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**Persistent Organic Pollutants Review Committee**
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Item 5 (a) (i) of the provisional agenda*

**Technical work: consideration of draft risk management evaluations: chlorinated paraffins with carbon chain lengths in the range C14–17 and chlorination levels at or exceeding 45 per cent chlorine by weight**

# Draft risk management evaluation: chlorinated paraffins with carbon chain lengths in the range $C_{14–17}$ and chlorination levels at or exceeding 45 per cent chlorine by weight

### Note by the Secretariat

## I. Introduction

1. At its eighteenth meeting, the Persistent Organic Pollutants Review Committee adopted decision POPRC-18/4 on chlorinated paraffins with carbon chain lengths in the range $C_{14–17}$ and chlorination levels at or exceeding 45 per cent chlorine by weight. In paragraph 3 of the decision, the Committee decided to establish an intersessional working group to prepare a risk management evaluation that included an analysis of possible control measures for those chemicals in accordance with Annex F to the Convention.

2. In accordance with decision POPRC-18/4 and the workplan for the preparation of risk profiles and risk management evaluations adopted by the Committee (UNEP/POPS/POPRC.18/11, annex III), the intersessional working group has prepared a draft risk management evaluation for chlorinated paraffins with carbon chain lengths in the range $C_{14–17}$ and chlorination levels at or exceeding 45 per cent chlorine by weight, which is set out in the annex to the present note, without formal editing. Additional information, information on global emission estimates for medium-chain chlorinated paraffins, and a compilation of comments and responses relating to the draft risk management evaluation are set out in documents UNEP/POPS/POPRC.19/INF/5, UNEP/POPS/POPRC.19/INF/6 and UNEP/POPS/POPRC.19/INF/7, respectively.

## II. Proposed action

3. The Committee may wish:

(a) To adopt, with any amendments, the draft risk management evaluation set out in the annex to the present note;

* UNEP/POPS/POPRC.19/1.

(b) To decide, in accordance with paragraph 9 of Article 8 of the Convention, on the basis of the risk profile adopted at its eighteenth meeting (UNEP/POPS/POPRC.18/11/Add.3) and the risk management evaluation, whether chlorinated paraffins with carbon chain lengths in the range $C_{14–17}$ and chlorination levels at or exceeding 45 per cent chlorine by weight should be recommended for consideration by the Conference of the Parties for listing in Annexes A, B and/or C to the Convention.

**Annex***

# Chlorinated paraffins with carbon chain lengths in the range $C_{14–17}$ and chlorination levels at or exceeding 45 per cent chlorine by weight

# Draft risk management evaluation

**June 2023**

* The annex has not been formally edited. The studies and other information referred to in this document do not necessarily reflect the views of the Secretariat, the United Nations Environment Programme (UNEP) or the United Nations. The designations employed and the presentation of the material in such studies and references do not imply the expression of any opinion whatsoever on the part of the Secretariat, UNEP or the United Nations concerning geopolitical situations or the legal status of any country, territory, area or city or its authorities.

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## Executive Summary

1. In April 2021, the United Kingdom of Great Britain and Northern Ireland (UK) submitted a proposal to list ‘chlorinated paraffins with carbon chain lengths in the range $C_{14–17}$ and chlorination levels at or exceeding 45 percent chlorine by weight’ (MCCPs) in Annexes A, B and/or C of the Convention. The proposal was submitted in accordance with Article 8 of the Convention and was reviewed by the Persistent Organic Pollutants Review Committee (POPRC) at its seventeenth meeting held in January 2022, where it was concluded that MCCPs meet all of the screening criteria specified in Annex D.

2. The risk profile for MCCPs was adopted at the eighteenth meeting, in October 2022, where the Committee decided:

(a) That MCCPs are likely, as a result of their long-range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted;

(b) To prepare a risk management evaluation (RME) that includes an analysis of possible control measures for MCCPs; and

(c) To invite Parties and observers to submit to the Secretariat the information specified in Annex F of the Convention.

3. Chlorinated paraffins (CPs), constitute a large group of manufactured industrial chemicals with different degrees of chlorination and chain length distributions depending on the application and feedstock. Due to the variation of levels of chlorination and positions where chlorine atoms sit on the carbon chain, the $C_{14}$–$C_{17}$ ‘medium chain chlorinated paraffins’ (MCCPs), can contain many thousands of possible different constituents.

4. Ongoing production and use of MCCPs have been indicated by several Parties. CPs have been produced commercially since the 1930s, and global production levels are indicated to have risen steadily since then. However, a more rapid increase in production levels has been indicated from around 2000-2014. This increase is attributed to rapidly growing production in China and India, which are now indicated to be the dominant producers of MCCPs, with the relative proportion of global production occurring in North America and Europe declining.

5. MCCPs are primarily used as secondary plasticisers in polyvinyl chloride (PVC), as extreme pressure additives in metalworking fluids (MWFs) and as additives to rubber (and other polymers), adhesives, sealants, paints. The relative distribution between uses varies considerably between different global regions. The relative proportion of MCCP use in PVC appears to be decreasing in some regions, with the proportion of use in adhesives and sealants now dominating. In some global regions (e.g. Europe, China), the use in MWFs is a relatively minor component of total uses, while in others (e.g. Japan, United States of America (USA)), the use in MWFs is more substantial.

6. The detection of MCCPs in a wide variety of PVC-containing consumer products raises the issue of the presence of MCCPs within products currently in use, and the implications for current and future waste management and release to the environment. The global trade of MCCP commercial products, and MCCP-containing products is also expected to be a significant route of MCCPs into certain markets or regions, and ultimately the environment.

7. MCCPs can be released to the environment throughout their lifecycle from production, use in industrial processes, during the service life of products (both consumer and industrial application), and disposal of waste and recycling of materials containing MCCPs. It is estimated that 20,000–85,000 tonnes of MCCPs are emitted per annum globally. Release to environment during the disposal of waste, e.g. via wastewater treatment is a key – and possibly the main – pathway to environment.

8. Alternatives to MCCPs have been investigated across each of the main use categories. While viable alternatives have been identified and are commercially available in most applications, it is considered that for some applications (e.g. within some applications of PVC and MWFs used in extreme conditions) it is more technically challenging to replicate the same performance and produce final products of comparable quality. This is to an extent associated with the dual role that MCCPs provide (plasticiser/flame retardant). However, in most uses, MCCPs can be substituted with minimal technical or economic impacts. Control measures for MCCPs are also being considered in Europe, with a restriction of MCCPs currently being prepared by the EU.

