EP

United Nations
Environment
Programme

Distr.
LIMITED

UNEP/OzL.Pro/ExCom/15/36
20 November 1994

ORIGINAL: ENGLISH

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

Fifteenth Meeting
Montreal, 13-16 December 1994

PROJECT PROPOSALS: THAILAND

This document includes the following project proposals and the Fund Secretariat's Comments and Recommendations. The project proposals have been grouped by project sector. The agency responsible for the implementation of the project is also indicated. The project proposals are presented in the order indicated below. The Fund Secretariat's Comments and Recommendations are presented at the front of the document.

Foam

- Elimination of the use of CFC in the manufacture of flexible PUF cold cured mouldings, integral sikn mouldings and rigid PUF articles at Thai Union	UNDP
- Elimination of the use of CFC in the manufacture of flexible PUF slabstock and cold cured mouldings st Somboon Paisarn	UNDP
- Elimination of the use of CFCs in the manufacture of flexible PUF slabstock at Karn Yang	UNDP

Solvent

- Phase-out of ODS solvents at Thai Airway	IBRD

PROJECT EVALUATION SHEET

COUNTRY OR REGION:	Thailand
PROJECT TITLE:	Investment project to phase out CFC-11 at: a) Karn Yang Yeen Yong Industry Ltd. b) C. Somboon Paisarn 85 Company Ltd. c) Thai Union PU Co. Ltd.
BUDGET:	a) US $170,000 b) US $225,000 c) US $525,000
INCREMENTAL COSTS:	a) US $170,000 b) US $225,000 c) US $525,000
ODS PHASE-OUT:	a) 110 tonnes CFC-11 b) 100 tonnes CFC-11 c) 45 tonnes CFC-11
COST EFFECTIVENESS[1]:	a) US $0.25/kg/yr. b) US $0.37/kg/yr. c) US $1.90/kg/yr.
PROJECT DURATION:	1 year
IMPLEMENTING AGENCY:	UNDP
NATIONAL COORDINATING AGENCY:	Ministry of Environment, Department of Industrial Works (DIW)
TECHNICAL REVIEW COMPLETED:	YES _X_ NO _

SECRETARIAT'S COMMENTS

1. The largest flexible polyurethane foam companies in Thailand are said to have switched to alternative blowing agents leaving CFC-11 use to smaller manufacturers (Thailand Country Programme, page 2-12). The consumption in 1991 of CFC-11 in the flexible polyurethane foam sector was supposed to be 200 tonnes.

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

2. These three projects will bring the number of projects approved in this subsector in Thailand to four. However, notwithstanding the apparent low consumption of CFC-11 in this subsector as reported in the country programme, the four projects will phase-out 442 tonnes CFC-11.

3. Karn Yang produces slabstock polyurethane flexible foam while Somboon Paisarn and Thai Union, said to be one of the largest foam producers, produce a range of specialty flexible polyurethane foams in addition to the slabstock. In addition, Thai Union also produces integral rigid polyurethane foam which is also being considered under this project.

4. At Karn Yang, CFC-11 will be phased out through substitution with a combination of water/methylene chloride for the production of low density flexible slabstock foam. Thus investment costs relate mainly to ventilation systems and other safety equipment and methylene chloride and additive metering systems.

5. At Somboon Paisarn and Thai Union in addition to investments made for the production of low density flexible polyurethane foam investments are made to meet the technological requirements of the production of the range of specialty foams. Thus, at Somboon Paisarn the production of cold cured moldings using all-water blown technology will necessitate replacement of the low pressure dispensing/metering machine with high pressure machine. At Thai Union, however, in addition to investment in the production of cold cured moldings additional investments are required for substitute technologies for integral and rigid polyurethane foam production where HCFC-22/partial water and HCFC-141b technologies will be used respectively. Investments are mainly in procurement of high pressure machines for the integral skin foam production and pre-mixing station and accessories for use with existing equipment for production of rigid foams.

6. The residual values of the low pressure machines have not been discounted from the project costs as this did not prove feasible. However, UNDP should ensure that the old replaced equipment are disposed of in accordance with the existing guidelines.

SECRETARIAT'S RECOMMENDATION

7. The Fund Secretariat recommends approval and funding of the projects as follows:

Karn Yang:	US $170,000
Somboon Paisarn:	US $225,000
Thai Union:	US $525,000

8. Approval of the projects for Somboon Paisarn and Thai Union is subject to the comments in paragraph 6 above regarding disposal of equipment replaced.

PROJECT EVALUATION SHEET

COUNTRY OR REGION:	Thailand
PROJECT TITLE:	Phase Out of ODS Solvents at Thai Airways
BUDGET:	US $482,600 US $24,600[1]
INCREMENTAL COSTS:	US $522,400 US $ 58,500[2] (unutilized original funding) US $463,900 (requested funding)
ODS PHASE-OUT:	8 MT of 1.1.1 TCA (0.8 weighted ODP tonnes) 6 MT of CFC-113 (4.8 weighted ODP tonnes)
COST EFFECTIVENESS:	US $93.29 per Kg. ODP saved
PROJECT DURATION:	1.5 years
IMPLEMENTING AGENCY:	World Bank
NATIONAL COORDINATING AGENCY :	Department of Industrial Works
TECHNICAL REVIEW COMPLETED:	YES _X_ NO _

SECRETARIAT'S COMMENTS

1. This project proposal covers phasing out of 14 MT ODS solvents used in aircraft maintenance operations at Thai Airways. ODS solvent degreasing units and manual and aerosol can based operations will be replaced with aqueous cleaning system, non-ODS solvents and no-clean options. Environment aspects are duly taken into consideration.

2. The Seventh Meeting of the Executive Committee approved US $100,000 for Thai Airways non-ODS Metal Cleaning project. Subsequent detailed analysis carried out by the World Bank resulted in substantial reconfiguration of the project proposal due to larger scope and diversity of required operations. World Bank contracted with SAS to develop a complete engineering design package for the project. This SAS contract was for US $41,500 and was paid from the original approved funds. Inputs for preparation of the project have also been provided by ICOLP, United States Environmental Protection Agency and Swedish Environmental Protection Agency. The project aims also to provide a basis for transfer of CFC-free technology in the airline industry in other Article 5 countries.

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1. Calculated for two years of operation (not discounted).
2. Unutilized portion remaining from funds previously approved for the World Bank (US $100,000).

3. Cost-effectiveness is low. It is difficult to make a comparison with other similar projects, since this is the first project which deals with such a diversity of cleaning operations.

SECRETARIAT'S RECOMMENDATIONS

4. The Fund Secretariat recommends approval of the project and funding in the amount of US $463,900.

5. It is further recommended that implementing agencies take into consideration the experience in preparation of this project while preparing similar projects in other Article 5 countries.

PROJECT COVER SHEET

COUNTRY:	Thailand
PROJECT TITLE:	THAI UNION elimination of the use of CFCs in the manufacture of Flexible PUF Cold cured moldings, Integral Skin moldings and Rigid PUF articles.
SECTOR COVERED:	Foamed Plastics
ODS USE IN SECTOR:	1510 MT (1993)
PROJECT IMPACT:	Phaseout of 45 MT of CFC-11
PROJECT DURATION:	One Year
PROJECT ECONOMIC LIFE:	10 Years
TOTAL PROJECT COSTS:	USD 525,000
PROPOSED MLF GRANT:	USD 525,000
COST EFFECTIVENESS:	USD 1.90/kg/yr (Unit Abatement Cost)
COORDINATING NATIONAL BODY:	Ministry of Environment Department of Industrial Works (DIW)
IMPLEMENTING AGENCY:	UNDP
APPRAISAL DATE:	September 4, 1994

PROJECT SUMMARY

Thai Union PU Co. Ltd., is one of the largest manufacturers of Flexible PUF products (cold cured moldings), semi-rigid PUF products (integral skin moldings) and rigid PUF products (imitation wood) in Thailand. The purpose of this project is to phase out the usage of CFC-11 in the manufacture of these products, by substituting it with HCFC-141b, (for the rigid foam products), HCFC-22 (for the integral skin moldings), and all-water blown system (for the cold cured products). This will involve the replacement of the existing low pressure dispensing machines in their flexible foam production lines, by high pressure machines and other associated equipment.

