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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 PROPOSAL: CAMEROON

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

- Investment Project for Phasing-out of CFCs at FAEM S.A.

PROJECT EVALUATION SHEET

COUNTRY OR REGION:	Cameroon
PROJECT TITLE:	Phasing out CFCs at FAEM S.A.
BUDGET:	US $1,689,696 Incremental capital cost US $ 155,860[1] Incremental operational cost
INCREMENTAL COSTS:	US $1,845,556
ODS PHASE-OUT:	45.60 MT of CFC-11 and 16.26 MT of CFC-12
COST EFFECTIVENESS:	US $29.83[2] per Kg. ODP saved
PROJECT DURATION:	18 months
IMPLEMENTING AGENCY:	UNIDO
NATIONAL COORDINATING AGENCY :	Ministry of Environment and Forest
TECHNICAL REVIEW COMPLETED:	YES _X_ NO _

SECRETARIAT'S COMMENTS

1. The project covers conversion of the domestic refrigerator manufacturing plant at FAEM S.A., Cameroon. Implementation of the project will result in an estimated annual phase out of 45.6 MT of CFC-11 and 16.26 MT of CFC-12. It represents about 64 per cent of ODS consumption in the domestic refrigerator sector.

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 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 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.

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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.)

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 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. An additional power back up generator requested by the project is considered not to be eligible for funding.

SECRETARIAT'S RECOMMENDATIONS

8. The Fund Secretariat recommends approval of the project and approval of capital costs at US $1,689,696.

9. The approval of incremental operational costs at US $155,860 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:	Cameroon
Project title:	Investment Project for Phasing out CFCs at FAEM S.A.
Sector Covered:	Domestic refrigeration/Rigid foams/ Refrigerant/Cold rooms
ODS Consumption in this Sector:	Estimated for 1993 61.86 MT of CFC 11 and CFC 12
Project impact:	Phase out of annual consumption of 45.60 MT of CFC 11, 8.5 MT of CFC 12 for production and 7.76 MT for service (Total ODP= 61.86 MT)
Project duration:	18 months
Project economic lifetime:	10 years
Total proposed project cost:	US$ 2,283,730
Project cost:	US$ 1,883,071
Implementing Agency's overheads:	US$ 244,799
Incremental Operating Cost: (one half year operational costs)	US$ 155,860
Proposed MF financing:	US$ 2,283,730
Cost effectiveness:	See Annex C: Unit Abatement cost
Counterpart enterprise:	FAEM, Duala, Cameroon
Implementing Agency:	UNIDO
Coordinating Ministry:	Ministry of Environment and Forest, Cameroon

PROJECT SUMMARY

This project will phase out 100% of the use of CFC 11 as blowing agent and CFC 12 as cooling agent for the production of domestic refrigerators, freezers, cold rooms insulation foam, but will not yet phase out the HCFC 22 refrigerant (ODP=0.05) for the production of air conditioners and cold rooms chillers.

The chosen replacement alternatives are <u>cyclopentane</u> as foam blowing agent and <u>HFC 134a</u> 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 Cameroon consists of one manufacturer which shares about 60% of all ODS consumed in Cameroon (103 MT). Details can be taken from the country program.

Cameroon does not produce the CFCs. The total consumption of CFCs in the production of polyurethane foam was about 21,3 MT in 1991 but not all has been used for this sector. The total consumption of CFC 12 in 1991 was 43,8 MT out of which 42,8 MT was used in the subsector. The demand for 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 are for

- refrigerators 25000 units per year,
- freezers 20000 units per year,
- air conditioners 15000 units per year, and
- cold storage chambers 100 units per year,

but the present production is much lower because of an actual crisis.

FAEM shares 60% of the refrigerator and freezer market in Cameroon itself and in the UDEAC countries (Cameroon, Gabon, Congo, C.A.R., Chad, Equat. Guinea) and services 70% of the refrigerators in Cameroon, while the rest of the units are imported.

Based on a 15 years life expectancy for refrigerators and freezers, a total of 997000 refrigerators, 880000 freezers, 540000 air conditioners and 8000 cold storage rooms are in use in Cameroon and the sub-region (UDEAC); half of them are in Cameroon. And approximately 7% will be re-charged annually with about 14,5 MT of new CFC 12 during refrigeration service in the UDEAC sub-region and 9,3 MT of new CFC 12 in Cameroon. Due partly to lack of equipment for the service sector, service staff often use CFC 12 for washing/flushing cooling systems, instead of using vacuum pumps and charging boards. This can have the effect of doubling CFC 12 consumption in the service sector.

Currently, FAEM (the only manufacturer in the sub-region) does not produce low energy consumption refrigerators and freezers. The insulation thickness reaches the standards of today's refrigerator technology with 35 mm insulation of refrigerators, 50 mm insulation of vertical freezers and 53 mm of chest freezers, but does not yet follow the dimensions used from some advanced manufacturers for the Northern Europe market. FAEM follows the ISO standard 7371 and publishes the energy consumption of each model.

