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Executive Committee of
the Multilateral Fund for the
Implementation of the Montreal Protocol

Thirteenth Meeting
Montreal, 25-27 July 1994

PROJECT PROPOSALS: EGYPT

This document includes the following project proposals and the Fund Secretariat's Comments and Recommendations:

- Phasing out ODS at the Refrigerator Plants of DELTA Industrial Co.;
- Phasing out ODS at the KIRIAZI Refrigerators Manufacturing Co.;
- Phasing out ODS at the Electrostar for Refrigeration Co.

PROJECT EVALUATION SHEET

COUNTRY OR REGION:		Egypt
PROJECT TITLE:		Phasing out ODS at the
	1)	Refrigerator Plants of Delta Industrial Co. (Delta)
	2)	Kiriazi Refrigerators Manufacturing Co. (Kiriazi)
	3)	Electrostar for Refrigeration Co. (Electrostar)

BUDGET:	Capital costs	
	Delta	US $1,774,674
	Kiriazi	US $1,192,356
	Electrostar	US $1,244,155
	Operational costs[1]	
	Delta	US $837,307
	Kiriazi	US $450,684
	Electrostar	US $206,430
INCREMENTAL COSTS:	Delta	US $2,581,981
	Kiriazi	US $1,643,040
	Electrostar	US $1,450,585
ODS PHASE-OUT:	Delta:	40 MT of CFC-11 & 57 MT of CFC-12
	Kiriazi:	101 MT of CFC-11 & 36 MT of CFC-12
	Electrostar:	30 MT of CFC-11 & 16 MT of CFC-12
COST EFFECTIVENESS[2]:	Delta:	US $26.93 per kg ODP saved
	Kiriazi:	US $11.99 per kg ODP saved
	Electrostar:	US $31.53 per kg ODP saved

PROJECT DURATION: 18 months for all the three companies

IMPLEMENTING AGENCY: UNIDO

NATIONAL COORDINATING AGENCY : Egyptian Environmental Affairs Agency (EEAA)

TECHNICAL REVIEW COMPLETED: YES _X_ NO _

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[1] Calculated for six months of operation.

[2] Determined as the ratio of incremental costs to the estimated annual saving of ODP ($\$/ODP_{Kg}$).

SECRETARIAT'S COMMENTS

1. Three projects are addressed together in these comments (See endnote 1 for a list of the projects).

2. Implementation of the three projects will result in an estimated annual phase-out of 171 MT of CFC-11 and 109 MT of CFC-12. It represents 32 per cent of the annual ODS consumption in the domestic refrigerator sector in Egypt.

3. The three projects were submitted for consideration of the Twelfth Meeting of the Executive Committee. The Executive Committee gave UNIDO permission to proceed. UNIDO has analyzed the incremental capital and operational costs with the Government of Egypt and with the enterprises in consultation with the Secretariat. The issues raised by the technical reviewer and the Secretariat regarding eligibility of costs of some equipment, possibility of modification of existing equipment, incremental operational costs were properly addressed.

4. The replacement alternatives chosen by the three companies are cyclopentane as foam blowing agent and HFC-134a as refrigerant. Projects include the redesign of all current refrigerator models and the conversion of the plants. The conversion of the production facilities at the three plants will cover the refrigeration system, insulating foam blowing system as well as the refrigeration service carried out by the three companies. Cyclopentane and HFC-134a technologies are ultimate conversion solutions. The three projects will be implemented within 18 months.

5. Refrigerator model redesign and the technical aspects of the conversion, including safety measures associated with cyclopentane application, will be supervised by a Chief Technical Advisor and specialized consultants appointed and fielded by UNIDO. A General Contractor will also be appointed by UNIDO for the implementation of the major project components (foaming system, refrigeration system, fire protection system, exhausting and ventilation system, on-the-job training, etc.). These arrangements would ensure a proper technology transfer and safe operations.

6. Incremental operational costs are associated with new HFC-134a compressor, refrigeration system optimization, higher cost of the refrigerant and extra polyurethane foam due to increased density. Incremental operational costs are calculated on the basis of average European price level for six months of operation. The companies accepted six month duration of operational costs. The Secretariat submitted a policy paper on the impact on the Fund of various operational cost durations in the domestic refrigeration sector. The operational cost durations will be an issue of discussion at the Thirteenth meeting of the Executive Committee.

7. Currently, in Egypt a new HFC-134a compressor plant is under construction by MCMC with the support of the MFMP. According to the rules of the MFMP, either the components manufacturing or the assembling company is eligible to receive incremental cost support, however, the new compressors from MCMC will not be available in time. Thus, the incremental cost of HFC-134a imported compressors at US $5 per piece is taken into account.

8. A new HFC-134a compressor could be made available from other sources of supply at a lower price. The Secretariat and UNIDO are of the opinion that incremental operating costs are likely to decrease during the coming two years and maybe sooner. The incremental operational costs will be incurred only after the full production of a new product is started, i.e. 18 months from the time funds are received.

9. For the refrigeration service, one-third of the requested evacuation and charging boards and leak detectors for HFC-134a is retained on the assumption that it will take a few years before the HFC-134a refrigerators will be available in sufficient number to warrant the requested number of service units.

SECRETARIAT'S RECOMMENDATIONS

10. The Fund Secretariat recommends approval of the three projects and approval of capital costs as follows:

US $1,774,674 for the Delta Industrial Co.
US $1,192,356 for the Kiriazi Refrigerators Manufacturing Co.
US $1,244,155 for the Electrostar for Refrigeration Co.

11. The approval of incremental operational costs at US $1,494,421 for three companies is contingent on a decision from the Executive Committee regarding the duration of operational costs.

12. UNIDO is requested to reassess the incremental operational costs on the basis of market prices prevailing at the time when actual costs are incurred. UNIDO is further requested to report back to the Executive Committee on the costs incurred. Agency overhead costs should be adjusted accordingly.

Endnote

EGYPT

Project	Installed Capacity Units/yr.	Actual Output Units/yr.	ODS Phase Out MT/yr.	Capital Costs (US$)	Operational Costs US $
Delta	420,000	207,814	97	1,774,674	837,307
Kiriazi	150,000	93,600	137	1,192,356	450,684
Electrostar	52,500	42,000	46	1,244,155	206,430
Total	622,500	343,414	280	4,211,185	1,494,421

PROJECT COVER SHEET

Country:	Egypt
Project Title:	Phasing out ODS at the ELECTROSTAR for REFRIGERATION Co., Egypt
Sectors Covered:	Domestic Refrigeration /Rigid Foam/Refrigerant
ODS Use in Sector (1990):	1,830 mt of CFC 11 and CFC 12
Project Impact :	Phase out of annual consumption of 30 mt CFC 11, 14 mt CFC 12 in the production and a gradual phase out of currently used 2 mt CFC 12 in the service sector (Total ODP = 46)
Project Duration:	18 months
Project Economic Life:	10 years
Total Project Cost:	US$ 1,574,672 (Total of capital cost and incremental operating cost for six month of operation)
Capital Cost:	US$ 1,337,278
Incremental Operating Cost:	US$ 237,395 (six month of operation)
Implementing Agency's Overheads (13%):	US$ 236,201
Proposed MF Financing:	US$ 1,810,873
Cost Effectiveness:	See Annex D: Unit Abatement Cost
Counterpart Enterprise:	ELECTROSTAR for REFRIGERATION Co. 6th of October City
Implementing Agency:	United Nations Industrial Development Organization (UNIDO)
Coordinating Ministry:	Egyptian Environmental Affairs Agency (EEAA)

PROJECT SUMMARY

This project will phase out 100 percent of the use of CFC 11 and CFC 12 for the production of refrigerators and freezers at ELECTROSTAR for REFRIGERATION Co. The chosen replacement alternatives are cyclopentane as foam blowing agent and HFC 134a as refrigerant. The project will include the redesign of all current refrigerator models and the conversion of the plants. The redesign of the existing refrigerator models covers activities like prototyping, testing, trial manufacturing and adaptation as well as reliability tests. The conversion of the production facilities covers the refrigeration system, insulating foam blowing system as well as the refrigeration service carried out by the company. The replacement alternatives and the time frame for phasing out the use of ODS will be in line with EEAA's ODS phase out programme.

I. BACKGROUND

A. Sector Background

The subsector for domestic refrigerators and freezers in Egypt consists of 9 manufacturers of which four to five companies are responsible for over 80 percent of the ODS consumption of CFC 11 and CFC 12.

Egypt does not produce any ODS. All ODS used in the country are directly imported by the users. In 1990 the total consumption was 1,830 mt of ODS.

The total installed production capacity for refrigerators and freezers is about 1,000,000 units per year, but the present production is only about 525,000 units per year. The manufacturers expect an increase of about 10 percent per year.

In total about 7,000,000 refrigerators and freezers are in use in Egypt of which about 10 percent per year will be serviced and a part of them recharged during refrigeration service with CFC 12. Because of lack of environmental awareness, know-how and equipment in the service sector, service staff very often use CFC 12 for washing/flushing of the cooling systems, instead of using vacuum pumps and charging boards. This causes up to 200 percent excess CFC 12 consumption in the service sector.

Currently no Egyptian company manufactures low energy refrigerators and freezers with an insulation thickness of 40 to 50 mm for refrigerators and 90 mm to 100 mm for freezers; however, the introduction of a limit for maximum energy consumption could be expected in the near future.

B. ELECTROSTAR's Background

ELECTROSTAR Refrigerators Manufacturing Co. (ELECTROSTAR), is a private company and one of the five largest manufacturers of domestic refrigerators and freezers. It employs 175 people and the installed annual production capacity is about 52,500 units. Between December 1992 and December 1993 the actual production was 42,000 units. ELECTROSTAR expects a 10 percent increase in the production for each of the next four years because of the introduction of 5 newly developed no-frost refrigerators as well as redesign of the current models.

In 1993 ELECTROSTAR used about 30 MT of CFC 11 and 14 MT of CFC 12 in the production process and 2 MT of CFC 12 in the refrigeration service.

Based on the installed capacity the budget for 1994 was made for 20,000 units of the 3 models fridge/freezers with two-doors, 15,000 units of the 3 models of refrigerators with one door, 10,000 units of 4 models of upright freezers, 13,000 units of 3 models of new no-frost fridge/freezer and freezers, 3,000 units of new defrost fridge/freezers as well as hotel absorption refrigerators, totalling to about 62,000 units.

ELECTROSTAR covers a share of about 8 to 10 percent of the local market; less than 2 percent of the units produced are being exported to Libya.

The technologies and know-how currently applied were imported from Zanussi/Italy, Electrolux/Sweden, Derby/Denmark and National/Japan.

ELECTROSTAR is currently running three separate production lines for foaming. This will be reduced to two lines in future. The company has no refrigerator design capabilities and no refrigeration performance test laboratory facilities. For this purpose, contacts have been established with NATIONAL/Japan to receive assistance in the redesign of refrigerators and in performance tests.

More detailed information on the current plant layout and the production equipment employed, as well as on the proposed new layout is shown in Annex H: "Current and Proposed New Plant Layout".

ELECTROSTAR has already recognized the need to be in compliance with the stipulations made in the Montreal Protocol and has agreed to participate in Egypt's ODS phase out programme.

II. PROJECT OBJECTIVE

The objective of this project is to eliminate the use of ODS such as CFC 11 and CFC 12 in the production of domestic refrigerators/freezers and in the refrigeration service at ELECTROSTAR through conversion to the use of HFC 134a as refrigerant for the cooling system and cyclopentane as blowing agent for the polyurethane insulation foam.

III. PROJECT DESCRIPTION

ELECTROSTAR is prepared to phase out ODS as soon as the new technologies have been acquired, the necessary machinery and equipment installed and the technical staff trained.

Among the technological options currently available on commercial basis and in line with the established policy of the Government of Egypt to phase out the use of ODS, ELECTROSTAR has chosen to replace CFC 12 by HFC 134a, because the new type compressors are available, and the technology is mature and commercially applied outside Egypt.

As blowing agent for polyurethane foam ELECTROSTAR decided to avoid the use of any transitional substance and to introduce as ultimate solution cyclopentane.

Through the project assistance will be provided in:

a) Procurement of new machinery and equipment;

b) Rebuilding of presently used machinery and equipment wherever technically and economically feasible;

c) Redesign, reconstruction, prototype manufacturing and testing of refrigerators/freezers;

d) Installation, commissioning, trial operation, start-up and on-the-job training;

e) Servicing.

The following machinery and equipment need to be rebuilt, replaced or added:

A. *Refrigeration System*

- The charging equipment and vacuum pumps must only be used for HFC 134a and in meeting the demand for cleaner and dryer cooling systems the existing charging equipment has to be replaced including the vacuum control.

- The charging boards have to be replaced by boards suitable for HFC 134a.

- Because the leak detectors react on Cl molecules, they need to be replaced.

- The currently used vacuum pumps, after being cleaned and connection hoses and gaskets being changed can also be used for HFC 134a.

- To optimize the cooling system for the application of HFC 134a and new specification for components used, performance tests for each model of refrigerator in an air-conditioned test room are needed. Therefore, a minimum specification of refrigeration test equipment needs to be provided (see Annex F: "Preliminary Specification of Refrigeration Test Equipment"). It is understood, that foam testing facilities cannot be financed by MFMP, as stated in the forthcoming para B: Foam System.

- To improve the performance of the cooling system and compensate for a little lower polyurethane insulation value due to the conversion to HFC 134a as the new refrigerant and cyclopentane for the foam, it is necessary to optimize the cooling system as well as the energy consumption to keep an acceptable TEWI value. Therefore, it is necessary to redesign, reconstruct and carry out performance tests for all redesigned models of refrigerators / freezers.

- The technical requirements for components such as tubes, condensers, evaporators, capillary tubes, heat exchangers and suction accumulators have to be in line with established standards, like DIN 8964, i.e. new rules for dryness and cleanliness need to be applied.

- The drier has to be equipped with 3 AA desiccant molecular sieves.

- The cooling system must not contain any chlorine and max. 1 % non-condensable gases.

- The capillary tube has to be optimized for an increased resistance at low evaporating temperatures.

- It will be necessary to train ELECTROSTAR's manufacturing and service technicians at the equipment suppliers' place in new foaming technology as well as in design/calculation and performance testing of cooling systems. During the installation and run-in of the new machinery and equipment the suppliers engineers will have to train ELECTROSTAR's technical staff.

B. *Foam System*

- In order to achieve an acceptable foam quality and insulation value at lowest price, high pressure foaming machines need to be introduced and ex-proofed. The polyol part of the machines have to be made explosion proof and encapsulated. It is also necessary to replace the stirrer in the polyol daily tank as well as the electrical components of the polyol part of the foaming machine.

  Adaptation of the currently used low pressure foaming machines for cyclopentane would require substantial modifications to be carried out at the machine supplier's premises. Apart from the substantial adaptation costs, a further burden would be the several weeks interruption of production for decommissioning, rebuilding, transportation and recommissioning of the machinery. Thus, the only economically viable solution is to replace the low pressure foaming machines with suitable high pressure ones.

  According to our information collected in Egypt, there is no domestic market for the second hand low pressure foaming machines, since not only the refrigerator plants, but also the foam manufacturers are replacing their low pressure foaming machines with high pressure machines. Thus, similarly to the previously approved by the MFMP foam sector projects the high pressure machines are budgeted at their full cost.

- Since cyclopentane and polyol cannot be delivered premixed in drums or tanks (like CFC 11 and polyol), it will be necessary to provide mixing stations.

- It is necessary to provide one tank for polyol, one for cyclopentane and one for isocyanate to automatically deliver the components to the mixing stations.

- For work safety when using the highly flammable and explosive cyclopentane and in order to meet the relevant requirements of the local authorities, it is recommended to have a gas detector system as well as a fire protection system installed in the foaming department.

- The provision and installation of an exhaust and ventilation system in the foaming department is necessary in order to achieve compliance with established safety rules for the machinery and the plant;

- All machinery and equipment which may come in contact with cyclopentane or the mix of polyol and cyclopentane must be encapsulated and explosion-proof;

- To make the foaming jigs explosion-proof, it is necessary to replace the electric heating elements by copper tubes in which hot water can circulate. (A cheaper option would be to automatically disconnect the existing electrical heating just before foam injection, using the control system of the foaming machine and a timer. For the sake of high operational safety it is, however, recommended to apply the water heater option.) ELECTROSTAR is ready to absorb 50% of the calculated costs of the modification of jigs and plugs. The foaming inner mould plugs have to be partially replaced/rebuilt using aluminium sheets to guarantee a constant temperature at the inner foam plug. The electric valves and microswitches to be used in connection with the foaming jigs need to be explosion-proof.

- All foaming jigs and plugs must be equipped with a good earth connection to avoid the appearance of static electricity.

- The workers's clothes and shoes have to be made of antistatic material and the floor needs to be covered with an antistatic paint.

- To keep control over the quality of the foam it is recommended to introduce a minimum specification of test equipment. Since currently no test equipment is being used by ELECTROSTAR it can, however, not be provided under this project.

C. *Refrigeration Service*

- ELECTROSTAR has about 370,000 refrigerators/freezers operating in Egypt. They are serviced mainly by the Company's 5 service centres. The amount of CFC 12 used by ELECTROSTAR for servicing/recharging is about 3 mt annually. It is estimated that through better service technologies 2/3 of the latter amount, i.e. about 2 mt could gradually be saved in future.

