MONTREAL PROTOCOL

ON SUBSTANCES THAT DEPLETE

THE OZONE LAYER

UNEP

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TECHNOLOGY AND ECONOMIC ASSESSMENT PANEL

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TEAP DECISION XXIX/9 WORKING GROUP REPORT ON HYDROCHLOROFLUOROCARBONS AND DECISION XXVII/5

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Montreal Protocol
On Substances that Deplete the Ozone Layer

2018 Report of the UNEP Technology and Economic Assessment Panel

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Foreword

The 2018 TEAP Report

The 2018 TEAP Report consists of five volumes:

Volume 1*: Decision XXIX/9 Working Group Report on hydrochlorofluorocarbons and decision XXVII/5*

Volume 2*: Decision XXIX/4 Task Force Report on destruction technologies for controlled substances*

Volume 3: *TEAP 2018 Progress report*

Volume 4: *MBTOC interim CUN assessment report*

Volume 5: *Decision XXIX/10 Task Force Report on issues related to energy efficiency while phasing down hydrofluorocarbons*

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TEAP DECISION XXIX/9 WORKING GROUP REPORT ON HYDROCHLOROFLUOROCARBONS AND DECISION XXVII/5

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Executive Summary

At their 29th Meeting, in 2017, parties took Decision XXIX/9, "Phase-out of hydrochlorofluorocarbons", which requested the TEAP to provide further assessment of the issues related to the phase-out of HCFCs, provided in response to Decisions XXVII/5 and XXVIII/8, and requested parties to provide relevant information for use by TEAP in providing this assessment.

TEAP appreciates the responses it has received from Armenia, Azerbaijan, Canada, Costa Rica, Japan, Kazakhstan, Mexico, Palau, Venezuela and an interested entity in the United States, and has incorporated the information where appropriate in this assessment.

In fire protection, the Decision XXVIII/8 report estimate remains unchanged that for non-Article 5 parties between 2020 and 2030 (as an upper limit for planning purposes and to assess impacts on the environment) volumes of HCFC-123 (for the production of HCFC-based Blend B) not exceeding 750 tonnes annually could be needed (combined with potential amounts required for servicing, this would imply a total consumption of about 900 tonnes annually, or almost 20 ODP tonnes).

- In fire protection, the earlier Decision XXVII/5 report identified an application, Aircraft Rescue and Fire Fighting (ARFF) at commercial and military airports, where certain requirements may currently only be met through the original halon 1211 or the use of an HCFC product, HCFC Blend B, in jurisdictions where their use is still allowable. Based on existing alternatives and technology option currently, TEAP considered in its report that there was some likelihood that there might be ARFF applications that would continue to need clean agents in the 2020 - 2030 timeframe that currently can only be met through the supply of halon 1211 or HCFC Blend B. (TEAP noted several new fire extinguishing agents under development that might change this situation in the near future. One zero ODP agent has recently been evaluated in ARFF applications; the results have not been published at the time of writing this report).

- An HCFC blend was also used in fixed fire protection systems to replace halon 1301. This was particularly true in parties that pursued early action to begin to eliminate halon 1301 in new systems. The blend consists of HCFC-22, HCFC-123 and HCFC-124. TEAP is aware that these systems are still used today in merchant shipping and military systems and are expected to continue until the end of their economic lifetime. While no new HCFC blend systems are expected to be installed today or in the future, there is a need to continue to maintain these systems. Therefore, small amount of HCFCs will also be needed to supply re-charge of these systems during the period 2020-2030. TEAP does not have sufficient data to project quantities needed for these systems, but would estimate that they would be less than those needed for HCFC Blend B in portable/steaming systems used to replace halon 1211.

