

**MONTREAL PROTOCOL
ON SUBSTANCES THAT DEplete
THE OZONE LAYER**



UNEP

**Chemicals Technical Options Committee
(CTOC)
2010 Assessment Report**

UNEP
REPORT OF THE
CHEMICALS TECHNICAL OPTIONS COMMITTEE

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**Montreal Protocol
On Substances that Deplete the Ozone Layer**

Report of the
UNEP Chemicals Technical Options Committee

2010 Assessment

ASSESSMENT REPORT

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Executive Summary

Process Agents

In the last four years more than seventy process agent applications have been reviewed by the CTOC (*see annex 1*). Parties have approved 17 process agent uses which are added to Table A. Also, 12 uses have been deleted from Table A as processes were abandoned or modified, often (but not always) as a result of MLF projects (*Decisions XIX/15 and XXI/3*).

As late as 2009, nominations for process agent status were still being received as Parties became aware of activities of their chemical industry sectors in which controlled substances were used.

Reporting of emissions to Table B has been less than complete.

A better standard of reporting of emissions needs to be achieved so that Table B gives a more reliable picture of emissions arising from process agent uses. When the CTOC and MLF will produce a joint report in 2011 according to the Decision XXI/3 (5), further deletions from Table A and a more complete update on phase-outs or suggestions for phase-outs could be possible.

A list of Parties with approved process agent uses could be provided to the Ozone Secretariat, so that requests for information could be targeted and followed up, rather than including such requests in global communications.

Laboratory and Analytical Uses

There are very few identified uses of ODS in laboratory and analytical procedures in non-Article 5 countries. Some use continues in several Article 5 countries.

Advice by experts is required, together with modest financial support for alternatives that have already been identified to be trialled in Article 5 countries, alongside current procedures that involve ODS. New standard methods need to be developed.

Advice delivered by experts to practitioners at laboratory level is most valuable. It can be augmented by national or regional meetings, by provision of advice through electronic means, and via information transfer involving ozone officers. It would be helpful to the phaseout for the Ozone Secretariat and experts identified by the CTOC to work with national and international standards bodies to establish new standard methods of analysis that do not use ODS. TEAP and the CTOC will keep Parties informed of advances on these fronts.

Feedstocks

An extensive listing of known use of ODSs as feedstocks has been compiled. Using volumes suggested by members of the CTOC and following guidelines for emission calculations suggested by the IPCC for the UNFCCC, estimates of emissions from these feedstocks have been generated.

The volumes used in the report have been built up from expert knowledge and cannot be verified directly. There is poor reporting of use of ODSs as feedstocks. Also, at the current time, the majority of the production from ODS feedstocks is for HFCs whose production is not reported to a public source of data. To improve the estimate of use and emissions, it will be necessary to identify more complete public sources or for all Parties to report feedstock usage. In addition, the IPCC guidelines do not well represent actual emissions during use of ODS as feedstock. Expert opinion suggests that the IPCC guidelines are maximal values and actual emissions may be lower at well managed facilities. Better emission mechanisms need to be considered.

Developed countries report to UNFCCC emission data for HFCs in their inventory reporting. Thus, discussions with UNFCCC may assist in developing new estimated sources of data for HFC production (which may have utilized ODSs as feedstock in their preparation). The reporting of ODS volumes for each feedstock uses by Parties through the Ozone Secretariat may enable a more complete quantification of this activity.

Solvents

Over 90 % of ODS solvent uses based on the peak consumption of 1994-95 have been reduced by changing to not-in-kind technologies and conservation. The remaining less than 10% of the ODS market is shared by several in-kind solvent alternatives.

The major challenge is the complete phase out of ODS solvents in Article 5 countries. Preferable alternatives have been identified and are generally available. Another hurdle to overcome is the economic impact on the small and medium size users who make up a major portion of the remaining ODS solvent market.

Regulatory changes will continue to impact on the use of solvents. In some cases, this may require solvent and/or equipment change or a new cleaning process. New idea of the definition of low-GWP and high-GWP alternatives which TEAP proposed may cause a profound effect on the use of solvent.

Destruction Technologies

In 2009, CTOC identified 176 destruction facilities in 27 countries including new technologies not listed in the 2002 Task Force Report.

Recently several emerging technologies have been requested for evaluation. Following Decision XXI/10, they will be reviewed when technical details are made available.

