs. 1960.00/Tonne
Chlorine gas (pipeline) ..	Rs. 304.92/Tonne
Calcium Chloride ..	Rs. 1771.00/Tonne

MANPOWER REQUIREMENTS

For a 10 Tonne/Day plant manufacturing Technical as well as Formuleted products.

OPERATING PERSONNEL - Requirement per shift of 8 hours.

Skilled	..	12
Manual workers	..	15

Note: Supervisory, Administrative and Maintenance staff are excluded.

RECOMMENDATION FOR A 10 TONNE/DAY PLANT

It is proposed that a 10 T/Day plant be put up in 2 streams each with a capacity of 5 Tonne/day of DDT economically integrated. Thus the benefits ofoptimum size and economics are obtained. Limiting the individual stream capacity to 5 tonne/day has the following advantages.

1. Optimum vessel dimensions falling within the standard vessel sizes readily available from vendors.
2. Improved process and quality control.
3. Flexibility in production.

For the same reasons, the formulation unit for the above plant can be in 2 streams, each stream with a capacity to produce 10 T/day of 50% wettable powder formulation of DDT. If there is a demand for the 25% emulsifiable concentrate a liquid formulation plant will be necessary.

CAPITAL COST

The approximate capital investment (excluding working capital) required for a completely independent 10 T/Day DDT project including the formulation unit on a green field site in India will be approximately Rs.60.0 million. Of this, the erected plant will cost Rs.40.0 million and the supporting utilities and offsites will cost Rs.20.0 million. However, in order to obtain an accurate estimate of the actual cost involved at a new site it would be necessary to prepare a Project Report taking into account local cost factors.

PRODUCTION COST

Conditions specific to the plant site will again have bearing on the cost of production. The operating labour figures shown reflect practice in India. For plants elsewhere the local labour policy should be taken into account. Other factors affecting production costs such as allowances for depreciation, taxes, insurance, employee social benefits and general plant overhead expenses have to be considered in accordance with local accounting practice to determine preliminary manufacturing cost.

The cost of production for a new plant in India will be of the order of Rs.10/- per Kilogram of Technical DDT and Rs.7.50 per Kilogram for 50% wettable powder formulation.

BY-PRODUCTS

The by-products of DDT manufacture are -

1) Hydrochloric acid, and

2) Spent sulfuric acid.

HYDROCHLORIC ACID

Hydrochloric acid gas given off during the chlorination of alcohol and benzene is absorbed in water using special absorbing towers. The concentration of acid produced is normally in the range of 30-33% and about 1.7 tonnes of 30% HCl is produced per tonne of DDT.

SPENT SULFURIC ACID

The acid seperated from the DDT after the condensation reaction between chlersl and monochlorobenzene is completed, contains an appreciable quantity of the sulfonic acid of monochlorobenzene. If an auxillary plant for the hydrolysis of spent acid is also put up, much of the MCB content of the acid which would otherwise be lost, can be recovered for reuse in the DDT plant thus improving the economics of DDT manufacture. After the recovery of MCB, about 1 tonne of spent acid having a strength of between 65 and 70% is obtained for every tonne of DDT produced.

EFFLUENT TREATMENT

A well designed and operated DDT plant produces hardly any toxic effluents. However, it is normal practice to provide an effluent treatment facility along with the DDT plant to treat all waste waters and other effluents produced in the plant and thus safeguard against any inadvertent pollution of the environment. It may be specifically noted that if there is no regional demand for the hydrochloric acid and spent sulfuric acid produced as by-products, it will be necessary to completely neutralise these acids before disposal.