- For ELECTROSTAR's refrigeration service simple mobile recovery units for CFC 12 (one for each of the 15 service cars currently used, plus additional units to be exchanged with the Central Collection Station) will be provided in order to prevent venting of CFC 12 and to reuse it. (The recovery units consist of a metal or plastic case, filled with activated carbon to absorb the remaining CFC 12 from the system. The CFC 12 will later be recovered from the activated carbon at the Central Collection Station and sent for reclamation.)

- 15 new mobile evacuation and charging boards for HFC 134a as well as leak detectors for service will also be provided (one each for the service cars currently used).

- ELECTROSTAR's service personnel will be trained in using HFC 134a as well as in CFC 12 recovery and recycling.

D. *Justification for Selection of Alternative Technologies*

As new refrigerant for domestic refrigerators and freezers most of the major manufacturers of compressors have chosen HFC 134a as replacement for CFC 12. The same refrigerant was selected by the compressor company under construction in Egypt with the assistance of the MFMP. Thus, for the Egyptian manufacturers of refrigerators and freezers there is for the time being no other option commercially available.

As new blowing agent for the polyurethane foam the situation is quite different. Some manufacturers use:

HCFC 141b with ODP	=	0.11
HCFC 142b with ODP	=	0.065
HCFC 142b + HCFC 22 with ODP	=	0.06
HFC 134a with ODP	=	0
Cyclopentane with ODP	=	0

This means, that the use of HCFC 141b, HCFC 142b and HCFC 142b + HCFC 22 blend could only be accepted as transitional substance for a limited time.

Currently all major European manufacturers are carrying out tests or have already started using cyclopentane. Therefore, EEAA recommends that the Egyptian manufacturers should introduce an ultimate solution as blowing agent and should not use any transitional substances.

At present HFC 134a is also too expensive, so it is very unlikely that it may become the ultimate blowing agent for polyurethane foam.

IV. INPUTS

1. *Capital Goods Replacement*

The following equipment for ELECTROSTAR needs to be rebuilt, replaced, as well as new equipment to be provided as specified below:

A. Refrigeration System

a1.	3 pcs.	HFC 134a charging boards with vacuum pump, leak check as well as refrigerant supply pump;
a2.	3 pcs.	HFC 134a leak detectors;
a3.	1 set	HFC 134a test equipment (minimum specification as for temperature, humidity, voltage regulation systems, as well as for measuring of temperature, pressure, voltage, current, energy consumption and to be added to the existing test equipment);
a4.	5 pcs.	existing vacuum pumps cleaned/renovated.

B. Foam System

b1.	2 pcs.	High pressure foaming machines with two heads (ex-proofed for use of cyclopentane);
b2.	2 pcs.	mixing station for cyclopentane and polyol with daily tank;
b3.	1 set	water heater system for foaming jigs/plugs;
b4.	1 set	gas detector system;
b5.	1 set	exhaust and ventilation system;
b6.	7 sets	foaming jigs (to be rebuilt); *ELECTROSTAR is willing to share 50% of costs of modification*
b7.	11 sets	foaming plugs (to be rebuilt); *ELECTROSTAR is willing to share 50% of costs of modification*
b8.		floor cover (antistatic);
b9.	2 sets	pipe installation (ex-proof) from mixers to foaming machines;
b10.	1 pc	tank for cyclopentane with pumps and pipe work;
b11.	1 set	fire protection system;
b12.	1 set	pumps and pipework from tank to mixers;
b13.	1 pc	water chiller for foaming machines.

C. Refrigeration Service

c1. 15 pcs. HFC 134a mobile evacuation and charging boards;

c2. 25 pcs. simple CFC 12 recovery units;

c3. 15 pcs. leak detectors for HFC 134a.

2. *Conversion/Training*

Within the framework of this project, technicians from ELECTROSTAR will be trained in (among others) the following areas:

- redesign and reconstruction of refrigerators and freezers;
- management and production control;
- quality control in relation to conversion;
- operation of the new machinery and equipment;
- maintenance of the new machinery and equipment;
- refrigeration laboratory tests;
- new technologies for foam and refrigerant;
- specifications for materials;
- safety regulations for flammable/explosive chemicals;
- refrigeration service.

3. *Model Redesign*

It is foreseen, that for all models redesign and reconstruction are required, followed by the manufacture of some prototypes and refrigeration performance tests. The model redesign will be carried out by ELECTROSTAR's staff under the supervision of the Chief Technical Advisor and specialized international consultants for this project.

As a common practice, modifications of the production lines will be carried out during evenings and off-days and, therefore, it will not cause any costs under this project.

V. PROJECT IMPLEMENTATION

The project implementation will be carried out by UNIDO in close cooperation with ELECTROSTAR. Necessary local coordination will be done by EEAA.

Purchase of know-how is not considered in the project budget. However, to substantively assist and supervise the technical aspects of the conversion process, to perform troubleshooting and to provide assistance in product redesign work a Chief Technical Advisor and specialized consultants will be appointed and fielded by UNIDO. The respective job descriptions will be prepared upon approval of the project.

After competitive bidding, performed according to UNIDO's rules and procedures, a General Contractor will be appointed by UNIDO for the implementation of the major project components (foaming system, refrigeration system, fire protection system, exhausting and ventilation system, etc.). The General Contractor will be responsible for the supply of equipment, installation, commissioning and on-the-job training of ELECTROSTAR's staff. The detailed Terms of Reference for the services to be provided by the General Contractor will be elaborated after project approval.

In order to guarantee a proper technology transfer and safe operation - in particular of the new foaming technology, using the highly flammable and explosive cyclopentane - the proposed General Contractor will issue an "Operational Safety Statement"[1].

The final equipment specification, the work plan and, consequently the Operational Safety Statement can only be elaborated after approval of the basic approach for project implementation by the MFMP.

The permission from the local authorities for the introduction of the new technologies under this project will have to be obtained by ELECTROSTAR. ELECTROSTAR will also be responsible for the compliance of the new technologies with established national standards.

Having accepted the conversion of its plants to the use of non-ODS under this project, ELECTROSTAR will be committed to provide the following inputs:

- All activities and costs related to the construction work needed (including the provision of technical infrastructure) to accommodate the new technologies introduced under this project. (The relevant construction work will have to be arranged by ELECTROSTAR under the supervision of the General Contractor and in line with the established milestones for this project. The costs for construction work are, therefore, not reflected in the project budget. The specification for construction work needed will be elaborated by the General Contractor after project approval and necessary site inspection.);

- Technical staff as required by the General Contractor;

- Provision of tools, transportation and lifting equipment as required;

[1] For negotiations to act as General Contractor, UNIDO has already established contacts with Messrs. POLYFA Trading A.S., DK-2650 Copenhagen-Hvidrove, Denmark.

- Local transport, communication and secretarial facilities for the General Contractor's and UNIDO's staff involved in the project's implementation.

UNIDO as Implementing Agency has the necessary experience and capabilities for the successful implementation of projects at enterprise level. Upon approval of the project by the MFMP the project's budget will be transferred to UNIDO. The respective project allotment document will then be issued by UNIDO's Finance Section. Any substantive or financial deviation from the approved project is subject to approval by the MFMP and UNIDO.

For the project implementation, milestones are set in Annex E.

VI. PROJECT COSTS

I. INCREMENTAL OPERATING COSTS

The currently produced models will require the following modifications, based on an average European price level:

Modification	Incremental Cost (US$)
HFC 134a compressor	5.00
Capillary tube	0.20
Evaporator/Condenser	1.70
Drier 3 AA	0.03
HFC 134a refrigerant	1.53
Cyclopentane	-0.75
Extra polyurethane foam	2.12
Total	**9.83** [2)]

The above mentioned prices are showing the difference between the component prices for CFC 11 and CFC 12 versus component prices for HFC 134a and cyclopentane.

The price increase will be caused by:

- 8 % to 10 % compressor price increase for the new HFC 134a compressor and plus about 10 % for a one size bigger compressor (to cope with the lower capacity at low evaporating temperature, but no heavy duty compressor, coping with significant

[2)] The above calculation includes the incremental costs for the HFC 134a compressor to be used. Currently, in Egypt a new HFC 134a compressor plant is under construction by MCMC with the support of the MFMP. According to the rules of the MFMP, either the components manufacturing or the assembling company is eligible to receive incremental cost support, however the new compressors from MCMC will not be available in time. Thus, the incremental cost of HFC 134a compressors at US$ 5 per piece is taken into account.

voltage fluctuations), totalling to an average of about US$ 5.0 per compressor, (see footnotes [2)] above);

- capillary tube average 1 m longer;

- evaporator/condenser 2 m longer;

- HFC 134a filling average about 10 % less compared with CFC 12 resulting in an incremental cost of US$ 1.53 per unit:

Refrigerant	Filling average/unit, kg	Price, US$	Cost, US$/unit	Incremental cost, US$/unit
CFC 12	0.35	1.88	0.66	
HFC 134a	0.31	7.07	2.19	1.53

- cyclopentane at US$ 1.55/kg will be used in a lower quantity as CFC 11 at US$ 1.80/kg, saving is US$ 0.75/unit:

Blowing agent	Blowing agent average per unit, kg	Price, US$	Cost, US$/unit	Saving, US$/unit
CFC 11	0.86	1.83	1.57	
C-pentane	0.52	1.57	0.82	0.75

- for polyurethane foaming at least 15 % more of the complete mix needs to be charged due to the higher foam density in the initial test period of about 1 year of foam production using cyclopentane (see also Annex G: "Technical Information Sheet of BASF"). The resulting incremental cost is US$ 2.12/unit:

Blowing agent	Foam average/unit, kg	Price, US$	Cost, US$/unit	Incremental cost, US$/unit
CFC 11	6.0	2.35	14.10	
C-pentane	6.9	2.35	16.22	2.12

- the currently used innerliner material is HIPS, type KR 2710 from BASF. According to our latest information this material could be used with cyclopentane blown foams as well. Thus, incremental cost is not calculated.

Based on above calculations, the total incremental operating costs for ELECTROSTAR the incremental operating costs are calculated for 42,000 units at US$ 9.83 and will be for one year of operation:

US$ 412,860

For six months of operation the total incremental operating cost will be as follows:

US$ 412,860 x 0.5 = US$ 206,430

Costs for transport and insurance of capital goods are included in the budgeted allocations for the respective items.

Costs for equipment installation, commissioning and on-the-job training of ELECTROSTAR's staff are calculated separately.

II. CONTINGENCY FUND

A contingency fund (15 percent of the total project budget) was calculated. The MFMP is proposed to cover unforeseen expenses which might be incurred during the project implementation, e.g. purchase of small testing instruments, which might be required during the conversion process, miscellaneous expenses, price escalation, etc.

III. TOTAL COSTS

- Investment costs will cover capital investment costs (at CIF basis) for modification of manufacturing facilities, materials, new machinery, testing equipment (see Annex A: "Equipment Specification and Cost Breakdown"), training, installation and consultancy services for modifications (see Annex B: "Labour Cost of Subcontractor's Services" and Annex C: "Project Budget").
- The incremental operating costs associated with this project are as above.
- Implementing Agency's overhead costs are 13 percent.
- For the complete costs breakdown see Annex C: "Project Budget".
- For the calculation of the unit abatement cost see Annex D: "Unit Abatement Cost".
- Requested funding by the MFMP: US$ 1,810,873

Annex A: Equipment Specification and Cost Breakdown

	Quantity	Unit cost, US$	Total cost, US$
Refrigeration system			
Charging boards for production	3	31,300	93,900
Cleaning and renov. of vacuum pumps	5	160	800
HFC 134a leak detectors	3	9,000	27,000
Test equipment	1	50,000	50,000
R12 collection station	1	2,500	2,500
Foaming system			
High pressure foaming machine, cabinets	1	160,000	160,000
High pressure foaming machine, doors	1	110,000	110,000
Mixing station	2	80,000	160,000
Water heater system	1	40,000	40,000
Gas detecting system	1	75,000	75,000
Exhaust and ventilation	1	45,000	45,000
Foaming jigs, rebuild. (50% cost sharing)	7	14,000	49,000
Foaming plugs, rebuild. (50% cost sharing)	11	5,000	27,500
Antistatic floor			3,000
Pipe installation for 2 machines	2	15,000	30,000
Cyclopentane tanks, pumps, piping	1	33,000	33,000
Fire protection system	1	30,000	30,000
Pumps and pipes from tank to mixer	1	45,000	45,000
Water chiller	1	11,000	11,000
Refrigeration service			
Evacuation and charging board	15	3,000	45,000
CFC 12 recovery unit for service cars	25	30	750
Leak detector for HFC 134a	15	160	2,400
Total			1,040,850

Annex B: Labour Cost of Subcontractor's Services

Title	Unit	Qty.	Unit cost, US$	Total cost, US$
A. Refrigeration system				
(1 supervisor for 2 weeks)				
Air ticket, Europe - Cairo	pc.	1	2,000	2,000
Expert fee	days	14	550	7,700
Daily subsistence allowance	days	14	130	1,820
Subtotal				11,520
B. Foam system				
(2 supervisors for 3 weeks each, 1 engineer for 1 week)				
Air ticket, Europe - Cairo	pc.	3	2,000	6,000
Expert fee	days	42	550	23,100
Engineer fee	days	7	750	5,250
Daily subsistence allowance	days	49	130	6,370
Local subcontract (piping, installation)				10,800
Subtotal				51,520
C. Refrigeration service				
(1 supervisor for 1 week)				
Air ticket, Europe - Cairo	pc.	1	2,000	2,000
Expert fee	days	7	550	3,850
Daily subsistence allowance	days	7	130	910
Subtotal				6,760
TOTAL				**69,800**

Annex C: Project Budget

Budget line		Duration, work months	Cost, US$
11-01	Chief technical advisor	1.0	13,000
11-50	International Consultants	2.0	25,000
21-01	Subcontract		1,110,650
32-01	Study tour on foaming technology, 2 technicians	0.5	8,000
32-01	Study tour on refrigeration technology, 1 technician	0.5	6,200
51-00	Miscellaneous:		
	15% contingency fund on capital cost		174,428
	Incremental operating cost		206,430
	15% contingency fund on operating cost		30,965
	Total miscellaneous cost		411,822
99-99	Subtotal		1,574,672
Implementing Agency Overhead, 13%			236,201
PROJECT TOTAL			1,810,873

Annex D: Calculation of Unit Abatement Cost

A	*ODS Phase out*	*Unit*	*Total Project*
A1	Average use of CFC 11 per year	mt	30
A2	ODP of CFC 11		1
A3	ODP-weighted CFC 11 phase out (A1*A2)	mt	30
A4	Average use of CFC 12 per year	mt	16
A5	ODP of CFC 12		1
A6	ODP-weighted CFC 12 phase out (A4*A5)	mt	16
A7	Total ODP weighted phase out (A3+A6)	mt	46
B	*Annualized capital cost*	*Unit*	*Total Project*
B1	Total investment cost		
	(model redefinition + production conversion)	US$	1,337,278
B2	Equipment life	year	10
B3	Discount rate	%	10
B4	Annualized capital cost (B1*0.1627)	US$	217,575
C	*Annual incremental operating cost*	US$	237,395
D	*Unit abatement cost*	*Unit*	*Total Project*
D1	Annualized capital cost per kg ODS phased out (B4/A7/1000)	US$/kg	4.73
D2	Annual incremental operating cost per kg ODS phased out (C/A7/1000)	US$/kg	5.16
D3	Unit abatement cost (D1+D2)	US$/kg	9.89

Annex E. Implementation Schedule

MILESTONES / MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Sign the project, receive funding	■																	
2. Appointment of General Contractor, site inspection		■																
3. Elaboration of a detailed project workplan		■																
4. Draft of plant layouts		■																
FOAM																		
5. Selection of equipment, bidding		■	■	■														
6. Training							■				■							
7. Rebuild jigs + plugs				■	■	■	■	■	■	■	■							
8. Purchase, installation, commissioning				■	■	■	■	■	■	■	■							
9. Prototyping and testing											■	■						
10. Start production with cyclopentane												■	■	■	■	■	■	■
REFRIGERANT																		
11. Redesign of models, training		■	■	■														
12. Selection of equipment, bidding		■	■															
13. Purchase, installation and commissioning			■	■	■	■	■	■	■									
14. Prototyping and testing							■	■	■	■	■	■	■	■	■	■		
15. Start production with HFC 134a											■	■	■	■	■	■	■	■

MILESTONES / MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
REFRIGERATION SERVICE																		
16. Selection of equipment, bidding																		
17. Purchase and training																		

It is estimated that after 18 months the complete conversion will have been carried out.

Annex F: Preliminary Specification of Refrigeration Test Equipment

A. *To be supplied by the company:*

1 pc. Thermoinsulated test room: W x L x H: 2,500 x 3,000 x 2,800 mm, walls consisting of min. 80 mm thick polyurethane insulated panels covered with 0.6 mm electrogalvanized PVC coated steel plates.

B. *To be financed by MFMP:*

3 pcs. fan motors (ventilators)
2 pcs. heating elements
1 pc. cooling element
1 pc. ice-bank cooling system, complete
1 pc. electronic thermostat
1 pc. voltage stabiliser
1 set fluorescent light and plugs for test room
1 set terminal box for test room for connection of electricity, pressure and temperature
1 pc. terminal box outside test room for regulation equipment
2 pcs. amp. (current) converters
2 pcs. power converters
2 pcs. pressure converters
1 pc. 5 volt DC converter
1 pc. 24 volt DC converter
2 pcs. S-system/thermostat converter
1 pc. current transformer + cables, etc.
2 pcs. input card STBTC for measuring temperatures
1 pc. software Labtech notebook for analyzing signals
1 pc. A/D card RTI 820 for PC
1 pc. Hard disk colour system/PC
1 pc. matrix printer colour system
1 pc. overhead operator control panel
1 pc. Vario transformer
1 pc. frequency meter, digital
1 pc. voltage meter, digital
1 pc. thermometer, digital
1 pc. temperature regulator
1 pc. amperemeter
1 pc. HFI protection relay
1 pc. regulator for fan motors
1 pc. current transformer
1 set relay, cables, clamps etc.