Periodic review of available destruction technologies will be necessary to provide updated technical guidelines for destruction of ozone depleting substances such as CFCs, halons and methyl bromide as well as for HFCs.

Carbon Tetrachloride (CTC) Emissions and Opportunities for Reduction

The TEAP/CTOC made a comprehensive review on CTC emissions, concluding that there is a significant discrepancy between reported emissions and the observed atmospheric concentrations under Decisions XVI/14 and XVIII/10.

The studies have not yet been completed on the production and consumption of CTC with particular emphasis on feedstock uses with the goal to estimate emissions and try to reconcile them with values calculated by atmospheric scientists.

No new information on CTC emission was obtained in the course of the CTOC activities by 2010. Further studies will be needed to improve and reconcile bottom-up and top-down calculations, to search for other unreported CTC emission sources, to revise the UNEP inventory data and to further revise the atmospheric lifetime of CTC.

1. Process Agents

1.1 Revision of Table A and Table B

Nominations for process agent uses have been reviewed by two Process Agent Task Forces (2001 and 2004) and since then by the CTOC as part of TEAP's annual progress reports. In the last four years, more than seventy process agent applications have been reviewed by the CTOC (*see Annex 1*). The Parties approved and added 17 process agent uses to Table A in Decision X/14. At the same time, 12 uses were deleted from the Table A as the processes were abandoned or modified, often (but not always) as a result of MLF projects (*Decisions XIX/15 and XXI/3*). As late as 2009, nominations for process agent status were received as Parties became aware of old or new activities of their chemical industry sectors in which controlled substances were used.

Information of ODS emissions from process agent uses in Table B has been less than complete. A better standard of reporting of emissions needs to be achieved so that table B gives a reliable picture of emissions arising from process agent uses.

1.2 Cooperation between TEAP/CTOC and MLF

Based on the further information from reports of the MLF projects, the following seven process agent applications, No. 4, 9, 17, 21, 23, 25 and 26 in the column of Decision XXI/3 in *Annex 1*, could be removed because Parties no longer operate facilities requiring these processes.. When the CTOC and MLF produce a joint report in 2011 (Decision XXI/3), a more complete update on phase-out or suggestions for phase-out will be achieved.

A list of Parties with approved process agent uses could be provided to the Ozone Secretariat, so that requests for necessary information could be targeted.

Parties and the MLF should prioritise efforts on eliminating those process agent uses that have the highest emissions.

Annex 1: Table of the reviewed list of uses of controlled substances as process agents (status through 2010 decisions)

Process Agent Application	Substance	Decision XVII/7	Decision XVII/8	Decision XIX/15	Decision XXI/3	Decision XXII/-***
Elimination of NCl_3 in chlor-alkali production	CTC	1		1	1	1
Chlorine gas recovery by tail gas absorption in chlor-alkali production	CTC	2		2	2	2
Production of chlorinated rubber	CTC	3		3	3	3
Production of Endosulfan	CTC	4		4	4	4
Production of Ibuprofen	CTC	5		5	5	**
Production of Dicofol	CTC	6		6	**	
Production of chlorosulfonated polyolefin (CSM)	CTC	7		7	6	5
Production Aramid polymer (PPTA)	CTC	8		8	7	6
Production of fluoropolymer resins	CFC-113	9		**		
Production of synthetic fibre sheet	CFC-11	10		9	8	7
Production of styrene butadiene rubber	CTC	11		**		
Production of chlorinated paraffin	CTC	12		10	9	8
Photochemical synthesis of perfluoropolyetherpolyperoxide precursors of Z-perfluoropolyethers and difunctional derivatives	CFC-12	13		11	10	9
Reduction of perfluoropolyetherpolyperoxide intermediate for production of perfluoropolyether diesters	CFC-113	14		12	11	**
Preparation of perfluoropolyether diols with high functionality	CFC-113	15		13	12	10
Production of Bromohexine hydrochloride	CTC	16		**		
Production of Diclofenac sodium	CTC	17		**		
Production of phenyl glycine	CTC	18		**		
Production of Cyclodime	CTC	19		14	13	11
Production of chlorinated polypropene	CTC	20		15	14	12
Production of chlorinated ethylene vinyl acetate (CEVA)	CTC	21		16	15	13
Production of methyl isocyanate derivatives	CTC	22		17	16	14
Production of 3-phenoxy benzaldehyde	CTC	23		18	17	15
Production of 2-chloro-5-methylpyridine	CTC	24		19	18	16