FAEM's Background

FAEM S.A. is a 100% private company operating over the last 15 years in the manufacture and sale of commercial and domestic refrigeration, air conditioner, cold rooms and gas cooker products for the Cameroon and UDEAC market (Gabon, Congo, C.A.R, Chad, Equat. Guinea).

FAEM is the only local producer in the sub-region and has approximately 60% of the market and, in 1993, it exported 46% of their production to Gabon, Congo, C.A.R, Chad and Equat. Guinea.

It employs 161 staff and the installed annual capacity is about

- 25000 refrigerators,
- 20000 freezers,
- 15000 air conditioners, and
- 100 cold room storage.

in one shift. From 1.1.93 to 31.12.93, the actual production was only 30000 refrigerator and freezer units. An increase of 10-15% per year is expected for the next four years.

FAEM has followed in the refrigerator section Phillips/Whirlpool and Zerowatt constructions, in the chest freezer section an IAR construction and in the air conditioner section an Airwell construction which were updated during the last 15 years. They do not yet have their own research capacity. They use tube on sheet evaporators in the insulation behind the innerliner, developed in the last 5 years to reduce costs and increase quality. The PUR lines are simple and only in low pressure but have all the moulds (36 units) and fixtures to produce 13 different models. The manufactured 13 refrigerators models are one series of table top 140 liter, 1 door refrigerator with freezer ** compartment 230 liter, 2 door refrigerator-freezer **** 320 liter, and a second series of 1 door refrigerator with ** freezer compartment 270 liter, 2 door refrigerator-freezer **** 300 liter, 2 door refrigerator-freezer **** 300 liter, 2 door refrigerator-freezer **** 410 liter.

The four chest freezer models are 200 liter, 300 liter, 500 liter and 600 liter. The chest freezer production represents 45% of the refrigerator and freezer production.

The 20 different assembled air conditioner models have the following cooling power and use HCFC 22:

1st serial: 15260W, 20645W, 30285W, 41975W, and 62770W
2nd serial: 3270W, 4375W, 5560W, 7125W, and 8905W
3rd serial: 2365W, 2565W, 2760W, 3520W, 4795W, 5595W and 7245W
4th serial: 20685W and 30000W
5th serial: 19700W

FAEM has 4 main lines:

- one main line for the production of the air conditioners and cool room cooling aggregates,
- one main line for the refrigerators,
- one main line for the chest freezers and
- one main line for gas cookers

The main line for the air conditioners and cooling room aggregates consists of steel works, painting, assembly, charging and testing lines.

The 2 main lines for the refrigerators and freezers use the same steel work and also the same PUR lines but separate preassembly, assembly, charging and testing lines.

FAEM uses standard polyurethane foam without CFC reduction. They used a free rising density of 32 kg/m^3.

FAEM's equipment for foaming and refrigerator charging is 5 to 10 years old but in good condition. The foaming equipments are the following:

- 1 low pressure foaming machine for cabinet, doors, chests and panels;
- 15 pneumatic jigs with cores in bell position for refrigerators;
- 4 pneumatic jigs with expandable core in bell position for chest freezer;
- 3 door moulds for the chest freezer;
- 8 door moulds for the refrigerators;
- 5 simple moulds in reserve; and
- 1 large mould for cold room panels.

The jigs are on rollers to be positioned to the foaming places upon model selection. The premixing of Polyol and CFC 11 is made manually by a balance.

All the 36 jigs for foaming of cabinets, doors and the panel are made of aluminium and steel and are not heated. Most of the jigs are pneumatically operated. The jigs for the cabinet and chests use the bell position.

In the charging and testing section, there are 3 lines: one air conditioner line, one refrigerator line and one chest freezer line. These 3 lines should be kept separate to avoid operation and quality problems. In the evacuation, charging and testing areas, FAEM has the following equipment:

- 5 pcs. vacuum pumps out of which only 2 have more than 8 m^3/h capacity so that they can be cleaned and used for R134a and the others have only a capacity of 6-7 m^2/h. 1 old vacuum pump is used for repair;

- 3 pcs. vacuum and charging stations (Danfoss), one for each evacuation, charging and testing line;

- 2 pcs. electronic leak detectors.

The climate conditions of the country require necessary performance parameters of refrigeration equipment to be competitive on the market. Presently, FAEM does not have its own performance test laboratory. However, in order to optimize the R134a cooling system and to ensure the quality, they will build up a separate test room and laboratory.

FAEM's Refrigeration Service

FAEM has its own network of service shops in Cameroon with a total of 10 service centers and 70 distributor's service shops. All the service shops are equipped with normal refrigeration service equipment. Till today, there is no CFC 12 recovery and/or recycling equipment in Cameroon.

FAEM service about 70,000 units per year.

During the last 15 years, equal to the average life time for refrigerators and freezers, FAEM has manufactured about 460,000 units of refrigerators and freezers and 210,000 air conditioners of which 5 to 10% is expected for refrigeration service each year. It means about 70,000 units for service each year.