350 kg tylose test packages 200 x 100 x 50 mm
150 kg tylose test packages 100 x 100 x 50 mm
50 kg tylose test packages with thermocouples, 200 x 100 x 50 mm
50 kg tylose test packages with thermocouples 100 x 100 x 50 mm
1,000 m Cu-Constantan thermocouples
2 pcs. Pressure transducers
1 set Software for testing according to ISO 5155.2

Rigid polyurethane foam for refrigeration with cyclopentane as blowing agent

Table 2

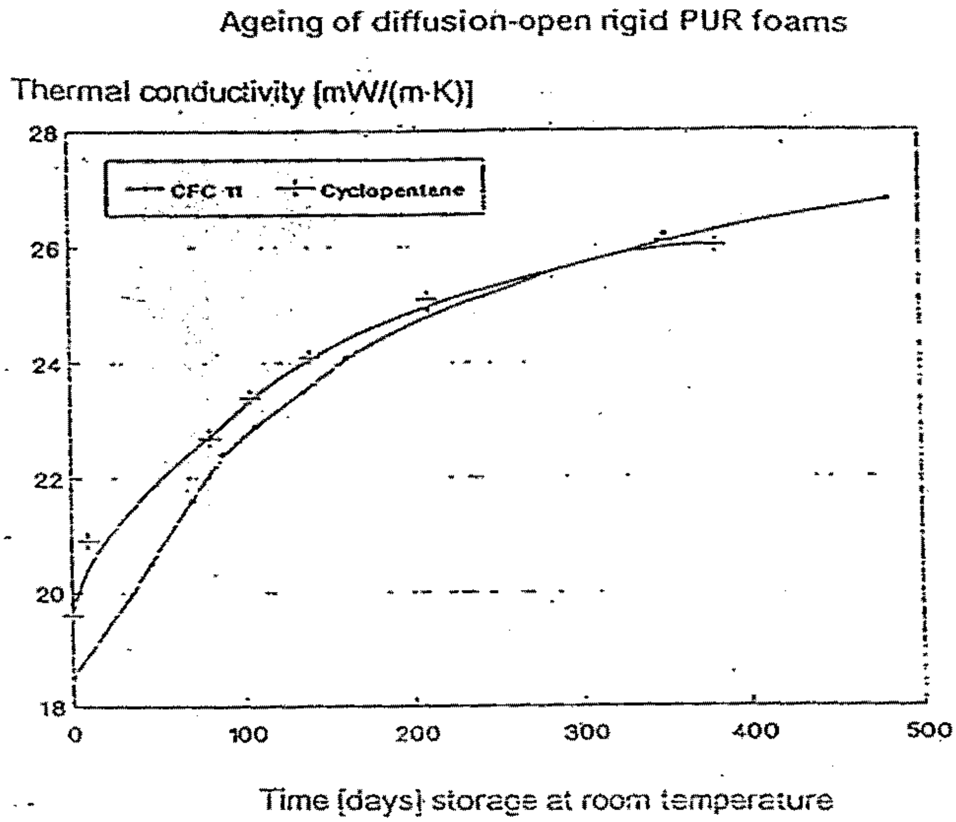
Properties of rigid PUR foam with cyclopentane as blowing agent

Blowing agent		Cyclo-pentane	n-Pen-tane	CFC 11
Polyol	[parts]	100	100	100
Blowing agent	[parts]	11	11	18
Isocyanate	[parts]	138	138	155
Molding density	[g/l]	39	39	34
Thermal conductivity* (initial K-value)	[relative %]	106	121	100
	[mW/m·K]	(18)	(20.5)	(17)
Compressive strength	[kPa]	140	140	120
Dimensional stability				
-30°C	[%]	<0.5	<0.5	<0.5
+80°C	[%]	<1.0	<1.0	<1.0

* Hesto lambda-control A 50-B single-plate instrument, mean temperature 23°C

Rigid polyurethane foam for refrigeration with cyclopentane as blowing agent

Figure 1



Note

The data in this publication are based on our current knowledge and experience. Due to the variety of possible effects during processing and use of our products, they do not free the processor from carrying out his own tests and trials. Our data must not be used to derive a legally binding assurance of certain properties or suitability for a particular application. Any protective rights and existing laws and regulations must be observed by the consignee of our products at his own responsibility.

BASF Aktiengesellschaft
D-6700 Ludwigshafen

Edition 08/93

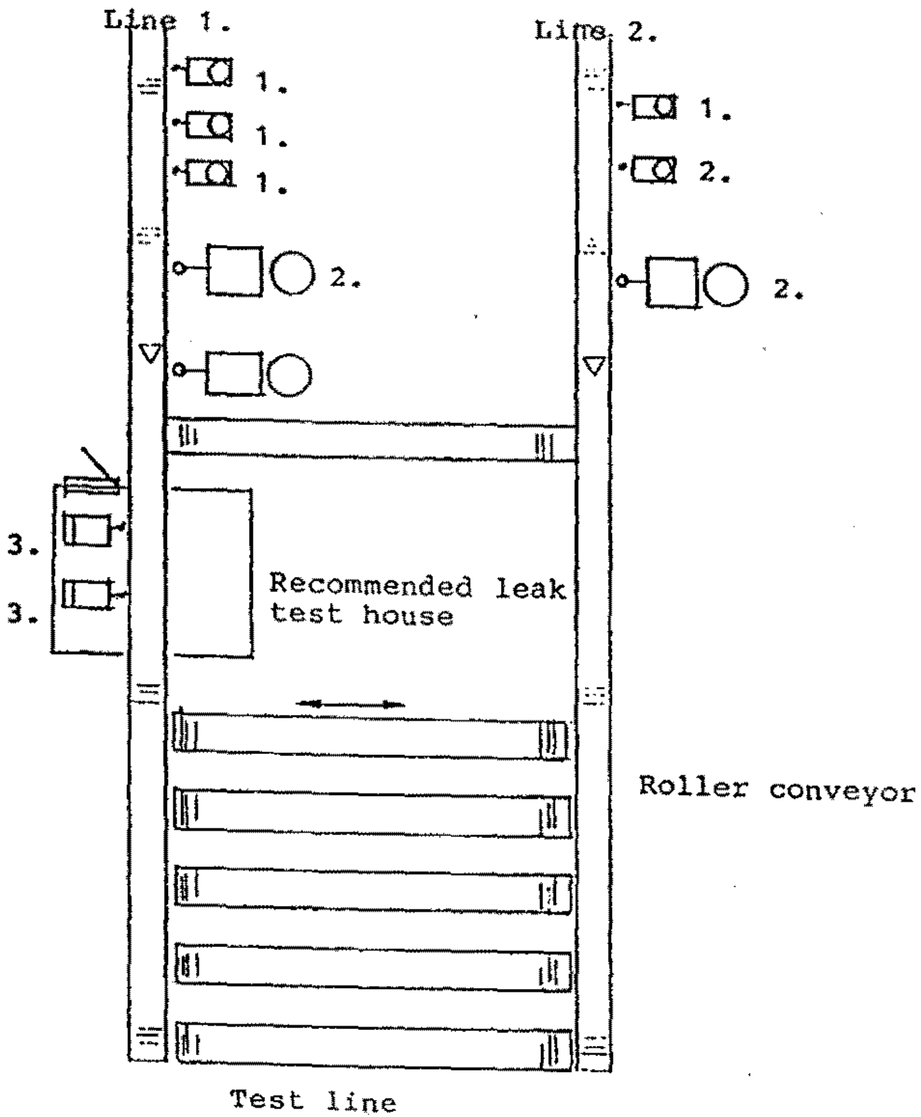
BASF

Polyurethane

Annex H/1 :Current and proposed new plant layout

Electrostar For Refrigeration Co. (ELECTROSTAR)

Refrigeration Lines.

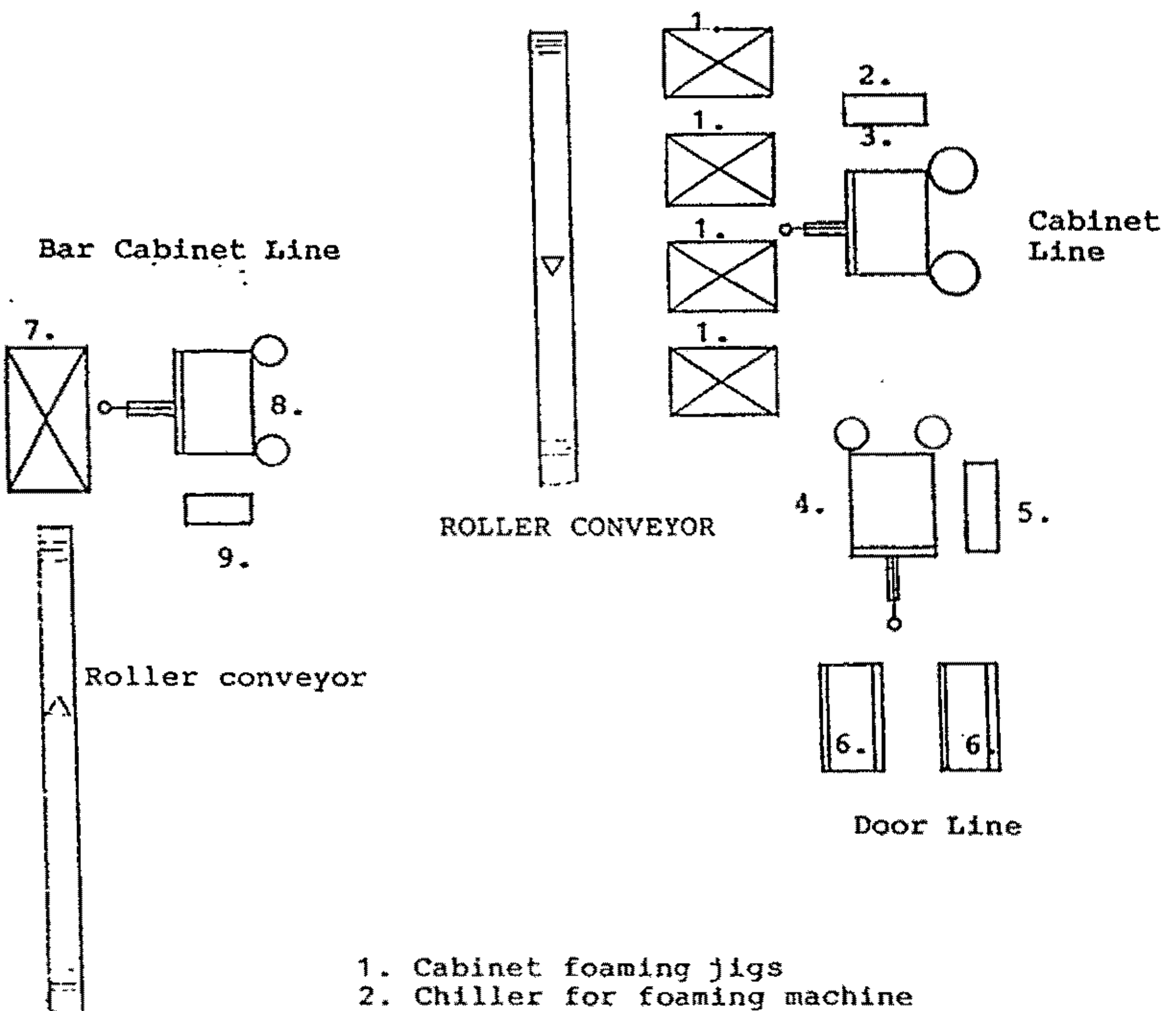


1. Vacuum pump
2. Charging board
3. Leak Detector

ANNEX H/2 : CURRENT AND PROPOSED NEW PLANT LAYOUT

Electrostar For Refrigeration Co. (ELECTROSTAR)

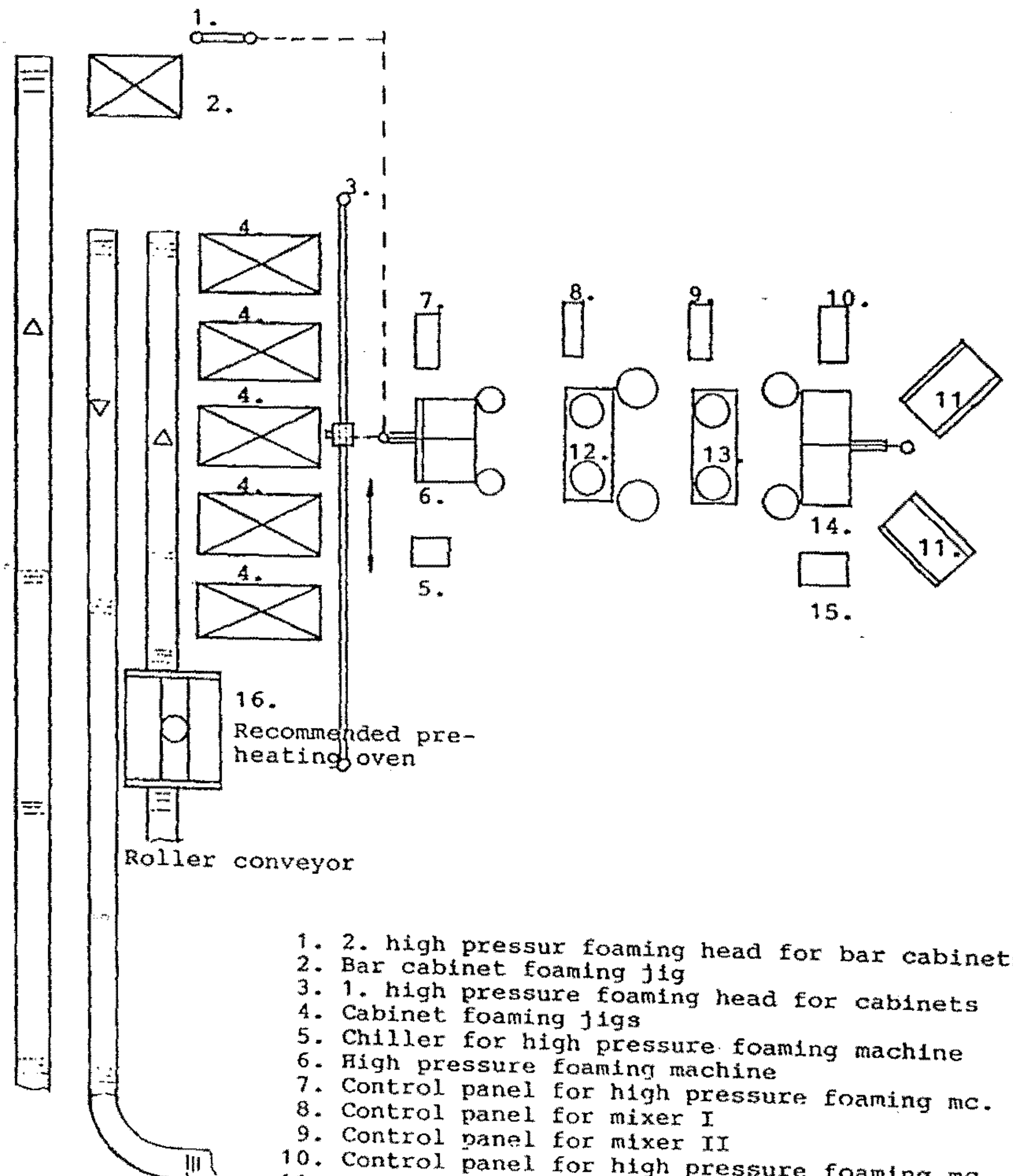
Foaming Lines



1. Cabinet foaming jigs
2. Chiller for foaming machine
3. Low pressure foaming machine
4. Low pressure foaming machine
5. Chiller for foaming machine
6. Door foaming jigs
7. Bar cabinet foaming jig
8. Low pressure foaming machine
9. Chiller for foaming machine

Annex II/3: Current and proposed new plant layout

Electrostar For Refrigeration Co. (ELECTROSTAR)



1. 2. high pressur foaming head for bar cabinets
2. Bar cabinet foaming jig
3. 1. high pressure foaming head for cabinets
4. Cabinet foaming jigs
5. Chiller for high pressure foaming machine
6. High pressure foaming machine
7. Control panel for high pressure foaming mc.
8. Control panel for mixer I
9. Control panel for mixer II
10. Control panel for high pressure foaming mc.
11. Door foaming jigs
12. Mixer for polyol and cyclopentane I
13. Mixer for polyol and cyclopentane II
14. High pressure foaming machine for doors
15. Chiller for high pressure foaming mc.

