MONTREAL PROTOCOL

ON SUBSTANCES THAT DEPLETE

THE OZONE LAYER

UNEP

REPORT OF THE
TECHNOLOGY AND ECONOMIC ASSESSMENT PANEL

APRIL 2002

VOLUME 1

PROGRESS REPORT

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Montreal Protocol
On Substances that Deplete the Ozone Layer

Report of the UNEP Technology and Economic Assessment Panel

April 2002

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Progress Report

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The TEAP thanks the Hungarian Ministry for Environment for hosting the TEAP meeting in Budapest, Hungary, where this report was discussed, composed and finalised.

Foreword

The April 2002 TEAP Report

The April 2002 TEAP Report consists of three volumes:

Volume 1: April 2002 TEAP Progress Report

Volume 2: April 2002 TEAP Replenishment Task Force Report

Volume 3: April 2002 TEAP Task Force on Collection, Reclamation and Storage Report, together with the

April 2002 TEAP Task Force on Destruction Technologies Report

Volume 1

Volume 1 contains an Executive Summary of all TEAP Report topics, as well as the Executive Summaries of Volumes 2 and 3.

Volume 1 contains

- An accounting framework for ODS production, consumption and emissions (being developed in co-ordination with the SAP);
- recommendations for essential use nominations;
- an update on laboratory and analytical uses (as requested in Decisions XI/13, X/19);
- a chapter on Campaign Production for MDIs (as requested in Decision XIII/10);
- the annual update on nPB production, use and emissions (as requested in Decision XIII/7);
- additional reports on process agent uses (as requested in Decisions X/14 and XIII/13).

Volume 1 also contains progress reports of TEAP Technical Options Committees (according to Decision VII/34). Finally, it presents an update on TEAP's changing membership and gives background and contact information for TEAP and TOC members (Decision VII/34).

Volume 2

Volume 2 is the Assessment Report of the TEAP Replenishment Task Force of the Funding Requirement for the Replenishment of the Multilateral Fund during 2003-2005, in response to Decision XIII/1.

Volume 3

Volume 3 includes reports of the Task Force on Destruction Technologies (TFDT) and the Task Force on Collection, Reclamation and Storage (TFCRS), in response to Decision XII/8.

April 2002,

The UNEP Technology and Economic Assessment Panel (including its alternates Tamás Lotz and Masaaki Yamabe):

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PROGRESS REPORT

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Funding Requirement for the 2003-2005 Replenishment

The TEAP Replenishment Task Force has determined the funding requirement for the 2003-2005 replenishment of the Multilateral Fund for:

- Projects (involving all ODS) necessary for compliance during 2003-2005;
- CFC projects necessary for compliance during 2005-2007;
- Non-CFC projects the implementation of which will yield a linear decrease in consumption after 2005, towards a next Montreal Protocol reduction step;
- Projects addressing the closure of production facilities;
- Non-investment activities, support costs and project preparation costs of the Implementing Agencies, and the costs for the Multilateral Fund Secretariat and for holding meetings of the Executive Committee.

The estimate given by the Replenishment Task Force amounts to US$574.5 million ± US$26.7 million (i.e., the range US$548-600 million).

Task Force on Collection, Recovery and Storage (TFCRS) Report

The TFCRS assessed use patterns, associated emissions and aspects of collection and storage of ODS from all relevant use sectors and presents an overview of inventories and their management in the different sectors and provides first estimates of historic and actual emission patterns from the different use sectors.

It is technically feasible to collect and recover CFCs and HCFCs contained in foams, refrigeration, and air-conditioning equipment and halons contained in fire protection equipment. Methyl bromide used as post harvest, structural or transport fumigation offers the broadest potential for collection and subsequent destruction. It is estimated that:

1) Between 350,000 and 400,000 ODP-tonnes of CFCs are contained in refrigeration equipment in 2002;

2) 450,000 ODP-tonnes of halon 1301 and of 330,000 ODP-tonnes of halon 1211 are installed in fire fighting equipment in 2002; and

3) 1.25 million tonnes of CFC-11 will be contained in installed foams in 2010.

The recovery of blowing agents from refrigerator cabinets costs approximately US $60-100/kg of CFC-11. The cost equates to approximately $25-35 per tonne of CO_2 equivalent--well within the range of investments being considered for CO_2 emission abatement in other sectors.

Task Force on Destruction Technologies (TFDT) Report

The TFDT applied updated two-stage screening criteria to 45 identified technologies. Eleven technologies are recommended for approval by the Parties for concentrated ODS and two are recommended for the destruction of ODS contained in foams. Technologies recommended for concentrated sources include: (1) cement kilns, (2) liquid injection incineration, (3) gaseous/fume oxidation, (4) reactor cracking, (5) rotary kiln incineration, (6) argon plasma arc, (7) inductively-coupled radio-frequency plasma, (8) nitrogen plasma arc, (9) microwave plasma, (10) gas phase catalytic dehalogenation, and (11) super-heated steam reactor. Destruction technologies recommended for diluted sources (foams) include (1) municipal solid waste incinerators and (2) rotary kiln incinerators.

Production, Use and Emissions of Ozone-Depleting Substances

TEAP is developing a comprehensive database of production, use, emissions and remaining inventory of all ODS across all use sectors using available data from AFEAS, the Ozone Secretariat, the Multilateral Fund, and sectoral data developed by TEAP and its TOCs. This database will be peer reviewed and placed on the TEAP website: www.teap.org.

Essential Uses in 2002

In 2002 Australia, the European Community, Japan, Poland, the Russian Federation, Ukraine, and the United States nominated essential use production exemptions for MDIs (for asthma and COPD) or provided additional information for nominations received in 2001 (Ukraine and Russian Federation).

Campaign Production

TEAP has reviewed the decisions of the Parties and does not believe that any changes are required to the Montreal Protocol or existing decisions in order to permit final campaign production of CFCs for MDIs. Nonetheless, if final campaign production is to be undertaken in 2005, a decision would be required at MOP-16 to approve these multiple year essential use nominations. Parties may wish to take a decision now that clarifies the timeline for submission of future projections of CFC requirements for which final campaign production may be required. Parties may also wish to consider a new decision requiring annual reporting on the use of any final campaign production stockpile.

CFCs Allocated for Essential Medical Uses Sold Into Other Uses

TEAP has confirmed that unusable metered dose inhalers (MDIs), manufactured using CFCs authorised for European and North American countries under the Essential Use Exemption (EUE), are decanted and separated into ingredients and that the salvaged CFCs are sold into the refrigeration and air-conditioning servicing market of at least one non-Article 5(1) country.

The quantities of CFCs typically recovered from unusable MDIs are relatively small compared to quantities emitted from the use of MDIs. However, much higher quantities are potentially available for use in non-essential uses if companies experience manufacturing problems or consider sale of EUE CFCs held in their stockpiles (current stockpiles of CFCs for MDIs are reported as about 4,000 tonnes). Furthermore, comparable opportunities exist for the diversion to non-critical uses of methyl bromide exempted for quarantine and pre-shipment (QPS), or allocated for emergency or critical use exemptions

TEAP also received and forwarded to the Ozone Secretariat a report that one country that was allocated CFCs for MDIs had sold the CFCs into other uses.

Laboratory and Analytical Uses

TEAP is unable to recommend new non-ODS methods or technology that would allow elimination of further uses of controlled substances for analytical and laboratory uses. A workshop could identify remaining uses of controlled substances and their potential substitutes, expediting the incorporation of new analytical methods into national and international standards.

2002 Update Report on nPB

Due to the uncertain toxicity and probable environmental restriction on the use of nPB and the economic conditions, the market for nPB has not developed significantly since the publication of the April 2001TEAP Progress Report. Proposed regulations in the EU and USA would restrict potential use within these jurisdictions and may discourage use elsewhere. An Italian company has started production of dry cleaning equipment specifically designed to operate with a nPB blend. Use of such equipment would shift use of non-ozone-depleting perchloroethylene to ozone-depleting nPB.

Process Agents

The TEAP Process Agent Task Force has updated Table A of Decision X/14 with an improved four-part presentation format and improved the technical evaluation of Table B in Decision X/14. TEAP recommends a four-part presentation format for Table A: 1) "Process Agents with negligible emissions," 2) "Process Agents with non-negligible emissions," 3) "Insufficient information to designate as process agents," and 4) "Not Process Agents."

Progress on Phasing Out ODS

Article 5(1) countries are well on the way to the scheduled phase-out, proceeding at the pace allowed by the funds replenished to the Multilateral Fund, to comply with Montreal Protocol control schedules. If project implementation is no limiting factor, the timing of the phase-out in Article 5(1) countries depends on the amount of financing available, since the phase-out is technically and economically feasible.

The largest continuing ODS use reported by non-Article 5(1) Parties under the Essential Use Exemption in 2001 was a total of 6,000 metric tonnes of CFCs for the manufacture of Metered-Dose Inhalers (MDIs). Alternatives to CFC MDIs continue to be introduced around the world thereby further reducing the need for CFC based MDIs.

Several non-Article 5(1) countries are currently occupied with the management of HCFC phase-out strategies in foams. A number of Article 5(1) countries are approaching the final CFC phase-out in the foam sector; however, delays in other countries have limited their progress to date. The technical acceptability of hydrocarbons has expanded as previous shortcomings have been overcome. Furthermore, the timing of availability of liquid HFCs has been clarified and preliminary transitions are underway.

In the methyl bromide sector, the adoption of alternatives in both Article 5(1) and non-Article 5(1) countries depends on economic factors, treatment efficacy, regulatory framework, and local infrastructure for training users in new techniques. Registration of chemicals for pre- and post-harvest treatments continues to be one of the major factors hindering the adoption of alternatives. On the other hand, non-chemical techniques such as floating tray technology, substrates, grafting, solarisation plus organic amendments and steam, do not require registration and are globally available. Training farmers to apply new techniques remains the single largest challenge facing the widespread adoption of alternatives. However, for the crops such as strawberries and tomatoes, which consume most of the MB, there has been significant progress in the development and registration of alternatives to MB.

In domestic refrigeration, HC-600a and HFC-134a continue to be the dominant alternative refrigerant candidates in new equipment. Stand-alone commercial equipment predominantly uses HFC-134a, but the use of HC-600a is increasing. R-404A has become the generally accepted refrigerant for condensing units and large centralised systems; developments are still ongoing for indirect systems using ammonia or hydrocarbons, with carbon dioxide as a heat transfer fluid. In transport refrigeration the use of R-404A is also predominant, whilst the use of R-410A is very slowly increasing. In AC, both R-407C and R-410A are being used as alternatives to HCFC-22. There has also been a modest commercialisation of hydrocarbon refrigerants in air-cooled air conditioners. The retrofit of CFC chillers is still proceeding at a very slow pace in many countries. Industry efforts to develop alternatives to HFC-134a mobile AC systems continue. Prototype mobile AC systems using carbon dioxide and systems using either HFC-152a or propane are currently being tested for cooling and energy performance.

TEAP Reorganisation; New Membership

Suely Carvalho, László Dobó, Yuichi Fujimoto, Sateeaved Seebaluck, Barbara Kucnerowicz-Polak and Robert van Slooten are no longer available to serve on the TEAP. Additional departures are expected in the period 2002-2003.

TEAP will have openings for one Article 5(1) expert from the Latin American and Caribbean Region to serve as Co-chair of the TEAP. In addition, there are openings for experts from a CEIT country, from a Sub-Saharan African country, China, Southeast Asia, and Japan to serve as Senior Expert members of TEAP or as a Co-chair of the Aerosol Product TOC or as a Co-chair of the Halons TOC. The Aerosol Product TOC is seeking medical and pharmaceutical experts in respiratory disease. The Methyl Bromide TOC is seeking agricultural economists as critical use exemptions are nominated and reviewed for decision by Parties.

3. Executive Summaries of April 2002 TEAP Reports, Volumes 2 and 3

3.1 Executive Summary - April 2002 Replenishment Task Force Report

The Task Force has estimated the funding requirement for project approvals necessary for compliance during the period 2003-2005, and necessary to enable compliance during 2005-2007. Project implementation beyond 2005 should result in a linear decrease towards a next Protocol reduction step.

This includes projects in both the consumption and production sectors (production closure projects) for all Ozone Depleting Substances. For some multi-year projects, project funding for the triennium has already been agreed upon by the Executive Committee. The funding requirement for all projects, i.e., those estimated and those agreed upon, totals between US$427.2 and US$475.4 million during 2003-2005, with the average at US$451.3 million.

The Task Force has also estimated the funding requirement for non-investment activities, project preparation costs of the Implementing Agencies, costs for the Multilateral Fund Secretariat and the costs for holding Executive Committee meetings. These costs are estimated at US$90.7 million.

The administrative costs for all Implementing Agencies for all projects in the triennium were determined at US$52.9 million. Based on guidelines from the Executive Committee, US$20.4 million must be subtracted from the total funding requirement since it is the value for non-investment activities to be subtracted from investment projects in the consumption sector in non-LVC countries. For further details about the need to subtract funding for non-investment projects, see item 3, “Non-investment Activities”, under the Cost Elements heading below.

The total funding requirement for the 2003-2005 replenishment to enable the Article 5(1) Parties to comply with the control schedules under the Montreal Protocol is therefore estimated at ***US$574.5 million* ± *US$26.7 million*** (i.e., the range US$548-600 million). The US$ 26.7 million uncertainty is based upon the fact that the Task Force has not been able to derive a one-point estimate for the funding requirement in the CFC consumption sector.

Background and Methodology

3.1.1 Mandate from the Parties to TEAP; Decision XIII/1

The Thirteenth Meeting of the Parties made a detailed request to TEAP to prepare a replenishment report and present it to the Open-ended Working Group at its 22nd Meeting to enable the Parties to decide at their Fourteenth

Meeting on the appropriate level of the 2003-2005 replenishment of the Multilateral Fund (Decision XIII/1).

3.1.2 TEAP Response; Replenishment Task Force

The TEAP constituted a Task Force of seven members from Australia, Belgium, Brazil, China, Hungary, The Netherlands, and Venezuela to prepare the report.

3.1.3 Technical and Financial Consultations

The Task Force carried out consultations with a wide range of financial and technical experts. Interviews were conducted during the 35th Meeting of the Executive Committee held in Montreal, December 2001. The Task Force extensively consulted the Secretariat of the Multilateral Fund, the Ozone Secretariat and the Implementing Agencies. A questionnaire was dispatched to all Parties, to members of the Ad-hoc Working Group on the 2003-2005 Replenishment (as appointed by the 13th Meeting of the Parties) and to the 2001 Executive Committee members. Thirty-two Parties responded to the questionnaire.

A small group of experts, selected by the Task Force, in consultation with the TEAP, reviewed the April 2002 draft of this report. The review group included the Chair and Vice-Chair of the 2001 Executive Committee from Germany and Tunisia, respectively, the Chief Officer of the Multilateral Fund Secretariat and the Deputy Executive Secretary of the Ozone Secretariat. The final review and completion of the document was subsequently carried out by the TEAP at its meeting in Budapest during 29 April-3 May 2002.

3.1.4 Data

The Replenishment Task Force used the data for the consumption and production of all ODS in all Article 5(1) countries as reported to the Ozone Secretariat; it included the most recent reports for the year 2000. Several countries had revised the data they had reported to the Secretariat for the years 1995-1998, which includes the baseline data. These revisions indicate that consumption for those years was higher than estimated in the 1999 Replenishment Task Force Report. Furthermore, CFC consumption by Article 5(1) Parties did not decrease during 1998-2000 as much as was expected in the 1999 Report.

More data on CTC, TCA and methyl bromide were available for this study than in 1999, so that clear trends could be derived and anomalies in data reporting could be corrected.

Project approvals through the year 2001 amounted to 116,611 ODP-tonnes of CFCs (with 9,836 ODP-tonnes expected to be approved during 2002).

Several methyl bromide phase-out projects, as well as a number of CTC projects in the solvent and process agent sector were approved through the year 2001.

Analysis shows that more than 80% of the baseline CFC consumption has already been addressed by projects in all Article 5(1) countries except in the countries with a baseline consumption between 100 and 360 ODP-tonnes, where the percentage is 60%.

The cumulative amount of CFCs implemented and phased out per year in the period 1995-2000 resulting from project approvals has been calculated for different country groups. Addition of the reported annual consumption values to the amounts implemented results in a relatively constant total amount of ODP-tonnes. This implies that, apart from project implementation, there are no important factors that lead to a decrease of the CFC consumption. This conclusion can be drawn to date, but may change in the near future. One interpretation that could be drawn is that the "overall", global impact of non-investment activities has been the compensation for consumption growth, which occurred in some Article 5(1) countries.

3.1.5 Cost Elements

This report provides estimates of the funding requirements for the major cost components of the 2003-2005 replenishment of the Multilateral Fund as follows:

- Investment projects to reduce consumption of CFCs, carbon tetrachloride (CTC), 1,1,1 trichloroethane (TCA), and methyl bromide;
- Investment projects to reduce production of the substances mentioned above, particularly CFCs and halons;
- Non-investment activities such as an information clearing-house and information exchange, the activities of regional networks, public awareness, institutional strengthening, training, refrigerant management plans (RMPs), halon banking plans, technical assistance, and country programme preparation and updating;
- Administrative costs of the Implementing Agencies;
- Project preparation costs of the Implementing Agencies; and
- Operating costs of the Multilateral Fund Secretariat and the costs for holding Meetings of the Executive Committee.

These six cost components were addressed individually as described below.

1. Investment Projects for the Consumption Sector

The study by the Replenishment Task Force used the following elements to estimate project approvals for investment projects in the consumption sector:

- Data on the production and consumption of all controlled substances as reported to the Ozone Secretariat by all Article 5(1) Parties;
- Investment projects' approvals as compiled by the Multilateral Fund Secretariat for the period 1991-2001 plus those listed in the Consolidated 2002 Business Plans of the Implementing Agencies;
- Implementation lags reflecting the time required for ODS reductions to be realised, i.e., a 0 to 6 year time lag (dependent on the substance and on the type of project). The implementation time lag functions were obtained from experience or from completion reports of projects;
- Cost-effectiveness figures determined from the Multilateral Fund Secretariat's database for the years 1998-2001, which were averaged.

Project approvals estimated for the triennium 2003-2005 are based on achieving compliance with the Protocol reduction steps, with linear interpolation where these lie outside the triennium:

- CFC: 50% and 85% reduction in 2005 and 2007, respectively;
- CTC: 85% in 2005, followed by a linear decrease towards the phase-out in 2010;
- TCA: 30% in 2005, followed by a linear decrease towards the 70% reduction step in 2010;
- MB: freeze in 2002, 20% reduction in 2005, followed by a linear decrease towards the phase-out in 2015.

For the CFC consumption sector countries were sub-divided into five Country Categories. The same version of the spreadsheet model that was applied in the 1999 Replenishment Study was used, where the countries in Categories 4 and 5 (the LVC countries) were assumed to not receive funding for investment projects, other than via Refrigerant Management Plans. All currently existing phase-out agreements with Article 5(1) countries were taken into account. An analysis was made of the reductions required following the "historic" Task Force spreadsheet approach versus those accorded in National Phase-out Plans and their cost effectiveness. This analysis showed significant differences in cost effectiveness. The Task Force compared the results of using the two different approaches to calculate the replenishment for the triennium 2003-2005. The Task Force determined the optimum solution to estimating the funding requirement for the CFC consumption sector to be the average of two approaches.

A lumped approach was used to determine the funding requirement for reductions necessary in the CTC (used as a solvent and as a process agent) and in the TCA consumption sectors, since only a small number of countries use significant amounts of these substances.

A data analysis for each country was performed to determine the reductions required for MB. This type of analysis shows substantial differences if compared to a lumped approach, largely because some countries have achieved, or plan to achieve reductions in MB consumption greater than those according to the agreed controls. The Task Force first assessed the impact of projects approved during 1998-2001 and to be approved during 2002 on the funding requirement. The consumption levels during the triennium 2003-2005 were then determined. Subsequently, the ODP tonnage that needs to be approved so that all countries will meet the freeze and the 20% reduction step in 2005 was estimated. This was followed by some reductions that were indicated when applying a linear reduction towards the phase-out by the year 2015.

There is no evidence that the relative prices of ODS or alternative substances are rising significantly in the coming years. Thus, there is little price incentive for a market-driven switch to alternatives. These market conditions are likely to continue during the triennium 2003-2005 in the absence of policy intervention to create scarcity of CFCs relative to those of alternatives. This conclusion has been drawn in spite of the fact that the reports from Article 5(1) Parties indicate that CFC consumption exceeds production by more than 6,000 ODP-tonnes annually, creating a market imbalance.

2. *Investment Projects in the Production Sector*

Estimates were based on the costs for projects already agreed with China for Halons and CFCs, and with India and the Democratic Republic of Korea for CFCs. This also includes an allowance estimated by the Task Force for additional Article 5(1) country agreements like those to be agreed during the 2003-2005 replenishment period. First estimates were made regarding compensation, i.e., the funding requirement, for the closure of CTC producing plants.

3. Non-investment Activities

In many cases, cost information for these activities, which support investment projects in phasing out ODS consumption (and production), were received by the Replenishment Task Force. They are based on the Business Plans of the Implementing Agencies, in particular UNEP, and on information from the Multilateral Fund Secretariat. In other cases, estimates were made by the Task Force based on extrapolation from data in the existing databases towards the future replenishment 2003-2005. The costs for non-investment activities were all split in costs for non-LVC and costs for LVC countries.

For the non-investment activities, the current guidelines as issued by the Executive Committee (particularly those issued at the 35th and 36th Meeting) were taken into account. This means that the costs for non-investment activities in non-LVC countries (countries with consumption larger than 360 ODP-tonnes as a baseline) have to be converted to an ODP tonnage using the conversion factor US$12.1/ODP kg. This tonnage has to be subtracted from the consumption that can be phased out by investment projects. The Task Force calculated the value of the above tonnage using the average cost effectiveness value of projects and subtracted it from the total funding requirement determined.

4. *Administrative Costs of the Implementing Agencies*

Different charges were applied to all types of project approvals. These charges were individually agreed by the Executive Committee or according to guidelines issued by the Executive Committee. In cases where no direct support cost information was available, estimates of the agency support costs were made on the basis of experience with similar types of projects. By adding all cost components the total funding for this element was determined.

5. Project Preparation Costs of the Implementing Agencies

Project preparation costs for the triennium 2003-2005 were estimated from the average of the project preparation costs per year during the period 1998-2001.

6. Operating Costs of the Multilateral Fund Secretariat and the costs for holding meetings of the Executive Committee

These costs were determined on the basis of planned expenditure on current operations, including the monitoring and evaluation part.

Funding Requirement for the 2003-2005 Replenishment of the Multilateral Fund

The Task Force has estimated the funding requirement for project approvals necessary for compliance during the period 2003-2005, and necessary to enable compliance during 2005-2007. Project implementation beyond 2005 should result in a linear decrease towards a next Protocol reduction step. The funding requirement for this replenishment period would be less than calculated if Parties choose to only finance the reduction step in the year 2005 (for CFCs, CTC, TCA and MB), allowing production and consumption to remain at the maximum level until the year when a next reduction step will be required. However, such a minimum-finance strategy would jeopardise the pace of phase-out and would not be administratively feasible, because projects cannot be instantly implemented at the time of this next substantial reduction step (e.g. 2007 for CFCs, 2010 for CTC and TCA). Project implementation is governed by a time lag between approval and implementation. It is for that reason that the reductions to be achieved beyond 2005 need to be partially addressed in this period. For example, the larger part of the funding requirement calculated for CFC investment projects is required for complying with the 35% reduction from 2005 to 2007 (when the consumption should be

15% of the baseline). This way of addressing the phase-out will also keep the momentum that exists.

The Task Force has also estimated the funding requirement for agreed production closure projects, non-investment activities, administrative and project preparation costs of the Implementing Agencies and costs for the Multilateral Fund Secretariat.

The funding requirement for the 2003-2005 replenishment to enable the Article 5(1) Parties to comply with the control schedules under the Montreal Protocol is estimated at ***US$574.5 million*** ± ***US$26.7 million*** (i.e., the range US$548-600 million). Details are given in the table below.

Replenishment Cost Components:	**US$ Million**
CFC Consumption Sector Projects	239.6
Chillers, investments for starting revolving funds	5.0
CTC/ TCA Consumption Sector Projects	58.1
MB Consumption Sector Projects	64.9
Investments: Production Sector	83.7
Non-investment activities; supporting Activities	71.5
Administrative costs of Implementing Agencies	52.9
Project preparation cost	9.3
MLF Secretariat/ Executive Committee Operational Costs	9.9
Non-investment activity value to be subtracted	-20.4
Total	**574.5**

The US$ 26.7 million uncertainty is based upon the fact that the Task Force has not been able to derive a one-point estimate for the funding requirement in the CFC consumption sector for the triennium 2003-2005.

3.2 Executive Summary – April 2002 TEAP Report of the Task Force on Collection, Recovery and Storage

The TFCRS assessed use patterns, associated emissions and aspects of collection and storage of ODS from all relevant use sectors. The assessment takes into account the different situations in Article 5(1) Parties, where production takes place for the Article 5(1) Parties (under "Basic Domestic Needs"), and in non-Article 5(1) Parties, where ODS production is still continuing.

