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

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Montreal, 25-27 July 1994

PROJECT PROPOSAL: SYRIA

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

- Investment Project for Phasing-out of CFC at Al-Hafez Refrigerator Co.

PROJECT EVALUATION SHEET

COUNTRY OR REGION:	Syria
PROJECT TITLE:	Phasing out CFCs at Al Hafez Refrigerator Co.
BUDGET:	US $2,408,220 Incremental capital cost US $475,057[1] Incremental operational cost
INCREMENTAL COSTS:	US $2,883,277
ODS PHASE-OUT:	68.2 MT of CFC-11 and 38.5 MT of CFC-12
COST EFFECTIVENESS:	US $27.02[2] per Kg. ODP saved
PROJECT DURATION:	18 months
IMPLEMENTING AGENCY:	UNIDO
NATIONAL COORDINATING AGENCY :	General Commission for Environmental Affairs
TECHNICAL REVIEW COMPLETED:	YES _X_ NO _

SECRETARIAT'S COMMENTS

1. The project covers conversion of two domestic refrigerator manufacturing plants at Al Hafez Co, Syria. Implementation of the project will result in an estimated annual phase out of 68.2 MT of CFC-11 and 38.5 MT of CFC-12. It represents about 64 per cent of ODS consumption in the domestic refrigerator sector in Syria.

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

3. Refrigerator model redesign and the technical aspects of the conversion, including safety measures associated with cyclopentane application, will be supervised by specialized consultants appointed and fielded by UNIDO. A General Contractor will also be appointed by UNIDO for

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[1] Calculated for six months of operation.

[2] Determined as the ratio of incremental costs to the estimated annual savings of ODP (US $ ODP/kg.)

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.

4. 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 company 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.

5. 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 had started, i.e. 18 months from the time funds are received.

6. 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 these service units.

7. The existing plants have an interruptible power supply back up equipment. Two additional power back up generators requested in the project are not considered to be eligible for funding.

SECRETARIAT'S RECOMMENDATION

8. The Fund Secretariat recommends final approval of the project and approval of capital costs at US $2,408,220 for the two plants.

9. The approval of incremental operational costs at US $475,057 is contingent on a decision from the Executive Committee regarding the duration of operational costs.

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

PROJECT COVER

Country/Region:	Syria
Project title:	Investment Project for Phasing out CFCs at Al Hafez Co.
Sector Covered:	Domestic refrigeration (Rigid foams and Refrigerant) without commercial and industrial refrigeration
ODS Consumption in this Sector:	Estimated for 1993 80 MT of CFC11 and 85 MT CFC 12, totally 165 MT ODS. In Syria the total consumption of CFC 11 is 493 MT and of CFC 12 is 795 MT
Project impact:	Phase out of annual consumption of 68,2 MT of CFC 11, 32,5 MT of CFC12 for production and 6 MT for service (Total ODP= 106,7 MT)
Project duration:	18 months
Project economic lifetime:	10 years
Total proposed project cost:	US$ 3,310,816
Project cost:	US$ 2,509,521
Implementing Agency's overheads:	US$ 326,238
Incremental Operating Cost: (half year operational costs)	US$ 475,057
Proposed MF financing:	US$ 3,310,816
Cost effectiveness:	See Annex C: Unit Abatement cost
Counterpart enterprise:	AL HAFEZ CO. Damascus/Syria
Implementing Agency:	UNIDO
Coordinating Ministry:	General Commission for Environmental Affairs

PROJECT SUMMARY

This project will phase out 100% of the use of CFC 11 as blowing agent and of CFC 12 as cooling agent for the production of domestic refrigerators and freezers of Al Hafez Co. in their 2 factories in Syria: Al Hafez factory and Safa factory.

The chosen replacement alternatives are cyclo-pentane as foam blowing agent and HFC 134a as refrigerant in refrigerators and freezers. The project will include the redesign of the refrigeration system for all currently produced models and the conversion of the plant.

The redesign of the models covers activities like prototyping, performance testing, trial manufacturing and adaptation, as well as reliability tests. The conversion of the production facilities covers the refrigeration system, insulation foam blowing system and the refrigeration service sector of the company.

BACKGROUND

Sector Background

The subsector for domestic refrigerators and freezers in Syria consists of two large manufacturers Al Hafez Co. and Barada and many very small scale manufacturers: 79 for domestic refrigerators, 49 for domestic freezers and also many for industrial and commercial refrigeration. In 1991 the total ODS consumption in Syria in the domestic refrigerator and freezer branch (without industrial and commercial refrigeration) was about 165 MT from which 64,7% are consumed by Al Hafez Company.

Syria does not produce the CFCs. The total consumption of CFCs in the production of different polyurethane foams was about 450 MT in 1991 but the majority has not been used for this sector. The total consumption of CFC 12 in 1991 was 759 MT. 60% of all ODS consumed in Syria in 1991 were used in the commercial and domestic refrigeration and the air conditioning subsectors. The demand of ODS at the moment is stagnant, but it is estimated that it will increase in the future if the conversion is not made.

The total installed production capacities of Al Hafez Company are as follows:

	Al Hafez Factory	**Safa Factory**	**Totals**
refrigerators and freezers:	75,000	50,000	125,000

but at the moment both factories produce only 65000 units because of a market crisis in the Middle East.

Al Hafez Co. shares with their Al Hafez factory and their Safa factory together 40% of the refrigerator and freezer market in Syria and service about 20% of the refrigerators in Syria.

Based on a more than 15 years life expectancy for refrigerators and freezers, a total of about 2,300,000 refrigerators, about 230,000 freezers and about 36,500 industrial and commercial refrigeration systems were operating in 1991. And approximately 7% will be re-charged annually with about 62 MT of new CFC 12 during refrigeration service in Syria. Partly due to lack of equipment for the service sector, service staff often use CFC 12 for washing/flushing the cooling systems, instead of using vacuum pumps and charging boards. This causes an up to 100% higher CFC 12 consumption in the service sector.

Currently, Al Hafez Company does not produce low energy consumption refrigerators but does already produce low energy consumption chest freezers. The insulation thickness reaches the standards of today's refrigerator technology with 35mm insulation of refrigerators, 50mm insulation of vertical freezers and 75 mm of chest freezers, but does not yet follow the dimensions used by some advanced manufacturers for the Northern Europe market. Al Hafez Company follows the international standard and local Syrian standard S.N.S 1068/92 and 810/90.

Al Hafez Company's Background

Al Hafez Company is a 100% private company in the ownership of the Al Hafez family operating in the manufacture and sales of commercial and domestic refrigeration since 1951. Probably they are the oldest manufacturer or one of the oldest manufacturers in the Middle East. In 1965 their first factory (Barada) was nationalized and in 1977 they founded Al Hafez company again. Today their market share is 40% in Syria by refrigerator quantities and much above by turnover as they concentrate on the upper market sector. 10% of their production is exported.

Al Hafez Company employs 390 staff and the installed annual capacity is about:

Al Hafez Factory	Safa Factory	Totals
75000	50000	125000

From 1.1.93 to 31.12.93, the actual production was only 65000 refrigerator and freezer units. An increase of 10% per year is expected for the next four years.

Al Hafez Company produces a very wide range of refrigerators and freezers: 26 different models, partially also in different versions, starting from 5 cu.ft table top till 24 cu.ft large NO FROST 2 door refrigerators. 10 % of their production is chest freezers. The major part of their production is the large 18 to 24 cu.ft (509l to 670l), often NO FROST refrigerators following the large American size dimensions. All models are developed together with the company Lematic which also updates the design of each model every 3-4 years.