- The possibility of meeting fire protection needs for HCFCs through the use of recycled or reclaimed HCFCs was addressed in the previous Decision XXVII/5 report and the situation remains the same. Recyclers of firefighting agents and refrigerants report that there are only small quantities of HCFC-123 being currently recycled. The main use of HCFC-123 is as a cleaning agent and as a low-pressure refrigerant in large (centrifugal) chillers. While the small amount being recycled may change as older chillers are phased out and replaced with non-HCFC-123 equipment, it does not appear at this stage that there will be sufficient quantity of HCFC-123 to meet the

potential demand of HCFC Blend B for ARFF applications in the period beginning in 2020, assuming that no new agents meet the approval of AHJs for this specific application beginning in 2020. The recyclers also report that there is no technical reason that they are aware of at this time that would prevent them from being able to recycle or reclaim HCFC-123 to appropriate purity levels sufficient for use in HCFC Blend B.

Solvent and other niche uses of HCFCs have been considered for non-Article 5 parties between 2020 and 2030. Based on the available information, if current solvent and other niche HCFC uses continue beyond 2020, annual use might be between around 250-500 tonnes (10s of ODP tonnes). Of this, about 50-200 tonnes is estimated for the annual HCFC requirements for existing aerospace or military equipment. These estimated amounts indicate those potentially needed to supply solvent and other niche applications as discussed below. Recycling may be feasible although relevant amounts have not been estimated in the absence of available information.

- The Decision XXVIII/8 finding remains unchanged that it is possible that some niche solvent applications, such as aerospace or military, might require small quantities of HCFCs, to service existing equipment (e.g., HCFC-121, -122a, -141b and -225ca/cb).

- The Decision XXVIII/8 finding remains unchanged that essential uses for non-Article 5 parties are likely to be required in small quantities for laboratory and analytical uses, and for the research into and development of new substances.

- There is a possibility that HCFC-225 may be required after 2020 in Japan for a solvent application that coats silicone oil on the surface of the needle/syringe to reduce pain at injection, at a rate of around a few hundred tonnes annually. At this time, TEAP is unaware of other non-Article 5 parties that may have this application.

- Several manufacturing processes use HCFCs as solvents in processes that might be considered similar to process agent uses, and would be potentially impacted by the 2020 control measures for HCFC production and consumption in non-Article 5 parties. Known applications include processes using HCFC-141b and HCFC-225ca/cb as solvents. The total known use of HCFCs in such processes has been revised downwards to about 10 tonnes annually. There is a small possibility that such HCFC use may remain after 2020 if alternatives cannot be found by then. Parties may wish to consider how to treat HCFC solvent uses in processes that are similar to process agent uses in relation to the 2020 control measures under Article 2.

- TEAP has become aware of an aerosol application using HCFCs in the Russian Federation. HCFC-22 and -141b are used as propellant and solvent, respectively, in a topical medical aerosol application in quantities of around 20 tonnes per year. With the variety of technically and economically feasible alternatives, HCFCs used in aerosols are unlikely to be justifiable as an essential use in non-Article 5 parties.

1 Introduction

1.1 Decision XXIX/9 and TEAP's approach to this response

At their 29th Meeting, in 2017, the Parties took Decision XXIX/9, "Phase-out of hydrochlorofluorocarbons", which requested TEAP to provide further assessment of the issues related to the phase-out of HCFCs, following previous responses to Decisions XXVIII/8 and XXVII/5, and requested parties to provide relevant information for use by the TEAP in providing this assessment. Decision XXIX/9 states:

Decision XXIX/9: Hydrochlorofluorocarbons and decision XXVII/5

Aware that parties not operating under paragraph 1 of Article 5 of the Montreal Protocol on Substances that Deplete the Ozone Layer are taking measures to reduce and eventually eliminate the production and consumption of the ozone-depleting substances listed in Annex C, group I (hydrochlorofluorocarbons),

Recognizing a need for continued consideration of issues related to hydrochlorofluorocarbons as indicated in paragraphs 12, 13 and 14 of decision XIX/6, and taking into consideration the report of the Technology and *Economic* Assessment Panel prepared in response to decisions XXVII/5 and XXVIII/8,

Noting that the Halons Technical Options Committee considers it possible that certain aircraft rescue and firefighting applications may continue to need clean agents between 2020 and 2030,

Noting also that the Medical and Chemicals Technical Options Committee has identified certain hydrochlorofluorocarbons used as solvents for which there may be a continued need in certain precision cleaning applications and manufacturing processes,

