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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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REHABILITATION OF LINDANE MANUFACTURING PLANT AT DURRES

SI/ALB/88/802

ALBANIA

Technical report: Findings and recommendations*

Prepared for the Government of the Socialist People's Republic of Albania
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Kishore Kumar, consultant
on Anti-corrosion

Backstopping officer: B. Sugavanam, Chemical Industries Branch

United Nations Industrial Development Organization
Vienna

2/90

* This document has not been edited.

C O N T E N T S

1. INTRODUCTION

The author of this technical report, on one month UNIDO assignment from 19th March, 89 to 18th April, 89, after having been briefed at Vienna by the Backstopping Officer Mr. B. Sugavanam, Chemical Industries Branch, visited the Lindane Manufacturing plant at Durress, Albania, between 23rd March, 89 to 16th April, 89, which is experiencing lot many problems, including serious corrosion problems and corrosion failures.

THE UNIDO ASSIGNMENT - As Anti-Corrosion Expert(Team Leader)

- To Advise on necessary measures to prevent corrosion of the plant due to acid materials produced
- To identify corroded plant machinery and provide suitable selection of replacement parts
- To advise on replacement of spare parts of immediate necessities
- To advise along with the fellow expert on improving the general maintenance of the plant etc.
- To give the likely cost for taking anti-corrosion measures

OBJECTIVES OF THE VISIT

* To see, inspect, and assess the overall condition of the plant.
* To study various corrosion problems, and identify grey areas.
* To identify corroded equipment, pipings, fitting needing replacements.
* To advise on suitable materials of construction, wherever necessary.
* To advise line of actions and suitable corrosion preventive measures.
* To advise on measures to improve their anti-corrosion activities, predictive maintenance, inspection practices.
* To give approx. estimation on likely cost to be incurred.

2. A B S T R A C T

During this visit to the Lindane manufacturing plant at Durres, Albania, the author, keeping in mind the main objectives, has tried to make an overall assessment of the health of the plant, by almost conducting a total technical auditing of the plant from corrosion and metallurgical angle, and has studied the various corrosion problems, examined the predictive maintenance aspects, and tried to identify the grey areas, the equipment condition, the need for replacements, and change in materials of construction, and has made suitable recommendations on line of actions, and preventive measures, and also suggested scope of improvement.

In general, the plant equipment, pipings, valves etc., are not in satisfactory state of condition barring few equipment in Lindane section, extraction & crystallization units. The grey areas, problematic equipment, corroded and damaged equipment needing replacements, causes, need for changing the metallurgy etc have been identified, and appropriate recommendations on line of actions required to be taken, on suitable measures to prevent corrosion, on measures to improve the predictive maintenance system etc have been made. Some other useful suggestions have also been offered. The initial expenditures on Anti-corrosion measures should have a shorter pay back period and will ultimately be beneficial.

Overall, the Lindane plant calls for a major revamp.

3. PEOPLE MET & DISCUSSED WITH

During my entire period of stay at Durres, Albania, and during my daily visits to the Lindane manufacturing plant, I met the following persons of the organisation, with whom I was associated in various meetings and discussions ;

NAME	DISCIPLINE/FUNCTION
MR. ADEM DIZDARI	DIRECTOR OF CHEMICAL PLANT
MR. MICHEL VASO	HEAD OF LINDANE PLANT, PROCESS CHEMIST
MR. GAZMEND GIYLI	INSTITUTE OF CHEMISTRY, TIRANA
MRS.VOJSAVA SHTYLLA	ELECTRICAL ENGINEER
MR. ARJAN BEQARI	PROCESS CHEMIST
MR. ABDULLA KACANI	CHIEF MECHANIC, MAINT. & REPAIRS
MRS.REVEKA DONA	OVERALL CHIEF OF OPERATION
MR. SHKELQIM SHTYLLA	TECHNOLOGICAL BUREAU (MECHANICAL ENGINEER)
MR. EDWARD MALLTEZI	MECH. ENGINEER & ANTI-CORROSION (PAINTING)
MR. AVDULLA MYDERIZI	CHIEF OF TECHNOLOGICAL BUREAU
MR. THOMA BERBERI	IN-CHARGE OF ELECTRICAL WORKSHOP

& SEVERAL OTHERS, WORKERS, DURING VISITS TO THE PLANT.

4. THE CHEMICAL PLANT AT DURRES

The Chemical Enterprise(now called 'Chemical Plant') at Durres, Albania, is owned by Govt. of Albania, the organisation being nearly 35 yrs. old, has nearly 1100 employees, in all. It has, besides Lindane manufacturing plant, few other plant also namely $Al_2(SO4)3$, Na2 Cr07, Mg SO4, few other pesticides plant(ZINEP, VAPAM, TMDT - all trade names),Sulphur grinding plant, Central workshop, School Reagents plant.

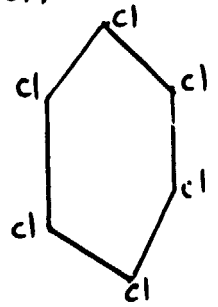
5. THE LINDANE MANUFACTURING PLANT

The Lindane plant, based on chinese process technology, was though constructed nearly 6 years ago, commissioned only around 1986, and it has been in operation hardly for 2½ to 3 years. It has nearly 70 (maximum) employees. It has designed rated capacity of 100 tons/yr. of production, but it actually produces hardly 1.5 to 2 tons a month with a maximum of 25 tons/yr. This plant is predominantly facing three types of major problems;

a) Gross under capacity utilization, hardly 25%
b) Chronic problem of corrosion
c) Quality of intermediates & finished products not upto the Mark.

LINDANE

Lindane is an insecticide containing atleast 99% of the gamma isomer of hexachlorocyclohexane (also called gamma HCH or gamma BHC). This has become one of the most important insecticides in the world. Being a chlorinated hydrocarbon, C6H6C16, lindane is attacked from all sides, although its physico-chemical characteristics and its biological activity make it a unique product, very different from crude HCH(BHC), and other chlorinated insecticides.



Mol. Wt. 290.9
M. Pt. 112.8°C
Density 1.85

Water solubility 10 mg/litre at 20°C
Vap.pressure 1.2x10 mbar at 20°C

White Crystalline solid, non-flamable, non-explosive. Avoid inhaling.

Odour - Weak to NIL, Weakly toxic to skin, toxic to eye.

Lindane is extracted from technical (crude) HCH by methanol, and the technical HCH is obtained by reaction of chlorine with benzene in the presence of ultra violet radiation.

MAIN PERSONNELS ATTACHED TO LINDANE PLANT OF DURRES

ORGANISATION OF LINDANE PLANT

MR. MICHAEL VASO	CHIEF OF LINDANE PLANT, PROCESS CHEMIST
MR. ARJAN BEQUARI	PROCESS CHEMIST
MR. EDWARD MALLTEZI	MECHANICAL ENGINEER(MAINT.& ANTI-CORROSION)
MR. SHKELQIM SHETYLLA	MECH.ENGINEER, TECHNICAL BUREAU
MR. AVADULLA MYDERIZI	CHIEF, TECHNICAL BUREAU

& OTHER WORKERS.

Lindane plant has process dept; maintenance dept; Electrical dept; chemical laboratory. It has no inspection personnel. No effluent or pollution control dept. There is an overall safety & Fire dept; for whole chemical plant. Their so called anti corrosion dept; consisting of 20 people is nothing but group of 20 painters(workers) for whole enterprise, who always and only use the common type of paint used for doors and windows. They are not aware of protective paintings, anti-corrosion paints etc. They also do not know the name of common type of paint that they use for doors & windows.