Process Agent Application	Substance	Decision XVII/7	Decision XVII/8	Decision XIX/15	Decision XXI/3	Decision XXII/-***
Production of Imidacloprid	CTC	25		20	19	17
Production of Bupropfenin	CTC	26		21	20	18
Production of Oxadiazon	CTC	27		22	21	19
Production of chloradized N-methylaniline	CTC	28		23	22	20
Production of Mefenacet	CTC	29		**		
Production of 1,3-dichlorobenzothiazole	CTC	30		24	23	21
Bromination of a styrenic polymer	BCM	31		25	24	22
Synthesis of ascorbic acid	CTC	32		**		
Synthesis of Ciprofloxacin	CTC	33		**		
Synthesis of Norfloxacin	CTC	34		**		
Synthesis of 2,4-dichlorophenoxyacetic acid (2,4-D)	CTC	35		26	25	23
Synthesis of diperoxydicarbonate	CTC	36		**		
Production of sodium dichloroisocyanurate	CTC	37		**		
Synthesis of di(-2-ethylhexyl)peroxidedicarbonate (DEHPC)	CTC			27	26	24
Production of radio-labelled cyanocobalamin	CTC	38		28	27	**
Production of high modulus polyethylene fibre	CFC-113	39		29	28	25
Production of vinyl chloride monomer	CTC			30	29	26
Production of p-bromobenzaldehyde	CTC		40	*		
Production of fenvalerate	CTC		41	*		
Manufacture of Losartan Potassium	BCM		42	*		
Production of 1,2-chloro-1,4-naphthoquinone	CTC		43	*		
Production of Prallethrin	CTC		44	32	31	28
Production of 2-methoxybenzoylchloride	CTC		45	*		
Production of o-nitrobenzaldehyde	CTC		46	33	32	29
Production of Salimusk	CTC		47	*		
Production of Epoxiconazole	CTC		48	*		
Production of benzophenone	CTC		49	*		
Production of Picloram; Lontrel	CTC		50	*		
Production of 3-methyl-2-thiophenecarboxaldehyde	CTC		51	34	33	30
Production of Difenconazole	CTC		52	*		

Process Agent Application	Substance	Decision XVII/7	Decision XVII/8	Decision XIX/15	Decision XXI/3	Decision XXII/-***
Production of 2-thiophenecarboxaldehyde	CTC		53	35	34	31
Production of 2-thiophene ethanol	CTC		54	36	35	32
Production of 5-amino-1,2,3-thiadiazol	CTC		55	*		
Production of Levofloxacin	CTC		56	*		
Production of cinnamic acid	CTC		57	*		
Production of Ertaczo	CTC		58	*		
Production of 3,5-dinitrobenzoyl chloride (3,5-DNBC)	CTC		59	37	36	33
Production of Fipronil (pesticide)	CTC		60	*		
Processing of Aluminium, Uranium	CTC, CFC		61	*		
Production of furfural	CTC		62	*		
Production of 3,3,3-trifluoropropene	CTC		63	*		
Production of triphenylmethylchloride	CTC		64	*		
Production of tetrachlorodimethylmethane	CTC		65	*		
Production of 4,4'-difluorodiphenylketone	CTC		66	*		
Production of 4-trifluoromethoxybenzenamine	CTC		67	*		
Production of 1,2-benzisothiazol-3-ketone	CTC		68	38	37	34
Production of Sultamicillin	BCM			31	30	27
Production of <i>m</i> -nitrobenzaldehyde	CTC			39	38	35
Production of Tichlopidine	CTC			40	39	36
Production of <i>p</i> -nitro benzyl alcohol	CTC			41	40	37
Production of Tolclofos methyl	CTC			42	41	38
Production of polyvinylidene fluoride (PVdF)	CTC				42	39
Production of tetrafluorobenzoyl ethyl acetate	CTC				43	40
Production of 4-bromophenol	CTC				44	41

* Do not meet criteria X/14,

** Phased out

*** Three applications was deleted from Table A (Decision XXI/3, #5, 11 and 27) in the 22nd MOP in Bangkok, Thailand

2. Laboratory and Analytical Uses

2.1 Introduction

Parties continued to show interest in the use of ODS for laboratory and analytical purposes. In 2007, Decision XIX/8 extended the global exemption to 31 December 2011, and then in 2009 the global exemption for all Parties was extended to 31 December 2014, with the exception of a few procedures for which it was agreed that suitable alternatives were available.