This TFCRS Report also presents an overview of ODS inventories and their management in the different sectors and provides first estimates of historic and actual emission patterns from the different use sectors.

3.2.1 Types of Emission

ODS can be emitted at various stages in the lifecycle of production, distribution, use, and disposal. Emission estimates for any given year need to account for early emissions of recently 'consumed' ODS as well as delayed emissions of historically used ODS. This means that there are emissions from both developed and developing countries for many years after the phase-out of ODS production.

This Report splits the use sectors into those with early emissions and those primarily with delayed emissions. Where it concerns early emissions, the focus is on non-Article 5(1) Parties essential uses and on current and/or recent use in Article 5(1) Parties. Meanwhile, where it relates to delayed emissions the focus is on inventories of ODS originating from sustained non-Article 5(1) portfolios and the increasing inventories present in the same applications in Article 5(1) Parties.

Uses with early emissions include solvents, aerosol products including MDIs, methyl bromide, and flexible foams. Delayed emissions are found in refrigeration and air conditioning equipment, rigid foams, and halon equipment.

For self-evident reasons, the main focus of interest under any review of collection, recovery and storage issues is on those applications that lead to delayed emissions and that are therefore characterised by considerable ODS inventories.

3.2.2 Technical feasibility of Collection, Recovery & Storage

It is technically feasible to collect and recover all forms of ODS retained in inventories characterised by delayed emissions. In some cases (e.g. refrigeration and halon equipment) the ODS is already contained in readily accessible containers. In the case of other applications, the ODS can be in locations which are much more difficult to access (e.g. cavity wall rigid foam insulation).

For many rigid foams including those contained in refrigerators, the recovery and destruction steps can be combined and the decision may be made that it is more cost-effective to directly incinerate a product containing the ODS than to extract the ODS for subsequent destruction.

Methyl bromide used as a post harvest, structural or transport fumigation (about 30% of current methyl bromide uses) offers the broadest potential for collection and subsequent destruction. The surplus methyl bromide can be adsorbed and then directly treated for destruction either chemically or by incineration.

3.2.3 Inventories and Collection Potential

It is known for quite some time that the ODS inventories stored in delayed emission applications are substantial. For certain cases, this assessment has been able to quantify these amounts. Inevitably, the assessment has involved a combination of 'top-down' and 'bottom-up' modelling and will be the subject of continuous refinement as more information emerges.

- Between 350,000 and 400,000 ODP-tonnes of CFCs are estimated to be contained in refrigeration equipment in 2002;
- 1.25 million ODP-tonnes of CFC-11 are still remaining in installed foams in year 2010;
- 450,000 ODP-tonnes of halon 1301 and 330,000 ODP-tonnes of halon 1211 are installed in fire fighting equipment in year 2002.

However, it is important to recognise that not all of this material will be accessible for collection and recovery, since decommissioning at end-of-life needs to take place first. The annual quantities of refrigerants potentially available for destruction are estimated to be around 9,000 ODP-tonnes. The quantities of blowing agents expected to be recovered from domestic refrigerators are expected to reach a rate of between 10,000 and 11,000 ODP-tonnes per annum with the currently installed recovery capacity. This could be increased by further investment but is likely to require additional local legislation. Sizeable amounts of halon 1211 could be collected for subsequent destruction.

3.2.4 Economic Implications of Collection, Recovery & Storage

This report has not been able to make a detailed assessment of the costs of collection, recovery and storage at the global level, since the range of technical options available and the cost of local logistics are highly variable.

Economic feasibility is demonstrated by examples of established commercial infrastructures. These exist in several sectors and in several regions of the world. The recovery of blowing agents from refrigerator cabinets costs approximately US$60-100 per kg of CFC-11. The cost equates to approximately US$25-35 per tonne of CO_2 equivalent. This is well within the range of investments being considered for CO_2 emission abatement in other sectors.

3.2.5 Barriers to Collection, Recovery & Storage

There are many barriers to the application of effective collection, recovery and storage. Examples of these can be listed as follows:

- Lack of appropriate legislation and infra-structures to ensure end-of-life decommissioning;
- Financial resistance where the 'polluter' (manufacturer or owner) has to pay;
- Installations of rigid construction foam can be within building structures that prohibit effective collection;
- Waste transportation management restricts movements within some countries and internationally.

3.2.6 Conclusions

The collection, recovery and storage of ODS is technically feasible and economically viable. The adoption of such measures depends to a large degree on the regulatory structures, the collection and recovery infrastructures and the way in which the financial burden is allocated.

Parties may wish to consider whether there is an over-arching role for the Montreal Protocol in stimulating this area of activity or whether, in fact, regional variations in both installed inventories and local logistics make action at the regional level more appropriate.

3.3 Executive Summary – April 2002 TEAP Task Force on Destruction Technologies Report

3.3.1 Recommended Technologies

This document presents a comprehensive assessment of technologies available for the destruction[1] of the current and anticipated global stocks of surplus ODS, including both dilute (including foams) and concentrated sources. The assessment incorporates updated information on the technologies and applies updated evaluation criteria developed by the recently reconvened UNEP Technology and Economic Assessment Panel (TEAP) Task Force on Destruction Technologies (TFDT).

The main purpose of this document is to recommend technologies for destroying surplus stocks of ODS, based on an assessment of their technical capability using available information. Although a significant amount of information specific to individual technologies is provided, it is not the

[1] Earlier versions of this document – and some other reports referenced – have often used the terms "destruction" and "disposal" interchangeably. Based on comments from the TFDT, the former term has been used exclusively here. Technologies that do not actually destroy ODS (*i.e.,* sequestering or long-term storage approaches) are not considered appropriate for the management of surplus ODS stocks.

intention here to rank the technologies meeting the criteria for recommendation.

The Task Force developed updated screening criteria, which were applied to 45 identified technologies. Sixteen technologies met the screening criteria. The "screened-in" technologies were then evaluated further with emphasis on actual data about ODS destruction performance. Of these, twelve technologies met the recommended criteria. Three of these twelve are in common commercial use. Only two technologies are recommended for the destruction of foams[2].

The recommended technologies are:

1. Concentrated sources:

- Cement Kilns
- Liquid Injection Incineration
- Gaseous/Fume Oxidation
- Reactor Cracking
- Rotary Kiln Incineration
- Argon Plasma Arc
- Inductively-Coupled Radio-Frequency Plasma
- Nitrogen Plasma Arc
- Microwave Plasma
- Gas Phase Catalytic Dehalogenation
- Super-Heated Steam Reactor

2. Diluted Sources (foams)

- Municipal Solid Waste Incinerators
- Rotary Kiln Incinerators

This report contains summary descriptions and discussions of screened-in technologies. More detailed descriptions of all the technologies are included as an Appendix.

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[2] The TEAP has confirmed one technology for recommendation for both concentrated and diluted sources, namely, rotary kiln incineration. As destruction of ODS from foams has only recently emerged as significant commercial practice, the technical information on diluted sources is still emerging. However, information on both Municipal Solid Waste Incineration from Europe and Rotary Kiln Incineration from Japan were sufficient to give the TEAP the confidence to recommend these two technologies, as listed.

This work took as its starting point documents developed by the United Nations Environmental Programme (UNEP) on this subject in 1992[3] and 1995,[4] and provides the most comprehensive evaluation of destruction technologies for ODS to date. The current work builds upon previous work by incorporating material acquired from numerous sources in the course of continued work in the year 2001 on the issue of ODS destruction. Additional literature research was conducted specifically for this initiative, and several technology suppliers were contacted for detailed clarifications and updates. This document also includes detailed information that has recently become available, which was originally presented at the *International Workshop on the Destruction of Ozone-Depleting substances* in Geneva, Switzerland, July 10, 2000.

During the course of the Task Force's efforts, a number of issues have been identified which merit further consideration by the Technical and Economic Assessment Panel. The Task Force has outlined these issues in the recommendations of this report.

3.3.2 Comments

The TEAP and its Task Force on Destruction Technologies provides the following for consideration by the Parties:

1. The list of destruction technologies can be updated on a bi-annual basis to ensure that the latest technological developments are available to the Parties.

2. Consideration can be given to linking the work of the TFDT with other multilateral agreements (e.g. Stockholm Convention on POPs, Basel Convention) to facilitate transportation of ODS across international borders so as to increase the economic viability of ODS destruction.

3. A short practical guide for the import and export of ODS for destruction could be incorporated in future TEAP workplans.

4. Destruction of foams can be investigated further to better assess the most appropriate technologies required for destruction to maximise the ODS capture and destruction.

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[3] UNEP 1992. Report of the *Ad Hoc* Technical Advisory Committee on ODS Destruction Technologies. United Nations Environment Program. May 1992.

[4] UNEP 1995. 1995 ODS Disposal Technology Update. United Nations Environmental Program: Report of the Technology and Economic Assessment Panel ODS Disposal Subcommittee Workshop held in Montreal, Canada, May 2-3, 1995. June 1995.

5. Further consideration can be given to the calculation of DRE for foams.

6. A more comprehensive review of regulations pertaining to ODS destruction in developed countries could be undertaken.

7. The overall calculation of DRE can be revisited taking into consideration ODP.

8. Technologies that convert ODS into useful compounds via chemical reactions can be investigated in the future work of the TFDT.

9. A review of existing facilities that have destroyed ODS or are commercially available for this function can be assembled. This review would be used for the development of a list of commercial destruction facilities world-wide. In this review, descriptions of the facilities would include; details about the plant, geographic location (country, city), capabilities, type of technologies, DREs , emission rates, certifications, etc. In addition, an analysis of their destruction process and their effectiveness in destroying various types of ODS can be included.

10. A more comprehensive study can be undertaken to assess ways on avoiding fugitive emissions when handling, crushing or grinding foams, prior to introduce them into the furnaces.

11. An assessment of the current total global ODS destruction capacity for CFCs, halons and foams can be considered on a country basis in an effort to put the issue of future technological developments into context.

12. An in-depth assessment of the price per kg for destruction of ODS material can be completed to better assess the cost implications for destroying anticipated stockpiles.

13. Consideration can be given to the estimation of carbon tetrachloride, which is likely to be co-produced in the production of chloromethanes and needs to be destroyed beyond 2010.

14. Possible ODS likely to be available in some of the large ODS consuming Article 5(1) Parties can be estimated and techno-economic feasibility for the destruction of those ODS can be assessed.

15. Additional information can be gathered to validate sampling and analytical methods for ODS compounds in exhaust gas streams, in order that experience in this area be shared.

4 Data on Emissions; Progress Report

4.1 Production, Use and Emissions of Ozone-Depleting Substances

Accurate estimates of the historic and future emissions of ozone-depleting substances are increasingly important. Improved data on emissions allows the Science Assessment Panel to better monitor and predict the atmospheric response to controls imposed by the Montreal Protocol, allows the Parties to re-evaluate existing controls and to consider new measures, and allows the reconciliation of atmospheric concentrations and emissions as a tool in verifying Protocol compliance. The quantities of ODS halon, refrigerant, and foam blowing agents in existing equipment and banks are now so large that a regime for prevention of emissions at the end of life of the equipment could benefit the ozone layer.

4.2 Harmonisation of TEAP and Other Estimates of ODS Production and Emissions

TEAP is developing a comprehensive database of production, use, emissions and remaining inventory of all ODS across all use sectors using available data from AFEAS, the Ozone Secretariat, the Multilateral Fund, and sectoral data developed by TEAP and its TOCs. This database will be peer reviewed and placed on the TEAP website: www.teap.org.

The Ozone Secretariat data provide more complete geographical coverage, but are not audited. The AFEAS data is audited, but does not include production from China, India or Korea. Independently from the Ozone Secretariat and AFEAS, the Halons Technical Options Committee collected halon production data through personal communications with individual companies producing halons throughout the world. The data collected by the HTOC and the Ozone Secretariat data collected from Parties are in remarkable agreement, with over 99% correlation.

ODS emissions occur at production, transportation, use, storage and disposal. Emissions from use occur relatively immediately for some applications (e.g. aerosol products, flexible foam manufacture, and solvents) and over a longer period of time for other applications that contain ODS (halons, insulating foam, refrigeration). In feedstock applications a substantial portion of ODS is chemically transformed and not emitted. Furthermore, ODS can be recovered and destroyed from contained applications (chamber methyl bromide fumigation, refrigeration and air conditioning equipment, insulating foam, and halon fire protection equipment). Thus, the ultimate portion and timing of emissions of produced ODS depends: 1) on their specific end use application, 2) on practices for containment, recycle and banking, and 3) on whether ODS are recovered from products at the end of useful life.

Each TEAP TOC estimated:

1. The quantity of each ODS used for each end use in each reported year. In many cases, the use was also specified for each geographical area.
2. The profile of emissions for each future year in each end use.

TEAP presents the information on spreadsheets and database summarising estimated historic and future annual emissions and the inventory of ODS held in stockpiles and banks and still contained in products. The spreadsheets and database allow separate presentation of emissions from historic production and predicted future production and allows explicit consideration of policy options that can change the emission profile.

Each sector requires a different approach to properly characterise its different applications and emission profiles. Some sectors are more simply characterised than others are.

Note that some ODS emissions are from sources other than industrial production. This complicates reconciliation between TEAP data and Science Assessment Panel calculations. The Science Assessment Panel (SAP 2002, Section 1.6) reports that methyl chloroform is emitted from biomass burning and that methyl bromide is emitted from ocean algae. Furthermore, fugitive emissions from carbon tetrachloride used as a feedstock to produce ODS may have been larger than previously estimated and/or may be higher per unit of output as the phase-out proceeds. The few production plants that remain open are operating below capacity or are not being fully maintained in anticipation of eminent closing.

4.3 Aerosol Sector

Manufacturers of aerosol ODS products maintain only small quantities of ODS in inventory and their consumer products are typically emitted within three year of sales. There are a few minor exceptions that are accommodated in this database. Under essential use allowances, MDI manufacturers maintain an inventory of ODS comparable to approximately one year of production.

TEAP estimates that the emission profile for all ODS aerosol products is 70% emitted in the year of sale, 20% in the year following sale, and 5% in the second year following sale.

4.4 Solvent Sector

ODS used as solvents, coatings, and adhesives are almost entirely emissive with the exception of small quantities of solvent contained in the contaminated waste residue removed from vapour degreasers if those soils are incinerated. When ODS solvents were used in developed countries, most contaminated residue from vapour degreasers were disposed in landfills where any ODS was emitted. Today, a very small quantity of ODS solvent is destroyed by responsible companies operating in developing countries with sophisticated waste handling facilities. Users maintain little, if any, inventory of ODS solvents.

TEAP estimates that the emission profile for all ODS solvents is 95% emitted in the year of sale and 5% in the year following sale.

4.5 Foam Sector

Estimating the emissions of ODS used for foam blowing is more complex than most other ODS sectors. There are 7 generic types of foam and each foam type can have more than one end use.   Most foam types can be produced with a choice of blowing agents. Each type of foam has its own general ODS emission profile from the foam matrix, but this emission profile can be effected by the specific application. For example, foam encased in a plastic or steel cabinet will have a slower emission profile compared to foam exposed directly to the atmosphere. The lifetime of a foam can be divided into three emission profile phases: production, use and end-of-life.

Estimated future emissions depend on assumptions about what will happen to the foam at the end of the product life. Policy options can have a significant impact on the amount of ODS ultimately emitted. For example, collection and incineration of foam results only in the emissions of ODS lost from handling while disposal in landfills allows most, if not all, ODS to be ultimately emitted.

The Foams TOC developed a model that calculates annual emissions through 2010 by geographic region based on sales of ODS into the foams industry, the types of foams produced, and the application of the foams.

4.6 Halon Sector

Prior to the Montreal Protocol, over 70% of annual halon emissions were from training, testing of equipment and servicing practices. Since the Montreal Protocol, improved halon management strives to eliminate testing, training, accidental, and leakage emissions and to only discharge halon to extinguish fires. Halons were the first ozone-depleting substance to be phased out under the Montreal Protocol, despite the fact critical uses remained for which there are no technically or economically feasible alternatives available. The early phase-out was accomplished by careful management of a relatively large global inventory of halon to service the very small number of critical uses for which there is no technically or economically feasible alternative. There are small emissions during system servicing, halon banking, and decommissioning.

For over a decade, the HTOC has maintained a database and model showing the global inventory of halons and the estimated annual emissions profiles. As a result, the TEAP has high confidence in the production, emissions and inventory data produced by the HTOC. There are a number of critical uses that need halons for more years, and destruction of inventories may not be an option at the present time. The current model assumes that halons from decommissioned systems are recovered when halon banks are in operation but are emitted if no halon bank infrastructure and market is available. Additional, unaccounted emissions result from the production of halon 2402 that may have increased over the past approximately 5 years.

Since the last examination of recovery factors used in the model, several halon recovery/ recycle programs have been undertaken in countries with economies in transition (CEIT). The possible effect that these programs will have on factors used in the model will be evaluated and if appropriate the revised factors will be applied to update the calculations. The updated calculations will be provided in the 2002 Assessment Report of the Halons Technical Options Committee.

4.7 Methyl Bromide

Current estimates of methyl bromide sales from 1984 though 1999 are derived from a variety of sources, including Ozone Secretariat data, with relatively close agreement of totals. Methyl bromide is used as a fumigant against pests for a variety of applications, and emission rates from each are different. Emission rates during soil fumigation depend on a large number of factors. The most significant factors include the type of surface covering; the time that surface covering is present; the soil type and condition during fumigation; the rate and depth of injection; and whether the soil is strip or broadacre fumigated. Under conditions that minimise emissions, emissions as low as 3% have been observed. It is unlikely, however, that these results can be achieved in commercial field applications.

Under current usage patterns, net emissions of applied quantities are estimated by MBTOC to be 31 – 88% for soil, 85 - 95% for perishable commodities, 69 – 79% for durable commodities and 90 - 95% for structural treatments respectively.

4.8 Refrigeration and Air-Conditioning Sectors

Estimating the emissions resulting from ODS use for refrigeration and foam blowing sectors is more complex than most other ODS sectors. A variety of ozone-depleting substances are used as refrigerants, in a wide range of refrigeration and air conditioning applications, and with widely differing servicing procedures around the world. This results in numerous widely differing emission profiles. Overall, emissions from refrigeration applications have been reduced in recent years (RTOC Assessment, 1998) but these systems represent only a small fraction of total emissions. As a result, a single emission function for refrigeration has been used for over 30 years (McCulloch et al. 2001; 2002). The emission function is essentially a normal distribution about a mean equipment lifetime of 4.5 years (corresponding to an average loss rate of 11% per year, which is in the mid-range of the loss rates described by Baker, 1999). TEAP is endeavouring to improve the estimating methodology by reconciling emission rates with specific applications.

4.9 Feedstocks and Process Agents

Feedstocks and Process agents are mostly transformed into non-ODS substances, however fugitive emissions and incomplete processing results in small atmospheric emissions. Carbon tetrachloride is primarily used as feedstock for the production of CFC-11 and -12 and from this process releases to the atmosphere arise only from fugitive losses.

5 Essential Uses and Sale of MDI-ODS to Other Uses

5.1 Review of Essential Use Nominations for MDIs

Decision IV/25 of the 4th Meeting and subsequent Decisions V/18, VII/28, VIII/9, VIII/10 and XII/2 have set the criteria and the process for the assessment of essential use nominations for metered dose inhalers (MDIs).

5.1.1 Review of Nominations

The review by the Aerosols, Sterilants, Miscellaneous Uses and CTC Technical Options Committee (ATOC) is conducted as follows:

- Three members of the ATOC independently review each nomination.
- Members prepare preliminary reports, which are forwarded to the Co-chair. The committee considers the results of these assessments and prepares a consensus report.
- For nominations where some divergence of view is expressed, additional expertise or information is sought.

Concurrent with the evaluation undertaken by the ATOC, copies of all nominations are provided to the Technology and Economic Assessment Panel (TEAP). The TEAP is able to consult with other appropriate individuals or organisations in order to assist in the review and to prepare the TEAP recommendations to the Parties.

5.1.2 Committee Evaluation and Recommendations

Nominations were assessed against the guidelines for essential use contained within the *Handbook on Essential Use Nominations* (TEAP, 2001). Further information can be requested if nominations are found to be incomplete.

The ATOC reviewed all of the submitted nominations for a production exemption. Production in this context includes import of ozone depleting substances for the purposes of manufacture.

In 2002 the following Parties nominated essential use production exemptions for MDIs (asthma and COPD) or provided additional information for nominations received in 2001 (Ukraine and Russian Federation).

Country	2002	2003	2004	2005	2006
Australia		✓	✓		
European Community			✓		
Japan		✓	✓		
Poland (1)		✓	✓	✓	✓
Russian Federation (2)	✓	✓			
Ukraine (3)		✓			
United States			✓		

(1) The nomination from Poland also included a request for a nasal inhaler (budesonide).

(2) Provided additional information for a nomination previously approved by the Parties in 2001.

(3) Provided additional information to be considered by the Parties in 2002 for a nomination previously approved by the Parties in 2001.

5.1.3 Observations

5.1.3.1 Exports

As developed countries near the latter stages of their transitions, the ATOC observes that nominations from these Parties contain increasing proportions of the requests for the production of CFC MDIs for export both to developing and developed countries. In some instances, the nominations do not contain details on these exports (e.g., classes of products being exported or details on the general destination of these exports). Such details would be useful to the ATOC to enable it to more fully evaluate the essential use requests and project future trends in CFC need and use.

5.1.3.2 Transfer flexibility

In at least one nomination it appears that a request for new CFC production is occurring whilst a large stock of CFC exists in that Party. This may be because of an inability to transfer bulk CFC between companies. Although the tonnage involved in this instance is small, the ATOC felt that this situation could occur in other Parties with larger volumes as the transition proceeds. Requesting new CFCs whilst an adequate stockpile exists appears to be contradictory. This could be managed more effectively by encouraging transfer of bulk CFCs and essential use allowances between MDI manufacturers.

5.1.3.3 Avoidance of reallocation of CFCs for MDIs to other uses

It has been reported that some quantities of CFC approved for MDIs under terms of the Essential Use Exemption may be occasionally reallocated to other uses. Parties may wish to consider improvements in the reporting and auditing framework to assure that adequate supplies are available for essential medical uses and that CFCs are not unnecessarily emitted.

5.1.4 Recommendations for Parties' Essential Use Nominations

Quantities are expressed in metric tonnes.

Australia

ODS/Year	**2003**	**2004**
Quantity	11 tonnes	11 tonnes

Specific Usage: MDIs for asthma and COPD

Recommendation: Recommend exemption

Comments: The nomination by Australia is detailed and addresses all relevant elements requested of the Parties. It is notable that Australia's transition is progressing well and ahead of schedule. Australia's request of 11 tonnes is small and stable from 2001 and 2002. Most of this production is for export to countries on the Pacific Rim. Australia's stockpile, while small in absolute quantities, represents at least 2 years of 2001's production, though this is not unreasonable for a country dependant on foreign CFC sources with a long supply chain.

European Community

ODS/Year	**2004**
Quantity	1884 tonnes

Specific Use: MDIs for asthma and COPD

Recommendation: Recommend exemption

Comments: From 2001 to 2003, the EC's essential use nominations were only slightly downward, but the amounts requested for 2004 represent a substantial decrease (28.5 per cent compared to the 2003 nomination) from those levels. The nomination still contains a request for domestic consumption (nearly 50 per cent or approximately 940 tonnes), the remaining 50 per cent going to both developed and developing countries. The nomination contains few details as to the intended destination of the exported products but does refer to exports proportionally increasing. The amount of the CFCs on hand (i.e., stockpile) is appropriate and approximates one year's production needs. MDI production in 2001 utilised some of this stockpile such that there was a substantial reduction in the amount held (3318 tonnes to 1960 tonnes).

Japan

ODS/Year	**2003**	**2004**
Quantity	40 tonnes	30 tonnes

Specific Usage: MDIs for asthma and COPD

Recommendation: Recommend exemption

Comments: Nominated amounts and stockpiles of CFC continue to decrease. The nominated tonnage for 2004 constitutes 28 per cent of the 1996 nomination. Japan discontinued domestic CFC production in 1995, and stockpiles have been diminishing to 114 tonnes from 304 tonnes in 1998. Due to ageing of stored CFC, just-in-time import of CFCs may be necessary during the remaining transition period. Forty eight per cent of MDI use was switched from CFC to HFC or to DPIs by the end of 2001. Two new CFC-free products were approved. Salbutamol CFC MDIs are no longer available. Exportation of CFC products is minimal (0.55 tonnes). The clarity of the nomination and the continued reduction in CFC volumes over several years in Japan is to be commended.

Poland

ODS/Year	2003	2004	2005
Quantity	240 tonnes	236 tonnes	236 tonnes

Specific Usage: MDIs for asthma and COPD

Recommendation: Recommend exemption for 2003 and 2004 only

Comments: The ATOC notes that the CFC tonnages nominated for 2003, 2004 and 2005 are not declining. Data from previous years suggests that CFC MDI use is declining. The rate of decline can accelerate, as new alternatives become available. Poland can be encouraged to further reduce CFC consumption in the coming years and this can be reflected in future nominations. Poland has recently prepared a transition strategy to support this process.