5a. THE MAIN SECTIONS OF LINDANE MANUFACTURING PLANT

There are basically three main sections ;

A) Benzene Hexachloride Section

B) Lindane Section

i) Extraction unit
ii) Crystallization unit
iii) Off-sites for storage tanks

C) Technological Residues - This section is not discussed in this report, since they do not treat the residues, and thereby they do not have any corrosion failures/problems in this section of Lindane plant.

5b PROCESS IN BRIEF

A) Benzene Hexachloride Section & production, in Brief :

Benzene hexachloride is obtained by photochemical reaction between benzene and chlorine these two being the main raw materials. The raw material quality being as follows ;

	Benzene (C6H6)	Chlorine(Cl2)
Density	0.874-0.881 gm/cm^3	Purity 99.5%
Purity	99.5%	Humidity 0.05%
Humidity	0.05%	
Boiling Pt.	78.1°C-81°C(interval)	

The photoreaction is performed in the two main enamelled reactors each of 1200 litres volume. The lid of the reactors are internally coated with lead (Pb). The constitution of the internal glass layer of the reactor is as follows ;

SiO2	69%	Al2O3	3%
B2O3	6%	Na2o + K2O + Li2O + CoO	17%
TiO2	5%		

PROCESS IN BRIEF :

The temperature range of the reaction is 45-55°C, the pressure of Cl2 at the entry of the reactor being 1.2 atm., above the atmospheric press, i.e. 2.2 absolute. The reaction is exothermic, the reaction time being 3 to 3.5 hours. The reactor is without an agitator, and it has a cooling system with cold water. The solution which is obtained in the end of the reaction has a concentration of about 20-30% of benzene hexachloride, the concentration of Lindane in benzene hexachloride being about 10-12%.

PROCESS IN BRIEF

The pipe which brings the Cl2 to the reactor is made of AISI 304 type of S.S, is of 25 mm ϕ and 2.5 mm thickness. The gases as a result of this reaction are carried through a lead pipe 65 mm ϕ and 8 mm thk. through an absorber with C6H6 (gases totally dissolved in C6H6). These gases are mainly vapours of C6H6, HCl gas, Cl_2 gas, and some other unidentified vapours. The part of these gases which escapes from the absorber is neutralised with 15-20% Sol^n of NaOH. The absorber, also enamelled, are two in number each 2000 litre capacity, the pressure in absorber being 1.2 absolute (0.2 atm. above the atmospheric pressure). The solution so obtained is then discharged to another enamelled absorber, also 2000 litre volume, where the acid solution (in water phase) is seperated from organic solution, according to their very little affinity for each other. After discharging the whole acid solution (2 to 5 litre), the remaining organic solution is washed with fresh water (about 100 litre). The mixture is then stirred up for about 15 minutes, and then left to settle/rest for another 15 minutes, and the water solution of dissolved HCl gas is then discharged. Acidity before and after washing, of the organic Sol^n, being from 0.1 - 1% to 0.01-0.1% respectively.

The water solution, so obtained as a result of washing the above mixture, having an acidity upto 10-12%, is further neutralised with 2-3% solution of Na_2CO_3, which brings the level of acidity down to 0.01% or even upto 0.001%. Again the free chlorine present in the solution is also eliminated by 5% solution of $Na_2S_2O_3$

and the treated organic solution is carried to the distillation reactor, 2000 litre volume, also enamelled, where the solution is subjected to intensive heating in order to evaporate the benzene. The time of this process is nearly 2.5 hrs; at a pressure of about 0.3-0.9 atm. above the atmospheric press.(1.3-1.9 absolute), the maximum temp. at the end of distillation being 105°C-107°C.

PROCESS IN BRIEF

The vapours of this distillation are condensed in a heat exchanger (total 3 exchangers), the cooling media being cooling water on the tube side of the exchanger. The condensed liquid, so obtained, is a mixture of C_6H_6 and water, which are then seperated according to the differences in their respective densities and non-affinity for each other.

There are 3 Distillation Columns, but only one is used for distillation, as one is badly damaged and put out of action, the other is also damaged but somehow repaired and used for neutralisation. These Columns do not have agitator. Only the one which is used for neutralisation has been modified to have an agitator.

At the bottom of the distillation reactor, some solid residues so settled in the process of distillation, gets gradually melted (temp. being around 107°C) by the time all C6H6 has evaporated, are taken out of the distillation RK through bottom nozzle, which then immediately crystallizes the moment it comes in contact with open atmosphere. Since this also contains some lindane, it is taken to extraction unit and further processed.

B) LINDANE SECTION - PROCESS IN BRIEF

In this section, the processes of extraction and the crystallization are performed in two stages.

PROCESS OF EXTRACTION :

The product obtained at the end of distillation and condensation processes in the Benzene hexachloride section, (the first part of the plant) is first dried-up, through a drying system with hot air, the maximum humidity of the product being 1%.

PROCESS IN BRIEF

The dried product is then sent to the grinding mill, where the product is powdered. This powdered dry benzene hexachloride is then carried to an enamelled reactor (4 in all, each 2000 litre vol.) with agitating system and fresh methanol. In this reactor, the product mix is agitated for about 1 to 1.5 hours in the temp. range of 40 ± 2°C, when the isomers get preferentially dissolved. At the end of 1.5 hrs. time, the extraction process is considered to be complete. Achieving the desired timing and temp. is indicative of the completion of extraction process.

There is yet one more step after this, where this agitated mixture/solution is subjected to distillation to remove the unwanted isomers and also to obtain the methanol. This part of the plant, however, does not work because most of the tubes of the two carbon steel exchangers are completely destroyed by corrosion.

PROCESS OF CRYSTALLIZATION

After extraction, the solution which is in the form of pulp, is carried to a press filter where at the end, the undissolved solid substance is seperated from the liquid solution. In this seperated liquid solution, lindane finally crystallizes, as it cools down. This crystallization takes place in the 4 Enamelled RKs of crystallation unit.

The solution mixed with lindane crystals is then carried to the centrifuge, when in presence of filter cloth, the lindane crystals get filtered out, so that liquid percolates the filter, while the crystals do not.

The Lindane so finally obtained here at Durres plant, is not pure upto the requirement, and the purity generally achieved here is from 80% to 90% maximum, due to process/technological problem, as per them, which they have to resolve.
The liquid solution percolated through the filter of the centrifuge is again recycled with fresh methanol.

5c. PROBLEMS & CORROSIVE CONDITIONS GENERATED DURING PROCESS AT LINDANE PLANT

* The humidity of the two main raw materials benzene & chlorine are the main factors determining the quantity of HCl formed during the reaction, creating corrosive conditions.

* In the presence of light, the chlorination of C_6H_6 takes place generating HCl, the main corrosive agent at Durres plant, causing corrosion of pipes, valves, tanks, pumps etc.

* Chlorine itself(the 2nd raw material) is a highly corrosive media, particularly in presence of moisture/humidity.

* Cooling water, which is presently not being treated in Durres plant, is by itself a highly corrosive fluid, this being a very good electrolyte, causing internal corrosion of exchanger's C-steel tubes.

* The lid of all the 8 reactors in BHC section are internally coated/ lined with 6mm thk lead, which suffer corrosion, their average life being 6 to 8 months maximum, Lead being the wrong material.

* All the 8 reactors, the 2 absorbers, the 3 Distillation reactors, 20 valves of BHC section are internally glass lined. The glass lining of all these are giving frequent and recurring problems of damages, failures, corrosion etc., so much so that these are proving to be very serious and a regular nuisance. The repair method used is not effective.

