EP

United Nations
Environment
Programme

Distr.
LIMITED

UNEP/OzL.Pro/ExCom/16/17
14 February 1995

ORIGINAL: ENGLISH

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

Sixteenth Meeting
Montreal, 15-17 March 1995

METHODOLOGY FOR CALCULATION OF OPERATIONAL COSTS IN METHYLENE CHLORIDE PROJECTS

EXECUTIVE SUMMARY

1. This paper is submitted in response to the request of the Executive Committee to the Fund Secretariat to consult with sector experts and the implementing agencies, to adopt a methodology for treatment of operational costs for future methylene chloride (MC) projects, and to report back to its Sixteenth Meeting (UNEP/OzL.Pro/ExCom/15/45, para 130). It is a collaborative effort between the Secretariat and UNDP with inputs from the other implementing agencies.

2. All flexible polyurethane foam projects approved under the Multilateral Fund, that use the methylene chloride technology as partial or exclusive ODS replacement technology were reviewed to identify any inconsistencies in the calculation of the incremental operational costs (IOC). Subsequently, all possible direct and indirect parameters that could influence the IOC were identified, qualified and, where possible, quantified. A review of flexible polyurethane slabstock foam production technology was also prepared to provide technical background information as a means of further clarifying the issues involved. This companion paper is submitted as information paper UNEP/OzL.Pro/ExCom/16/Inf.3.

3. On the basis of the review of the approved projects and the parameters identified, a method for calculating the incremental operational cost was derived, based on a specific sample project. This is shown in Annex III to the paper. The following recommendations were also made for the consideration of the Executive Committee.

RECOMMENDATIONS

I <u>Factors to be Considered in Calculating Incremental Operational Costs (IOC)</u>

The following factors should be taken into account when calculating IOC.

(a) <u>Relative prices of methylene chloride and CFC-11</u>

The prices should be determined locally using the ratio MC/CFC-11 of 0.9/1.0. All pricing should also be guided by Executive Committee decision regarding pricing of commodities, namely that national pricing be used except where it was higher than 20% of the regional border price (UNEP/OzL.Pro/ExCom/12/37, para. 62). For 1995 the prices of urethane grade and non-urethane grade MC may not exceed US $1.00 and US $0.80 respectively. Where available, the price of urethane grade MC should be used.

(b) Catalysts

Amine: A 10% increase in amine catalyst corresponds to 10 pphp[1] MC. The need for additional or different catalyst should be justified. (Current price of catalyst is US $7.50/kg).

Tin: A 25% increase in tin octoate, corresponding to 10 pphp MC should be allowed (Current price is US $6-8/kg)

(c) Polyol

If the need for a better or different stabilized polyol as well as its local availability are established price increase of up to US $0.10/kg should be allowed.

(d) Toluene diisocyanate (TDI)

When forced cooling or softening technologies are used both the increased use of TDI and decreased use of MC should be taken into account in the IOC calculation. Replacement of ten parts of MC by 10 parts of TDI and one part of water should be considered.

(e) Softener

The cost of softener may be taken into account only when detailed formulations are developed. The calculation should also take account of adjustments in MC use.

(f) Yield loss

Initial incremental yield loss of 3% declining by 1% each year should be allowed.

(g) Incremental energy costs

Incremental energy costs will be eligible only in the event that the substitute technology results in increased energy consumption. However, if this increase results in expansion in production capacity of the foam (whether intentional or inadvertent) it should not be considered in the calculation of IOC. Calculation of incremental energy cost should be based on KW multiplied by run hours per year and local unit price.

(h) Incremental maintenance costs

Maintenance costs should be based on additional eligible equipment installed. The incremental maintenance costs should be calculated based on 5% of the eligible incremental equipment investment costs.

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1 pphp: parts per hundred parts of polyol, the standard expression in foam formulations. If pphp are assumed kg's then a standard formulation would amount to about 150 kg, after accounting for gas losses. Such conversion has been used in the calculation of the IOC effect of the use of a softener.

II Factors not to be Considered in Calculating Incremental Operational Costs

The following should not be considered when calculating IOC.

(a) Cost of Water

Cost of water is usually minimal. Generally, de-ionized water is used in foam formulations. This is particularly critical if MC is used, since iron content could trigger scorching. Therefore where not already installed, a water softener or de-ionizer would usually be included in the investment costs.

(b) Equipment type

Does not have any incremental effect on operational costs.

(c) Equipment Condition

This should be the liability of the enterprise concerned.

(d) Proficiency (Expertise)

Since differences in proficiency or expertise at the plant level is usually taken into account when assessing technology transfer and/or training costs, proficiency or expertise should not be considered in IOC calculation.

(e) Recurrent training

Only staff time is involved and cannot be considered as incremental.

(f) Safety

MC does not cause any safety concerns beyond those that have been dealt with under investment and chemical use. Hence, health and safety issues other than those considered already should not be taken into account, e.g. incremental operational cost of occupational health or safety monitoring programmes, etc.

III Other Recommendations

Since the cost of equipment e.g. forced cooling systems, ventilation systems, etc. influence components of operational costs, efforts should be made to standardize their prices either within or between recipient countries, taking account of external factors such as freight charges.