On several occasions the CTOC was asked to describe the uses and to provide lists of suitable alternatives, and much information of this type was made available in the annual TEAP reports. The 2009 TEAP Progress Report contained information about case studies in Australia, European Union, Japan and the United States, showing the way that Parties managed such uses and, in some cases, had eliminated them.

2.2 Status on Laboratory Uses

There are laboratory uses of some ODS – notably methyl bromide (MB) and carbon tetrachloride (CTC) – for which it is difficult to find alternatives because portions of the ODS molecules are incorporated in the products of the chemical reactions. Since the ODS are destroyed, through conversion to non-ODS products, and laboratory procedures are in any case conducted on a much smaller scale than those in industry, the likely emissions from such uses are small.

Despite some trials by interested laboratories, there is one laboratory solvent use of CTC for which does not yet have an alternative (bromination reactions using N-bromo-succinimide).

Other laboratory uses of ODS, as common solvent or cleaning agent, for example, have largely been phased out in developed countries and are disappearing from laboratories in developing countries, by alternatives with similar polarity and solvent properties

2.3 Status on Analytical Uses

The most common analytical procedures using ODS is use of CTC (and in some cases CFC-113) as a solvent for infrared analyses of hydrocarbons. The hydrocarbons in question are those involved in contamination of water, soil or air by petroleum-derived oils. The best alternative to CTC is tetrachloroethylene (perchloroethylene) which has been shown to perform satisfactorily in such analyses and is widely available in global markets. This alternative was suggested by the CTOC and the trials were successfully conducted in an Article 5 country. A new commercial product (S-316) that can also substitute for CTC is also available on world markets, but it is expensive and many users of CTC, especially in Article 5 countries, have not switched to the new analytical medium. Alternatives have also been identified for other analyses using CTC or 1,1,1-trichloroethane (TCA), and introduced into practice in a number of countries.

CTOC members, supported by implementing agencies as UNDP and UNIDO, have provided advice and guidance to laboratory personnel and ozone officers, directly or advising through regional networks meetings.

2.4 Importance of Standard Analysis

The reluctance of analytical laboratories to replace CTC in hydrocarbon analysis, while there may be a cost factor, arises from the fact that CTC is specified in standard analytical methods that have great value in quality assurance and quality control (QA&QC). Assurance that an analysis has been done properly and the result is repeatable and may be compared with other results obtained by standard analysis is an important tenet of analytical chemistry. Such assurance is sought by company management, who are aware that customers who purchase a company's products, and regulators who monitor environmental performance, will insist that results be reported on the basis of standard methods.

There is a need, therefore, for the development of new standard methods, ones that do not involve the use of ODS. By the other hand, some standard methods present one or more alternative solvents to ODS, but there is need of awareness activities, in order to make trials and validate those methods with the alternatives. The Ozone Secretariat, in conjunction with the CTOC, is engaged with national and international standards associations in the development of new methods of analysis.

3. Feedstocks

An extensive listing of known use of ODSs as feedstocks has been compiled. These are for products as diverse as other fluorochemicals, polymers and films, pharmaceuticals, fine chemicals, etc. The CTOC has estimated emissions from feedstock use based on expert knowledge and utilizing guidelines for emission calculations suggested by the IPCC for the UNFCCC.

The volumes estimated in the report have been built up from expert knowledge and cannot be verified directly. There is poor reporting of use of ODSs in feedstocks. Also, at the current time, the majority of the feedstock use is for the production of HFCs which have no publicly reported data on the amount of production. To improve the estimate of use and emissions it will be necessary to identify more complete public sources or for all Parties to report feedstock usage. In addition, it is felt that the IPCC guidelines do not well represent actual emissions during use of ODS as feedstock. Expert opinion suggests that the IPCC guidelines are maximal values and actual emissions from well managed plants are lower. Better emission mechanisms need to be considered.

Developed country Parties to UNFCCC report emission data for HFCs in their inventory reporting, discussions with UNFCCC may assist in developing new sources of data for HFC production (which may have utilized ODSs as feedstock in their preparation). The reporting by Parties of ODS volumes used as feedstocks through the Ozone Secretariat may enable a more complete quantification of this activity. Alternatively, inquiries to select Parties might improve understanding of this activity.