Recently Al Hafez Co. has built up a new washing machine factory.

The manufactured refrigerators are the following:

TWO DOOR NO FROST REFRIGERATORS:

Model	Volume	Refr. Volume	Freezer Volume
NT 2491	670l	454l	216l
NTW 2491	670l	454l	216l
NT 2090	560l	391l	169l
NT 2194	560l	391l	560l
NTW 2090	560l	391l	560l
NT 1887	509l	380l	129l
NTL 1887	509l	380l	129l
NT 1690	440l	305l	135l
NTL 1690	440l	305l	135l
NTW 1690	440l	305l	135l
NT 1390	369l	249l	120l
NTL 1390	369l	249l	120l
NTW 1390	369l	249l	120l

TWO DOOR DEFROST REFRIGERATORS:

Model	Volume	Refr. Volume	Freezer Volume
ET 2491	670l	446l	224l
ETW 2491	670l	446l	224l
ET 1887	522l	381l	141l
ETL 1887	522l	381l	141l
ETW 1887	522l	381l	141l
ET 1690	440l	305l	135l
ETL 1690	440l	305l	135l
ETW 1690	440l	305l	135l
ET 1390	369l	249l	120l
ETL 1390	369l	249l	120l
ETW 1390	369l	249l	120l

SINGLE DOOR REFRIGERATORS:

Model	Volume	Refr. Volume	Freezer Volume
CE 1990	522l	448l	74l
CE 1689	444l	396,5l	47,5l
CE 1390	369l	327l	42l
CE 887	210l	195l	15l
CEL 887	210l	195l	15l
HC 585	142l	127l	15l
HCL 585	142l	127l	15l

VERTICAL FREEZER:

Model	Volume	Freezer Volume
NVF 1487	417l	417l
VF 1487	417l	417l
VF 890	210l	210l

CHEST FREEZER:

Model	Volume	Freezer Volume
CF 1601	453l	453l
CF 1301	368l	368l
CF 1001	280l	280l
CF 801	227l	227l

Al Hafez Co. has 2 pcs modern high pressure PUR lines from Hennecke (HK650), each one in each of their 2 factories and totally 8 PUR fixtures for cabinets, all in bath position and heated

and 5 preheating ovens. 3 further fixtures are at the moment under construction. They have 17 plugs for the cabinets and chests and 21 moulds for doors from which 5 are used in a multilayer daylight press and 15 are single fixtures. Each of the 2 factories has its own lines consisting of:

- steel cabinet and door lines
- thermoforming lines
- preassembly lines for cabinets, chests, doors and small items
- PUR lines (5 cabinet fixtures at Al Hafez Factory, 3 cabinet fixtures at Safa factory)
- high pressure modern PUR machine, simple premixing station
- assembly lines
- evacuation and charging lines
- repair line
- testing line
- packing line.

Al Hafez Company uses standard polyurethane foam without CFC reduction. They use a density of 32 kg/m^3.

Al Hafez Co.'s equipment for foaming and refrigerator charging is 5 to 8 years old but in good condition. The foaming equipments are the following:

- 2 pcs high pressure foaming machines (Hennecke HK650) for cabinet, doors and chests, one for each factory

- 8 pcs automatic fixtures, electrically heated with 17 plugs in bath position for refrigerators and freezers, 3 of them are expandable for chest freezers

- 21 door moulds, from which 6 are to be mounted on a daylight press and 15 as single fixtures.

The fixtures are all electrically heated and Al Hafez Co. uses 5 preheating ovens in addition.

The premixing of polyol and CFC 11 is made manually by a balance.

In the charging and testing section, there exist in each factory 1 production line (total 2 lines) and 1 repair line (total 2 repair lines). In the evacuation, charging and testing areas, Al Hafez Co. has following equipment in their 2 factories:

- 40 pcs. vacuum pumps which can be cleaned and used for R134a.
- 2 pcs. automatic vacuum and charging stations (Danfoss), one for each factory
- 2 pcs. electronic leak detectors.
- 2 pcs. service evacuation and charging lines
- 2 pcs service leak detectors

Al Hafez Co. has a well equipped performance test laboratory in which they can simulate climate conditions up to 43°C. To optimize the R134a cooling system and to improve the quality, they still need some new equipment.

Al Hafez Co.'s Refrigeration Service

Al Hafez Co. has its own network of service shops all over in Syria with 5 main service centers in Damascus, Homs, Aleppo, Hama, Latakia and 10 service cars. Furthermore their refrigerators are serviced by their distributor's service shops. All the service centers are equipped with normal refrigeration service equipment; altogether 20 sets. Till today, there exists no CFC 12 recovery equipment for domestic refrigeration in Syria.

Al Hafez Co. services about 25000 units per year.

During the last 15 years, equal to the average life time for refrigerators and freezers, Al Hafez Co. has manufactured about 250000 units of refrigerators and freezers of which 5 to 10% is expected to require service each year.

With an average CFC 12 refrigerant charge of refrigerators and freezers of 0,300 kg + 30% for the loss, a total of 400 g weighted by the quantity of models serviced on the market, means the total use of CFC 12 for Al Hafez Co.'s service is about 6 MT of CFC 12. Only a part of the service needs recharge of freon.

PROJECT OBJECTIVE

The objective of this project is to eliminate the use of ODS as CFC 11 and CFC 12 in the production and services of domestic refrigerators and freezers at Al Hafez Co. through conversion to the use of HFC 134a as refrigerant for the refrigerators and freezers and cyclopentane as blowing agent for the polyurethane insulation foam.

PROJECT DESCRIPTION

Al Hafez Co. is prepared to phase out ODS in the refrigeration section as soon as the new technology has been acquired, the necessary machinery and equipment installed and the technical staff trained.

Among the technological options currently available on a commercial basis, Al Hafez Co. has chosen to replace CFC 12 by HFC 134a, as long as no better solution is available, because the new type of compressors are available, the technology is matured and commercially applied. For a hydrocarbon solution (isobutane or propane), the service problem in the Middle East is not yet solved and not controllable by the producer, so there is still a high risk of accidents if hydrocarbons are used as refrigerant.

For the blowing agent (CFC 11) for polyurethane foam, Al Hafez Co. has decided to avoid the application of any transitional substance and to introduce cyclopentane as an ultimate solution.

The refrigeration systems need to be optimized in connection with the change to the new components for HFC 134a refrigeration system in order to reduce the refrigerators' and freezers' energy consumption.

Assistance, through the project, is sought for:

a. Procurement of new machinery and equipment;

b. Rebuilding and partially replacing presently used equipment, such as vacuum pumps, PUR machines, fixtures, etc.

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

d. Installation, commissioning, training of national personnel in Europe and on-the-job training, trial operation and start-up etc.

For the 5 refrigeration service centers of Al Hafez Co., each center needs 1 recovery unit and 2 mobile recovery units for CFC 12 as well as 3 sets of equipment which will be used for servicing HFC 134a refrigeration systems, one in each center and each car only because the service of R134 refrigerators will start only in small scale.

The following machinery and equipment needs to be rebuilt, replaced or new has to be added:

A. Refrigeration System

- The 2 automatic production vacuum and charging boards of the 2 refrigerator and of the freezer lines -each in one of the 2 factories- have to be replaced by boards suitable for HFC 134a as the refrigeration system is sensitive to chlorine.