* Due to humidity present in C_6H_6 & Cl_2 , about 2 to 5 litres of HCl acid having a concentration of upto 30% is produced in the reactors and carried elsewhere in the system, the main corrosive agent.

* Further, the concentration of free chlorine in solution vary between 1 to 5 gm/litre. N2 gas is occasionally passed through the solution to reduce the free chlorine content, and the same at times reduces to 0.5 gms/litre, but till it is done, the free Cl_2 remains high.

CORROSIVE CONDITIONS & SOURCE OF PROBLEMS - CONTINUED

* The method of repair adopted at Lindane plant for repairing the broken/damaged glass linings has been to use "putty", having 80% pulverised steel, 20% epoxy resin-two component material, temp. resistant upto 120°C, the ingredients of the hardener being diazeetan, diamin (Tridimethylaminomethyl) etc. But this does not work well and does not last.

* The AISI 304 S.S. pipe 25mm ϕ, 2.5 thk carrying Cl_2 to the reactor has suffered minor to moderate corrosion.

* The gases which are passed through absorbers are chiefly HCl and Cl_2 gases, highly corrosive.

* The acidity of the organic solution before washing and neutralising is as high as 0.1 - 1%.

* The majority of the C-steel tubes of the two C.steel exchangers are badly corroded and leaking, in the BHC section, so much so that they have become, more or less, non functional.

* The atmosphere over Lindane plant at Durres, and for that matter on the entire chemical plant, is highly corrosive, due to presence of Cl2 ranging from 0.5 to 1.5 ppm but generally upto 20 ppm (due to leakages), HCl, So2, chloride (the plant being located near sea), Co2 etc. This has caused external corrosion of equipment, pipings, components, structures, stairs, railings, platforms, walk ways. All these require a very good and systematic protective painting programme using the right type of protective paints & procedures, to protect them from such severe external corrosion.

* Some of the pipelines in Cl_2, HCl (upto 30% concentration) etc., services in use are made of Lead and S.S., which are failing/ corroding, as expected, as none of these materials are suitable for the service.

CORROSIVE CONDITIONS & SOURCE OF PROBLEM - CONTINUED

* The type and quality of glass used for the linings is also not really tested and ascertained, and the fact that the glass linings so used are being attacked by the process fluid, indicates that the glass used is perhaps of not the right type.

* The corrosion/failure of weld joint on 3"ϕ S.S. discharge line, at nozzle to pipe fillet weld, partly due to erosion, and is mainly due to inadequate welding procedure for S.S., and no means to check the quality and soundness of weldment; and again use of S.S. in chloride and HCl environment.

* The C-steel frame of the Press Filter in extraction unit, which suffers some corrosion, is not considered alarming, and it simply need cleaning the surface and the right protective coating.

* The three S.S. tanks (2nd, 3rd, 4th, 300 litres each) again in HCl, water environment suffers corrosion on its body, weld joints, and severely at the bottom under deposits, bottom being flat.

* In case of 4 pumps (Body C.I, shaft S.S), some pittings were found on the shaft only, not considered alarming.

6. PROBLEMATIC EQUIPMENTS IN LINDANE PLANT

A detail list in tabulated form of various equipment, Reactors, Columns, Tanks, pipings, fittings, valves etc., with details of problems being faced, in the various sections of the plant, has been outlined in annextures IA to IF, which may please be referred, for description, quantity, dimensions, service/operating conditions, materials of construction presently in use, problems with them, and appropriate remarks in each case, and finally identifying the most problematic equipments & pipings etc. needing attention.

7. FINDINGS & ASSESSMENT

OVERALL SUMMARY

The process technology of the Lindane manufacturing plant at Durres, Albania is by China, who also supplied the 8 main Reactors, enamelled inside, sometime in 1981-82. Around 1982, the relation of Albania with china, however, got severed, and as a result there was no support and help, afterwards, from China. The plant was constructed around 1982, with all other equipment like columns, tanks, exchangers, valves, pumps, pipings etc made in Albania. The plant was started only in 1985/86. During all these period between 1982 and 1986, the plant equipment remained in idle condition. No performance guarantee run was given by the Licensor. Right from beginning, the plant has been giving very low production, never more than 25% of the rated capacity. The plant is designed to produce 100 tons/yr., but it has never produced more than 25 tons/yr.

The Lindane plant is hardly 2½ to 3 years old. They started experiencing corrosion problems after 6 months of the start-up of the plant only, though the very low production was there right from the day one. This only means that corrosion is perhaps not the main root cause of very low production. No doubt, by now there are many serious corrosion problems, and corrosion failures in the entire lindane plant, requiring immediate attention. There are several equipments identified by the author during this visit, which are in bad shape, giving reccurring problems of leakages, corrosion, and failures. The plant equipment have, in general, suffered both internal and external corrosion. The atmosphere over the plant is highly corrosive comprising of sulphur, So_2, HCl, Cl_2, Nacl, Co_2, moisture/humidity etc. The internal atmosphere within the process equipment, particularly in BHC section is highly aggressive and corrosive.

OVERALL SUMMARY - CONTINUED

Causes of all these problems vary from use of wrong materials of construction in several cases, to corrosion, erosion, physical damages, thermal shocks to glass linings and their gross failure thereby causing localised corrosion of base carbon steel, absence of even the basic inspection & testing tools and gadgets for "On-stream" condition monitoring and periodic checks of the health of plant equipment, absence of proper protective painting programme etc. There was also no proper record or evidence of stage inspection and certification of the quality of originally fabricated and supplied equipment for good workmanship, particularly for the quality, type and soundness of original glass linings supplied, heat exchangers, weld joints, valves etc. There is no practice for treating cooling water for corrosion, which is the main cooling media in exchangers, Reactor jackets. This area also needs attention.

The Lindane manufacturing plant at Durres, and most of its equipments, barring few, are, overall, not in good state of health, and much is required to be done on priority to bring back the plant in good operating condition, in terms of replacement of most corroded and damaged equipment, pipings, fittings etc; changing the materials of construction in some cases, where wrong materials have been used, procuring atleast 3 or 4 most important NDT condition monitoring instruments on priority required for regular monitoring of the condition of plant equipment, going for an effective protective painting programme, adopting and following good inspection practices and predictive maintenance philosophy, treating the cooling water effectively and scientifically necessary for reducing corrosion bycooling water, possibly to employ atleast one metallurgist with some corrosion background to take care of this important area, and also to impart proper and adequate training to the engineers & technical

OVERALL SUMMARY - CONTINUED

staff of the plant in this vital area for educating and bringing the required awareness. considered important for maintaining quality, reliability and safety of plant equipment.

Nearly 70% of the plant equipment, pipings, fittings in the Lindane plant are not in satisfactory state of health, mainly due to severe internal corrosion, and also to external corrosion to a great extent.

The main causes, the grey areas, behind all these corrosion problems, failures, and poor condition of the plant equipment can be summarised as follows ;

i) Highly corrosive atmosphere prevailing in and around the plant.
ii) Severe and highly corrosive process conditions in B.H.C.
iii) Use of wrong/Incompatible Materials of Construction in some cases.
iv) Absence of effective protective painting programme.
v) Absence of cooling water treatment programme.
vi) Use of inadequate welding procedures, and no means to control weld quality, at Lindane plant.
vii) No means or facilities available for the regular monitoring of plant equipment condition. State of ignorance.
viii) Absence of Inspection practices, and predictive maintenance concept. Lack of awareness in "Equipment Quality, Reliability & Safety Management". No good Maintenance practices.
ix) Lack of proper and adequate Training.
x) Lack of Documentation & Record Keeping & Information System.
xi) No back-up support at all from their Chinese Licensor/Collaborator.
xii) Gross failure of Reactors glass linings due to one or more of the following reasons ;
    a) Physical damages/mishandling & Ineffective Repair procedures followed.
    b) Erosion/Turbulance inside valves, reducers, nozzles.
    c) Corrosion(perhaps incompatible type & quality of glass)
    d) Thermal shocks.
    e) The universal fact that to achieve perfect repairs of damaged glass linings is extremely difficult, and that glass linings once damaged become a regular maintenance nuisance. No Spark Tester available.
xiii) Lack of welding skill, with no good/trained welder.