National Ozone offices should be encouraged to assist consultants of implementing agencies by providing up-to-date information on prevailing levels and regulations on taxes and duties in their respective countries.

METHODOLOGY FOR CALCULATION OF OPERATIONAL COSTS IN METHYLENE CHLORIDE PROJECTS

INTRODUCTION

1. At is Fifteenth Meeting, the Executive Committee, considering the flexible polyurethane foam (PUF) projects which use methylene chloride as replacement for CFC-11 (methylene chloride projects) brought before it at that and previous meetings, noted the variable treatment of operational cost calculations in those projects. The Executive Committee, therefore, requested the Secretariat to consult with sector experts and the implementing agencies, to adopt a methodology for treatment of operational costs for future methylene chloride (MC) projects, and to report back to its Sixteenth Meeting (UNEP/OzL.Pro/ExCom/15/45, para 130). This paper is in response to that request.

2. On the basis of a framework prepared by the Secretariat and agreed to by the implementing agencies, UNDP was requested to lead the preparation of the paper using the expertise of its sector experts. A draft was prepared by UNDP an circulated to all implementing agencies and the Secretariat for their comments. The draft was reformatted by the Secretariat taking account of the comments provided and further discussions with the Sector experts.

3. A review of technical aspects of the production of flexible polyurethane slabstock foam, which includes the properties of methylene chloride was prepared for further clarification of the technology. This document is presented as information paper UNEP/OzL.Pro/ExCom/Inf.3.

BACKGROUND INFORMATION

4. Methylene chloride is frequently used to replace CFC-11 as an auxiliary blowing agent (ABA) in the manufacture of flexible polyurethane slabstock foam. It is a potentially cost-effective replacement technology, because it is considerably cheaper than CFC-11. Today, the use of CFCs in flexible PUF has been virtually eliminated in developed countries and many developing countries have made great strides towards the same goal. The first projects completed with grants of the Multilateral Fund have been flexible foam operations.

5. The standard blowing agent for flexible polyurethane foam is carbon dioxide, generated from the reaction between water and toluene diisocyanate (TDI). Auxiliary blowing agents (ABAs) are used because there are limits to the foam properties that can be achieved with chemically generated carbon dioxide as the sole blowing agent and because of the exothermic nature of the water/TDI reaction. Excessive heat, which can be generated in the process, can lead to scorching or even auto-ignition of the foam during the manufacturing process and subsequent curing. The use of ABAs makes it possible to decrease the reaction temperature and also to soften the foam, and to decrease the foam density.

6. CFCs have for years functioned as the ABAs of choice. In view of the need to phase out the CFCs, methylene chloride's combination of properties, such as zero ozone depletion potential (ODP), low boiling point, relative inertness, relatively low toxicity and virtually non-flammability, etc. have led to its use as an auxiliary blowing agent in the flexible PUF industry as a replacement for CFCs.

7. Methylene chloride's volatility can trigger, however, high concentrations in the production area, requiring careful handling, training of personnel, institution of occupational safety and health measures, such as improved ventilation, in order to avoid over-exposure. Long-term repeated exposure to doses below current health standards, however, does not appear to lead to any adverse human health effects. The weight of all available evidence suggests that under those circumstances, methylene chloride does not produce mutagenic, carcinogenic, teratogenic, or irreversible neurotoxic effects in humans. UNDP and the World Bank provide a fact sheet called: "Properties of Methylene Chloride" to potential users of MC through the investment projects sponsored by them. These agencies also perform industrial health surveys prior to and after plant conversion to ensure the application of proper standards.

8. Unlike CFC-11, methylene chloride is difficult to process in relatively large amounts. In addition it tends to propagate scorching in the foam block. The use of a softener or forced cooling, however, can reduce or eliminate these consequences. Softeners or soft cooling technique may impact the amount of MC needed, the incremental use of chemicals as well as the yield and the plant maintenance. Not only will forced cooling alleviate MC-related scorching but also with formulation and chemical adjustments it could replace MC entirely., This is generally done when MC is a regulatory problem (Argentina, several US states), but sometimes also to produce firmer foams at lower densities.

9. Although MC is capable of replacing CFCs without any significant limitations, at slightly lower weight and at lower costs, the "learning curve" can be considerable, as the process is less "forgiving". In the USA, for instance, foam manufacturers informed USEPA that it takes about one year to fully convert. In the developing countries this learning curve could be considerably longer, say 2-4 years. Also, contamination of MC or other chemicals by metals can cause severe scorching. This calls for the use of only "Urethane Grade" MC or special stabilized polyols.

10. Potentially there are incremental savings to be derived from the replacement of CFC-11 with MC. However, the level of such savings or incremental costs, if the project incurs incremental costs depends on several direct and indirect factors or parameters which are discussed later. These include the choice of technology (as dictated by product requirements) which dictates the relative consumption of process chemicals, product quality or yield losses, incremental maintenance costs and incremental energy consumption, as well as interplay between the levels of consumption of chemicals. The use of auxiliary technologies (e.g. technologies using softening agents and those using forced cooling) reduce the use of MC but increase the use of TDI and water.

11. In the projects that have come before the Executive Committee, the potential savings from the use of Methylene Chloride as a replacement technology have been frequently, but inconsistently, offset by other unfavourable factors, such as lower production yields, use of more additives to maintain the foam quality, safety requirements, etc., While these factors may often lead to legitimate incremental costs there is a need for some unified standards to be agreed upon, for all projects in this sub-sector, to achieve a certain degree of equity and transparency.