- The 3 service evacuation and changing boards (1 on both repair lines in the production and 1 in the laboratory) have to be replaced by systems suitable for HFC 134a.

- Because the 2 existing production leak detectors react on chlorine molecules, they need to be replaced by special leak detectors for R134a. Also 2 existing service leak detectors used in the repair lines have to be replaced.

- There exist 40 vacuum pumps. After having applied a special cleaning technology (described in Annex D) they can be re-used, but for a better vacuum control, needed for R 134a, they also need vacuum control manifolds.

- To optimize the cooling system for the application of HFC 134a in connection with the use of the new components for HFC 134a, new performance test for each model has to be completed.

Therefore some few new test equipment and material need to be provided.

- To optimize the cooling system and compensate for a little lower polyurethane insulation value due to the conversion to cyclopentane for the foam in comparison to CFC 12 foam and HFC 134a as the new refrigerant, it is necessary to optimize the cooling system as well as the energy consumption to keep an acceptable GWP value. The 5% higher thermal conductivity of the PUR foam blown by c-pentene in comparison to the one blown by R11, only existing in the first 10 months because of higher aging effects of R11, can be easier

compensated by its optimization, and thermal bridges can be removed. So no increase of insulation thickness with strong cost effects (modifications of PUR foam plugs, door moulds, thermoform moulds, plastic injected part moulds) will have to be made and such tremendous costs can be avoided.

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

- The drier for HFC 134a has to be with a desiccant with 3AA pores or a desiccant XH7 (Union Carbide).

- The cooling system must not contain any chlorine and max. 1% non-condensable gases, therefore, a new cleaning liquid has to be used.

- The capillary tube has to be optimized for an increased resistance at low evaporating temperatures because the volume flow with HFC 134a is about 80% of the volume flow with CFC12.

B. Foam system

- All equipment to the polyol section of the existing 2 high pressure machines (polyol tank (10 bar), and the polyol pumps, pipes) has to be replaced and parts of the heads have to be replaced and safety devices have to be added in all sections including the Isocyanate section.

- The existing 8 fixtures can be changed in the way that the c-pentane can be exhausted and that the electrical heater of the fixture will be automatically disconnected at the time of foaming and the fixtures will be entered in a house.

- The same can be made with the door jigs.

- The final specification of the cyclopentane to be used (purity and mix) will be defined after having carried out a market review in Syria and an assessment of its availability. The current price level is about US$ 1,73 including packing and transport. For the time being, there are no manufacturers of cyclopentane in Syria.

- Since cyclopentane and Polyol cannot be delivered premixed in drums or tanks (as CFC 11) it is necessary to provide a premixing station in each of the 2 factories of Al Hafez Co. For safety reasons, the premixing should be made outside the production building so that only premixed Polyol and not pure c-pentane will be transported into the foaming areas.

- For work safety using the highly flammable and explosive cyclopentane, it is necessary to have a gas detector system in the foaming department as well as a fire protection system, in each of the 2 factories.

- It is necessary to provide one tank for cyclopentane in each factory, in order to be able to automatically deliver the components to the premixing station.

To operate c-pentane PUR lines in Syria, the following conditions can only be accepted under the safety operation aspects:

1. The c-pentane tank has to be made under-ground 5-10 m away from the factory building

2. The pure c-pentane should not enter any working area so that the premixing should also be made outside the working area and factory building near the building, to avoid heating of tubes because of the very high viscosity of polyol for cyclo-pentane at low temperatures (+ 5°C).

3. Only well trained operators should enter the foaming area and should manipulate any jig inside the foaming area, and only specially trained maintenance technicians are allowed after stoppage and switching off of the PUR lines and machines, to enter the foaming area, the PUR machine rooms and premixing rooms.

   - To keep control over the new foaming chemicals as well as the foam (because of its higher density and lower insulation value), test equipment (specified in Annex 1: "Specification for Equipment") is necessary.

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

   - 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.

   - Because of the flammable and explosive cyclopentane, all machinery and equipment which will come in contact with the cyclopentane or the mix of polyol and cyclopentane have to be explosion proof. For cost reasons the construction should be made to the extend possible that all electrical components are positioned outside the foaming area or switched off like the electric heater of jigs (expensive water heaters are not necessary) during the time of foaming.

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

   - Al Hafez's technicians have to be carefully selected and trained at the equipment supplier's place in new foaming technology as well as in design/calculation and performance test and calculation/design of cooling systems. During the installation and starting up of the new machinery and equipment, the supplier's engineers will have to train Al Hafez's technical staff in all aspects of the operations. The result of the training have to be controlled before the operation of the equipment can be given over.

   - Storage tanks will be pressurized by nitrogen and cabinets or door jigs for foaming which will come into contact with c-pentane will be cleaned of air by nitrogen.

C. Refrigeration Service

Though Al Hafez have for each of this service centers 4 sets of R12 service equipment, we reduce it to 1 set per center and service car for R134a. So to cover the requested service in the future each of the 5 refrigerator service centers of Al Hafez Co. and each of the 10 service cars should get only 1 pc. R134a mobile charging boards, 1 pc electronic leak detectors for R 134a and 1 pc. of mobile recovery units for R12. Furthermore each center should collect the R12 from the mobile recovery units to send the R12 back to the reclaiming center for reclaiming by further stationary recovery units for R12.

This equipment will only cover Al Hafez' service centers but not the service shops for Al Hafez Co.'s distributors for refrigerators and freezers.

E. Justification for Selection of Alternative Technologies

All major manufacturers of compressors have agreed to use HFC 134a as replacement for CFC 12 as the new refrigerant for domestic refrigerators and freezers.

The alternative to use hydrocarbons like isobutane or propane or mixtures of it as refrigerant is already available on the market and used by some major producers in Germany and Italy, but their application in a Middle East country at this stage of development still seems risky. Even if we would change the cooling system construction in a way that the refrigerators will be supplied from the factory completely hermetically closed, there is a risk in the market that after the first unauthorized service, the system will not be correctly closed again and will cause an accident. In addition the filling requires very exact quantities with max. +/- 1 g and stronger deviation will cause higher GWP than the R134a. This exactness in filling in addition to the risks needs cartouch systems or very expensive charging equipment so that the price advantage of hydrocarbons in comparison to R134a is more than lost. In case such hydrocarbons really gain a large part of the market and the service men are aware of these new risks and the service conditions in these countries can be strongly improved, we will think again about switching to these new refrigerants or others cheaper than HFC 134a, but for the time being HFC 134a should be used in Syria.

For the new blowing agent of the polyurethane foam the situation is as follows:

Upon recommendation of the HCFC blowing agent manufacturers (HCFC 141b with ODP = 0,1 HCFC 142b with ODP = 0,065 and HCFC 142b/22 with ODP = 0,06) and one PUR manufacturer (ICI), many European, American and Far East manufacturers tried to use these blowing agents, but could not solve the technical problems. In addition HCFC would only be a temporary solution.

Nearly all refrigerator producers in Europe and the Far East have already switched or will switch in the near future to c-pentane as a blowing agent because of its good insulation values and cheaper costs of materials (inner liner, PUR quantities). The manufacturing technology with highly flammable and explosive c-pentane is meanwhile so mature and the control systems are so perfect and safe that it can be applied even in developing countries if some strict processing regulations are followed and regularly controlled and the staff in this

section are well selected and trained. But the technical solutions for c-pentane PUR foaming in developing countries have to be made as safe or even safer than the ones in Europe. We have to take into consideration that the workers in developing countries often do not have the high degree of professional education and theoretical knowledge of such complicated machines as in developed countries; this will increase the cost.