4. Solvents

4.1 Introduction

As is reported in the IPCC/TEAP SROC, over 90% of the ODS solvent use had been reduced through conservation and substitution with not-in-kind technologies by 1999. The phaseout of the remaining less than 10% of the original solvent use are shared by several organic solvent alternatives, especially by the in-kind alternatives to CFC-113 which include HCFCs, HFCs and HFEs (hydrofluoroethers) with minimal use of PFCs such as perfluorohexane in non-Article 5 countries.

Not-in-kind alternatives options include no-clean mainly in electronics and aerospace, aqueous systems in degreasing and precision cleaning, hydrocarbon in precision mechanics and oxygenated solvents in diverse cleaning applications. The primary substitutes for 1,1,1-trichloroethane (TCA) and CTC cover chlorocarbon alternatives such as trichloroethylene, perchloroethylene and methylene chloride. Also, a brominated substance, n-propyl bromide, with similar solvent properties to those of the chlorinated solvents, has taken a significant market share in recent years for defluxing, general cleaning and adhesives applications in spite of its concerned toxicity.

The in-kind substitutes for CFC-113 and CFC-11 are fluorinated alternatives such as hydrochlorofluorocarbons (HCFC-141b and HCFC-225ca/cb), perfluorocarbons (primarily C6F14), hydrofluorocarbons (HFC-43-10mee, HFC-365mfc and HFC-245fa, HFC-c447ef) and hydrofluoroethers (HFE-449s1, HFE-569sf2). HFCs are available in all regions but their uses have been primarily in non-Article 5 countries due to relatively high cost and importance of high tech industries. Their growth is expected to be minimal due to the increasing concern about their high GWP. In Article 5 countries, use of HCFC-141b has been increasing especially in China, India, and Brazil and its consumption exceeded 5,000t.

4.2 Status in Article 5 Countries

As shown in UNEP database, consumption and production amount of ODSs in Annex A and Annex B have been decreasing steadily in Article 5 countries.

Although the complete phase out of those substances has not come yet, progress in achieving the phase-out in Article 5 countries has been good, given the widespread use of ozone-depleting solvents and the variety and complexity of their applications. Of the various uses, the large-scale electronics industry has progressed furthest towards a complete phase-out, although this is not the case with small- and medium-sized enterprises (SMEs). Full phase-out for metal cleaning applications is hampered by the large number of small users, many of whom are undercapitalised. In precision cleaning applications, users have been aggressively implementing alternatives. Some enterprises are still searching for solutions for cleaning precision parts that are especially vulnerable to residues or reactions, or that have unusually stringent cleanliness criteria.

The challenges that are facing the world are complete phase out of ozone depleting substances in Article 5 countries. Preferable alternatives have been identified

throughout the world and are generally readily available, so to keep providing information and knowledge about what are the acceptable alternatives is quite important. A second major hurdle to be overcome is the economic considerations. However, the biggest problem is being able to identify the SMEs that, collectively, make up a major portion of the solvent market.

The remained issue to note is promotion of the replacement process of essential uses in non Article 5 countries.

The selection of the alternative technologies to ODS solvents for Article 5 countries should be:

- "No-clean", keep-clean
- Aqueous/hydrocarbon-surfactant cleaning
- Organic solvent cleaning (with solvents less toxic than non-ozone-depleting halogenated solvents)
- Non-ozone-depleting halogenated solvents (HFC, HFEs, TCE, PCE)
- Organic solvent cleaning (with solvents more toxic than non-ozone-depleting halogenated solvents)
- HCFC-225, and some PFCs

All applications to the Multilateral Fund that propose the use of aqueous or hydrocarbon surfactant cleaning require funding for pollution prevention, recycling, waste water treatment, shower and eye-wash facilities and drying equipment, as appropriate. Applications that involve the use of organic and hydrogenated solvents require containment equipment, adequate ventilation control, and/or low emission equipment. The guidelines for all processes should include requirements for personnel safety, for example, the use of eye guards and other personal protection equipment by workers who perform the cleaning operation and means for the measurement of operator exposure.

4.3 Regulatory Changes

The regulatory changes continue to impact use of solvents as well as containment, emission, safety, health and recycling requirements. In some cases, they may require solvent and/or equipment change or a new cleaning process. The new definition of low-GWP and high-GWP alternatives which TEAP proposed this year may cause a profound effect on the remaining use of ODS and HFC solvents.