OVERVIEW OF APPROVED PROJECTS

12. As of January 1995, there had been 27 investment projects and 3 technical assistance projects (with an investment character) approved by the Executive Committee, that used methylene chloride as partial or exclusive replacement technology in the flexible polyurethane slabstock foam sub-sector. Grants totalling about US $12.7 million have been approved for this category of projects, leading to a phase-out of about 3,300 tonnes of CFC-11. Table 1 of Annex II provides a breakdown of the costs of these projects.

13. The cost of the projects relate to equipment, trials, training, incremental operational costs/benefits, others such as civil works and contingencies, including Agency fees. The percentage of each cost item relative to the total cost of the projects is shown below.

COST CATEGORY	% OF TOTAL COST
Equipment Costs	76
Trials, etc.	7
Technology Transfer	5
Training	4
Incremental Operational Costs	(6)
Other costs	3
Contingencies	11

14. It is worthy to note that of these 30 projects only 4 show incremental operational benefits; the others indicate costs and benefits to be about equal, or do not make any mention of any operational costs/benefits (mainly technical support projects). These four projects differ from the others in the size of the cost difference between CFC-11 and MC, the inclusion of substantial growth in production, and the prices of catalysts.

15. In order to be able to analyze incremental operational costs, it is imperative that the project document provides sufficient information. This is only the case in 17 of the 30 projects (57%). Many project documents just mention that "incremental recurrent costs are assumed to be non existing", or similar phrases. While this may be true, some quantitative treatment would certainly strengthen the argument. In some other cases, projects contain additional foam categories and therefore cost elements not entirely related to flexible slabstock.

16. Table 2 of Annex II, in a mostly qualitative way, shows the different factors that have been used in the 17 projects where sufficient information had been provided. These indicate the ratio of CFC-11/MC, relative prices of CFC-11 and MC, additional chemicals used such as catalysts and softeners, yield losses, maintenance costs, energy costs and cost of safety related measures.

17. A brief analysis of how these factors have been applied in calculating project costs is provided below.

(a) Ratio CFC/MC:

18. This ratio varies between 1/0.85 and 1/1. About 60% of the projects assumed 1/1; while 35% assumed 1/0.85 and 5% assumed 1/0.9.

(b) Prices of CFC-11 and MC

19. The price of CFC-11 generally ranged between US $2.00 and US $2.50/kg. Except in China and Thailand, (where recently imports from non-traditional supplier countries have depressed the price level). The MC price is predominantly quoted as US $1.50/kg with noticeable exceptions in Indonesia, China and Uruguay. Local production may play a role. Only in one case is the use of the more expensive urethane grade MC indicated.

(c) Chemicals

20. Most projects include higher use of **catalysts (tin 70%; amine 75%)** and the use of a **softener (60%)**. Interestingly, the use of a softener is not always made to reflect on the MC consumption. The projects that list higher **TDI** (China) include forced cooling (FC) technology. However, some other projects that include FC do not include TDI changes (Indonesia). One reason could be that some of these projects were among the first to include FC technology and that the possible changes in formulation were probably not yet clearly understood, or at least not reflected.

21. A change in **Polyol** is included in only one project. One of the two companies involved has a unique and rather incomparable manufacturing programme, which may account for this exception. Some projects mention potential costs of "BHT-free" Polyol (BHT--butylated hydroxy toluene--is an antioxidant that interferes with an FC system by evaporating and precipitating as a powder in the system), but do not actually cost it, probably because this product is not (yet) available on the local market.

(d) Yield

22. About 70% of the projects includes unfavourable production yield in its IOC calculations. The "learning curve" of using MC is generally mentioned as the reason and all projects show this by the assumption that regular yields are gradually re-established over 2-4 year period.

(e) Maintenance

23. Almost 50% of the projects include increased maintenance costs related to new investment.

(f) Energy

24. About 65% of the projects includes higher energy costs, related to more ventilation and/or the use of forced cooling. This is, however not used in a consistent way. Six projects that include FC as well as increased ventilation do not mention higher energy costs (China, Uruguay).

(g) Safety

25. About 50% of the projects mention the costs for recurrent training to keep workers alert on the hazardous properties of MC. These costs are generally consolidated with increased maintenance. There is no pattern: projects that do not mention recurrent training are not different in character!

FACTORS THAT INFLUENCE OPERATIONAL COSTS

26. In determining the factors that potentially impact the IOC, all relevant operational cost elements were identified. Those cost elements that may be impacted by the replacement of CFC-11, will be considered as **"direct parameters"**, while those that do not directly constitute cost elements but can influence those elements will be considered as **"indirect parameters"**.