9. Several Parties and observers have outlined specific uses of MCCPs that could be considered for exemptions to a listing under the Convention. This typically applies to uses where MCCPs are required to meet specific safety/quality standards and where viable alternatives are not currently available. This includes: (i) use in extreme pressure additives for MWFs in high specification components for specific sectors (e.g. motor vehicles,[1] aerospace and defence, other safety-critical uses); (ii) uses in PVC in the production of spare parts of specific products, where high performance and/or safety standards are required and (iii) uses in adhesives/sealants in specific applications where high performance and/or safety standards are required (e.g. in building/construction for preventing water

[1] Defined as: motor vehicles covering all land-based vehicles, such as cars, motorcycles, agriculture and construction vehicles and industrial trucks.

penetration and fracture). There are varying levels of evidence presented for the different exemptions. In some cases, the information provided by Parties and observers in support of specific exemptions such as those listed under (i) have been relatively detailed and presents a stronger evidence base of the technical and economic challenges of replacing MCCPs. This includes the use of PVC in EEE used for 'social infrastructure', and spare parts for automobiles which is supported by well evidenced information. For the remaining uses including PVC use in cables for construction, calendered films, rubber and plastic insulation, and those listed under (iii), limited detail has been provided on the specific use, application, requirement, and lack of alternatives. Further information has been requested to understand these although it has not been received in time for the submission of the final draft of the RME.

10. MCCPs are considered to have 'unknown or variable' constituents and, as such, $C_{14}$–$C_{17}$ chloroalkane constituents that are in the scope of this RME could ('unintentionally') be present in other commercial CP products (e.g. Long chain chlorinated paraffins (LCCPs)). However, this is not considered 'unintentional production' in the strict meaning of the Convention, rather the limiting of the presence of $C_{14–17}$ congeners in other commercial CP products can be considered as a measure, as part of a listing under the Convention to limit this potential route of release.

11. The handling and disposal of waste is a particularly important consideration for MCCPs, given the considerable volumes that are expected to be present in current in-use stocks that will ultimately go into waste streams in the future. Introducing waste management measures, including controls for products and articles upon becoming waste, would contribute to ensuring that wastes containing MCCPs at concentrations above the established low persistent organic pollutant (POP) content limit are disposed of in such a way that the POP content is destroyed or irreversibly transformed.

12. Having prepared a RME and considered the management options, the Persistent Organic Pollutants Review Committee recommends, in accordance with paragraph 9 of Article 8 of the Convention, that the Conference of the Parties to the Stockholm Convention consider listing 'chlorinated paraffins with carbon chain lengths in the range $C_{14–17}$ and chlorination levels at or exceeding 45 percent chlorine by weight' in Annex A, with specific exemptions, and a specified limit on the permitted concentration for these substances in other CP commercial products.

# 1 Introduction

13. Two separate information documents accompany this risk management evaluation (RME), providing additional information and supporting evidence. For clarity (and as documents numbers have not yet been assigned to these documents), throughout this document, these are cited as follows:

(a) UNEP/POPS/POPRC.19/INF/5 – providing supplementary information to the RME;

(b) UNEP/POPS/POPRC.19/INF/6 – providing a separate global emission estimates.

## 1.1 Chemical Identity

14. Polychlorinated *n*-alkanes, also known as chlorinated paraffins (CPs), are a family of manufactured industrial chemicals with different degrees of chlorination and carbon chain length distributions depending on the paraffin feedstock, which is in part dictated by the specific application. CPs are generally subdivided according to their chain length as short (SCCPs: $C_{10}$–$C_{13}$), medium (MCCPs: $C_{14}$–$C_{17}$), and long chain CPs (LCCPs: $C_{18}$–$C_{30}$).

15. This RME focusses on *any CP that has constituents with 14 to 17 carbon atoms ($C_{14–17}$) and chlorination levels at or exceeding 45% chlorine by weight*. These congeners[2] are the principal constituents of substances called "medium-chain chlorinated paraffins" (MCCPs) in Europe, North America and Australia, and major constituents of several products manufactured in Asia (e.g., CP-52) (see UNEP/POPS/POPRC.18/5/Add.1). Due to the possible confusion regarding different product names, the proposal for listing is based on specific chain lengths and degrees of chlorination. For purposes of this RME, the term "MCCPs" is used to refer to the specific congeners that are within this scope throughout the document.

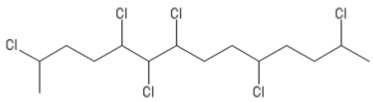
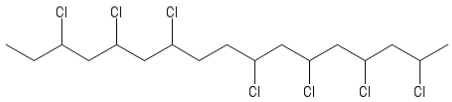
16. Key information for CPs with $C_{14–17}$ chain lengths and chlorination levels at or exceeding 45% chlorine by weight, including molecular formula, structural formula and trade names, is provided in **Table 1** below. Around 40 CAS numbers have been used to identify the whole chlorinated paraffin family. An indicative list of relevant CAS numbers is presented in the supplementary information accompanying the risk profile (UNEP/POPS/POPRC.18/INF/10), however it is noted that this is not an exhaustive list of every individual CAS number that is within the scope of this RME.

[2] For clarity, a CP constituent is an individual structural isomer, i.e., chlorine atoms are in defined molecular positions on the carbon chain. CP congeners are groups of isomers with the same structural formula such as $C_{14}Cl_3$, $C_{15}Cl_4$, without the chlorine position being defined. CP homologues are groups of constituents with the same carbon chain length but varying number of chlorine atoms, e.g., the $C_{14}$ homologue.

17. Existing CAS numbers do not define the level of chlorination by weight in the substance (e.g. 'Alkanes, $C_{14–17}$, chloro'). In practice this means that there may be several different commercial products, varying by chlorine content, sold under the same CAS number. Furthermore, under the same level of chlorination many different compositions could be contained. The percentage chlorine content represents only an average level of chlorination so a much wider range of constituents may be present in any given product. Therefore, higher and lower chlorination levels will be present for a product with a given average chlorination level. Further information on CAS numbers, chain length and chlorination, including an overview of theoretical chlorine content of constituents for $C_{14–17}$ chain lengths is provided in the risk profile (UNEP/POPS/POPRC.18/5/Add.1) and the associated information document (UNEP/POPS/POPRC.18/INF/10).

18. In this RME, a distinction is made between CPs (referring to the specific chemical substance/congener) and CP-containing products (i.e. the commercial product). The chlorine content in commercially available CP products is usually between 40% and 63% by weight, with the majority of products containing chlorine content between 45% and 52% by weight. The chlorination process involves a random substitution of hydrogen by chlorine atoms along the carbon chain of the paraffin feedstock; therefore, CP products contain many thousands of constituents (Yuan et al., 2020; Tomy et al., 1997).[3] It is estimated that theoretically, the number of isomers actually present in MCCP mixtures could be around 1 million (Vetter et al., 2022). Therefore, "MCCPs" is considered a substance of Unknown or Variable composition, Complex reaction product or Biological (UVCB) material.