As far as possible, workers should not enter the closed PUR premixing room, the PUR machine room and the foaming area. Only very good trained operators and maintenance technicians with antistatic clothes and shoes should enter this section. Maintenance should only be made after all machines are switched off and strong ventilation backed up by emergency power supply - because of the power supply situation in Syria - are switched on.

The cyclopentane tanks as well as the premixing stations for mixing the c-pentane inside the Polyol compound should be placed outside the production building and closed so that no unauthorized person can enter this section. Inside the work building, only premixed c-pentane should be pumped and the double tube pipe should be placed in a way, that in the worst case no ignition and no accumulation of c-pentane up to the LEL-level in a closed unventilated room, trunk channel, etc. is possible.

The design of the machines, the layout of the building and piping of Polyol compound including c-pentane and every detail must be made in a way that it will fulfill the most strict safety and operation regulations in developed countries.

INPUTS

1. Capital Goods Replacement

   A. Refrigeration System

In the 2 factories the following equipment needs to be changed as well as new equipment is to be provided as specified below:

A.1 2 pcs. HFC 134a production refrigerant charging boards with vacuum pump, refrigerant supply pump and vacuum check;

A.2 2 pcs. HFC 134a service charging board with vacuum pump, refrigerant supply, pump for repair;

A.3 The existing 40 pcs.vacuum pumps have to be cleaned and refilled;

A.4 2 pcs. refrigerant supply pump for HFC 134a.

A.5 2 pcs production HFC 134a leak detectors;

A.6 2 pcs service HFC 134 a leak detectors for repair lines;

A.7 1 set of refrigerant test equipment and material for laboratory;

A.8 40 pcs. vacuum control for existing 40 pcs. vacuum pumps, which can be cleaned to be used for R134a, to increase the vacuum control on the more delicate R134a charging process;

B. Foam System

In the 2 factories the following equipment needs to be changed or new equipment has to be provided as specified below:

B.1 The major part of the 2pcs high pressure foaming machines for c-pentane each with two foaming heads and 2 heads as spare parts (replacing of Polyol tank, pump, pipes and refitting of mixing heads (2 in the production and 2 for spare parts, inserting pressure controls in all sections etc.) one for each factory;

B.2 2 pcs. premixing stations for cyclopentane and polyol, one for each factory;

B.3 2 pcs. gas detector system with control boards, one for each factory, each with 23 pcs gas sensors and 7 ventilation sensors for safety reason;

B.4 2 sets foam test equipment, mainly a balance, essential to control the foam and to avoid bubbles;

B.5 2 sets exhausting and ventilation systems, one for each factory;

B.6 8 pcs. foaming jigs for all refrigerator cabinets and chest freezers have to be refitted to get defined venting channels for c-pentane;

B.7 1 pc. foaming multi layer press for refrigerator doors have to be modified to get defined air channels;

B.8 15 pcs door foaming jigs have to be modified to get defined air channels;

B.9 17 pcs. refrigerator cabinet and chest foaming plugs (14 fixed and 3 expandable) for the jigs have to be slightly modified to get defined jigs venting channels;

B.10 21 pcs door foaming profiles have to be slightly modified to defined jigs venting channel;

B.11 2 sets of pipe installation ex-proof from cyclopentane tank to premixers and from premixing to polyol tank;

B.12 2 sets of antistatic floor cover, one for each factory;

B.13 2 sets fire protection systems, one for each factory;

B.14 2 pcs. tank for cyclopentane with all necessary safety devices pressurized by nitrogen, one for each factory;

B.15 4 pcs. pumps and pipe for tank, 2 sets of 2 pumps and pipes for both factories;

B.16 2 pcs. backup power supply systems for ventilators, one for each factory;

B.17 2 sets of houses for PUR machine, premixing station and foaming jigs, one for each factory;

B.18 2 sets of spare parts, one for each factory;

We propose a layout so that special heating of the pipes for high viscose polyol compound can be avoided. No chillers are needed as Al Hafez Co. must have it in the past for their Hennecke HK650 PUR machine.

C. Refrigeration Service

C.1 15 pcs. HFC 134a charging boards for refrigeration service, one for each of the service centers and one for each of the 10 service cars;

C.2 15 pcs. mobile recovery units for CFC 12;

C.3 5 pcs. stationary recovery units;

C.4 15 pcs. electronic leak detectors for HFC 134a, one for each of the 5 service centers and one for each of the 10 service cars;

2. Conversion/ Training

Within the framework of the project, personnel from Al Hafez Co. will be trained in (among others) the following areas:

- 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 material;
- safety regulations for flammable/explosive chemicals.

To select the right staff of Al Hafez Co., a profile of qualifications and skills and their level for each training has to be fixed to make sure that the training programs are effective and the standards of the qualifications necessary for the operation have to be controlled.

It has to be made sure that after the training, the selected and trained staff will really work on the agreed position in the factory.

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 costs for theses activities are included in the training component for technical staff, as well as in the international expert component.

As a common practice, modifications of the production lines will be carried out during evenings and off days and will therefore not cause any losses in the regular production. It is not necessary to stop the production except for a few days to switch the production from the old to the new equipment.

PROJECT IMPLEMENTATION

The project will be implemented by UNIDO in close cooperation with General Commission for Environmental Affairs. Local coordination will be carried out by Al Hafez Co.

The project will include supply of equipment, installation, commissioning, training in Europe and on-the-job training of Al Hafez's staff. In order to guarantee a proper transfer in particular of the new foaming technology using the highly flammable and explosive cyclopentane, the proposed contractor is requested to issue an "Operational Safety Statement".
For the operation of such technology using highly inflammable and explosive materials, a local authorization for the operation is needed and such lines have to be regularly controlled by the responsible local authority. The local authorities should be already involved in the stage of engineering of the plant to avoid that an installed expensive plant is not allowed to be started.

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

Any construction work needed to accommodate the equipment for the new foaming technology using cyclopentane will have to be carried out by Al Hafez Co. and is not reflected in the project budget. The specification for construction work will be elaborated by the selected contractor after project approval and as an outcome of his necessary site inspection.

The proposed tentative work plan of the project implementation is as follows:

ACTIVITIES

	Months: 1 2 3 4 5 6 7 8 9 10 11 12 14 16 18
General:	
1. Sign the project,receive funding	X
2. Make a detailed project workplan	X
3. Initial training of management	X
FOAM:	
4. Selection of equipment	XXXXXXX
5. Authorization by local authorities	XXXXXXX
6. Training	X XX
7. Manufacturing of equipment, installation, commissioning	XXXXXXXXXXX
8. Start production	XXXXXXX
REFRIGERANT:	
9. Redesign of models, training	XXXXXXXX
10. Selection of equipment	XX
11. Purchase, installation and commissioning	XXXXXXXX
12. Prototypes and testing	XXXXXXXXXXXXX
13. Start production with HFC 134a	XXXXXX
Refrigeration Service:	
14. Selection of equipment	XXXXXX
15. Purchase, installation commissioning and training	X XX

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

PROJECT COSTS

I. INVESTMENT COSTS

The investment costs will cover capital investment costs for modification of manufacturing facilities, new machinery, materials, testing equipment, training, installation and consultancy services for modifications. Capital investment costs are shown in Annex A: "Equipment Specification and Cost Breakdown".