ODS/Year	2003	2004	2005	2006
Quantity	0.6 tonnes	0.6 tonnes	0.6 tonnes	0.6 tonnes

Specific Usage: Nasal inhalers

Recommendation: Unable to recommend

Comments: The ATOC is unable to recommend because this nomination is not for an essential use.

Russian Federation

ODS/Year	2002	2003
Quantity	396 tonnes	391 tonnes

Previously approved by Parties in 2001.

Specific Usage: MDIs for asthma and COPD

Parties' Decision: Exemption approved for MDIs for asthma and COPD only for 2002 and 2003. Quantities were approved as above at the 13th Meeting of the Parties following a clarification and adjustment made by the Russian Federation of its original nomination made in early 2001.

Comments: The Russian Federation states in its clarification that the quantities are intended for MDIs for salbutamol only (and therefore for asthma and COPD only). The quantities provided in the clarification were about 100 tonnes less than the original request from the Russian Federation as a result of its diligent review.

Ukraine

ODS/Year	**2003**
Quantity	120 tonnes

Specific Usage: MDIs for asthma and COPD

Parties' Decision: Exemption was authorised by Parties with the proviso that the CFCs only be used for the production of MDIs for asthma and COPD. Ukraine was requested by the Parties at the 13th meeting to provide additional information for its 2003 nomination for consideration by the Parties at the 14th Meeting.

Comments: The initial nomination received in 2001 was for a total of 144 tonnes of CFC-11 and -12 for 2002 for eleven named products (each with an individual CFC requirement). The ATOC identified that six products were MDIs for asthma/COPD (63.4 tonnes), two were cardiac drugs (5 tonnes) and the remaining three were uncertain (probably analgesic throat and/or nasal sprays, 36 tonnes). The ATOC only considered the six products for asthma/COPD to be essential and was unable to recommend the quantities for the other products. In addition, a total of 40 tonnes were requested for "technological processes". This appears excessive for the production of the respiratory products.

The additional information provided by the Ukraine in further support of its 2003 nomination states that the quantities required are for MDIs for asthma/COPD and does not mention the previously requested non-essential products. ATOC is unclear whether the nomination still includes CFCs for non-essential uses since the quantity remains at 120 tonnes. Parties may wish to consider approving a quantity of CFCs for MDIs for asthma and COPD only. However the quantity required for this in the 2003 nomination is unclear.

United States

ODS/Year	**2004**
Quantity	2975 tonnes

Specific Usage: MDIs for asthma and COPD

Recommendation: Recommend exemption

Comments: The nominated tonnage for 2004 represents a decrease of about 10 per cent compared to the 2003 nomination.

There are now two HFC albuterol (salbutamol) MDIs approved which satisfy one requirement for non-essentiality under the proposed United States' regulation. When the second product has one year post marketing data, and the regulation is finalised, the FDA may begin proceedings to remove albuterol from the list of essential CFC MDIs. As approximately half of CFCs used are for albuterol, de-listing of this product will have a very significant impact on the use of CFCs. If this happens in 2004 the actual CFC requirement would be considerably less than the nominated amount.

A dry powder combination product of salmeterol and fluticasone has achieved significant market penetration in the last year. Together with the four other DPIs on the United States' market, this is likely to reduce future CFC needs.

5.1.5 Review of Previously Authorised Essential Uses (Decision VII/28 (2a) and (2b))

Under Decision VII/28 (2a) and (2b), Parties decided that:

"(a) The Technology and Economic Assessment Panel will review, annually, the quantity of controlled substances authorised and submit a report to the Meeting of the Parties in that year;

(b) The Technology and Economic Assessment Panel will review, biennially, whether the applications for which exemption was granted still meets the essential-use criteria and submit a report, through the Secretariat, to the Meeting of the Parties in the year in which the review is made;"

The ATOC reviewed the essential use nominations for MDIs for asthma and COPD received in 2002 and concluded that CFC MDIs remain essential for patient health until an adequate range of technically and economically feasible alternatives are available. In 2001, the Parties approved the quantities requested by the Ukraine for 2002 and 2003 with the proviso that they only be used for the production of MDIs for asthma and COPD. Additional information provided by the Ukraine was insufficient for the ATOC to determine that the approved quantities were only for asthma and COPD.

New CFC-free product launches are continuing. As most nominations are received two years in advance, Parties can continue to monitor and manage their own CFC acquisition and usage under authorised essential use quantities, and adjust their nominated quantities annually on an "as needed" basis. The ATOC will continue to monitor the changing market situation.

As the CFC transition progresses and the volume requirements for CFC continue to decline it will be critical to continue to review the need for new CFC production and balance this with depletion of CFC reserves and the continued introduction of alternatives.

5.1.6 Reporting Accounting Framework for 2001

The following table presents Reporting Accounting Frameworks for 2001, provided by Parties in response to Decision VIII/9(9):

"*To approve the format for reporting quantities and uses of ozone depleting substances produced and consumed for essential uses as set out in annex IV to the report of the Eighth Meeting and beginning in 1998 to request each of the Parties that have had essential use exemptions granted for previous years, to submit their report in the approved format by 31 January of each year;*".

Reporting Accounting Framework for 2001, as reported by Parties

	A	B	C	D		E	F	G	H	I	J	K	L
Country	**Year of Essential use**	**Amount Exempted for year of Essential use**	**Amount acquired by Production**	**Amount Acquired for Essential uses by import & Countries of Manufacture**		**Total Acquired for Essential use**	**Authorized but not Acquired**	**On Hand Start of the Year**	**Available for use in current year**	**Used for Essential use**	**Quantity contained in Exported Product**	**Destroyed**	**On Hand end of Year**
				Amount	**Country(s)**								
Australia	**2001**	11	1.68	0*	N/A	1.68	9.32	131.33	133.01	46.43	31.73	3.25	83.33
EC	**2001**	2604.577*	2205.469	0		2205.469	399.108*	3317.732	5523.201	3322.413	1579.275	240.35	1960.438
Japan	**2001**	88.20	0	6.00	UK	6.00	82.20	184.89	190.89	60.16	0.55	17.52	113.21
Hungary	**2001**	1.75					1.75	1.734	1.734	0.46			1.274
Poland	**2001**	320	0	178.33	Holland	178.33	141.67	64.66	242.6	178.56	108.83	2.62	61.42
United States	**2001**	3,101	135	2,674	EU	2,809	292	1,877	4,686	2,375	168	400	1,910

* These figures are not consistent with the actual amount exempted, which was 3270 tonnes. The amount authorised and not acquired would therefore be 1064.53

5.2 Response to Essential Use Nomination of CFC-113 by Poland

The Solvents TOC has reviewed the Essential Use Exemption request received from Poland for CFC-113. After extensive discussion, the committee concluded that the applicant did not provide sufficient information and did not adequately evaluate available alternatives to the ODS solvent, nor greases that dissolve more readily in available alternative solvents. The committee also believes that the application described is not unique and many other countries have found alternative solutions to the similar problem.

Therefore the TEAP is unable to recommend an essential use exemption.

5.3 CFCs Allocated for Essential Medical Uses Sold into Other Uses

At the March 2002 meeting of the TEAP Task Force on Collection, Recovery and Storage it was reported that unusable metered dose inhalers (MDIs), manufactured using CFCs authorised under the Essential Use Exemption (EUE), are decanted and separated into ingredients and that the salvaged CFCs are sold into the refrigeration and air-conditioning servicing market of at least one non-Article 5(1) country.

TEAP notified the Ozone Secretariat, which in turn contacted the International Pharmaceutical Aerosol Consortium (IPAC)[5] seeking information and inviting company representatives to meet with the TEAP and the Ozone Secretariat during the 29 April to 3 May 2002 meeting, where new applications for MDI essential uses were considered and where previous authorisations were reviewed. The ATOC discussed the general issue at its 23 to 26 April 2002 meeting.

IPAC did not attend the TEAP meeting but provided copies of North American and European reports confirming the practice by some MDI manufacturers.

Information Provided in Nominations for Essential Use of MDIs

TEAP reviewed the information in 2002 nominations for CFC MDIs:

- Most nominations do not make clear what happens to CFCs reclaimed or recovered from MDI manufacture.

- The nomination by the government of Japan states that CFCs recovered from MDIs are destroyed.

[5] IPAC members include: Armstrong Pharmaceuticals, AstraZeneca, Aventis Pharmaceuticals, Boehringer Ingelheim, Chiesi Farmaceutici, GlaxoSmithKline, and IVAX.

- The nomination by the government of the USA states that: "EPA regulations prohibit the sale of CFCs produced under the authority of essential use allowances into any other market."

- The nomination by the government of Australia states that small quantities of CFCs recovered from the manufacture of MDIs are sold into non-pharmaceutical uses.

Information from Other Sources

A report commissioned by IPAC and submitted to the European Climate Change Partnership as part of its Working Group on Fluorinated Gases states:

> *"At present, CFC containing 'reject' MDIs are often sent to a recycling centre in Oklahoma, USA. Around half of all reject units manufactured world-wide, including many from the EU, are returned via this route. Here the CFC gas is removed and recycled into the refrigeration or automobile industry. The recovered gas must be filtered and fractionated to ensure that dose levels of drugs are reduced to tolerable levels, thus adding some extra cost. No CFC gas is allowed to return into the pharmaceutical industry, it is generally used in the car air conditioning market."*[6]

The United States Federal Register for the Proposed Rule for the 2002 Essential Use Allocation references recycling of CFCs from MDIs:

> *"EPA is aware that certain companies extract and recycle CFCs from MDIs that are "off-specification" and are thus not marketable. These recycled CFCs are often sold for use in non-essential applications."*[7]

Initial Estimates of Annual Quantities of MDI CFCs Sold

TEAP estimates that roughly 3-7 metric tonnes of CFCs per annum could have been sold in typical years.

Implications for Nominations for Essential Use

Until now, TEAP and its Aerosol Products TOC did not realise that some MDI manufacturers are engaged in the sale of CFCs allocated for essential

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[6] Enviros March, "Study of the Use of HFCs for Metered Dose Inhalers in the European Union," Final Report to the European Climate Change Partnership, Page19, Paragraph 3, 1 December 2000.

[7] Federal Register/ Vol. 66, No. 212 / Thursday, November 1, 2002 / Proposed Rules, Page 55151.

uses into non-essential uses. The quantities of CFCs typically recovered from unusable MDIs are relatively small compared to quantities emitted from the use of MDIs. However, much higher quantities are potentially available if companies experience manufacturing problems or consider sale of EUE CFCs held in their stockpiles (current stockpiles of CFCs for MDIs are reported as about 4000 tonnes).

Furthermore, comparable opportunities exist for the diversion to non-critical uses of methyl bromide exempted for quarantine and preshipment (QPS), or allocated for emergency or critical use exemptions.

The criteria for essential use under Decision IV/25, paragraph (b) of the Parties to the Montreal Protocol requires that:

> *"(i) all economically feasible steps have been taken to minimise the essential use and any associated emission of the controlled substance;"*

Marketing of CFCs allocated as essential uses for MDIs into other uses such as refrigerants would result in increased total emissions—in contradiction to the above essential use criteria.

Therefore, the Parties to the Montreal Protocol may wish to:

1) Clarify that ODS allocated by Essential Use Exemptions can only be used for their nominated uses and that unusable or surplus quantities should normally be destroyed. They can be reallocated into uses nominated and approved by Parties as essential.
2) Require the purchase and destruction of a comparable quantity of CFCs from stocks produced prior to the 1996 phase-out to offset the emissions that have resulted from the practice of selling EUE ODS to non-essential uses.
3) Require as a condition for approval of future EUEs, destruction of unusable and surplus ODS.

TEAP has clarified the Essential Use Reporting Accounting Framework to accurately report quantities of CFC recovered and destroyed in future years.

An Additional Report of Alleged Misuse of CFCs Authorised for MDIs

TEAP and its ATOC received a report that the government of one country, with an essential use authorisation for production of CFCs for MDIs, has allegedly auctioned some or all of its allocation to other, unauthorised uses. Such action would violate the terms of the essential use exemption, may jeopardise the supply of medicine to patients, and would place domestic MDI manufacturers at a competitive disadvantage to foreign competitors. TEAP has passed this information on to the Ozone Secretariat for its consideration.

Reporting Accounting Framework for Essential Uses Other than Laboratory and Analytical Applications

All quantities should be in metric tonnes.

A	B	C	D		E (C+D)	F (B-E)	G	H (G+E)	I	J	K	L[2] (H-I-K)
Year of Essential Use	Amount Exempted for year of Essential Use	Amount Acquired by Production	Amount Acquired for Essential Uses by Import and Country(s) of Manufacture		Total Acquired for Essential Use	Authorised but not Acquired	On Hand Start of Year[3]	Available for Use in Current Year	Used for Essential Use	Quantity Contained in Products Exported	Destroyed[4]	On Hand End of Year[5]
			Amount	Country(s)								

1 Note that essential use for particular year may be the sum of quantities authorised by decision in more than one year.

2 If a transfer between Parties of an essential use has been made for the year, then the Parties should report the quantity transferred to or from another Party and identify the other Party involved in the transfer.

3 Where possible, national governments should include quantities on hand as of 1 January 1996. National governments not able to estimate quantities on hand as of 1 January 1996 can track the subsequent inventory of ODS produced for essential uses (Column L).

4 Unusable or surplus ODS allocated for essential use cannot be used in non-essential applications and should normally be destroyed. Unusable or surplus ODS allocated for essential use can be reallocated into uses nominated and approved by Parties as essential.

5 Carried forward as “On Hand at Start of Year” for next year.

6. Laboratory and Analytical Uses

Under Decision X/19, the TEAP is asked to report annually on "*the development and availability of laboratory and analytical procedures that can be performed without using the controlled substances in Annexes A and B of the Protocol,*" in order to enable the Meeting of the Parties to "*decide on any uses of controlled substances which should no longer be eligible under the exemption for laboratory and analytical uses and the date from which any such restriction should apply.*"

6.1 Update on Laboratory and Analytical Uses

A new method has been published for the analysis of oil/grease in water by B. Minty, E.D. Ramsay and I. Davies, "*Development of an automated method for determining oil in water by direct aqueous supercritical fluid extraction coupled on-line with infra-red spectroscopy*", Analyst, 2000, 12, pp. 2356-2263. This has been demonstrated to produce comparable results to the traditional infrared method.

This new method will assist Parties in complying with Decision XI/15.

6.2 Elimination of ODS in Laboratory and Analytical Uses under Decision XI/15

The Eleventh Meeting of the Parties decided in Decision XI/15 to eliminate the following uses from the global exemption for laboratory and analytical uses for controlled substances (Decision X/19) from the year 2002:

a) Testing of oil, grease and total petroleum hydrocarbons in water;

b) Testing of tar in road-paving materials; and

c) Forensic fingerprinting.

Three Parties (the European Community, Norway and Poland) have requested and been granted, emergency exemptions for the year 2002 in order to continue their use of ODS for the testing of oil, grease and total petroleum hydrocarbons in water. The European Community (EC) requested 19.8 tonnes of ODS; Norway requested 2.0 tonnes of CFC-113; and Poland requested 0.01 tonnes of CFC-113 and 2.0 tonnes of carbon tetrachloride. These Parties are in the process of changing over from analytical procedures using ODS to non-ODS procedures.

The EC notes that full implementation is dependent upon: the adoption of standards by competent authorities operating in all Member States; validation by the competent authority of the detection limit of the new procedures compared to those that used ODS; and, in some Member States, adjustment of wastewater discharge permits and monitoring programs by reference to non-ODS methods.

In February 2002, the United States Environmental Protection Agency issued a final rule which extended the general exemption for controlled "Class 1 ozone depleting substances" for use in essential laboratory and analytical applications through 2005 as consistent with the Montreal Protocol. It also clarified that use of these substances for the testing of "oil and grease" and "total petroleum" in water, testing of tar in road paving materials, and forensic fingerprinting, are not considered essential under its exemption.

6.3 Recommendations

TEAP is unable to recommend new non-ODS methods or technology that would allow elimination of further uses of controlled substances for analytical and laboratory uses.

TEAP and several countries have recommended a workshop on the elimination of controlled substances in laboratory and analytical uses and the EC has submitted a request for proposal to hold such a workshop. Such a workshop could assemble and document the new methods that have enabled the phase out of the uses as defined under Decision XI/15. This would assist Parties, including Article 5(1) countries, to revise their analytical standards and thereby eliminate ODS use. The workshop could also identify remaining uses of controlled substances and their potential substitutes. This could expedite the incorporation of new analytical methods into national and international standards.

7 Response to Decision XIII/10: Campaign Production

7.1 Introduction

7.1.1 Terms of Reference

Decision XIII/10 of the Thirteenth Meeting of the Parties requested the Technology and Economic Assessment Panel (TEAP) to consider and report to the Fourteenth Meeting on issues related to the campaign production of chlorofluorocarbons (CFCs) for chlorofluorocarbon metered-dose inhalers (CFC MDIs), in particular:

"Noting that the Technology and Economic Assessment Panel and Technical Options Committee review recommended that just-in-time production of CFCs for the manufacture of metered-dose inhalers is the best approach to protect the health of patients,

Noting, however, the possibility that just-in-time production of CFCs for the manufacture of CFC based MDIs may not be available through to the end of the transition, and that the end of just-in-time production could come unexpectedly,

1. *To note with appreciation the work of the Technology and Economic Assessment Panel and its Technical Options Committees in studying the issue of campaign production of CFCs for manufacturing CFC-based MDIs;*

2. *To request the Technology and Economic Assessment Panel and Technical Options Committees to analyse the current essential-use decisions and procedures to identify if changes are needed to facilitate expedient authorisation for campaign production, including information needed for the review and authorisation of nominations for campaign production quantities, the contingencies for under- and over-estimation of the quantities needed for a campaign production, the timing of the campaign production vis-à-vis export and import of those quantities, the oversight and reporting on the use of campaign production quantities, and the flexibility in ensuring that the campaign production is used only in the manufacture of MDIs for the treatment of asthma and chronic obstructive pulmonary disease or that any excess is destroyed;*

3. *To request the Technology and Economic Assessment Panel to present its findings to the Open-ended Working Group in 2002;*

4. *To request the Technology and Economic Assessment Panel to continue to monitor and report on the timing of the likely need for campaign production. "*

7.1.2 Definitions

For the purposes of this response the following definitions were used:

- *Just-in-time supply* – The supply of the quantity of CFC required by a MDI manufacturer to assure continuous production.
- *Periodic Campaign Production* – The operation of a CFC production plant during a defined time period to produce a specific quantity of pharmaceutical-grade CFCs for future use, after which the facility is switched over to produce another product(s) or shut-down until further production of the desired CFCs is required.
- *Final Campaign Production* – The operation of a CFC production plant for a period of time to produce a specific quantity of pharmaceutical-grade CFCs for multiple year use after which the facility is irreversibly modified to produce a different product or dismantled.
- *Pharmaceutical-grade CFCs* – CFCs produced under Good Manufacturing Practices with sufficient purity so that they are acceptable to health regulatory authorities for use in human inhalation products. These regulations vary between countries.

7.2 Status of Just-in-time CFC Supply

There are currently three producers of pharmaceutical-grade CFC-11/12 in non-Article 5(1) countries, both in the European Union. At the time Decision XIII/10 was taken by the Parties, there was uncertainty as to how long the facility operated by Honeywell at Weert in the Netherlands, which is currently a critical supplier of CFC-11/12 for MDI manufacture, would continue to operate.

This uncertainty has now been clarified. In October 2001, the Dutch Minister of Housing, Spatial Planning and the Environment stated that CFC production for essential uses would be allowed to continue through 31 December 2005, not withstanding commercial considerations. Furthermore, a second producer of CFC-11/12 in the European Union is currently modifying its CFC production to enable the manufacture of pharmaceutical-grade CFCs for supply to the United States. At the present time, the acceptability of the CFCs from this source for MDI manufacture in the United States is being determined.

There are two producers of pharmaceutical-grade CFC-114 in non-Article 5(1) Parties. One of these sources recently announced that it would cease production. For the near term, the remaining supplier is reportedly committed to its continuing production.

7.3 Difficulties Associated with Campaign Production

The ATOC considers that the transition is unlikely to be complete in some non-Article 5(1) countries, including the United States, prior to the closure of the CFC production facility in the Netherlands at the end of 2005.

The ATOC continues to believe that just-in-time supply of CFCs is the preferable option throughout the transition. However, in the event that final campaign production is required, it is necessary to evaluate now the steps needed to initiate and conduct it.

A number of difficulties are associated with final campaign production:

- Forecasting the quantity of CFC that would be required.
- The reliance solely on stored CFCs.
- A possible delay in the transition from CFC MDIs resulting from the availability of CFCs from an excessive final campaign stockpile.
- The essential use procedures of individual Parties, and of the Protocol, may need to be modified.
- Excess CFCs will have to be destroyed and the cost of destruction may need to be borne by the MDI manufacturer.

7.4 Forecasting of CFC Volumes

There are a number of uncertainties in projecting CFC volume requirements:

- When CFC-free reformulation programmes will be completed;
- The introduction and uptake of CFC-free alternatives;
- The national determinations of non-essentiality;
- The dynamics of the market share between remaining CFC products and alternatives; and
- The role of existing CFC stockpiles and their transfer between MDI manufacturers.

The further into the future that a company projects its CFC requirements, the greater is the uncertainty. The ATOC believes that, if final campaign production is required, the decision to initiate can be taken as late as possible, compatible with guaranteed supply.

7.5 Storage Requirements

If a final campaign is needed, the necessary storage capacity will depend on the cumulative requirements expected beyond 2005.

For example, it seems likely that by 2005 the United States requirements for pharmaceutical-grade CFC may be less than 1000 tonnes per year. It is less certain for how long after 2005 CFCs will be required in the United States and the rate at which their use will decline. It is not unreasonable to assume that up to 3000 tonnes of CFCs could be the total needed to meet the cumulative United States' requirements for MDI production after 2005. However, this figure could be an over estimate. As MDI producers in the United States held an inventory of close to 2000 tonnes at the end of 2001 and other storage facilities exist, storage of this size should not pose great operational problems. Similar considerations may hold for other regions/countries. (Refer to the *April 2002 Report of the TEAP Task Force on Collection, Recovery and Storage* for further information).

7.6 Timing of Actions for a Future Decision on Final Campaign Production

With just-in-time supply, the CFC manufacture takes place in the same year for which the essential use licence is issued by the national authorities. Final campaign production presents new issues concerning the timing of nominations, authorisations and licensing. For example, if a final campaign production were to take place during 2005, the CFCs produced would be used in 2005 and subsequent years. Under the current, essential use nomination system, Parties would usually nominate essential use volumes for 2005 by 31 January 2003.

The ATOC believes that, in order to maintain just-in-time supply for the longest possible time and to optimise the accuracy of projections, the Parties may wish to consider authorising campaign production at the latest possible date. If final campaign production is necessary in 2005, the Parties may wish to consider making nominations for all future years to be supplied by that campaign by 31 January 2004, instead of 31 January 2003. Under this scenario, the volumes would be authorised by the Parties at MOP-16 in 2004. A producer could then manufacture the authorised CFCs during the calendar year 2005. If the Parties determine that, with existing stockpiles and continued CFC production, final campaign production is not required, then the existing annual essential use procedure would apply.

7.7 Further Actions Required

ATOC has reviewed the Decisions of the Parties and does not believe that any changes are required to the Montreal Protocol or existing decisions in order to permit final campaign production. Nonetheless, if final campaign production is to be undertaken in 2005, a decision would be required at MOP-16 to approve these multiple year nominations. The Parties may wish to take a decision now that clarifies the timeline for submission of future projections of CFC requirements for which final campaign production may be required.

Parties may wish to consider a new decision requiring annual reporting on the use of any stockpile of CFCs created in a final production campaign. Furthermore, Parties may need to change local or national regulations in order to permit final campaign production. Such changes may require a significant time period to come into effect.

8 2002 Update Report on nPB

In Decision XIII/7, Parties requested an annual update on the evolution of use and emissions of n-propyl bromide; this report provides the most recent available data.

8.1 Production

Due to the uncertain toxicity and probable environmental restriction on the use of nPB and the economic conditions, the market for nPB has not developed significantly since the publication of the 2001 Report (TEAP, 2001).

An independent report (Ruckriegal, 2000) forecasts future nPB production at 66,000 tonnes, which is slightly higher than the 2001 TEAP "Most Likely Estimate" of 40,000 tonnes ± 20,000 tonnes and substantially less than the TEAP "Upper Bound" estimate of 250,000 tonnes ± 25,000 tonnes. Ruckriegal indicates that about 55% of the nPB production will be used for cleaning applications, 7 % for aerosols and 38% for adhesives.

8.2 Regulatory Influences

Proposed regulations in the EU and USA would restrict potential use within these jurisdictions and may discourage use elsewhere. The UK has proposed to the EU a new Classification and Labelling requirement for the substance (EU, 2001). These are shown in Table 8-1 below.