**Table 1. Information pertaining to the chemical identity of MCCPs**

| | |
|---|---|
| Common name<br><br>IUPAC Chem. Abstracts | Medium chain chlorinated paraffins (MCCPs)<br><br>*Alkanes $C_{14}$–$C_{17}$, Chloro** |
| Other names | Chlorinated paraffins, $C_{14–17}$ |
| Molecular formula | $C_xH_{(2x-y+2)}Cl_y$, where x = 14 to 17 and y = ≥ 5 to 17 |
| Molecular weight | 370-826 g/mol (approximately) |
| CAS registry number | See UNEP/POPS/POPRC.18/11/Add.3 |
| Trade names | Cereclor, Chlorinated Paraffin, Chlorinated paraffin liquid, grade XP-470 (liquid), grade XP-52 (liquid), chlorinated paraffins (CP-470), chlorinated paraffins (CP-52), Chloroparaffin, Chlorparafin, Electroclor, Essechlor, Hordaflex, Hordalub, Paroil |
| Structural formulas of the isomers | Example structures of two representative constituents of CPs with $C_{14}$ and $C_{17}$ chain lengths (hydrogen atoms removed for simplicity) are provided below:<br><br>$C_{14}H_{24}Cl_6$<br><br>$C_{17}H_{29}Cl_7$ |

## 1.2 Conclusions of the Review Committee regarding Annex E information

19. At its eighteenth meeting (Rome 26–30 September 2022), the Committee evaluated the risk profile for MCCPs in accordance with Annex E. The Committee adopted the risk profile for MCCPs in decision POPRC-18/4 and:

(a) Decided, in accordance with paragraph 7(a) of Article 8 of the Convention, that chlorinated paraffins with carbon chain lengths in the range of $C_{14–17}$ and chlorination levels at or exceeding 45% chlorine by weight are likely as a result of their long-range transport, to lead to significant adverse human health and environmental effects such that the global action is warranted;

(b) Also decided, in accordance with paragraph 7(a) of Article 8 of the Convention and paragraph 29 of the annex to decision SC-1/7 of the Conference of the Parties, to establish an intersessional working group to prepare a risk management evaluation that includes an analysis of possible control measures for chlorinated paraffins with carbon chain lengths in the range of $C_{14–17}$ and chlorination levels at or exceeding 45% chlorine by weight in accordance with Annex F to the Convention;

(c) Invited Parties and observers to submit to the Secretariat the information specified in Annex F, in accordance with paragraph 7(a) of the Article 8 of the Convention, before 5 December 2022.

[3] Tomy et al. (1997) includes a formula for the calculation of the number of isomers.

20. The IUPAC name and CAS number cover a broader range of chlorination than the scope proposed in this document.

### 1.3 Data sources

21. The RME is primarily based on information that has been provided by Parties to the Convention and Observers according to Annex F to the Convention. Information was submitted by the following:

(a) Parties: Argentina, Canada, European Union (EU), Guatemala, Hungary, Japan, Netherlands, Norway, Oman, Qatar, Republic of Korea, Saudi Arabia, Sweden, UK;

(b) Observers: International Coordinating Council of Aerospace Industries Associations (ICCAIA), European Automobile Manufacturers' Association (ACEA), World Chlorine Council (WCC), Chlorinated Paraffins Industry Association (CPIA), Alaska Community Action on Toxics (ACAT) and International Pollutants Elimination Network (IPEN).

22. In addition, information has been used from open information sources as well as scientific literature (see the list of references). The following key references were used as a basis to develop the current document:

(a) Risk profile for MCCPs (UNEP/POPS/POPRC.18/11/Add.3);

(b) Information submitted by Parties and observers according to Annex E;

(c) European Chemicals Agency (ECHA) Annex XV Proposal for Identification of MCCPs as Substances of Very High Concern (SVHC) (ECHA, 2021a) and Annex XV Restriction Proposal reports and accompanying documents (ECHA, 2022a);

(d) European Commission (2021) Study to support the review of the list of restricted substances and to assess a new exemption request under Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS);

(e) A review of key scientific literature, and further material and comments provided by Parties and observers.

### 1.4 Status of the chemical under international conventions

23. MCCPs are currently not subject to any international conventions. OSPAR (the Commission for the Protection of Marine Environment of the North-East Atlantic) has concluded that action on the whole range of CPs (including MCCPs) is likely to be needed (OSPAR Commission 2009) (see UNEP/POPS/POPRC.19/INF/5, section 2.1, for further information).

### 1.5 Any national or regional control action taken[4]

24. In the EU,[5] MCCPs (alkanes, $C_{14–17,}$ chloro; CAS No. 85535-85-9) were assessed under the Existing Substances Regulation (EC) No. 793/93 (EC 2005, EC 2007, UK, 2008), and via a transitional Annex XV dossier under the REACH Regulation (Environment Agency, 2010). Subsequently, MCCPs underwent Substance Evaluation under the EU REACH regulation. It was concluded that MCCPs meet the REACH Annex XIII criteria for Persistent, Bioaccumulative and Toxic (PBT) and for very Persistent, very Bioaccumulative (vPvB) properties (Environment Agency, 2019). “MCCPs” have been identified as substances of very high concern (SVHCs),[6] and a proposal to restrict “MCCPs”[7] in the EU was published in 2022 (ECHA, 2022a).

25. Directive 2011/65/EU (RoHS 2) requires EU Member States to ensure that electrical and electronic equipment (EEE) does not contain the substances listed in Annex II in excess of the specified maximum tolerated value. In May

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[4] This is non-exhaustive and only covers recent control actions taken.

[5] EU and the three European Free Trade Association (EFTA) States (Iceland, Liechtenstein, and Norway).

[6] On 23 June 2021 ECHA published the decision (D(2021)4569-DC) that medium-chain chlorinated paraffins (MCCP) (UVCB substances consisting of more than or equal to 80% linear chloroalkanes with carbon chain lengths within the range from $C_{14}$ to $C_{17}$)) are identified as substances of very high concern meeting the criteria under Article 57 of REACH. https://echa.europa.eu/documents/10162/af3efea2-1518-3bbe-0bf5-3867131c2f4c

[7] The proposed EU REACH Restriction covers the manufacturing of substances, and the placing on the market of substances, mixtures and articles if the overall concentration of the chloroalkanes listed below is equal or greater than 0.1% wt.

‘Linear chloroalkanes with the following molecular formulae: $C_{14}H_{30-y}Cl_y$ with y = 3 to 11; $C_{15}H_{32-y}Cl_y$ with y = 3 to 8; $C_{16}H_{34-y}Cl_y$ with y = 3 to 8; $C_{17}H_{36-y}Cl_y$ with y = 6 to 9’.

2022, following a technical assessment, the European Commission published an initiative proposing to add MCCPs to the list of restricted substances (Annex II).[8]

26. The Australian Department of Health published a risk assessment of MCCPs in June 2020 (NICNAS, 2020). This report concluded that MCCPs meet Australia's domestic PBT criteria and that some congener groups may meet the Annex D screening criteria for POPs under the Stockholm Convention.