With an average CFC 12 refrigerant charge of refrigerators and freezers of 0,180 kg + 30% for the loss and an average charge of HCFC 22 of 2,8 kg + 10% for loss for air-conditioners weighted by the quantity of models produced on the market total use of CFC 12 for FAEM's service is about 8,2 MT of CFC 12 and 7,76 MT of HCFC 22.

PROJECT OBJECTIVE

The objective of this project is to eliminate the use of ODS as CFC 11 and CFC 12 in the production of domestic refrigerators, freezers and cold rooms insulation at FAEM 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. The conversion of the refrigerant HCFC 22 (ODP=0.05) is not yet foreseen as the manufacturers of air conditioners and chillers in USA, Japan and Europe did not yet prepare new systems and the environmental pressure on the use of HCFC 22 with a low ODP value of 0.05 is not as high as for CFC 12.

PROJECT DESCRIPTION

FAEM 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, FAEM has chosen to replace CFC 12 by HFC 134a, because the new type of compressors are available, the technology is mature and commercially applied as long as no better solution is available. For a hydrocarbon solution (isobutane or propane), the service problem in African countries is not yet solved and not completely controllable by the producer, so there is still a high risk of accidents in case hydrocarbons are used as refrigerant.

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

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 of presently used equipment, such as vacuum pumps;

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 10 refrigeration service centres of FAEM, each center needs 1 recovery unit and 3 mobile recovery units for CFC 12 as well as in the beginning only 2 sets of equipment which will be used for servicing HFC 134a refrigeration systems. Also FAEM's air conditioner services centers should get recovery equipment for the HCFC 22 to avoid that a large quantity (average 2,8 kg) will be escaped into the atmosphere.

By the involvement of smaller capacity and high variation of models, the concepts of the main lines are as follows - 1 main line for refrigerator, 1 main line for freezers, 1 main line for air conditioners and should be kept in future, so that only one combined PUR section for refrigerators, freezers and cold rooms should be installed but 2 separate main lines for preassembly, assembly, charging and testing to avoid mistakes and to reach the same capacity.

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

A. Refrigeration System

- The 2 charging boards of the refrigerator line and of the freezer line have to be replaced by boards suitable for HFC 134a as the refrigeration system is sensitive to chlorine.

  The charging board of the air-conditioner line (HCFC 22) will be kept.

- Because the 2 existing leak detectors are not resistant to cholorine, they need to be replaced by special leak detectors for R134a.

- Only 2 of the 5 vacuum pumps, after having applied a special cleaning technology (described in Annex D) can be re-used, 2 have to be replaced, one can still be used for the air conditioner line.

- To optimize the cooling system for the application of HFC 134a in connection with the use of the new components for HFC 134a a new performance test for each model has to be completed. Therefore, some new test equipment needs 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 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 c-pentane blown foam, in comparison to the one blown by R11, will only exist during the first 10 months because of higher aging effects of R11 and can be easily compensated by the optimization of future process aimed to remove the thermal bridges. So no increase of insulation thicknesses with strong cost effects (modification of the PUR foam plugs, door moulds, plastic injected part moulds) will have to be made.

- 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 cleanliness 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 CFC 12.

B. Foam system

No low pressure PUR machines for c-pentane are available in the market. A high pressure machine which reduces the cycle time from 10-14 minutes to 6-7 minutes in the PUR section and therefore, allows to substantial reduction of the quantity of jigs and of the cost of changing or replacing the existing 24 cabinets and chest jigs and 11 door moulds.

This time reduction and reduction of necessary PUR jigs can only be reached if the position of foams is changed from bell to bath position.

To reach the installed capacity of 45000 refrigerators and freezers with a high pressure PUR machine, only 3 jigs for cabinet and chest and 3 jigs for doors are sufficient if the bath positions for cabinet and chest are selected.

To rebuild all the 36 PUR moulds for high pressure foam and to heat them, it will cost US$ 0,6-0,9 Mio. No reliable company would sign an operational safety statement and the local authority will not allow such operation of a plant with rebuilt moulds which enter and leave the foaming sector.

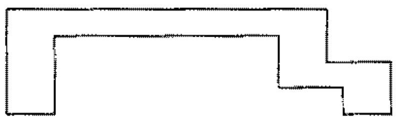
The purchase of 3 new jigs for cabinets and chests is much cheaper than to rebuild the existing jigs of cabinets and chests. The variation of outer dimensions of refrigerators and chest freezers can be achieved by simple aluminium plates to be mounted on the jig wall. So only one innerliner core per model is needed from which the 4 cores of the chest freezer must be expandable.

In addition, jigs in bell position with high pressure PUR machine and a higher viscosity of foam for c-pentane will cause big bubbles in the foam in which c-pentane will accumulate and destroy the innerliner and in the worst case scenario, can cause explosions even after distribution.

A solution like the ones used in Japan to keep the bell position is even more expensive because it needs 3 heads parallely with 3 separate PUR machines.