DIRECT PARAMETERS

27. Foam products are defined by foam formulations[2]. Examples of common formulations containing auxiliary blowing agents are given in Annex I. Table-1 also lists the elements or direct parameters of the manufacturing costs of a standard foam type containing an ABA, and provides a summary of qualitative indications of changes to be expected when CFC-11 is replaced by MC. Four scenario's have been considered in comparison with CFC-11. These are:

- o **Replacement by MC alone (MC);**
- o **Simultaneous introduction of a softener (MC/SOF);**
- o **Simultaneous introduction of FC-technology (MC/FC);**
- o **Simultaneous introduction of forced cooling and a softener (MC/SOF/FC).**

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2 The foam industry commonly refers to "foam formulations", or "foam types" for the individual products it produces. The basic ingredients in flexible PUF types are the same, but the relative amounts can change, resulting in different density and hardness. Additional ingredients to enhance a particular appearance or property can be introduced, such as pigment/dye, flame retardant etc. Yield losses are based on the emission of the blowing agent(s), start/stop losses, flushing of the mix-head and production deficiencies.

Table-1: Foam manufacturing costs under different scenarios

	COST ELEMENT	SCENARIOS				
		1	2	3	4	5
		CFC	MC	MC-Softener	MC/FC	MC+Softener+ Forced Cooling
	CHEMICALS					
(i)	Polyol	x	same	same	**(change)**	**(change)**
(ii)	TDI	x	same	**higher**	**higher**	**higher**
(iii)	Water	x	same	**higher**	**higher**	**higher**
(iv)	CFC-11	x	-	-	-	-
(v)	Methylene chloride	-	-	**lower**	**lower**	**lower**
(vi)	Amine catalyst(s)	x	**(change)**	**(change)**	**(change)**	**(change)**
(vii)	Tin catalyst	x	**higher**	**higher**	**higher**	**higher**
(viii)	Surfactant	x	same	same	same	same
(ix)	Softener		-	**x**	-	**x**
	YIELD					
(x)	Liner	x	same	same	same	same
(xi)	Flush	x	same	same	same	same
(xii)	Quality	x	**lower**	**lower**	**(lower)**	**(lower)**
	OTHER					
(xiii)	Labour	x	same	same	same	same
(xiv)	Energy	x	**(higher)**	**(higher)**	**higher**	**higher**
(xv)	Maintenance	x	same	same	**higher**	**higher**
(xvi)	Training	x	**(higher)**	**(higher)**	**higher**	**higher**
(xvii)	Testing	x	same	same	same	same
(xviii)	Staff	x	same	same	same	same
(xix)	Facilities	x	same	same	same	same

Note: Information in brackets indicates a parameter that is not universally recognized. Bold printed items indicate cost items that are effected by the replacement of CFC, i.e. "direct parameters". An "x" indicates inclusion in the operation cost.

INDIRECT PARAMETERS

28. A number of factors may indirectly impact the IOC. These include:

- o customer requirements,
- o type of equipment,
- o condition of equipment,
- o the impact of combined technologies,
- o type and quality of chemicals used, and
- o proficiency of company staff/workers.

29. The following paragraphs briefly address the impact of these indirect factors.

Customer Requirements

30. The production programme of an enterprise is naturally based on customer needs. High/low density, firm/soft, open/closed cell foams are legitimate requirements for particular applications that can lead to individually designed production programmes. Although this factor is legitimate, it cannot be universally applied and can only be quantified on a case by case basis.

Type of Equipment

31. A frequently used classification of production methods for flexible polyurethane slabstock foam is as follows:

- **Traditional Process (declining conveyor),**
- **Maxfoam/Varimax (horizontal conveyor),**
- **Vertifoam (vertical conveyor),**
- **Boxfoam (no conveyor).**

These production methods are equipment related and do not influence the foam chemistry (ratio, incremental chemicals used...). They do, however, influence the yield. Boxfoam shows the highest process latitude, followed by Maxfoam/Varimax, Vertifoam and finally the traditional method. In practice, however, plant staff and production personnel get attuned to the production equipment, and absorb the change in blowing agent and related modifications in about the same time period as CFC technology. Hence the type of production equipment cannot be a legitimate factor to consider in IOC.

Condition of Equipment

32. Every company is responsible for its own house keeping. Therefore, the Fund should not be liable for the condition of the existing equipment. Thus, costs related to the condition of the equipment cannot be considered as legitimate.

Combined Technologies

33. The processing difficulties encountered with the use of MC for certain foam formulations would result in the use of a softener or forced cooling. This may impact the amount of MC needed, the incremental use of chemicals as well as the yield and the plant maintenance. However, calculation of the IOC using these factors showed a net benefit of US $0.01/kg in the case of the use of softeners and net incremental cost of US $0.02/kg in the case of forced cooling. Hence these two cases could be treated as incremental cost-neutral technologies. In cases where the use of these technologies are found to influence the IOC, then the issue of the enterprise profiting from the possibility of producing firmer foams at low density should be considered before addressing the IOC. These costs and benefits could also make the forced cooling technology cost-neutral.

Type/Quality of Chemicals

34. Chemicals used in flexible PUF technology are not completely standardized in chemical constitution as well as in quality. Polyols, catalysts and surfactants and even methylene chloride can show differences that affect the changes required in the changeover from CFC-11 to MC. However, every project includes technology transfer component. It seems reasonable to expect that as part of this transfer the choice of chemicals will be optimized to the extent possible. Situations in which this cannot be achieved, such as insufficiently stabilized Polyols or impure methylene chloride, call generally for auxiliary technologies and impact in this way the cost of operation. Thus, the type and quality of chemicals can be considered as a legitimate parameter of IOC assessment.