27. In Canada, an assessment of chlorinated alkanes, including MCCPs, published in 2008 (Canada, 2008), concluded that MCCPs met the criteria for toxicity to the environment and human health, as set out in paragraphs 64 (a) and 64 (c) of the *Canadian Environmental Protection Act, 1999* (CEPA, 1999). Following this assessment, and a 2012 update on the human health assessment of long-chain chlorinated alkanes, chlorinated alkanes containing 10-20 carbons have been added to the List of Toxic Substances in Schedule 1 to CEPA 1999 (Health Canada, 2012). Canada has also listed MCCPs on the National Pollutant Release Inventory (NPRI) under the category "Chlorinated alkanes, medium-chain, $C_nH_xCl_{(2n+2-x)}$, $14 \leq n \leq 17$",[9] with an annual reporting threshold of 1000 kg at 1% concentration manufactured, processed, or otherwise used. Federal Environmental Quality Guidelines (FEQGs) were published in 2016 for chlorinated alkanes in water, sediment, fish tissue, and mammalian wildlife to protect aquatic life and non-human mammalian consumers of aquatic life (Canada, 2016). The aquatic FEQGs are applicable to both marine and freshwater.

28. In the United States of America (USA), the United States Environmental Protection Agency (US EPA) conducted a review in response to premanufacture notices (PMNs) submitted by manufacturers/importers of chloroalkane chemicals. This was followed by a significant new use rule (SNUR) under the U.S. Toxic Substances Control Act (TSCA) issued in September 2019, indicating permitted uses/conditions for these chemicals. The US EPA concluded in the 2019 SNUR that these chloroalkanes "have been manufactured, processed and used for the uses described in the PMNs for more than 40 years; manufacture, processing, distribution in commerce, use and disposal of the PMN substances in accordance with the provisions of the TSCA section 5(e) order do not create an unreasonable risk of injury to health or the environment" (US EPA, 2019).

29. Guatemala (2022, Annex F) is currently considering several options to control imports and uses of CPs.

# 2 Summary information relevant to the risk management evaluation

## 2.1 Production, uses and emissions

### *2.1.1 Production*

30. The commercial production of CPs started in the 1930s. Glüge et al. (2016) estimated that the global manufacture of CPs can be divided broadly into three time periods:[10] (i) 1935–1974: production volumes < 35,000 tonnes/year; (ii) 1975–2005: global CP production increased from 60,000 to 350,000 tonnes/year; (iii) 2006–2012: global (total) CP production increased much more rapidly, up to 1.1 million tonnes/year. Limited information is available from 2013 to present; however, modelling by Chen et al. (2022) suggests overall global production began to fall during this period. The CP manufacturing industry has indicated that production of CPs has been lower in recent years partly due to the global Covid-19 pandemic in 2020-2021, which is reported to have influenced the operation of downstream rubber and plastic processing companies, for example in China (CCAIA, 2020) and elsewhere.

31. The CP manufacturing industry (CPIA, 2022) has indicated the industry differs broadly between global regions (e.g. between Asia and the USA/EU, which are indicated to collectively represent the vast majority of global production, see below). For example, it is suggested that the USA and EU based production on the chain length of the paraffin feedstock, while in Asia, production tends to focus only on the chlorination level. It is suggested that in China, three 'standard' products are produced: 45% (liquid), 52% (extrusion), 70% (solid), and that the CP-52 is the most common,[11] as this is the chlorination level desirable in the widest range of application, e.g. 52% is indicated to be the standard working level for PVC used globally. It was suggested that, when levels reduce down to 40% the technical properties for desired applications become less favourable. These geographical differences mean that it is not possible to estimate a precise proportion of global production that will fall within the exact scope of this RME.

[8] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13469-Hazardous-substances-in-electrical-and-electronic-equipment-list-of-restricted-substances-update-_en.

[9] Including, but not limited to, chloroalkanes, $C_{14-17}$ (CAS RN 85535-85-9), as well as substances or components of mixtures which meet the molecular formula definition. Source : https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/substances-list/threshold.html.

[10] Note to reader – unless stated otherwise, reference to tonnes refers to 'metric tonnes'.

[11] It is indicated in the risk profile (UNEP/POPS/POPRC.18/5/Add.1) that CP-52 accounted for 80% of the total commercial CP production in China in 2005.

However, it is indicated by the CPIA (2022) that globally ~95% of production will be for CP above the 45% chlorination threshold used.

32. Based on modelling by Chen et al. (2022), it is estimated that the global cumulative production of MCCPs in the period 1930 to 2020 was ~18.5 million tonnes, with MCCPs constituting the majority (57%) of total global CPs production. This substantial proportion of MCCPs in the total CP emissions has largely been attributed to MCCPs and LCCPs replacing SCCPs in their applications following the listing of SCCPs under the Convention but could also be linked to the ban of other chemicals such as pentabromodiphenyl ethers (ECHA, 2022a; Stiehl et al., 2008).

33. Different authors have produced estimates for production of CPs and MCCPs for different geographies and timescales. The information presented in the risk profile (UNEP/POPS/POPRC.18/INF/10) suggested that current global production of CPs with $C_{14}$–$C_{17}$ chain lengths could be in the region of 800,000 tonnes/year. To date, information on the regional and global production of CPs are still limited and incomplete, especially with respect to a breakdown of the total CP production into SCCPs, MCCPs, and LCCPs. In the emissions inventory prepared for this RME (see UNEP/POPS/POPRC.19/INF/6), production rates for 16 countries or regions (e.g. the EU) were estimated for the period 2000-2020. Based on this global production of MCCPs was estimated to be 920,000 tonnes per annum in 2020.

34. Ongoing production of MCCPs has been reported in China, India, Japan, Republic of Korea, EU, UK, USA and Qatar (UNEP/POPS/POPRC.19/INF/5). Production of CPs is also expected to be ongoing in other countries, as indicated in Chen et al. (2022) and document UNEP/POPS/POPRC.19/INF/6, e.g. Russia, Thailand, Bangladesh, South Africa, Egypt, Jordan and Brazil; however data on the quantities of MCCP production is lacking. An overview and discussion of reported production data by different countries is provided in document UNEP/POPS/POPRC.19/INF/5. There are currently estimated to be up to 300 CP producers globally.[12]

35. A geographic shift in MCCPs production has been observed in recent years (see ECHA, 2022a; Chen et al., 2022). Manufacture of CPs has decreased in Europe and North America, but has increased significantly in Asia (e.g. India, China) (ECHA, 2022a). It is indicated by the CP industry (MCCP REACH Consortium, 2021) that the global CP industry is dominated by China and India, with 70-80% of the global production located in these countries. The increase in CP manufactured volumes in the period 2005-2012 is also indicated to resulted from production in these two countries (Van Mourik, 2016; UNEP/POPS/POPRC.19/INF/5; UNEP/POPS/POPRC.19/INF/6).

### *2.1.2 Uses*

36. Due to their physical and chemical properties (varying carbon chain lengths and chlorine content, high chemical stability, flame resistance, viscosity, low vapour pressure, and strength at low temperatures) and low costs of production, CPs are used for a wide range of applications (ECHA, 2022a). A detailed overview of the key uses of MCCPs, including the technical functions, and typical working concentrations of MCCPs is provided in document UNEP/POPS/POPRC.19/INF/5. The main uses of MCCPs globally are as a secondary plasticiser, flame retardant and viscosity modifier and adhesion promoter in polyvinyl chloride (PVC), as extreme pressure additives in MWFs and as additives to paints, adhesives, sealants, rubbers and other polymeric materials (UNEP/POPS/POPRC.18/5/Add.1; Glüge et al., 2018). In addition to these primary uses, it is also noted that recycled PVC materials containing MCCPs are used to produce a range of products, for example 'street furniture' e.g. traffic cones and roadside barriers (British Plastics Federation, 2021).