Prepared by: Mr. M. Sarangapani
Reviewed by: Dr. Hubert Creyf

PROJECT OF THE GOVERNMENT OF THAILAND

THAI UNION: CONVERSION TO CFC-FREE TECHNOLOGY IN THE MANUFACTURE OF INTEGRAL SKIN MOLDINGS, COLD CURE MOLDINGS AND RIGID POLYURETHANE FOAM ITEMS

1. PROJECT OBJECTIVE

The objective of this project is to phaseout the use of CFCs in the manufacture of flexible, integral skin and rigid PUF products at Thai Union PU Co. Ltd., Thailand.

2. SECTOR BACKGROUND

About 50% of the total amount of imported CFC-11 in Thailand is consumed in the foam production industry. ODS are used as blowing agents in the production of five types of foams in Thailand: appliance insulation, flexible foams, rigid construction/insulating foams, polystyrene packaging, and miscellaneous applications. In 1991, ODS consumption (primarily CFC-11 and to a lesser extend CFC-12) in this sector was almost 1,600 t. An estimated 500 t of CFC-11 was used int he production of rigid PUF in refrigerators/freezers, while 200 t of CFC-11 was used for flexible PUF, 420 t for rigid PUF in insulation/construction and 190 t for other foams. About 200 t of CFC-12 was used as a blowing agent in other applications.

The Country Programme for ODS phaseout was finalized in 1993. For the foam sector, 1998 was set as the target year for complete phaseout of both CFC-11 and CFC-12 in Thailand. Already, the government is actively taking concrete measures towards implementing this programme. Several investment projects involving production conversion to non-ODS technology are presently under implementation by the World Bank and UNDP, and implementation of this project is within the overall sectoral strategy.

3. ENTERPRISE BACKGROUND

Thai Union PU Co. Ltd., is a 100% Thai owned private enterprise, and manufactures the following products:

o Rigid Foam: Imitation Wood, Furniture, etc.
o Integral Skin Moldings: Steering wheels, bicycle seats, etc.
o Cold-Cured Molding: Automotive seats, molded chairs, etc.

The company consumed 45 t/y of CFC-11 in the production of the above. The company has one Kraus Maffei high pressure dispensing machine for the rigid foam line, two Elastogran low pressure dispensing machines for the integral skin products and one Elastogran low pressure dispensing machine for the cold-cured products.

4. PROJECT DESCRIPTION

Under this project Thai Union will phase out the usage of CFC-11 from its production of above mentioned PUF products as under:

Rigid Foam: CFC-11 (12 t) will be replaced by HCFC-141b. The existing machines will be retained. However, a premixing station and buffer tank with transfer pump will be required to be installed.

Integral Skin: CFC-11 (10t) will be replaced by HCFC-22/partial water. The existing two low pressure machines will be replaced by two high pressure machines of equivalent capacity. In addition, pre-mixing/blending stations and a buffer tank with transfer pump will be installed.

Cold Cured Molding: CFC-11 (23 t) will be replaced by all-water blown system. The increase viscosity of the foam mix will be catered to by replacing the present low-pressure machine by a high pressure machine. Low OH value extended polyols will have to be used.

5. TECHNOLOGY

5.1 OVERVIEW AND SELECTION

In case of **rigid foam,** the routes to replace the CFCs in the process are as under:

- o CFC-11 > Partial Water + HCFC-141b > ?
- o CFC-11 > Partial Water + HCFC-22 > HFC-134a, HFC-152a
- o CFC-11 > (cyclo) pentane

In addition, HCFC-123 and water-blown technologies have been suggested, but these are either immature in technology, of limited availability or of limited applicability.

The first route described above (also called the liquid solution) employs technology that is closely related to the existing one. The final step in this route is not yet decided. One potential solution is HCFC-356, but full water blown foam, with improved skin formation remains an option, specifically int he "lesser demanding" system.

The second route above, (also called the gas solution) utilizes a gaseous mixture of physical blowing agents. The final step in this route is seen as the introduction of (gaseous) HFCs. However the high diffusion rate of HCFC-22, limits its use to "encapsulated" systems.

The third route, or the (cyclo) pentane technology has been introduced recently on a commercial basis, but its flammable nature requires safety conditions and limits its use to enterprises that can cope with such substances.

In case of **integral skin moldings**, most applications currently utilize HCFC-22 or to a lesser extent HCFC-141b as the blowing agent. This results in a well defined skin, with good overall physical properties. The skin is relatively thick, with a smooth surface and is paintable. Pentane is also being used to a small extent. Development efforts for safer substitutes are continuing down several pathways, including HFC-134a, all water, molecular sieve and pentane.

In case of **cold-cured moldings**, all water-blown system is the best substitute for the CFC-11. However, changed mixing ratios, increase the viscosity of the foam mix. This can be handled by a high pressure mixing/dispensing machine only, which will have to be installed in place of the present low-pressure machine. In addition choices of the polyol blend and isocyanate variant, suitable to the process, will have to be made.

5.2 IMPACT ON THE PRODUCTION PROCESS

Rigid Foam Products: Use of HCFC-141b will result in change of mixing ratio, leading to increased viscosity of the foam mix. This will require a high pressure dispenser and a premixing unit. Presently, this enterprise already uses a high pressure dispenser for the rigid foam products. However, a premixing unit needs to be installed to ensure proper mixing. Due to the higher cost of HCFC-141b compared to that of CFC-11, certain incremental operating costs can be foreseen, however these will be neutralized by the savings emanating from the substitution of CFC-22 by water-blown system, in the cold-cured moldings.

Integral Skin Products: Use of HCFC-22 in place of CFC-11, will lead to changed mixing ratios, causing increased viscosity of the foam mix. The present two low pressure machines will be replaced by high pressure ones. Also, a premixing station and a buffer tank will have to be installed. There will be slightly increased operating costs, which however, will be neutralized by the savings accruing to this enterprise, due to the replacement of CFC-11 by all water blown system in the cold-cured molding line.

Cold-Cured Moldings: Increased viscosity of the foam mix is expected due to the new mixing ratios and polyol blends, because of water as the blowing agent. To handle this, the existing low pressure dispensing machine will be replaced by a high pressure one. Extended polyols will be required, are more expensive, adding to the operating costs. However, the savings due to the replacing of CFC-11 with water, and the lower costs of the isocyanates (due to the TDI levels in the blends), will in effect neutralize the increased costs due to the extended polyols.

Extensive trials for stabilizing the product range will be required. Also, training and technology would be required.