II. INCREMENTAL OPERATING COSTS

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

Modification	Incremental cost (US$)
- HFC 134a compressor	5,95
- Capillary tube modification	0,10
- Condenser modification	1,10
- Evaporator modification	2,00
- 3 AA drier	0,05
- HFC 134a refrigerant	0,92
- Extra cost for foam with cyclopentane and higher density(+15%) minus lower blowing agent costs	0,90
Total	US$ 11,02

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 level is higher than in the other projects because 50 % of real Al Hafez refrigerator production are large refrigerators of 18 cu.ft (509l) and above and further 20% large freezers which need large compressors with a size of more than 220W and capacity of more than 195 Kcal/h. Furthermore half of their production are NO FROST models which increase the absolute and respective also relative cost by the switching from R12 to R 134a in the components.

All the prices are without customs duty and tax.

The price's increase will be caused by:

- compressor for the new HFC 134a compressor and 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), averaging to 10%;

- capillary tube prolongation and changes (average plus US$ 0,10);

- evaporator and condensers in the average 1-2 coils or 1-2 serpentine or few fins larger, average US$ 2,00 respective US$ 1,10 more;

- HFC 134a charge about 16% less than with CFC 12 based on an average charge weighted by the produced quantities of 0,4 kg CFC 12 at US $3,00/kg as a current price and a current price for HFC 134a at US $5,75/kg, excluded any customs tax: 0,400 kg x 0,84 x US $(5,75 - 3,00)/kg = US $0,924;

Comparative cost analysis of foam systems

R11 System				Cyclopentane System			
Chemicals	Weight %	Price/kg	Cost US$	Chemicals	Weight %	Price/kg	Cost US$
Polyol+ MDI	86	1,60	1,376	Polyol + MDI	94	1,70	1,598
R11	14	3,30	0,462	c-pentane	6	1,73	0,1038
		Average:	1,838			Average:	1,7018

Ph costs $/kg:	1,838	Ph costs $/kg:	1,702
Kg per unit:	7,5	Kg per unit:	8,63
Total costs $/unit:	13,79	Total cost $/unit:	14,69

Incremental cost difference: US $0,90.

The operating cost of the enterprise after the conversion is not expected to change much: 5 more experienced persons with higher wages (5 persons each US $25,000.00 per year) minus 2 persons with lower wage (US $13,000,00 each) because of the automatization and more complicated machines and safety precautions which will increase the costs of 1 year for each of the 2 factories by US $99,000.00 per year.

In the last 12 months Al Hafez produced 68,250 units. So the total incremental operating cost increase will be (68,250 x US $11.02)+(2 x US $99,000) totaling US $ 950,115. from which the incremental cost of half a year will be covered by the Fund: US $ 475,057.

Costs for transport and insurance of capital equipment is included in the allocations of the budget for the respective items.

III. CONTINGENCY FUND

A contingency fund (15% of the total budget) is proposed to cover unforeseen expenses which might be incurred during the project implementation, e.g. purchase of small testing instruments which will be needed during the conversion process, miscellaneous expenses, etc.

IV. TOTAL COSTS

- Investment cost, see Annex A: "Equipment Specification and Cost Breakdown".
- The net incremental operating cost as above.
- Executing agency's overhead cost are 13%.
- For the complete cost breakdown see Annex B: "Project Budget"
- For the calculation of the unit abatement cost see Annex C: "Unit Abatement Cost".
- Requested funding by the MFMP: US$ 4,450,098.50

(1) It was agreed that Al Hafez will request the Montreal Fund to cover the incremental operating cost for a half year of operation of the converted plant.

Annex A:

Investment with Equipment Specification and cost Breakdown

	Description	Qty.	Unit cost US$	Total cost US$
A.	Refrigeration System:			
A.1	Charging board for HFC 134a	2	30,500	61,000
A.2	Repair charging board for HFC 134a	2	1,000	2,000
A.3	Vacuum pump (40 renovations)	40	100	4,000
A.4	Refrigerant supply pumps	2	7800	15,600
A.5	Production leak detector for HFC 134a	2	10,000	20,000
A.6	Electr. leak detector for R134 for repair line	2	250	500
A.7	Test equipment for prototypes	1 set	31,250	31,250
A.8	Vacuum control (for existing pumps)	40	70	2,800
A.9	Prototype Material	26 sets	1,000	26,000
B.	Foam System:			
B.1	High pressure foaming machine with two heads rebuilt and 2 spare heads rebuilt	2	160,000	320,000
B.2	Premixing station	2	80,000	160,000
B.3	Gas detector system	2	70,000	140,000
	- Gas feelers	46	1,500	69,000
B.4	Foam test equipment	2 sets	1,000	2,000
B.5	Exhausting and ventilation	2 sets	190,000	380,000
B.6	Modification of foam jigs for cabinet/chest	8	12,000	96,000
B.7	Modification of daylight press for doors	1	20,000	20,000
B.8	Modification of foam jigs for doors	15	3,200	48,000
B.9	Modification of foam plug for refrigerator	17	10,000	170,000
B.10	Modification of foam moulds for doors	21	3,500	73,500
B.11	Pipe installation from tank to premixing stations	2 sets	10,000	20,000
	Pipe installation from premixing to PUR machine	2 sets	11,000	22,000
B.12	Antistatic floor	700 m^2	38	26,600
B.13	Fire protection system	2 sets	9,000	18,000
B.14	Tank for cyclo pentane	2)	42,000	84,000
B.15	Pumps, pipe work for tank	2)		
B.16	Power supply backup	2	45,000	90,000
B.17	Materials for starting up (10 sets of 26 models each at US $300)	10x26	300	78,000

C. Refrigeration Service:

C.1	Charging board for service	5	1,000	5,000
C.2	Recovery unit for CFC 12	5	1,500	7,500
C.3	Recovery bags for CFC 12 (mobile)	45	18	810
C.4	Electronic leak detector for R 134a	15	250	3,750
C.5	Incremental spare part costs	1 set	500	500
	Subtotal*		USD	1,997,810

* The following equipment and installation work are not included in the budget:

a. Pre-heating ovens for foaming (existing);

b. Roller conveyor or conveyors for transport of cabinets in and out of pre-heating oven and foaming jigs.

c. Tank and installation for pipe lines for HFC134a to the charging boards.

d. Any building work inside and outside for the installation of the tank and the premixing station for cyclopentane.

e. Any special place for the truck as well as for the pipe delivery system from truck to tank for cyclopentane.

f. Any change of lay-out in factory which requires changing the position of the machinery and equipment as well as new installation of the old equipment.

g. Steel construction for floor for new foaming equipment.

Tax & Custom Duty are not included in the prices for the machinery and will not be covered by this project.

Specification for Machinery

A. Refrigeration System:

A.1 Evacuation and charging board for HFC 134a for production.
Fully automatic board with vacuum check
2 stages vacuum pumps 8 m^3/h
4 charging channels - built-in supply pump
Refrigerant: HFC134a
Charges: Min 50g - Max 2200 g +/- 1% or 1g

A.2 Evacuation and charging boards (normally used in service) to repair line.