37. Estimates of the volumes of use for MCCPs, and the relative distribution between key use categories, have been made at a global level (Chen et al., 2022) and European level (ECHA, 2022a; EU, 2022 Annex F). The emissions inventory prepared for this RME (see UNEP/POPS/POPRC.19/INF/6) provides estimated volumes of MCCPs globally and for some specific countries for different uses. These estimates suggest that use of MCCPs in flexible PVC is the biggest by volume globally (54%), followed by uses in rubber (17%), sealants and adhesives (13%) and MWFs (11%). According to Geyer et al. (2017), the global use pattern for PVC is dominated by building and construction (69%) with smaller volumes in industrial machinery (12%) and electrical/electronic equipment (8%).

38. The relative distribution of the uses of MCCPs varies considerably between different global regions (see UNEP/POPS/POPRC.19/INF/6, Tables 2a and 2b). For example, in 2020, use in Asia was dominated by PVC and rubber, in North America by MWFs and in Europe by adhesives and sealants. Discrepancies exist between the estimates in different sources, for example, between the estimates from modelling in Chen et al. (2022), the EU REACH Restriction proposal (2022a), and direct input from industry (CPIA, 2020; MCCP REACH Consortium,

[12] The information document of the MCCPs risk profile (see UNEP/POPs/POPRC.18/INF/11) comments that Chen et al (2022) and Li et al (2018) estimate that there are around 100–150 CP producers in China. By extrapolation based on production rates this would suggest around 70–90 producers in India. EU registrations suggests up to 10 producers in the EU. A total of five producers have been identified in North America. Chen et al (2022) estimate that Russian production makes up 7% of global rates (equating to perhaps 10–20 producers). Brazil is also known to produce CPs but at lower quantities; again by extrapolation it could be estimated to have around 10 producers.

2023; CPIA, 2023). This relates largely to the differences in data sources and/or assumptions used in making these estimates. This is discussed in further detail in document UNEP/POPS/POPRC.19/INF/6.

39. In Europe, information gathered directly from producers and users, indicates that use of MCCPs is currently dominated (~60%) by adhesives and sealants (EU, 2022, Annex F; ECHA, 2022a). As modelled in document UNEP/POPS/POPRC.19/INF/6, use of MCCPs in sealants and adhesives is estimated to have increased globally from 8,000 tonnes in 2000 to 35,000 tonnes in 2020. It is indicated that up to 1996, the dominant use category in Europe was use in PVC (83% of the total). Since then, a decline in use for MCCPs in PVC was reported, attributed, in part, to MCCPs being less compatible with primary plasticisers such as diisononyl phthalate (DINP). The decrease in the use of MCCPs may be a consequence of the gradual substitution of diethylhexyl phthalate (DEHP) by DINP and other higher phthalate plasticisers (ECHA, 2021a).

40. In China, information provided by the Chinese CP industry (CCAIA, 2020) suggests that the current distribution of uses for CPs in China is: polyurethane grout (25%); cable material particles (19%); soft curtain (10%); mine conveyor belt (9%); PVC soft tube (8%); rubber insultation (7%); rubber track (6%); carpet (3%); and others (13%). Assuming that the distribution is also applicable to MCCPs, this suggests a higher demand from use in polyurethane adhesives and a relatively lower proportion of use in PVC than suggested by Chen et al. (2022) and UNEP/POPS/POPRC.19/INF/6; however, all sources indicate a relatively low proportion of use in MWFs in China.

41. In the USA, it is indicated that, based on industry data (CPIA, 2023), use of MCCPs is dominated by polymer and rubber (55-60%) and MWFs (35-40%). This is in contrast with the Chen et al. (2022) modelling and document UNEP/POPS/POPRC.19/INF/6 estimates, which suggested the dominant use in North America is MWFs (>50%). However, the sources are in agreement that use of MCCPs in MWFs in North America appears more significant than in other global regions (e.g. Asia, Europe). Canada (2022, Annex F) reported that MCCPs were used mainly in the formulation of MWFs; followed by use in PVC plastics; rubber and elastomers; paints and coatings; and adhesives and sealants.

### *2.1.3 __Trade__*

42. The assessment made in document UNEP/POPS/POPRC.19/INF/6 indicates that China, India, and Europe are all exporters of MCCPs. More information regarding the recipients is available in document UNEP/POPS/POPRC.19/INF/6. The information presented in document UNEP/POPS/POPRC.19/INF/5 indicates that considerable volumes of MCCP-containing products are being traded globally. Furthermore, modelling and analysis conducted by Chen et al. (2022) suggest a net transboundary trade of CP containing products. Global trade in products or articles that are expected to contain MCCPs (e.g. PVC, MWFs, rubber, adhesives and sealants, electronic equipment and cables, and rubber conveyor belts) could represent an important ongoing and future route of MCCPs entering the market (and subsequently the environment) for certain regions and could potentially lead to release of MCCPs related to use and disposal of these products in global regions that do not produce the MCCPs or these products or articles. The emission estimates illustrate that North America and Europe may be net-importers of MCCP containing commodities, while Central and East Asia are net-exporters (see UNEP/POPS/POPRC.19/INF/6).

43. The emissions estimates developed in document UNEP/POPS/POPRC.19/INF/6 also highlight the potential importance of the trade in waste PVC between global regions. For other finished articles the data is either incomplete or not at the required level of detail to produce estimates.

### *2.1.4 __Emissions__*

44. MCCPs can be released to the environment throughout their lifecycle from production, use in industrial processes, during the service life of products (both consumer and industrial applications), and disposal of waste and/or recycling of materials containing MCCPs (Guida et al., 2020). The available monitoring data summarised in the risk profile (UNEP/POPS/POPRC.18/ 11/Add.3) shows widespread occurrence of MCCPs in the environment in multiple regions of the world, including remote regions, indicting ongoing release to the environment from this lifecycle. Furthermore, Guida et al. (2020) highlight the importance of industrial areas, where CPs are likely used, as being ‘hotspots’ of environmental contamination and human exposure. Relatively high atmospheric levels of MCCPs (210–430 ng $m^{-3}$) have been measured in air samples taken in five cities in China associated with CP-related industries (especially the metal working and PVC production industries) (Li et al., 2023).

45. Emissions estimates for MCCPs have been developed previously. For example, Chen et al. (2022), quantified global MCCP emissions based on modelling, but recognised the lack of available emission factors and monitoring data. Other key references include Glüge et al. (2018), the EU REACH Restriction proposal (ECHA, 2022a), previous EU risk evaluations, and risk assessments in the USA as well as relevant OECD emission scenario documents. These references highlight that with a few exceptions, data on emissions, and in particular emission estimates at national/international level are scarce, representing a significant area of uncertainty.