Proficiency (Expertise)

35. The quality and the level of experience of staff/ personnel in every plant are naturally different and consequently the "learning curve" for the successful application of MC could vary from enterprise to enterprise. Differences in proficiency should, however, result in different cost for technology transfer and/or training, which are a part of the investment capital costs. Thus, the level of proficiency should not be considered a factor in the IOC.

OBSERVATIONS

36. From the review of the approved flexible polyurethane foam projects, the analysis made regarding direct and indirect parameters and the comments received from the implementing agencies, the following observations can be made.

(a) Incremental Operational Costs in Methylene Chloride projects have been treated inconsistently and in many cases lack quantification.

(b) The replacement of CFCs in the foam formulation with MC leads to an incremental benefit to be included in the IOC calculation. Prices vary considerably over time and by region. Currently, CFC-11 is sold for about US $1.65-2.00/Kg excluding taxes & duties.

(c) Prices of MC vary considerably and unexplainably. It has to be assumed that in some instances taxes have not been entirely eliminated. This is frequently a difficult task for the expert that prepares a particular project as his/her expertise is more process oriented than focused on political/economical issues. As at January 1995, the price of non urethane grade MC was about 0.70/Kg FOB, excluding taxes & duties, with some regional variances of generally not more than US $0.10. The price of urethane grade MC was US $0.10-0.35 higher, when available. "Closed" markets with indigenous production, such as China, could deviate from these prices.

(d) Auxiliary technologies that are installed to enhance processing with MC (forced cooling, softeners) were found to be virtually cost-neutral.

(e) The equipment costs in some projects are quite high and sometimes vary within and between recipient countries. This situation requires a review, since the net operational costs/savings are also dependent on equipment costs through elements such as maintenance and energy costs.

(f) The blowing efficiency of MC decreases with increased relative amounts. Depending on the formulation, CFC- replacement ratio's between 1/0.7 and 1/1.0 with an average of 1/0.9 corresponding to the most common ABA-containing foam (density $17kg/m^3$), can be found in various projects.

(g) MC extracts more energy from the foam system. Consequently more amine catalyst, and sometimes modification of the amine catalysis is needed. However, modification, is not universally needed or necessarily more expensive and would need justification on a case-by-case basis.

(h) More tin catalyst will also be required. Analysis of the relationship between the amount of MC used and the related increase in demand for tin catalyst shows that such increase in demand would be on average about 25%.

(i) More energy use is related only to additional ventilation and/or the use of forced cooling.

(j) The use of additional equipment will require increased preventive maintenance.

(k) Recurrent training in the safe use of a hazardous chemical (MC) and/or the use of complicated equipment with formulations that can overheat and self-ignite if not treated properly, is mandatory. However, training is always provided under capital costs. After initial training covered under capital costs, it can be performed by the staff and therefore should cost only time of company staff.

CONCLUSIONS AND RECOMMENDATIONS

37. On the basis of the above review and analysis and the conclusions derived therefrom, a methodology for calculating incremental operational cost using a specific sample project has been derived. This is included as Annex III to the paper.

Recommendations

38. The following recommendations were also made.

- Factors to be Considered in Calculating Incremental Operational Costs

(a) Relative prices of methylene chloride and CFC-11

The prices should be determined locally using the ratio MC/CFC-11 of 0.9/1.0. All pricing should also be guided by Executive Committee decision regarding pricing of commodities, namely that national pricing be used except where it was higher than 20% of the regional border price (UNEP/OzL.Pro/ExCom/12/37, para. 62). For 1995 the prices of urethane grade and non-urethane grade MC may not exceed US $1.00 and US $0.80 respectively. Where available, the price of urethane grade MC should be used.

(b) Catalysts

Amine: The need for an additional or different amine catalyst should be justified. Where amine catalyst is required 10% increase should be allowed (Current price of catalyst is US $7.50/kg).

Tin: A 25% increase in tin octoate, corresponding to 10 pphp[3] MC should be allowed (Current price is US $6-8/kg)

(c) Polyol

If the need for a better or different stabilized polyol as well as its local availability are established price increase of up to US $0.10/kg should be allowed.

(d) Toluene diisocyanate (TDI)

When forced cooling or softening technologies are used both the increased use of TDI and decreased use of MC should be taken into account in the IOC calculation. Replacement of ten parts of MC by 10 parts of TDI and one part of water should be considered.

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[3] pphp: parts per hundred parts of polyol, the standard expression in foam formulations. If pphp are assumed kg's then a standard formulation would amount to about 150 kg, after accounting for gas losses. Such conversion has been used in the calculation of the IOC effect of the use of a softener.

(e) Softener

The cost of softener may be taken into account only when detailed formulations are developed. The calculation should also take account of adjustments in MC use.

(f) Yield loss

Initial incremental yield loss of 3% declining by 1% each year should be allowed.

(g) Incremental energy costs

Incremental energy costs will be eligible only in the event that the substitute technology results in increased energy consumption. However, if this increase results in expansion in production capacity of the foam (whether intentional or inadvertent) it should not be considered in calculation IOC. Calculation of incremental energy cost should be based on KW multiplied by run hours per year and local unit price.