4.3.1 European Regulation Changes

Regulation on F-gases came into effect in 2006 in EU, covering refrigerants in automobiles. The new European chemical policy called REACH (Registration Evaluation and Authorization of Chemicals) came into effect as a new regulation in mid 2007. It could impact substances availability for certain uses (including solvents) in cases where low sales volumes cannot support the testing regime required by REACH or where the re-assessed properties of the substance militate against its use. New regulation on CLP (Classification, Labelling and Packaging) will come in this December, where ODSs, such as CFCs, halons, CTC, Methylchloroform, HFBCs and HCFCs, are classified as hazardous to the ozone layer

4.3.2 Japanese Regulation Changes

The PRTR (Pollutant Release and Transfer Register) regulation which came into effect in 2002 requires reporting of release and transfer of 354 substances including all ODSs and chlorinated solvents. The other regulation which has a major effect in controlling cleaning operation is the VOC (volatile organic compound) regulation. It came into effect from April 2006. The quantity of VOCs emitted in industrial cleaning in 2007 was 124,000 tons. Of those VOCs emitted, 35% was chlorinated solvents such as methylene chloride (17%), trichloroethylene (10%) and perchloroethylene (4%). In order to achieve reduction in emission, various combinations of cleaning equipments, operating manuals and peripherals to suit the processes are needed and efforts are made to develop such systems.

4.4 n-Propyl bromide

Concerns have been expressed during the current assessment period about the increasing use of n-propyl bromide (1-bromopropane, $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$, n-PB, CAS No. 106 94 5) as a solvent in a range of applications. Its boiling point, 71°C, is comparable to that of CFC-113 (48°C), hexane (69°C), methyl chloroform (TCA, 74°C) and trichloroethylene (87°C). Its solvent properties are typical of those of lower molecular weight hydrocarbons and organohalogen compounds.

Because of the presence of bromine in the molecule there is the potential for ozone depletion arising from transfer of n-PB to the stratosphere, and decomposition there with release of bromine atoms. Analogies are drawn with methyl bromide, a lower homologue of n-PB which finds extensive use as a fumigant and has ozone depleting potential (ODS) of 0.6. The intermediate homologue, ethyl bromide, has few commercial uses.

Complete and accurate data on production and uses of n-PB have been difficult to obtain. The global production level was estimated to be 20,000-30,000 metric tonnes in 2007, with production taking place in several A(5) and non-A(5) countries. n-PB is not classified or registered as a controlled chemical substance like CFCs, and HCFCs (ODS class I and II) nor designated as a hazardous air pollutant in the Clean Air Act in the USA or reportable compound for pollution release (emission) and transfer (PRTR) in Europe and Japan no information is available about n-PB emissions.

Because emitted n-PB is rapidly destroyed in the lower atmosphere, and therefore does not give rise to significant stratospheric bromine concentrations, its ODP is calculated to be in the range of 0.02-0.1, similar to those of HCFCs.

Proposals to restrict the use of n-PB are based on both ozone-depletion and toxicity concerns. The American Council of Government Industrial Hygienists (ACGIH) and Israel have set an exposure guideline of 10ppm, with Europe setting the lowest 8-hour occupational exposure limit (OEL) value in humans and enforcing the tightest labelling classification. The US EPA is proposing to allow n-PB in some, but not all, end uses as a solvent, with a TLV (Threshold Limit Value) of 10ppm as an 8-hour time-weighted

average of exposure (TWA) through its SNAP (Significant New Alternatives Policy) Program, although OSHA has not yet issued a Permissible Exposure Limit (PEL) for n-PB.

5. Destruction Technologies

5.1 Introduction

Following the discovery of the ozone hole and establishment of the Montreal Protocol, the first report of the “Ad-Hoc Technical Advisory Committee on ODS Destruction Technologies” was published in May, 1992.

TEAP was requested to establish two task forces; a task force on collection, recovery and storage and a task force on destruction technologies. Their reports were published in April, 2002. The task force on collection, recovery and storage reported (1) technical feasibility of collection, recovery and storage, (2) inventories and collection potential, (3) economic implication, and (4) barrier to collection, recovery and storage. The task force on destruction technologies reported in May, 2002 that the criteria of the destruction were (1) destruction and removal efficiency (DRE), (2) emissions of PCDDs/PCDFs, (3) emissions of acid gases, particulate matter and carbon monoxide, and (4) technical capability (scale of destruction). The task force concluded that sixteen ODS destruction technologies met the screening criteria among 45 technologies.