Table 8-1 *Proposed UK Classification and Labelling for nPB*

Classification	Label #	Warning	Text
	R10		Inflammable
Repr Cat 2:	R60		May impair fertility
Repr Cat 3:	R63		Possible risk of harm to the unborn child
Xn:	R48/20	Harmful:	Danger of serious damage to health by prolonged exposure through inhalation
Xi:	R36	Irritant:	Irritating to eyes
Xi:	R37	Irritant:	Irritating to respiratory system
Xi:	R38	Irritant:	Irritating to skin
	R67		Vapours may cause drowsiness and dizziness
	S2		Keep out of the reach of children
	S9		Keep container in well ventilated place
	S53-45		Avoid exposure – obtain special instructions before use - in case of accident or if you feel unwell, seek medical advice immediately

8.3 New Applications

An Italian company has started production of dry cleaning equipment specifically designed to operate with an nPB blend, produced by a European company (Donini, 2001, Clean Show, 2001). Use of such equipment would shift use of non-ozone-depleting perchloroethylene to ozone-depleting nPB. The risks inherent in using nPB may be higher than those for perchloroethylene, for which toxicology and epidemiology are well known.[8]

An Israeli producer of nPB also promotes it for dry cleaning (DSBG, 2000).

8.4 New Production Facilities

No Party has reported new production facilities for nPB.

8.5 Toxicity: Occupational Exposure Limits Based on Animal Testing

No significant new studies on animals have been published since the publication of the 2001 TEAP Report.

One nPB manufacturer has completed an intensive study of all the documents available on the toxicity of nPB (Atofina, 2001) and concludes:

"Based on the current knowledge available on nPB and the toxic effects highlighted in animals, the assessment of ATOFINA leads to the conclusion that an 8-hour occupational exposure limit value (OEL) in humans should not exceed 5 ppm.

Because:

- *potential excessive exposures to any volatile solvent in open applications cannot be easily prevented,*
- *it is difficult to keep exposure levels of nPB below this OEL,*
- *and, it is difficult to control the distribution of marketed solvents to prevent uncontrolled industrial uses or other misuses of the product,*

ATOFINA CONFIRMS ITS POSITION AND HAS DECIDED NOT TO MARKET nPB IN SOLVENT APPLICATIONS."

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[8] Published data on perchloroethylene in the dry cleaning industry does not indicate a significant increase in morbidity or mortality due to exposure, although there may be some increase in emphysema due to exposure over many years but without a statistical certitude of cause and effect (DFG, 1992).

Another company, Amity, has reduced its recommended OEL from 100 to 50 ppm for the USA only, retaining 100 ppm for their other markets. The following table is an updated summary of occupational exposure limits recommended by companies.[9]

8.6 Exposure Limits Recommended by Companies Marketing nPB

Company	Trade Name	Recommended Occupational exposure limits, ppm	Country
Atofina	Not manufactured as a solvent	5	France
Great Lakes Chemicals.	Hypersolve (manufacture ceased)	10	USA
Albemarle	Abzol	25	USA, France
Dead Sea Bromine Group	---	25	Israel
Petroferm	Lenium	25	USA
M.G. Chemicals	Contact Cleaner - NPB Heavy Duty	50	Canada
Amity USA	Leksol	50	USA
Adhesive Technologies	Not manufacturing	100	USA
Albatross USA	VDS-3000	100	USA
Alpha Metals	VaporEDGE 1000	100	USA
Amity UK	Leksol	100	UK
Enviro Tech International	Ensolv	100	USA
Poly Systems USA	Solvon	100	USA
Tech Spray	1640 Bulk	100	USA
Baker.	1-bromopropane	Not reported	USA
Micro Care	---	Not reported	USA

The US National Toxicology Program's Center for the Evaluation of Risks to Human Reproduction (CERHR) has published a draft report on the effects of nPB (NTP, 2001). This is a synthesis report of known documents relating to the reproductive and developmental toxicity of the substance. Each document is discussed with regard to its utility for the CERHR Evaluation Process and its strengths and weaknesses are highlighted. At the time of publication, the final summary starts with "There are insufficient data upon which to evaluate the reproductive toxicity of 1-BP in humans." It is expected that a final report will be available in 2002.

[9] To account for differences between animal species and humans and for the idiosyncratic differences between individuals, toxicologists typically set human exposure limits ten times lower than the same levels demonstrated for laboratory test animals. A newly proposed method of mathematically modelling OELs is believed to permit the reduction of the uncertainty factor from the conventional 10 to 2 (SLR, 2001). A recalculation, according to this model, suggests an OEL of 90 ppm.

Some long-term toxicity studies are ongoing, but results are unlikely to be published within the near future. It is emphasised that no chronic toxicity animal testing of nPB has been completed.

8.7 Toxicity: Effects of nPB on Humans

No epidemiological study of the effects on humans has been published. However, one published scientific paper (Sclar, 1999) reported the case of a 19 year-old male exposed to nPB who suffered a severe neuropathic condition. The conditions of exposure are unknown. The effects are similar to those described by Ichihara (2000) in rats exposed to nPB. In a private communication, Sclar (2002) indicated that another person, working in the same facility under the same conditions, was similarly afflicted and that a female working with an nPB solvent in a different plant reported similar symptoms. Sclar also states that no known degenerative disease or substance abuse would cause the pathological changes observed in the first patient and that there was no relevant viral condition.

The Sclar (1999) paper suggests that the problems encountered by his patient may have been partially due to transdermal uptake. Another document (ETI 2001) has also suggested that dermal uptake could contribute to toxic effects.

These are isolated, anecdotal, cases with no conclusive proof of causation. However, they support the application of the precautionary principle in determining operator exposure levels.[10]

8.8 Potential Problem of nPB Stability

There is a hypothesis that some nPB solvent blends may be chemically unstable with a small proportion of the nPB converted to *iso*-PB, an isomer that is believed to be more toxic than nPB. The quantity of isomer in nPB is regulated in some countries to a ceiling of 0.1% by weight. This hypothesis is chemically plausible, but the STOC has not yet determined the conditions under which this may happen, if any.

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[10] Decision XIII/7 states the following precautionary principle:

"2. To request Parties to urge industry and users to consider limiting the use of nPB to applications where more economically feasible and environmentally friendly alternatives are not available, and to urge them also to take care to minimize exposure and emissions during use and disposal;"

8.9 nPB Industry Rebuttal of Toxicity Concerns

Some nPB manufacturers dispute toxicity concerns and predict that further testing and ultimate regulatory decisions will allow the use of nPB at higher occupational exposure limits than currently advocated.

8.10 Conclusions

- An independent nPB market assessment predicting a 65 tonnes global market supports TEAP's "Best Estimate" of 40 tonnes ± 20 tonnes per annum.
- Toxicity and regulatory restrictions remain uncertain.
- With continuing regulatory uncertainty and economic conditions, nPB sales and emissions have not changed significantly from last year.
- One new nPB application, dry cleaning, has been commercialised.

Industry and users can take additional measures to protect personnel from skin contact. If the solvent enters into protective clothing, such as gloves, these should be removed and changed immediately to minimise occlusive dermal uptake.

8.11 References

Atofina 2001: http://groups.yahoo.com/group/solvents_group/message/184

Clean Show 2001: http://www.natclo.com/0108/news.html

DFG 1992: Occupational Toxicants Volume 3, Tetrachloroethylene, Deutsche Forschungsgemeinschaft, ISBN 3-527-27023-X, published by VCH, D-6940 Weinheim

Donini 2001: http://www.donini.com/newsita.html (in Italian)

DSBG 2000: http://www.deadseabromine.com/brome/brome.nsf/ExtensionsByUNID/19719865A573C99E4225661900552235?OpenDocument#up

ETI 2001: Derivation of an Occupational Exposure Limit for n-propyl bromide, EnviroTech International Inc., USA

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Ichihara 2000: 1-Bromopropane, an alternative to ozone layer depleting solvents, is dose-dependently neurotoxic to rats in long-term inhalation exposure, G. Ichihara et al., Toxicol Sci 55:116-123 (2000)

NTP 2001: NTP-CERHE Expert panel report on reproductive and developmental toxicity of 1-bromopropane DRAFT, NC, USA 12 October 2001

Ruckriegal 2000:Comments regarding n-propyl bromide test nomination per Federal Register Notice March 2, 2000 (Vol 65, No. 42, pp11329-11331: M.J. Ruckriegal, Poly Systems USA Inc., 2000)

Sclar 1999: Encephalomyeloradiculoneuropathy following exposure to an industrial solvent, G. Sclar, Clin Neurol Neurosurg 101:199-202 (1999)

Sclar 2002: Private communication to Brian Ellis, Neurotoxicology of nPB, G. Sclar, 11 February 2001

SLR 2001: Overview of Occupational Exposure Limit Development for n-Propylbromide, Mark Stelljes, SLR International Corp, Concord, CA, USA, 12th Annual Workshop on Solvent Substitution and Toxic Elimination, Phoenix, Arizona, USA, 12 December 2001

TEAP 2001: Report of the Technology and Economic Assessment Panel, April 2001, ISBN 92-807-2034-1, UNEP Ozone Secretariat, Nairobi, Kenya

US EPA 2001: The EPA SNAP Program: Updates on SNAP, nPB and HCFC-141b, Margaret Sheppard, 12th Annual Workshop on Solvent Substitution and Toxic Elimination, Phoenix, Arizona, USA, 12 December 2001.

9 TEAP Report on Process Agents as Requested by Parties in Decisions X/14 and XIII/13

Decision XIII/13 requests the TEAP to finalise its evaluation on process agents (requested by decision X/14) and to report to the Parties at the 22nd Meeting of the Open-ended Working Group, in 2002. This request notes the recently completed MLF Executive Committee report on process agents and that additional information requested by the TEAP that has been received by the Ozone Secretariat.

TEAP has carefully reviewed previous TEAP/PATF reports and newly available technical information and data and submits the following supplement to the April 2001 Report of the TEAP Process Agent Task Force and its October 2001 supplement.

TEAP has 1) updated Table A with an improved four-part presentation format, 2) improved the technical evaluation of Table B, and 3) secured sponsorship of a periodic workshop where experts from process agent users and government authorities can collaborate on further reducing and more accurately reporting emissions, including technology co-operation for Article 5(1) and non-Article 5(1) countries.

1. Update Table A

TEAP recommends a four-part presentation format for Table A to distinguish process agent uses when emissions have been minimised from those that have not, to list uses that are not yet determined to qualify as process agents, and to list uses already assessed and determined to not satisfy the technical criteria that define process agents.

Table A, Category 1. “Process Agents with negligible emissions”: Meets technical criteria based on the definition in the 1997 TEAP PATF Report and emissions have been minimised to negligible levels.

Table A, Category 2. “Process Agents with non-negligible emissions”: Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.

Table A, Category 3. “Insufficient information to designate as process agents or to determine not to be process agents.”

Table A, Category 4. “Not Process Agents”: Does not qualify as a process agent according to technical criteria.

Parties that support continuing ODS uses not qualifying as feedstock or process agents and therefore not included in Table A, category 1 and 2 can submit nominations for Emergency or Essential Use and can submit additional information to the Secretariat for reconsideration by TEAP as feedstock or process agent:

An "Emergency Exemption" can be promptly granted by the Ozone Secretariat after TEAP review, where appropriate.

"Essential Use Exemptions" can be submitted by 31 January each year for review by TEAP and Decision by Parties at the annual MOP.

Consideration or reconsideration of use as a feedstock or process agent can be undertaken annually.

2. Re-evaluation of the "Make-up or Consumption" and "Maximum Emissions" as presented in Table B.

Table B was developed from the best available estimates of use and emissions of controlled substances as process agents. Estimating and monitoring regimes differ substantially among Parties and use and emissions of process agents generated within a chemical process are not currently reported. Furthermore, the arbitrary limits on use and emissions may undesirably constrain the manufacture of pharmaceutical, safety, and energy efficiency products that depend on process agents.

Therefore, TEAP recommends that Parties require national governments to certify that process agent emissions are negligible, pending the development of harmonised practices to accurately estimate and report emissions from process agent inputs and process agents generated within chemical processes. This certification procedure would be comparable to the requirements for use of ODS as feedstocks.

3. Periodic workshops will be organised on reducing and more accurately reporting process agent emissions.

Environmental authorities and companies using process agents need a forum to 1) collaborate on monitoring and estimating emissions, 2) to share best practices to minimise emissions, and 3) to present not-in-kind alternatives to the use of process agents or products made with process agents.

TEAP will report progress in its periodic update reports.

4. TEAP definitions from the 1997 PATF Report:

"Process Agent: A controlled substance that because of its unique chemical and/or physical properties, facilitates an intended chemical reaction and/or inhibits an unintended chemical reaction.

Controlled substances are typically used in chemical processes as process agents for at least two of the following unique chemical and/or physical properties:

1) *Chemically inert during a chemical reaction*

2) *Physical properties, e.g.*
   - *boiling point*
   - *vapour pressure*
   - *specific solvency*
3) *To act as a chain transfer agent*
4) *To control the desired physical properties of a process, e.g.,*
   - *molecular weight*
   - *viscosity*
5) *To increase plant yield*
6) *Non-flammable/non-explosive*
7) *To minimise undesirable by-product formation*

Note 1: Refrigeration, solvent cleaning, sterilisation, aerosol propellants and fire-fighting are not process agents according to this definition.

Note 2: Parties need not consider use of ODS for foam blowing, tobacco puffing, caffeine extraction, or fumigation because these uses are already covered in other Decisions and/or by Technical Options Committee Reports."

TABLE A - List of uses of controlled substances as process agents

No.	Process	Process Agent	Party	Category
1	Chlor-alkali - Elimination of NCl_3	CTC	EU, USA, Canada	1
2	Chlor-alkali - Elimination of NCl_3	CTC	Brazil	2
3	Chlor-alkali - Chlorine recovery by tail gas absorption	CTC	EU, USA, Canada	1
4	Chlor-alkali - Chlorine recovery by tail gas absorption	CTC	Brazil	2
5	Production of Chlorinated Rubber	CTC	EU	1
6	Production of Chlorinated Rubber	CTC	India, China	2
7	Production of Endosulfan	CTC	India	2
8	Production of Ibuprofen	CTC	India	2
9	Production of Dicofol	CTC	India	2
10	Production of Chlorosulfonated Polyolefin (CSM)	CTC	USA	1
11	Production of Chlorosulfonated Polyolefin (CSM)	CTC	China	2
12	Production of Aramid Polymer PPTA	CTC	EU	1
13	Production of Fluoroplymer resins	CFC-113	USA	1
14	Production of Synthetic fibre sheet	CFC-11	USA	1
15	Production of Styrene Butadiene Rubber (SBR)	CTC	Brazil, South Korea	2
16	Production of Chlorinated Paraffin	CTC	China	2
17	Production of Vinorelbine	CFC-113	Unknown	3
18	Photochemical synthesis of perfluoropolyetherpolyperoxide precursors of Z-perfluoropolyethers and difunctional derivatives	CFC-12	EU	1
19	Reduction of perfluoropolyetherpolyperoxide intermediate for production of perfluoropolyether diesters	CFC-113	EU	1
20	Preparation of perfluoropolyether diols with high functionality	CFC-113	EU	1
21	Production of ketotifen	CTC	Unknown	3
22	Production of anticol	CTC	Unknown	3
23	Production of disulfiram	CTC	Unknown	3
24	Production of tralomethrine	CTC	Unkown	3
25	Production of Bromohexine hydrochloride	CTC	India	2
26	Production of Diclofenac sodium	CTC	India	2

No.	Process	Process Agent	Party	Category
27	Production of Cloxacillin	CTC	India	3
28	Production of Phenyl glycine	CTC	India	2
29	Production of Isosorbid mononitrate	CTC	India	3
30	Production of Omeprazol	CTC	India	3
31	Manufacture of vaccine bottles	CFC-12	Unknown	3
32	Production of Cyclodime	CTC	EU	1
33	Production of Chlorophenesin	CTC	China	3
34	Production of Chlorinated polypropene	CTC	China	2
35	Production of Chlorinated EVA	CTC	China	2
36	Production of methyl isocyanate derivatives	CTC	China	2
37	Production of 3-phenoxy benzaldehyde	CTC	China	2
38	Production of 2-chloro-5-metyhlpyridine	CTC	China	2
39	Production of Imidacloprid	CTC	China	2
40	Production of Buprofenzin	CTC	China	2
41	Production of Oxadiazon	CTC	China	2
42	Production of Chloradized N-methylaniline	CTC	China	2
43	Production of Mefenacet	CTC	China	2
44	Production of 1,3-Dichlorobenzothiazole	CTC	China	2
45	Bromination of a styrenic polymer	BCM (Bromochlor omethane)	USA	2

Further Information Regarding Table A Processes

Process 1	**Chlor-alkali**
Process Agent	CTC
Case Study	CS-1
Application	Elimination of NCl_3
Reason Used	Safety and quality of product
Product Use	Chlorine is a universal chemical, used in more than 60% of all chemical synthesis
Used In	EU, USA, Canada
Included in Decision X/14	Yes – 1
Category	Category 1 – Meets technical criteria based on the definition in the 1997 TEAP PATF Report and emissions have been minimised to negligible levels.
Identified Alternatives	No general alternatives. Some plant specific alternatives
Notes	CTC is the traditional and efficient agent to extract nitrogen trichloride (NCl_3) from liquid chlorine. NCl_3 is a highly explosive substance inadvertently produced in chlor-alkali plants when the electrolysed salt contains nitrogenous impurities. Both sea salt and mined salt contain such impurities, although there is more in salt from the latter source. The nitrogen is at the ammonia (rather than nitrate) oxidation level, often in the form of protein material, and exposure to chlorine converts it to nitrogen trichloride. While some uses of chlorine can tolerate the presence of small proportions of nitrogen trichloride, when the focus of the operation is the production of liquid chlorine then NCl_3 can build up to a dangerous concentration.
Source of Information	Case Study CS-1 available from: http://www.teap.org

Process 2	**Chlor-alkali**
Process Agent	CTC
Case Study	CS-1
Application	Elimination of NCl_3
Reason Used	Safety and quality of product
Product Use	Chlorine is a universal chemical, used in more than 60% of all chemical synthesis
Used In	Brazil (see 1997 PATF Report)
Included in Decision X/14	Yes – 1
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	No general alternatives. Some plant specific alternatives
Notes	CTC is the traditional and efficient agent to extract nitrogen trichloride (NCl_3) from liquid chlorine. NCl_3 is a highly explosive substance inadvertently produced in chlor-alkali plants when the electrolysed salt contains nitrogenous impurities. Both sea salt and mined salt contain such impurities, although there is more in salt from the latter source. The nitrogen is at the ammonia (rather than nitrate) oxidation level, often in the form of protein material, and exposure to chlorine converts it to nitrogen trichloride. While some uses of chlorine can tolerate the presence of small proportions of nitrogen trichloride, when the focus of the operation is the production of liquid chlorine then NCl_3 can build up to a dangerous concentration.
Source of Information	Case Study CS-1 available from: http://www.teap.org

Process 3	**Chlor-alkali**
Process Agent	CTC
Case Study	CS-2
Application	Chlorine recovery by tail gas absorption
Reason Used	Safety, yield
Product Use	Chlorine is a universal chemical, used in more than 60% of all chemical synthesis
Used In	EU, USA, Canada
Included in Decision X/14	Yes – 2
Category	Category 1 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report and emissions have been minimised to negligible levels.
Identified Alternatives	Plant specific alternatives only
Notes	CTC has been the solvent of choice for the tail gas recovery process. Strict requirements for stability in the presence of chlorine, corrosivity, acceptable toxicity, mutual solubility with chlorine, and vapour pressure have excluded the use of alternate substances. The absorption/stripping tail gas process allows for essentially complete recovery of all of the chlorine as liquid product. Other technologies do exist for partial recovery of the tail gas chlorine or for conversion of the tail gas to a different product.
Source of Information	Case Study CS-2 available from: http://www.teap.org

Process 4	**Chlor-alkali**
Process Agent	CTC
Case Study	CS-2
Application	Chlorine recovery by tail gas absorption
Reason Used	Safety, yield
Product Use	Chlorine is a universal chemical, used in more than 60% of all chemical synthesis
Used In	Brazil (see 1997 PATF Report)
Included in Decision X/14	Yes – 2
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Plant specific alternatives only
Notes	CTC has been the solvent of choice for the tail gas recovery process. Strict requirements for stability in the presence of chlorine, corrosivity, acceptable toxicity, mutual solubility with chlorine, and vapour pressure have excluded the use of alternate substances. The absorption/stripping tail gas process allows for essentially complete recovery of all of the chlorine as liquid product. Other technologies do exist for partial recovery of the tail gas chlorine or for conversion of the tail gas to a different product.
Source of Information	Case Study CS-2 available from: http://www.teap.org

Process 5	**Production of Chlorinated Rubber**
Process Agent	CTC
Case Study	CS-3
Application	Chemical inert solvent for high quality product
Reason Used	Inert solvent
Product Use	Heavy duty anti-corrosive coatings and adhesives
Used In	EU
Included in Decision X/14	Yes – 3
Category	Category 1 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report and emissions have been minimised to negligible levels.
Identified Alternatives	Aqueous process
Notes	Chlorinated rubber is used in surface coatings and solvent based inks. An important criterion which drives the choice of CTC is its role in determining the quality of the product, but a number of different processes are used for the production of chlorinated rubber so the search for alternatives has explored many possibilities. Two main lines of investigation can be distinguished: CTC use is maintained in the process but the emissions have been virtually eliminated. The reduction of more than 99% of CTC emissions from CR production in the EU, in less than 5 years, shows that CR can be produced in an environmentally responsible manner. The very low emissions achieved have resulted from very precise process control and facility maintenance achieved at the EU plant As well, the National government has provide a high degree of compliance monitoring. These important factors have resulted in the extremely low emissions of CTC achieved by the EU facility. a water based process has been developed after five years of research and development. The aqueous process does not require the use of CTC as a process agent, but there is some possibility of inadvertent production of CTC from the aqueous process.
Source of Information	Case Study CS-3 and the 2001 PATF Report. Both are available from: http://www.teap.org

Process 6	**Production of Chlorinated Rubber**
Process Agent	CTC
Case Study	None
Application	Chemical inert solvent for high quality product
Reason Used	Inert solvent
Product Use	Heavy duty anti-corrosive coatings and adhesives
Used In	India, China
Included in Decision X/14	Yes – 3
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Aqueous process
Notes	Chlorinated rubber is used in surface coatings and solvent based inks. An important criterion which drives the choice of CTC is its role in determining the quality of the product, but a number of different processes are used for the production of chlorinated rubber so the search for alternatives has explored many possibilities. Two main lines of investigation can be distinguished: CTC use is maintained in the process. Emissions can been virtually eliminated, however the capital cost to upgrade the plant is extremely high and operating costs will increase significantly. As well a very high degree of maintenance is required to maintain effectice emission control. a water based process has been developed after 5 years of research and development. The aqueous process does not require the use of CTC as a process agent, however there is some possibility of inadvertent production of CTC from the aqueous process. For a plant operating in an Article 5(1) country it is likely that the aqueous process would result in much lower emissions than the CTC based process.
Source of Information	2001 PATF Report available from: http://www.teap.org

Process 7	**Production of Endosulfan**
Process Agent	CTC
Case Study	CS-4
Application	Solvent
Reason Used	Inert solvent
Product Use	Biodegradeable insecticide
Used In	India
Included in Decision X/14	Yes – 4
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Aromatic solvent
Notes	The insecticide Endosulfan, which is widely used by cotton growers, is produced in two stages, the second of which involves the reaction of thionyl chloride ($SOCl_2$) with the two $-CH_2OH$ groups of the initial adduct, forming a new seven-membered ring. The initial patent in this area does not describe the use of a solvent during this second stage, but while some plants operate in this way (probably using excess thionyl chloride as a solvent which is recovered when the reaction has taken place) others use CTC as solvent, recovering it at the conclusion of the reaction and recycling it in the process. There are few specific chemical requirements for such a solvent and so CTC should be easily replaced in this process and several companies have made such a substitution. Thus, one company uses ethylene dichloride (EDC) while another reports successful use of an aromatic solvent, but in the latter case flammability of the selected solvent may be an issue. The adoption of the alternatives requires only a small change in the production process
Source of Information	Case Study CS-4 available from: http://www.teap.org

Process 8	**Production of Ibuprofen**
Process Agent	CTC
Case Study	CS-5
Application	Solvent for Friedel-Crafts synthesis
Reason Used	Inert solvent
Product Use	Anti-inflammatory drug
Used In	India
Included in Decision X/14	Yes – 5
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Ethylenedichoride (EDC)
Notes	The initial step in production of the anti-inflammatory drug Ibuprofen involves the Friedel Crafts acylation of isobutyl benzene with acetyl chloride in the presence of aluminium chloride and a suitable solvent, and in the initial patent CTC was used for this purpose. As in the case of Endosulfan, however, a range of solvents might be employed and it is reported that ethylene dichloride (EDC) is an acceptable substitute for CTC.
Source of Information	Case Study CS-5 available from: http://www.teap.org