PROJECT COVER SHEET

Country:	Egypt
Project Title:	**Phasing out ODS at the Refrigerator Plants of DELTA INDUSTRIAL Co., Egypt**
Sectors Covered:	Domestic Refrigeration /Rigid Foam/Refrigerant
ODS Use in Sector (1990):	1,830 mt of CFC 11 and CFC 12
Project Impact :	Phase out of annual consumption of 40 mt CFC 11, 50 mt CFC 12 in the production and a gradual phase out of currently used 7 mt CFC 12 in the service sector (Total ODP = 97)
Project Duration:	18 months
Project Economic Life:	10 years
Total Project Cost:	US$ 2,905,460 (Total of capital cost and incremental operating cost for six month of operation)
Capital Cost:	US$ 1,942,557
Incremental Operating Cost:	US$ 962,903 (six month of operation)
Implementing Agency's Overheads (13%):	US$ 435,819
Proposed MF Financing:	US$ 3,341,279
Cost Effectiveness:	See Annex D: Unit Abatement Cost
Counterpart Enterprise:	DELTA INDUSTRIAL CO.; plants at ALMAZA and NASR CITY, Cairo
Implementing Agency:	United Nations Industrial Development Organization (UNIDO)
Coordinating Ministry:	Egyptian Environmental Affairs Agency (EEAA)

PROJECT SUMMARY

This project will phase out 100 percent of the use of CFC 11 and CFC 12 for the production of refrigerators and freezers at DELTA INDUSTRIAL CO.'s plants ALMAZA and NASR CITY, Cairo. The chosen replacement alternatives are cyclopentane as foam blowing agent and HFC 134a as refrigerant. The project will include the redesign of all current refrigerator models and the conversion of the plants. The redesign of the existing refrigerator models covers activities like prototyping, testing, trial manufacturing and adaptation as well as reliability tests. The conversion of the production facilities covers the refrigeration system, insulating foam blowing system as well as the refrigeration service carried out by the company. The replacement alternatives and the time frame for phasing out the use of ODS will be in line with EEAA's ODS phase out programme.

I. BACKGROUND

A. Sector Background

The subsector for domestic refrigerators and freezers in Egypt consists of 9 manufacturers of which four to five companies are responsible for over 80 percent of the ODS consumption of CFC 11 and CFC 12.

Egypt does not produce any ODS. All ODS used in the country are directly imported by the users. In 1990 the total consumption was 1.830 mt of ODS.

The total installed production capacity for refrigerators and freezers is about 1,000,000 units per year, but the present production is only about 525,000 units per year. The manufacturers expect an increase of about 10 percent per year.

In total about 7,000,000 refrigerators and freezers are in use in Egypt of which about 10 percent per year will be serviced and a part of them recharged during refrigeration service with CFC 12. Because of lack of environmental awareness, know-how and equipment in the service sector, service staff very often use CFC 12 for washing/flushing of the cooling systems, instead of using vacuum pumps and charging boards. This causes up to 200 percent excess CFC 12 consumption in the service sector.

Currently no Egyptian company manufactures low energy refrigerators and freezers with an insulation thickness of 40 to 50 mm for refrigerators and 90 mm to 100 mm for freezers; however, the introduction of a limit for maximum energy consumption could be expected in the near future.

B. Delta's Background

DELTA INDUSTRIAL Co. (DELTA) is a public company and the largest manufacturer of refrigerators in Egypt. It employs more than 1,000 staff and the installed annual production capacity is about 420,000 units in one shift. From September 1992 to September 1993 the actual production was 207,814 units. DELTA expects a 5 - 10 percent increase in the production for each of the next four years because of a low price policy.

DELTA is using the brand name "IDEAL" and is running two factories, one called ALMAZA and another, called NASR CITY.

For the insulation of the refrigerators produced by ALMAZA polyurethane "plates" supplied from another company are being used. No change of this cheap, but very energy inefficient insulation technology is planned for the time being. (It has, however, been estimated that through a better capacity utilization of the existing high pressure foaming machines at NASR CITY plant all cabinets could be foamed for ALMAZA plant.)

In 1992 DELTA used 40 mt of CFC 11 and 50 mt of CFC 12 for the manufacturing process and 7 mt of CFC 12 for the refrigeration service.

DELTA is currently manufacturing 2 models of two-door fridge/freezers and 3 models of single-door refrigerators. The main products are 9 and 10 cu ft single-door refrigerators, of which currently 125,000 units are being manufactured annually.

DELTA covers a share of about 50 percent of the local market and exports less than 2 percent (to Libya, earlier also to Russia and Rumania).

DELTA has imported the currently applied technologies and know-how from Bosch/Germany as well as from other European manufacturers.

The insulation thickness of the refrigerators produced at NASR CITY plant is 35/55 mm and 68 mm for the freezer section.

More detailed information on the current plant layouts and the production equipment employed, as well as on the proposed new plant layouts is shown in Annex H: "Current and Proposed New Plant Layouts".

DELTA has already recognized the need to be in compliance with the stipulations made in the Montreal Protocol and has agreed to participate in Egypt's ODS phase out programme.

II. PROJECT OBJECTIVE

The objective of this project is to eliminate the use of ODS such as CFC 11 and CFC 12 in the production of domestic refrigerators and in the refrigeration service at DELTA through conversion to the use of HFC 134a as refrigerant for the cooling system and cyclopentane as blowing agent for the polyurethane insulation foam.

III. PROJECT DESCRIPTION

DELTA is prepared to phase out ODS as soon as the new technologies have been acquired, the necessary machinery and equipment installed and the technical staff trained.

DELTA has accepted to replace CFC 12 with HFC 134a because the new type of compressors are available and the technology is mature and commercially applied outside Egypt.

Initially, DELTA considered to start in 1994 on their own initiative with 50% CFC - reduced foam. Now, DELTA decided to avoid the application of any transitional substance and to introduce as an ultimate solution cyclopentane as blowing agent for polyurethane foam.

Through the project assistance will be provided in:

a) Procurement of new machinery and equipment;

b) Rebuilding of presently used machinery and equipment wherever technically and economically feasible;

c) Redesign, reconstruction, prototype manufacturing and testing of refrigerators/freezers;

d) Installation, commissioning, trial operation, start-up and on-the-job training;

e) Servicing.

The following machinery and equipment need to be rebuilt, replaced or added:

A. *Refrigeration System*

- The charging equipment and vacuum pumps must only be used for HFC 134a and in meeting the demand for cleaner and dryer cooling systems the existing charging equipment has to be replaced including the vacuum control.

- The charging boards have to be replaced by boards suitable for HFC 134a.

- Because the leak detectors react on Cl molecules, they need to be replaced.

- The currently used vacuum pumps, after being cleaned and connection hoses and gaskets being changed can also be used for HFC 134a.

- To optimize the cooling system for the application of HFC 134a and new specification for components used, performance tests for each model of refrigerator in an air-conditioned test room are needed. Therefore, a minimum specification of refrigeration test equipment needs to be provided (see Annex F: Preliminary Specification of Refrigeration Test Equipment). It is understood, that foam testing facilities cannot be financed by MFMP, as stated in the forthcoming para B: Foam System.

- To improve the performance of the cooling system and compensate for a little lower polyurethane insulation value due to the conversion to HFC 134a as the new refrigerant and cyclopentane for the foam, it is necessary to optimize the cooling system as well as the energy consumption to keep an acceptable TEWI value. Therefore, it is necessary to redesign, reconstruct and carry out performance tests for all redesigned models of refrigerators / freezers.

- The technical requirements for components such as tubes, condensers, evaporators, capillary tubes, heat exchangers and suction accumulators have to be in line with established standards, like DIN 8964, i.e. new rules for dryness and cleanliness need to be applied.

- The drier has to be equipped with 3 AA desiccant molecular sieves.

- The cooling system must not contain any chlorine and max. 1 percent non-condensable gases.

- The capillary tube has to be optimized for an increased resistance at low evaporating temperatures.

- It will be necessary to train DELTA's manufacturing and service technicians at the equipment suppliers' place in new foaming technology as well as in design/calculation and performance testing of cooling systems. During the installation and run-in of the new machinery and equipment the suppliers engineers will have to train DELTA's technical staff.

B. *Foam System*

- To adapt the currently used high pressure foaming machines for cyclopentane, the polyol part of the machines have to be made explosion proof and encapsulated. It is also necessary to replace the stirrer in the polyol daily tank as well as the electrical components of the polyol part of the foaming machine.

- Since cyclopentane and polyol cannot be delivered premixed in drums or tanks (like CFC 11 and polyol), and following the current and the proposed new plant layout (NASR CITY plant), it will be necessary to provide two mixing stations to serve one foaming machine each for cabinets and one mixing station for the two foaming machines for doors.

- It is necessary to provide one tank for cyclopentane and adapt the existing tanks for the other components to automatically deliver the components to the mixing stations.

- For work safety when using the highly flammable and explosive cyclopentane and in order to meet the relevant requirements of the local authorities, it is recommended to have a gas detector system as well as a fire protection system installed in the foaming department.

- The provision and installation of an exhaust and ventilation system in the foaming department is necessary in order to achieve compliance with established safety rules for the machinery and the plant;

- All machinery and equipment which may come in contact with cyclopentane or the mix of polyol and cyclopentane must be encapsulated and explosion-proof;

- To make the foaming jigs explosion-proof, it is necessary to replace the electric heating elements by copper tubes in which hot water can circulate. (A cheaper option would be to automatically disconnect the existing electrical heating just before foam injection, using the control system of the foaming machine and a timer. For the sake of high operational safety it is, however, recommended to apply the water heater option.) The electric valves and microswitches to be used in connection with the foaming jigs need to be explosion-proof.

- All foaming jigs and plugs must be equipped with a good earth connection to avoid the appearance of static electricity.

- The workers's clothes and shoes have to be made of antistatic material and the floor needs to be covered with an antistatic paint.

- To keep control over the quality of the foam it is recommended to introduce a minimum specification of test equipment. Since currently no test equipment is being used by DELTA it can, however, not be provided under this project.

C. *Refrigeration Service*

- DELTA serviced in 1992 about 158,000 refrigerators and freezers. Out of them about 12,000 were recharged, using 0.6 kg CFC 12 each, totalling to 7.2 mt. In the same period about 4,505 compressors were changed, using also about 0.6 kg each, totalling to 2.7 mt. The total quantity of CFC 12 used was about 9.9 mt. It is estimated that through better service technologies 2/3 of the latter amount, i.e. about 7 mt could gradually be saved in future.

- For DELTA's refrigeration service simple mobile recovery units for CFC 12 (one for each of the 37 service cars currently used, plus additional units to be exchanged with one of the two Central Collection Stations) will be provided in order to prevent venting of CFC 12 and to reuse it. (The recovery units consist of a metal or plastic case, filled with activated carbon to absorb the remaining CFC 12 from the system. The CFC 12 will later be recovered from the activated carbon at the Central Collection station and sent for reclamation)

- 37 new mobile evacuation and charging boards for HFC 134a as well as leak detectors for service will also be provided (one each for the service cars currently used).

- DELTA's service personnel will be trained in using HFC 134a as well as in CFC 12 recovery and recycling.

D. *Justification for Selection of Alternative Technologies*

As new refrigerant for domestic refrigerators and freezers most of the major manufacturers of compressors have chosen HFC 134a as replacement for CFC 12. The same refrigerant was selected by the compressor company under construction in Egypt with the assistance of the Multilateral Fund for the Implementation of the Montreal Protocol (MFMP). Thus, for the Egyptian manufacturers of refrigerators and freezers there is for the time being no other option commercially available.

As new blowing agent for the polyurethane foam the situation is quite different. Some manufacturers use:

HCFC 141b with ODP	=	0.11
HCFC 142b with ODP	=	0.065
HCFC 142b + HCFC 22 with ODP	=	0.06
HFC 134a with ODP	=	0
Cyclopentane with ODP	=	0

This means, that the use of HCFC 141b, HCFC 142b and HCFC 142b + HCFC 22 blend could only be accepted as transitional substance for a limited time.

Currently all major European manufacturers are carrying out tests or have already started using cyclopentane. Therefore, EEAA recommends that the Egyptian manufacturers should introduce an ultimate solution as blowing agent and should not use any transitional substances.

At present HFC 134a is also too expensive, so it is very unlikely that it may become the ultimate blowing agent for polyurethane foam.

IV. INPUTS

1. *Capital Goods Replacement*

The following equipment for DELTA's two plants needs to be rebuilt, replaced, as well as new equipment to be provided as specified below:

A. Refrigeration System

a1. 6 pcs. HFC 134a charging boards with vacuum pump, leak check as well as refrigerant supply pump;

a2. 6 pcs. HFC 134a leak detectors;

a3.	1 set	HFC 134a test equipment (the set will be used for both plants; minimum specification as for temperature, humidity, voltage regulation systems, as well as for measuring of temperature, pressure, voltage, current, energy consumption and to be added to the existing test equipment);
a4.	139 pcs.	existing vacuum pumps cleaned/renovated.

B. Foam System

b1.	4 pcs.	Existing high pressure foaming machines (2 for cabinets and 2 for doors) have to be ex-proofed;
b2.	3 pcs.	mixing station for cyclopentane and polyol with daily tank;
b3.	1 set	water heater system for foaming jigs/plugs;
b4.	1 set	gas detector system;
b5.	1 set	exhaust and ventilation system;
b6.	12 sets	foaming jigs/plugs for cabinets (to be rebuilt);
b7.	2 sets	foaming jigs/plugs for doors (to be rebuilt);
b8.		floor cover (antistatic);
b9.	3 sets	pipe installation (ex-proof) from mixers to foaming machines;
b10.	1 pc	tank for cyclopentane with pumps and pipe work;
b11.	1 set	fire protection system;
b12.	1 set	pumps and pipework from tank to mixers;

C. Refrigeration Service

c1.	37 pcs.	HFC 134a mobile evacuation and charging boards;
c2.	100 pcs.	simple CFC 12 recovery units;
c3.	37 pcs.	leak detectors for HFC 134a.

2. *Conversion/Training*

Within the framework of this project, technicians from DELTA will be trained in (among others) the following areas:

- redesign and reconstruction of refrigerators and freezers;
- management and production control;
- quality control in relation to conversion;
- operation of the new machinery and equipment;

- maintenance of the new machinery and equipment;
- refrigeration laboratory tests;
- new technologies for foam and refrigerant;
- specifications for materials;
- safety regulations for flammable/explosive chemicals;
- refrigeration service.

3. *Model Redesign*

It is foreseen, that for all models redesign and reconstruction are required, followed by the manufacture of some prototypes and refrigeration performance tests. The model redesign will be carried out by DELTA's staff under the supervision of the Chief Technical Advisor and specialized international consultants for this project.

As a common practice, modifications of the production lines will be carried out during evenings and off-days and, therefore, it will not cause any costs under this project.

V. PROJECT IMPLEMENTATION

The project implementation will be carried out by UNIDO in close cooperation with DELTA. Necessary local coordination will be done by EEAA.

Purchase of know-how is not considered in the project budget. However, to substantively assist and supervise the technical aspects of the conversion process, to perform troubleshooting and to provide assistance in product redesign work a Chief Technical Advisor and specialized consultants will be appointed and fielded by UNIDO. The respective job descriptions will be prepared upon approval of the project.

After competitive bidding, performed according to UNIDO's rules and procedures, a General Contractor will be appointed by UNIDO for the implementation of the major project components (foaming system, refrigeration system, fire protection system, exhausting and ventilation system, etc.). The General Contractor will be responsible for the supply of equipment, installation, commissioning and on-the-job training of DELTA's staff. The detailed Terms of Reference for the services to be provided by the General Contractor will be elaborated after project approval.

In order to guarantee a proper technology transfer and safe operation - in particular of the new foaming technology, using the highly flammable and explosive cyclopentane - the proposed General Contractor will issue an "Operational Safety Statement"[1].

The final equipment specification, the work plan and, consequently the Operational Safety Statement can only be elaborated after approval of the basic approach for project implementation by the MFMP.

The permission from the local authorities for the introduction of the new technologies under this project will have to be obtained by DELTA. DELTA will also be responsible for the compliance of the new technologies with established national standards.

Having accepted the conversion of its plants to the use of non-ODS under this project, DELTA will be committed to provide the following inputs:

- All activities and costs related to the construction work needed (including the provision of technical infrastructure) to accommodate the new technologies introduced under this project. (The relevant construction work will have to be arranged by DELTA under the supervision of the General Contractor and in line with the established milestones for this project. The costs for construction work are, therefore, not reflected in the project budget. The specification for construction work needed will be elaborated by the General Contractor after project approval and necessary site inspection.);

- Technical staff as required by the General Contractor;

- Provision of tools, transportation and lifting equipment as required;

- Local transport, communication and secretarial facilities for the General Contractor's and UNIDO's staff involved in the project's implementation.

UNIDO as Implementing Agency has the necessary experience and capabilities for the successful implementation of projects at enterprise level. Upon approval of the project by the MFMP the project's budget will be transferred to UNIDO. The respective project allotment document will then be issued by UNIDO's Finance Section. Any substantive or financial deviation from the approved project is subject to approval by the MFMP and UNIDO.

For the project implementation, milestones are set in Annex E.

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[1] For negotiations to act as General Contractor, UNIDO has already established contacts with Messrs. POLYFA Trading A.S., DK-2650 Copenhagen-Hvidrove, Denmark.