46. As part of this RME, global emission estimates have been developed (see UNEP/POPS/POPRC.19/INF/6). This used the references in the paragraph above along with additional references[13] to develop emission estimates from the different MCCPs lifecycle stages on a temporal (2000–2020) and regional basis to air, soil, water, residue (landfill), and product (as per Annex C emission reporting). This was not intended to supersede existing references but provide additional context and insight. The results of this assessment indicate that globally environmental releases to air, soil, and water for MCCPs have increased since 2000, from around 8,600 tonnes per annum to 20,000 tonnes in 2020. This reflects the increasing production and use of MCCPs over the same time period. As a comparison, Chen et al. (2022) estimate annual global emissions in 2020 to air, soil, and water were around 85,000 tonnes. The difference between the estimates illustrate a potentially wide range for global releases. The estimate reported by Chen et al (2021) is significantly higher primarily because the authors assume much higher rates of release to wastewater (and thus the environment). The work in document UNEP/POPS/POPRC.19/INF/6 has aimed to provide a balance in the references used, with release rates to wastewater that are more closely aligned to the EU REACH restriction. It could therefore be assumed that these two sets of estimates represent the potential range in emissions to the environment as between 20,000 and 85,000 tonnes per annum globally (see UNEP/POPS/POPRC.19/INF/6 for further discussion). Document UNEP/POPS/POPRC.19/INF/6 also indicates that Asia has the highest emission by region, making up 50% of total global environmental releases.

47. The assessment suggests that the most emissive use of MCCPs globally comes from rubber (35%) followed by MWFs (29%), and then PVC uses (20%). However, these estimates are highly sensitive to the assumptions made regarding the proportion of indoor and outdoor use (and the associated emission factors) which are difficult to refine (see UNEP/POPS/POPRC.19/INF/6 for further discussion). Based on the sensitivity analysis the emission rates for PVC and rubber fall within the same overall range. These estimates indicate that the majority of MCCP emissions globally are associated with products or articles with relatively long (up to 20+ year) service life, which has significant implications for handling and disposal of waste. However, a substantial proportion of emissions are estimated to come from the more ‘direct’ application in MWFs.

48. The assessment (see UNEP/POPS/POPRC.19/INF/6) estimates that 8% of all MCCP emissions to air, soil, and water globally come from the manufacture of MCCPs. The manufacture of MCCPs is a dry process, with emissions of MCCPs most likely to come from either generation of contaminated dusts, volatilisation and dust drift, or cleaning of containers and equipment. Where production processes include recovery of chlorine gas and hydrochloric acid and due to the volatility of CPs being considered low, emissions to air are also likely to be low (BiPRO, 2007, cited in ECHA, 2021a). Chen et al. (2022) and document UNEP/POPS/POPRC.19/INF/6 suggest a more substantial issue for manufacture of MCCPs is the release to wastewater or to surface water (either directly or indirectly via wastewater treated effluent) and management of contaminated sludge. While management of sludges varies geographically, land spreading is a major pathway for disposal globally and potentially the single biggest source of release to the environment.

49. CPs from metalworking/metal cutting fluids may be released into aquatic environments from drum disposal, carry-off and spent bath use, as well as the cleaning of metallurgical facilities (BiPRO, 2007, cited in ECHA, 2021a). However, there is the potential for MWFs to be recovered and treated. For example, the CP industry notes that very few metalworking operators surveyed in the USA reported discharge of waste oils/fluids to surface water, but instead indicated use of regulated hazardous waste handlers to dispose of these wastes[14] (WCC-CPIA 2022a Annex F). The survey also suggested that onsite treatment was primarily separation of oil and water, with chlorinated paraffins retained in the oily fraction. Similarly, in the EU, waste oils are regulated under the Waste Framework Directive.[15] This states that waste oils must be collected and managed separately from other wastes (i.e., they cannot be passed to sewer); and furthermore, where technically and economically feasible different grades of waste oil should not be mixed together to form a batch. The EU Waste Framework Directive also requires operators to consider the hazardous nature of wastes in terms of consignment and final management options (including irreversible destruction). Japan (2023a) has also indicated the use of labelling of these wastes as they contain chlorine, noting that users are required to manage this waste separately from other processed oils, and incinerate it at a higher temperature. It is noted that the emission factors for releases to wastewater vary significantly for MWFs (the EU REACH Restriction proposal estimates 5% released to wastewater following onsite treatment (which is also used in document UNEP/POPS/POPRC.19/INF/6), while other references estimate releases of 23% (Chen et al, 2022) and 90–93% (US EPA risk assessment provided by CPIA, 2022 Annex F)), which is attributed in part to differences in the assumed level of waste treatment prior to release.

[13] OECD exposure scenario documents, EU specific environmental release category (SPERCs) emission factors, trade databases (including UN Comtrade, Volza Global, and Zauba), Annex F submissions, additional literature references for MCCP working concentrations, waste practices, recycling rates, and expert judgement and assumptions.

[14] Survey responses were received from 30 companies representing over 65% of the MCCP and LCCP containing MWF used in the USA (in 2014). 28 out of the 30, reported no (zero) release to water.

[15] Directive 2008/98/EC on waste.

50. The emission estimates modelled in document UNEP/POPS/POPRC.19/INF/6 indicate that release to the environment via wastewater treatment works are a key pathway to the environment. This is similar to Chen et al. (2022), who estimated wastewater treatment accounted for ~84% of the cumulative global emissions (assuming direct release to wastewater of expired/waste MWF). However, there are some differences depending on application and life-cycle stage. For example, the global emission estimates for PVC and rubber suggest during manufacture, direct release to the environment contributes around 60% of all emissions, with 40% via wastewater. During service life of articles containing PVC and rubber, the extent of outdoor use is a critical factor in defining emission pathways. For metalworking fluids, release to the environment during application is estimated to be almost 100% via wastewater, with less than 1% direct release as emissions to air.

51. Releases from waste result from the disposal of articles and materials containing MCCPs, and the high release factor during the manual handling and shredding of waste, especially waste from adhesives/sealants (e.g. in construction waste). The importance of this life-cycle stage was highlighted by waste processes being estimated to account for 71% to 84% of the total lifetime releases to environment within the EU (2022, Annex F). MCCPs can leach from products when disposed of to landfill. For example, Brandsma et al., 2021 investigated the release of CPs from new and used spray polyurethane foams (SPFs), noting the end-of-life phase is particularly significant as these materials are challenging to recycle.

52. Even with a restriction/prohibition of production and use of MCCPs, and better controls on potential emissions during production, emissions to the environment are likely to continue due to the emission of MCCPs from products that are currently in use Chen et al. (2022). For example, paints, adhesives, and sealants used in construction, as well as PVC in cables and other applications are likely to remain in use for many years. This also reflects that the production and use of MCCPs has grown globally from around 350,000 tonnes in 2000 to 920,000 tonnes in 2020, and that where the service life of treated articles can range anywhere from 5 to 25 years, a very significant bank of in-use stock now exists, which will have consequences for the waste cycle in future years.