The jigs in bell position enter the foam from the back side of the refrigerators:

(A)

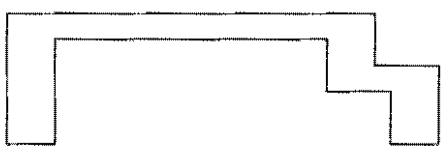


The poured-in foam will flow down

(B)

While the foam reached the lowest edges, the PUR reaction starts on all areas, so the rising foam will be blocked by foam already raised from the walls.

(C)



N_2 bubbles will remain in the foam which can only be avoided if the injection is made in parallely with 3 heads and synchronized, which needs 3 independent high pressure PUR machines (Japanese style).

In the N_2 bubbles, the c-pentane will accumulate and after a while will destroy the plastic foodliner.

Rebuilding of bell positioned jigs used with c-pentane can only be accepted with 3 parallel working high pressure PUR machines to synchronously inject the PUR foam through 3 heads into the bell jig.

Also to put the bell position jig upside down is not possible in this case, because of opening the jig and handling of the cabinet. In addition, such moulds made for low pressure are often, like in our case, not heated. To integrate the heating system, change of the opening etc. the restructuring costs are higher than the new moulds.

Even, if the content of an activator in the polyol compound is reduced to gain slow starting material, (because of the higher viscosity of c-pentane driven foam and the need to double the quantities of jigs to reach the same capacity) the cost will not be lower than new built ones which, in addition are much safer.

Because of the cost and safety aspects - in the production and at the customer - and the strong reduction of cycle time by a high pressure PUR machine with jigs in bath position, the 24 existing bell position jigs for the cabinets and chests should be replaced by only 3 new jigs optimally designed for the use of c-pentane.

To change the 11 door moulds to c-pentane suitable versions, it is also cheaper to make only 3 new universal door jigs suitable for the safe operation of c-pentane driven PUR.

This will reduce the costs and ensure a safe operation of the PUR section and will facilitate obtaining permission to operate the lines in Cameroon.

The customer is ready, under the condition that he will gain safe new installations which are cheaper than the rebuilt old ones, to pay himself half of the necessary supporting cores of his wide range of products (13 refrigerators models and 4 freezer models) so that the Fund would only have to pay for 5 different refrigerator cores and 4 freezers.

In order to achieve an acceptable foam quality and insulation value at the lowest price, the existing one low pressure foaming machine has to be replaced by a high pressure foaming machine with two foaming heads.

The final specification of the cyclopentane to be used (purity and mix) will be defined after having carried out a market review in Cameroon and an assessment of its availability. The current price level is about US$ 1,90 plus packing and transport.

For the time being, there are no manufacturers of cyclopentane in Africa.

Since cyclopentane and polyol cannot be delivered premixed in drums or tanks (as CFC 11), it is necessary to provide a premixing station. For safety reasons, 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.

It is also necessary to provide one tank storage system for cyclopentane, in order to be able to automatically deliver the components to the premixing station.

To operate c-pentane PUR lines in Africa, 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 tank,

3. The operators should not enter the closed foaming area and should not manipulate any jig inside the foaming area,so only special trained maintenance technicians are allowed after stoppage of the line to enter the foaming room, PUR machine room and premixing room.

4. The mix heads have to be automatically positioned and flexible gun tubes should as much as possible, be avoided.

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 exhausting 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 to the extent possible should be made in a way 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.

FAEM's technicians have to be carefully selected and trained, at the equipment suppliers' 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 suppliers' engineers will have to train FAEM's technical staff in all aspects of the operations. The result of the training has to be verified before the operation of the equipment can be given over.

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

C. Refrigeration Service

Although FAEM has in each of their service centers 4 sets of service equipment for R12 we reduce the service equipment to R134a to 2 sets per center so that one can be used outside and one inside the center. So to cover the requested service in the future each of the 10 refrigerator service centers of FAEM should get 2 pcs of R134a mobile charging boards, 2 pcs of electronic leak detectors for R 134a and 3 sets 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 producer for recycling.

Furthermore FAEM should start to collect HCFC 22 in their 10 service centers for their air conditioner service as the involved quantities are 20 and more times larger than for refrigerators.

This equipment will only cover FAEM's service centers but not the 70 service shops for FAEM's refrigerators and freezers.

E. Justification for Selection of Alternative Technologies

All major manufacturers of compressors have accepted 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 an African 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 as the R134a. This exactness in filling, besides 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 the African countries can be strongly improved, we will think again about switching to these new refrigerants or other cheaper ones as the HFC 134a, but for the time being HFC 134a should be used in Cameroon.

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 till today 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 blowing agent because of its good insulation values and cheaper costs of materials. The manufacturing technology with high 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, for example, in Europe; 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 room. Only very good trained maintenance technicians with antistatic clothes and shoes should enter this section after all machines are switched off and strong ventilation backed up by emergency power supply 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 worse 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

The following equipment needs to be replaced as well as new equipment 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 1 pcs. HFC 134a service charging board with vacuum pump, refrigerant supply, pump for repair;

A.3 2 pcs. evacuation stations 16 m^3/h, inclusive pass/fail, 2 evacuation hoses, Pirani vacuum gauge;

A.4 2 pcs. HFC 134a leak detectors;

A.5 1 set of refrigerant test equipment and material for laboratory mainly 1 exact balance essential to control the foam and to avoid bubbles;

A.6 2 pcs. vacuum control for existing vacuum pumps, which can be cleaned to be used for R134a;

B. Foam System

The following existing equipment needs to be replaced with new ones as specified below:

B.1 1 pc. high pressure foaming machine for c-pentane with two foaming heads.