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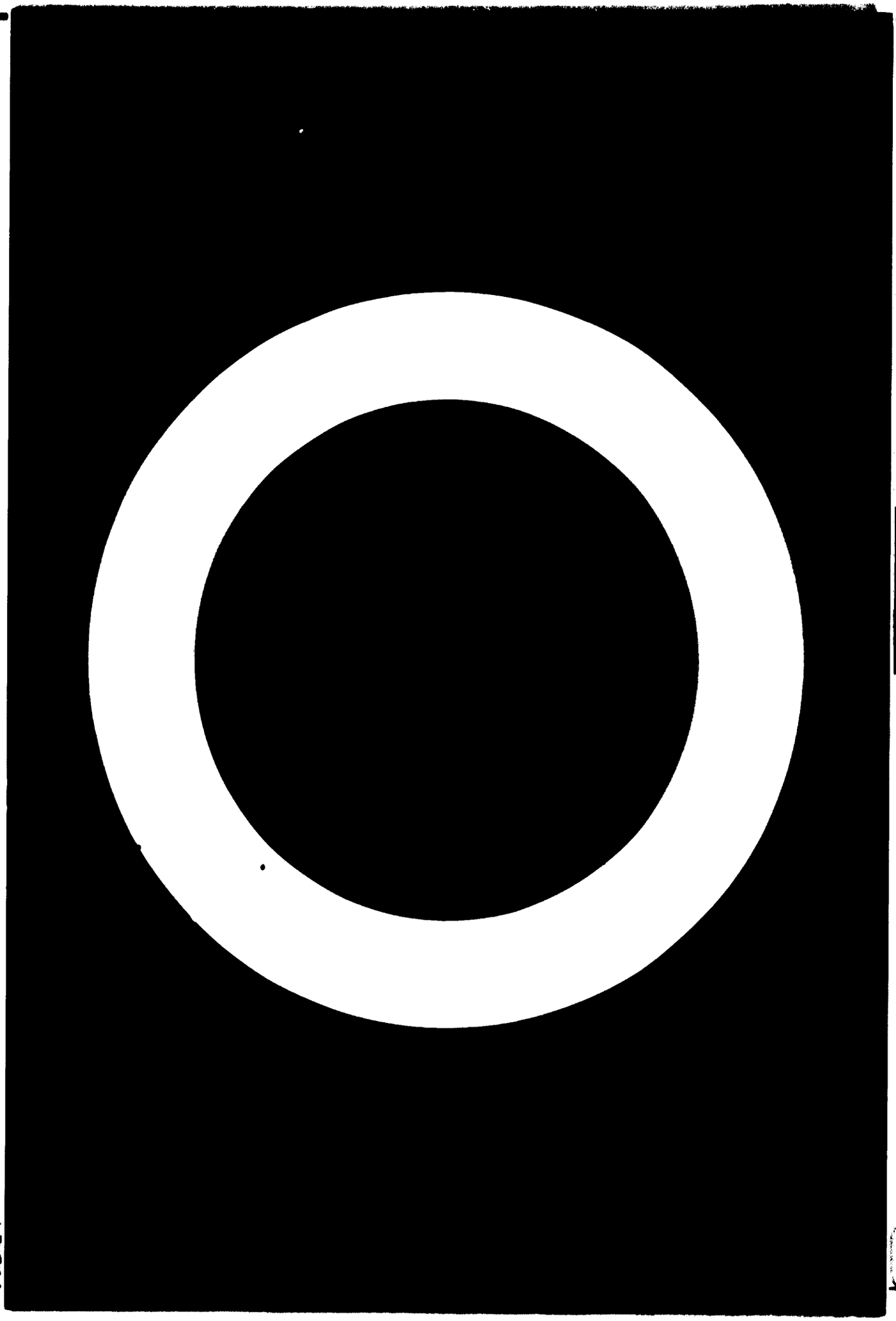