6. PROJECT COSTS

6.1 CAPITAL COSTS

The following is the summary of the expected costs of new machinery and modification/introduction of systems:

Rigid Foam Products:	
Pre-mixing Station..........................	USD 60,000
Buffer Tank..........................	USD 5,000
Integral Skin Moldings:	
Two high pressure dispensing machines	USD 200,000
Pre-mixing station..........................	USD 60,000
Buffer Tank	USD 5,000
Cold Cured Molding:	
High Pressure 2-Component Machine..................	USD 112,500
Technology, Transfer & Training.....................	USD 10,000
Trails and Start-Up	USD 25,000
Contingencies..........................	USD 47,500
TOTAL	**USD 525,000**

6.2 OPERATING COSTS

Rigid Foam Products: Replacement of CFC-11 by HCFC-141b will result in slightly increased operating costs, HCFC-141B being presently more expensive than CFC-11. However, this difference in prices is expected to be negligible or even nil in future, as the market responds to the phase out program.

Integral skin products: CFC-11 will be replaced by HCFC-22 which is slightly more expensive. However, as explained above, this price difference will soon be reduced or even eliminated in future.

Cold Cure Moldings: The changeover from CFC-11 to all-water blown system), will result in marginally increased operating costs due to the more expensive polyol blend that is required to be used. However, these increases are compensated by the saving resulting from the substitution of CFC-11 with water.

Following is the typical scenario for the overall project before and after phaseout:

Before:	45 t of CFC-11 @ USD 1.65/kg	USD 74,250
After:	Rigid Foam - 7 t of HCFC-141b USD 4.00/kg...	USD 28,000
	Integ Skin - 5 t of HCFC-22 @ USD 3.50/kg..	USD 17,500
	Cold Cure - 61 t of polyol @ USD 0.25/kg	USD 4,800

6.3 UNIT ABATEMENT COSTS

a) Incremental Capital Costs........... USD ~~640,000~~ 525,000
b) Project Economic Life .... 10 Years
c) Incremental Recurring Costs .... -0-
d) CFC Consumption (1993).............. 45,000 kg
e) Capital Recover Factor.............. 0.16275

Unit Abatement Cost (a * e + c)/d USD ~~2.31~~ 1.90/kg/y

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7. FINANCING PLAN

The company requests disbursement of the full project costs amounting to **USD ~~640,000~~.** 525,000

8. PROJECT IMPLEMENTATION

8.1 MANAGEMENT

UNDP will be the implementing agency for this project and will work in cooperation with the recipient and the DIW, Government of Thailand.

8.2 PROCUREMENT

UNDP will oversee the procurement and provide technical and procedural assistance.

8.3 SCHEDULE

TASK	TIME FOR COMPLETION					
	Q1	Q2	Q3	Q4	Q5	Q6
1. Preparation						
MLF Approval	X					
Pre-Audit	X					
Order Confirmation(s)	X					
2. Installation						
Arrival, Customs			X			
Installation			X			
3. Start-up, Training						
Machine Start-Up				X		
Trials/Training				XXX		
4. Post-Audit/Commission				X		

9. PROJECT IMPACT

The implementation of this project will result in the phase-out of at least 45 t of CFCs in the first year of implementation. The project employs commercially and environmentally acceptable technology.

10. ANNEXES

Annex a: Project Technical Review

TECHNICAL REVIEW

1. COUNTRY: Thailand

2. **PROJECT TITLE:** **THAI UNION - Elimination of the use of CFCs in the Manufacture of Flexible PUF Cold-cure Mouldings, Integral Skin Mouldings and Rigid PUF Articles**

3. **(SUB) SECTOR:** **About 50% of the total amount of imported CFC-11 in** Thailand is consumed in the foam production industry. As part of its national ODS phaseout strategy, the **Government of Thailand has decided to phase out the use of CFC-11 in the production of flexible polyurethane foam by 1997 and has already taken measures to implement this strategy. This project is an integral part of this sector strategy.**

4. **CP RELATIONSHIP:** **MMI and UNDP, in cooperation with NCLI and NEPA, are formulating a sector strategy for the phaseout of CFCs in automotive trim.**

5. **TECHNOLOGY:** **The company wants to eliminate the use of CFC-11 in three production lines:**

5.1 Flexible melding: through only water blown technology;

5.2 Integral skin foam: through replacement by HCFC-22;

5.3: Rigid non-insulating foam: through replacement by HCFC-141b.

The first two technologies are fully justified, and will result in an important ODS reduction.

The third mentioned technology could be accepted if the rigid foam had an insulating function. However, as long as no fully water blown formulation is available, which is technically acceptable in the wood imitation production, the HCFC-141b technology can be accepted. It is hence strongly suggested that the company, perhaps together with its raw material supplier, should investigate in all water blown formulations.

6.	**ENVIRONMENTAL**	**The ODP values for HCFC-141b (0.1) and HCFC-22 (0.05) are acceptable. The GWP values are respectively 0.11 and 0.35. Both HCFCs have an acceptable smog potential.**
7.	PROJECT COST:	7.1 Moulding The use of water as a CO2 generator tends to increase **the viscosity of the reaction products. Hence, a high pressure 2-component machine is an integral part of the technology.** **7.2 Integral skin foams** **The same phenomenon of increased viscosity will occur when CFC-11 is replaced by HCFC-22. Hence HP-units are necessary together with a premix station.** **7.3 Rigid foam** **The capital costs identified can be accepted.**
8.	**IMPLEMENTATION:**	**One year is a normal time for such a change-over.**
9.	**RECOMMENDATION:**	**The project can be accepted but the company must promise to change to water blown rigid foam as soon as the technique is available.**

PREPARED BY: **Dr. Hubert Creyf**
UNDP Foam Sector Project Reviewer

DATE: **26 October 1994**

PROJECT COVER SHEET

COUNTRY:	Thailand
PROJECT TITLE:	SOMBOON PAISARN elimination of the use of CFCs in the manufacture of Flexible PUF slabstock and Cold cured moldings.
SECTOR COVERED:	Foamed Plastics
ODS USE IN SECTOR:	1510 MT (1993)
PROJECT IMPACT:	Phaseout of 100 MT of CFC-11
PROJECT DURATION:	One Year
PROJECT ECONOMIC LIFE:	10 Years
TOTAL PROJECT COSTS:	USD 225,000
PROPOSED MLF GRANT:	USD 225,000
COST EFFECTIVENESS:	USD 0.37/kg/yr (Unit Abatement Cost)
COORDINATING NATIONAL BODY:	Ministry of Environment Department of Industrial Works (DIW)
IMPLEMENTING AGENCY:	UNDP
APPRAISAL DATE:	September 22, 1994

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PROJECT SUMMARY

C. Somboon Paisarn 85 Company Ltd. is a 100% Thai owned private enterprise which produces a variety of flexible foams (having densities from 14 to 65 kg/cu. m) and also some specialty foams (such as packaging, antistatic, sponges, polymer filled, etc.). They also make automotive seats and pillows in the moldings category. Under this project, the company will phase out the use of CFC-11, substituting it with a combination of water/methylene chloride and accelerated cooling (for the flexible slabstock). The company will also phase out the CFC-11 usage in the flexible molded foams category, using CO_2/water as a substitute.

Prepared by: Mr. M. Sarangapani
Reviewed by: Dr. Hubert Creyf

PROJECT OF THE GOVERNMENT OF THAILAND

SOMBOON PAISARN: CONVERSION TO CFC-FREE TECHNOLOGY IN THE MANUFACTURE OF FLEXIBLE PUF SLABSTOCK/MOLDING

1. PROJECT OBJECTIVE

The objective of this project is to phaseout the use of CFCs int he manufacture of flexible PUF at Somboon Paisarn.

2. SECTOR BACKGROUND

ODS are used as blowing agents int he production of five types of foams in Thailand: appliance insulation, flexible foams, rigid construction/insulating foams, polystyrene packaging, and miscellaneous applications. Producers of these foam products used almost 1600 MT of ODS in 1991, primarily CFC-11 and to a lesser extent CFC-12.