TEAP was requested by Decision XVII/10 to establish the task force on foam end-of-life issues, focusing on handling and destruction of insulation foams and technical and economic aspects of recovery and destruction of blowing agents from appliance and building insulation foams. The report of the task force of collection, recovery and storage in May, 2005, concluded (1) a new practically-valuable parameter, recovery and destruction efficiency (RDE), (2) anaerobic degradation of ODS in landfilling, and (3) economic factors affected by segregation of foams from other materials and infrastructure of transport, and (4) estimated banks of CFCs (1.5 million tonnes) and HCFCs (0.75 million tonnes).

The IPCC/TEAP special report in 2005 described emission scenarios and recovery/destruction of HFCs, PFCs and SF₆ as well as CFCs and HCFCs. A1 scenario of SRES (Special Report on Emission Scenarios for IPCC Third Assessment Report in 2001) indicated that while global emissions of ODS, HFCs-total and PFCs-total are 842 kt, 93 kt and 14 kt in 2000, respectively, those in 2010 are projected to be 786 kt, 298 kt and 17 kt, respectively. Particularly, the emissions of HFC-23 were 12.6 kt in 2000 and were projected to be 14.8 kt in 2010, and those of HFC-134a were 80.0 kt in 2000 and were to be 175.7 kt in 2010. The special report explained recovery, recycling and reclamation of ODS and HFCs. The report also described the destruction of a by-product of HFC-23, which is produced in HCFC-22 manufacturing by 1.4% to 4% and has a GWP of 14,310.

5.2 Recent Progress

5.2.1 Environmentally Sound Management of Banks of ODS

By Decision XX/7 TEAP was requested to establish the Task Force on “Environmentally Sound Management of Banks of Ozone-depleting Substances.” The Interim report in June, 2009 and Phase 2 report in October, 2009 drew main

conclusions. (1) The evaluation of ODS flow reaching to the waste streams indicated that while opportunity for end-of-life management of ODS, for example, in refrigerant will be over by 2025 in developed countries, the management of CFCs in refrigerant will be over the next 10-15 years and that of HCFC-22 will be prevalent up to 2030 in developing countries. (2) Synergy of ODS with other waste issues indicated importance of integrating ODS into wider waste management strategies, based on cost analyses of the recovery and destruction which were composed of segregation/collection equipment containing ODS, transport of recovered equipment, recovery of ODS from equipment, transport of recovered ODS to destruction, and destruction of ODS. The synergy of ODS with other waste issues was supported by three sub-regional examples in EU, Brazil and Japan. (3) A further collaboration of the ozone, climate and other environmental benefit indicated annual benefits in excess of 400 Mtonnes of CO₂-eq were available from management of low and medium effort banks reaching to the waste stream.

5.2.2 Update of the screened-in destruction technologies of 2002 TF Report

As described in the 2002 TEAP Task Force on Destruction Technologies, only sixteen destruction technologies were screened-in. However, from the documents distributed by the Ozone Secretariat until October 2009, the CTOC identified at least 176 destruction facilities in 27 countries which are being operated. Present destruction facilities are operated by a variety of technologies far wider than the 2002 Task Force technologies. The technologies applied are classified into four categories, i.e. high temperature incineration, furnaces dedicated to manufacturing, plasma, and other non-incineration.

Furnaces dedicated to manufacturing include cement kilns, lime rotary kilns, electric furnace, sulphuric acid recovery furnace and lightweight aggregate kilns. Other non-incineration technologies include catalytic destruction, chemical treatment and solid-phase alkaline reactor. As indicated in the 2002 Task Force report, the suggested minimum standards of technical performance are guidelines for selecting the destruction technologies.

Current destruction technologies other than the sixteen TEAP recommended technologies were evaluated against the performance criteria of their own countries, as well as by those of the 2002 Task Force report. The United States of America, for instance, has established their domestic technologies permitted by the Resource Conservation and Recovery Act requirements and ODS has been destroyed under MACT (Maximum Achievable Control Technology) standards for destruction efficiency (DE) and atmospheric emissions. In European countries, ODS is destroyed by the technologies recommended by the 2002 Task Force report and by a variety of incinerators that are used for PCB/POPs destruction. Japan has permitted the destruction technologies based on the Law of Fluorocarbon Recovery and Destruction.