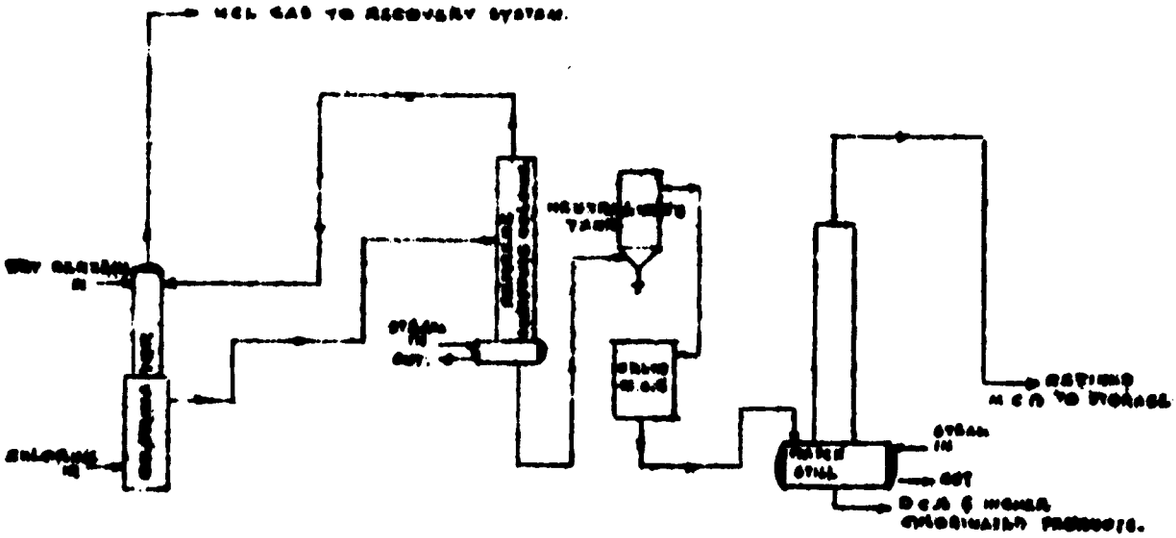
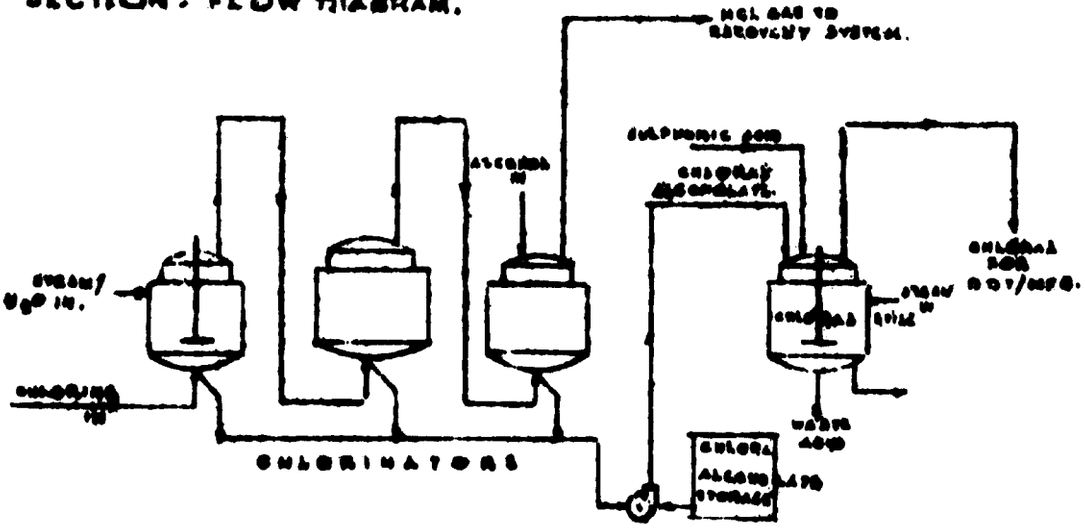
a.