Recalling the procedure laid down in paragraph 9 of Article 2 of the Montreal Protocol for adjustments and *reductions* in production and consumption of controlled substances,

To request the Technology and Economic Assessment Panel, in relation to Annex C, group I, substances, to assess requirements for the period from 2020 to 2030 for parties not operating under paragraph 1 of Article 5 and to provide information on the following:

(a) Areas and volumes of possible needs in fire suppression sectors that may require the use of clean agents;

(b) Areas and volumes of possible needs for solvent applications, including servicing;

(c) Areas and volumes of possible other niche uses;

(d) Existing or emerging applications and processes for alternatives related to items (a) to (c) above and the possibility of meeting identified needs through the use of recycled or reclaimed hydrochlorofluorocarbons;

1. To invite parties and other interested entities to provide additional information to the Secretariat by 15 January 2018 for inclusion in the Panel's progress report;
2. To request the Panel to report on the assessment referred to above by 15 March 2018;

To respond to Decision XXIX/9, TEAP continued to collect relevant information including

the information provided by parties and other entities, contained in the Annex to this report, and updated the relevant Decisions XXVII/5 and XXVIII/8 assessments, where needed.

1.2 The Working Group Composition

TEAP further established a dedicated working group from within its membership, to address its response to Decision XXIX/9, as follows:

Member	Affiliation	Party	A5/NA5
Roberto Peixoto	RTOC	Brazil	A5
Suely Carvalho	TEAP	Brazil	A5
Adam Chattaway*	HTOC	USA	NA5
Helen Tope*	MCTOC	AUS	NA5
Shiqiu Zhang	TEAP	PRC	A5
Marta Pizano	MBTOC	Colombia	A5
Keiichi Ohnishi	MCTOC	Japan	NA5
Helen Walter-Terrinoni	FTOC	USA	NA5

*Co-chairs

The working group conducted its work electronically and via teleconference.

2 Information on areas and volumes of needs in fire protection, solvents, and other niche applications

2.1. Fire protection

In fire protection in the earlier Decision XXVII/5 report, TEAP identified an application, Aircraft Rescue and Fire Fighting (ARFF) at commercial and military airports, where certain requirements may currently only be met through the original halon 1211 or the use of an HCFC product, HCFC Blend B, in jurisdictions[1] where their use is still allowable. In certain cases, ARFF vehicles may also contain larger quantities of clean agent in internal tanks that provide increased fire extinguishing capability and can be dispersed from a further standoff distance than from portable extinguishers. Additionally, even in jurisdictions that still allow ODS use in fire protection, TEAP noted some requirements within ARFF have non-halon and non-HCFC alternatives, albeit some of them are high-GWP HFCs. Based on existing alternatives and technology options today, TEAP considered in its report that there was some likelihood that there might be ARFF applications that would continue to need clean agents in the 2020 - 2030 timeframe that currently can only be met through the supply of halon 1211 or HCFC Blend B. (TEAP noted several new fire extinguishing agents under development that might change this situation in the near future.)

Although a zero ODP fire suppression agent has been shown to be effective in some aircraft rescue and firefighting applications, it is not yet approved for all of these applications. Work is continuing in this area and the agent was recently evaluated by the United States Federal Aviation administration. The results of this evaluation have not been published at the time of writing this report. Therefore, at this point in time, there will still be a need to use HCFCs in the period 2020-2030. The Decision XXVII/5 and XXVIII/8 reports estimated the annual requirement of HCFC-123 to be 900 tonnes (almost 20 ODP tonnes). It is possible that this estimate can be revised downward in the future, once the uptake of the zero ODP agent is known.

An HCFC blend was also used in fixed fire protection systems to replace halon 1301. This was particularly true in parties that pursued early action to begin to eliminate halon 1301 in new systems. The blend consists of HCFC-22, HCFC-123 and HCFC-124. TEAP is aware that these systems are still used today in merchant shipping and military systems and are expected to continue until the end of their economic lifetime. While no new HCFC blend systems are expected to be installed today or in the future, there is a need to continue to maintain these systems. Therefore, small amount of HCFCs will also be needed to supply re-charge of these systems during the period 2020-2030. TEAP does not have sufficient data to project quantities needed for these systems, but would estimate that they would be less than those needed for HCFC Blend B in portable/steaming systems used to replace halon 1211.