## 2.2 Identification of possible control measures

### *2.2.1* ***<u>Overview</u>***

53. The objective of the Convention (Article 1) is to protect human health and the environment from POPs. This may be achieved by listing MCCPs in:

(a) Annex A or B – to eliminate or restrict releases from intentional production and use as well as import and export (Article 3). This listing could also allow for time-limited specific exemptions or acceptable purposes for the production or use of MCCPs for specific applications, where demonstrated to be appropriate, and encouraging substitution in these applications; and/or

(b) Annex C to reduce or eliminate, where feasible, unintentional production (Article 5).

54. Upon listing under the Convention, Parties are required to take appropriate actions to manage stockpiles and wastes (Article 6). Being mindful of the precautionary approach referred to in Article 1 of the Convention, the aim of any risk management strategy for MCCPs should be, to the extent possible, to reduce and eliminate emissions and releases of MCCPs. This RME considers socio-economic information submitted by Parties and observers to enable a decision to be made by the Conference of the Parties regarding possible control measures.

### *2.2.2* ***<u>Control measures for releases from intentional production and use</u>***

55. As outlined above (section 2.1), quantitative estimates for the levels of ongoing production and use of CPs, including MCCPs specifically, have been made at national, regional (e.g., EU (see ECHA, 2022a)) and global levels (see UNEP/POPS/POPRC.19/INF/5; UNEP/POPS/POPRC.19/INF/6; Chen et al., 2022). The risk profile (UNEP/POPS/POPRC.18/11/Add.3) notes that following national and international restrictions on the use of SCCPs (including listing under the Convention), the supply of MCCPs has increased significantly as the main drop-in replacement. This increase in supply, and consequent environmental emissions, is reflected in the levels of MCCPs in environmental samples.

56. Global trade, both of MCCP commercial products and products and articles containing MCCPs potentially represents a further route of MCCPs into the market and ultimately release to the environment. The decreasing trend in the modelled production volumes of CPs as a whole estimated by Chen et al. (2022) after 2015, potentially indicates that non-CP alternatives are becoming increasingly available, and that substitution is actively taking place in most uses. The listing of MCCPs in Annex A, without specific exemptions, could be considered as a control measure to eliminate the production and the remaining uses at the global scale and to prevent the re-introduction of other uses. Listing under Annex A with specific exemptions would also allow for continued production or use of MCCPs for specific applications, in accordance with that Annex and with Article 4. Listing MCCPs under Annex B would allow for the registration of specific exemptions or acceptable purposes for the production and use of MCCPs, in accordance with that Annex, and with Article 4.

57. The efficacy and efficiency of control measures targeting intentional production and use of MCCPs (i.e. listing under Annex A, with or without specific exemptions, or listing under Annex B) and the potential inclusion of specific exemptions or acceptable purposes in the context of the Convention, will need to consider the availability and technical and economic feasibility of alternatives across different uses, as well as the implications for monitoring and enforceability. This is further considered, in relation to the information submitted by Parties and observers and a review of additional data, in the subsequent sections of this RME and in document UNEP/POPS/POPRC.19/INF/5, section 9.

### *2.2.3 Control measures for releases from unintentional production*

58. Article 5 of the Convention covers measures to reduce or eliminate releases from unintentional production, requiring Parties to take measures to reduce the total releases derived from anthropogenic sources of each of the chemicals listed in Annex C, with the goal of their continuing minimisation and, where feasible, ultimate elimination. As discussed in relation to the listing of SCCPs previously,[16] although unintentional production of MCCPs is limited to one source category (the manufacture of other CP mixtures using hydrocarbon feedstocks), control measures for this source of release could be considered. Listing MCCPs under Annex C could also reduce releases into the environment as a result of the 'unintentional production' of MCCPs during the manufacture of other CP mixtures.

59. The scope of MCCPs covered by this RME is based on specific carbon chain length and degree of chlorination, and specifically includes *"any CP product that has constituents with 14 to 17 carbon atoms ($C_{14–17}$) and a chlorination level at or exceeding 45% Cl wt"*. In this context, it is important to clarify whether the presence in commercial CP products of such constituents are considered:

(a) As the result of "unintentional production" in the context of Article 5 and Annex C of the Convention;[17]

(b) As "(unintended) constituents" subject to control measures as defined in Article 3 and Annex A, or B of the Convention; or

(c) As "unintentional trace contaminants", as defined in note (i) of Annexes A and B, and therefore exempted from control measures under the Convention.

60. Listing under Annex C could be considered as a potential control measure (as was initially considered for the proposed listing of SCCPs) as the presence of MCCPs in other CP commercial products is possible. However, it will need to be considered if this strictly constitutes *'unintentional production'* of these constituents and if this would be the most effective or appropriate means of controlling the emissions to the environment, compared with setting controls to limit the presence of MCCPs in other chlorinated paraffin mixtures to a specified level, as was implemented for SCCP (note (vii) in Annex A) in all products (substances, mixtures and articles).

### *2.2.4 Control measures for releases from stockpiles and wastes*

61. Chen et al., (2022) reported model estimates that a total of ~18.8-24.4 million tonnes of MCCPs have been produced and used globally (from 1930 to 2020),[18] ~40% of which still resided within in-use products by 2020, with the majority globally expected to be residing in PVC products (78%), followed by rubber and other plastics (11%) and adhesives and sealants (8%). Stocks of MCCPs contained in articles in use will be available for long-term emissions in the future, which emphasises the importance of this life-cycle stage in terms of the potential environmental release.

62. As discussed in section 2.1, the waste phase is expected to be important for MCCPs. Guida et al. (2020) suggested that due to the relatively high historic production of CPs (in comparison with most POPs currently listed under the Convention),[19] the amount of waste containing CPs and the quantity of CPs released to the environment during waste management is also expected to be high. Wastes containing MCCP are likely to include PVC, MWFs, rubber, adhesives and sealants, electronic equipment and cables, rubber and mine conveyor belts, polyurethane grout, cable material particles, soft curtains, PVC soft tube, rubber insultation, rubber track, carpets etc. and are likely to be found in waste streams from building and demolition as well as from industrial applications. The emissions estimates provided in document UNEP/POPS/POPRC.19/INF/6 suggests that, in 2000, 77,000 tonnes of MCCP (within finished mixtures and articles) was consigned to landfill globally, rising to 214,000 tonnes in 2020. Over the period 2000 to 2020 this creates a stock of 2.8 million tonnes of MCCP residing within landfills globally. Further information and background on MCCPs in stockpiles and waste is provided in document UNEP/POPS/POPRC.19/INF/5.

[16] See UNEP/POPS/POPRC.12/11/Add.3.

[17] i.e. formed and released unintentionally from anthropogenic sources.

[18] Based on the estimation that from 1930−2020 MCCPs accounted for 57−74% of global in-use stocks of CPs (Chen et al., 2022).