MONOCHLORO BENZENE FLOW DIAGRAM.



ALCOHOL CHLORINATION & CHLORAL SECTION - FLOW DIAGRAM.



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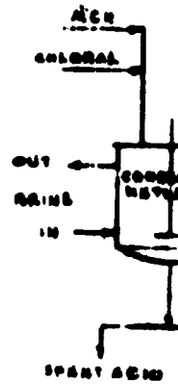
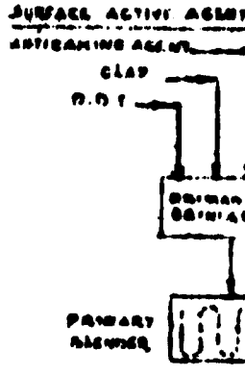


FORMULATION C



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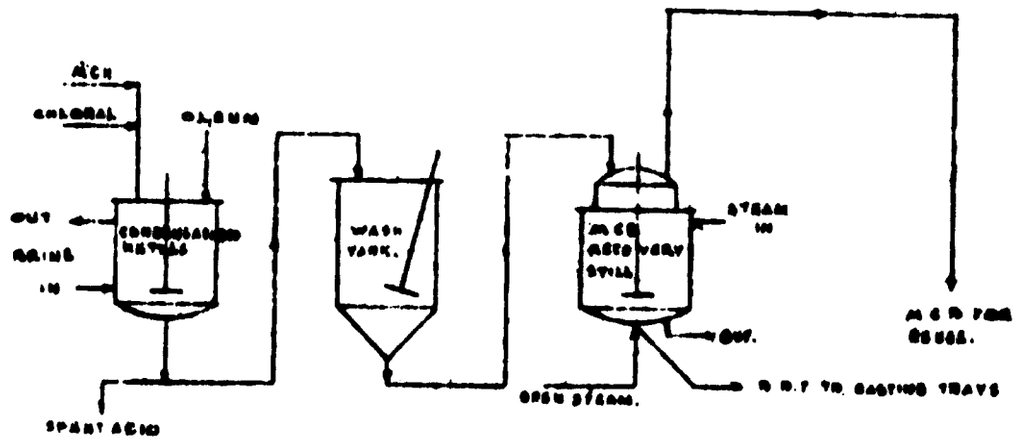
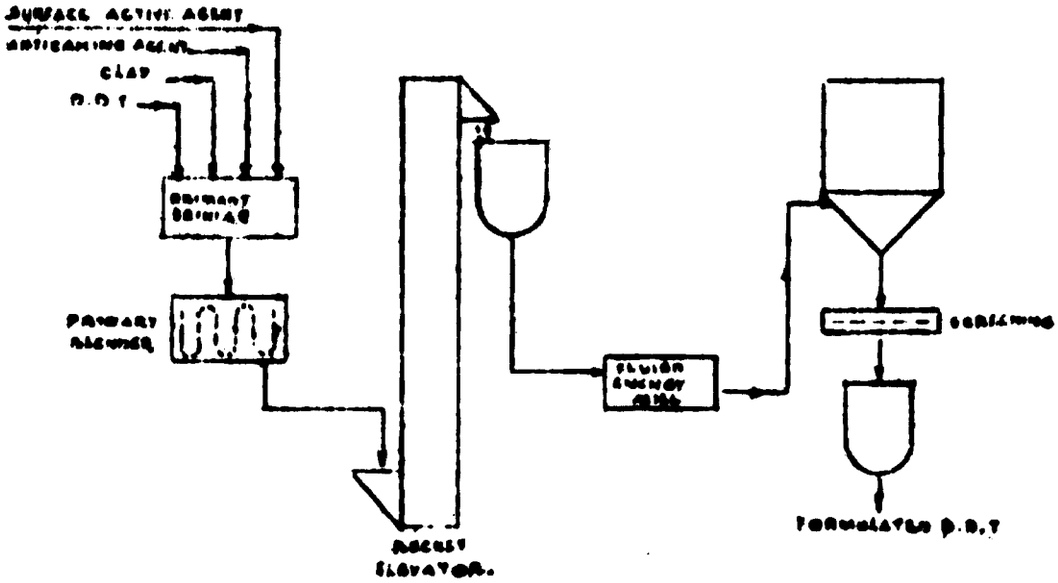
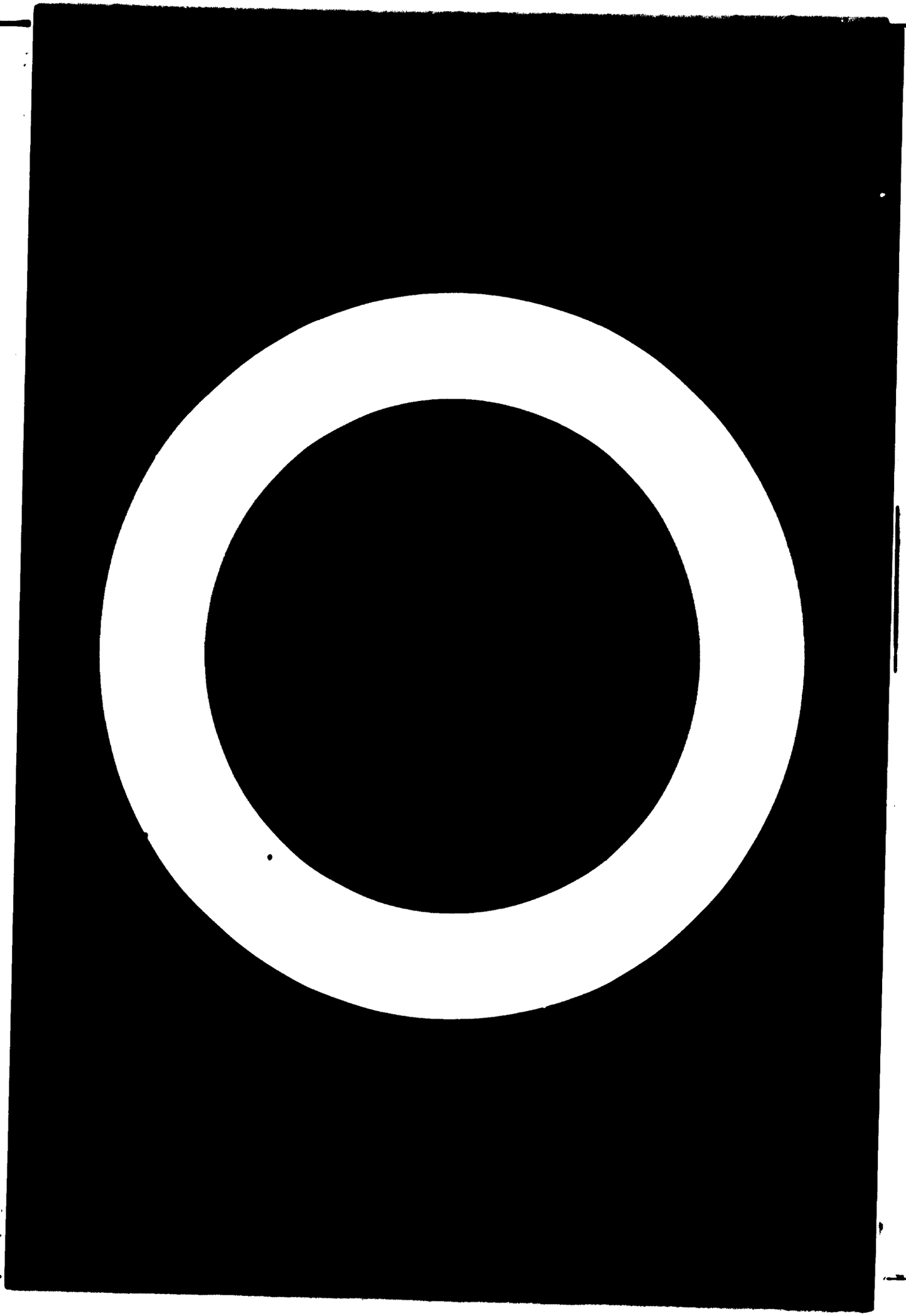
D D T SECTION - FLOW DIAGRAM.