OVERALL SUMMARY - CONTINUED

The local plant management cannot be blamed also mainly because they have had no back-up support from beginning from their licensor, and even now no proper guidance is available to them. They have been carrying on with whatever they have been given by their licensor/ designer, right or wrong, with no follow-up, back-up services. Further, there are several specialised materials and services requirements not available in the country, and nevertheless the factors of ignorance, helplessness, and lack of awareness as indicated above have prevailed upon them.

The author has, within the limited time, studied the many problems of corrosion, failures, and the related aspects, and has, more or less, done a thorough technical auditing of the Lindane plant from author's objectives point of view. The summary statements on all problematic equipment, pipings, fittings etc of the entire lindane manufacturing plant can be seen in annextures IA to IF. The recommendations on replacements, materials of construction, measures to prevent corrosion, preventive maintenance with predictive philosophy, along with suggested line of actions etc have been offered in the following chapter, after this overall summary.(Annxs.IIA & IIB)

COST ASPECTS :

The initial expenditures going to be incurred on the anti-corrosion measures suggested, cannot be considered substantial or very high, by any standard, since here is a case of reviving the plant from its present limping stage, and bringing the plant into full operation, which, of course, also depends upon removing the operational limitations and problems related to process, as may be advised by the UNIDO consultant on process. The expenditures so incurred on all anti corrosion measures and other measures suggested to improve the overall maintenance/condition of the plant, will ultimately pay and considerably reduce the present exhorbitant losses in production.

OVERALL SUMMARY - CONTINUED

It is actually the ultimate effective cost that is to be seen, which will certainly prove to be insignificant and justified, when compared with the benefits, in-waiting, in the long term.

There are, however, some issues and possible measures to minimise corrosion but related to process and their acceptability in process, which will have to be jointly seen, reviewed along with the process chemist Expert of UNIDO in the next visit of the split mission. The short period of two weeks (actually hardly 8-9 working days) may, however, be a major constraint.

Recommendations and views on these issues will be thus reported in Part II of the report along with the Expert process chemist's report after the author's joint study and review during the second visit. Similarly the details on cooling water treatment methods will be offered in the Part-II of the report, since the data required on cooling circulating water have yet to be generated by the local management, since there has so far not been any practice here of analysing circulating cooling water. Also the addresses of possible vendors, suppliers, manufacturers, parties etc., concerning several matters appearing in this report, known to the author, and which will be helpful to all concerned, will be offered in Part II of the report during the second visit of the split mission.

* A WORD ON PROCESS INSTRUMENTATIONS

Overall, it was very clear that the Lindane plant is rather poorly equipped with process instruments essential to control and monitor some important process parameters like pH, temp., flow, pressure, concentration etc. In the openion of the author, their process instrumentations need badly a total revamp and modernisation, for example they have none for pH controls & monitoring, none for concentration, flow meter (Diaphgram type) only for steam & water, thermometers for temperature, no flow meters for chlorine etc., monometers for pressure etc. This aspect will have to be looked into by the Process Expert of UNIDO, as process instrumentations are extremely important for efficient operation of the plant.

OVERALL SUMMARY - CONTINUED

* MANUAL ON CORROSION & INSPECTION MANAGEMENT FOR IMPROVED MAINTENANCE.

Two copies of Manual prepared by the author for general information on Corrosion & Inspection management, various NDT instruments, Inspection practices, methods & techniques, classification and inspection schedulings etc necessary for good and efficient maintenance and predictions, were handed over, one to the Lindane plant and the other to the Committee of Science & technique, Tirana. They found the manual very informative.

* The circulating cooling water analysis was not made available to the author till the last day. Promised to be given in my 2nd visit. Advise on this will thus be offered in Part II of the report.

* Some decisions on the possibility of using process corrosion inhibitor, sacrificial anodes for the cathodic protection of Carbon steel parts of the exchangers and tanks etc will be taken in the 2nd visit after joint review with the process expert.

* Some other information such as welding procedure, spark Tester, detail painting procedure, various addresses of vendors, suppliers, manufacturers etc., corrosion inhibitors for C.W. etc will be offered in part II of the report.

* On the advise of the author, arrangements for taking photographs of corroded parts, components in the Lindane plant were made by plant personnels, and few photographs were taken for study, though the quality of photographs, were rather poor. These photographs have been handed over to the Back Stopping Officer, Mr. B.Sugavanam at Vienna.

* On the advise and initiative of the author, as the same was considered necessary, and with the help of plant management a visit was undertaken to a Fertiliser plant in Fier, to examine the u/s instrument with them and to borrow the same for u/s survey at Durres plant. This survey was conducted on 14-4-89 and 15-4-89. The results of this exercise are discussed separately.

* We had two series of meetings at Tirana with Committee of Science & Technique on the visit of the author and on the overall status & views etc. (on 11-4-89 and 4-4-89), with Mr. METILIRFICO & MR. SAFA KUMBARO along with Mr. Michael Vaso of Lindane plant & Mr. Gazmend Giyli of Inst. of Chemistry, Tirana.

* GLASS LININGS

For the service conditions prevailing in all the Enamelled Reactors in Lindane plant, glass lining, no doubt, is quite compatible, there are, however, several factors, which either make it incompatible or a regular maintenance nuisance, if not taken care of. First o. all, it is the type and quality of glass used which matters a lot. In this case, Borosilicate glass would be appropriate one, but in absence of any test certificate etc., it is not known as to what is the type and quality of glass actually used. Secondly, there is also no record, or evidence to suggest that the glass linings done were originally defect free as there is no record of Inspection certificate etc. Furthermore, absence of a 'Spark Tester" in the lindane plant, has made it impossible to check the condition of the glass linings in service, though on visual inspection they looked to be bad, when couple of Reactors were opened and inspected by the author.

Glass linings break or get adversely affected easily by several ways such as corrosion, erosion, poor lining workmanship, thermal shocks, rough or mishandling being very fragile and brittle, and once it gets damaged particularly at curvatures, sharp edges, it becomes almost impossible to get a perfect repair. It then becomes a regular headache and a maintenance nuisance. It is for these reasons, glass lining is to be avoided. Moreover, the 'Spark Tester' the only

instrument to monitor the condition of glass lining, works on a very high electric voltage system, which is not really very safe to use, if used carelessly. The author has, therefore, avoided recommending Glass lining (Borosilicate Glass) again.

* The author was also once taken to JLORA to visit NaOH,(Caustic Soda), Na2Co3 (soda Ash) and PVC plants on 10-4-89, and to have an idea of their corrosion problems. It was observed that they were facing lot of problems and were struggling to solve them. UNIDO can perhaps offer to help them and can perhaps take up the matter with them.

* People here desired that I should deliver some lectures at Tirana before audience of technical personnels from various institutions, industries etc. However, due to lack of time, this could not be done and the same can perhaps be done in the 2nd visit of the split mission.