(h) Incremental maintenance costs

Maintenance costs should be based on additional eligible equipment installed. The incremental maintenance costs should be calculated based on 5% of the eligible incremental equipment investment costs.

- **Factors not to be Considered in Calculating Incremental Operational Costs**

39. The following should not be considered when calculating IOC.

(a) Cost of Water

Cost of water is usually minimal. Generally, de-ionized water is used in foam formulations. This is particularly critical if MC is used, since iron content could trigger scorching. Therefore where not already installed, a water softener or de-ionizer would usually be included in the investment costs.

(b) Equipment type

Does not have any incremental effect on operational costs.

(c) Equipment Condition

This should be the liability of the enterprise concerned.

(d) Proficiency (Expertise)

Since differences in proficiency or expertise at the plant level is usually taken into account when assessing technology transfer and/or training costs, proficiency or expertise should not be considered in IOC calculation.

(e) Recurrent training

Only staff time is involved and cannot be considered as incremental.

(f) Safety

MC does not cause any safety concerns beyond those that have been dealt with under investment and chemical use. Hence, health and safety issues other than those considered already should not be taken into account, e.g. incremental operational cost of occupational health or safety monitoring programmes, etc.

III **Other Recommendations**

40. Since the cost of equipment e.g. forced cooling systems, ventilation systems, etc. influence components of operational costs, efforts should be made to standardize their prices either within or between recipient countries, taking account of external factors such as freight charges.

41. National Ozone offices should be encouraged to assist consultants of implementing agencies by providing up to date information on prevailing levels and regulations on taxes and duties in their respective countries.

ANNEX I

MODEL FORMULATIONS FOR FLEXIBLE POLYURETHANE SLABSTOCK MANUFACTURED WITH AUXILIARY BLOWING AGENTS

COMPONENT	15 Kg/m³	FIRM	18 Kg/m³	FIRM	22 Kg/m³	FIRM
POLYOL	100	100	100	100	100	100
TDI	71	71	57	57	47	47
(index)	(115)	(115)	(108)	(108)	(112)	(112)
WATER	5.5	5.5	1.5	4.5	3.6	3.6
CFC-11	13		5		10	
MC		12		5		9
AMINES (20%)	0.7	0.8	0.5	0.6	1.3	1.5
TIN (33%)	0.8	1.1	0.7	0.8	0.7	0.9
SURFACTANT	1.3	1.3	1.0	1.0	1.4	1.4

REMARKS:

Polyol : 15 Kg/22 Kg: 3500 Mw, 48 OH
18 Kg : 3000 Mw, 56 OH

TDI : 2,4/2,6-Toluene diisocyanate 80/20

Amine : Dabco TL, 20% diluted with polyol

Tin : Stannous octoate, 33% in DOP

Surfactant: BF 2370 (low activity)