Process 9	**Production of Dicofol**
Process Agent	CTC
Case Study	CS-6
Application	Solvent
Reason Used	Inert solvent
Product Use	Broad spectrum acaracide
Used In	India
Included in Decision X/14	Yes – 6
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Dichloroethane (ethylene dichloride)
Notes	Mites and ticks are controlled with the acaricide Dicofol, the molecule of which is closely related to DDT and Dicofol is in fact prepared from that substance. CTC is used as a solvent in two of the three stages of that process. In the second stage, the reaction involves chlorination and so a non-reactive solvent is required, but in the third stage the CTC is used as a water-immiscible solvent to extract the Dicofol product. It is reported that dichloroethane (ethylene dichloride) is an acceptable substitute for CTC, although certain technical changes are required in both stages.
Source of Information	Case Study CS-6 available from: http://www.teap.org

Process 10	**Production of Chlorosulfonated Polyolefin (CSM)**
Process Agent	CTC
Case Study	CS-7a
Application	Chlorination agent
Reason Used	Safety, yield
Product Use	High tech coatings, protective materials
Used In	USA
Included in Decision X/14	Yes – 7
Category	Category 1 **-** Meets technical criteria based on the definition in the 1997 TEAP PATF Report and emissions have been minimised to negligible levels.
Identified Alternatives	No viable alternative as yet for majority of products. Non-ODS for limited application.
Notes	These flexible materials find use mainly because of their oil and grease resistance and general durability. In North America, no viable alternative to the use of CTC has been found for the full range of products and processes of commercial significance. Of the many investigated possibilities chloroform seemed promising, but it leads to a 40% reduction of production capacity and to inadvertent formation of large quantities of CTC. The reaction conditions are particularly harsh, involving reaction of the polyolefin with chlorine and sulphur dioxide at moderately elevated temperature.
Source of Information	Case Study CS-7a available from: http://www.teap.org

Process 11	Production of Chlorosulfonated Polyolefin (CSM)
Process Agent	CTC
Case Study	CS-7b
Application	Chlorination agent
Reason Used	Safety, yield
Product Use	High tech coatings, protective materials
Used In	China
Included in Decision X/14	Yes – 7
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	No viable alternative as yet for majority of products. Non-ODS for limited application.
Notes	These flexible materials find use mainly because of their oil and grease resistance and general durability. In North America, no viable alternative to the use of CTC has been found for the full range of products and processes of commercial significance. Of the many investigated possibilities chloroform seemed promising, but it leads to a 40% reduction of production capacity and to inadvertent formation of large quantities of CTC. The reaction conditions are particularly harsh, involving reaction of the polyolefin with chlorine and sulphur dioxide at moderately elevated temperature. In China, the possibility of using chlorobenzene as a process agent was investigated, but this option was abandoned for the following reasons: energy consumption is much higher than when using CTC due to the higher boiling point of chlorobenzene chemical stability of the solvent to chlorine and sulphur dioxide is lower than that of the CTC process plant safety was compromised by the flammability, explosivity and toxicity of chlorobenzene.
Source of Information	Case Study CS-7b available from: http://www.teap.org

Process 12	**Production of Aramid Polymer PPTA**
Process Agent	CTC
Case Study	CS-8
Application	Chlorination specific solvent
Reason Used	Quality, safety, waste reduction
Product Use	Asbestos replacement, public and military safety products
Used In	EU
Included in Decision X/14	Yes – 8
Category	Category 1 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report and emissions have been minimised to negligible levels.
Identified Alternatives	No viable alternative as yet
Notes	Fibres produced from these substances are light weight and have high tensile strength, good flame resistance and good chemical stability. They may be used in protective helmets, cladding for chemical storage and transport containers, non-asbestos brake linings, and bullet-proof vests. The polymer is formed by reaction of two monomers, paraphenylenediamine and terephthaloyl dichloride (TDC). The second of these monomers is formed in a preliminary stage which involves chlorination of *p*-xylene, in CTC, followed by fusion of the chlorination product, hexachloro-*p*-xylene with terephthalic acid. A commercial non-ODS process for the production of the raw material TDC is known. This is however based on a different chemical reaction and the process is carried out with the use of phosgene as a raw material. Such use is only technically and commercially viable when phosgene is already available on the site or, where new plant is required, it may be used for more than one product. A research and development program to find an ODS free alternative to the existing production process is showing promising progress.
Source of Information	Case Study CS-8 available from: http://www.teap.org

Process 13	**Production of Fluoropolymer resins**
Process Agent	CFC-113
Case Study	CS-9
Application	Specific solvent
Reason Used	Specific dispersant, chemical inert
Product Use	Extreme temperature electrical insulation, inert coatings
Used In	USA
Included in Decision X/14	Yes - 9
Category	Category 1 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report and emissions have been minimised to negligible levels.
Identified Alternatives	The facility currently produces a full range of products. Alternative for portion of products have been implemented and efforts and investment to eliminate all use of ODS process agents continues..
Notes	Members of this family of polymers are commonly used in non-stick cookware and high-performance electrical insulation. In North America, close to fifty potential process agents for use in polymer production have been explored over the past eight years as part of a research and development program. Much of the product line was converted away from CFC-113 (CF_3-CCl_3) during 1997 and 1998. However, there are still specific critical use applications for which non-ODS process agents have yet to be found. Efforts are continuing to find an acceptable process agent or suitable processing conditions for these products. In Japan, a plant for manufacture of fluoropolymer resins has been converted to a non-ODS process utilising a proprietary technology, but the facility does not produce the full range of products.
Source of Information	Case Study CS-9 available from: http://www.teap.org

Process 14	**Production of synthetic fibre sheet**
Process Agent	CFC-11
Case Study	CS-10
Application	Spinning agent
Reason Used	Quality, safety, yield
Product Use	Protective wrappings, very strong sheets
Used In	USA
Included in Decision X/14	Yes - 10
Category	Category 1 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report and emissions have been minimised to negligible levels.
Identified Alternatives	Conversion to non-ODS process agent underway.
Notes	Sheets derived from synthetic fibres such as high-density polyethylene are widely used in protective clothing, sterilisation packaging, and air filtration. The fibres are formed by extrusion in a spin cell of solutions of the polymer in a low-boiling solvent which vaporizes as the fibrous mass is formed and may then be recovered for recycling. No simple, safe, drop-in candidate has been identified to replace CFC-11 in the existing facilities, despite a continuing (more than twelve years) program that has examined over one hundred and twenty possible process agents. A non-ODS process agent has been developed, but it requires completely new spinning and recovery facilities to use it. The first two new commercial facilities were started in 1995, and a third in 2000. Process safety management is key to the safe operation of these facilities. Continued safety analysis has shown that process safety can be significantly improved with the addition of new solution mixing technology. This technology will be retrofitted on the first two facilities at considerable expense and down time over the next three years. In addition, a new fourth generation facility is being constructed. This fourth generation technology will form the basis for future capacity expansions. Confirmation of this fourth generation technology is needed to allow full conversion of all operations from CFC-11.
Source of Information	Case Study CS-10 available from: http://www.teap.org

Process 15	**Production of Styrene Butadiene Rubber (SBR)**
Process Agent	CTC
Case Study	None
Application	Solvent
Reason Used	Chain transfer agent
Product Use	Synthetic rubber, strong and resistant to extreme temperatures and climate
Used In	Brazil, South Korea (see 1997 PATF report)
Included in Decision X/14	Yes - 11
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Mercaptans
Notes	CTC is used as a chain transfer agent in the manufacture of this type of synthetic rubber which is strong and resistant to extreme temperatures and climate. No CTC is used to manufacture this product in China.
Source of Information	1997 PATF Report available from: http://www.teap.org

Process 16	Production of Chlorinated Paraffin
Process Agent	CTC
Case Study	CS-12
Application	Solvent
Reason Used	Inert solvent
Product Use	Lubricant additive, flame retardant for plastics, plasticizer in rubber paints
Used In	China
Included in Decision X/14	Yes - 12
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Aqueous processes
Notes	These substances, with chain lengths between 10 and 26 carbons and chlorine content of 28-70%, are produced by chlorination of respective paraffin fractions derived from petroleum refining. They are used variously as high-pressure lubricants, as plasticizers and as flame-retardants, depending on their physical properties. The lower members of the family are bio-accumulative and are generally being phased-out in developed countries. Chlorination may be undertaken in the absence of a solvent provided the product is liquid at reaction temperatures, but the highly chlorinated materials are solids, making it necessary to use a solvent such as CTC to reduce the viscosity of the reaction mixture. Aqueous processes are probably available as well.
Source of Information	Case Study CS-12 available from: http://www.teap.org

Process 17	**Production of of Vinorelbine**
Process Agent	CFC-113
Case Study	None
Application	Unknown
Reason Used	Unknown
Product Use	Pharmaceutical
Used In	Unknown
Included in Decision X/14	Yes - 13
Category	Category 3. Insufficient information to designate as a process agent or to determine not to be a process agent.
Identified Alternatives	*m*-chloroperbenzoic acid in dichloromethane followed by trifluoroacetic anhydride in the same solvent.
Notes	This is an anticancer drug (antineoplastic) manufactured by modification of a natural product from the vinca alkaloid family and known as nor-5í-anhydrovinblastine. The original publications do not mention CFC-113, but instead report the use of *m*-chloroperbenzoic acid in dichloromethane followed by trifluoroacetic anhydride in the same solvent. It is possible that in manufacture, CFC-113 has been found to be more satisfactory from a chemical point of view than dichloromethane. Production quantities of such a drug are likely to be very small when compared to basic chemicals such as chlorine or chlorinated rubbers.
Source of Information	No information regarding this process agent application has been supplied to either the PATF or the TEAP. The notes are based on the results of a literature search.

Process 18	**Photochemical synthesis of perfluoropolyetherpolyperoxide precursors of Z-perfluoropolyethers and difunctional derivatives**
Process Agent	CFC-12
Case Study	CS-14
Application	
Reason Used	
Product Use	
Used In	EU
Included in Decision X/14	Yes - 14
Category	Category 1 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report and emissions have been minimised to negligible levels.
Identified Alternatives	
Notes	
Source of Information	Case Study CS-14 available from: http://www.teap.org

Process 19	**Reduction of perfluoropolyetherpolyperoxide intermediate for production of perfluoropolyether diesters**
Process Agent	CFC-113
Case Study	CS-15
Application	
Reason Used	
Product Use	
Used In	EU
Included in Decision X/14	Yes - 15
Category	Category 1 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report and emissions have been minimised to negligible levels.
Identified Alternatives	
Notes	
Source of Information	Case Study CS-15 available from: http://www.teap.org

Process 20	**Preparation of perfluoropolyether diols with high functionality**
Process Agent	CFC-113
Case Study	CS-16
Application	
Reason Used	
Product Use	
Used In	EU
Included in Decision X/14	Yes - 16
Category	Category 1 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report and emissions have been minimised to negligible levels.
Identified Alternatives	
Notes	
Source of Information	Case Study CS-16 available from: http://www.teap.org

Process 21	Production of ketotifen
Process Agent	CTC
Case Study	None
Application	Unknown
Reason Used	Unknown
Product Use	Pharmaceutical
Used In	Unknown
Included in Decision X/14	Yes – 17a
Category	Category 3. Insufficient information to designate as a process agent or to determine not to be a process agent.
Identified Alternatives	Likely
Notes	This substance is an antihistamine which is structurally similar to the tricyclic antidepressants. The first stage in its synthesis involves reaction of a CTC solution of an alkene (-CH=CH-) with N-bromosuccinimide and benzoyl peroxide, to form a dibromo-compound (-CHBr-CHBr-) which is further modified in subsequent stages. None of these later stages involves the use of CTC. Investigations should easily identify a suitable replacement solvent.
Source of Information	No information regarding this process agent application has been supplied to either the PATF or the TEAP. The notes are based on the results of a literature search.

Process 22	**Production of anticol**
Process Agent	CTC
Case Study	None
Application	Unknown
Reason Used	Unknown
Product Use	Pharmaceutical
Used In	Unknown
Included in Decision X/14	Yes – 17b
Category	Category 3. Insufficient information to designate as a process agent or to determine not to be a process agent.
Identified Alternatives	Unknown
Notes	No information was provided or located on this substance or any related process. Anticol appears to be used as a pharmaceutical.
Source of Information	No information regarding this process agent application has been supplied to either the PATF or the TEAP. The notes are based on the results of a literature search.

Process 23	**Production of disulfiram**
Process Agent	CTC
Case Study	None
Application	Unknown
Reason Used	Unknown
Product Use	Pharmaceutical
Used In	Unknown
Included in Decision X/14	Yes – 17c
Category	Category 3. Insufficient information to designate as a process agent or to determine not to be a process agent.
Identified Alternatives	In the first of two stages in its production, diethylamine is reacted with carbon disulphide in aqueous alkali, and then this product is oxidized with sodium hypochlorite, again in aqueous solution, in the second stage.
Notes	Disulfiram is taken to sensitise users against alcohol consumption. Nothing in the chemical literature indicates the use of CTC as reported to the PATF. In the first of two stages in its production, diethylamine is reacted with carbon disulphide in aqueous alkali, and then this product is oxidised with sodium hypochlorite, again in aqueous solution, in the second stage.
Source of Information	No information regarding this process agent application has been supplied to either the PATF or the TEAP. The notes are based on the results of a literature search.

Process 24	Production of tralomethrine
Process Agent	CTC
Case Study	None
Application	Unknown
Reason Used	Unknown
Product Use	Insecticide
Used In	Unknown
Included in Decision X/14	Yes - 18
Category	Category 3. Insufficient information to designate as a process agent or to determine not to be a process agent.
Identified Alternatives	Unknown
Notes	Tralomethrine is a synthetic pyrethrin, which like all members of this chemical family is an ester formed from a cyclopropane carboxylic acid and an aromatic alcohol. No further details are available which would indicate whether CTC is ever used in the production process and if so, whether this would be a process agent or not.
Source of Information	No information regarding this process agent application has been supplied to either the PATF or the TEAP. The notes are based on the results of a literature search.

Process 25	Production of Bromohexine hydrochloride
Process Agent	CTC
Case Study	CS-19
Application	Unknown
Reason Used	Unknown
Product Use	Pharmaceutical
Used In	India
Included in Decision X/14	Yes - 19
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report however emission rates have not been minimised.
Identified Alternatives	Likely
Notes	The molecule of bromohexine hydrochloride, which is used as an expectorant, is constructed by joining two major portions at a central nitrogen atom. The original patent describes how one portion is elaborated through conversion of a $-CH_3$ group to $-CH_2Br$. This bromination is effected by a selective brominating agent and, although no solvent is mentioned in the patent, it is likely that CTC is involved since it is commonly employed in such reactions. As in other cases previously discussed, however, it should be easy to find a replacement solvent.
Source of Information	Case Study CS-19 available from: http://www.teap.org

Process 26	**Production of Diclofenac sodium**
Process Agent	CTC
Case Study	CS-20
Application	Solvent
Reason Used	Yield
Product Use	Pharmaceutical
Used In	India
Included in Decision X/14	Yes - 20
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Yes
Notes	This anti-inflammatory drug has been synthesized in a number of ways, but the most elegant (and presumably commercially advantageous) method involves the use of oxalyl chloride (Cl-CO-CO-Cl) and a Friedel Crafts reaction catalysed by aluminium chloride. The original patent describes the use of "tetrachloroethane" as solvent for this stage of the synthesis, and it is possible that this is a misprint for tetrachloromethane - CTC. The reaction is conducted under mild conditions, so there would be no need to take advantage of the higher boiling point of the tetrachloroethane, but its greater solvent power may have been the reason for its use if indeed it was the solvent involved. In the scheme shown in Case Study CS-20, CTC is used (in conjunction with perchloroethylene) in the very first step, the chlorination of phenol. The choice of solvent affects the selectivity of the reaction so that 2,6-dichlorophenol is favoured over the alternative product, 2,4-dichlorophenol.
Source of Information	Case Study CS-20 available from: http://www.teap.org

Process 27	**Production of Cloxacillin**
Process Agent	CTC
Case Study	None
Application	Unknown
Reason Used	Unknown
Product Use	Pharmaceutical
Used In	India
Included in Decision X/14	Yes - 21
Category	Category 3. Insufficient information to designate as a process agent or to determine not to be a process agent.
Identified Alternatives	Likely
Notes	Cloxacillin is a semi-synthetic penicillin formed by reaction of the natural penicillanic acid and an acid chloride, which is in turn formed from a synthetic acid. The formation of the acid chloride involves reaction of the acid with thionyl chloride ($SOCl_2$), and the original patent describes this reaction as being carried out in excess thionyl chloride, which thus plays the role of solvent as well as reactant. CTC could conceivably be used as solvent in this reaction, but finding a substitute for CTC should be possible.
Source of Information	No information regarding this process agent application has been supplied to either the PATF or the TEAP. The notes are based on the results of a literature search.

Process 28	**Production of Phenyl glycine**
Process Agent	CTC
Case Study	CS-22
Application	Solvent
Reason Used	Unknown
Product Use	Pharmaceutical
Used In	India
Included in Decision X/14	Yes - 22
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Unknown
Notes	The solvent CTC is known to be used in two successful chemical reactions which use this amino-acid (C-phenyl glycine). In the first reaction, HCl in dry CTC is used to form the hydrochloride salt, which is then reacted with thionyl chloride to convert the –COOH group to the acid chloride. This product, being similarly insoluble in CTC, is washed with CTC to effect purification.
Source of Information	Case Study CS-22 available from: http://www.teap.org

Process 29	Production of Isosorbid mononitrate
Process Agent	CTC
Case Study	None
Application	Unknown
Reason Used	Unknown
Product Use	Pharmaceutical
Used In	India
Included in Decision X/14	Yes - 23
Category	Category 3. Insufficient information to designate as a process agent or to determine not to be a process agent.
Identified Alternatives	Yes
Notes	This is a vasodilating drug, similar in its effects to the nitro-glycerine (glyceryl trinitrate) that is used by angina sufferers. Isosorbid dinitrate, and presumably the mononitrate, may be prepared from sorbitol by reaction with a typical nitric-and-sulphuric acid nitrating mixture. The published chemistry provides no indication of the use of CTC.
Source of Information	No information regarding this process agent application has been supplied to either the PATF or the TEAP. The notes are based on the results of a literature search.

Process 30	**Production of Omeprazol**
Process Agent	CTC
Case Study	None
Application	Unknown
Reason Used	Unknown
Product Use	Pharmaceutical
Used In	India
Included in Decision X/14	Yes - 24
Category	Category 3. Insufficient information to designate as a process agent or to determine not to be a process agent.
Identified Alternatives	Likely
Notes	This anti-ulcer drug is produced by joining together two building blocks. One of these is primed for the coupling step by reacting it with thionyl chloride ($SOCl_2$) to convert a $-CH_2OH$ group into a $-CH_2Cl$ group. The literature descriptions of this step do not mention the use of a solvent, but CTC would be an appropriate choice, as it is for other reactions (see above) involving thionyl chloride. However, as before, suitable replacement solvents could be found at the expense of a little research and possibly minor adjustments to plant.
Source of Information	No information regarding this process agent application has been supplied to either the PATF or the TEAP. The notes are based on the results of a literature search.

Process 31	Manufacture of vaccine bottles
Process Agent	CFC-12
Case Study	None
Application	Unknown
Reason Used	Unknown
Product Use	Unknown
Used In	Unknown
Included in Decision X/14	Yes - 25
Category	Category 3. Insufficient information to designate as a process agent or to determine not to be a process agent.
Identified Alternatives	Unknown
Notes	A number of fluorine-containing substances (including CFC-12 and HFC-134a) have been used to treat the interior surfaces of glass bottles, at temperatures near 500^{o}C, so as to make the surface hydrophobic. This is probably done so that the contents do not wet and spread over the surface, and are thus completely removable by syringe, ensuring that the intended dose is delivered.
Source of Information	No information regarding this process agent application has been supplied to either the PATF or the TEAP. The notes are based on the results of a literature search.

Process 32	**Production of Cyclodime**
Process Agent	CTC
Case Study	CS-26
Application	Solvent
Reason Used	Inert solvent
Product Use	Extreme and adverse temperatures in aeronautic hydraulic system components
Used In	EU
Included in Decision X/14	No
Category	Category 1 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report and emissions have been minimised to negligible levels.
Identified Alternatives	Unknown
Notes	Cyclodime is a synthesis intermediate used for the manufacture of polymer raw materials. The polymers produced are used for technical applications (such as hydraulic systems) in the aerospace, aeronautics, automotive and appliance industries. The materials are dissolved in CTC and then reacted under powerful light radiation in order to produce the crude Cyclodime by a photochemical reaction in CTC used as a solvent. The use of CTC is at present essential in this process due to its stability and as it is the only suitable solvent known to not decompose under the aggressive photochemical reaction conditions. Evaluation of other solvents under process conditions, such as non-fully halogenated compounds has led to the resulting polymer raw material being unsatisfactory for the production of the final polymers, primarily due to the breakdown of the solvent during the photochemical reaction and the formation of free radicals.
Source of Information	Case Study CS-26 available from: http://www.teap.org

Process 33	Production of Chlorophenesin
Process Agent	CTC
Case Study	None - see Chapter 5 of 2001 PATF Report
Application	Unknown
Reason Used	Unknown
Product Use	Pharmaceutical
Used In	China
Included in Decision X/14	No
Category	Category 3. Insufficient information to designate as a process agent or to determine not to be a process agent.
Identified Alternatives	Unknown
Notes	
Source of Information	Chapter 5 of 2001 PATF Report available from: http://www.teap.org

Process 34	**Production of Chlorinated polypropene**
Process Agent	CTC
Case Study	None - see Chapter 5 of 2001 PATF Report
Application	Solvent
Reason Used	Yield, quality of product
Product Use	Coating materials, adhesives, silk screen inks
Used In	China
Included in Decision X/14	No
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Unknown
Notes	
Source of Information	Chapter 5 of 2001 PATF Report available from: http://www.teap.org

Process 35	**Production of Chlorinated EVA**
Process Agent	CTC
Case Study	None - see Chapter 5 of 2001 PATF Report
Application	Solvent
Reason Used	Yield, quality of product
Product Use	Coating materials, silk screen inks inks
Used In	China
Included in Decision X/14	No
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Unknown
Notes	
Source of Information	Chapter 5 of 2001 PATF Report available from: http://www.teap.org

Process 36	**Production of methyl isocyanate derivatives**
Process Agent	CTC
Case Study	None - see Chapter 5 of 2001 PATF Report
Application	Solvent
Reason Used	Inert solvent, yield, quality, safety
Product Use	Pesticide
Used In	China
Included in Decision X/14	No
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Unknown
Notes	
Source of Information	Chapter 5 of 2001 PATF Report available from: http://www.teap.org

Process 37	**Production of 3-phenoxy benzaldehyde**
Process Agent	CTC
Case Study	None - see Chapter 5 of 2001 PATF Report
Application	Solvent
Reason Used	Inert solvent, yield, quality, safety
Product Use	Pesticide
Used In	China
Included in Decision X/14	No
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Unknown
Notes	This substance is a precursor to a number of synthetic pyrethrin insecticides.
Source of Information	Chapter 5 of 2001 PATF Report available from: http://www.teap.org

Process 38	**Production of 2-chloro-5-methylpyridine**
Process Agent	CTC
Case Study	None - see Chapter 5 of 2001 PATF Report
Application	Solvent
Reason Used	Inert solvent, yield, quality, safety
Product Use	Intermediate for Imidacloprid
Used In	China
Included in Decision X/14	No
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Unknown
Notes	
Source of Information	Chapter 5 of 2001 PATF Report available from: http://www.teap.org

Process 39	Production of Imidacloprid
Process Agent	CTC
Case Study	None - see Chapter 5 of 2001 PATF Report
Application	Solvent
Reason Used	Inert solvent, yield, quality, safety
Product Use	Pesticide
Used In	China
Included in Decision X/14	No
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Unknown
Notes	
Source of Information	Chapter 5 of 2001 PATF Report available from: http://www.teap.org

Process 40	**Production of Buprofenzin**
Process Agent	CTC
Case Study	None - see Chapter 5 of 2001 PATF Report
Application	Solvent
Reason Used	Inert solvent, yield, quality, safety
Product Use	Pesticide
Used In	China
Included in Decision X/14	No
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Unknown
Notes	
Source of Information	Chapter 5 of 2001 PATF Report available from: http://www.teap.org

Process 41	**Production of Oxadiazon**
Process Agent	CTC
Case Study	None - see Chapter 5 of 2001 PATF Report
Application	Solvent
Reason Used	Inert solvent, yield, quality, safety
Product Use	Herbicide
Used In	China
Included in Decision X/14	No
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Unknown
Notes	
Source of Information	Chapter 5 of 2001 PATF Report available from: http://www.teap.org

Process 42	Production of Chloridized N-methylaniline
Process Agent	CTC
Case Study	None - see Chapter 5 of 2001 PATF Report
Application	Solvent
Reason Used	Inert solvent, yield, quality, safety
Product Use	Intermediate for Buprofenzin
Used In	China
Included in Decision X/14	No
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Unknown
Notes	
Source of Information	Chapter 5 of 2001 PATF Report available from: http://www.teap.org

Process 43	**Production of Mefenacet**
Process Agent	CTC
Case Study	None - see Chapter 5 of 2001 PATF Report
Application	Solvent
Reason Used	Inert solvent, yield, quality, safety
Product Use	Pesticide
Used In	China
Included in Decision X/14	No
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Unknown
Notes	
Source of Information	Chapter 5 of 2001 PATF Report available from: http://www.teap.org

Process 44	**Production of 1,3-Dichlorobenzothiazole**
Process Agent	CTC
Case Study	None - see Chapter 5 of 2001 PATF Report
Application	Solvent
Reason Used	Inert solvent, yield, quality, safety
Product Use	Intermediate for Mefenacet
Used In	China
Included in Decision X/14	No
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Unknown
Notes	
Source of Information	Chapter 5 of 2001 PATF Report available from: http://www.teap.org

Process 45	**Bromination of a styrenic polymer**
Process Agent	BCM (Bromochloromethane)
Case Study	To be prepared and submitted
Application	Solvent
Reason Used	Inert solvent, quality, safety, waste reduction
Product Use	Flame retardant for use in engineering thermoplastics
Used In	USA
Included in Decision X/14	No
Category	Category 2 - Meets technical criteria based on the definition in the 1997 TEAP PATF Report, but emission rates have not been minimised.
Identified Alternatives	Unknown
Notes	
Source of Information	Supporting information submitted to UNEP will be made available at: http://www.teap.org once clearance has been obtained.