B.2 1 pc. premixing station for cyclopentane and polyol;

B.3 1 pc. gas detector system with control board, 28 pcs gas sensors, ventilation sensors for safety reason;

B.4 1 set foam test equipment;

B.5 1 set exhausting and ventilation system;

B.6 3 pcs. foaming jigs for all refrigerator cabinets and chest freezer chest in the size of the largest model with distance aluminium plates to fit all models and with compressor compartment support;

B.7 3 pcs. foaming jigs for all refrigerators and freezers doors with distance aluminium plates to fit all models;

B.8 1 pc. jig for cooling room panel (rebuilt);

B.9 5 pcs. new refrigerator foaming fixed plugs for the jigs;

B.10 4 pcs. chest freezer expandable plugs for the jigs;

B.11 pipe installation ex-proof from cyclopentane tank to pre-mixers and from premixing to Polyol tank;

B.12 floor cover antistatic;

B.13 1 set fire protection systems;

B.14 1 pc. tank for cyclopentane with all necessary safety devices pressurized by nitrogen;

B.15 2 pcs. pumps and pipe for tank;

B.16 1 pc. backup power supply system for ventilators;

B.17 1 pc. Chillers (in the past they did not need one for the low pressure PUR machine).

B.18 1 set of houses for PUR machine, premixing station and foaming jigs;

B.19 1 pc. automatic transport of foaming head;

B.20 1 set of spare parts

Because of the temperatures all over the year, heating of the pipes for high viscose polyol compound is not needed.

C. Refrigeration Service

C.1 20 pcs. HFC 134a charging boards for refrigeration service, one at each center and one for the service man working outside each center;

C.2 30 pcs. mobile recovery units for CFC 12;

C.3 10 pcs. stationary recovery units;

C.4 10 pcs. mobile recovery units for R 22

C.5 20 pcs. electronic leak detectors for HFC 134a, one to be at each service center (in-house) and one for the service man servicing outside each service center;

2. Conversion/Training

Within the framework of the project, personnel from FAEM 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 FAEM, 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 is required, followed by the manufacture of some prototypes and refrigeration performance tests. The costs for these 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 the Ministry of Environment and Forest. Local coordination will be carried out by FAEM.

The project will include supply of equipment, installation, commissioning, training in Europe and on-the-job training of FAEM'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 high 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 Ministry of Environment and Forest, Cameroon and 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 FAEM 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:

WORKPLAN	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	XXXXXX
REFRIGERANT:	
9. Redesign of models, training	XXXXXXXX
10. Selection of equipment	XX
11. Purchase, installation and commissioning	XXXXXXX
12. Prototypes and testing	XXXXXXXXXXXXXXXX
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$)
- HFC 134a compressor		5,00
- Capillary tube modification		0,10
- Condenser modification		1,30
- Evaporator modification		1,70
- 3 AA drier		0,05
- HFC 134a refrigerant		0,42
- Extra cost for foam with cyclopentane and higher density(+16%) mingling lower blowing agent costs		0,81
Total	US$	9,38

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.
All the prices are without customs duty and tax.

The price 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%. FAEM's actual average price difference at their suppliers are US $5,85 but by using other sources they can reduce it to US $5;

- capillary tubes prolongation and changes plus average US $0,10;

- evaporator and condenser increase;

- HFC 134a charge about 16% less than with CFC 12 based on an average charge weighted by the produced quantities of 0,18 kg at US $3,00/kg and a current price for HFC 134a at US $5,75/kg, excluded any customs tax): 0,160 kg x 0,84 x US $(5,75-3,00)/kg;

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:	6,80	Kg per unit:	7,82
Total costs $/unit:	12,50	Total cost $/unit:	13,31

Incremental cost difference: US $0,81.

The operating cost of the enterprise after the conversion is not expected to change much: 3 more experienced operators with higher wages (3 persons each USD 6,500.00 per year) minus 1 operator with lower wage (USD 3,250.00) because of the automatization will increase the costs of 1 year by USD 16,250.00 per year.

So the total incremental operating cost increase will be for the produced 31,500 units per year US $311,720,-- in the first year (31,500 x US $9,38 +US $16,250,-- = US $311,720,--) from which the incremental cost for half a year will be covered by the fund: US $155,860,-.