3. ENTERPRISE BACKGROUND

C. Somboon Paisarn 85 Company Ltd., is a 100% Thai owned private enterprise, established in 1985. The company produces @ 2000 MT of flexible slabstock PUF (for mattresses, sheets, etc.) and @ 120 MT of cold cured moldings (for automotive seats, pillows, etc.) per year. The company has a continuous slabstock production line, and a low pressure OMS machine for cold-cured moldings.

4. PROJECT DESCRIPTION

Under this project Somboon will phase out the usage of CFC-11 from its production of flexible foams as under:

Slabstock Foam: CFC-11 will be replaced by methylene chloride. The polyol will need a softener additive. For facilitating this changeover, storage and metering systems for the MC/softener have to be added. Rapid cooling system (for neutralizing the higher exotherm), water lance system (for fire extinguishing), standby electric power generator, and modifications/improvements to the ventilation systems (to overcome the hazard of working in the MC environment) will also have to be implemented.

Cold Cured Molding: CFC-11 will be replaced by all-water blown process. The existing low pressure dispensing/metering machine will be replaced by a high-pressure machine, to take care of the increased viscosity of the foam mix. "Extended Range' polyols of low OH values and isocyanate variants will be used to produce the all-water blown cold cured moldings in similar density.

5. TECHNOLOGY

5.1 OVERVIEW AND SELECTION

There are numerous options to replace CFCs int he manufacture of flexible PUF slabstock. These are described and reviewed in UNEP's "Technical Options Handbook". The use of the methylene chloride in place of CFC-11, constitutes the most economical and environmentally acceptable solution, provided adequate safeguards int he production process and premises, are adopted.

In case of cold-cured moldings, all-water blowing is the best interim substitute for the CFC-11. However, changed mixing ratios, increased the viscosity of the foam mix. This can be handled by a high pressure mixing/dispensing machine only, which will have to be installed in place of the present low-pressure machine. also, choices of the polyol blend and isocyanate variant suitable to the process, will have to be made.

5.2 IMPACT ON THE PRODUCTION PROCESS

Slabstock Foam: The sue of methylene chloride requires the installation of a suitable (non-corrosive, acid-proof) storage and metering system as well as adequate ventilation in production and curing area, to limit workers' exposure to an acceptable level. Higher water levels will result in increased exotherm. therefore, an accelerated curing system will be installed as well as a duplex water lance system to put out high-scorch blocks. A 23 KVA diesel generating set, will be installed to provide back-up power to the exhaust system, in the event of an electricity failure. Safety and production training will be required and this will be provided by an outside expert. Further, the use of methylene chloride calls for certain precautions. Presence of metal ions as impurities can cause rapid increase in exotherm, that can even lead to auto-ignition.

Cold-Cured Moldings: The existing low pressure dispensing/metering machine will be replaced by a high pressure machine. Increased viscosity of the foam mix is expected due to the new mixing ratios and polyol blends, resulting from the introduction of water as the blowing agent. The "Extended range" polyols are more expensive and will add to the operating costs.

6. PROJECT COSTS

6.1 CAPITAL COSTS

The following is the summary of the expected costs of new machinery and modification/introduction of systems:

Slabstock:

MC Metering and storage system	USD 30,000
Metering/Storage system for additives	USD 15,000

Ventilation system	USD	30,000
Water lance duplex system	USD	10,000
Trials & Start-Up	USD	5,000
Cold Cured Molding:		
High Pressure 2-Component Machine..................	USD	100,000
Trials and Start-Up	USD	5,000
Technology, Transfer & Training.....................	USD	10,000
Contingencies	USD	20,000
TOTAL	**USD**	**225,000**

6.2 OPERATING COSTS

Slabstock: The operating costs after conversion are highly dependent on the final choice of formulation. Conversion to methylene chloride will result in lower operating costs, but maximizing water (minimizing the use of ABA) and the use of some additive to maintain quality in softer foams will result in increased costs. The net result is thought to be about even, because of the large margin of choice that is available. It is therefore suggested not to consider incremental recurrent cost of the slabstock operations, due to the large margin of potential variation.

Cold Cured Moldings: The changeover from CFC-11 to Water-blown system, will result in marginally increased operating costs, due to the more expensive polyol blend, that is required to be used. However, these increases are compensated by the savings resulting from the substitution of CFC-11 with water. Following is a typical scenario:

Before: 24,000 kg of CFC-11 @ USD 1.65/kg...USD 39,600
After: 432 MT of polyol @ USD 100/MT ....USD 43,200

The incremental operating costs occurring as above are negligible and are expected to even out rapidly, due to market forces.

6.3 UNIT ABATEMENT COSTS

a) Incremental Capital Costs........... USD 225,000
b) Project Economic Life .... 10 Years
c) Incremental Recurring Costs .... -0-
d) CFC Consumption (1993).............. 100,000 kg
e) Capital Recover Factor.............. 0.16275

Unit Abatement Cost (a * e + c)/d USD .037/kg/y

7. FINANCING PLAN

The company requests disbursement of the full project costs amounting to **USD 310,000.**

8. PROJECT IMPLEMENTATION

8.1 MANAGEMENT

UNDP will oversee the implementation of this project and provide technical assistance.

8.2 SCHEDULE

TASK	TIME FOR COMPLETION					
	Q1	Q2	Q3	Q4	Q5	Q6
1. Preparation						
MLF Approval	X					
Pre-Audit	X					
Order Confirmation(s)	X					
2. Installation						
Arrival, Customs			X			
Installation			X			
3. Start-up, Training						
Machine Start-Up				X		
Trials/Training				XXX		
4. Post-Audit/Commission				X		

8.3 PROCUREMENT

UNDP/OPS will execute the project and oversee the procurement activities. OPS policies on bidding procedures, contractor selection, disbursement procedures and project certification will apply, ensuring fair bidding and accountable financial management.

9. PROJECT IMPACT

The implementation of this project will result in the phase-out of at least 100 MT of CFCs in the first year of implementation. The project employs commercially and environmentally acceptable technology.

10. ANNEXES

Annex a: Project Technical Review

9. PROJECT IMPACT

The implementation of this project will result in the phase-out of at least 100t of CFCs in the first year of implementation. The project employs commercially and environmentally acceptable technology.

ANNEXES

Annex A: Technical Review

TECHNICAL REVIEW

PREPARED BY: Dr Hubert Creyf
UNDP Foam Sector Project Reviewer

DATE: 20 October 1994

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1. **COUNTRY:** Thailand

2. **PROJECT TITLE:** SOMBOON PAISARN - Elimination of CFCs in the Manufacture of flexible PUF slabstock and cold cure mouldings

3. **(SUB) SECTOR:** Foamed Plastics

4. **CP RELATIONSHIP:** About 50% of the total amount of imported CFC-11 in Thailand is consumed in the foam production industry. As part of its national ODS phaseout strategy, the Government of Thailand has decided to phase out the use of CFC-11 in the production of flexible polyurethane foam by 1997 and has already taken measures to implement this strategy. This project is an integral part of this sector strategy.

5. **TECHNOLOGY**

5.1 Flexible slabstock: One of the most attractive economic solutions in replacing CFC-11 is the use of methylene chloride, combined with addition of water and softening agents and application of the rapid cure technology.

Drawbacks are:
a - the emission of MC
b - the inside air quality
c - the increased fire risk for critical formulations

Therefore:

a) the emission legislation of Thailand must be consulted, to see whether the emission is allowed. It can however be argued that MC emission is not contributing to smog formation;

b) the TLV value for MC in most western countries is 50ppm; the MC-concentration must be monitored at all working places, and corrected if necessary;

c) special management procedures must be strictly followed in order to take care of risky formulations. A strict no-smoking rule must be instituted since MC passing through a lighted cigarette tip can be decomposed to the toxic phosgene.