FORMULATION OF D.D.T - FLOW DIAGRAM.





APPENDIX 5

Note on visit to the caustic chlorine plant Viet-Tri 80km north of Hanoi

1. Location - on river branch of Red River, supplying caustic lye 30% to adjacent pulp and paper mill (0.7 Dhong/1 kg) also on railway line.

2. Capacity - 5000 tons per year, caustic and chlorine

3. Type of cells - 50 diaphragm cells - originally built in 1958 by PRC. Damaged by bombs - being rebuilt.

4. Other products: a) Benzene hexachlorides (BHC)
   2000 - 2500 tons/year as pesticides
   Price 1.1 Dhong/1 kg

   b) Sodium hyposulphite
   1000 tons per year
   Price 0.4 Dhong/1 kg

   c) Polyvinyl chloride (PVC)
   using acetylene generated from calcium carbide brought from another factory
   500 tons/year 2.5 Dhong/1 kg

   d) Hydrochloric acid as 31% acid 150 Dhong/1 ton

5. Number of employees: 500
   men: 350
   women: 150

6. Raw materials and utilities

   a) Electric power 2000 kw, 0.1 Dhong/kwh

   b) Salt (from a southern province by barge/rail)
   150 Dhong/ton

7. Yearly sales: 8 million Dhong

8. Profit after tax: 4 million Dhong

9. Reports to General Service of Chemistry

10. Engineers: 20 (men:16, women:4)
    Chemists: 12

11. Average earning per worker:70 Dhong/month

12. Bonus: 40,000 Dhong per year for all workers

13. Pay of fresh engineers: 75 Dhong/month
    After five years: 88 Dhong/month

14. Retirement age: 55 for men
    50 for women

    After 20 years service: Pay: 150 Dhong/month and 80% of salary as pension

15. Worker's amenities: Housing colony for all 500 workers
    Rent: 1 % of salary
    Hospital and canteen available

16. Safety record: excellent

APPENDIX 6

TABLE 4. Anti Malaria Programmes - South East Asia Region

Estimated DDT Requirements (metric tons)

Country	Formulation	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	Total 1972-1981
Burma	75% wdp	400	2,232.5	2,279.4	2,227.1	2,375.7	2,611.2	2,714.7	2,673.6	2,779.7	2,966.1	3,053.1	25,913.1
Ceylon	75% wdp	1,570	2,175.3	2,227.5	1,915.2	1,517.1	1,584.0	1,187.7	926.7	618.6	591.9	412.9	13,156.9
India	75% wdp	7,000	7,733.0	3,810.0	2,500.0	700.0	-	-	-	-	-	-	14,773.0
	50% wdp	8,000	6,000.0	6,000.0	6,000.0	6,000.0	5,400.0	6,000.0	6,000.0	6,000.0	6,000.0	6,000.0	59,400.0
Indonesia	75% wdp	4,000	4,069.1	7,432.0	10.308.3	13,365.1	16,273.5	24,043.2	19,768.4	11,768.4	12,683.1	7,043.1	126,754.2
Maldives	75% wdp	5.3	6.4	4.0	7.2	5.0	4.6	4.6	4.8	1.8	1.8	1.8	42.0
Nepal	75% wdp	800	965.2	710.2	516.5	257.8	262.6	264.6	242.6	245.0	211.0	225.2	3,900.7
Thailand	75% wdp	2,660	4,243.0	4,114.8	4,103.7	4,167.1	4,304.0	2,768.2	2,732.2	2,352.2	1,858.3	1,973.8	32,617.3
Total metric tons	75% wdp	16,435.3	21,424.5	20,577.9	21,578.0	22,387.8	25,039.9	30.983.0	26,348.3	17,765.7	18,312.2	12,709.9	217,157.2
Total metric tons	50% wdp	8,000.0	6,000.0	6,000.0	6,000.0	6,000.0	5,400.0	6,000.0	6,000.0	6,000.0	6,000.0	6,000.0	59,400.0