PROGRESS REPORTS

10. Aerosols, Sterilants, Miscellaneous Uses and Carbon Tetrachloride Technical Options Committee (ATOC) Progress Report

10.1 Introduction

This section covers new developments since the April 2001 TEAP Report related to aerosol products (other than metered dose inhalers, MDIs) and metered dose inhalers. Information for sterilants, miscellaneous uses and carbon tetrachloride will be provided in the 2002 Assessment.

10.2 Aerosol Products (other than MDIs)

There are no technical barriers for the transition to alternatives for aerosol products other than MDIs. However, some consumption of CFCs in aerosols still remains in Article 5(1) countries and CEIT. The remaining main uses for CFCs in these countries have been identified as:

- Non-MDI medical aerosols such as local anaesthetics, throat sprays, nasal sprays, wound sprays, vaginal products and traditional Chinese medicines;
- Industrial/technical aerosols such as electronics cleaners, spinnerette sprays, anti-spatter sprays and tyre inflators;
- Personal hygiene products filled in small volume cans;
- Insecticide and disinfectant sprays for use aboard aircraft.

The ATOC estimates that the consumption of CFCs in the non-MDI aerosol products sector was approximately 4,300 tonnes in 2001 in CEIT and Article 5(1) countries. This represents a 71% reduction in CFC consumption from 1997 (14,700 tonnes). For the first time, the ATOC can report that CFC consumption in the non-MDI aerosol products sector in Article 5(1) countries and CEIT has reduced to below that consumed for global CFC MDI manufacture.

The closure of CFC production facilities in the Russian Federation has resulted in some CFC reduction in the aerosol products sector. China and India have signed stepwise phase out plans for CFC production, but the effect of these on the aerosol products sector is not yet apparent. These and many other Article 5(1) countries and CEIT continue to use CFCs for the remaining applications stated above and others. These products can either be reformulated to use non-CFC propellants, or replaced by not-in-kind substitutes.

The most progress has taken place in the Russian Federation from 7,800 tonnes in 1997 to 200 tonnes in 2001, representing a 97% reduction. Both independent conversions and those partially funded by the Global Environment Facility have considerably reduced aerosol CFC consumption.

In China, slightly less than 2000 tonnes of CFCs are still used for the production of medical aerosols, which include traditional Chinese medicines, as well as for industrial/technical products and aircraft disinfectants. The use of aerosols is increasing and new pharmaceutical products with CFCs continue to be developed. Local efforts to begin the reformulation of these products are underway and progressing, but this is being impeded by a lack of locally produced pharmaceutical-grade propellants, both HFCs and hydrocarbon aerosol propellants (HAPs).

India still has over 300 tonnes of remaining CFC consumption in aerosol products. UNDP is currently assisting the Ministry of Environment and Forests in preparing a Terminal Umbrella Project. This will result in the elimination of the remaining CFC consumption during 2002 and 2003.

The situation in other Article 5(1) countries and CEIT remains similar to that which was reported previously. The remaining usage of CFCs in aerosols is small, distributed in many countries and difficult to identify. Specific actions from governments and their national ozone offices will be needed to achieve final phase out.

Comprehensive CFC consumption data for aerosol products is difficult to obtain. An estimate showing a regional break down of CFC consumption for 2001 is as presented in Table 10-1.

Table 10-1 *CFC consumption in non-MDI aerosols in 2001 (tonnes)*

ASEAN Countries*	700
China	1,800
South Asian Countries**	400
Latin America	400
Middle East, Africa	400
Russian Federation	200
Other CEIT and CIS***	400
Total	4,300

* Brunei, Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, Vietnam
** Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka
*** CIS: Successor States of the former Soviet Union

The reformulation of the non-MDI medical aerosol products and industrial/technical aerosols may require technical and financial assistance. In the case of medical aerosols, approval by national health and drug authorities will be required, after pharmacological and toxicity tests and clinical trials. Currently, more expensive products result if the new replacement products require the use of HFCs.

10.3 Metered Dose Inhalers

10.3.1 Trends in CFC Consumption

The following trends in CFC use for MDIs have been drawn from Reporting Accounting Frameworks submitted by non-Article 5(1) countries manufacturing CFC MDIs as essential uses (see Figure 10-1 and Figure 10-2).

Total CFC use for non-Article 5(1) countries manufacturing MDIs has fallen by about 28% from 8,290 tonnes in 1996 to an estimated 5,983 tonnes in 2001 (excluding year 2001 information for the Russian Federation and Ukraine). ATOC estimates that a total of 7,500-8,000 tonnes of CFCs was used world wide for the manufacture of MDIs in 2001, including an estimated 1,500-2,000 tonnes used in Article 5(1) countries for local manufacture of CFC MDIs.

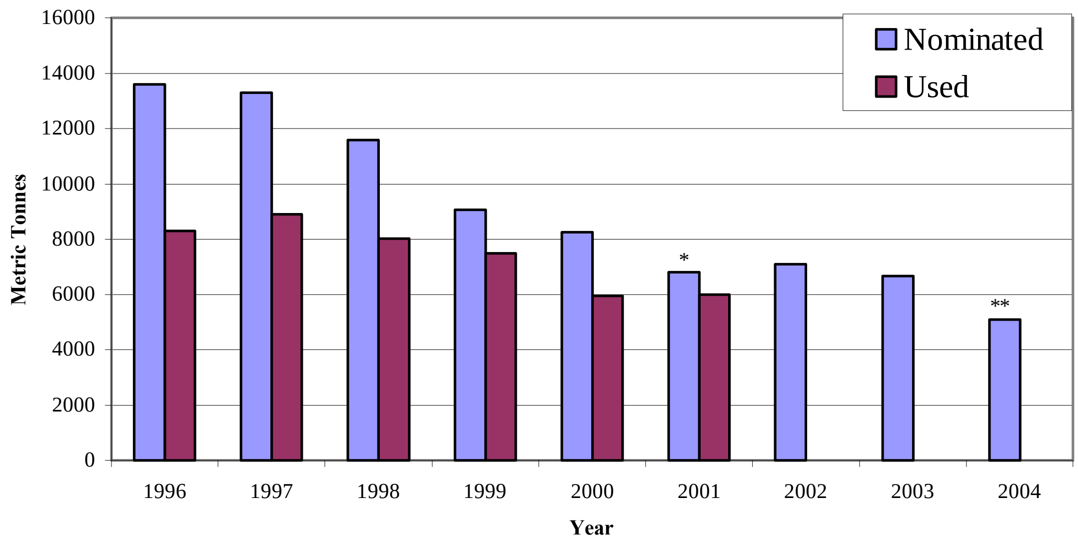

Figure 10-1 *Total amounts of CFCs exempted or nominated and used for essential uses for MDIs 1996-2004, as reported by Parties*

Note:
* Year 2001 quantities do not include data for the Russian Federation. In 2001, the Russian Federation did not have an essential use exemption. Year 2002 and 2003 indicates quantities approved by the Parties, which in these years includes the Russian Federation.

** Year 2004 indicates quantities nominated. This excludes the Russian Federation and the Ukraine, which have not yet submitted nominations for this year.

These reductions reflect the fact that alternatives continue to be introduced around the world. For example, of the estimated 450 million MDIs manufactured world-wide in 2001 approximately 350 million were CFC MDIs and 100 million HFC MDIs (up from an estimated 70 million in 1999). In some countries (e.g. Japan and the United States) there has been a recent increase in the sale of DPIs. This should further reduce the need for CFC MDIs.

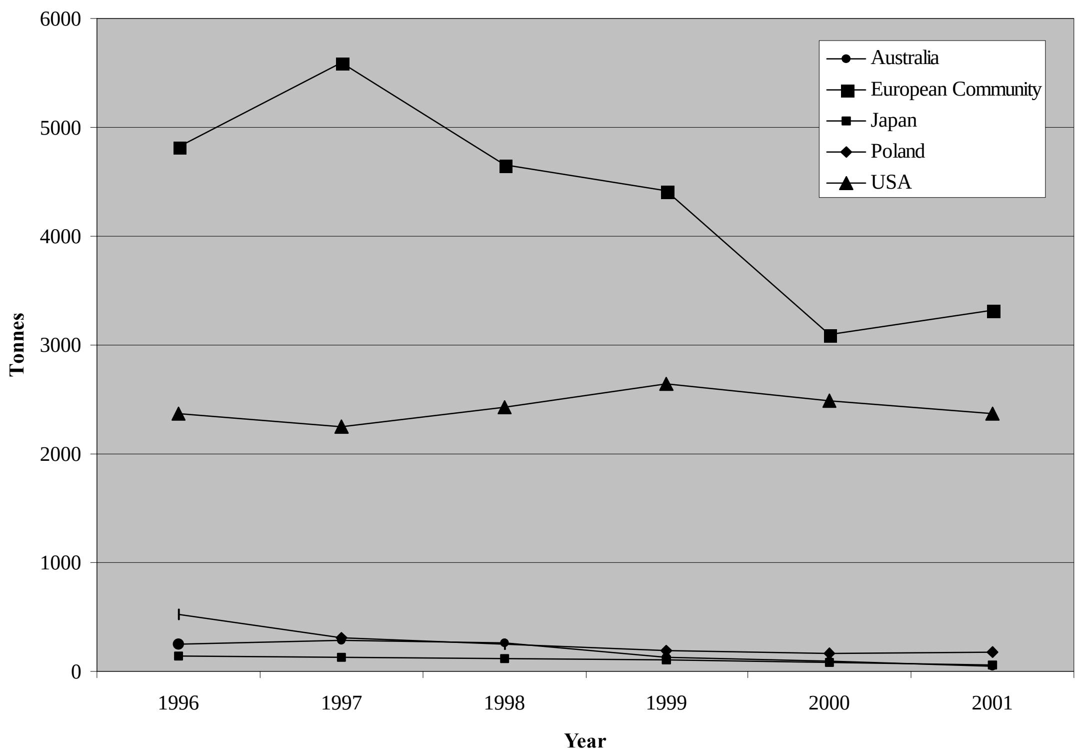

Figure10-2 *Total amounts of CFCs used by a selection of nominating Parties for MDIs 1996-2001, as reported by Parties*

10.3.2 Availability of Alternatives

HFC MDIs – HFC MDIs continue to be introduced and commercialised around the world with salbutamol still the most widely approved product. An additional short-acting beta-agonist and cromone products have become available in several countries, and an anticholinergic product has been approved for use in one country. Furthermore, one or more inhaled corticosteroids have been approved in over 30 countries. Among the Article 5(1) countries, one company in India has made progress in local production of HFC MDIs. Overall, over 30 Article 5(1) countries have at least one HFC

MDI available. While the uptake has been negligible in most Article 5(1) countries, in the Philippines over 50% of MDIs are now HFC-based.

Dry Powder Inhalers – The introduction of new dry powder inhalers (DPIs) using existing technologies is continuing around the world. Available data indicate that while overall inhaler use remains steady, the use of DPIs continues to increase. In the United States recent approval of a bronchodilator-corticosteroid combination DPI has had a significant impact on use of DPIs in that country. In Europe, DPIs, CFC MDIs and HFC MDIs now have equal market share (in unit terms). In Japan, over the last two years, sales of DPIs have increased five fold and now account for 30% of the inhaler market.

Novel Delivery Systems – A number of sophisticated pulmonary delivery systems that do not use propellants are in development. These take the form of novel DPIs or liquid-based systems. While commercial availability of these is still in the future (one liquid based system is now reported to be in the approval process), it is expected that some may serve as alternatives to CFC MDIs when used to deliver asthma/COPD drugs. However, as many of these novel systems are being developed to deliver drugs into the systemic circulation via the lungs (e.g. insulin for diabetes), they will not be considered as substitutes for existing CFC MDIs for asthma and COPD.

10.3.3 Experiences inTransition

The rate of transition from CFC MDIs to non-CFC products has varied from country to country. This has occurred for a number of reasons including price considerations, differences in medical practice and patient preferences.

Brand by brand transition has generally occurred at comparable prices but its success is influenced by the above factors. In some countries there is a significant proportion of generic CFC MDIs that are priced lower than the brand name CFC MDIs and HFC alternatives. Since payers (purchasers, health authorities, insurance companies etc.) will continue to favour lower priced medicines, countries will have to address the means to have payers accept the non-CFC alternatives.

Trends in the reduction of the use of CFC MDIs have been mirrored by the uptake of HFC MDIs and, in some countries, by the very successful launch of DPIs. The introduction of an HFC MDI does not necessarily lead to a successful transition. Experience in some countries indicates that transition can only be achieved by phasing out the corresponding CFC product once the alternative is widely available.

Despite widespread educational initiatives, transition does not appear to be a high priority amongst most healthcare providers, many of whom have taken a passive approach to transition. Pharmaceutical companies' educational and marketing endeavours have been the driving force in the uptake of alternatives.

Reviewing all possible methods of transition (e.g. drug by drug, brand by brand, category by category, targets and timetables) it is clear that action by patient organisations, health professional organisations and the pharmaceutical industry will not alone drive the transition. Parties may wish to consider official action (e.g. a target and timetable approach) to achieve CFC MDI phase out. This will involve collecting appropriate market data and evaluating the economic factors involved.

Several countries have developed and implemented effective transition processes. Japan is a good example of such a country and is expected to phase out CFC MDIs by 2005. This has been accomplished by the collaboration of the various pharmaceutical companies and the relevant government authorities.

Transition Strategies

Decision XII/2 of the Parties states that each non-Article 5(1) Party should develop and submit a national/regional transition strategy to the Ozone Secretariat by 31 January 2002. Article 5(1) Parties are encouraged to submit CFC MDI transition strategies by 31 January 2005.

By 31 January 2002, 8 out of 43 non-Article 5(1) Parties had submitted interim or final transition strategies. Recently, the Ozone Secretariat also received transition policies from Poland and from the Hong Kong Special Administrative Region of the People's Republic of China. A number of Parties have indicated they will shortly submit or update strategies.

The policy for Poland is based on a category-by-category transition similar to that operating in the EC, and expects to complete the majority of the transition by 2006.

In contrast, the Hong Kong policy is based on encouraging the registration and marketing of an adequate range of alternative CFC free MDIs of comparable prices to CFC MDIs. Precise criteria for triggering a transition process are not given. A survey of Hong Kong patients and healthcare workers suggested a number of concerns, some of which are clinically important (e.g. availability and cost) and some which have been seen to be less important elsewhere (e.g. patient discomfort with DPIs).

10.3.4 Article 5(1) Country and CEIT Considerations

Under the Montreal Protocol, a complete phase-out of overall CFC consumption is mandated by 2010 for Article 5(1) countries. In 2005, there will be a 50% reduction from baseline levels in CFC consumption for basic domestic needs in developing countries. This will include consumption for MDI production, which will then compete with other uses of CFCs within the 50% cap.

Current Status

Multinational pharmaceutical producers provide the vast majority of MDIs in most Article 5(1) countries and CEIT. In a few countries (e.g. Brazil, Mexico), local manufacture accounts for some MDIs, but the majority comes from multinational producers. In others (e.g. China, Cuba and India), local manufacture accounts for a significant proportion of production. Each of these patterns will have a different impact on the development of transition plans.

Although CFC-free inhalers are already available in at least 30 Article 5(1) countries, uptake has been very low. However the ATOC is aware that the Philippines (an importing country) has begun its transition process and is more than 50% completed. In contrast, India has a local manufacturer producing the majority of the MDIs used in that country. Whilst this manufacturer has introduced at least three non-CFC MDIs, this introduction alone has not been sufficient to drive transition to these products. This is similar to the experience in developed countries.

Barriers to Transition in CEIT and Article 5(1) Countries

It is acknowledged that there are major concerns over the cost and/or availability of healthcare in all countries, particularly in CEIT and Article 5(1) countries. Notably, inhaled therapies are usually more expensive than commonly available oral medications that are less effective and maybe more hazardous. For the purpose of this document, ATOC has limited its comments to CFC MDI transition issues.

It is important that countries collect accurate basic data on inhaler use if effective transition plans are to be developed. If such data already exist, the ATOC is not aware of them.

Current experience is that transition plans will only be successfully implemented if there is a frank discussion among the major stakeholders, that is, MDI producers, health and environmental agencies. In addition, there will be a need to involve national medical professional organisations. International organisations or programs, for example, Global Initiative for Asthma (GINA), Global Initiative on Obstructive Lung Disease (GOLD), International Union Against Tuberculosis and Lung Disease (IUATLD) and WHO, also may have roles to play. This is relevant for all Article 5(1) countries and CEIT, irrespective of whether they have local manufacturing or not.

Since price is such an important factor in the use of inhaled therapy, the price of CFC alternatives will be a major barrier to transition, unless they are no more expensive than comparable CFC products.

There has been a lack of awareness by healthcare providers regarding the need for change from CFC to CFC-free inhalers. In developed countries already advanced in their transition process, multinational pharmaceutical companies have been more effective than governments and NGOs in educating healthcare providers. This may also prove to be the case in developing countries and CEIT. Countries should consider this likelihood in developing their transition strategies.

For the purposes of considering funding, Article 5(1) countries and CEIT can be divided into two broad categories: those with manufacture of MDIs by local companies and those without.

Those countries with CFC MDI manufacture by local companies will require an interventionist transition policy. This may require assistance with the development of alternative formulations, modification of manufacturing plant and fulfilling of regulatory obligations for marketing. This assistance may vary, depending on whether local manufacture is undertaken independently, or under a licensing agreement. As has been the case in developed countries, an evaluation of whether reformulation of a specific drug is technically feasible may be needed. This and similar aspects of transition policy will require input by appropriate pharmaceutical and technical experts in order to ensure optimal use of any development funding.

Most countries do not have local manufacture of CFC MDIs and supply of MDIs is wholly or largely by import. In those countries, national transition policies may be less interventionist, as in many developed countries. Experience in developed countries, where the supply of CFC MDIs comes from import by multinational companies, is that CFC alternatives can be introduced promptly where it is feasible within the regulatory framework of a country (e.g. Canada).

Experience in developed countries has been that education has largely been provided by MDI manufacturers, supplemented by information from health authorities and patient support groups. Support for educational efforts in developing countries may be needed to facilitate transition, dependent on local circumstances.

The CFC MDI transition has proved to be complicated, as it is influenced by medical, technical, economic and regulatory factors. In Article 5(1) countries, this transition is occurring as a part of the overall phase-out of CFCs (with a 50% reduction from baseline levels in CFC consumption for basic domestic needs in developing countries in 2005). Competition for supply of CFC between all uses may compromise supply of CFCs for MDIs. Therefore, ATOC strongly recommends that in order to protect patient health, MDI transition strategies be developed now, especially by those countries with local MDI manufacture, not withstanding the date of 31 January 2005 (by which time Article 5(1) countries are encouraged to develop MDI transition strategies).

The development of transition policies could be facilitated by a series of regional workshops.

11. Foams Technical Options Committee (FTOC) Progress Report

11.1 General Introduction

This update is the third foam sector review published since the 1998 Report of the Flexible and Rigid Foams Technical Options Committee. It builds on the update provided by the Technical Options Committee early last year (published in the Report of the Technology and Economic Assessment Panel in April 2001) and provides important new information that has emerged since then. The purpose of these updates is to highlight changes in technology that have occurred in the last year rather than to offer a comprehensive review of the current technologies available. Such a comprehensive review will be the subject of the 2002 Report of the Flexible and Rigid Foams Technical Committee which is currently in preparation.

The key conclusions from this update report are as follows:

- Several developing countries are approaching final phase-out in the foam sector. However, delays in other developing countries have limited progress and are threatening compliance
- Several developed countries are currently occupied with the management of HCFC phase-out strategies
- The financial constraints of SMEs remain key factors in many transition strategies, both in developing and developed countries
- The technical acceptability of hydrocarbons has expanded as several previous short-comings have been overcome
- The timing of availability of liquid HFCs has been clarified and preliminary transitions are underway. There is now a clearer picture of how HFCs will ultimately be used in practice. However, there is concern in some specific sectors about whether technologies can be validated in time to support HCFC phase-out within the existing regulatory frameworks
- The market share of insulation foams continues to grow against alternative insulation materials because of their excellent insulation efficiency and structural integrity. Increased concerns over climate change will continue to drive this growth further
- There remains concern among users about the possibility of a supply/ demand imbalance for HCFC-141b once the phase-out in developed countries takes place. This extends to the maintenance of adequate geographic supply chains

- The sustained availability of CFC-11 at low prices continues to hinder phase-out

11.2 Technology Status

This section covers the technology status in the polyurethane, extruded polystyrene and phenolic foam sectors.

11.2.1 Polyurethane

Flexible Foams

Slabstock Foams - Continuous: The increasing regulatory scrutiny around the world is continuing to encourage other alternatives. CO_2 (LCD)[11] has emerged as a strong contender and continues to grow at the expense of other ODS replacement technologies. There are now over 100 plants in commercial use with an additional 11 plants sold for laboratory work to support further technology refinement. The learning curve, which has typically been viewed as being around two years, may, in reality, be an under-estimate. In parallel, three large-scale variable pressure plants have been constructed in the past year. Most plants have outputs of >10,000 tons per year and are therefore situated in high volume markets such as Italy.

Slabstock Foams – Discontinuous: There continues to be a lack of alternatives in this sector although variable pressure technologies are beginning to take further hold, with 8 plants now in use in Brazil despite the fact that this technology is still unsupported by the Multilateral Fund. Methylene chloride continues to be the basis of around 50% of the global capacity. However, existing regulatory constraints such as a 25ppm workplace limit and other emission controls in the United States make it difficult to operate in some regions. For the US, acetone continues to offer a good alternative because of its favourable classification as a non-VOC. However, the further spread of this technology is limited by high licensing costs.

Moulded Foams: With the exception of acoustic insulation, the anticipated penetration of CO_2-based technologies (GCD and LCD) has not taken place. For the most part there continues to be reliance on CO_2 (water) which is now believed to have fully replaced any remaining HCFC-141b use. In general terms most moulding processes are moving to cold cure and hot cure processes are believed to be on the way out.

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[11] Carbon dioxide or CO_2 as a blowing agent in foam can be chemically generated from the reaction between water and isocyanate but also added as an auxiliary blowing agent in liquid or gas form. The different options are hereafter referred to as CO_2 (water), CO_2 (LCD) and CO_2 (GCD).

Integral Skin Rigid Foams: The lower densities, better skin quality and better economics of CFC-based technologies all continue to be barriers to transition. The dominant alternative technology is CO_2 (water) although a considerable amount of HCFC-141b is also used, particularly in India.

Integral Skin Flexible Foams: The currently available technical options are CO_2 (water), HCFC-141b, HFC-134a and hydrocarbons. CO_2 (water) continues to be the benchmark and the use of in-mould coatings, although not universally accepted because of cost, is increasingly overcoming some of the earlier problems with skin quality. Nonetheless, skin quality continues to be the key measure of all technologies. Most OEM manufacturers in Europe are now using CO_2 (water) although there has been a significant learning curve. The use of in-mould coatings is not inevitable. There is also a small use of pentane. Liquid HFCs continue to be assessed and will be used where skinning requirements and investment costs dictate.

Rigid Foams

The use of blowing agent blends in the rigid foam sector is increasingly becoming the norm. Combinations of liquid HFCs with CO_2 (water) are proving cost effective in several challenging applications, while HFC/HC blends are being considered elsewhere. Even within generic blowing agent types, blends are becoming the norm (e.g. HFC-365mfc/HFC227ea and n-pentane/ iso-pentane/ cyclopentane).

Appliance Foam – Domestic Refrigerators and Freezers: Energy efficiency continues to be the dominant issue in this field throughout the world. New energy standards are being introduced regularly in several regions, making the high performing appliances of five years ago, among the poorer performers today. Accordingly, HFC-245fa is still the focus of most attention in North America. HFC-134a is also being used by at least one manufacturer.