5.2 Cold cure molding: The most environmentally sound solution to eliminate CFC 11, is the proposed replacement by water and "Extended Range" polyols.

6. ENVIRONMENTAL IMPACT:

6.1. Flexible slabstock: MC has no ODP or GWP. Its contribution to smog formation is negligible. However, local emission laws must be controlled.

6.2. Cold cure molding: The proposed technology has no environmental impact.

7. PROJECT COSTS:

The costs presented for the ventilation system [USD 30,000] seem to be too high for only 10 m of encapsulation. USD 20,000 will be more realistic.

8. IMPLEMENTATION:

The proposed project duration of one year, is acceptable.

9. RECOMMENDATION:

It is recommended that the project be approved.

PROJECT COVER SHEET

COUNTRY:	THAILAND
PROJECT TITLE:	KARN YANG elimination of the use of CFCs in the manufacture of Flexible PUF Slabstock
SECTOR COVERED:	Foamed Plastics
ODS USE IN SECTOR:	1510 t (1993)
PROJECT IMPACT:	Phase out of 110 t of CFC-11
PROJECT DURATION:	One Year
PROJECT ECONOMIC LIFE:	10 Years
TOTAL PROJECT COSTS:	USD 170,000
PROPOSED MLF GRANT:	USD 170,000
COST EFFECTIVENESS:	USD 0.25/kg/yr (Unit Abatement Cost)
COORDINATING NATIONAL BODY:	Ministry of Environment Department of Industrial Works (DIW)
IMPLEMENTING AGENCY:	UNDP
APPRAISAL DATE:	September 22, 1994

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PROJECT SUMMARY

Karn Yang Yeen Yong Industry Ltd. Part. is a 100% Thai owned private enterprise which produces flexible slabstock PUF. Under this project, this enterprise will phase out the use of CFC-11, substituting it with a combination of water/methylene chloride for its production of low density flexible slabstock foam. The project also envisages installation of the necessary safety equipment, trials and training.

Prepared by: Mr. M. Sarangapani
Reviewed by: Dr. Hubert Creyf

PROJECT OF THE GOVERNMENT OF THAILAND

KARN YANG: CONVERSION TO CFC-FREE TECHNOLOGY IN THE MANUFACTURE OF FLEXIBLE PUF SLABSTOCK

1. PROJECT OBJECTIVE

The objective of this project is to phase out the use of CFCs in the manufacture of flexible slabstock PUF at Karn Yang, Thailand.

2. SECTOR BACKGROUND

ODS are used as blowing agents in the production of five types of foams in Thailand: appliance insulation, flexible foams, rigid construction/insulating foams, polystyrene packaging, and miscellaneous applications. Producers of these foam products used almost 1600 t of ODS in 1991, primarily CFC-11 and to a lesser extent CFC-12.

3. ENTERPRISE BACKGROUND

Karn Yang Yeen Yong Industry Ltd. Part is a 100% Thai owned private enterprise, established in 1964, and has 150 employees. The company produced 200 t/y of flexible slabstock PUF (for mattresses, sheets, etc.) of densities ranging from 14-40 kg/cu.m in 1993 and consumed 110 t CFC-11.

The company has one Laaderberg machine, one Vertifoam machine and one box machine.

4. PROJECT DESCRIPTION

Under this project Karn Yang will phase out the usage of CFC-11 from its production of flexible foams. CFC-11 will be replaced by Methylene Chloride. The polyol will need a softener additive. For facilitating this changeover, storage and metering systems for the MC/Softener have to be added. Rapid cooling system (for neutralizing the higher exotherm), water lance system (for fire extinguishing), standby electric power generator, and providing ventilation systems (to overcome the hazard of working in the MC environment) will also have to be implemented.

Separate metering and storage systems for Methylene Chloride/Additives, will be provided, for the Laaderberg Machine and the Vertifoam machine. For the box machine MC/additive will be routed form one of the above systems.

5. TECHNOLOGY

5.1 OVERVIEW AND SELECTION

There are numerous options to replace CFCs int he manufacture of Flexible PUF slabstock. These are described and reviewed in UNEP's "Technical Options Handbook". The use of methylene chloride in place of CFC-11, constitutes the most economical and environmentally acceptable solution, provided adequate safeguards in the production process and premises, are adopted.

5.2 IMPACT ON THE PRODUCTION PROCESS

The use of methylene chloride requires the installation of a suitable (non-corrosive, acid-proof) storage and metering system as well as adequate ventilation in production and curing area, to limit workers' exposure to an acceptable level. A duplex water lance system to put out high-scorch blocks. A 25 KVA diesel generating set, will be installed to provide back-up power to the exhaust system, in the event of an electricity failure. Safety and production training will be required and this will be provided by an outside expert. The storage, transfer lines and metering pumps need to be of all-stainless steel construction.

6. PROJECT COSTS

6.1 CAPITAL COSTS

The following is the summary of the expected costs of new machinery and modification/introduction of systems:

Laaderberg Machine:		
MC Metering and storage system (upgrading)..	USD	10,000
Metering/Storage System for additives	USD	15,000
Ventilation System	USD	40,000
Fall plates	USD	5,000
Vertifoam Machine:		
MC Metering and storage system (upgrading)..	USD	10,000
Metering/Storage System for additives	USD	10,000
Ventilation system	USD	20,000
Box Machine:		
Ventilation system	USD	10,000
Water Lance system	USD	10,000
Trials and Start-Up........................	USD	15,000
Training...................................	USD	10,000
Contingencies	USD	15,000
TOTAL	**USD**	**170,000**

It is generally seen that the impact of the phase out on the operating costs is not significant.

6.2 UNIT ABATEMENT COSTS

a)	Incremental Capital Costs	USD 170,000
b)	Project Economic Life	10 Years
c)	Incremental recurring costs	-0-
d)	CFC Consumption (1993)	110,000 kg
e)	Capital Recovery Factor	0.16275

Unit Abatement Cost (a * e + c)/d **USD 0.25/kg/y**

7. FINANCING PLAN

The company requests disbursement of the full project costs amounting to

USD 170,000
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8. PROJECT IMPLEMENTATION

8.1 MANAGEMENT

UNDP will be the implementing agency for this project and will work in cooperation with the recipient and the DIW, Government of Thailand.

8.2 SCHEDULE

TASK	TIME FOR COMPLETION					
	Q1	Q2	Q3	Q4	Q5	Q6
1. Preparation						
MLF Approval	X					
Pre-Audit	X					
Order Confirmation(s)	X					
2. Installation						
Arrival, Customs			X			
Installation			X			
3. Start-up, Training						
Machine Start-Up				X		
Trials/Training				XXX		
4. Post-Audit/Commission				X		

8.3 PROCUREMENT

UNDP will oversee the procurement and provide technical and procedural assistance.

9. PROJECT IMPACT

The implementation of this project will result in the phase-out of at least 100t of CFCs in the first year of implementation. The project employs commercially and environmentally acceptable technology.

ANNEXES

Annex A: Technical Review

TECHNICAL REVIEW

1. COUNTRY :	Thailand
2. PROJECT TITLE :	KARNYANG elimination of the use of CFCs in the manufacture of PUF slabstock.
3. (SUB) SECTOR :	Foamed Plastics
4. CP RELATIONSHIP :	Unknown
5. TECHNOLOGY :	The project proposed to replace CFC11 with MC and extra water on three different production machines. The proposed technology is perfectly acceptable on the condition that the local TLV for MC be met, in the workplaces. If not, the ventilation must be adapted. Weak points are paper take-off and saw. The TLV for MC in many western countries is 50 ppm. The workers must have a practical training in fire fighting.
6. ENVIRONMENTAL IMPACT :	MC has no ODP, and its effect on lower ozone formation is very low.