HTOC and TEAP are not aware of any other existing or emerging fire protection applications that will require HCFCs.

The possibility of meeting fire protection needs for HCFCs through the use of recycled or reclaimed HCFCs was addressed in the previous Decision XXVII/5 report and the situation remains the same. Recyclers of firefighting agents and refrigerants report that there are only small quantities of HCFC-123 being currently recycled. The main use of HCFC-123 is as a

[1] Some jurisdictions, such as the European Union, have banned or limited the use of halons or HCFCs in fire protection. Other jurisdictions such as the U.S. have not banned halon or HCFC use in fire protection and they continue to be used to meet certain requirements. HCFC based agents are reported as being used in both Article 5 and non-Article 5 parties. For non-Article 5 parties, they are reported as being used in Australia, Canada, Israel, Japan, and the U.S.

cleaning agent and as a low-pressure refrigerant in large (centrifugal) chillers. While the small amount being recycled may change as older chillers are phased out and replaced with non-HCFC-123 equipment, it does not appear at this stage that there will be sufficient quantity of HCFC-123 to meet the potential demand of HCFC Blend B for ARFF applications in the period beginning in 2020, assuming that no new agents meet the approval of AHJs for this specific application beginning in 2020. The recyclers also report that there is no technical reason that they are aware of at this time that would prevent them from being able to recycle or reclaim HCFC-123 to appropriate purity levels sufficient for use in HCFC Blend B.

2.2. Solvent and other niche uses

Solvent and other niche uses of HCFCs have been considered for non-Article 5 parties between 2020 and 2030. Based on the available information, if current solvent and other niche HCFC uses (as identified below) continue beyond 2020, annual use might be between around 250-500 tonnes (10s of ODP tonnes). Of this, about 50-200 tonnes is estimated for the annual HCFC requirements for existing aerospace or military equipment. These estimated amounts indicate those potentially needed to supply solvent and other niche applications. Recycling may be feasible although relevant amounts have not been estimated in the absence of available information.

Non-Article 5 parties are likely to require HCFCs for laboratory and analytical uses, for example to be used as analytical standards for the measurement of atmospheric levels of HCFCs, and for the research into and development of new substances. For example, the European Union has previously reported the following laboratory and analytical uses that may continue to require HCFCs post-2020 due to slow progress in moving to alternatives.

- Reference chemical (in analytical methods) e.g. HCFC-21, HCFC-22, HCFC-31, HCFC-122, HCFC-123, HCFC-124, HCFC-133a, HCFC-141b, HCFC-142b, HCFC-151a, HCFC-233;
- Feedstock (reagent in laboratory chemical synthesis) e.g. HCFC-22, HCFC-242, HCFC -252;
- Solvent (inert solvent in laboratory chemical synthesis) e.g. HCFC-31;
- Reference chemical (in toxicological studies) e.g. HCFC-21;
- ODS as a component in samples to be tested.

The quantity of HCFCs imported and produced in the European Union for these laboratory and analytical uses will most likely remain below 1 ODP tonne.

Canada has indicated very small quantities of HCFCs considered essential post-2020 to calibrate enforcement tools used to identify concentrations and types of HCFCs in bulk shipments and products.

From data reported by parties on laboratory and analytical uses in 2016, the annual consumption of HCFCs in non-Article 5 parties was reported to be 20kg (HCFC-21, -22, -123, -141b, -233, -242, -252, HBFC-21B2, -22B1).