In Europe, the use of cyclopentane/iso-pentane blends is becoming ever more dominant (estimated 70% of market currently) and is growing elsewhere. In addition, there is some use of cyclopentane/iso-butane blends. Pure cyclopentane also remains an option technically but is less cost-effective than other hydrocarbon blends. However, HFCs are not ruled out for the future as energy standards continue to tighten.

Although use of hydrocarbons in Mexico represents still less than 20% of the total blowing agent consumption in the appliance sector, new investments by at least one manufacturer have focused on hydrocarbon-based technology with a view to supplying the US market. This suggests that the current energy standards for the US can be met using this technology and that the main barrier to transition to hydrocarbons in North America remains the safety aspects (and related costs) of conversion and, in some cases, the VOC implications.

In Japan, all producers but one have moved to hydrocarbon technologies based on cyclopentane rather than blends. The remaining producer is using HCFC-141b for existing models and is investigating alternatives for new models.

Replacement options under the Multilateral Fund continue to be strongly directed towards permanent solutions in the appliance sector, in line with the preference expressed by the Executive Committee. Varying progress has been made with alternatives in three of the key centres of population : China, India and Brazil. China is estimated to have already achieved an 80% phase-out of previous CFC use with the overwhelming majority of the replacement being hydrocarbon-based (often cyclo/iso blends). Around 10% has moved to HCFCs in anticipation of a second move to HFCs. This is particularly the case for small producers of items such as chest freezers. In Brazil, the dominant blowing agent currently in use is HCFC-141b. In India, many companies have announced transitions, but few have yet moved. Currently, 50% of capacity is still CFC-based with 30% cyclopentane and 20% HCFC-141b. The use of pure cyclopentane is often preferred in developing countries because it is easier to transport (lower vapour pressure).

Some other developing countries are also having difficulty stimulating transition, either because of size, regulatory and supply constraints or because of domestic economic circumstances and resulting priorities.

Appliance Foam – Commercial Refrigeration: A common global trend is the increasing inclusion of the commercial refrigeration sector in future energy efficiency targets. This is tending to drive manufacturers to more energy efficient solutions and the relatively minor use of CO_2 (water) foams in some vending machine designs is being increasingly challenged. However, the fact that there is significantly more design flexibility in the commercial refrigeration sector means that there is not quite the same focus on thermal efficiency ‘per unit of thickness’ as there is in the domestic refrigeration sector. In addition, the moulding process can provide the opportunity to use hydrocarbons for some manufacturers, although not all are convinced that they should follow this route and are waiting for the emergence of liquid HFC solutions, where these meet wider environmental objectives.

Water Heaters: This application is also being increasingly challenged by more stringent energy standards both in Europe and the United States. In Germany several producers moved initially to CO_2 (water) technology but have now switched to hydrocarbons to ensure the ability to reach a 2003 reduction target in energy usage of 30%. Some reports suggest that hydrocarbons are gaining credence globally, particularly for high volume applications. This represents a substantial shift for several of the larger global producers. HFC and HFC/CO_2 (water) blends are expected to be reserved for more specialist and lower volume models.

Flexible-faced Laminate (boardstock): The transition of the boardstock industry in the United States to hydrocarbon blowing agents is imminent as the phase-out of HCFC-141b approaches. The use of HFCs will be limited to specific products and where HFC-245fa is used it will be as a co-blowing agent with increased amounts of CO_2 (water) in order to contain costs. A recent change in the method for declaring the aged value for the thermal conductivity of boardstock (based on a 15 year weighted average) has led to hydrocarbon blown foam being assessed as having the same thermal performance as HCFC-containing foams. However, this assessment is based on a thin-slicing approach – a method that is not universally accepted in the foam sector. Fire performance issues still remain to be finalised as problems persist with consistency of fire test methods.

In Japan, most manufacturers are still using HCFC-141b as their prime blowing agent but are looking to either HFCs or hydrocarbons for the next transition. Fire performance requirements in Japan are set to increase shortly (ISO 5660) and this may work against the hydrocarbon option.

In Europe, 95% of flexible-faced laminate producers are using n-pentane as their prime blowing agent. The barriers are consistently being pushed in this area and FM4450 is now an achievable standard in Europe with pentane-based products.

The European Union is considering introducing a Framework Directive to cover the use of HFCs in a variety of applications, including foams. This is likely to define responsible use criteria, expected uptake, resulting baseline emissions and likely mitigation strategies. An alternative strategy being considered is to extend certain emission elements of the existing European Regulation on ODS to include HFCs. Some European countries (e.g. Austria, Denmark and Switzerland) are going further by prescribing early phase-out.

Composite (Sandwich) Panels - Continuous: This market continues to grow rapidly in Europe and has already reached a level above that of flexible-faced laminate. Since last year's report, which indicated the widespread acceptance of isopentane/CO_2 (water), growing problems have been encountered in obtaining insurance approval in certain countries. One insurance industry test (LPC 1181) is proving particularly troublesome and the foam manufacturers are striving to find ways of complying. HFCs may prove to be the only course open for some products.

In the US, a mix of blowing agents is being used including HCFC-141b, HCFC-22 and HFC-134a. HCFC-142b/22 could be a technical option where regulation permits. Hydrocarbon is also an option for Class II applications such as garage door panels. Although continuous production exists in the United States, it should be noted that this only equates to 5% of the parallel market size in Europe. While there is no new information on this market in Japan, it has been noted that China is modifying its fire codes to allow for the wider use of composite panels in construction applications.

From a machinery cost perspective, it is estimated that a line specified for hydrocarbon adds 15- 30% to the overall cost depending on precise configuration and location. However, this is offset by lower operating costs and is not viewed as prohibitive by investors when investing in new equipment. Accordingly, many companies are taking the precautionary step at the outset to avoid a more costly upgrade later.

Composite (Sandwich) Panels – Discontinuous: For discontinuous panel producers the situation is rather more difficult. The costs of upgrade to hydrocarbon are substantial (up to $0.5 million) and are often beyond the financial reach of smaller businesses, particularly those not supported by outside funding. Pre-mixing of blowing agents is a potential option but opinion is still split on the advocacy of this approach.

For the majority, HCFC-141b remains the preferred blowing agent in the short-term with the expectation of eventually switching to HFC blends or HFC/CO_2 (water) systems. There is still confusion in the United States about the future acceptability of other HCFC blends and some are seeking to get their plants qualified for HCFC-22 use. For those applications that are less sensitive to insulation performance and dimensional stability (e.g. doors), the manufacturers are also looking to CO_2 (water) systems and HFC-134a. HFC blends may also have a part to play in this application.

In developing countries, where MLF funding has been available, there has been a greater move towards hydrocarbon, although a lot of HCFC-141b is still used.

Spray Foam: Hydrocarbon uptake in the United States continues to be a future development even though some systems houses are looking closely at the option. Spray foam industries in other parts of the world are watching with interest, but neither Japanese or European contractors are expecting to see hydrocarbon technologies to be adopted very widely, if at all.

A full industry test programme has been sponsored in the United States by the EPA to assist the Sprayed Polyurethane Foam Association (SPFA) in leading the transition away from HCFC-141b. Although test results with HFC-245fa/ CO_2 (water) blends are encouraging, it looks likely that phase-out of HCFC-141b use will not happen until after the 1st January 2003 production phase-out. Provisions being considered meeting this requirement include the holding of stockpiles. However, a tightly controlled exemption process is probably the most likely outcome. Concern exists that the uncontrolled import of polyol pre-blends from Mexico could undermine the transition strategy.

The potential for the use of both HFC-245fa/CO_2 (water) and HFC-365mfc/HFC227ea continues to be assessed in both Japan, where HCFC-141b is dominant, and Europe. However, emissions potential will continue to be a focus of attention as the decision is reached on whether to adopt a European Framework Directive or not.

Pure CO_2 (water) systems have not been ruled out in any of the major markets and new technology developments are bringing the performance of these systems closer to that of other alternatives. However, there may be fire performance issues as well as density and thermal penalties to be considered. Nonetheless, changes are being made in the US spray foam standards to make them more performance related. This will allow CO_2 (water) blown systems to be included in roof specifications despite their lower closed cell structures.

One Component Foam: These systems are intended primarily for gap filling and are widely used throughout the construction industry. There has been a significant debate about the ability to use hydrocarbons such as butane/propane mixes or dimethylethers in these systems. Indeed, the factory (can filling) process has caused some fires. More importantly, charge size is believed to be a safety concern in the use phase and the industry is now strongly defending the option of using HFCs in some future formulations. Since this is essentially an emissive application, there is concern that the widespread use of HFC-134a could have a significant impact on Greenhouse Gas emission targets (already a reality in Germany). Accordingly, HFC-152a is also being considered because of its lower relative GWP. Although HFC-152a is flammable, it can be blended in such a way as to avoid this problem. In the meantime, safety concerns are resulting in the continued use of HCFCs (particularly HCFC-22) outside Europe where other technologies have not yet been proven.

PU Block – Continuous: This sector is now increasingly moving towards hydrocarbon technologies with HFCs being viewed only for products requiring the associated performance enhancements related to such issues as fire performance. HCFC-141b will continue to be used to some extent until regulations force phase-out.

PU Block – Discontinuous: In the discontinuous block foam sector, there is also increased expectation that the market will eventually move towards hydrocarbons. Some estimates suggest that market penetration could be greater than 50% ultimately. However, as with panel manufacture, the move to hydrocarbons will need to progress with the investment cycle since the cost of retrofitting existing equipment is likely to be prohibitive. However, prices are decreasing and a new ‘pentane-capable’ discontinuous plant would now only be expected to cost less than $200,000.

The balance of block foam manufacture is likely to switch to liquid HFCs co-blown systems with CO_2 (water). However, the extent to which CO_2 (water) can be relied upon will be limited by overall exotherm control and dimensional stability constraints.

Pipe-in-pipe: This application is primarily directed at serving the district heating market, particularly in the more centralised societal structures, most specifically in China. This approach is also, finding wider acceptance in other parts of the world as the use of small to medium combined heat and power (CHP) units increases because of their higher efficiency and reduced greenhouse gas emissions.

In the ‘pipe-in-pipe’ sector, the switch to hydrocarbon technology in Europe took place relatively early because the products have high added value, thereby negating the impact of conversion costs. The main preference has been for blends of linear hydrocarbons with cyclopentane. Interest in hydrocarbon based foam systems is also beginning to be seen in North America. HCFCs continue to be used where producers are small companies and these are likely to switch to either HFC-245fa or HFC-365mfc in due course. China continues to use HCFC-141b as its primary blowing agent. However, bearing in mind the longevity of district heating systems and the lack of obvious emission mechanisms, this use of HCFCs and HFCs is perceived to present little concern in a global climate change context.

Refrigerated Transport: The refrigerated transport sector splits into three prime sub-sectors:

- Fixed road transport bodies
- Containers and other demountable units
- Tankers and other shaped vessels

For the flat-sided units, requirements can be met by either pre-fabricated panels, cut block foams or injected/spray systems. The latter is the only real option for tankers and other shaped units. Thickness constraints and foam resilience continue to be the key drivers in material selection.

More recently some producers of truck bodies have been willing to consider hydrocarbons and have been able to meet relevant energy requirements. However, with the majority of global reefer construction being based in China, there is still reliance on HCFC-141b. This segment will likely consider HFCs in future.

Picnic Coolers/ Thermoware: In developed countries, many of the major producers of picnic boxes and other thermoware have been investigating CO_2 (water) systems. Early adhesion problems appear to have been overcome and those still using HCFCs are likely to switch within the next 2-3 years. This, however, is not the case in developing countries where CFC-11 transitions are typically still moving to HCFC-141b, at least in part because of the lack of availability of appropriate CO_2 (water) blown systems. It is believed that low level HFC formulations and/or physical changes to processes should be sufficient to overcome any barriers to ODS phase-out in this sector.

Hydrocarbons continue to be an option in this sector, but are likely to remain the preserve of larger producers who can invest appropriately in the necessary safety measures.

11.2.2 Extruded Polystyrene

The divide between European and North American technologies and markets is becoming increasingly clear as national and European-wide regulations on HCFC phase-out are implemented.

In Europe, the phase out of use of HCFC-142b/22 took place on 1st January 2002. CO_2 and CO_2/alcohol systems have taken significant market share, except in markets where traditionally heavy focus is put on thermal conductivity performance. Technological limitations on thickness (i.e. currently no greater than 100-120 mm) still exist either in actual production or in post-production performance vis-à-vis dimensional stability. HFC-134a, in particular, is the alternative blowing agent preferred for those markets and applications where high thermal insulation performance is demanded. Its low polymer solubility is offset by blending, either with HFC- 152a or an organic solvent. The XPS industry in Europe has committed to study plant emission reduction potential via recapture and recovery technology for HFCs used in its processes as part of its ‘responsible use’ justification.

In North America, the XPS industry has still not yet identified a way to transition from HCFCs owing to the particular challenges of the North American market. The ability to produce wide and thin foam section is still the key issue. In many cases the required fire performance within the existing building codes in use across the USA cannot be met at the high densities used in Europe because of the higher fuel loadings resulting. This prevents the adoption of either CO_2 or HFC-134a technologies. The SNAP decision on the on-going acceptability of HCFCs in XPS in the US is still awaited.

For XPS sheet, there is a problem in the use of hydrocarbons in area of non-attainment and, accordingly, there is a trend to switch to HFC-152a where VOC concerns exist.

In Japan, there is some hydrocarbon use in XPS and this appears to be growing on the back of new, improved products. This reflects a particular set of fire regulations in Japan and further information is being sought to clarify the criteria by which XPS products are qualified.

11.2.3 Phenolic Foam

The two major markets for phenolic foam materials continue to be in Europe and Japan. The European market is expected to be boosted by the adoption of harmonised fire standards across the EU over the next five years. This will be particularly the case for internal lining materials. However, the effect is less clear for fabricated pipe insulation until the appropriate test configurations and reference scenarios are finalised.

In Japan, one chemical company commercialised its 10 million m^2 continuous laminator in October 2000. In contrast with its European counterparts, the plant will produce a low-density hydrocarbon blown system. This again reflects the different standard and building code structure in Japan and will be the subject of further coverage in the 2002 Full Report.

In discontinuous block foam manufacturing processes, the combination of process safety and product fire requirements makes phenolic foam is more reliant on liquid HFC formulations than other sectors of the foam industry. Indeed, limited production of foams based on HFC-365mfc has continued in 2001 and technical evaluation of HFC-245fa has begun. For the production of pipe sections in particular, consideration is being given to methods of reducing blowing agent wastage during fabrication.

There is growing interest in sandwich panels using phenolic foam cores, based on the fire performance of the material. However, the presence of a metallic skin is likely to make the selection of blowing agent less sensitive and, for continuous production at least, an engineered solution could emerge for the use of hydrocarbon blowing agents.

In India, the transition to n-pentane as a blowing agent is complete, although the product is less competitive than it was previously because the premium chargeable for phenolic fire performance has been eroded by poorer thermal performance.

11.2.4 Polyolefin Foam

In Europe most, if not all, polyethylene foams have already switched to hydrocarbon blowing agents. At present, the industry has no plans to make use of HFCs when they are introduced. This is in contrast to Japan where upwards of 600 tonnes of HFC-134a is being used in this sector. Some methylene chloride is also in use. In South East Asia, the main blowing agents are butane or LPG which again contrasts with Brazil and Argentina where 350 tonnes of HFC-134a is used. A broader understanding of the technology and market drivers for these decisions is being sought.

11.3 Blowing Agent Availability

A more comprehensive quantitative analysis of ODS use in the foam sector is planned as part of the 2002 Assessment Report. Accordingly, this section only deals with qualitative issues affecting transition.

11.3.1 Liquid HFC Availability

The time-lines for the introduction of commercial production of liquid HFCs continue to be focused on the second half of 2002. Both Solvay and Honeywell are already supplying larger scale sample quantities from pilot plant facilities (Solvay produced 300 tonnes of HFC-365mfc from its pilot plant in 2000 and Honeywell now has capacity to produce HFC-245fa of approximately 450 tonnes per year). A follow-up announcement from Central Glass in Japan indicates that they are planning to bring a 5,000 tonne per annum plant for HFC-245fa on-stream by October 2003, having 'broken ground' on the project in March of this year. The plant capacity for HFC-365mfc from Solvay will be 15,000 tonnes per annum.

The patent constraints surrounding the use of HFC-365mfc in North America persist. It is unlikely that there will be any short-term resolution of this issue.

11.3.2 On-going Availability of HCFCs for Developing Countries

The drop in demand for HCFCs in developed countries will inevitably have a considerable effect on the on-going availability of HCFCs for foam uses and existing suppliers of HCFCs are reviewing their options. However, plants for the production of HCFCs still fall into two categories:

- Dedicated HCFC-141b production units
- 'Swing' plants which can adjust the balance between HCFC-141b and HCFC-142b production

It is expected that several further dedicated HCFC-141b plants in developed countries will close after 2004. However, because HCFC-142b is required as a feedstock for PvDF manufacture and will be manufactured on an on-going basis, access to both HCFC-142b and HCFC-141b is likely to remain. In addition to this, there are now several dedicated HCFC-141b production units in developing countries (e.g. currently three in China).

Much continues to depend on how the usage pattern for HCFC-141b will look in developing countries once the CFC phase-out programme is complete. This remains a contentious research area at present, but the TEAP has a mandate to review the situation in 2003.

End-of-Life Issues

Developing material recycling pressures in Japan and Europe, together with specific blowing agent recovery legislation in the latter have led to an increased focus on the management of domestic refrigerators at end of life. The technologies developed for these purposes have potential to be extended to cover other foam products at end-of-life, but the practicality and economics of this approach is still under question at this time. These developments are dealt with in depth in the report recently published by the TEAP Task Force on Collection, Recovery and Long-term Storage.

12. Methyl Bromide Technical Options Committee (MBTOC) Progress Report

This section on methyl bromide (MB) summarises meetings held in the past year on alternatives to MB; updates information on alternatives for preharvest and postharvest uses; provides information on technological developments that capture and destroy MB; provides examples that may assist the Parties in categorising MB treatments as 'quarantine', 'pre-shipment', or non-QPS; and summarises activities by several Parties known to be considering application procedures for critical uses of MB.

12.1 Meetings on Alternatives to Methyl Bromide

An international conference on alternatives to MB was held in San Diego, California in November 2001. More than 100 papers were presented that highlighted progress on the development of alternatives to MB for QPS and non-QPS uses. The Proceedings of the Conference can be downloaded from www.mbao.org.

The USDA Eastern Shore Meeting on Alternatives to Methyl Bromide was held in May 2001 in Maryland, USA. There were industry, government and academia present from Canada and the United States.

The Canadian Industry-Government Workshop on alternatives to MB for postharvest uses was held in Vancouver February 2002. This was attended by the grain millers and the Pest Control Association in Canada.

A workshop was held in Australia in October 2001 to develop strategies to control the use of MB for quarantine and pre-shipment (QPS) treatments. The results of the discussions are on www.ea.gov.au/atmosphere/ozone/methylbromide/finaldraft.html

In Spain, an international conference on alternatives to MB was held in Sevilla in March 2002 and was attended by more than 250 researchers, extension workers, farmers and industry representatives from 40 countries. The Proceedings of the conference contain 94 scientific papers can be downloaded from www.europa.eu.int/comm/environment/ozone/conference/index.htm.

All conferences and workshops were well attended and the information presented covered a wide range of alternatives to MB that were either in use or at an advanced stage of development. There were also reports on new fumigants and progress on the registration of alternatives for major uses of MB.

12.2 Updates on Alternatives

Adoption of alternatives in developed and developing countries depends on socio-economic factors, treatment efficacy, regulatory and local training infrastructure for training users in new techniques.

Registration of chemicals for pre- and post-harvest treatments continues to be one of the major factors hindering the adoption of alternatives. This is particularly problematical for registration of chemicals for use on small-volume crops. The chemical industry is unwilling to invest in new chemicals as cost-recovery is not possible within the required commercial timeframe. On the other hand, non-chemical techniques such as floating tray technology, substrates, grafting, solarisation plus organic amendments and steam, do not require registration and are available.

Training farmers to apply new techniques remains the single largest challenge facing the widespread adoption of alternatives.

For the larger crops such as strawberries and tomatoes that consume most of the MB, however, there has been significant progress in the development and registration of alternatives to MB.

Preplant Treatments

Recent registration of 1,3-dichloropropene (1,3-D) + chloropicrin mixture in several countries, and the widespread adoption of solarisation + biofumigation in Spain, are helping to promote commercial adoption of alternatives to MB for pre-plant uses.

The potential registration of iodomethane (methyl iodide) in the United States may provide an alternative for high-value commodities.

Several products such as sodium azide, propylene oxide and propargyl bromide are showing promising results in trials but further tests are required before their value as alternatives to MB can be determined.

New formulations of some chemicals such as emulsifiable 1,3-D + chloropicrin are providing alternatives that are effective and potentially safer methods for strawberry bed fumigation.

There are concerns over the variation in effectiveness of a number of the alternatives. There is a need for longer term trials over several seasons to determine the negative effects of any chemical and non-chemical alternatives adopted.

Commercial adoption of soilless production systems continues to increase as alternatives to MB, especially in cooler regions, high-value industries such as floriculture and crops produced for export markets where consistent quality and supply are of paramount importance.

New work is being carried out on dimethyl disulfide as a soil fumigant that, in preliminary tests, was reported to be biologically effective against several resistant forms of soil-borne fungi.

Steam is now an officially approved alternative to MB for disinfesting farm equipment potentially contaminated with golden cyst nematode (*Globodera rostochiensis)*. Golden nematode is a quarantine pest present in New York State in the United States but not present in other States where the equipment may be re-located.

Postharvest Treatments

In March 2002 sulfuryl fluoride (SF), primarily used as a structural and timber fumigant, was granted an Experimental Use Permit allowing the use of this gas on raisins and walnuts in California. This is the initial step to broaden the registration to include specific food commodities and therefore SF has the potential to replace MB in for use on US raisins and walnuts. Efficacy studies conducted in USA, UK and Germany, and full scale validation trials conducted in mills in these countries and Italy, were completed as part of the informational requirements for future registration. A new SF production facility in the USA is expected to be completed in 2004.

Chestnuts were previously reported by MBTOC as one of the few uses of MB without an alternative. Recent research shows SF may be a suitable non-quarantine treatments for controlling moth and beetle pests in fresh chestnuts (Vinghes and Ducom 2001) and for fresh walnuts and almonds (Zettler and Gill 1999).

Carbonyl sulfide is a fumigant that is reported to control insects, nematodes and grain fungi. It is rapidly desorbed from timber and durable commodities. It has recently received an experimental Maximum Residue Limit allowance in Australia allowing further tests to be carried out on food products in that country.

Recent work on cyanogen for use as a timber fumigant has found it to be a potent biocide that kills insects, nematodes, fungi and bacteria. Cyanogen penetrates and diffuses through both hard and soft timber more quickly than MB.

Ecogen Ltd in Holland has commercialised the use of inert atmospheres + heat as a postharvest treatment to control pests in a few days in a wide range of durable commodities such as tobacco, cocoa beans, rice, cereals, peanuts and spices as well as furniture and artefacts. The inert atmospheres are generated by burning propane or methane. This system is used commercially in the port of Rotterdam where 22 chambers the capacity to treat about 80,000 tonnes per year. Additional capacity is under construction. Treatments are also carried out in barges, factories, warehouses, silos and museums. A system is being built for treating shipping containers.

MBTOC previously reported no alternative to MB used for killing vertebrate pests in aircraft. Linde AG has recently used high levels of carbon dioxide for up to 12 hours to disinfest aircraft. High levels of CO_2 therefore show promise as a replacement for MB for this purpose.

Increased use of irradiation for disinfestation and other uses has been made possible by recent developments in commercial x-ray and high-powered electron beam accelerator equipment. For example, Hawaii now uses commercial x-ray equipment for the control of quarantine pests in fruit exported to mainland USA. Commercial irradiator operators in the United States are now using irradiation for treatment of commodity pests and diseases that were previously treated with MB.

A transportable, flexible, low-cost, plastic storage system has been developed in Israel and was reported to control all four developmental stages of *Ephestia cautella* and *Tribolium castaneum* when exposed to a 23-75 mm vacuum for 3-7 days at 30ºC (Finkelman *et al.* 2002). This equipment would be suitable for non-QPS treatments for control of these pests prior to longer-term storage of cocoa beans. This vacuum treatment has not been previously reported by MBTOC.

MB Capture Equipment

Legislation in the State of Victoria in Australia on ozone depleting substances requires recapture systems for MB for postharvest uses, except in extenuating circumstances. A system based on sorption of MB onto activated carbon is being used to capture and destroy MB after commodity fumigation. The system has been applied to a fixed installation (Hobart, Tasmania) and freight containers (Melbourne, Victoria). The MB absorbed on carbon is decomposed by treatment with aqueous sodium thiosulphate solution. The carbon is then rinsed, air dried and re-used. The process avoids the need to transport hazardous waste from the fumigation site.