7. PROJECT COST :	**The project costs can be accepted as presented. The cost for removal of 1 t ODS is 1.864 USD, which is very favourable.**
8. IMPLEMENTATION :	**One year is acceptable**
9. RECOMMENDATION :	**to be accepted with remarks made on health aspect under 5.**

PREPARED BY : Dr.Hubert Creyf
UNDP Foam Sector Project Reviewer

DATE : 25 October 1994

THE MONTREAL PROTOCOL ON
SUBSTANCES THAT DEPLETE THE OZONE LAYER
PROJECT COVER SHEET

COUNTRY:	Kingdom of Thailand
SECTORS COVERED:	Solvents
ODS CONSUMPTION IN SECTOR:	4,220 tons CFC-113, 9,520 1,1,1-TCE (1992)
PROJECT TITLE:	Phase-out of ODS Solvents at Thai Airway (99.6% of ODS)
PROJECT DURATION:	1.5 years
PROJECT IMPACT:	14 tons ODS; TAC = 12.5
Incremental Project Costs	Capital Operating Cost $482,000 $12,300/year
PROPOSED OTF GRANT [1]	$507,200 (to Thai Airways) 15,200 (IFCT fee) $522,400 (Total) -58,500 (from first MPEC funding)
NET INCREASE IN GRANT REQUEST	$463,900
IMPLEMENTING ENTERPRISE:	Thai Airways International
NATIONAL COORDINATING AGENCY:	Department of Industrial Works
IMPLEMENTING AGENCY	The World Bank

PROJECT SUMMARY

1. The project will result in elimination of about 14 tons per annum of ODS at Thai Airways, resulting in a 99.6 percent phase-out of ODS. (Phasing out 50 kg of aerosol used for applying rain repellant onto aircraft windshields has been deferred due to cost ineffectivity.) The project reduces the number of solvent degreaser stations and substitutes aqueous cleaning technology for the existing ODS solvents. This project has a high priority not only for Thailand but globally due to complexity with respect to diversity of aircraft components, flight safety and choice of environmentally safe alternatives. This complexity required cooperation between national and international aircraft manufacturers and maintenance organizations, solvent experts and equipment suppliers.

Technical Assessment: The project has been reviewed and supported by the OORG reviewer, Art Fitzgerald and his comments during project preparation were fully taken into consideration in final scope and costs. His comments are attached.

[1] Net OTF request includes credit of $58,500 left from $100,000 approved by MPEC for this project. $41,500 was used for engineering design by SAS.

PROJECT OBJECTIVES

2. The prime objective is to phase-out substantially all ODS solvents use in critical and complex aircraft maintenance operations in a cost effective manner at Thai Airways.

3. Another objective is to provide a basis for transfer of ODS-free technology to the airline industry world-wide in eligible countries requiring assistance. Related activity within the framework of Industry Cooperative for Ozone Layer Protection (ICOLP), has already facilitated the preparation of a separate general purpose manual that can be used by other commercial airlines to eliminate ODS solvent applications.

SECTOR BACKGROUND

4. The total use of ODS in the solvent sector in Thailand, for 1992, is estimated to be about 13,700 tons. On an unweighted basis, solvent cleaning sector accounts for approximately 66 percent of the country's ODS consumption. The main solvent use areas are electronics, metal/precision cleaning, and contact drying. Aircraft maintenance covers all the three areas including coating applications. Thailand's consumption of ODS-solvent in the maintenance of civil aircraft for 1995 is forecast to increase, by approximately 30 percent annually, to an annual emission of about 20 tons. Project implementation shall result in a virtually total elimination of ODS-solvent consumption in the civilian aircraft maintenance sector. The CFC-113 consumption for the solvent sector in Thailand, for 1991-1992, was 3,200 - 4,200 tons. 1,1,1-trichloroethane consumption for the same period was 7,100 - 9,500 tons.

ENTERPRISE BACKGROUND

5. Thai International Airlines (Thai Airways) is 100% locally owned enterprise. Thai Airways is the sole national airline and operates, both domestic and international routes, to 80 destinations world wide. Thai operates and maintains about 69 aircraft and 233 engines. Thai Airways also provides servicing facilities to external carriers. Heavy maintenance services are carried out on approximately 12 aircraft and 100 engines annually. Details are given in the engineering study completed by Scandinavian Airlines System (SAS) for this project. Existing technology utilized in the maintenance of aircraft has been provided by SAS and SAS continues to provide support on an as needed basis.

PROJECT DESCRIPTION [2]

6. The annual consumption of ODS-solvents (1,1,1-TCE, CFC-113) at Thai Airways during the period 1990-1992 was approximately 14 tons. Current operations service metals, plastics, and composite parts, electromechanical devices, precision components and electronics and requires quality assured alternative technology to maintain the air-worthiness and safety of civil

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[2]/ The original project proposal (approved by MPEC in ---- for $100,000) was based on one degreaser operation and use of TCE as replacement solvent. Subsequent detailed enquiring analysis by SAS showed that Thai has eight degreasers in use, that will be consolidated to 7. This layer scope, plus the need for custom design, plus the decision to not use TCE as a solvent on environmental grounds, explain the substantial increase in project scope and costs component compared to the original proposal. When the larger size was realized, the Bank contracted with SAS (on behalf of Thai Airways) to develop a complete engineering design package for the project. That SAS contract was for $41,500 and was paid from the original MPEC approved funds.

aircraft. Thai does not use CTC. The company has about 8 solvent degreasing units of which one has been mothballed and 6 are operated with bulk ODS-solvents. The 6 unit are located in 6 shops which are widely spread out at the maintenance facility. Diverse manual and aerosol can based operations account for approximately 1.4 tons/yr of ODS consumption. Manual and aerosol based operations are extensively used at all locations including on board the aircraft. ODS-solvents are used widely for maintenance of critical components, e.g. aircraft engines, landing gears, engine fuel control units, filters, avionics and guidance systems, oxygen systems etc.

7. Design has been based on proven alternatives with other users. An important criteria in the selection of alternatives has been the objective to avoid, or reduce to minimum, environmental and safety hazards. An Environmental Assessment is provided in Annexure 5 of the SAS report. The Feasibility Study and relevant alternatives have been developed in cooperation with Scandinavian Airlines System and Volvo Aero Support. Inputs for preparation of the project have also been provided by ICOLP, USEPA and Swedish EPA.

The major components include; purchase and installation of one i-line aqueous cleaning system including a waste-management system; one batch cleaning unit based on alcohol-poly fluorohexane use; two no-clean options; and one hydrocarbon based cleaning booth. Two of the options use existing equipment subsequent to minor modification measures.

8. For the Thai facility, the following options are deemed viable and are recommended.

- Aircraft Engine Maintenance Shop:

  a) Aqueous cleaning (CEE-BEE A7X7) including waste-management of effluents.

- Avionic Maintenance and Oxygen Bottle Shops:

  a) Oxygen equipment: isopropanol alcohol (IPA), polyfluorohexane (PFC) system
  b) Bench top operations: n-heptane or IPA options.

- Bearing and Filter Shop:

  a) Bearing shop: Does not use ODS-solvents.
  b) Filter shop: No clean option is recommended by scrapping the few remaining oil filters. Alternatively cleaning can be achieved by using JP-4 jet fuel or terpene cleaning (Penetone Citriclean XPC) in conjunction with aqueous or white spirit rinse. For the Thai facility, the no-clean option has been chosen whereby discardable filters, not requiring ODS cleaning, will be introduced.