VI. PROJECT COSTS

I. INCREMENTAL OPERATING COSTS

The currently produced models will require the following modifications, based on an average European price level:

1. Almaza plant:

Modification	Incremental Cost (US$)
HFC 134a compressor	5.00
Capillary tube	0.20
Evaporator/Condenser	1.70
Drier 3 AA	0.03
HFC 134a refrigerant	0.74
Total	**7.67** [2]

The incremental operating costs for **Almaza plant** for one year of operation are calculated for 156,750 units at US$ 7.67:

Total US$ 1,202,272

2. Nasr City plant:

Modification	Incremental Cost (US$)
HFC 134a compressor	5.00
Capillary tube	0.20
Evaporator/Condenser	1.70
Drier 3 AA	0.03
HFC 134a refrigerant (0.190 kg)	0.95
Cyclopentane	-0.75
Extra polyurethane foam	2.12
Total	**9.25** [2]

[2] The above calculation includes the incremental costs for the HFC 134a compressor to be used. Currently, in Egypt a new HFC 134a compressor plant is under construction by MCMC with the support of the MFMP. According to the rules of the MFMP, either the components manufacturing or the assembling company is eligible to receive incremental cost support, however the new compressors from MCMC will not be available in time. Thus, the incremental cost of HFC 134a compressors at US$ 5 per piece is taken into account.

The incremental operating costs for **NASR CITY plant** for one year of operation are calculated for 51,064 units at US$ 9.25:

Total US$ 472,342

The above mentioned prices are showing the difference between the component prices for CFC 11 and CFC 12 versus component prices for HFC 134a and cyclopentane.

The price increase will be caused by:

- 8 % to 10 % compressor price increase for the new HFC 134a compressor and plus about 10 % for a one size bigger compressor (to cope with the lower capacity at low evaporating temperature, but no heavy duty compressor, coping with significant voltage fluctuations), totalling to an average of about US$ 5.0 per compressor, (see footnotes [2)] above);

- capillary tube average 1 m longer;

- evaporator/condenser 2 m longer;

- HFC 134a filling average about 10 % less compared with CFC 12 resulting in a unit incremental cost as shown below:

a. *ALMAZA plant*

Refrigerant	Filling average/unit, kg	Price, US$	Cost, US$/unit	Incremental cost, US$/unit
CFC 12	0.17	1.88	0.32	
HFC 134a	0.15	7.07	1.06	0.74

b. *NASR CITY plant*

Refrigerant	Filling average/unit, kg	Price, US$	Cost, US$/unit	Incremental cost, US$/unit
CFC 12	0.21	1.88	0.39	
HFC 134a	0.19	7.07	1.34	0.95

- cyclopentane at US$ 1.55/kg will be used in a lower quantity as CFC 11 at US$ 1.80/kg, saving is US$ 0.75/unit:

Blowing agent	Blowing agent average per unit, kg	Price, US$	Cost, US$/unit	Saving, US$/unit
CFC 11	0.86	1.83	1.57	
C-pentane	0.52	1.57	0.82	0.75

- for polyurethane foaming at least 15 % more of the complete mix needs to be charged due to the higher foam density in the initial test period of about 1 year of foam production using cyclopentane (see also Annex G: "Technical Information Sheet of BASF"). The resulting incremental cost is US$ 2.12/unit:

Blowing agent	Foam average/unit, kg	Price, US$	Cost, US$/unit	Incremental cost, US$/unit
CFC 11	6.0	2.35	14.1	
C-pentane	6.9	2.35	16.22	2.12

- the currently used innerliner material is HIPS type KR 2710 from BASF. According to our latest information this material could be used with cyclopentane blown foam as well. Thus, incremental cost is not calculated.

Based on above, the total incremental operating costs for DELTA (ALMAZA plant and NASR CITY plant) for **one year of operation** are:

<u>US$ 1,674,614</u>

For six months of operation the total incremental operating cost will be as follows:

US$ 1,674,614 x 0.5 = <u>US$ 837,307</u>

Costs for transport and insurance of capital goods are included in the budgeted allocations for the respective items.

Costs for equipment installation, commissioning and on-the-job training of DELTA's staff are calculated separately.

II. CONTINGENCY FUND

A contingency fund (15 percent of the total project budget) was calculated. The MFMP is proposed to cover unforeseen expenses which might be incurred during the project implementation, e.g. purchase of small testing instruments, which might be required during the conversion process, miscellaneous expenses, price escalation, etc.

III. TOTAL COSTS

- Investment costs will cover capital investment costs (at CIF basis) for modification of manufacturing facilities, materials, new machinery, testing equipment (see Annex A: "Equipment Specification and Cost Breakdown"), training, installation and consultancy services for modifications (see Annex B: "Labour Cost of Subcontractor's Services" and Annex C: "Project Budget").
- The incremental operating costs associated with this project are as above.
- Implementing Agency's overhead costs are 13 percent.
- For the complete costs breakdown see Annex C: "Project Budget for DELTA".
- For the calculation of the unit abatement cost see Annex D: "Unit Abatement Cost".
- Requested funding by the MFMP: US$ 3,341,279

Annex A: Equipment Specification and Cost Breakdown

	Quantity	Unit cost, US$	Total cost, US$
ALMAZA PLANT			
Refrigeration system			
Charging boards for production	2	31,300	62,600
Cleaning and renov. of vacuum pumps	100	160	16,000
HFC 134a leak detectors	4	9,000	36,000
Test equipment	1	50,000	50,000
R12 collection station	1	2,500	2,500
NASR CITY PLANT			
Refrigeration system			
Charging boards for production	1	31,300	31,300
Cleaning and renov. of vacuum pumps	39	160	6,240
HFC 134a leak detectors	2	9,000	18,000
Foaming system			
Modif. of high pressure foaming machines	4	50,000	200,000
Mixing station	3	80,000	240,000
Water heater system	1	50,000	50,000
Gas detecting system	1	130,000	130,000
Exhaust and ventilation	1	120,000	120,000
Pipe installation from mixers	3	20,000	60,000
Antistatic floor			5,000
Fire protection system	1	75,000	75,000
Cabin foaming jigs and plugs, rebuild.	12	14,000	168,000
Door foaming jigs and plugs, rebuild.	2	14,000	28,000
Cyclopentane tanks, pumps, piping	1	33,000	33,000
Pumps and pipes from tank to mixer	1	46,000	46,000
R12 collection station	1	2,500	2,500
Refrigeration service			
Evacuation and charging board	37	3,000	111,000
CFC 12 recovery unit for service cars	100	30	3,000
Leak detector for HFC 134a	37	160	5,920
Total			**1,500,060**

Annex B: Labour Cost of Subcontractor's Services

Title	Unit	Qty.	Unit cost, US$	Total cost, US$
A. Refrigeration system				
(2 supervisors for 3 weeks each)				
Air ticket, Europe - Cairo	pc.	2	2,000	4,000
Expert fee	days	42	550	23,100
Daily subsistence allowance	days	42	130	5,460
Subtotal				32,560
B. Foam system				
(2 supervisors for 5 weeks each, 1 engineer 2 times 2 weeks)				
Air ticket, Europe - Cairo	pc.	4	2,000	8,000
Expert fee	days	70	550	38,500
Engineer fee	days	28	750	21,000
Daily subsistence allowance	days	98	130	12,740
Local subcontract (piping, installation)				10,800
Subtotal				91,040
C. Refrigeration system				
(1 supervisor for 2 weeks)				
Air ticket, Europe - Cairo	pc.	1	2,000	2,000
Expert fee	days	14	550	7,700
Daily subsistence allowance	days	14	130	1,820
Subtotal				11,520
TOTAL				**135,120**

Annex C: Project Budget

Budget line		Duration, work months	Cost, US$
11-01	Chief technical advisor	1.0	13,000
11-50	International Consultants	2.0	25,000
21-01	Subcontract		1,635,180
32-01	Study tour on foaming technology (2 technicians)	0.5	8,000
32-01	Study tour on refrigeration technology (2 technicians)	0.5	8,000
51-00	Miscellaneous:		
	15% contingency fund on capital cost		253,377
	Incremental operating cost		837,307
	15% contingency fund on operating cost		125,596
	Total miscellaneous cost		1,216,280
99-99	Subtotal		2,905,460
Implementing Agency Overhead, 13%			435,819
PROJECT TOTAL			3,341,279

Annex D: Calculation of Unit Abatement Cost

A	***ODS Phase out***	Unit	Total Project
A1	Average use of CFC 11 per year	mt	40
A2	ODP of CFC 11		1
A3	ODP-weighted CFC 11 phase out (A1*A2)	mt	40
A4	Average use of CFC 12 per year	mt	57
A5	ODP of CFC 12		1
A6	ODP-weighted CFC 12 phase out (A4*A5)	mt	57
A7	Total ODP weighted phase out (A3+A6)	mt	97
B	***Annualized capital cost***	Unit	Total Project
B1	Total investment cost		
	(model redefinition + production conversion)	US$	1,942,557
B2	Equipment life	year	10
B3	Discount rate	%	10
B4	Annualized capital cost (B1*0.1627)	US$	316,054
C	***Annual incremental operating cost***	US$	962,903
D	***Unit abatement cost***	Unit	Total Project
D1	Annualized capital cost per kg ODS phased out (B4/A7/1000)	US$/kg	3.26
D2	Annual incremental operating cost per kg ODS phased out (C/A7/1000)	US$/kg	9.93
D3	Unit abatement cost (D1+D2)	US$/kg	<u>13.19</u>

Annex E. Implementation Schedule

MILESTONES / MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Sign the project, receive funding	■																	
2. Appointment of General Contractor, site inspection		■																
3. Elaboration of a detailed project work-plan		■																
4. Draft of plant layouts		■																
FOAM (NASR CITY plant only)																		
5. Training						■				■	■							
6. Selection of equipment, bidding		■	■	■														
7. Rebuild foaming machines									■	■								
8. Rebuild foaming jigs/plugs									■	■								
9. Purchase, installation commissioning				■	■	■	■	■	■	■	■							
10. Prototyping & testing											■	■						
11. Start production with cyclopentane											■	■	■	■	■	■	■	■
REFRIGERATION																		
I. NASR CITY plant and first line of ALMAZA plant																		
12. Redesign of models, training		■	■	■														
13. Selection of equipment, bidding		■	■															
14. Purchase, installation commissioning and training				■	■	■	■	■	■									
15. Prototyping and testing										■	■	■	■					

MILESTONES / MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
16. Start production with HFC 134a											■	■	■	■	■	■	■	
II. Second line of ALMAZA plant																		
17. Redesign of models, training			■	■	■													
18. Selection of equipment, bidding			■	■														
19. Purchase, installation commissioning and training					■	■	■	■	■	■	■							
20. Prototyping & testing											■	■	■	■	■	■		
21. Start production with HFC 134a												■	■	■	■	■	■	■
REFRIGERATION SERVICE																		
22. Selection of equipment, bidding			■	■														
23. Purchase and training				■	■	■												

It is estimated that after 18 months the complete conversion will have been carried out.

Annex F: Preliminary Specification of Refrigeration Test Equipment

A. *To be supplied by the company:*

1 pc. Thermoinsulated test room: W x L x H: 2,500 x 3,000 x 2,800 mm, walls consisting of min. 80 mm thick polyurethane insulated panels covered with 0.6 mm electrogalvanized PVC coated steel plates.

B. *To be financed by MFMP:*

3 pcs. fan motors (ventilators)
2 pcs. heating elements
1 pc. cooling element
1 pc. ice-bank cooling system, complete
1 pc. electronic thermostat
1 pc. voltage stabiliser
1 set fluorescent light and plugs for test room
1 set terminal box for test room for connection of electricity, pressure and temperature
1 pc. terminal box outside test room for regulation equipment
2 pcs. amp. (current) converters
2 pcs. power converters
2 pcs. pressure converters
1 pc. 5 volt DC converter
1 pc. 24 volt DC converter
2 pcs. S-system/thermostat converter
1 pc. current transformer + cables, etc.
2 pcs. input card STBTC for measuring temperatures
1 pc. software Labtech notebook for analysing signals
1 pc. A/D card RTI 820 for PC
1 pc. Hard disk colour system/PC
1 pc. matrix printer colour system
1 pc. overhead operator control panel
1 pc. Vario transformer
1 pc. frequency meter, digital
1 pc. voltage meter, digital
1 pc. thermometer, digital
1 pc. temperature regulator
1 pc. amperemeter
1 pc. HFI protection relay
1 pc. regulator for fan motors
1 pc. current transformer
1 set relay, cables, clamps etc.

350 kg tylose test packages 200 x 100 x 50 mm
150 kg tylose test packages 100 x 100 x 50 mm
50 kg tylose test packages with thermocouples, 200 x 100 x 50 mm
50 kg tylose test packages with thermocouples 100 x 100 x 50 mm
1,000 m Cu-Constantan thermocouples
2 pcs. Pressure transducers
1 set Software for testing according to ISO 5155.2

Rigid polyurethane foam for refrigeration with cyclopentane as blowing agent

Table 2

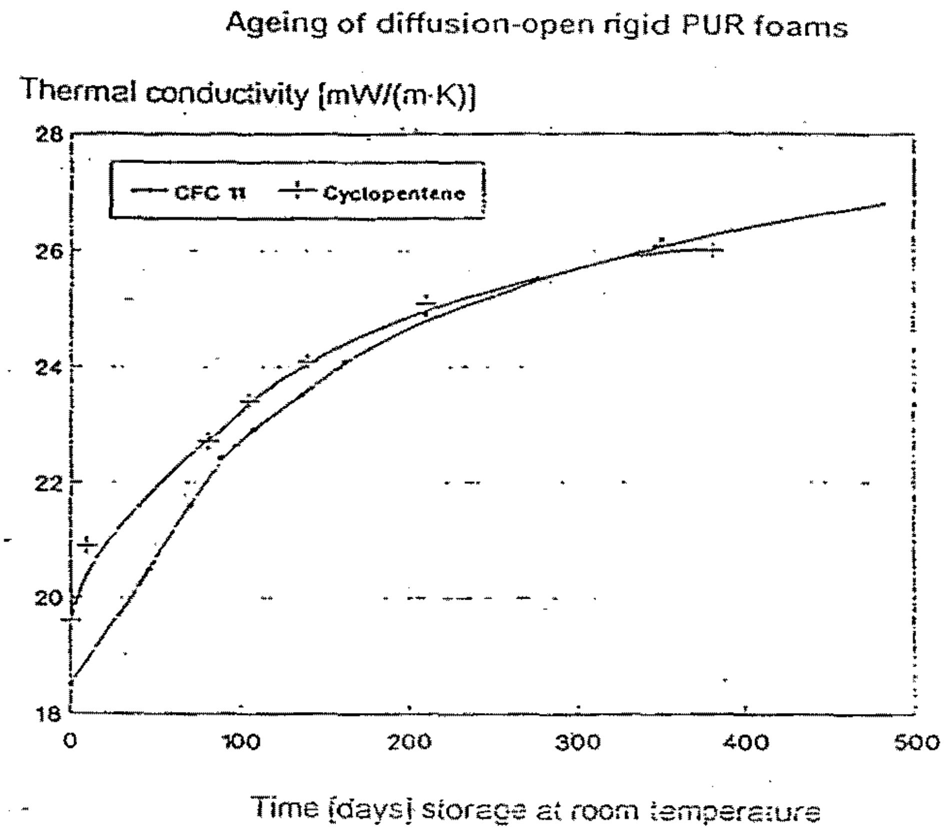
Properties of rigid PUR foam with cyclopentane as blowing agent

Blowing agent		Cyclo-pentane	n-Pen-tane	CFC 11
Polyol	[parts]	100	100	100
Blowing agent	[parts]	11	11	18
Isocyanate	[parts]	138	138	155
Molding density	[g/l]	39	39	34
Thermal conductivity* (initial K-value)	[relative %]	106	121	100
	[mW/m·K]	(18)	(20.5)	(17)
Compressive strength	[kPa]	140	140	120
Dimensional stability				
-30°C	[%]	<0.5	<0.5	<0.5
+80°C	[%]	<1.0	<1.0	<1.0

* Hesto lambda-control A 50-B single-plate instrument, mean temperature 23°C

Rigid polyurethane foam for refrigeration with cyclopentane as blowing agent

Figure 1



Note

The data in this publication are based on our current knowledge and experience. Due to the variety of possible effects during processing and use of our products, they do not free the processor from carrying out his own tests and trials. Our data must not be used to derive a legally binding assurance of certain properties or suitability for a particular application. Any protective rights and existing laws and regulations must be observed by the consignee of our products at his own responsibility.