12.3 Examples that May Assist in Categorising 'Quarantine' and 'Pre-Shipment'

Canada, Australia and China have recently reported increased consumption of MB for QPS. However, MBTOC noted that it is very difficult to obtain data that accurately separates QPS (exempt) from non-QPS (not exempt) uses, and in addition, many countries might not have distinguished between quarantine and pre-shipment uses when they reported data. MBTOC is currently undertaking a survey on QPS consumption, the results of which will be included in the MBTOC 2002 Assessment.

MBTOC developed the following methodology and tables that may be of assistance in determining whether a treatment could be considered as 'quarantine', 'pre-shipment' or neither one of them. Note that in the first column of table one and two, an 'a' or 'b' preceded by the same numeral indicates that only a or b must be answered. Underlined text is explanatory and is not part of the text in the Decisions pertaining to 'quarantine' and 'pre-shipment'. The bracketed capital letters (A), (B) and (C) refer to the logical structure of the particular question.

In the light of the responses in Tables 12-1 and 12-2, this section provides examples of MB treatments considered by MBTOC to be quarantine, pre-shipment and non-QPS treatments. These responses are in addition to those supplied previously in the TEAP 1999 report (p. 27) and the 1998 MBTOC Assessment Report (p. 298).

Pre-shipment Treatment Applied but not Exported Within 21 Days

Question: Is the MB volume exempt when used for a pre-shipment that is exported more than 21 days after treatment?

Comment: Pre-shipment applications in Decision XI/12 are defined as those "…non-quarantine applications applied within 21 days prior to export …". 'Export' is deemed to have occurred when a product leaves the country. The volume of MB would not be exempt under the pre-shipment definition if the product was exported more than 21 days after treatment ('No' in Table 12-2, row 2).

Table 12-1 Quarantine Treatment Logic Table

QUARANTINE TREATMENT				
✓	**Question**	**Yes**	**Not sure**	**No**
1a	Quarantine pest (including disease) of (A) potential importance to the areas endangered thereby and (B) not yet present there? (A)+(B) Is the quarantine pest present in the area of origin but absent in the destination area?			
1b	Quarantine pest (including disease) (A) present but (B) not widely distributed and being (C) officially controlled? (A)+(B)+(C) Is the quarantine pest present in the destination area but not widely distributed and being officially controlled?			
2a	MB treatment to prevent (A) introduction, (B) establishment and (C) spread of quarantine pest? (A)+(B)+(C) or (A)+(B) or (A)+(C) or (B)+(C)			
2b	MB treatment to (A) prevent introduction or (B) establishment or (C) spread of a quarantine pest? (A) or (B) or (C) If yes, state which …			
3a	*Performed* by a (A) national plant authority or (B) national animal authority or (C) national environmental protection authority or (D) national health authority? (A) or (B) or (C) or (D) If yes, state which …			
3b	*Authorised* by a (A) national plant authority or (B) national animal authority or (C) national environmental protection authority or (D) national health authority? (A) or (B) or (C) or (D) If yes, state which …			
Quarantine treatment?				
	Are all 3 'Yes' boxes checked? If so, the treatment is consistent with the definition of Quarantine in Decision VII/5.			

Table 12-2 Pre-shipment Treatment Logic Table

PRE-SHIPMENT TREATMENT				
✓	**Question**	**Yes**	**Not sure**	**No**
1	Non-quarantine pest?			
2	MB applied within 21 days prior to export?			
3	Exported (out of the country)			
4a	Applied to meet the official requirements of the importing country? Documentary evidence of requirements…			
4b	Applied to meet the existing official requirement of the exporting country? Existing for all countries on 3 December 1999			
5a	Official = *Performed* by a national plant authority, national animal authority, national environmental authority, national health authority or national stored product authority? State which one …			
5b	Official = *Authorised* by a national plant authority, national animal authority, national environmental authority, national health authority or national stored product authority? State which one …			
Pre-shipment treatment?				
	Are all 5 'Yes' boxes checked? If so, the treatment is consistent with the definition of Pre-shipment in Decision XI/12.			

Unauthorised Treatment to Control Pests on Exported Products

Question: If an exporter of a product decides to fumigate with MB after harvest at the point of export in order to ensure any live pests are killed and therefore avoid possible treatment on import, is the MB in this treatment considered QPS and exempt?

Comment: If this treatment was neither officially authorised by the "…national plant, animal, environmental, health or stored product authority" in the exporting country, nor by the "…national plant, animal, environmental, health or stored product authority" in the importing country for a specific quarantine or non-quarantine pest, the treatment is not consistent with the QPS definitions and therefore cannot be considered QPS.

If the official authority declared it to be a ‘quarantine’ treatment, the quarantine pest would need to be determined as the objective of the treatment (Table 12-1, 1a or 1b would need to be ‘yes’, and 2a or 2b would need to be ‘yes’).

If the objective of the treatment was a non-quarantine pest in the importing country, the authority in the exporting country that authorises the treatment may wish to sight documentary evidence of the official requirement for fumigation from the importing country national plant, animal, environmental, or health authority.

If the objective of the treatment was a non-quarantine pest in the exporting country, the authority may wish to sight documentary evidence that this requirement by a national plant, animal, environmental, or health authority was in *existence* either before 3 December 1999 (the final day of the Meeting of the Parties in which this Decision XI/12 was agreed), or before 7 Oct 1994 for non-Article 5(1) Parties and 7 December 1995 for Article 5(1) Parties. MBTOC considers that ‘existing’ in Table 12-2 (4b) connate a further restriction referring to a time in the past, rather than the time in the present that would be adequately described without the word ‘existing’ in Decision XI/12.

MBTOC noted that a national plant, animal, environmental protection or health authority that operates within the nation or country at a state, regional or local level would qualify as an authorising authority. There may also be within the country a federal authority that officially delegates quarantine and pre-shipment authorisations to a plant, animal, environmental, health or stored product authority officially operating as the legally authorised agent at state, regional or local level.

Stored Product Manufacturing and Storage Facilities and Structures

Question: Some government health authorities limit stored product contamination due to pest infestation. A facility may routinely fumigate with MB to minimise pest infestation. Can this be considered a quarantine treatment?

Comment: Unless the MB treatment is specifically authorised by a national plant, animal, environmental protection or health authority to control “… quarantine pests (including diseases)…”, this MB treatment does not fall within Decision VII/5 and therefore this MB use is not exempt (Table 12-1, 1b or 1a are not ‘Yes’).

A national plant, animal, environmental protection or health authority that operates within the nation or country at a state, regional or local level would qualify as an authorising authority. There may also be within the country a federal authority that officially delegates quarantine authorisations to a plant, animal, environmental, health or stored product authority officially operating as the legally authorised agent at state, regional or local level.

12.4 Critical Use Application Procedures

The "Handbook of Critical Use Nomination Procedures for Methyl Bromide" is expected to be placed on the UNEP-Ozone Secretariat website in May 2002. It will contain a schedule for submissions which reflects the schedule and international review process contained in "Handbook on Essential Use Nominations June 2001" (see www.teap.org) already developed for use by the Parties for other ozone depleting substances. Both documents will be revised in the future, if necessary.

Several individual Parties are considering application procedures in order to submit nominations for exemptions in 2005 or later years to the Ozone Secretariat in January 2003. All Parties will then consider these nominations at the Meeting of the Parties in late 2003. The following, while not intending to be all-inclusive, provides examples of progress made by some Parties.

In the United States, a *Federal Register* notice of 10 May 2002 requests applications for Critical Use Exemptions from users and groups of users in the United States that believe that an exemption to allow time-limited use of MB after 2005 may be justified.

In the European Community, Article 3(2)(ii) of EC2037/00 on Ozone Depleting Substances provides that any proposals for a critical use exemption to allow the production, importation and use of MB after 1 January 2005 to be submitted to the European Commission by the Member State in which the applicant is located. The EC nomination would be considered at the Meeting of the Parties along with any other nominations. If the Parties approve a volume of MB for critical uses, the Commission is then required, in accordance with the management procedures referred to in Article 18(2), to determine annually the quantities and users who may take advantage of the exemption. Such production and importation shall be allowed only if no adequate alternatives or recycled or reclaimed MB is available from any of the Parties.

12.5 References

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13. Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee (RTOC) Progress Report

13.1 Domestic Refrigeration

New equipment conversion from CFC refrigerants is complete in non-Article 5(1) countries and accelerating in Article 5(1) countries. The 15 to 25 year typical life span for domestic refrigerators results in older product manufactured using CFC-12 refrigerant still comprising the majority of units in the installed base. This in-turn significantly retards the rate of conversion from CFC-12 in service refrigerant demand.

HC-600a and HFC-134a continue to be the dominant alternative refrigerant candidates to replace CFC-12 in domestic refrigeration new equipment. Both of these have demonstrated mass production capability for safe, efficient, reliable and economic use. In practice, similar product efficiencies result from the use of either refrigerant. Independent studies have concluded that other design parameters introduce more efficiency variation opportunities than is presented by the refrigerant choice. Comprehensive refrigerant selection criteria include safety, environmental, functional and performance requirements. A grossly simplified summary of relative considerations for these two refrigerants is:

- HC-600a uses historically accepted mineral oils. Designs must take care to properly deal with the flammable nature of the refrigerant.

- HFC-134a uses moisture sensitive polyolester oils. Manufacturing processes must take care to properly maintain low moisture levels. Long-term reliability requires more careful avoidance of contaminants compared to previous CFC-12 based production or servicing.

No significant new technology options are expected to emerge which will significantly alter options for conversion to ozone safe refrigerants in the remaining Article 5(1) countries still using CFC-12 in new equipment. All required technologies are mature and readily available; availability and prioritisation of capital resources are dictating conversion timing. Anticipated technology enhancements include incremental improvements in component hardware, modified control and defrost algorithms, and modified refrigeration system configurations. All of these have objectives of improved unit performance and/or energy efficiency. In many cases this efficiency is provided at the cost of increased complexity or reduced tolerance to abnormal conditions. Current technology units, in many circumstances, use less than one-half of the electrical energy required by the units they replace. Proven, reliable equipment can yield significant improvements without resorting to higher cost and more complex designs practising leading edge technologies.

Government regulations and voluntary agreements on energy efficiency and labelling programs have demonstrated effectiveness in modifying product offerings in several countries.

13.2 Commercial Refrigeration

Commercial refrigeration installations are very different, in terms of size, depending on the country type and the kind of shops. Commercial refrigeration comprises three main different groups of equipment.

1. Stand-alone Equipment: Many different types exist, including vending machines, ice machines, etc. All kinds of small equipment are installed in stores or public areas in many Article 5(1) countries as well as in non-Article 5(1) countries. The number of those pieces of equipment ranges between 10 and 12 million world-wide; their refrigerant charge varies from 200g up to 1 kg. The usual HFC refrigerant is HFC-134a, which replaces CFC-12. The use of HCs (R-600a) has started in a number of European countries. Large “soft drink” companies have indicated that they will phase out HFCs within the next few years, but HFC-134a is clearly the actual dominant option in this subsector.

2. Condensing Units: These are typically installed in specialised shops; their refrigerant charge varies between 1 and 5 kg. The estimated global number of units is in the order of 2.5 million. The refrigerant choice depends on the level of temperature applied. HFC-134a or R-404A are the current preferred options for the medium temperature level, whereas R-404A is applied for low temperature levels. Due to safety concerns, HCs have not become a wide spread option for the refrigerant charges applied.

3. Centralised Systems: The number of supermarkets where a wide range of refrigerating capacities is used, is estimated at 120,000. The refrigerant charges applied vary from 100 kg up to 1,500 kg. The refrigerating system of centralised systems is installed in a machinery room and the refrigerant circulates back and forth from this machinery room to the display cases installed in the sales area. A new concept called “distributed system” drastically limits the amount of refrigerant piping by installing the compressors in sound-proof boxes inside or nearby the sales area. The choice of refrigerant is greatly dependent on regulations that apply.

CFC-12 is still used in the commercial refrigeration sector in Article 5(1) countries. HCFC-22 is used in the commercial sector in the USA. Since 1 January 2001, the application of HCFCs in new equipment is prohibited in Europe; therefore R-404A is the preferred choice. In Japan CFC-12 has been replaced by R-134a and, in some cases, by R-407C.

Many developments are still taking place where it concerns indirect systems; this in order to limit the refrigerant charge and/or to allow the use of ammonia or HCs. CO_2 is currently used as a heat transfer fluid or a low temperature refrigerant. At present supermarket and cold store companies are thoroughly evaluating the different options, however, initial cost is still the main driving factor. Another issue that is analysed is the energy consumption because indirect systems may lead to higher energy consumption levels. To reach similar energy consumption levels as direct systems, the indirect system design becomes more complex and more expensive, which again may be prohibitive for application.

13.3 Transport Refrigeration

The Transport Refrigeration Sector contains the sub-sectors reefer ships, intermodal refrigerated containers, road and rail transport, refrigeration and air-conditioning on merchant marine and air-conditioning in railcars.

Generally spoken, these subsectors have been characterised by a continuing increase of the use of HFCs in new systems during 2001-2002; this mainly as a replacement for CFC-12. The substitution of HCFCs is also continuing where mainly the mixture R-407C is applied for air-conditioning and R-404A, as well as R-507A, for refrigeration applications. The introduction of the new refrigerant mixture R-410A in the transport sector market is very slow, particularly in small systems such as in refrigerated road transport systems.

In the ship-sectors HCFC-22 still is the only important refrigerant and its substitution in new ship equipment shows a very slow start. Ammonia has only gained a niche market to date; it can be stated that the ship subsector is the most conservative subsector of the whole transport sector in relation to the substitution of chlorine containing refrigerants. In intermodal refrigerant containers the development of CO2-Systems has slowed down; this is partially caused by changing government positions of one or more member states of the European Union concerning the application of HFCs.

Apart from the small amount of equipment that uses R-410A in road transport, interest in the development of CO2-systems is increasing in this subsector, however, no commercialisation has taken place.

In air-conditioning systems in railcars some interesting developments are occurring. After the development of air-cycle based air conditioning systems for high speed trains, the German Railway (DB) is now also interested in the development of CO2-Systems. Other railway companies are mainly focusing on the use of HFC-134a systems for these applications. A progressive and early change from chlorine containing refrigerants to HFCs could well be delayed due to regulatory uncertainty in Europe where it concerns HFC applications.

13.4 Air Conditioning & Heat Pumps (Air-Cooled Systems)

There has been significant progress made in the selection and application of alternative refrigerants in air-cooled air conditioners and heat pumps in recent years. The replacement refrigerants having the largest market penetration are the HFC blends. In North America, R-410A has become the dominant HCFC-22 replacement. In Asia and Europe both R-407C and R-410A are being used as alternatives to HCFC-22 in air-cooled air conditioning applications. Commercial availability of systems using HFC refrigerants is currently also occurring in some Article 5(1) countries.

Hydrocarbon and CO_2 refrigerants are being investigated through a number of research initiatives. There has been modest commercialisation of hydrocarbon refrigerants in air-cooled air conditioners. However, commercialisation of air-cooled CO_2 air conditioners has not taken place to date.

In recent years, there has been a significant shift toward the use of non-ducted (or duct-free) split residential air conditioners as the entry-level air conditioning product in developing countries—particularly in Asia. This trend has resulted in a slowing of the growth rate of window mounted and through the wall air-conditioner with a corresponding increase in the growth of non-ducted split-type air conditioners. The majority of this growth has occurred in Article 5(1) countries.

Hydrocarbon refrigerants may also be suitable replacements for HCFC-22 in some categories of products—particularly low charge level applications. This under the assumption that international safety standards are developed to define the specific design and application requirements.

Retrofitting of existing air conditioners may be possible using a number of HFC blends. The most promising retrofit refrigerant candidate is R-407C. However, significant quantities of HCFC-22 will still be required to service air-cooled air conditioners in most Article 5(1) countries during the 2002-2020 period.

13.5 Chillers

A number of changes have occurred in recent years. Screw and scroll compressors are significantly increasing market share at the expense of reciprocating compressors. HCFC-22 is being displaced by HFC-134a in screw chillers and, in air-cooled systems in Europe, by R-407C. In positive-displacement equipment, air-cooled chillers are increasing market share relative to water-cooled chillers. Centrifugal chillers are offered with either HFC-134a or HCFC-123 as refrigerants; HCFC-22 no longer is offered in water-cooled centrifugal chillers.

The replacement or retrofit of CFC chillers is proceeding at a slow pace except in countries that have mandated near-term CFC chiller replacement.

The phase-out of HCFCs is being managed differently in various countries. The European Union member states mandated the phase-out of HCFC-22 beginning in 2001. The refrigerants found to be most promising for positive displacement chillers in terms of ability to satisfy performance and safety criteria are HFC-134a and blends of HFCs. For flooded evaporators, common in chillers larger than 700 kW, HFC-134a and HCFC-123 are employed as refrigerants in new equipment.

Near-term alternatives to "traditional" vapour-compression chillers include the absorption cycle and vapour-compression cycles using ammonia, zeotropic refrigerant mixtures, and - for very small chillers - hydrocarbons.

Options for existing chillers using CFCs are (1) continued operation as-is by retaining and containing the CFC, using CFC refrigerant that has been stockpiled or recovered from other units for make-up; (2) retrofit of chillers to operate with alternative refrigerants (HFCs or HCFCs); or (3) early retirement and replacement with new chillers using HCFCs, HFCs, or other (in the USA) "SNAP-approved" refrigerants.

In Article 5(1) countries, chillers are not used as commonly as in developed countries. However, technologies tend to be the same with equipment often imported or produced locally in a joint venture with a developed-country manufacturer. Thus, the latest technologies in equipment, refrigerants, and servicing equipment and practices are available and commonly used in all countries. While consumption of CFCs is permitted in Article 5(1) countries through 2009, their use in new equipment is decreasing. Some Article 5(1) countries are already banning the import or manufacture of equipment using CFC refrigerants.

13.6 Vehicle Air Conditioning

The vehicle air conditioning industry continues to develop less emissive HFC-134a systems. Field survey results show that new HFC-134a systems are better than new CFC-12 systems were, as evidenced by the fact that the repair rate of HFC-134a systems over their first six years of life is only one-third that of CFC-12 vehicles of comparable age. A field survey of the effectiveness of on-site refrigerant recovery and recycling shows that, after the recycling process is complete, the average amount of refrigerant ready for reuse is 60% of the original charge. This attests to the value of recycling as a means of reducing both emissions and the need for newly produced material. Updated HFC-134a service scenarios and emission estimates and are provided based on the above information.

Industry efforts to develop alternatives to HFC-134a continue. Prototype carbon dioxide systems and prototype systems using either HFC-152a or propane are currently being tested for performance and energy use against that of HFC-134a systems under the SAE Alternate Refrigerants Cooperative Research Program. Testing is scheduled for completion in late 2002. Although prototypes are being constructed for testing, many commercial issues remain to be resolved before these alternative systems can be brought to market. Given successful development, the first of these systems might become available in the market in the 2005-8 timeframe.

13.7 Refrigerant Conservation

Refrigerant conservation is now a major issue in refrigerating system design, installation, and service as environmental impacts from refrigerant release include not only ozone depletion, but also global warming. Safety issues come into play for refrigerants such as hydrocarbons or ammonia. Progress has been made in limiting refrigerant emissions over the last couple of years, and is actually still increasing.

Most Article 5(1) countries have established national programs to recover and reuse refrigerants. In principle there is great potential in recovery and recycling of CFCs in low volume consuming (LVC) countries. However, the price of virgin material is often still so low that there is no incentive to recover the refrigerant. This also because there is an influx of used refrigeration equipment and cheap CFCs, some of which are smuggled.

Some Article 5(1) countries have undertaken measures to put a partial or total ban on sales of CFCs. Others have put regulations in place to control imports of new CFCs as well as CFC-based equipment.

Among the existing tools, the Refrigerant Management Plan (RMP) is an integrated approach including the participation of industry, institutions and service engineers to phase out ozone depleting substances in low volume consuming countries. The RMP's role is essential to aid OEMs and particularly refrigeration service companies to be able to reduce and subsequently phase-out their consumption in a co-ordinated, planned and cost effective manner. It will do so through the implementation of actions including (i) appropriate and adequate training of technicians in good practices and containment of refrigerants, (ii) training courses how to retrofit equipment, (iii) the establishment of recovery and recycling programs for refrigerants, (iv) the training of customs officers to follow up on new import regulations, (v) the drafting of new national regulations, and (vi) the introduction of harmonised regional standards. The successful implementation of the various components of the RMPs is expected to lead to an effective phase-out of ODS within the requirements of the Montreal Protocol.

14. Solvents Technical Options Committee (STOC) Progress Report

14.1 Report on Small and Medium Users

The STOC reports that, due to the poor cost-effectiveness of solvent elimination projects, small and medium sized enterprises (SMEs) in Article 5(1) countries continue to use large quantities of ozone-depleting solvents. Companies, which have little or no technical cleaning expertise may face difficult problems that cannot be solved by the National Ozone Units. To solve this problem, the STOC will incorporate within the 2002 Assessment Report a series of sub-sectoral, self-contained guidelines on the selection of alternatives to ozone-depleting solvents. Internet and e-mail references will provide further sub-sectoral details.

14.2 Report on Halogenated Solvents

The STOC has prepared a report on the proper use of halogenated solvents. This report is currently going out for peer review, in particular concerning the toxicology aspects it addresses. It is expected that this report will be part of the STOC 2002 Assessment Report.

15. TEAP Reorganisation; New Membership

In 2002, the Scientific, Environmental Effects, and Technology and Economics Assessment Panels will undertake an integrated full Assessment for the Montreal Protocol. The TEAP Assessment will include separate full reports for each of its Technical Options Committees. In preparation for this Assessment, TEAP is continuing to replenish and restructure its membership in accordance with the Terms of Reference approved by the Parties.

Two concerns regarding TEAP operation are whether new expertise is coming in as required and whether adequate continuity of membership is maintained. In order to illustrate these factors, the attached figure presents the record of TEAP membership from 1988 through 2001. There has been substantial turnover. Out of 42 members serving since 1988, only three members remain from the first Assessment carried out in 1989.

- Nine TEAP members served for 14, 15 or 16 reports (i.e., three members were involved in the drafting of 14 reports, three members in the drafting of 15 reports and three members in the drafting of 16 reports, which is the total number of TEAP assessment and progress reports published since 1989);
- 19 TEAP members served for a maximum of 12 and a minimum of 5 reports;
- 14 TEAP members served for only one or two TEAP reports.

In summary, 14 members have served less than two years on the TEAP, 19 members have served between two and eight years and 9 members have served nine years or more on the TEAP (with three current TEAP members being founding members). Here a year of service by a member is based on the appearance of the member's name in the TEAP reports published for a given year.

Suely Carvalho, László Dobó, Yuichi Fujimoto, Sateeaved Seebaluck, Barbara Kucnerowicz-Polak and Robert van Slooten are no longer available to serve on the TEAP. Additional departures are expected in 2002-2003.

TEAP will have openings for one Article 5(1) expert from the Latin American and Caribbean Region to serve as Co-chair of the TEAP. It will also have openings for experts from a CEIT country, a Sub-Saharan African country, China, Southeast Asia, and Japan to serve as Senior Expert members of TEAP or as a Co-chair of the Aerosol Product TOC or as a Co-chair of the Halons TOC. The Aerosol Product TOC is seeking medical/pharmaceutical experts in respiratory disease as countries face the challenges of phasing out CFC MDIs world-wide. The Methyl Bromide TOC is seeking agricultural economists as critical use exemptions are nominated and reviewed for decision by Parties.

Candidates for all TEAP positions must be technical or economic experts and should have demonstrated committee management and report writing skills. Each member is expected to have writing skills in English and must be computer literate.

In replacing members, TEAP will increase Article 5(1) and CEIT participation and improve its expertise balance so that it can provide a full inventory of alternatives and substitutes including descriptions of environmental acceptability, technical performance and economic feasibility. The TEAP will limit the size of the TOCs to 20-30 members by eliminating the system of alternates prevalent in some committees and by avoidance of duplication of expertise.

16. TEAP Member Biographies

The following contains the background information for all TEAP members as at 1 May 2002. Note that in 2002, Senior Expert Members László Dobó and Yuichi Fujimoto decided to retire from TEAP. TEAP appointed alternates Tamás Lotz and Masaaki Yamabe on an interim basis to assist in the completion of the 2002 assignments requested by Parties.

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Paul K. Ashford, Co-chair of the Rigid and Flexible Foams Technical Options Committee is the principal consultant of Caleb Management Services. He has over 20 years direct experience of foam related technical issues and is active in several studies concerning future policy for the foam sector. His funding for TEAP activities, which includes professional fees, is provided under contract by the Department of Trade and Industry in the UK. Other related non-TEAP work is covered under separate contracts from relevant commissioning organisations including international agencies (e.g. UNEP DTIE), governments and trade associations.

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Jonathan Banks, Co-chair of the Methyl Bromide Technical Options Committee, is a private consultant. He currently has contracts with Environment Australia and the Australian Quarantine Inspection Service related to methyl bromide and use of alternatives. He is an honorary fellow with the CSIRO Stored Grain Research Laboratory, a government/industry funded research laboratory engaged in finding improved ways of protecting stored grain, including developing and commercialising alternatives to methyl bromide. His funding for TEAP and MBTOC activities is through an Epson Australia Fellowship, a competitive fellowship administered by Environment Australia.

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