- Fuel and Pneumatic and Hydraulic Shops:

  a) Fuel and Pneumatic Shop: The Main Engine Control Unit can be cleaned in an aqueous based system (Brulin 815GD) followed by luke-warm water rinsing and drying by compressed air or in oven at 100oC. Pneumatic valves can be cleaned in white spirit.

  b) Hydraulic Shop: According to Thai-job crd, hydraulic fluid filters are already being cleaned in TRO petrol. Majority of component maintenance manuals specify white spirits hence this methods should be standardized.

- Aerosols and other ODS-Solvents Consumables

  - For most aerosol uses alternatives have been identified. All ODS products can be expected to be substituted within six months. The alternatives are mostly based on organic hydrocarbons. In a few instances they may contain HCFCs (HCFC 22, and HCFC 141 b). For one application, where CFC-113 is used as a carrier for a rain repellant, an alternative physio-chemical surface seal system has been recommended as a substitute. However, due to cost ineffectivity, introduction of this alternative has been deferred.

Justification for Alternative Technology

9. Alternative selection has been constrained by four important criteria:

1. Alternatives must be proven, robust and acceptable for satisfactory and reliable maintenance of aircraft body and engine components.

2. Application and use of alternatives should avoid, or reduce to minimum, risk to general and work place environment.

3. Alternative should be cost effective in phasing out the use of ODS.

4. Technology should be transferable to other facilities, world-wide, in phasing out the use of ODS-solvent.

10. A number of alternatives have been assessed for each application. For example, in the engine shop a more expensive aqueous based substitute, along with waste-management system, has been opted disregarding a less expensive investment for the introduction of chlorinated solvents (e.g. trichloroethylene). Chlorinated solvents are now frequently showing up on regulatory lists of controlled chemicals because of safety and environmental concerns. Although chlorinated solvents meets criteria 1 and result in lower capital investment cost, the saving obtained in choosing trichloroethylene has a high risks in being offset by the clean up of spillage into soil and ground water., this risk is ever present even in the best operated manufacturing processes. For Thai Airways, subsequent to the World Bank OORG review, an aqueous based on aqueous cleaning along with waste-management, is recommended. In order to assure stable operation of the critical waste management system, a set of spares is included to avoid protracted system down time.

11. In the Avionics and Oxygen Bottle shop, IPA-PFC and n-heptane alternatives have been selected. Environmental and safety issues with respect to IPA and n-heptane are mainly the flammability issues associated with IPA and n-heptane. While fire-safety issues associated with flammable solvents can be rectified, impact from use of PFC is of concern. The Aviation and Oxygen Shop, however, services critical oxygen equipment. Due to reactivity of oxygen under pressure and the intended use for breathing, all components coming into contact must be free of foreign substances. In this regards, the only acceptable lubricant is based on a fluorocarbon oil or grease, e.g. krytox. Besides CFC-113, the Krytox data sheet states that only perfluorocarbon can be used. An advanced degreaser has been assessed and recommended. Additionally, rationalization of operations at two shops to one shop will enable replacement of two current degreasers with one unit using the non-ODS technology. This approach limits consumption of PFC to about 80kg/y, compared to about 1600 kg/y of CFC-113 presently being used for the purpose. While a majority of the PFC loss would be to the atmosphere, the soils from the machine are estimated to contain about 20kg.

12. In the Filter shop a cost effective and reliable no clean system based on disposable filters is recommended. Disposal of the filters i s not a problem and there are no other issues of emissions.

13. In the fuel and Hydraulic Shops, aqueous and hydrocarbon alternatives are to be introduced. These are reliable and cost effective substitution. Substitution with the aqueous alternative uses existing equipment, subsequent to a minor retrofit. An extra HC-booth is to be installed to assure safe use of flammable substitute.

14. Elimination of ODS-solvents via aerosols in one use, for coating of aircraft window shields, requires a critical alternative Surface Seal System. This is the only currently known alternative for elimination of CFC-113 in the application.

PROJECT COST

15. The total capital cost associated with the phase out of ODS solvents at Thai maintenance facility is estimated to cost US$482,600 (Annex 1). Transportation costs shall be borne by Thai Airways.

Incremental Recurrent Costs/Savings

16. If the project was not undertaken, the annual operating cost, exclusive of tax, would be US$67,300. If the project is implemented, the annual operating cost increase to US$79,600. A detailed breakdown of operating costs is provided in Annex 2. The annual incremental operating costs associated with the phase out are appraised at US$12,300.

OTF Funding and Financing Plan

The total Project incremental cost, based on incremental recurrent costs for two years are US$507,200 (and without discounting incremental operating cost. Two years incremental costs represent a reasonable period for Thai Airways, since the cost for some filters in the design have been converted to throwaway type to save on capital costs and reduce energy consumption in running the aqueous cleaning system. This funding level would result in an OTF grant as described below:

Incremental Capital Cost	$ 482,600
Incremental operating costs	$ 24,600
subtotal	$ 507,200
3% FA fee to IFCT	15,200
subtotal	522,400
Credit for unutilized original funding	58,500
Net Request for new OTF funding	$ 463,900

Local Ownership Ratio

17. Thai is 100 percent locally owned.

UNIT ABATEMENT COST

18. The unit abatement cost is estimated to be US$12.5 per kilogram ODP phase-out. The cost appears acceptable given the variety of applications that are being covered, the quality and reliability criteria that are fulfilled and the inherent replication potential of the program at other airline facilities. The numbers are derived from annualized incremental capital cost of US$80,700, the annual incremental recurring cost of US$12,300 and saving of 14,000 kg of ODS solvents per year.

FINANCIAL AND ECONOMIC ANALYSIS

19. The project entails an initial investment followed by a net annual incremental operating cost resulting in a net outflow of cash for each year of the project's entire economic life. The economic and financial rates of return for the project are thus undefined.

FINANCIAL HEALTH OF THE ENTERPRISE

20. To be completed by IFCT.

PROJECT IMPLEMENTATION

21. The project will be carried out at Thai Airways and the enterprise will be fully responsible for the implementation of the Project.The project, upon approval and availability of the OTF grant, shall be completed within 1.5 years from start of activities as indicated below in Table IV

Table IV - Project Schedule

Description	Quarters					
Procurement Equipment	Q1	Q2	Q3	Q4	Q5	Q6
Install Infrastructure	X					
Install Equipment	X	X	X			
Test and Train			X	X		
Check and Adjust System				X	X	X

22. Procurement and Disbursement. The project will comply with Bank and IFCT procedures.

REQUIRED REGULATORY ACTIONS. None

RESULTS

Direct Project Impact

23. The project will eliminate about 14 tons of CFC-113 and 1,1,1-TCE annually used in maintenance operations including 6 shops operating 6 bulk cleaning facilities. Replacement of one aerosol application for aircraft windshield has been deferred due to cost ineffectivity.

Indirect Project Impact

24. This project has a high priority not only for Thailand but globally for other developing country airlines due to its complexity with respect to diversity of aircraft components, issues of flight safety and environmentally sound technology.