* On invitation from the Director, a visit to the Institute of Chemistry at Tirana was first planned on 11-4-89 but could not materialise as the Director of the Institute was on emergency call to the Minister. This visit was undertaken on 13-4-89, when I was showed the various laboratories (all very small ones & few only) of the Institute and the Director along with his senior colleagues had long group discussion with me, when they posed, several of their corrosion problems to me and wanting solutions from me.

* The cost of fabricating/replacing equipment can be obtained from the manufacturers/fabricators by inviting quotations, or budgetory offers., which can only give an idea of the present cost of replacement.

* It was rather surprising to find that though the Lindane plant had several important and large Glass lined Reactors, but neither the glass linings were originally tested for its quality and defects, nor they had any 'Spark Tester' with them for its regular monitoring to help better maintenance. Now, of course, this 'Spark Tester' will only be required if they again want to continue with G.L.S.

ULTRASONIC THICKNESS SURVEY & FLAW DETECTION EXERCISE

On the initiative and insistence of the author, one such instrument from a Fertiliser plant at Fier (one digital & one flaw detector) was arranged, by taking a personal visit to Fier along with Lindane plant personnels. This survey could be made possible only on 14th & 15th April, 89 (the last two days of author at Durres), and therefore this exercise was carried out randomly, and in rather hurry as also the Technician from Fier had some other commitments somewhere else.

This exercise was done in a limited manner as most of the reactors in the Lindane plant, barring the two Absorber reactors, are jacketted from outside, hence the body/shell of those reactors could not be checked. However, on the basis of results of the two Absorber Reactors, it can be presumed only that there has not been significant uniform attack on the carbon steel back-up plate and perhaps only localised attack wherever glass linings are damaged/cracked. No obvious internal defe cts could be detected on random checks. This only suggests that perhaps the carbon steel back-up plates are still in satisfactory condition and mechanically strong and can perhaps be reused for relining as back-up plate, but at the same time this may not be practically or technically feasible as well as not really an economically viable proposition.

8. RECOMMENDATIONS

The following recommendations are made in order of priority and importance ;

1. Lindane plant needs to be adequately equipped with all essential process instrumentations, for flow, pH, temperatures, pressures, concentrations, etc., for efficient operation, as may be advised by the process technology expert.

2. Urgent procurement of some basic and essential NDT instrument for the regular monitoring of equipment condition, as recommended below ;

SR.NO.	NAME OF INSTRUMENT	MANUFACTURER/SUPPLIERS	APPROX.PRICE
1ST PHASE			
(i)	Ultrasonic Thickness Meter. DM1 OR DM2	M/s. KRAUTKRAMER GmbH 5 Koln Luxemburger Strab 2449 West Germany	$ 3000/00 (Three thousand)
(ii)	Ultrasonic Flaw Detector USM-2 (Training will be required) This instrument, if short of money, can be bought in phase II also. This will also require proper training of one or two persons for its proper use and interpretation of results.	" " "	$ 4000/- (Four thousand)
(iii)	Visual Inspection Kit (Aid for Inspection)	M/s. P.W.Allen & Co. 25, Swan Lane, Evasham, Worcestershire, WR11 4 PE, U.K.	$ 1000/- (One thousand)
(iv)	Dye Penetrant Test Kit (For surface defects of welds) (About 6 sets of three types of penetrants)	M/s. P. Met Company Baroda, Gujarat,India	$ 500/- (Five hundred)
2ND PHASE			
(i)	CK-3 Portable "CORROSOMETER"	M/s.Magha Corporation 11808, So Bloom Field Avenue, Santa Fe springs CA 90670, USA.	$ 3000 (Three thousand)

(ii)	'Elcometer' Minitector-150	M/s. Elcometer Instruments Ltd; Edge Lane, Droylsden Manchestor, M-35 6BU England	$ 500 each (Five hundred)
(iii)	'Elcometer' Paint Thickness Gauge, (Magnetic Type)		
(iv)	High Voltage Spark Tester This would be necessary for testing the integrity of non-metallic linings.	M/s.Electro Medical Apparatus Company 3, M.A. Sarang Street, (south) DONGRI, BOMBAY-400 009.	$ 400 (Four hundred)

3. Replacements of equipment, pipings, fittings, parts, with suitable materials of construction, to be taken up as per the recommendations and priority given in annextures IIA & IIB.

4. Regular protective painting programme must be followed using proper anti-corrosion protective paint system for the protection of equipment, pipings etc from external corrosion. It is necessary to paint all tanks, vessels, columns, reactors, exchanger shell, pipings etc externally using special anti-corrosion paints namely "High-build polyurethane" (2 component, aliphatic), and "Coal Tar Epoxy Paint" for railings, stairs, platforms, pillars, structures etc. A very good surface preparation (cleaning of surface, removal of old rust etc) using hard brush, emery paper would be necessary.

	Application of Paint	Manufacturer/Supplier
For Equipment, pipings etc.	a) Proper Surface Preparation b) One coat of Polyurethane Primer c) Two coats of 'High-build Polyurethane	Total Cost Approx. $ 4000 700-1000 litres(Four thousand M/s. Grand Polycoats Co.Ltd; 306, Kashyap Complex, Productivity Road, BARODA-390 005 (Gujarat), INDIA Cable: "POLYCOAT", BARODA Telex: 0175-533 MCOM IN 0175-388 BPC IN Phone: 322884, 320682

For Railings, Stairs, Pillars, Platforms etc

a) Proper surface preparation
b) One coat of zinc rich primer(Inorganic)
c) Two coats of "Coal Tar Epoxy"

This painting programme should be repeated every 2 to 3 years and be followed/applied in dry weather only. Painting must not be done while it is raining or humid.

5. There is also an acute need for regular treatment and monitor of cooling water. The raw water used at Lindane plant appears to be soft water, which being more corrosive, needs to be adequately treated. It is recommended to treat the water with organophosphonate based corrosion inhibitor. The detail treatment procedures will be offered in my second visit. Lindane plant has been advised to analyse their recirculating cooling water and give me the analysis results necessary to work out the detail procedure. This is yet to be organised by them.

6. It is essential to develop and train atleast two good welders, so as to have the required welding skill and knowledge of welding techniques including TIG method of welding, and also inculcate habit of checking and testing the weld quality and soundness, which will lead to good maintenance.

7. It is very essential for the plant management to have a regular 'Equipment condition Monitoring programme', Inspection planning and schedulings, periodic thickness checks at various points/ locations, on all equipment, pipings etc and keep perfect record and watch, maintain equipment data & history cards, necessary for improving the cverall maintenance.

8. It is advisable for the Lindane plant management to recruit one Metallurgist with corrosion background and knowledge of

Inspection & NDT techniques to look after this vital area of corrosion control, inspection, condition monitoring etc., which is presently a grey area. This will greatly help in improving overall maintenance.

9. Adequate and proper training of the technical personnels attached with Lindane plant in the area of operation, preventive & predictive maintenance, welding technology, inspection techniques etc. would greatly help in bringing awareness, in improving overall maintenance, ultimately leading to more efficient operation of the plant.

9. ACKNOWLEDGEMENT BY THE AUTHOR

The author wishes to record his sincere thanks and gratitude to the management and all those of Lindane manufacturing plant of Durres who have been associated with him for their very cordial approach, their full cooperation extended to the author in accomplishing this task. The author is particularly impressed by the affection shown by the people of Lindane plant, and it was a great pleasure in working with them.

The author is also very grateful to the United Nations Industrial Development organisation, Vienna, for giving this opportunity of serving UNIDO, and the Govt. of Albania. It has been a very useful experience indeed.

The author is extremely thankful to his parent organisation M/s. I.P.C.L., Baroda(India), and Govt. of India, for having allowed him to take up this UNIDO assignment.