Manufactured on a Maxfoam Unit, September-December 1993

TABLE 1

INCREMENTAL COST DATA FOR APPROVED FLEXIBLE SLABSTOCK PUF PROJECTS

MLF CODE	TITLE	ODS (t)	CAPITAL COSTS (USD) EQT	TRS	TTR	TRN	OTH	CTG	TOTAL	PRICE (USD/KG) CFC	MC	TOTAL OPER COSTS	TOTAL PROJECT COST	PROJ. TIME (YRS)	UAC (US$/KG/Y)	COST EFFECT (US$/KG/Y)	APPROVAL DATE	AGENCY
CPR/FOA/10/1NV/32	TIANJIN	180	908,750	25,000	20,000	16,500	0	109,750	1,080,000	2.5	1.2	0	1,080,000	1.5	0.977	6.000	JUNE 1993	UNDP
CPR/FOA/15/1NV/81	GAOFENG	180	255,000	10,000	40,000	10,000	100,000	43,400	458,400	1.3	0.9	0	458,400	1	0.414	2.547	DEC 1994	IBRD
CPR/FOA/15/1NV/82	DONGFENG	110	151,600	12,000	40,000	10,000	20,000	35,000	268,600	1.3	0.9	0	268,600	1	0.397	2.442	DEC 1994	IBRD
CPR/FOA/15/1NV/85	BEIJING FOAM	100	515,000	25,000	20,000	0	75,000	85,000	720,000	1.3	0.9	0	720,000	1	1.172	7.200	DEC 1994	IBRD
EGY/FOA/08/1NV/05	MISR FOAM	121	328,000	65,000	24,000	60,000	0	20,000	497,000	2.5	1.5	0	497,000	1	0.668	4.107	OCT 1992	UNDP
EGY/FOA/11/1NV/20	HORSE FOAM	120	236,400	10,000	0	10,000	95,000	33,600	385,000	2.5	1.5	0	385,000	0.75	0.522	3.208	NOV 1993	UNDP
EGY/FOA/11/1NV/19	DEKHEILA	130	570,000	10,000	15,000	0	0	55,000	650,000	2.5	1.5	0	650,000	1	0.814	5.000	NOV 1993	UNDP
EGY/FOA/12/1NV/22	FOAM IND.& HYMA	170	360,000	20,000	45,000	20,000	32,000	48,000	525,000	2.5	1.5	0	525,000	0.75	0.503	3.088	MAR 1994	UNDP
EGY/FOA/15/1NV/31	EL TAWIL	36	95,000	5,000	5,000	5,000	3,000	8,000	121,000	2.5	1.5	0	121,000	1	0.547	3.361	DEC 1994	UNDP
GHA/FOA/12/INV/07	UMBRELLA PRJ	316	245,400	20,000	35,000	0	15,000	29,600	345,000	2.5	1.5	0	345,000	0.75	0.178	1.092	MAR 1994	UNDP
IND/FOA/13/INV/07	U-FOAM	35	253,500	15,000	0	10,000	15,000	35,000	328,500	3.5	1	0	328,500	1	1.528	9.386	JULY 1994	UNDP
IDS/FOA/11/TAS/11	50 SMALL CO.S	100	1,000,000	103,000	197,000	15,000	35,000	250,000	1,600,000	2.5	0.75	0	1,600,000	2	2.604	16.000	NOV 1993	IBRD
IDS/FOA/13/INV/15	ROYAL ABADI	120	302,000	27,000	10,000	10,000	2,000	37,500	388,500	2.5	0.75	−151000	237,500	1	−0.015	1.979	JULY 1994	IBRD
IDS/FOA/13/INV/16	ERLANGGA	100	488,000	30,000	10,000	10,000	2,000	59,000	599,000	2.5	0.75	−220000	379,000	1	0.295	3.790	JULY 1994	IBRD
IDS/FOA/15/INV/18	MUSI MASSEJAHTE	120	288,000	17,000	10,000	10,000	2,000	63,000	390,000	2.1	0.75	0	390,000	1	0.532	3.250	DEC 1994	IBRD
IDS/FOA/15/INV/19	POSITIVE FOAM	90	554,000	34,000	10,000	10,000	4,000	60,000	672,000	2.1	0.75	−223000	449,000	1	0.437	4.989	DEC 1994	IBRD
IDS/FOA/15/INV/20	MULTIKARYA	200	287,700	34,000	10,000	10,000	2,000	20,000	363,700	2.1	0.75	−240000	123,700	1	−0.174	0.619	DEC 1994	IBRD
JOR/FOA/07/INV/06	3 COMPANIES	25	0	30,000	0	0	0	0	30,000	2.5	1.5	0	30,000	2	0.195	1.200	JUN 1992	IBRD
JOR/FOA/15/INV/16	UMBRELLA PRJ	114	293,200	15,000	22,500	0	0	37,800	368,500	2.5	1.5	0	368,500	0.75	0.526	3.232	DEC 1994	IBRD
MAL/FOA/12/INV/26	PEXAFOAM	120	105,000	50,000	0	20,000	0	20,000	195,000	2.5	1.5	0	195,000	1	0.264	1.625	MAR 1994	UNDP
MAL/FOA/12/INV/27	N.Y.L.	55	65,000	30,000	10,000	10,000	0	15,000	130,000	2.5	1.5	0	130,000	1	0.385	2.364	MAR 1994	UNDP
MAL/FOA/12/TAS/33	SMALL SCALE	80	600,000	150,000	24,000	170,000	0	101,000	1,045,000	2.5	1.5	0	1,045,000	1	2.126	13.063	MAR 1994	UNDP
MAL/FOA/13/INV/35/	PHOENIX	61	105,000	25,000	10,000	10,000	0	15,000	165,000	2.5	1.5	0	165,000	1	0.440	2.705	JULY 1994	UNDP
PAN/FOA/13/INV/05	3 COMPANIES	26	95,000	15,000	15,000	15,000	0	15,000	155,000	2.5	1.5	0	155,000	1	0.970	5.962	JULY 1994	UNDP
PHI/FOA/12/TAS/26	SMALL CO.S	35	600,000	0	56,000	24,000	0	65,000	745,000	2.5	1.5	0	745,000	1	3.464	21.286	MAR 1994	UNDP
PHI/FOA/13.INV/27	FOAMCRAFT	90	95,000	50,000	10,000	10.000	0	20,000	185,000	2.5	1.5	0	185,000	1	0.335	2.056	JULY 1994	UNDP
THA/FOA/13/INV/30	LUCKY	187	460,000	- 50,000	25,000	10,000	5,000	55,000	605,000	1.65	1.5	0	605,000	1	0.527	3.235	JULY 1994	UNDP
THA/FOA/15/INV/36	SOMBOON	100	85,000	5,000	3,000	2,000	0	10,000	105,000	1.65	1.5	0	105,000	1	0.171	1.050	DEC 1994	UNDP
THA/FOA/15/INV/37	KARN YANG	110	120,000	15,000	5,000	5.000	10,000	15,000	170,000	1.65	1.5	0	170,000	1	0.252	1.545	DEC 1994	UNDP
URU/FOA/13/INV/*	7 COMPANIES	88	120,000	35,000	10,000	15.000	0	20,000	200,000	2.1	0.7	0	200,000	1	0.370	2.273	DEC 1994	UNDP
	TOTALS	3319	9,581,550	932,000	681,500	497,500	417,000	1,380,650	13,490,200	2.27	1.23	−834000	12656200		0.410	3.813		

KEY:

EQT	EQUIPMENT COST	OTH	OTHER COSTS (SUCH AS CIVIL WORKS, ETC.)
TRS	COST OF TRIALS	CTG	CONTINGENCIES (INCLUDING AGENCY FEES)
TTR	TECHNOLOGY TRANSFER COSTS	MC	METHYLENE CHLORIDE
TRN	COST OF TRAINING	UAC	UNIT ABATEMENT COSTS