- above figures relate to M.E.P. (Malaria Eradication Programme)

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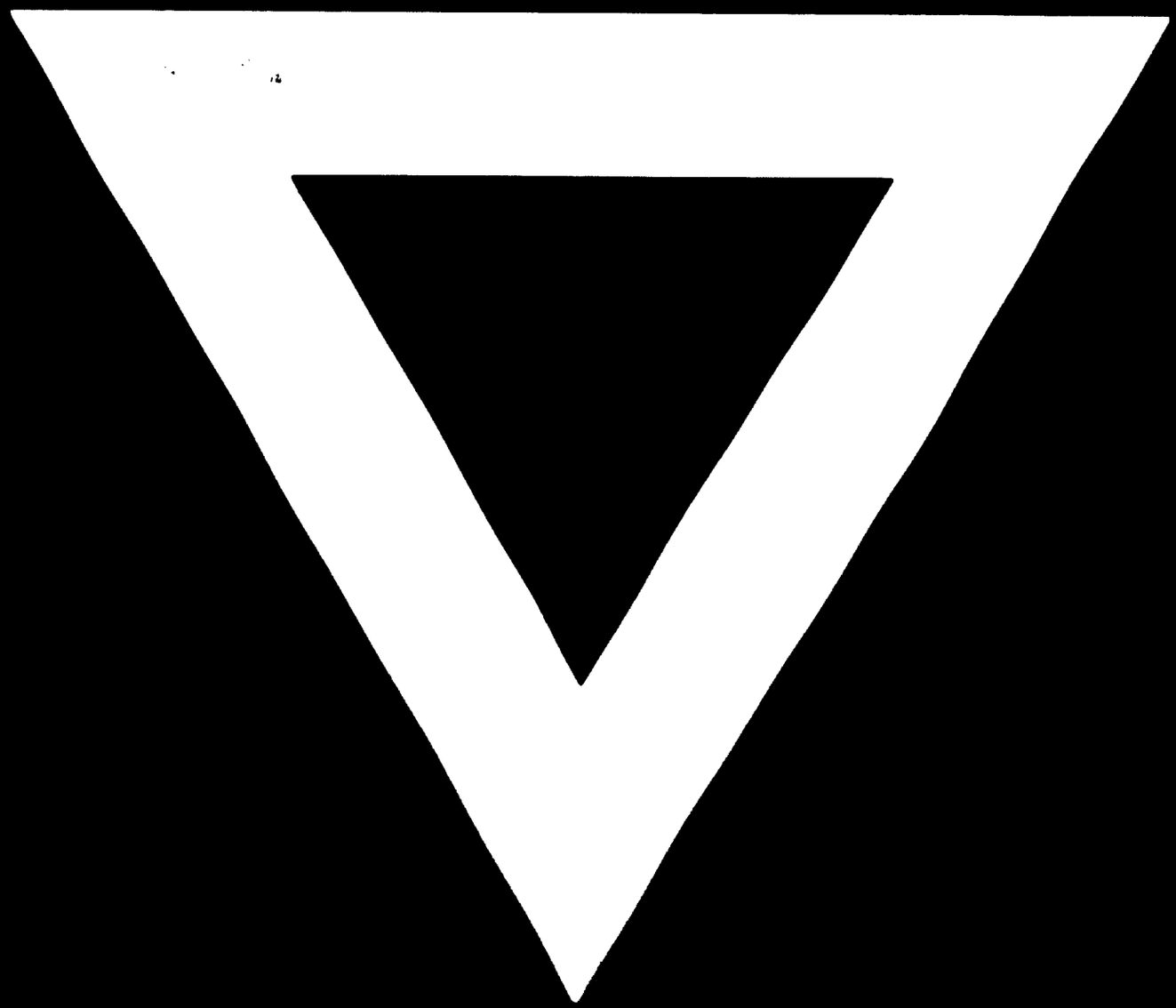

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