ANNEXTURE - IA

SR. NO.	EQUIPMENT, PIPINGS, FITTINGS	QTY.	. DIMENSION	SERVICE/OPERATING CONDITION	DESCRIPTION PROBLEM	PRESENT MAT.OF. CONST.	REMARKS
1.	Main Reactor Enamelled C.S+G.L 8.5mm+1.5mm BHC SECTION	2	1200 litres each 2000mm x 900mm ϕ x 10mm thk.	Temp. 45-60°C press. 2.2 Absolute C6H6 with 0.06% moist dry Cl2 wet HCl upto 30% concenn.	Glass lining corroded and badly damaged all around. Basic C.Steel corroded and leaked repeatedly.Several times repairs done, but does not last long.	C-Steel lined internally with glass	Very bad condition. Irrepairable. Perhaps type of glass used is not compatible. <u>Needs to be replaced</u>
2.	BHC SECTION Small Reactors Enamelled C.S + G.L 6.5mm + 1.5MM	6	600 litres Each 1600mm X 700mm ϕ X 8mm Thk.	Same as Above	Same as above	Same	Same as Above Mostly damaged at the bottom nozzle (severe) <u>Not so Bad</u>
3.	The covers of all the above 8 Reactors are C-steel internally lined with Lead, but the Lead lining does not last for more than 6 months, and corrods fast. BHC SECTION						LEAD UNSUITABLE WRONG MATERIAL
4.	The 8 Reactors are also 1/2 height jacketted. The top covers have underneath either rubber or asbestos gaskets on uneven flange surface of the Reactors & fail.						ORDINARY RUBBER OR GASKETS NOT THE RIGHT MATERIAL

5.	Absorber Reactors C.S. + G.L. 10.5 1.5 BHC SECTION	2	2000 litres each 1850mm X 1200mm ϕ X 12mm Thk.	Temp. 25°C-35°C winter 5°C-10°C press. 1.2 absolute Benzene, moisture,HCl, wet Cl2.	Same problem as in the case of 2 above main Reactors.	C-steel lined with Glass	Bad Condition Almost Irreparable Type & Quality of Glass used, perhaps unsuitable. Need to be replaced.
6.	Distillation Reactors Enamelled 12.5 + 1.5mm B.H.C.SECTION	3	2000 litres each 1600mm X 1300mm ϕ X 14mm Thk.	Temp.upto 105°C press. 1.9 Absolute Benzene, moisture, HCl, wet Cl2.	Severely corroded/damaged one is out of action. One is in action. One is used for Neutralisation.	C-Steel lines internally with Glass.	Severely corroded/ Damaged. Most Bothering. Glass not compatible. Only one is in use. Need to be replaced.

ANNEXTURE - IB

1.	2.	3.	4.	5.	6.	6.	7.
7.	Heat Exchanger BHC SECTION	3.	Tubes 32 mmϕ X 3mm Thk Shell Thk 4mm	S/S Benze Vapour steam, HCl vapour, Cl2, 1% BHC Temp. 78°C-110°C press. 1.9 atm. T/S-Cooling water temp 3 to 5°C.	*Internal corrosion of S.S. on tube side as well C.S. tubes by C.W. *Very severe corrosion on C.S. tubes. Most of the tubes corroded & leaking. Corrosion of tube to T/S seal weld. * Some corrosion on shell.	Shell-C. steel in all 3 Tube S.S 304 in 1st exchanger C-steel tubes in 2nd and 3rd Exchangers.	No Treatment given to C.W.shell can be reused. S.S tubes can work for some more time. C.Steel tubes gone. All to be replaced with right MOC. External protection of shell regd.
8.	C-steel tanks BHC SECTION	4	Two 1400mm ϕ 2000mm Ht 5mm Thk Two 1785mm ϕ 1500mm Ht 5mm Thk	Ambient Temp 25% -35°C Condensed vapour of benzene & water is stored to separate H2O & C6H6.	Not much of a problem. Some External corrosion.	C-steel with no internal protection	Tanks fairly good. External protective coating required.
9.	Pipelines a)From Main R^k to Neutralization R^k	1	65mm ϕ 8mm Thk	Carry gas from main R^k from its upper part to Absorber	Very fastly corrodes, more severe from welds, but everywhere.	Lead	Lead Unsuitable Needs to be replaced with suitable material.

1.	2.	3.	4.	5.	6.	7.	8.
	b) From Absorber to Neutralizer	1 + few more	65mm ϕ 8mm Thk	Carry gases, free Cl2, HCl Vapour, C6H6 vapour.	Very Same as above.	Lead	Same as Above.
	c) C.W.pipelines in all parts of plant.	Few	52mm ϕ 3mm Thk.	Cooling water	Not much problem	C-steel	Satisfactory condition so far. C.W.Treatment however required.
	d) From Collector of steam to inside of Distillation Reactor	1+ 1	Teflon solid 40mm ϕ O.D. 10mm Thk C.S. 25mm ϕ O.D. 2.5 mm	Carry steam at 110°C + other products.	No problem	Teflon	Nothing to be
	e) From Cl2 Tank to inside of photosynthesis Rk.	1 for each Rk	25mm ϕ 2.5mm Thk	Carry Dry Chlorine with 0.06% moist. in Cl2 at 30-40°C.	Corrosion in both OD & ID	S.S.304	Material Unsuitable To be replaced with suitable material.
	f) Supply line between C6 H6 Tank and Rks.	2	36mm ϕ 5mm Thk	C6H6 with	No problem on C-steel portion. Pb lines corrode very fast	Some portion made of C.Steel(between Tanks & Absorber) Remaining portion made of Lead (Bet.Absorber & Rk)	Lead Unsuitable.

ANNEXTURE-IC

SR. No.	EQUIPMENT, PIPINGS, FITTINGS ETC.	QTY.	DIMENSIONS	SERVICE/OPERATING CONDITIONS	DESCRIPTION OF PROBLEM	PRESENT MATS. OF CONSTN.	REMARKS
	g) Line between two Reactors	2	65mm ϕ 8mm Thk	C6H6 with dissolved free Cl2 + water ambient.	Pb line corrodes very fast.	Lead	Lead unsuitable
	h) Valves	20	8 are S.S. 80mm ϕ 3mm Thk 12 are Enamelled 6 are 80mm ϕ 6 are 50mmϕ	Mixture of Reaction C6H6, moisture, HCl, free Cl2, sometimes product of main R^k goes 40-45°C	Most of the valves G.L. badly corroded & damaged. Frequent repairs. In case of S.S, it is purely weld failure of pipe to pipe fillet weld.	8 are of S.S C-steel internally lined with glass(12). In case of S.S weld poor welding, No welding skill.	In Bad Condition Need to be replaced with suitablelining material S.S-Lack of welding skill
10.	Grinding Mill	1	-	Grinds solid BHC Which has mois- & HCl.	Some corrosion on some parts reported.		Inspected. Only some roughening of internal surfaces. Not to worry.
11.	EXTRACTION UNIT	4	2000litres 1600mm Ht 1300mm ϕ 14mm Thk	upto 40°C, Atm. press, Solution of BHC & Methanol Little water. Acidity 0.001 to .009%.	No problem Mild Atmosphere.	C.S. + Glass	Nothing to be done Except External painting by suitable coating material.