5.2.3 Article 5 countries

CTOC is aware that technology transfer to Article 5 countries has begun take place. The ODS destruction project in Indonesia using cement kiln project was supported by

the Japanese government and a private company. Such assistance to A-5 countries is likely to increase since ODS destruction can be expected to be more emphasized in such countries.

Since 1993 EU and USA have destroyed 114,603 and 38,278 tonnes of ODS, respectively. Japan has destroyed 25,925 tonnes of CFCs, HCFCs and HFCs. Recently, Korea, China, Brazil and some A-5 countries have started destruction of ODS.

The CTOC is also aware that movement of waste ODS from countries where they have been withdrawn from service, but in which no destruction facilities exist, to other countries (sometimes neighbouring countries) where destruction facilities are available, can prove difficult. The Basel Convention applies but there is also reluctance on the part of many countries to accept waste from other countries for destruction.

5.2.4 Evaluation of reported emerging technologies

CTOC has received three kinds of emerging destruction technologies for evaluation and recommendation. Although some information about these technologies are confidential, CTOC expects to be able to advise Parties on their technical performance. Appropriate advice has been sent to the inventors regarding technical performance of these technologies and suitable substances to be destroyed under destruction conditions. When detailed technical information is made available, these technologies will be evaluated as requested in Decision XXII/10.

A fourth technical proposal concerns the applicability of current destruction technologies to methyl bromide (MB). Although MB among ODS is the most difficult to destroy by incineration, annual amounts of MB destruction ranging from year of 1991 to 2003 were reported by USA (May 2009). The amount destroyed in 2002 was 4,713 metric tones. Commercial recapture systems for MB have been developed based on adsorption of MB from treatment containers and chambers on activated carbon. An emerging destruction technology was attempted by contacting MB released from activated carbon with liquid scrubber containing thiosulfate solution. Another technology for MB destruction was attempted by a plasma technology in Australia.

Revision of the Montreal Protocol assessments of destruction technologies is necessary: Firstly, technical guidelines for methyl bromide might be required, since the 2002 Task Force report was limited to CFCs (concentrated and dilute sources) and halons. Secondly, there is a proposed opinion to specify authorised methods for destruction because of current technologies far wider than those in the 2002 Task Force report. Thirdly, current fluorocarbons to be recovered and destroyed are not limited to ODS, since the mobile and stationary air-conditioners, for example, contain HFC-134a and other HFC and HFC blends as well as CFC-11, CFC-12, HCFC-22, and other ODSs. Finally, comprehensive disposal technologies including recovery and destruction are established for products and equipment containing ODS. Such a view point may also be helpful for Article 5 countries where ODS recovery/destruction facilities are expected to increase in future. Furthermore, technical, economic and legal mechanisms are desired for ODS recovery and destruction in Article 5 countries.

6. Carbon Tetrachloride (CTC) Emissions and Opportunities for Reduction

Following Decision XVI/14, in 2006 CTOC reported estimates of releases of CTC by chemical industry. For confidentiality reasons, exact usage volumes were not available, and in addition it was necessary to estimate releases on the basis of anticipated small percentage losses. Bottom-up estimated emissions were in the range 12,000-17,000 tonnes/year. Working from the measured atmospheric concentration of CTC and estimates of its tropospheric lifetime, however, top-down annual emissions are estimated to be closer to 70,000 tonnes/year. Just how this discrepancy could be reconciled is not obvious, but CTOC drew attention to possible under-reporting of CTC use and to uncertainties in the atmospheric lifetime (with a longer lifetime, lower emissions would suffice to maintain the observed atmospheric concentrations). Decision XVIII/10 requested reconsideration of the matter but in 2007 CTOC reported that their investigations were incomplete. They were able, however, to dismiss the role that landfill emission might play in CTC emissions, and to report that the Science Assessment Panel had confirmed the CTC lifetime (26 years) and suggested regions where unaccounted CTC emissions might be occurring. In 2008 the TEAP/CTOC reported to the OEWG in Bangkok that SAP emission estimates of 70,000 tonnes/year are inconsistent with reliable estimates of CTC production (200,000 tonnes, including 161,000 tonnes used as feedstock). There the matter rests although there is growing support for the view that, while emissions may be underestimated, the gap is too large to be closed unless there is reconsideration of the atmospheric lifetime of CTC.