Table A1-1 Breakdown of Investment Costs (US$)

NO.	Description	US$
1.	Training and Engineering	8,400
2.	Materials Compatibility and Process Development	1,200
4.	Alternative Systems - Engine Shop 1 Aqueous Cleaner (CEE-BEE) 1 Waste Treatment System (Membrane Filter & Evaporator) - Avionics and oxygen Systems Shops 1 IPA-PFC System - Filter Shop 1 Set No-Clean Filter A 1 Set No-Clean Filter B	 235,860 77,000 77,000 incl. in op. costs
	- Fuel and Hydraulic Shop 1 White Spirit Booth 1 Aqueous Cleaner (Brulin)	 11,000 :
5.	Spares	9,200
6.	Facility Modification - Electrical - Piping - Ventilation	 36,000
7.	Transportation (US$0.42/ton.km) - incl. shipping - incl. insurance	 Courtesy Thai Airways
8.	SUBTOTAL	459,660
9.	CONTINGENCY (5%)	22,940
11.	TOTAL	482,600

INCREMENTAL OPERATING COSTS/SAVINGS

Table A2-1 Breakdown of Incremental Recurring Costs/Savings

NO.	Description	Quantity	Unit Cost @ US$	~~Pre~~-Project Costs US$	Post-Project Cost US$
1.	Solvent/Media Cost per Year				
	Current Systems Engine Shop – 1,1,1-trichloroethane Avionics & Oxygen – CFC-113 Filter – CFC-113 Fuel & Hydraulics - CFC-113 Aerosols – CFC-113	 8,000 kg/Y 1,600 kg/Y 1,000 kg/Y 2,000 kg/Y 1,400 kg/Y	 1.0/kg 4.3/kg 4.3/kg 4.3/kg 4.3/kg	 8,000 6,900 4.300 8,600 6,000	
	Alternative Systems Engine Shop - CEE-BEE or Ardox & pH adjuster) - Water	 12 changes/Y 104 m3/Y	 1716,7/change 0.48m3		 20,600 50
	Avionics & Oxygen - IPA - PFC	 26 kg/Y 78 kg/Y	 2.0/kg 30.0/kg		 2,450
	Fuel & Hydraulics - Brulin - White Spirit Aerosols - HC/HCFC/HFC	 50 kg/Y 1,000 l/Y 2,000 kg/Y	 2.5/kg 0.25/kg 4.5/kg		 350 9,000
2.	Electricity Engine Shop - Current System - Aqueous System including Waste treatment	 60,000 kWh/Y 290,000 kWh/y	 0.1/kWh 0.1/kWh	 6,000	 29,000
	Avionics & Oxygen - Current System - IPA-PFC	 2,300 kWh/Y 21,000 kWh/Y	 0.1/kWh 0.1/KWh	 230	 2,100
	Filter - Current System - No Clean	 2,160 kWh/Y	 0.1/kWh	 216	
	Fuel & Hydraulics - Current System - HC-Booth/retro	 500 kWh/Y	 0.1/kWh	 50	
3.	Waste Treatment Engine Shop - Current System - Aqueous System (including treatment chemicals)	 1,600 kg/Y 52 m3/Y	 7.5/kg 4.0/m3 1,050.0/Y	 12,000	 1,250
	Avionics & Oxygen - Current System - IPA-PFC	 320 kg/Y 20 kg/Y	 7.5kg 7.5kg	 2,400	 150
	Filter - Current System - No Clean	 200 kg/Y 65 filters/Y	 7.5/kg 1.5/filter	 1,500	

No.	Description	Quantity	Unit Cost @ US$	Pre-Project Cost US$	Post-Project Cost US$
	Fuel & Hydraulics - Current System - HC aqueous	 400 kg/Y 200 kg/Y	 7.5/kg 7.5/kg	 3,000	 1,500
4.	Maintenance Engine Shop - Current System - Aqueous System	 40 man.h/ Y 1.5 % of CC	 51/man.h	 2,000	 4,700
	Avionics & Oxygen - Current System - IPA-FFC	 40 man h/Y 2.0 % of CC	 51/man. h	 2,000	 1,500
	Filter - Current System Filter A Filter B Equipment	 28/Y 37/Y 20 man h/Y	 11.2/filter 22.1/filter 51/man h	 314 818 1,000	
	- No Clean Filter A Filter B Fuel & Hydraulics - Current System - HC-aqueous	 28/Y 37/Y 40 man h/Y 4 man h/Y	 131.2/ filter 81.0/filter 51/man.h/ 51/man.h	 2,000	 3,674 2,997 200
5.	Subtotal Pre-project			67,330	
6.	Subtotal Post project				79,600
7.	TOTAL ANNUAL INCREMENTAL COST				12,300

COUNTRY OF ORIGIN: Kingdom of Thailand

PROJECT TITLE : Phase-out of ODS Solvents at Thai Airway (99.6% of ODS)

SECTOR/SUB-SECTOR: Solvents

Technology.

1. Aircraft Engine Maintenance Shop.

   a) Aqueous cleaning (CEE-BEE A7X7) including waste management of effluents.

2. Avionic Maintenance and Oxygen Bottle Shops:

   a) Oxygen equipment: isopropyl alcohol (IPA), perfluorohexane (PFC) system.

   b) Bench top operations: n-heptane or IPA options.

3. Bearing and Filter shop:

   a) Bearing shop: does not use ODS solvents.

   b) Filter shop: A no-clean option is recommended; by scrapping the few remaining (solvent cleanable) filters. Alternatively cleaning can be achieved by using JP-4 jet fuel or terpene cleaning (Penetone Citriclean XPC) in conjunction with aqueous or white spirit rinse.
   For the Thai facility the no-clean option has been chosen whereby discardable filters not requiring ODS cleaning will be introduced.

4. Fuel Pneumatic and Hydraulic Shops:

   a) Fuel and Pneumatic shop: The main engine control unit can be cleaned in an aqueous based system (Brulin 815GD) followed by luke-warm water rinsing and drying by compressed air or in an oven at 100 °C.
   Pneumatic valves can be cleaned in white spirit.

   b) Hydraulic Shop: According to the Thai job card, hydraulic filters are being cleaned in TRO petrol. The majority oof component maintenance manuals specify white spirits, hence this method should be standardised.

5. Aerosols and other ODS solvent consumables

   For most aerosol uses alternatives have been identified. All ODS products can be expected to be substituted within six months. The alternatives are mostly based on hydrocarbons. In a few instances they may contain HCFCs (22, and 141b). For one application where CFC 113 is used as a carrier for a rain repellent, an alternative physico chemical surface seal systen has been recommended as a substitute. However, due to cost ineffectivity, introduction of this alternative has been deferred.

Assessment of the selected technology:

The selection of the aqueous cleaning system based on the CEE-BEE A7X7 method in combinatin with a compreheb=nsive waste water treatment system is fully justified because;

It has been fully evaluated by the Scandinavian Airline System staff who also participated in this project.

It will have less potential environmental risk than the chlorinated solvent system proposed originally.

The waste water system supplied with the aqueous cleaner will ensure minimum environmental impact via the waste stream.

The IPA PFC cleaning sytem will be justified because:

The PFC is a very good solvent for the Krytox (perfluoro ether) grease used in the oxygen system. It can only be dissolved in a fluorinated solvent.

The design of the cleaner chosen, is unique, incorporating an hermetic lid and underlid operation, thus minimising PFC losses, both during ther operating phase and during idling time. This is very important as PFC has a high GWP, and is expensive.

The small scale cleaning operation with n heptane and IPA will have minimal impact, but safe working will have to be ensured owing to the flammability of the two solvent options.

The fuel, pneumatic and hydraulic shops.

The proposals for these operations, consisting of a good aqueous system (Brulin 815GD) and white spirit elsewhere, will result in minimum environmental impact.

Overall, the proposal provides a safe and effective alternative to the existing systems and the estimated Unit Abatement Costs at $12.5 is low.

B. H. Baxter.