1.	2.	3.	4.	5.	6.	7.	8.
12.	Press Filter(Extraction unit)	1	-	Product from above Reactors, where solids & liquids are separated.	The C.steel frame of the press filter gets affected by corrosion.	C.steel frame others not known.	Inspected.Minor PROBLEM.Only some protection required to be given to the frame.
13.	Supply line (Extraction unit)	1		Carry the same above product from press Filter.	No problem.	PVC	Inspected.Both corrosion & erosion. SS not really suitable. Also welding method not proper.Porosities No D.P. tests done etc.
14.	Discharge line(Extraction unit)	1	3"ϕ	Same product/ Environment as above.	Failures of pipe to pipe fillet weld jts.reported repeatedly nozzle to pipe jts.mainly weld failure. No Welding skill.	AISI 304 No Trained welder.	Inspected. Both Corrosion & erosion. SS not really suitable. Also welding method not proper.Porosities. No D.P.tests done etc.
15.	CRYSTALLIZATION UNIT	4.	1600mm Ht 1300mm ϕ 14mm Thk	Same product solution but also C6H6,45% methanol,Liq. BHC,little water,little Cl2, 0.1-0.3% HCl,30% solid dissolved substance,15°C-40°C	No problem No damage Mild Atmosphere	C.steel + Glass	Nothing to be done.

ANNEXTURE - IE (LINDANE SECTION)

1.	2.	3.	4.	5.	6.	7.	8.
16.	The centrifuge(After crystallization)	1	-	After crystalization, the solution goes to centrifuge Temp.15°C, Atm. press.Lindane crystals & Liq. soln.get separated.	No problem with centrifuge Mild condition.	AISI 304	Nothing to be done.
17.	Supply line to centrifuge	1	4"ϕ	" "	No problem	Rubber(Type not known)	Nothing to be done.
18.	Small storage Tanks	5	3000 litres 2000mm Ht 1400mm ϕ 4mm Thk	Tank1 only Fresh Methanol	No problem in 1st Tank. Non corrosive media.	All S.S.Either 304 or 321 (Not known)	Nothing to be done in 1st tank.
				Tanks 2nd,3rd, & 4th Soln. of methanol,Isomers including lindane dissolved in it,HCl, water.No. Cl2 Ambient.	Bottom of Tanks badly corroded. Also corrosion overall on Body, Welds etc.	S.S.304	3 Tanks in bad condition S.S.not really suitable for this. Also Crevice corrosion widely at the bottom. Flat bottom. Couple of tanks made upside down.
				5th Tank	Never used.Hence no problem,really.	C-steel	Only some idle period corrosion.Some protection reqd; if the tank is to be used. Also, C.S.may not be suitable.

1.	2.	3.	4.	5.	6.	7.	8.
19.	Centrifugal Pumps	4	4.5 kw 2900 RPM can push upto 20 meter height. Discharge capacity 3 litre/Sec.	All pumps handle more or less same soln, BHC dissolved in methanol, little H2O, HCl, Ambient temp. No chlorine.	No problem on body. Some pittings on shafts. No shaft has ever failed.	Body-Cast Iron Shafts-S.S. Type not known.	Pittings on earlier carbon-steel. Now S.S.shaft considered minor. Only some light grinding & passivation needed. Not really a problem.
20.	Heat Exchanger No Cl2	1		This exchanger, meant for Lindane section, was to condense the vapour of methanol from Distillation, highly acidic, but got very bad. Shellside vapours of methanol, HCl, Steam T/S-C.W No Cl2.	Got very badly corroded in the beginning itself, on both shell side & tube side, more on shell side (O.D.)	C-steel	Now rendered useless. Discarded. Will have to be replaced with suitable material, if required to be used in future. Treatment of Cooling also required.
21.	Methanol Distilln. Columns & One pump with it.	Columns 2 Pump 1	-	Not in use since beginning. Not required because of under capacity utilisation of the plant.	Process problem capacity under utilisation.	-	Process Expert to to look into this.

1.	2.	3.	4.	5.	6	7.	8.
22.	Dosimeter Tank Below the Press Filter	1	500 litres 800mm ϕ 900mm Ht Thk 3mm	Product from press filter. Lindane, HCl, Isomers, No Cl2, No solvent, H2O ambient.	Badly pitted & pinholes. Suffers mainly External Corrosion. Also internal. At places thro' & thro' pinholes.	S.S.	Need protective painting of right type.
23.	In general, the steel structures, stairs, railings, platforms, walkways etc.	Many	-	Corrosive External Atmosphere within the Lindane plant.	All suffering severe corrosion. May be unsafe to stand walk.	C-Steel	Needs thorough & regular protective painting Programme.

ANNEXTURE - IIA

RECOMMENDATIONS ON MATS. OF CONSTRUCTION & REPLACEMENTS

IN ORDER OF PRIORITY & IMPORTANCE

SR. NO. & PRIORITY	EQUIP./PIPINGS/FITTINGS	QUANTITY TO BE REPLACED	M.O.C. & ACTIONS RECOMMENDED
1.	Two severely corroded Enamelled Distillation Reactors of BHC section(Debottlenecking)	Two	Carbon steel internally lined with Tantalum or PV-DF sheets.
2.	Badly corroded and damaged, 80 mm dia Glass Lines Valves(BHC)	Twelve	Carbon steel internally lined with PTFE or PVDF.
3.	Two Large Enamelled Main Reactors of B.H.C. In very bad condition. Irreparable.	Two	Carbon steel internally lined with Tantalum or PVDF sheets.
4.	All Lead pipelines as per Annextures IB & IC.	Several (But all not-v. long)	Carbon steel pipes internally lined with PTFE or viton-'A' Rubber
5.	The Lead linings of the covers/Lid of 8 Reactors of B.H.C.	Lead linings of Eight Lids/ Covers.	To be lined with PTFE or PVDF or Tantalum.
6.	Carbon steel Exchangers in B.H.C., Badly corroded.	Two	* Shell & Covers of C-steel with cathodic protection. * Tubes of Tantalum, or Graphite if Heat Transfer is no problem.
7.	Absorber Reactors of BHC & its Gasket Materials	Two	Carbon steel internally lined with Tantalum or PVDF sheets.

IMP. NOTE : All Equipment must be fabricated under stage Inspection by a Third Party Inspection Agency such as M/s. Lyods, and Test Certificates & Inspection Certificates must be made available.

ANNEXTURE-IIB

RECOMMENDATION ON REPLACEMENTS & M.O.C. IN PRIORITY

SR. NO. &	EQUI./PIPINGS/FITTINGS	QUANTITY TO BE REPLACED	MATS. OF CONST. & ACTIONS RECOMMENDED
8.	LINDANE SECTION		
	Carbon steel Heat Exchanger of Lindane Section, Badly corroded, fast, discarded.	ONE	* Carbon steel shell & Domes with Cathodic protection. * Hestelloy-B Tubes, or Tantalum, or Titanium tubes, or Graphite if no H.T. problem.
9.	Small stainless steel storage Tanks.(Only Three out of five). Bottoms very badly corroded. Also corrosion on body. (Lindane Section)	THREE 2nd,3rd, & 4th	Carbon steel lined internally with either Hestelloy-B sheet or lined with Nitrile rubber or silicone Rubber(K) or PTFE with improved bottom design to prevent Crevice corrosion. No flat bottom. Bottom should be curving outwards U
10.	Dosimeter Tank of S.S. Corroded with Pin holes.	ONE	C-steel internally lined with viton-? rubber or NORDEL rubber or PVDF.
11.	Smaller Enamelled Reactors in B.H.C. section	SIX	Carbon steel internally lined with PVDF or Tantalum.
12.	All Gasket Materials	All, wherever required	Asbestos covered/Enveloped with PTFE to resist corrosion as well as to take the profile of uneven gasket flange faces.