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) proposed to cover unforeseen expenses which might be incurred during the project implementation, e.g. purchase of small testing instruments whose needs will be caused 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$ 3,736,736.21

It was agreed that FAEM will request the Multilateral Fund to cover the incremental operating cost for 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
	- Repair charging board for HCFC 134a	1	1,000	1,000
A.2	Vacuum pump (2 renovations)	2	300	600
A.3	2 Stages vacuum stations (Replacements)	2	9,600	19,200
A.4	Production leak detector for HFC 134a	2	10,000	20,000
A.5	Test equipment for prototypes	1 set	30,000	30,000
A.6	Vacuum control (for existing pumps)	2	500	1,000
	- Incremental spare part costs	1 set	1,000	1,000
A.7	Prototype Material	9 sets	1,000	9,000
B.	Foam System:			
B.1	High pressure foaming machine with two heads	1	160,000	160,000
B.2	Premixing station	1	80,000	80,000
B.3	Gas detector system	1	70,000	70,000
	- Gas feelers	28	1,500	42,000
B.4	Foam test equipment	1 set	1,000	1,000
B.5	Exhausting and ventilation	1 set	150,000	150,000
B.6	New foam jigs for cabinet/chest	3	90,000	270,000
B.7	New foam jigs for doors	3	23,000	69,000
B.8	Foam jigs for cooling room panel (rebuilt)	1	50,000	50,000
B.9	New foam plug for refrigerator	5	19,000	95,000
B.10	New foam plug for chest freezer	4	29,000	116,000
B.11	Pipe installation from tank to premixing stations	1	9,000	9,000
	- Pipe installation from premixing to PUR machine	1	12,000	12,000
B.12	Antistatic floor	210 m^2	38	7,980
B.13	Fire protection system	1 set	9,000	9,000
B.14	Tank for cyclopentane	1)	48,000	48,000
B.15	Pumps, pipe work for tank	1)		
B.16	Power supply backup	1	45,000	45,000
B.17	Compressor cooler (drier)	1	45,000	45,000
B.18	Materials for starting up with 50 % cost sharing (9 sets of 30 pc.s of US $250,--)	30x9	250	33,750

	Description	Qty.	Unit cost US$	Total cost US$
C.	Refrigeration Service:			
C.1	- Charging board for service	5	1,000	5,000
C.2	- Recovery bags for CFC 12 (mobile)	60	18	1,080
C.3	- Recovery unit for CFC 12	10	1,500	15,000
C.4	- Electronic leak detector for R 134a	20	250	5,000
C.5	- Incremental spare part costs	1 set	1,000	1,000
	Subtotal*		US$	1,482,610

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

a. Pre-heating ovens for foaming;

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 HFC 134a 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 layout 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 m3/h
4 charging channels - built-in supply pump
Refrigerant: HFC 134a
Charges: Min 50g - Max 2200g +/- 1% or 1g

A.2 Vacuum pump renovation in 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.3 Vacuum station 16 m^3/h, 2-stages vacuum pump, incl. Pirani vacuum gauge with pass/fail indication for vacuum ok, 2 evacuation hoses with Hansen 2 H

A.4 Leak detector for production for HFC 134a
Type HLD 400
Sensitivity range: 0.5 to 150 g/year.
Microprocessor controlled.
Calibration gas: HFC 134a
Calibration: Automatic by the incorporated leak standard

A.5 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 7310

The charging board and leak detector mentioned for the production, service or repair will be used.

B. Foam System:

B.1 High pressure foaming machine for cyclopentane

Essentially, the machine comprises the following assemblies:

1 pc. Special metering pump NG 28 P for polyol-pentane, in corrosion-proofed design, suited for a pre-pressure 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 isocynate

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 mix head

1 pc. Throttle-controlled mix head with:
2 hydraulically controlled recirculation injectors for polyol and isocyanate, polyol injector equipped with leakage monitoring device,
1 hydraulically controlled injector for inertizing the 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-mix head 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 litres, 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.

1 pc. Work tank for Isocyanate

Size 250 litres, working pressure 4 bar, double-walled for temperature control with unpressurized water, made of normal steel, with stirrer 51 min -1, 0.25 kW; with parallel inspection pipe for optical filling level display and with possibility for connecting level switches which are adjustable in height; compl. with all necessary fittings and accessories as well as connector for dry compressed air.

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.

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 5 kW 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.

1 pc. Temperature control device for the isocyanate work tank for raw material temperature control via the double jacket of the work tank; with electr. heating of 5 kW and 1 cooling system for direct cooling by means of cold water of about 14°C; water consumption during cooling 40 l/min. max.

1 pc. Heat exchanger unit with circulation pump (pentane suited)

In case of higher requirements having to be met by the raw material temperature control system, like for example in the case of multiple metering, long mix head lines, quick shot sequence, etc. we recommend to use compl heat exchanger units ensuring an automatic raw material temperature control by means of constant circulation, which is not part of the PUR equipment and therefore later mentioned.

Equipment for 1 component
1 heat exchanger WTK2R with abt. 10.5 MJ/h
(= ca. 2500 kcal/h) at a cooling water temperature of 15°C and the fluid having to be cooled down from 24 to 20°C,
1 circulation pump with a capacity of abt. 20 l/min, with double shaft sealing and leakage monitoring device on the polyol side

1 compl piping system

The heat exchanger is connected to the temperature control device of the work tank.