TABLE 2

VARIOUS FACTORS THAT INFLUENCE INCREMENTAL OPERATIONAL COSTS

MLF CODE	TITLE	RATIO (CFC : MC)	INFLUENCE OF COST DIFF (CFC – MC)	INFLUENCE OF CHEMICALS ADDED					INFLUENCE OF YIELD	INFLUENCE OF MAINT–ENCE	INFLUENCE OF ENERGY COSTS	INFLUENCE OF SAFETY COSTS
				TIN	AMINE	SOFTENER	TDI	POLYOL				
CPR/FOA/10/INV/32	TIANJIN	1 : 0.9	X				X		X *			
CPR/FOA/15/1NV/81	GAOFENG	1 : 1	X			X	X					
CPR/FOA/15/1NV/82	DONGFENG	1 : 1	X			X	X					
CPR/FOA/15/1NV/85	BEIJING FOAM	1 : 1	X			X	X					
EGY/FOA/11/1NV/20	HORSE FOAM	1 : 1	X		X	X				X		X
EGY/FOA/12/1NV/22	FOAM IND.& HYMA	1 : 1	X	X	X	X		X	X	X	X	X
GHA/FOA/12/INV/07	UMBRELLA PRJ	1 : 0.85	X	X	X	X			X	X	X	X
IDS/FOA/13/INV/15	ROYAL ABADI	1 : 0.85	X	X	X				X		X	
IDS/FOA/13/INV/16	ERLANGGA	1 : 0.85	X	X	X				X		X	
IDS/FOA/15/INV/18	MUSI MASSEJAHTE	1 : 0.85	X	X	X				X		X	
IDS/FOA/15/INV/19	POSITIVE FOAM	1 : 0.85	X	X	X				X		X	
IDS/FOA/15/INV/20	MULTIKARYA	1 : 0.85	X	X	X				X		X	
JOR/FOA/15/INV/16	UMBRELLA PRJ	1 : 1	X	X	X				X	X	X	X
MAL/FOA/13/INV/35	PHOENIX	1 : 1	X	X	X	X			X	X	X	X
PHI/FOA/13/INV/27	FOAMCRAFT	1 : 1	X	X	X	X			X	X	X	X
THA/FOA/13/INV/30	LUCKY	1 : 1	X	X	X	X			X	X	X	X
URU/FOA/13/INV/*	7 COMPANIES	1 : 1	X	X	X	X			X	X		X

KEY: X INDICATES THAT IMPACT OF THIS FACTOR IS CONSIDERED
* INDICATED A POSITIVE YIELD

ANNEX III

IOC CALCULATION

ASSUMPTIONS

ITEM	PRICE (US $/t)	CONSUMPTION (t/y) BEFORE	CONSUMPTION (t/y) AFTER	INFORMATION SOURCE
CFC-11	2,000	18	-	Navin Fluorine
MC	800	-	16.2	U-Foam
AMINES	7,500	3	3.1	Standard
TIN	8,000	4	4.25	Standard
ENERGY (/KWh)	0.10		45,000	Power Cy.
PRODUCTION	2,000	900	900	Recipient

INVESTMENT IN EQUIPMENT : US $150,000
CFC/MC RATIO : 1.00/0.90
YIELD LOSS : 3/2/1/0%/y on 25% of production[4]
MAINTENANCE : 5% of equipment investment

IOC CALCULATION

COST ITEM	1995 US $ X 10,000	1996 US $ X 10,000	1997 US $ X 10,000	1998 US $ X 10,000	TOTAL
BASELINE					
CFC-11	36	36	36	36	
Amines	22.5	22.5	22.5	22.5	
Tin	32	32	32	32	
TOTAL	**90.5**	**90.5**	**90.5**	**90.5**	
POST-PROJECT					
MC	13	13	13	13	
Amines	23.3	23.3	23.3	23.3	
Tin	34	34	34	34	
Incr. Yield Loss	13.5	9	4.5	0	
Incr. Energy	4.5	4.5	4.5	4.5	
Incr. Maintenance	7.5	7.5	7.5	7.5	
TOTAL	**95.8**	**91.3**	**86.8**	**82.3**	
IOC	5.3	0.8	(3.7)	(7.2)	
Discount Factor	0.91	0.83	0.75	0.68	
NPV	**4.8**	**0.7**	**(2.8)**	**(4.9)**	**(2.2)**

4 Only 25% of the production uses MC

ANNOTATIONS

Costs were determined as follows:

1. Baseline Costs

Baseline costs of chemicals calculated by multiplying the price of the chemical by annual use. No sales increases allowed.

2. Post Project Costs

(a) MC: 90% of CFC-11 use multiplied by MC price. No sales increases included.

(b) Amine: Increase by 10% on MC foam alone.

(c) Tin: Increase by 25% on MC foam alone.

(d) Yield loss: Calculated on MC foam alone.

3. Incremental Operational Cost (IOC)

(a) IOC: Difference between baseline cost and post project cost.

(b) Discount factor: Based on 10% interest rate.

(c) Net Present Value (NPV): IOC X Discount factor.