A.3 Vacuum pump renovation
Min capacity 8 m^3/h
Time for evacuation to vacuum level for the appliances
Max 15 minutes
Maximum limit of non-condensable gases 1% (vol) after evacuation

A.4 Refrigerant HFC 134a supply pump

A.5 Leak detector for production for HFC 134a
Type HLD 400
Sensitivity range: 0.5 to 150g/year.
Microprocessor controlled.
Calibration gas: HFC 134a
Calibration: Automatic by the incorporated leak standard

A.6 Electronic leak detector for repair line

A.7 Test equipment for performance test for HFC 134a
The test equipment is completed by:

a. Pressure transducers for HFC 134a for suction and discharge pressure range +/- 0.005 bar
b. Materials for prototypes
c. Computerized refrigerator test recorder with PC, registration program, temperature interface and 2 feelers, humidity interface and feeler, printer,
d. Performance test materials acc. to ISO 7371
e. Service charging board for HFC 134a
f. Service leak detector for HFC 134a

A.8 Vacuum control for existing pumps (pressure gauge/switch).

B. Foam System:

B.1 The existing 2 pcs. high pressure foaming machine Hennecke HK 650 has to be rebuilt for cyclopentane and the polyol sections have to be replaced. Some safety devices (pressure control) even in the isocyanate section have to be added so that at the end each machine comprises the following assemblies:

1 pc Special metering pump NG 28 P for polyol-pentane, in corrosion-proofed design, suited for a prepressure of 10 bars, nominal output 40 (32) l/min., with high-capacity rotary shaft seal and leakage monitoring device.

1 pc Additional venting valve of the pump housing with return to the work tank (closed design)

1 pc Metering pump NG 28, max. nominal output 40 (32) l/min. for Isocyanate

2 pcs AC motors 15 kW/1,500 rpm (11 kW/1,200 rpm) for polyol and isocyanate

1 pc Hydraulic unit with 2 accumulators, valves and accessories

1 pc Leakage-free special filter on suction side in rust-proof design for polyol-pentane mixture

1 pc Edge filter on suction side in corrosion-resistant design for isocyanate

2 pcs Contact pressure gauge with min. contact, suction side 2 pcs Contact pressure gauge with min./max. contacts, pressure side

2 pcs Safety valve in special steel design

2 pcs Throttles valve for setting the circulation pressure, placed in media return lines Polyol throttle valve equipped with connection to leakage monitoring device

2 pcs Removable, large-sized leakage basin inside the machine frame

4 m Flexible lines to the mixhead

1 pc Throttle-controlled mixhead with:
2 hydraulically controlled recirculation injectors for
polyol and isocyanate, polyol injector equipped with leakage monitoring device,
1 hydraulically controlled injector for inertizing the to be foam filled cavity
1 hydraulically switched, adjustable mixture throttle
1 cleaning piston
1 removable outlet pipe (with 2-component)

1 pc Device for checking the switching function of the isocynate- mixhead nozzle (a polyol-pentane mixing as single component is not possible)

1 pc flow sensor for nitrogen-gas for inertizing

1 pc Tank station consisting of:

1 pc Work tank, special design suitable for pentane, size 250 liters, operating pressure up to 10 bar for polyol/pentane mixture, double-walled for temperature control with unpressurized water, inner shell made of stainless steel
with
1 stirrer driven via coupling and motor (no stirrer shaft seal)
1 filling level sensor for continuous measurement via the refilling control system
1 filling level sensor for preventing overfilling, in compliance with the regulations of the local water resources law
1 set of fittings and accessories for connecting nitrogen supply
2 pneumatically driven self-closing safety ball valves with solenoid valves
1 non-return valve 10 bar, firmly set
1 safety valve, adjustable, for limiting the rise of tank pressure during refilling

Tank design in compliance with the regulations valid in one of the developed countries with the highest safety standards, delivered with a test certificate like TÜV.

Tank design in compliance with the regulations valid in the one of the developed countries with the highest safety standards delivered with a test certificate like TÜV.

1 pc Temperature control device in special design for polyol/pentane

for raw material temperature control via the double jacket of the work tank; with electr. heating of 5kW and 1 cooling system for direct cooling by means of cold water of about 14°C produced by a chiller as cold water is not available in this country at all times of the year.

1 pc System for automatic transfer from the premixing station polyol/blowing agent mixture

The filling level is measured and displayed by a sensor (component of tank). When the set min. filling level has been reached, the premixing machine is started and the filling valve of the work tank is opened.

When the set max. filling level has been reached, the replenishing procedure is finished.

The filling process is monitored by a timer. When the time is exceeded, filling is interrupted immediately and a signal is given. When the overfilling sensor is reached/responds, the replenishing procedure is also interrupted and a signal is given.

This filling control has interfaces for a superior safety control and corresponds to the valid regulations in developed countries.

A necessary chiller to temperate the tanks is not delivered as this should exist on the existing PUR machine from Hennecke HK 650.

B.2 1 pc Pre-mixing station

Independent unit for automatic metering and mixing of polyol with pentane
The pre-mixing station is a metering device for the production of polyol/pentane mixture with a constant mixing ratio which can be preselected.
The premixing station operates according to the principle of difference metering. By means of the first part of a tandem pump, a partial quantity is taken from the constant polyol stream metered by the main pump. The other half of the tandem pump delivers a defined greater volume back into the polyol stream resulting in an automatic feeding of the missing partial quantity out of the pentane line which is under pre-pressure.

The required mixing ratio can be set by means of the frequency-controlled drive motor of the tandem pump.

The pentane throughput is precisely recorded and documented by means of a mass flow meter; the polyol throughout by means of a gear-type flow meter. The mixing of the component streams meeting each other takes places by static mixing elements. The tightness of the system towards the outside is obtained by the design (tandem pump) and the use of suitable construction elements. In order to avoid corrosion by hydrous polyols, all component-contacting parts are corrosion-resistant. Only sealing materials with proven resistance to polyol, pentane and nitrogen have to be used.

The advantages of the metering principle are:

- high metering accuracy by favourable Polyol/blowing agent ratio and favourable viscosities of the fluids (no pure blowing agent)
- high metering accuracy obtained by small pressure differences at the metering pumps
- no blowing agent leakage
- good mixing by static mixer

The Premixing station consists of the following construction elements:

1 pc edge filter
1 pc contact pressure gauge 0-10 bar
1 pc gear wheel metering pump set for basic Polyol
1 pc gear tandem pump set for metering of blowing agent
2 pcs static mixer kits
1 pc pressure switch 0.100 bar
1 pc pressure gauge 0-60 bar
1 pc safety valve on the Polyol side
1 pc flow meter for blowing agent
1 pc special shut-off valve for blowing agent
1 pc contact pressure gauge 0-10 bar (blowing agent)
1 pc pipe filter
1 pc pneumatic safety shutoff valve (blowing agent)

All connecting pipe lines made of special steel; with special screw connections.
As secondary safety equipment, the Premixing station has to include an overall casing with an exhaust socket (DN 100) -at the lower third of the back wall - for connecting a run-controlled fan to be provided separately (below); design for example in accordance with VDMA regulation 24169, part 1;

1 pc 1 electr. control system

By means of this electric control, given rated values are automatically monitored and kept constant in a closed control circuit within given limit values.

Control, data entry and display of relevant parameters are effected via PC compatible control computer with a 16-line LCD display as well as a foil keyboard.

Control:

- Switching motors and valves on and off as well as corresponding monitoring functions
- Pressure monitoring (contact pressure gauges),
- Switching the machine off in case limit values are exceeding
- Error message: optical and acoustical fault indication, message in plain language on the LCD display

Operation modes:

a) automatic operation
b) manual operation
c) test operation

Data entry:

via function keys with LEDs or entry keys; entry of desired blowing agent portion as well as entry possibility for correction factor for converting the flow quantities.