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.

1 pc. Heat exchanger unit with circulation pump

In case of higher requirements having to be met by the raw material temperature control system like for example in the case of multiple metering, long mix head lines, quick shot sequence, etc. it is necessary to use compl. heat exchanger units ensuring an automatic raw material temperature control by means of constant circulation, which is not part of the PUR equipment and therefore later mentioned.

Equipment for 1 component:
1 heat exchanger WTK2R with abt. 10.5 MJ/h
(= abt. 2500 kcal/h) at a cooling water temperature of 15°C and the fluid having to be cooled down from 24 to 20°C,
1 circulation pump with a capacity of about 20 l/min,
1 compl piping system

The heat exchanger is connected to the temperature control device of the work tank.

1 pc. System for automatic transfer from the tank farm for isocyanate

For automatic refilling of the work tank, with 3 level switches adjustable in height, 1 pneumatically operated shut-off valve with limit switch monitoring.

The pre-pressure in the circular line with overflow valve to be available is supposed to lie above the pre-pressure in the work tank.

1 pc. Refrigerating machine for re-cooling the water for the temperature control devices designed as air-cooled compressor unit with a cooling capacity of about 17 MJ/h (= about 4000 kcal/h) - at an ambient temperature of about 30°C (43°C max.)

Advantage: No water consumption due to closed circuit with temperature control devices.

Such equipment did not exist in their low pressure PUR machine, therefore it has to be added.

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 will 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 o-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 by the buyer; 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: 28 pcs
Flammable limits: In air 1.4-8%

B.4 Foam Test Equipment
Scale 0-1000 gr +/- 0.01 g
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
Electrical heating elements and all electric components have to be automatically disconnected in 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 Foaming Door Jigs
Electrical heating elements and all electric components have to be automatically disconnected in 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.8 Rebuild of cooling room panel jig

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 pre-mixers 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

B.15 Connection for nitrogen pre-pressure
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.17 Chiller
Cooling range: 0-15°C
Pump capacity: about 6000 ltr/h
Circulation medium: water
Cooling capacity: 15 kW

B.18 House for foaming jigs
Steel house with connection for ventilation and exhausting and an improved exhausting at jigs built around the foaming jigs

B.19 Automatic transportation of foaming head
Carriage for 10 m
Tubes for isocyanate and polyol component
Hanger for head

C. Refrigeration Service:

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

C.2 Mobile Recovery unit for CFC 12 (Recycling system)
Capacity: 1100 g CFC
Type RE-I
Oil separator

C.3 Recovery unit for CFC 12
Capacity: 1100 g CFC 12
Type RE-III

C.4 Recovery units for HCFC 22
Capacity: min. 60 kg/h
Type: Fast

C.5 Electronic leak detector for R 134a

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.	7.0	80,000
	Consultancy in checking/exproofing of PUR machine, tanks, premixing and foaming places, preparation and introduction of safety rules, regulations and manuals * safety training of FAEM's staff (two weeks, two specialists)	4.0	20,000
	Local subcontract for provision of: * Tank for cyclopentane * Pumps, pipe work for tank, * pipe installation from tank, from tank to premixing and from premixing to PUR machine and from PUR machine to foaming place including installation and commissioning of the system * Antistatic floors		76,980
	Local subcontract for provision of: * Fire protection system including equipment installation, training and commissioning of the system		9,000
	Subcontract for provision of: * Exhausting and ventilation including equipment installation and commissioning of the system		150,000
	Study Tours:		
	Study tour (2 weeks) of three FAEM'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 FAEM's Engineers in new foaming technology, testing, maintenance, quality and safety control	4.0	20,000
Equipment:		
A. Foaming System:		
- Machinery:		1,143,950
High pressure foaming machines (cabinets and doors)	160,000	
Premixing stations	80,000	
Gas detector systems with sensors	112,000	
Foam test equipment	1,000	
Power backup	45,000	
Chiller	45,000	
Foam jigs for cabinet and chest	270,000	
Foam jigs for doors	69,000	
Foam jigs for cooling rooms	50,000	
Plugs for cabinet	95,000	
Plugs for chest	116,000	
Materials for starting up (9 x 30 x US $250,--) 50% cost sharing	33,750	
Equipment installation, commissioning & local training (4 weeks, two supervisors and 1 engineer 2 weeks)	67,200	
B. Refrigeration System:		
- Machinery:		170,840
Charging boards for HFC 134a	61,000	
Charging board for repair line	1,000	
Vacuum pumps renovation	600	
Vacuum pump replacements	19,200	
Production leak detectors	20,000	
Vacuum controls,	1,000	
Incremental spare part costs	1,000	
Equipment installation, commissioning & local training (two weeks, 1 specialist)	11,520	
Test and monitoring equipment	30,000	
Materials for prototypes,	9,000	
Equipment installation, commissioning & local training (3 weeks, 1 specialist)	16,520	