BASF Aktiengesellschaft
D-6700 Ludwigshafen

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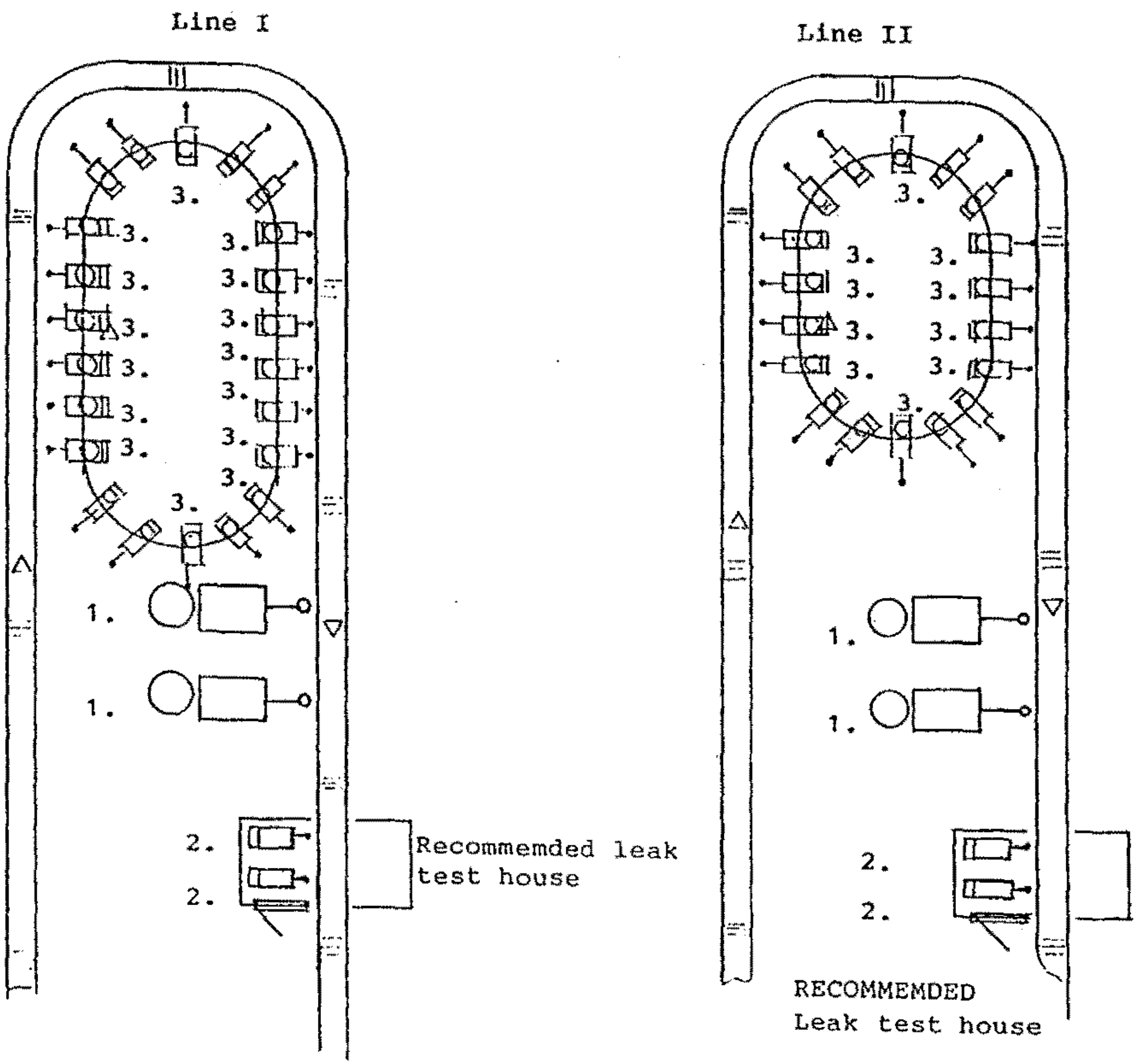
BASF

Polyurethane

Annex H/1: Current and proposed new plant layout

Delta Industrial Co. (ALMAZA)

Refrigeration Line

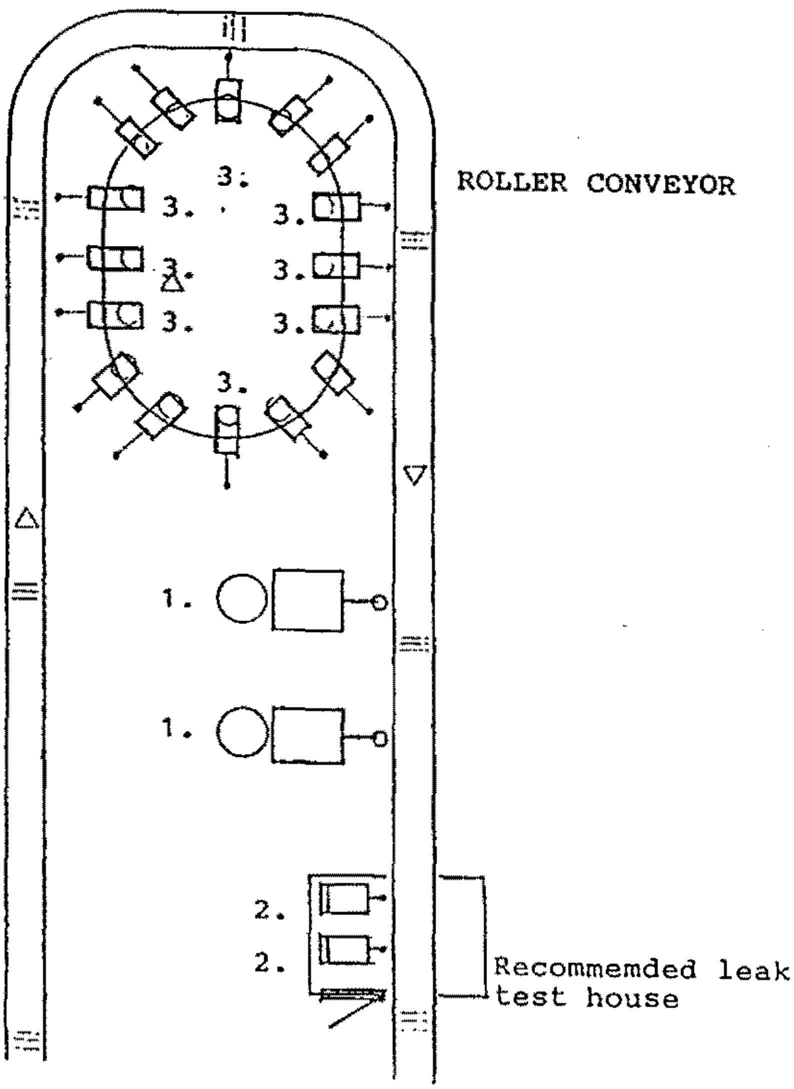


1. Charging board
2. Leak Detector
3. Vacuum pump with vacuum control

Annex H/2 : Current and proposed new plant layout

Delta Industrial Co. (Nars City Factory)

Refrigeration Line

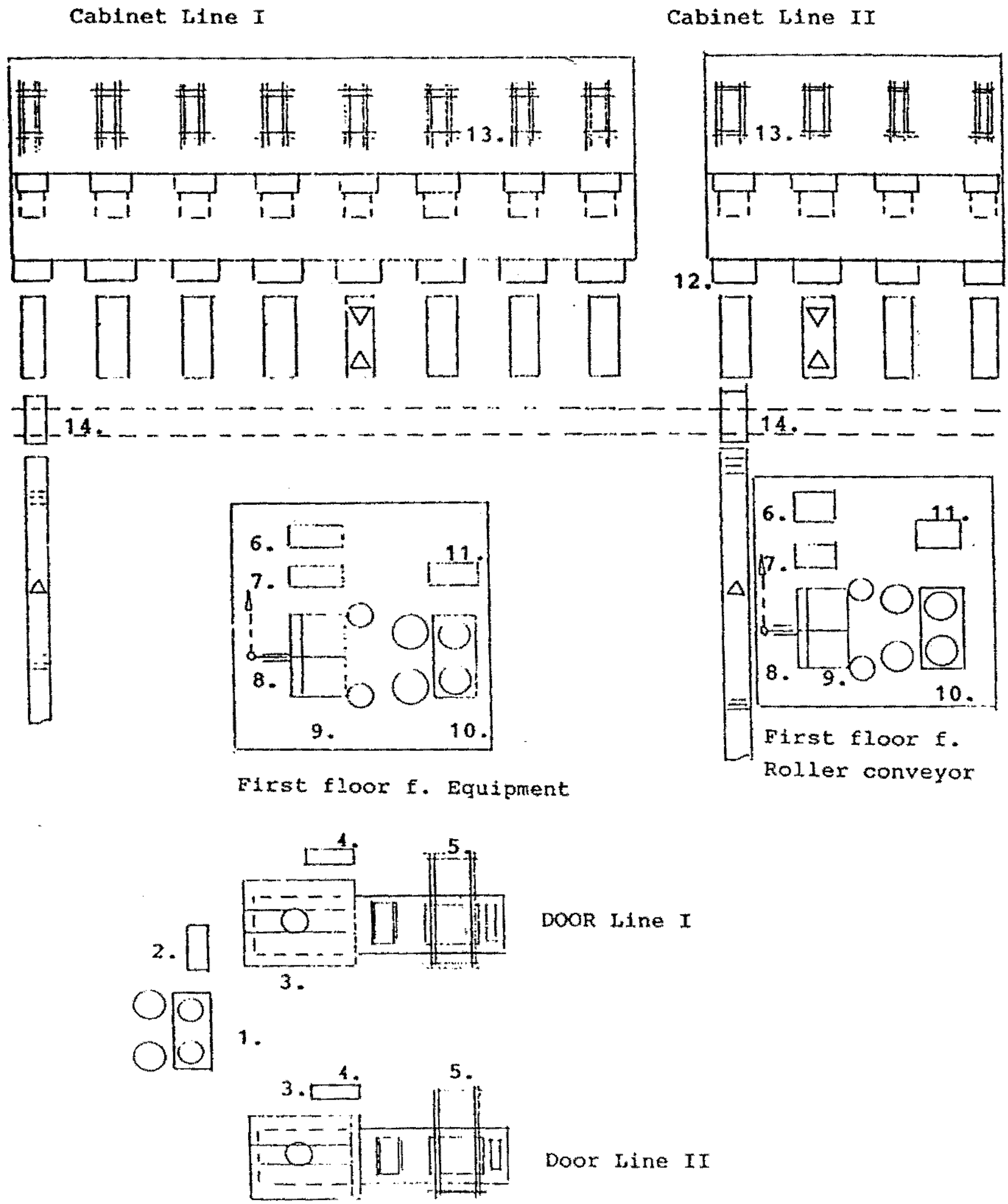


1. Charging board
2. Leak Detector
3. Vacuum pump

Annex H/3: Current and proposed new plant layout.

Delta Industrial Co. (Nasr City Factory)

Foaming Lines



Annex H/4: Current and <u>proposed</u> new plant layout.

Delta Industrial Co. (Nasr City Factory)

Foaming Lines:

1. Mixing unit for polyol + cyclopentane for door foaming
2. Control panel for mixer
3. Door pre-heating oven
4. Control panel
5. Door foaming jigs with high pressure foaming machine
6. Control panel for high pressure foaming machine
7. Chiller for foaming machine
8. High pressure foaming machine for cabinets with connection to foaming heads.
9. High pressure foaming machine for cabinets
10. Mixer for polyol and cyclopentane
11. Control panel for mixer
12. Pre-heating oven for cabinets
13. Cabinet foaming jigs. Automatic
14. Transport carriage for cabinets

NB: Pos. 6,7,8,9,10 and 11 are placed on a platform over the foaming jigs.

Exc. the 3 mixing stations is it the current equipment and layout.

PROJECT COVER SHEET

Country:	Egypt
Project Title:	Phasing out ODS at the KIRIAZI Refrigerators Manufacturing Co., Egypt
Sectors Covered:	Domestic Refrigeration /Rigid Foam/Refrigerant
ODS Use in Sector (1990):	1,830 mt of CFC 11 and CFC 12
Project Impact :	Phase out of annual consumption of 101 mt CFC 11, 30 mt CFC 12 in the production and a gradual phase out of currently used 6 mt CFC 12 in the service sector (Total ODP = 137)
Project Duration:	18 months
Project Economic Life:	10 years
Total Project Cost:	US$ 1,826,849 (Total of capital cost and incremental operating cost for six month of operation)
Capital Cost:	US$ 1,308,562
Incremental Operating Cost:	US$ 518,287 (six month of operation)
Implementing Agency's Overheads (13%):	US$ 274,027
Proposed MF Financing:	US$ 2,100,876
Cost Effectiveness:	See Annex D: Unit Abatement Cost
Counterpart Enterprise:	KIRIAZI Refrigerators Manufacturing Co., 10th of Ramadan City
Implementing Agency:	United Nations Industrial Development Organization (UNIDO)
Coordinating Ministry:	Egyptian Environmental Affairs Agency (EEAA)

PROJECT SUMMARY

This project will phase out 100 percent of the use of CFC 11 and CFC 12 for the production of refrigerators and freezers at KIRIAZI Refrigerators Manufacturing Co. The chosen replacement alternatives are cyclopentane as foam blowing agent and HFC 134a as refrigerant. The project will include the redesign of all current refrigerator models and the conversion of the plants. The redesign of the existing refrigerator models covers activities like prototyping, testing, trial manufacturing and adaptation as well as reliability tests. The conversion of the production facilities covers the refrigeration system, insulating foam blowing system as well as the refrigeration service carried out by the company. The replacement alternatives and the time frame for phasing out the use of ODS will be in line with EEAA's ODS phase out programme.

I. BACKGROUND

A. Sector Background

The subsector for domestic refrigerators and freezers in Egypt consists of 9 manufacturers of which four to five companies are responsible for over 80 percent of the ODS consumption of CFC 11 and CFC 12.

Egypt does not produce any ODS. All ODS used in the country are directly imported by the users. In 1990 the total consumption was 1.830 mt of ODS.

The total installed production capacity for refrigerators and freezers is about 1,000,000 units per year, but the present production is only about 525,000 units per year. The manufacturers expect an increase of about 10 percent per year.

In total about 7,000,000 refrigerators and freezers are in use in Egypt of which about 10 percent per year will be serviced and a part of them recharged during refrigeration service with CFC 12. Because of lack of environmental awareness, know-how and equipment in the service sector, service staff very often use CFC 12 for washing/flushing of the cooling systems, instead of using vacuum pumps and charging boards. This causes up to 200 percent excess CFC 12 consumption in the service sector.

Currently no Egyptian company manufactures low energy refrigerators and freezers with an insulation thickness of 40 to 50 mm for refrigerators and 90 mm to 100 mm for freezers; however, the introduction of a limit for maximum energy consumption could be expected in the near future.

B. KIRIAZI's Background

KIRIAZI Refrigerators Manufacturing Co. (KIRIAZI), is a private company and one of the five largest manufacturers of domestic refrigerators and freezers. It employs 512 people and the installed annual production capacity is about 150,000 units in one shift. Between December 1992 and December 1993 the actual production was 93,600 units. KIRIAZI expects a 10 percent increase in the production for each of the next four years because of a low price policy, combined with high product quality.

KIRIAZI is planning to build a new refrigerator and freezer factory in connection with a newly built factory for washing machines and cookers.

In 1993 KIRIAZI used 101 MT of CFC 11 and 30 MT of CFC 12 in the production as well as 6 MT of CFC 12 in the service sector. The company has already tested 50 percent CFC-reduced polyurethane foam, but until now normal CFC 11 mixed with polyol is being used.

KIRIAZI currently manufactures 2 models of two-door fridge/freezers, 1 model of no-frost fridge/freezer with two-doors as well as 3 sizes of chest freezers. A 330 litres fridge/freezer with two doors takes the biggest share of the production output, of which currently 60,000 units are being manufactured annually. The annual production of the other models is about 10,000 units.

KIRIAZI covers a share of about 20 to 25 percent of the local market and exports less than 2 percent (to Libya, earlier also to Russia and Romania).

KIRIAZI imported the currently applied technologies and know-how from Zerowatt/Italy. The company has developed its own chest freezer range, however it does not have its own refrigeration test facilities.

The insulation thickness of KIRIAZI's refrigerators is only 25 mm, 40 mm for the freezer section and only 50 mm for the chest freezers. Therefore, redesign of the polyurethane foam system would lead to decreased energy consumption figures through decreased insulation losses. This modification, however, cannot be financed by the Multilateral Fund for the Implementation of the Montreal Protocol (MFMP).

More detailed information on the current plant layout and the production equipment employed, as well as on the proposed new layout is shown in Annex H: "Current and Proposed New Plant Layout".

KIRIAZI has already recognized the need to be in compliance with the stipulations made in the Montreal Protocol and has agreed to participate in Egypt's ODS phase out programme.

II. PROJECT OBJECTIVE

The objective of this project is to eliminate the use of ODS such as CFC 11 and CFC 12 in the production of domestic refrigerators and in the refrigeration service at KIRIAZI through conversion to the use of HFC 134a as refrigerant for the cooling system and cyclopentane as blowing agent for the polyurethane insulation foam.

III. PROJECT DESCRIPTION

KIRIAZI is prepared to phase out ODS as soon as the new technologies have been acquired, the necessary machinery and equipment installed and the technical staff trained.

Among the technological options currently available on commercial basis and in line with the established policy of the Government of Egypt to phase out the use of ODS, KIRIAZI has chosen to replace CFC 12 by HFC 134a, because the new type compressors are available, and the technology is mature and commercially applied outside Egypt.

As blowing agent for polyurethane foam KIRIAZI decided to avoid the use of any transitional substance and to introduce as ultimate solution cyclopentane.

Through the project assistance will be provided in:

a) Procurement of new machinery and equipment;

b) Rebuilding of presently used machinery and equipment wherever technically and economically feasible;

c) Redesign, reconstruction, prototype manufacturing and testing of refrigerators/freezers;

d) Installation, commissioning, trial operation, start-up and on-the-job training;

e) Servicing.

The following machinery and equipment need to be rebuilt, replaced or added:

A. ***Refrigeration System***

- The charging equipment and vacuum pumps must only be used for HFC 134a and in meeting the demand for cleaner and dryer cooling systems the existing charging equipment has to be replaced including the vacuum control.

- The charging boards have to be replaced by boards suitable for HFC 134a.

- Because the leak detectors react on Cl molecules, they need to be replaced.

- The currently used vacuum pumps, after being cleaned and connection hoses and gaskets being changed can also be used for HFC 134a.

- To optimize the cooling system for the application of HFC 134a and new specification for components used, performance tests for each model of refrigerator in an air-conditioned test room are needed. Therefore, a minimum specification of refrigeration test equipment needs to be provided (see Annex F: Preliminary Specification of Refrigeration Test Equipment). It is understood, that foam testing facilities cannot be financed by MFMP, as stated in the forthcoming para B: Foam System.