Data display:

- Rated value of blowing agent portion
- Actual value of blowing portion
- Throughout quantity

Technical data (with 59 cycles)

In general:

- adjustable blowing agent portion	4 - 25 vol %
- necessary Polyol entry pressure	min. 4 bar, max. 10 bar
- necessary Pentane entry pressure	min.3 bar, max. 10 bar
- exit pressure of mixture	max. 15 bar
- compressed air supply	min. 5 bar
- Polyol viscosity	max. 10,000 m Pas

The connecting line from Premixing station to work tank (Polyol- Pentane-mixture) has to be designed for an operating pressure of 60 bar.

output of basic Polyol min.	9,2 l/min.
drive	N = 1,1, kW
output of blowing agent:	
- continuously adjustable -	0,36 to 2,3 l/min.
drive of tandem pump	N= 1,1, kW

B.3 Gas detector system with control board for gas sensors and 9 air flow controls of fan motors
Number of gas sensors: 23 pcs
Flammable limits: In air 1.4-8%

B.4 Foam Test Equipment
Scale 0-1000gr +/- 0.01g
Measuring glass 0-1000 cm^3 +/- 1 deviation
Shearing box for foam
Foam knife
Stirrer
Laboratory cup for foam
Freezers to measure dimension stability are existing

B.5 Exhausting and ventilation
Capacity: 2 steps a min 4000 m^3/h and min 8000 m^3/h
Air change: 53 times per hour
Total capacity: Min 16000 m^3/h
Point exhausting: Min 30 pcs
Ex-proof or placed outside O-Zone

B.6 Foaming cabinet jigs modification
Electrical heating elements and all electric components have to be automatically disconnected at time of foaming.
Earth connection of jigs.
Automatic opening, in and out of cabinets
Path position
Gas venting profiles with connectors to exhaust system

B.7 Modification of daylight press to get different air channels and disconnection of electrical components.

B.8 Foaming door jigs modification
Electrical heating elements and all electric components have to be automatically disconnected at time of foaming.
Earth connection of jigs.
Automatic opening, in and out of cabinets
Path position
Gas venting profiles with connectors to exhaust system

B.9 Modification of the refrigertor foam plugs.

B.11 Pipe installation from tank for cyclopentane to mixing stations with double wall tubes and leak control (Built-in SD valves for separation into sectors in case proposed layout will not be followed)

Pipe installation from premixers to foaming machines double wall tubes or hoses without any assembly, with leak control for polyol.
(Built-in SD valves separation into sectors in the polyol line in case proposed layout will not be followed).

B.12 Antistatic floor
Painting of floor in foaming area with antistatic paint

B.13 Fire protection systems
Foam spray system for polyurethane chemicals and cyclopentane according to local regulation

B.14 Tank for cyclopentane
30 m^3 capacity, made of double wall steel
Pressure: 7 bar
Insulation of tank
Valves and fittings for connection
Connection for nitrogen pre-pressure

B.15 Pumps and Pipe work for cyclopentane tank
2 pcs. double pumps ex-proof of which one is only used during repair works of the other
Level control for tank with shut-down valve
2 pcs. gas detectors connected to the gas detector system of the PUR machine
Pump for tank for loading at tank
Level control at leak container for cyclopentane

B.16 Power supply backup station to ensure venting during power supply interruption.

B.17 House for foaming jigs
Steel house with connection for ventilation and exhausting and an improved exhausting at jigs built around the foaming jigs

C. Refrigeration Service:

C.1 Service charging board for HFC 134a
manually operated
2-stages vacuum pump
Refrigerant: HFC 134a
Charge: 50g to 500 g +/- 5g
Hoses connection with quick connectors

C.2 Recovery unit for CFC 12
Capacity: 1100g CFC 12

C.3 Mobile Recovery unit for CFC 12 (Recycling system)
Capacity: 1100g CFC
Type RE-I
Oil separator

C.4 Electronic leak detectors for HFC 134a for service

Annex B: Project Budget

Budget line	Description	Duration w/m	Budget US$
	General consultancy in production layout, refrigeration production and refrigeration system design as well as the changes in construction because of changing the foaming position, preparation of technical specifications, assistance for technical and commercial evaluation of bids, supervision of construction and of the plant etc.	8.0	80,000
	Consultancy service in checking/ex-proofing of PUR machine, tanks, premixing and foaming places, preparation and introduction of safety rules, regulations and manuals, safety training of staff	4.0	20,000
	Local subcontract for provision of: * 2 Tanks for cyclopentane * 2 sets of pumps, pipe work for tank, * 2 sets of pipe installation from tank, from tank to premixing and from premixing to PUR machine and from PUR machine to foaming place * 2 sets of antistatic floors including installation and commissioning of the system		152,600
	Local subcontract for provision of: * 2 sets of fire protection system including equipment installation, training and commissioning of the system		18,000
	Subcontract for provision of: * 2 sets of exhausting and ventilation including equipment installation and commissioning of the system		380,000
	Study Tours: Study tour (2 weeks) of three AL Hafez Co.'s Managing Director and chief engineers to potential suppliers of foaming refrigeration technology, machinery and equipment to be familiar with technical, safety and commercial modalities of plant conversion	1.5	20,000

Training:			
Individual/small group training abroad of four Al Hafez's engineers in new foaming technology, testing, maintenance, quality and safety control		4.0	20,000
A. Foaming System:			
- Machinery; service and starting up			1,388,000
2 pcs	Rebuilt high pressure foaming machines (cabinets and doors)	320,000	
2 pcs	Premixing stations	160,000	
2 sets	Gas detector systems with sensors	209,000	
2 pcs	Foam test equipments	2,000	
2 pcs	Power backups	90,000	
8 pcs	Modification of foam jigs for cabinet and chest	96,000	
15 pcs	Modification of foam jigs for doors	48,000	
1 pce	Modification of daylight presses for doors	20,000	
17 pcs	Modification for plugs for cabinets and chest	170,000	
21 pcs	Modification of moulds for doors	73,500	
equipment, installation, commissioning & local training (9 weeks, two supervisors and 2 engineers 2 weeks)		96,500	
10 sets Material for starting up x26 models (each US $300,--)		78,000	
B. Refrigeration System:			
- Machinery:			191,190
2 pcs	Charging boards for HFC134a	61,000	
2 pcs	Charging boards for repair line	2,000	
40 pcs	Vacuum pumps renovation	4,000	
2 pcs	Refrigerant supply pumps	15,600	
2 pcs	Production leak detectors	20,000	
2 pcs	Repair of leak detector	500	
40 pcs	Vacuum controls,	2,800	
Equipment installation, commissioning & local training (two weeks, 1 specialist)		11,520	
Test and monitoring equipment		31,250	
Materials for prototypes, including equipment installation, commissioning & local training (3 weeks, 1 specialist)		26,000 16,520	

D. Refrigeration Service			
- Machinery			24,320
5 pcs	Charging board for service	5,000	
5 pcs	Recovery units for CFC 12	7,500	
45 pcs	Recovery bags for CFC 12	810	
15 pcs	Electronic leak detectors	3,750	
1 set	Spare parts	500	
Equipment installation, commissioning and training (1 week, 1 specialist)		6,760	
Subtotal			2,294,110
Miscellaneous: Contingency Fund (10% of the costs of all equipment, and services calculated)			215,411
Subtotal I			326,238
Agency's Overheads (13% of all)			
Subtotal II			2,835,759
Incremental operating cost (half a year of operation)			475,057
TOTAL		US$	3,310,816

Refrigeration Service (Unit Abatement Cost)

By investment in recovery units, it will be possible to recover about 50% of the used CFC12 from the refrigerators and freezers for service, if a central reclaiming station for CFC 12 will be established in Syria.