Information was also provided by Japan and relevant technical experts on a solvent use of HCFC-225 for syringe/needle coating. This solvent application coats silicone oil on the surface of the needle/syringe to reduce pain at injection. The solvent properties required are non-flammability, good solvency with the silicone oil, and quick evaporation after coating. A few hundred tonnes are used for this purpose annually. Alternative non-ODS solvents are under investigation. HCFC-141b is also used for this purpose in Article 5 parties in similar or

higher volumes. There is a possibility that HCFC-225 may be sought after 2020 in Japan for this solvent use. At this time, TEAP is unaware if other non-Article parties may have this application. Alternative topical creams are available as pain relief for injections. However, without additional information about the specific use and possible alternatives, TEAP is uncertain whether this application would qualify as an essential use in non-Article 5 parties.

It is possible that some other niche solvent applications, such as aerospace or military, might also require small quantities of HCFCs, potentially to service existing equipment (e.g. HCFC-122, -122a, -141b, -225). For example, HCFC-225 replaced CFC-113 in precision cleaning and cleanliness verification of sensitive equipment, such as oxygen systems, in aerospace applications. HCFO-1233zd has undergone successful laboratory testing for this application, but for at least one important user there is currently no on-going production of large systems that would allow the proving of the efficacy of this solvent in the actual conditions of use. If HCFO-1233zd or other alternatives, such as HFEs, fail to demonstrate adequate performance, the application would need to continue to use HCFC-225 (or the original CFC-113). It is estimated that aerospace and military applications currently require small quantities of HCFCs globally, possibly less than about 50 tonnes annually, with the possibility of expansion over time. Such HCFC solvent uses are unlikely to exceed several hundred metric tonnes (i.e., several ODP tonnes) annually for the period 2020-2030. It is not clear whether quantities would be available and suitable from stockpiled or recycled sources.

Several manufacturing processes use HCFCs as solvents in processes that might be considered similar to process agent uses and might be potentially impacted by the 2020 control measures for HCFC production and consumption in non-Article 5 parties. They are used either as reaction solvents, or as solvents for extractive distillation due to the unique affinities to certain chemicals. Known applications include processes using HCFC-141b and HCFC-225 as solvents. The total known use of HCFCs as solvents in such processes has been revised downwards to about 10 tonnes per year. Alternative processes and/or solvents are under development. There is a small possibility that such HCFC use may remain after 2020 if alternatives cannot be found by then. Parties have made a range of decisions relating to the use of controlled substances as process agents, as summarised in TEAP's previous response to Decision XXVIII/8. Parties may wish to consider how to treat HCFC solvent uses in processes that are similar to process agent uses in relation to the 2020 control measures under Article 2.

Since TEAP's previous response to Decision XXVIII/8, TEAP has become aware of an aerosol application using HCFCs in the Russian Federation. HCFC-22 and -141b are used as propellant and solvent, respectively, in a topical medical aerosol application in quantities of around 20 tonnes per year. The product is an aerosol foam used to provide local anti-inflammatory and antiseptic action, and to stimulate healing. In this country, other analogues exist that perform a similar function, although patients and doctors are claimed to prefer this particular aerosol foam. In other non-Article 5 parties, similar products do not use HCFCs for this purpose. Very good foams are produced using HFC-152a or liquefied petroleum gas (LPG), and pumps and creams are also available. Alternatives provide effective topical pain relief. With the variety of technically and economically feasible alternatives, HCFCs used in aerosols are unlikely to be justifiable as an essential use in non-Article 5 parties.

Sterilants uses will almost certainly not require any production of HCFCs for essential uses in non-Article 5 parties. There are a variety of technically and economically feasible alternatives to the use of HCFCs in sterilization, making them unlikely to be justifiable as an essential use in non-Article 5 parties.

Annex 1: Parties' submissions in response to Decision XXIX/9

TEAP notes the responses received from Armenia, Azerbaijan, Canada, Costa Rica, Japan, Kazakhstan, Mexico, Palau, Venezuela and an interested entity in the United States. TEAP has incorporated relevant information where appropriate into this assessment. The substantive parts of parties' submissions will be compiled in a separate document, in pdf format. This document will be posted on the Ozone Secretariat website in time for the 40th Open-ended Working Group at the following link: http://conf.montreal-protocol.org/meeting/oewg/oewg-40/presession/SitePages/Home.aspx.