- To improve the performance of the cooling system and compensate for a little lower polyurethane insulation value due to the conversion to HFC 134a as the new refrigerant and cyclopentane for the foam, it is necessary to optimize the cooling system as well as the energy consumption to keep an acceptable TEWI value. Therefore, it is necessary to redesign, reconstruct and carry out performance tests for all redesigned models of refrigerators / freezers.

- The technical requirements for components such as tubes, condensers, evaporators, capillary tubes, heat exchangers and suction accumulators have to be in line with established standards, like DIN 8964, i.e. new rules for dryness and cleanliness need to be applied.

- The drier has to be equipped with 3 AA desiccant molecular sieves.

- The cooling system must not contain any chlorine and max. 1 percent non-condensable gases.

- The capillary tube has to be optimized for an increased resistance at low evaporating temperatures.

- It will be necessary to train KIRIAZI's manufacturing and service technicians at the equipment suppliers' place in new foaming technology as well as in design/calculation and performance testing of cooling systems. During the installation and run-in of the new machinery and equipment the suppliers engineers will have to train KIRIAZI's technical staff.

B. ***Foam System***

- In order to achieve an acceptable foam quality and insulation value at lowest price, high pressure foaming machines need to be introduced and ex-proofed. The polyol part of the machines have to be made explosion proof and encapsulated. It is also necessary to replace the stirrer in the polyol daily tank as well as the electrical components of the polyol part of the foaming machine.

  Adaptation of the currently used low pressure foaming machines for cyclopentane would require substantial modifications to be carried out at the machine supplier's premises. Apart from the substantial adaptation costs, a further burden would be the several weeks interruption of production for decommissioning, rebuilding, transportation and recommissioning of the machinery. Thus, the only economically viable solution is to replace the low pressure foaming machines with suitable high pressure ones.

  According to our information collected in Egypt, there is no domestic market for the second hand low pressure foaming machines, since not only the refrigerator plants, but also the foam manufacturers are replacing their low pressure foaming machines with high pressure machines. Thus, similarly to the previously approved by the MFMP foam sector projects the high pressure machines are budgeted at their full cost.

- Since cyclopentane and polyol cannot be delivered premixed in drums or tanks (like CFC 11 and polyol), it will be necessary to provide mixing stations.

- It is necessary to provide one tank for cyclopentane to automatically deliver the components to the mixing stations.

- For work safety when using the highly flammable and explosive cyclopentane and in order to meet the relevant requirements of the local authorities, it is recommended to have a gas detector system as well as a fire protection system installed in the foaming department.

- The provision and installation of an exhaust and ventilation system in the foaming department is necessary in order to achieve compliance with established safety rules for the machinery and the plant;

- All machinery and equipment which may come in contact with cyclopentane or the mix of polyol and cyclopentane must be encapsulated and explosion-proof;

- To make the foaming jigs explosion-proof, it is necessary to replace the electric heating elements by copper tubes in which hot water can circulate. (A cheaper option would be to automatically disconnect the existing electrical heating just before foam injection, using the control system of the foaming machine and a timer. For the sake of high operational safety it is, however, recommended to apply the water heater option.) KIRIAZI is ready to absorb 50% of the calculated costs of the modification of jigs and plugs. The foaming inner mould plugs have to be partially replaced/rebuilt using aluminium sheets to guarantee a constant temperature at the inner foam plug. The electric valves and microswitches to be used in connection with the foaming jigs need to be explosion-proof.

- All foaming jigs and plugs must be equipped with a good earth connection to avoid the appearance of static electricity.

- The workers's clothes and shoes have to be made of antistatic material and the floor needs to be covered with an antistatic paint.

- To keep control over the quality of the foam it is recommended to introduce a minimum specification of test equipment. Since currently no test equipment is being used by KIRIAZI it can, however, not be provided under this project.

C. *Refrigeration Service*

- KIRIAZI has about 700,000 refrigerators/freezers operating in Egypt. They are serviced mainly by the Company's service centre. The amount of CFC 12 used by KIRIAZI for servicing/recharging is 7-8 mt annually. It is estimated that through better service technologies 2/3 of the latter amount, i.e. about 6 mt could gradually be saved in future.

- For KIRIAZI's refrigeration service simple mobile recovery units for CFC 12 (one for each of the 26 service cars currently used, plus additional units to be exchanged with the Central Collection Station) will be provided in order to prevent venting of CFC 12 and to reuse it. (The recovery units consist of a metal or plastic case, filled with activated carbon to absorb the remaining CFC 12 from the system. The CFC 12 will later be recovered from the activated carbon at the Central Collection Station and sent for reclamation.)

- 26 new mobile evacuation and charging boards for HFC 134a as well as leak detectors for service will also be provided (one each for the service cars currently used).

- KIRIAZI's service personnel will be trained in using HFC 134a as well as in CFC 12 recovery and recycling.

D. ***Justification for Selection of Alternative Technologies***

As new refrigerant for domestic refrigerators and freezers most of the major manufacturers of compressors have chosen HFC 134a as replacement for CFC 12. The same refrigerant was selected by the compressor company under construction in Egypt with the assistance of the MFMP. Thus, for the Egyptian manufacturers of refrigerators and freezers there is for the time being no other option commercially available.

As new blowing agent for the polyurethane foam the situation is quite different. Some manufacturers use:

HCFC 141b with ODP	=	0.11
HCFC 142b with ODP	=	0.065
HCFC 142b + HCFC 22 with ODP	=	0.06
HFC 134a with ODP	=	0
Cyclopentane with ODP	=	0

This means, that the use of HCFC 141b, HCFC 142b and HCFC 142b + HCFC 22 blend could only be accepted as transitional substance for a limited time.

Currently all major European manufacturers are carrying out tests or have already started using cyclopentane. Therefore, EEAA recommends that the Egyptian manufacturers should introduce an ultimate solution as blowing agent and should not use any transitional substances.

At present HFC 134a is also too expensive, so it is very unlikely that it may become the ultimate blowing agent for polyurethane foam.

IV. INPUTS

1. *Capital Goods Replacement*

The following equipment for KIRIAZI needs to be rebuilt, replaced, as well as new equipment to be provided as specified below:

A. Refrigeration System

a1.	2 pcs.	HFC 134a charging boards with vacuum pump, leak check as well as refrigerant supply pump;
a2.	2 pcs.	HFC 134a leak detectors;
a3.	1 set	HFC 134a test equipment (minimum specification as for temperature, humidity, voltage regulation systems, as well as for measuring of temperature, pressure, voltage, current, energy consumption and to be added to the existing test equipment);
a4.	26 pcs.	existing vacuum pumps cleaned/renovated.

B. Foam System

b1.	2 pcs.	High pressure foaming machines (ex-proofed for use of cyclopentane);
b2.	2 pcs.	mixing station for cyclopentane and polyol with daily tank;
b3.	1 set	water heater system for foaming jigs/plugs;
b4.	1 set	gas detector system;
b5.	1 set	exhaust and ventilation system;
b6.	10 sets	foaming jigs (to be rebuilt); *KIRIAZI is willing to share 50% of costs of modification*
b7.	15 sets	foaming plugs (to be rebuilt); *KIRIAZI is willing to share 50% of costs of modification*
b8.		floor cover (antistatic);
b9.	2 sets	pipe installation (ex-proof) from mixers to foaming machines;
b10.	1 pc	tank for cyclopentane with pumps and pipe work;
b11.	1 set	fire protection system;
b12.	1 set	pumps and pipework from tank to mixers;
b13.	1 pc	water chiller for foaming machines.

C. Refrigeration Service

c1. 26 pcs. HFC 134a mobile evacuation and charging boards;

c2. 76 pcs. simple CFC 12 recovery units;

c3. 26 pcs. leak detectors for HFC 134a.

2. *Conversion/Training*

Within the framework of this project, technicians from KIRIAZI will be trained in (among others) the following areas:

- redesign and reconstruction of refrigerators and freezers;
- management and production control;
- quality control in relation to conversion;
- operation of the new machinery and equipment;
- maintenance of the new machinery and equipment;
- refrigeration laboratory tests;
- new technologies for foam and refrigerant;
- specifications for materials;
- safety regulations for flammable/explosive chemicals;
- refrigeration service.

3. *Model Redesign*

It is foreseen, that for all models redesign and reconstruction are required, followed by the manufacture of some prototypes and refrigeration performance tests. The model redesign will be carried out by KIRIAZI's staff under the supervision of the Chief Technical Advisor and specialized international consultants for this project.

As a common practice, modifications of the production lines will be carried out during evenings and off-days and, therefore, it will not cause any costs under this project.

V. PROJECT IMPLEMENTATION

The project implementation will be carried out by UNIDO in close cooperation with KIRIAZI Refrigerators Manufacturing Co.. Necessary local coordination will be done by EEAA.

Purchase of know-how is not considered in the project budget. However, to substantively assist and supervise the technical aspects of the conversion process, to perform troubleshooting and to provide assistance in product redesign work a Chief Technical Advisor and specialized consultants will be appointed and fielded by UNIDO. The respective job descriptions will be prepared upon approval of the project.

After competitive bidding, performed according to UNIDO's rules and procedures, a General Contractor will be appointed by UNIDO for the implementation of the major project components (foaming system, refrigeration system, fire protection system, exhausting and ventilation system, etc.). The General Contractor will be responsible for the supply of equipment, installation, commissioning and on-the-job training of KIRIAZI's staff. The detailed Terms of Reference for the services to be provided by the General Contractor will be elaborated after project approval.

In order to guarantee a proper technology transfer and safe operation - in particular of the new foaming technology, using the highly flammable and explosive cyclopentane - the proposed General Contractor will issue an "Operational Safety Statement"[1].

The final equipment specification, the work plan and, consequently the Operational Safety Statement can only be elaborated after approval of the basic approach for project implementation by the MFMP.

The permission from the local authorities for the introduction of the new technologies under this project will have to be obtained by KIRIAZI. KIRIAZI will also be responsible for the compliance of the new technologies with established national standards.

Having accepted the conversion of its plants to the use of non-ODS under this project, KIRIAZI will be committed to provide the following inputs:

- All activities and costs related to the construction work needed (including the provision of technical infrastructure) to accommodate the new technologies introduced under this project. (The relevant construction work will have to be arranged by KIRIAZI under the supervision of the General Contractor and in line with the established milestones for this project. The costs for construction work are, therefore, not reflected in the project budget. The specification for construction work needed will be elaborated by the General Contractor after project approval and necessary site inspection.);

- Technical staff as required by the General Contractor;

- Provision of tools, transportation and lifting equipment as required;

[1] For negotiations to act as General Contractor, UNIDO has already established contacts with Messrs. POLYFA Trading A.S., DK-2650 Copenhagen-Hvidrove, Denmark.

- Local transport, communication and secretarial facilities for the General Contractor's and UNIDO's staff involved in the project's implementation.

UNIDO as Implementing Agency has the necessary experience and capabilities for the successful implementation of projects at enterprise level. Upon approval of the project by the MFMP the project's budget will be transferred to UNIDO. The respective project allotment document will then be issued by UNIDO's Finance Section. Any substantive or financial deviation from the approved project is subject to approval by the MFMP and UNIDO.

For the project implementation, milestones are set in Annex E.

VI. PROJECT COSTS

I. INCREMENTAL OPERATING COSTS

The currently produced models will require the following modifications, based on an average European price level:

Modification	Incremental Cost (US$)
HFC 134a compressor	5.00
Capillary tube	0.20
Evaporator/Condenser	1.70
Drier 3 AA	0.03
HFC 134a refrigerant	1.12
Cyclopentane	-0.89
Extra polyurethane foam	2.47
Total	**9.63** [2)]

The above mentioned prices are showing the difference between the component prices for CFC 11 and CFC 12 versus component prices for HFC 134a and cyclopentane.

The price increase will be caused by:

- 8 % to 10 % compressor price increase for the new HFC 134a compressor and plus about 10 % for a one size bigger compressor (to cope with the lower capacity at low evaporating temperature, but no heavy duty compressor, coping with significant

[2)] The above calculation includes the incremental costs for the HFC 134a compressor to be used. Currently, in Egypt a new HFC 134a compressor plant is under construction by MCMC with the support of the MFMP. According to the rules of the MFMP, either the components manufacturing or the assembling company is eligible to receive incremental cost support, however the new compressors from MCMC will not be available in time. Thus, the incremental cost of HFC 134a compressors at US$ 5 per piece is taken into account.

voltage fluctuations), totalling to an average of about US$ 5.0 per compressor, (see footnotes [2)] above);

- capillary tube average 1 m longer;

- evaporator/condenser 2 m longer;

- HFC 134a filling average about 10 % less compared with CFC 12 resulting in an incremental cost of US$ 1.12 per unit:

Refrigerant	Filling average/unit, kg	Price, US$	Cost, US$/unit	Incremental cost, US$/unit
CFC 12	0.25	1.88	0.47	
HFC 134a	0.225	7.07	1.59	1.12

- cyclopentane at US$ 1.55/kg will be used in a lower quantity as CFC 11 at US$ 1.80/kg, saving is US$ 0.89/unit:

Blowing agent	Blowing agent average per unit, kg	Price, US$	Cost, US$/unit	Saving, US$/unit
CFC 11	1.00	1.83	1.83	
C-pentane	0.60	1.57	0.94	0.89

- for polyurethane foaming at least 15 % more of the complete mix needs to be charged due to the higher foam density in the initial test period of about 1 year of foam production using cyclopentane (see also Annex G: "Technical Information Sheet of BASF"). The resulting incremental cost is US$ 2.47/unit:

Blowing agent	Foam average/unit, kg	Price, US$	Cost, US$/unit	Incremental cost, US$/unit
CFC 11	7.0	2.35	16.45	
C-pentane	8.05	2.35	18.92	2.47

- the currently used innerliner material is HIPS type KR 2710 from BASF. According to our latest information this material could be used with cyclopentane blown foam as well. Thus, incremental cost is not calculated.

Based on above calculations, the total incremental operating costs for KIRIAZI the incremental operating costs are calculated for 93,600 units at US$ 9.63 and will be for one year of operation:

US$ 901,368

For six months of operation the total incremental operating cost will be as follows:

US$ 901,368 x 0.5 = US$ 450,684

Costs for transport and insurance of capital goods are included in the budgeted allocations for the respective items.

Costs for equipment installation, commissioning and on-the-job training of KIRIAZI's staff are calculated separately.

II. CONTINGENCY FUND

A contingency fund (15 percent of the total project budget) was calculated. The MFMP is proposed to cover unforeseen expenses which might be incurred during the project implementation, e.g. purchase of small testing instruments, which might be required during the conversion process, miscellaneous expenses, price escalation, etc.

III. TOTAL COSTS

- Investment costs will cover capital investment costs (at CIF basis) for modification of manufacturing facilities, materials, new machinery, testing equipment (see Annex A: "Equipment Specification and Cost Breakdown"), training, installation and consultancy services for modifications (see Annex B: "Labour Cost of Subcontractor's Services" and Annex C: "Project Budget").
- The incremental operating costs associated with this project are as above.
- Implementing Agency's overhead costs are 13 percent.
- For the complete costs breakdown see Annex C: "Project Budget".
- For the calculation of the unit abatement cost see Annex D: "Unit Abatement Cost".
- Requested funding by the MFMP: US$ 2,100,876

Annex A: Equipment Specification and Cost Breakdown

	Quantity	Unit cost, US$	Total cost, US$
Refrigeration system			
Charging boards for production	2	31,300	62,600
Cleaning and renov. of vacuum pumps	26	160	4,160
HFC 134a leak detectors	2	9,000	18,000
Test equipment	1	50,000	50,000
R12 collection station	1	2,500	2,500
Foaming system			
High pressure foaming machine, cabinets	1	160,000	160,000
High pressure foaming machine, doors	1	110,000	110,000
Mixing station	2	80,000	160,000
Water heater system	1	40,000	40,000
Gas detecting system	1	75,000	75,000
Exhaust and ventilation	1	45,000	45,000
Foaming jigs, rebuild. (50% cost sharing)	10	4,500	22,500
Foaming plugs, rebuild. (50% cost sharing)	2	14,000	14,000
Antistatic floor			3,000
Pipe installation for 2 machines	2	15,000	30,000
Cyclopentane tanks, pumps, piping	1	33,000	33,000
Fire protection system	1	30,000	30,000
Pumps and pipes from tank to mixer	1	45,000	45,000
Water chiller	1	11,000	11,000
Refrigeration service			
Evacuation and charging board	26	3,000	78,000
CFC 12 recovery unit for service cars	76	30	2,280
Leak detector for HFC 134a	26	160	4,160
Total			1,000,200

Annex B: Labour Cost of Subcontractor's Services

Title	Unit	Qty.	Unit cost, US$	Total cost, US$
A. Refrigeration system				
(1 supervisor for 2 weeks)				
Air ticket, Europe - Cairo	pc.	1	2,000	2,000
Expert fee	days	14	550	7,700
Daily subsistence allowance	days	14	130	1,820
Subtotal				11,520
B. Foam system				
(2 supervisors for 4 weeks each, 1 engineer for 2 weeks)				
Air ticket, Europe - Cairo	pc.	3	2,000	6,000
Expert fee	days	56	550	30,800
Engineer fee	days	14	750	10,500
Daily subsistence allowance	days	70	130	9,100
Local subcontract (piping, installation)				10,800
Subtotal				67,200
C. Refrigeration service				
(1 supervisor for 1 week)				
Air ticket, Europe - Cairo	pc.	1	2,000	2,000
Expert fee	days	7	550	3,850
Daily subsistence allowance	days	7	130	910
Subtotal				6,760
TOTAL				**85,480**