Al Hafez's service organization is expected to service about 25,000 refrigerators and freezers per year with an average CFC12 refrigerant charge of 0,40 kg CFC 12; but not all need recharging.

Based on an investment for refrigerant servicing recovery equipment of CFC 12 for US$ 8,310.00 and an average reclaiming of CFC12 per year of 1,5 MT ODP the annualized capital cost per kg ODS saved will be only US$ 1,352.04 (10 years life time and 10% discount rate). So for the recovery service we will come to Unit Abatement Cost of US$ 0,90/kg ODP phased out.

The above mentioned is based on delivery of recovery units to all Al Hafez Co.'s main service centers, but not to the service shops of their distributors.

Annex C: Calculation of Unit Abatement Cost:

A	ODS Phase out		Total Project
A1	Average use of CFC 11 per year	MT	68,2
A2	ODP of CFC 11		1
A3	ODP-weighted CFC 11 phase (A1*A2)	MT	68,2
A4	Average use of CFC 12 per year plus service	MT MT	32,5 6
A5	ODP of CFC 12		1
A6	ODP weighted CFC 12 phase out (A4 x A5)	MT	38,5
A7	Total ODP-weighted phase out	MT	106,7
B	Annualized capital cost		
B1	Total investment cost (model redefinition + production conversion)	US$	3,345,983
	Equipment life	Year	10
B3	Discount rate	%	10
B4	Annualized capital cost (B1 x 0.1627)	US$	544,391.43
C	Annual incremental recurrent cost (1/2)	US$	475,057.50
D	Unit Abatement cost		
D1	Annualized capital cost per kg ODS phase out (B4/(A7 x 1000)	$/kg	5,10
D2	Annual 1/2 incremental recurrent cost per kg ODP phased out (C/A7 x 1000)	$/kg	4,45
D3	Unit abatement cost (D1+D2)	$/kg	9,55

* Without the investment for the refrigeration service (US$ 34,320 + 8% + 13% = US$ 41,884.13 the annualized capital cost per kg ODS phased out will be US$ 537,576.89 divided by 100,700 kgs ODP the Unit abatement cost without the investment for refrigeration service will be US$ 5,34 for the investment plus US$ 4,72/kg for 1/2 incremental costs totalling US$ 10,06/kg ODP with less phasing out of ODP.

Annex D: Cleaning Technology for Vacuum Pumps

If vacuum pumps which have been used for evacuating of CFC 12 systems have to be used for HFC 134a refrigeration systems, it is possible to clean the pumps and use them, if:

a. the vacuum pump is in good condition; and
b. the vacuum pump has a minimum capacity of 8m(3)/hour.

Cleaning process

1. Replace the hose from the vacuum pump to the connector (Hansen coupling) for the service tube of the compressor (or filter) with a new one;

2. The connector (Hansen coupling) can still be used also for HFC 134a refrigerator system;

3. Load the vacuum with about 50 cm3 Ester oil via the hose and start the vacuum pump. Let it run for 30 minutes;

4. Empty the vacuum pump of the used Ester oil and charge it again with 50 cm3 Ester oil;

5. Start the vacuum pump and let it run for another 30 minutes;

6. Empty the vacuum pump for the second time and recharge it with 50cm3 of Ester oil;

7. Start the vacuum pump for the third time and let it run for 30 minutes;

8. Empty the vacuum pump and now it is ready for use for HFC 134a refrigeration systems;

9. Connect the vacuum pump to a HFC 134a refrigeration system and evacuate the system down to the specified vacuum level;

10. Connect the refrigeration system to the HFC 134a charging board and re-evacuate. Charge again with the specified amount of HFC 134a;

11. Start the compressor and let the system run for about one hour. If some mineral oil or chloride is still left the vacuum-pump on the suction side it will be transferred to the HFC 134a refrigeration system and the capillary tube will be blocked after few minutes.

Note: After the vacuum pump has been washed with Ester oil, it should only be used for HFC 134a refrigeration systems.

WS Atkins Consultants Limited
Technical Review

1. Country of Origin : Syria

2. Project Title : Investment Project for Phasing out CFC's at Al Hafez Co. (Foam Aspects)

3. Sector / sub-sector : Domestic Refrigeration / Rigid Foam installation

4. Relationship to Country Programme

Not known

5. Technology

a) Cyclopentane foaming is inherently more hazardous than other available alternatives. However the project proposal includes the relevant safety features (technological & procedural) necessary for this type of plant :

i) cyclopentane will be stored under ground outside the factory building

ii) premixing of polyol and cyclopentane is done outside the factory building

iii) local safety regulations have been taken into account

b) The technology involved is not transitional cyclopentane has a zero ODP.

c) There is no technology transfer agreement at present

There is no licensing agreement

Alternative foaming technology (HCFC 141b, HCFC142b , HCFC 142b/22) was considered.

The technology selected is the most cost effective available, which will enable the plant to be converted without loss of product quality.

6. Environmental Impact

a) Cyclopentane has a zero ODP

b) The proposal details appropriate measures to minimize health and safety impact

7. Project Costs

a) The cost elements detailed in the budget appear to be necessary for the conversion

b) These cost elements would not be expected to be present prior to the conversion of the plant.

Cost of Equipment

c) The existing CFC 11 foaming equipment is modern and was supplied by Hennecke (HK650). No reference is made to the baseline cost of existing equipment.

The project involves upgrading and refurbishing some existing equipment where this is feasible, in some cases equipment cannot be modified and complete replacement is necessary.

The cost of the modification elements is approximately $727,500 which represents approximately 30 % of the total foam project cost.

In particular the following items appear expensive : B1 - rebuild of foaming machines, B3- gas detectors, B5 - exhaust and ventilation system, B14 - Cyclopentane storage installation, B18 materials for start up.

It is estimated that these items could be reduced by as much as $370,000 by selecting alternative suppliers and detailed rationalisation of installation scope of supply.

The fate of scrapped equipment is not addressed

The modification of the existing equipment will not result in an increase in production capacity.

d) Training and technology familiarisation is essential particularly safety training. The training cost elements indicate training abroad and on site training. The cost level seems reasonable.

There will be some redundant production costs. The project includes for 780 redundant units this should be a maximum figure and effort should be made to reduce this.

e) The operating cost components are appropriate

No transitional period is required
There are no operating savings

Other Costs

f. Consultancy costs, and Implementing Agency Overhead costs are reasonable

A contingency of 8% of all equipment, services and incremental operating costs is included, this is appropriate.

Cost Effectiveness

g) The unit abatement cost for the foam section of the overall project is 5.4 $/kg, the ratio of net incremental costs to immediate ODP phase out is 29.3 $/kg this indicates a good level of cost effectiveness

The project is environmentally cost effective

Implementation Time

h) The proposed implementation time frame is feasible.

Recommendations

i) Approval after modification :

The cost of new and modified equipment and the installation of the ventilation system should be reviewed, it is estimated that these costs could be reduced by approximately $240,000 by selection of alternative equipment supplier and rationalisation of installation contracts.

The level of redundant production at start up is excessive, a value of approximately $130,000 would be more reasonable for a facility of this scale based on the number of units and operating cost cited..