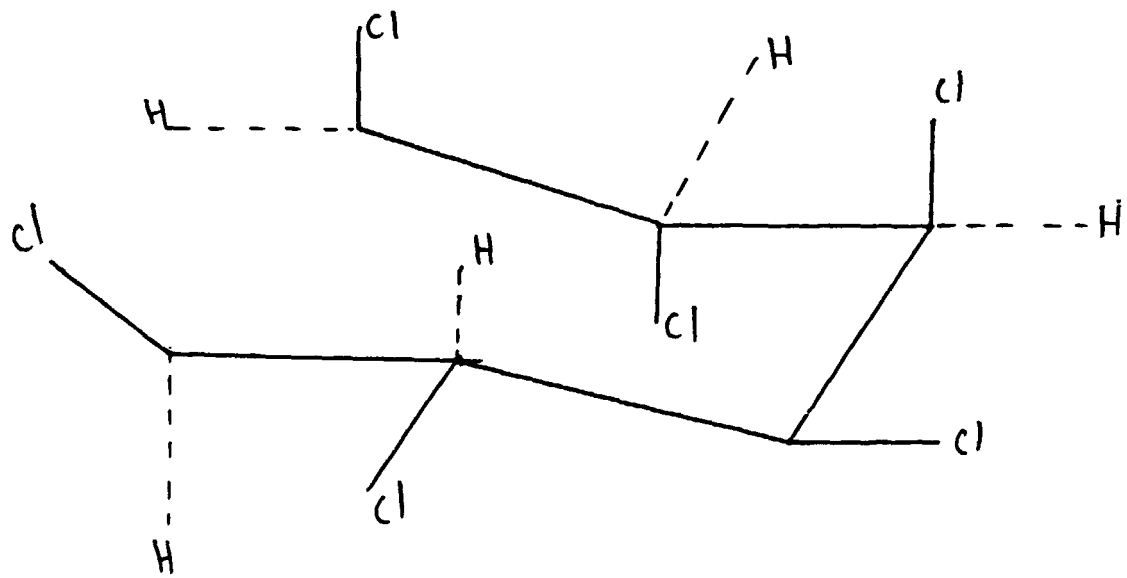
IMP. NOTE : All Equipment must be fabricated by Reputed Fabricators under a Third Party Inspection Agency such as M/s. Lyods and Test Certificates & Inspection Certificates must be made available.

ANNEXTURE - III

SOME USEFUL TECHNICAL INFORMATION ON-LINDANE
LINDANE

Lindane is by definition an insecticide containing atleast 99% of the gamma isomer of hexachlorocyclohexane(also called gamma HCH or gamma BHC). Lindane produced by member companies of C.I.E.L. has a minimum purity of 99.5% gamma HCH.

Gross Formula C6H6Cl6
Chemical Name Gamma Isomer of 1,2,3,4,5,6 hexachlorocyclohexane
Mol. Wt. 290.9
Structural Formula



Commercialised and used in most countries, in particular in all the countries of the European Economic Community (EEC), in USA and in Soviet Union, Lindane has become one of most important insecticides in the world. Being a "Chlorinated hydrocarbon", Lindane is attacked from various sides although its physico-chemical characteristic and its biological activity make it a unique product of its kind, very different from crude HCH(BHC) and other chlorinated insecticides.

Common Name - Technical product containing atleast 99% gamma HCH is called Lindane (AFNOR-150)

Pure Product - Gamma HCH (AFNOR-150), Gamma BHC

Melting pt. - 112.8°C

Vapour press - 1.2 X 10^{-5} mbar at 20°C

Water solubility - 10 mg/litre at 20°C

Partition Coefficient for octanol water 4611 (109 p 3.7)

Density - 1.85

Appearance - White crystalline solid. Pure product is non-inflammable

Odour - Weak to Nil (the characteristic musty smell of Technical HCH is attributed to the presence of contaminants particularly of heptachlorocyclohexane)

Manufacturing: Lindane is extracted from Technical (Crude) HCH by methanol. Technical HCH is obtained by reaction of Chlorine with Benzene in presence of ultra-violet radiation.

Only gamma HCH has the properties required for an insecticides and as such, the high %ge (99%) of gamma isomer in Lindane make it a very powerful insecticide. The structure of Lindane is very different from those of the other chlorinated insecticides like DDT, Chlordane, endosulfan etc. Lindane is very potent insecticide and used for various applications such as soil treatment on open surface, Foliage treatment, Seed treatment i.e. Agriculture against soil insects pests (80% of the total quantity), 5% in the vetinary field for prophylactic and curative treatments of animals against scabies, ticks etc., 10% in Timber protection for the control of capricorn, death watch beettes, bark boress, termites etc., 5% in other minor fields of application. Even traces of Lindane of the order of 1 ppb (one part in one billion (10^9 parts) corresponding to 1 mg in $1m^3$ of water or 1 metric ton of food, can be identified and measured by Gas chromatography coupled with mass spectrometry. In the case of drinking water, where EEC regulations impose levels of 0.1 ppb the sensitivity of methods of analysis is around 0.001 ppb.

It is difficult to visualise such low values. To make it clear, one ppb is equivalent to one minute in 2000 years, 40 kilometers compared to the length of the equator. When discussing traces or residues, one should keep these relationships in mind.

Lindane residues found in food are far below the maximum residue limits fixed by the official authorities, which are considered as levels not presenting any risk to humans. (ranging from 0.005 to 0.025 or 0.01 or 0.059 or maximum 0.206 ppm).

The acceptable daily intake value (a.d.i.) for humans fixed by the Food & Agricultural Organisation FAO, and the world health organisation(WHO) of the UN is 0.01 mg/kg/day.

The maximum dose which will not provike any observable effect in chronic toxicity tests in rats is 1.25 mg/kg/day. Thus the ingestion of less than 0.001 mg/kg/day gives a safety margin of more than 1 : 1250.

The FAO/WHO have fixed the maximum residue limit of lindane in milk at 0.01 mg/kg of milk corresponding to 0.25 mg/kg in milk fat. In Franch, the country with the highest lindane consumption in the world, the survey conducted between 1970 to 1977 demonstrated the average concentration of Lindane in milk to be 0.1 mg/kg of milk fat, and again in 1981, the lindane concentration was 0.03 mg/kg milk fat.

A human weighing 60 Kg and drinking 2 litres of standardized milk per day(i.e. milk containing 0.01 mg lindane/kg milk) would absorb only 0.02 mg of lindane i.e. 0.00033 mg/kg/day. This corresponds to 3.3% of the acceptable daily intake for humans (a.d.i.) and 3788 times lower than no effect level in rats.

The application of lindane does not present any risk for users working under normal condition of good agricultural practice(printed safety warnings, away from children etc.). A dose of 100 mg of lindane can be sustained by an adult in good health but doses of 600 to 1200 mg can be fatal in cases of oral administration.

Lindane has no influence on future generations. A low embryotoxicity has been observed in mice only at doses highly toxic to the dams (pregnant females).

Lindane is not carcinogenic in rats or mice. The chronic toxic no effect level (NOEL) in rats in above or equal to 1.25 mg/kg. The lindane also can be safely used without carcinogenic hazard to the consumer.

Lindane is one of the major insecticides used to control flies, bed bugs, chagas, bugs, lice, ticks, cockroaches, ants, earworms, sand flies, mosquitoes, and so forth.

Lindane is no explosives, not inflammable. Use any extinguishing agent. Avoid contact with skin, eyes, clothes from accidental spilling. Wear plastic or rubber gloves, glasses or a protective mask for face & boots. Avoid inhailing Lindane vapour and dust. Lindane should be considered toxic to skin, eyes, inhalation. Wash thoroughly with water & soap.