Annex C: Project Budget

Budget line		Duration, work months	Cost, US$
11-01	Chief technical advisor	1	13,000
11-50	International Consultants	2	25,000
21-01	Subcontract		1,085,680
32-01	Study tour on foaming technology (2 technicians)	0.5	8,000
32-01	Study tour on refrigeration technology (1 technician)	0.5	6,200
51-00	Miscellaneous:		
	15% contingency fund on capital cost		170,682
	Incremental operating cost		450,684
	15% contingency fund on operating cost		67,603
	Total miscellaneous cost		688,969
99-99	Subtotal		1,826,849
Implementing Agency Overhead, 13%			274,027
PROJECT TOTAL			**2,100,876**

Annex D: Calculation of Unit Abatement Cost

A	*ODS Phase out*	*Unit*	*Total Project*
A1	Average use of CFC 11 per year	mt	101
A2	ODP of CFC 11		1
A3	ODP-weighted CFC 11 phase out (A1*A2)	mt	101
A4	Average use of CFC 12 per year	mt	36
A5	ODP of CFC 12		1
A6	ODP-weighted CFC 12 phase out (A4*A5)	mt	36
A7	Total ODP weighted phase out (A3+A6)	mt	**137**
B	***Annualized capital cost***	*Unit*	*Total Project*
B1	Total investment cost		
	(model redefinition + production conversion)	US$	**1,308,562**
B2	Equipment life	year	10
B3	Discount rate	%	10
B4	Annualized capital cost (B1*0.1627)	US$	212,903
C	***Annual incremental operating cost***	US$	**518,287**
D	***Unit abatement cost***	*Unit*	*Total Project*
D1	Annualized capital cost per kg ODS phased out (B4/A7/1000)	US$/kg	1.55
D2	Annual incremental operating cost per kg ODS phased out (C/A7/1000)	US$/kg	3.78
D3	Unit abatement cost (D1+D2)	US$/kg	5.34

Annex E. Implementation Schedule

MILESTONES / MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Sign the project, receive funding	■																	
2. Appointment of General Contractor, site inspection		■																
3. Elaboration of a detailed project workplan		■																
4. Draft of plant layouts		■																
FOAM																		
5. Selection of equipment, bidding		■	■	■														
6. Training							■				■							
7. Rebuild jigs + plugs				■	■	■	■	■	■	■	■							
8. Purchase, installation, commissioning				■	■	■	■	■	■	■	■							
9. Prototyping and testing											■	■						
10. Start production with cyclo pentane												■	■	■	■	■	■	■
REFRIGERANT																		
11. Redesign of models, training		■	■	■														
12. Selection of equipment, bidding		■	■															
13. Purchase, installation and commissioning			■	■	■	■	■	■	■									
14. Prototyping and testing							■	■	■	■	■	■	■	■	■	■		
15. Start production with HFC 134a											■	■	■	■	■	■	■	■

MILESTONES / MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
REFRIGERATION SERVICE																		
16. Selection of equipment, bidding																		
17. Purchase and training																		

It is estimated that after 18 months the complete conversion will have been carried out.

Annex F: Preliminary Specification of Refrigeration Test Equipment

A. To be supplied by the company:

1 pc. Thermoinsulated test room: W x L x H: 2,500 x 3,000 x 2,800 mm, walls consisting of min. 80 mm thick polyurethane insulated panels covered with 0.6 mm electrogalvanized PVC coated steel plates.

B. To be financed by MFMP:

3 pcs.	fan motors (ventilators)
2 pcs.	heating elements
1 pc.	cooling element
1 pc.	ice-bank cooling system, complete
1 pc.	electronic thermostat
1 pc.	voltage stabiliser
1 set	fluorescent light and plugs for test room
1 set	terminal box for test room for connection of electricity, pressure and temperature
1 pc.	terminal box outside test room for regulation equipment
2 pcs.	amp. (current) converters
2 pcs.	power converters
2 pcs.	pressure converters
1 pc.	5 volt DC converter
1 pc.	24 volt DC converter
2 pcs.	S-system/thermostat converter
1 pc.	current transformer + cables, etc.
2 pcs.	input card STBTC for measuring temperatures
1 pc.	software Labtech notebook for analyzing signals
1 pc.	A/D card RTI 820 for PC
1 pc.	Hard disk colour system/PC
1 pc.	matrix printer colour system
1 pc.	overhead operator control panel
1 pc.	Vario transformer
1 pc.	frequency meter, digital
1 pc.	voltage meter, digital
1 pc.	thermometer, digital
1 pc.	temperature regulator
1 pc.	amperemeter
1 pc.	HFI protection relay
1 pc.	regulator for fan motors
1 pc.	current transformer
1 set	relay, cables, clamps etc.

350 kg tylose test packages 200 x 100 x 50 mm
150 kg tylose test packages 100 x 100 x 50 mm
50 kg tylose test packages with thermocouples, 200 x 100 x 50 mm
50 kg tylose test packages with thermocouples 100 x 100 x 50 mm
1,000 m Cu-Constantan thermocouples
2 pcs. Pressure transducers
1 set Software for testing according to ISO 5155.2

Rigid polyurethane foam for refrigeration with cyclopentane as blowing agent

Table 2

Properties of rigid PUR foam with cyclopentane as blowing agent

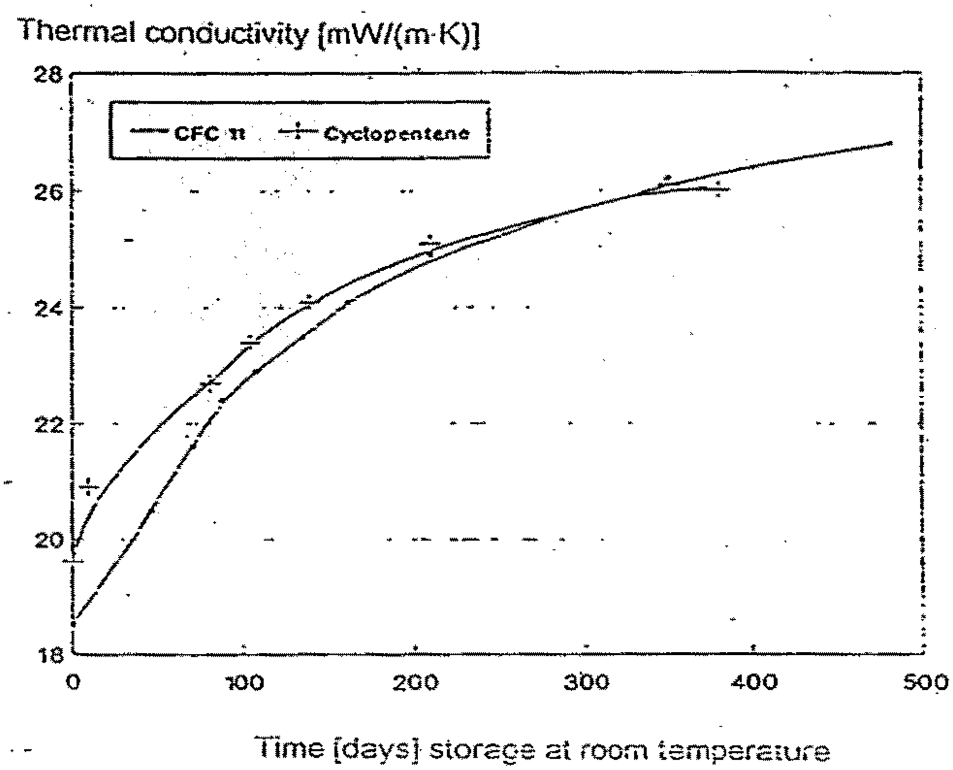
Blowing agent		Cyclo-pentane	n-Pen-tane	CFC 11
Polyol	[parts]	100	100	100
Blowing agent	[parts]	11	11	18
Isocyanate	[parts]	138	138	155
Molding density	[g/l]	39	39	34
Thermal conductivity* (initial K-value)	[relative %] [mW/m·K]	106 (18)	121 (20.5)	100 (17)
Compressive strength	[kPa]	140	140	120
Dimensional stability				
-30°C	[%]	<0.5	<0.5	<0.5
+80°C	[%]	<1.0	<1.0	<1.0

* Hesto lambda-control A 50-B single-plate instrument, mean temperature 23°C

Rigid polyurethane foam for refrigeration with cyclopentane as blowing agent

Figure 1

Ageing of diffusion-open rigid PUR foams



Note

The data in this publication are based on our current knowledge and experience. Due to the variety of possible effects during processing and use of our products, they do not free the processor from carrying out his own tests and trials. Our data must not be used to derive a legally binding assurance of certain properties or suitability for a particular application. Any protective rights and existing laws and regulations must be observed by the consignee of our products at his own responsibility.

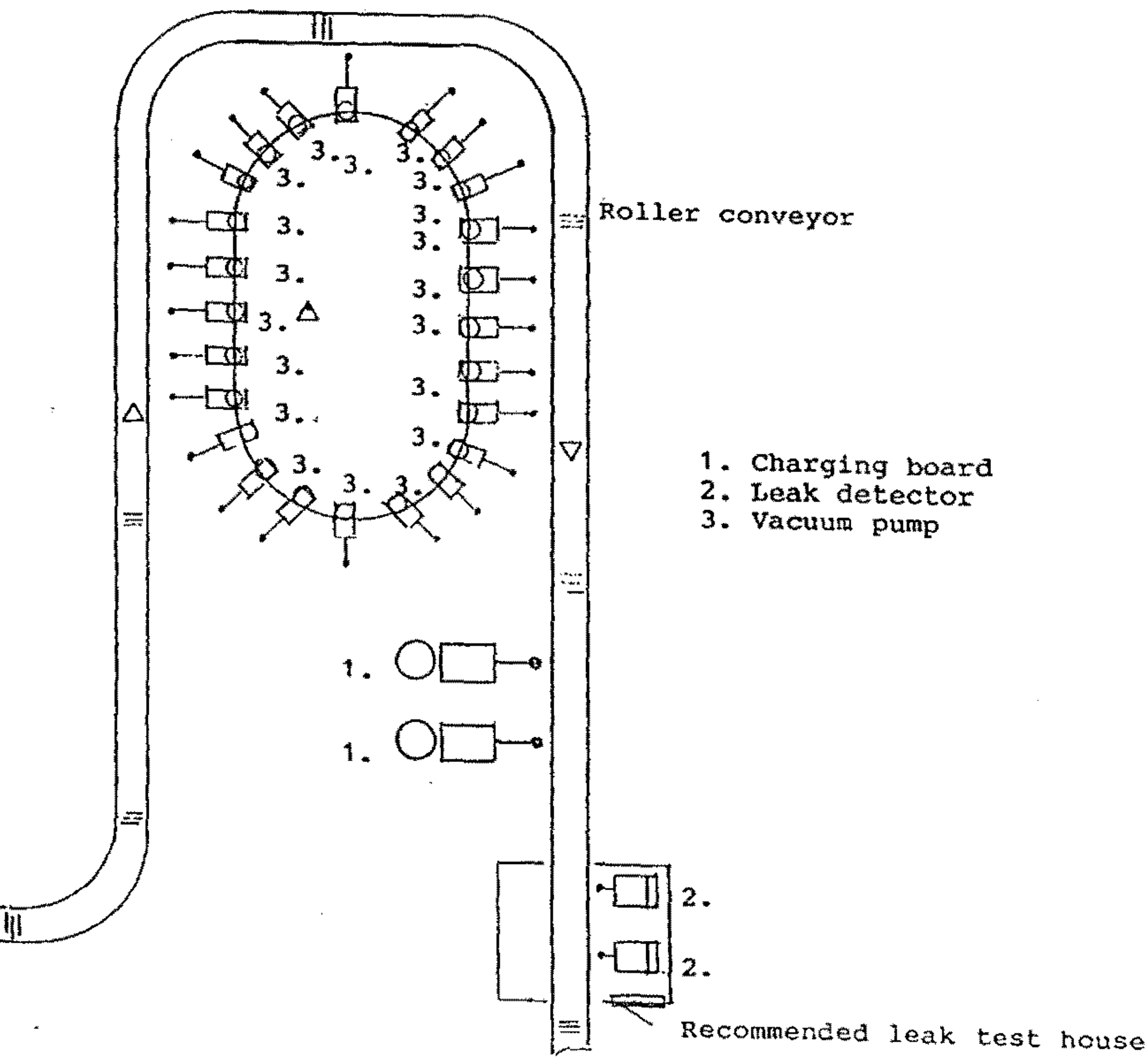
BASF Aktiengesellschaft
D-6700 Ludwigshafen

Edition 08/93

Annex H/1: <u>Current</u> and <u>proposed</u> new plant layout

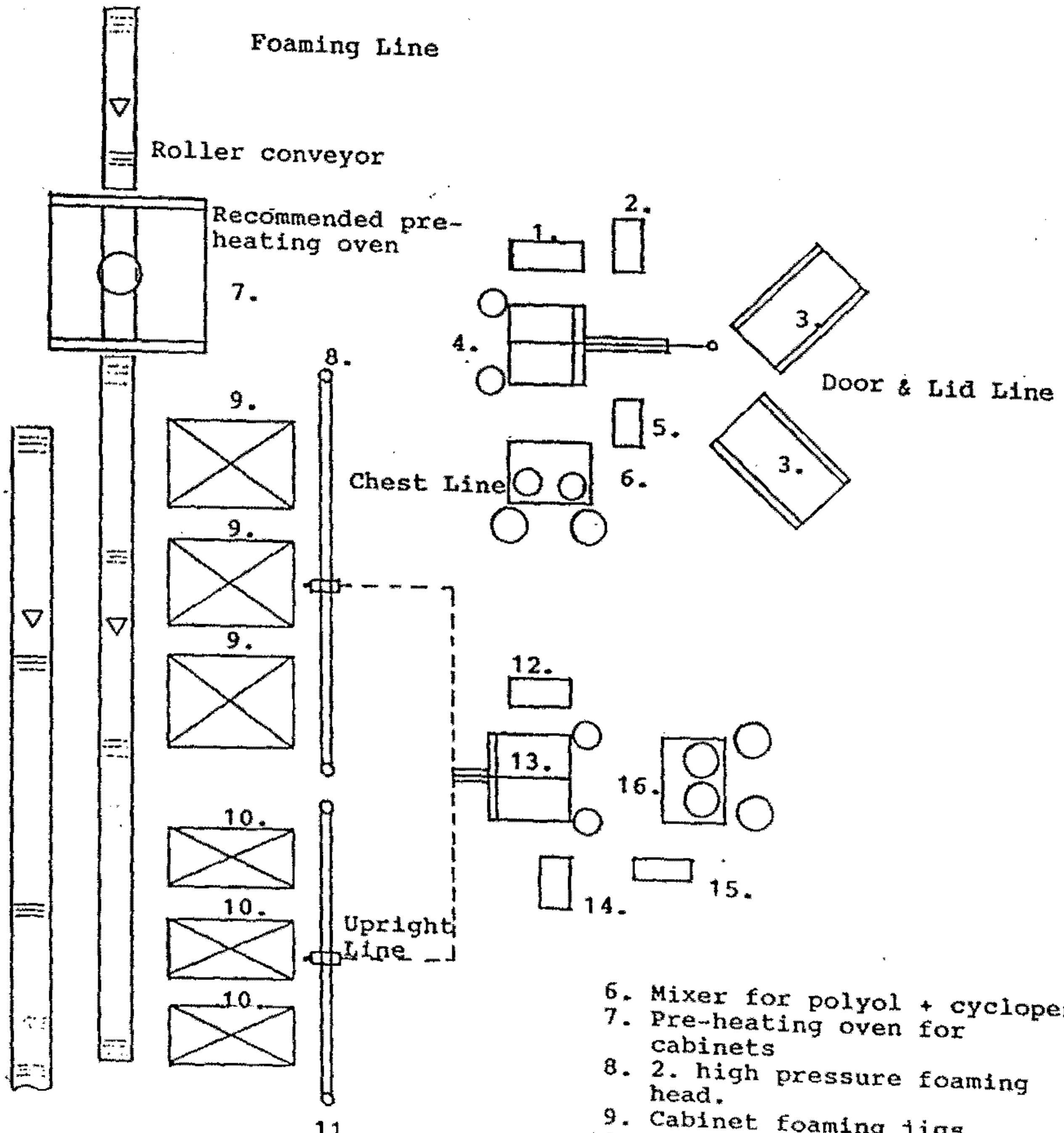
Kiriazi Refrigerators Manufacturing Co. S.A.E.
(KIRIAZI)

Refrigeration Line.



Annex II/2 : Current and proposed new plant layout.

Kiriazi Refrigerators Manufacturing Co. S.A.E.
(KIRIAZI)



1 Chiller for foaming machine
2. Control panel for high pressure
3. Door and lid foaming jigs
4. High pressure foaming machine
5. Control panel for mixer
16. Mixer for polyol + cyclopentane

6. Mixer for polyol + cyclopent.
7. Pre-heating oven for cabinets
8. 2. high pressure foaming head.
9. Cabinet foaming jigs
10. Cabinet foaming jigs
11. 2. High oressure foaming head.
12. Chiller for foaming machine
13. High pressure foaming mach.
14. Control panel f. foam. mc.
15. Control panel for mixer