C. Refrigeration Service		
- Machinery		33,840
Charging board for service for R134a	5,000	
Recovery units for CFC 12	15,000	
Recovery bags for CFC 12	1,080	
Electronic leak detector for R134a	5,000	
Spare parts	1,000	
equipment installation, commissioning and training (1 week, 1 specialist)	6,760	
Subtotal		1,724,610
Miscellaneous:		
Contingency Fund (10% of the costs of all equipment and services calculated)		158,461
Subtotal I		244,799
Agency's Overheads (13% of all)		
Subtotal II		2,127,870
Incremental operating cost (half year of operation)		155,860
TOTAL		US$ 2,283,730

Refrigeration Service (Unit Abatement Cost)

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

FAEM's service organization is expected to service about 70,000 refrigerators and freezers per year with an average CFC 12 refrigerant charge 0,18 kg CFC 12. In the air conditioner section, the service is much less but the involved quantities (more than 10,000/year) with the average 2,8 kg HCFC 22 (ODP=0,05) will also cause more than 1,4 MT ODP which can be reduced to more than half if recovery reclaiming equipment will be introduced.

Based on an investment for refrigerant servicing equipment for CFC 12 of US $16,800 and for CFC 22 of US $35,000.00 and an average recovery of CFC 12 per year of 3,9 MT and of HCFC 22 of 14 MT respective 0,7 MT ODP the annualized capital cost per kg ODS saved will be only US $8,427.86 (10 years life time and 10% discount rate). So for the recovery service of CFC 12 and CFC 11 we will come to an Unit Abatement Cost of US$ 0.18/kg ODP phased out for recovery.

The above mentioned is based on delivery of recovery units to all FAEM's main service centres, but not to their 70 service shops.

Annex C: Calculation of Unit Abatement Cost:

A	ODS Phase out		Total Project
A1	Average use of CFC 11 per year	MT	45,60
A2	ODP of CFC 11		1
A3	ODP-weighted CFC 11 phase (A1*A2)	MT	45,60
A4	Average use of CFC 12 per year plus service	MT MT	8.5 7,76
A5	ODP of CFC 12		1
A6	ODP weighted CFC 12 phase out (A4 x A5)	MT	16,26
A7	Total ODP-weighted phase out	MT	61.86
B	Annualized capital cost		
B1	Total investment cost (model redefinition + production conversion)	US$	2,918,477
	Equipment life	Year	10
B3	Discount rate	%	10
B4	Annualized capital cost (B1 x 0.1627)	US$	474,836.21
C	Annual incremental recurrent cost (1/3)	US$	155,860
D	Unit Abatement cost		
D1	Annualized capital cost per kg ODS phase out (B4/(A7 x 1000)	$/kg	7.67
D2	Annual 0.5 incremental recurrent cost per kg ODP phased out (C/A7 x 1000)	$/kg	2.52
D3	Unit abatement cost (D1+D2)	$/kg	10.19

* Without the investment for the refrigeration service (US $83,840 + 8% + 13% = US $102,318,34) the annual capital cost per kg ODS phased out will be US $458,189.01 divided by 54,100 kgs ODB the unit abatement cost without the investment for refrigeration service will be US $8.47 for the investment plus US $2.52/kg for 1/2 incremental costs totalling US $10.99/kg ODP with less phasing out of ODP (-7.76 MT).

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 8 m^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 cm^3 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 cm^3 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 50 cm^3 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 in 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 : Cameroon

2. Project Title : Investment Project for Phasing out CFC's at FAEM S.A (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 automatic transfer of foam heads item B.19 $87,000 is not necessary for the conversion and should be omitted.

b) The remaining 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 5 to 10 years old but quoted to be in good condition. No reference is made to the baseline cost of existing equipment.

The low pressure foaming equipment cannot be modified and complete replacement is necessary of the majority of the equipment in this project.

Some of the cost elements could be reduced by selecting alternative suppliers.

In particular the following items appear expensive : B1 - high pressure foaming machine, B3- gas detectors, B5 - exhaust and ventilation system, B6 & B7 - foam jigs for cabinet/chest and doors, B9 & B10 - new foam plugs for refrigerators and freezers, B14 - Cyclopentane storage installation. It is estimated that these items could be reduced from a total cost of $1,197,800 to approximately $870,000 providing a net reduction of $327,000

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 according to the standard calculation is 6.72 $/kg, the ratio of net incremental costs to immediate ODP phase out is 41.9 $/kg this indicates a relatively good level of cost effectiveness over the life time of the project but a relatively high investment cost per ODP tonne phased out.

The latter financial indicator could be reduced to approximately $30/kg if the cost savings cited above were achieved

The project is environmentally cost effective

Implementation Time

h) The proposed implementation time frame is feasible.

Recommendations

i) Approval after modification :

Item B.19 - automatic transport of foam heads should be deleted ($87,000)

The cost of new equipment should be reviewed, it is estimated that these costs could be reduced by as much $327,000 by selection of alternative equipment supplier. This depends however on the compatibility of existing equipment.