[19] For example, it was indicated that the volumes of the following POPs listed under the Convention were: PFOS: 12,200 tonnes per year (2004); DDT 68,800 tonnes per year between 1971-81 and currently much lower. DecaBDE 1,100,000–1,250,000 tonnes in total from 1970–2005.

63. Introducing waste management measures, including controls for products and articles upon becoming waste (in accordance with Article 6), would contribute to ensuring that wastes containing MCCPs at concentrations above the low POP content limit (LPCL) are disposed of in such a way that the POP content is destroyed or irreversibly transformed so that they do not exhibit the characteristics of POPs. Alternatively, waste containing POPs may be disposed of in an environmentally sound manner when destruction or irreversible transformation does not represent the environmentally preferable option, or the POP content is below the regulated threshold. These measures would also address waste handling, collection, transportation and storage to eliminate or reduce emissions and the resulting exposure to MCCPs.

64. Listing MCCPs under the Convention would eliminate or reduce the MCCP content in new products, thereby reducing releases from the waste stream in the longer term. In addition, Parties would be required to implement management measures to address the waste streams of existing MCCPs stocks in accordance with Article 6. If MCCPs are listed under the Convention, a LPCL would need to be established in cooperation with the Basel Convention and wastes containing MCCPs at or above a LPCL would need to be handled in accordance with the provisions of Article 6.

65. Waste management activities should take into account international rules, standards, and guidelines, including those that may be developed under, or in cooperation with, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, and relevant global and regional regimes governing the management of hazardous wastes. Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with MCCPs would be developed by an expert group jointly with the Basel Convention. Parties should also consider emission reduction measures and the development of guidance and use of best available techniques and best environmental practices (BAT/BEP) in the waste management phase. In addition, Parties must endeavour to develop appropriate strategies for identifying sites contaminated with MCCPs, as these have been highlighted as potential ‘hot spots’ for environmental pollution for MCCPs (Guida et al., 2020). If contaminated sites are identified and remediation is undertaken, it must be performed in an environmentally sound manner, in accordance with Article 6 to the Convention (paragraph 1(e)).

## 2.3 Efficacy and efficiency of possible control measures in meeting risk reducing goals

### *2.3.1 <u>Intentional Production</u>*

66. For listing of MCCPs under Annex A or B, the efficiency of the control measure is closely related to the availability of alternatives (see section 2.4 for further discussion), and whether it is possible to transition to the alternatives through the supply chain without loss of technical function or incurring excessive socio-economic costs (see section 2.5 for further discussion). The efficacy and technical feasibility of the control measures relate to how emissions and exposure can be limited as far as possible and substitution to safer alternatives can be best promoted.

67. In terms of the scope of the proposed listing, the ECHA (2022a) REACH Restriction proposal also considered the effectiveness and practicality of restricting MCCPs based on a defined carbon chain length and % chlorination.[20] ECHA (2022a) concluded that this approach could be considered ‘effective’ in that it is targeted to the identified risk (i.e. the presence of congeners with PBT and/or vPvB properties). However, the ECHA (2022a) report also highlights the challenges of this approach in practice. For example, ECHA (2022a) note that the chlorination level is a parameter which is controlled during the manufacturing process of chloroalkanes, and that it is commonly understood in the supply chain that chlorine content refers to the average degree of chlorination for the substance itself, rather than the degree of chlorination of the congener groups. ECHA (2022a) argued that this would mean that a wider range of congener groups than those with a degree of chlorination above an average of 45% could be present and would in principle need to be taken into account when determining whether a product would fall within the scope of the restriction. ECHA (2022a) argued that, as the commercially available chloroalkanes generally include more than one carbon chain length and more than one congener group, a definition based on carbon chain length and a chlorination level should be specific to the congener groups and not to an entire substance, as the proposed listing may therefore create confusion if the definition is not clearly understood and applied to congener groups by all actors in the supply chain. Furthermore, if manufacturers/importers of chloroalkanes only indicate the degree of chlorination of the substance, for downstream users, independently analysing the average degree of chlorination of the chloroalkane precursor that contributes to the composition of their product is cumbersome and could potentially require the quantification of all the chloroalkanes congener groups (ECHA, 2022a).

68. However, the CP manufacturing industry (MCCP Consortium, 2023) has indicated that there may also be practical challenges with using such a congener based approach (as proposed for the EU Restriction), largely due to the range of $C_{14}$–$C_{17}$ chloroalkane congener groups which are themselves complex and variable groupings of isomers with the same molecular weight. The primary chloroalkane commercial products subject to the (ECHA, 2022a) restriction proposal are considered to be UVCB substances, defined by their starting materials and the chemical reactions used to make them. Due to validated lab availability and the need for specific methodologies, MCCP

[20] See section E.1.1.1 of the Appendix to the EU REACH Restriction proposal.

Consortium (2023) considered that most of the suppliers of these substances (or importers of articles containing these substances) will not be able to perform the complex congener analysis needed for comparison with the families of congeners in the proposed ECHA Restriction. The CP industry (MCCP Consortium, 2023) indicated that, while carbon-chain length of the starting material is likely to be relatively straight-forward to apply to well-defined chloroalkanes, some CP products, particularly those produced in Asia, often do not have precisely defined feedstocks and are manufactured based on chlorination level alone (e.g. CP-52). The CP industry (MCCP Consortium, 2023) has indicated this complex congener analysis could be very challenging for suppliers (and importers) to carry out in practice. They indicated that a more simplified or targeted consideration of the chain length of the paraffin feedstock and the manufacturing process involved (e.g. based only on chlorination or other chemical reactions) could be considered for the ECHA Restriction. Further discussion of these issues is provided in section 2.3.4.

***Prohibition (Listing within Annex A without specific exemptions)***

69. The efficacy of a listing in Annex A without exemptions would provide the maximum benefit to avoid human health and environmental impacts by eliminating all manufacturing and use (and therefore future emissions to the environment and associated exposure). The section on alternatives (see section 2.4) identifies a wide set of available options for substituting MCCPs, suggesting that, for the majority of uses, alternatives already exist and have been commercialised. A listing under Annex A without exemptions would also prevent import of MCCP-containing articles into other global regions where MCCPs are not currently produced.

***Information on the uses where exemptions may be needed based on requests by Parties and observers***

70. Inputs from Parties and observers (e.g. in Annex F submissions and comments) have identified a number of uses of MCCPs where exemptions are requested. In most cases, this has been based on a consideration (by those Parties and observers) on the current availability of technically feasible alternatives, and the technical and (socio)economic implications associated with substitution, as well as the estimated timeline for transition to alternatives. This section outlines and discusses the uses proposed for an exemption. More detailed information presented by the Parties and observers relating to proposed exemptions is provided in document UNEP/POPS/POPRC.19/INF/5. A summary of key information is provided below for each of the use categories where exemptions have been proposed.

71. Key sectors highlighted include aerospace and defence, automotive,[21] construction and medical applications. It is noted that, in a number of these industries, alternatives to CPs have been investigated for many years, and while some have identified and implemented alternatives to specific applications for some uses of MWFs, lubricants, adhesives, and maskants[22] (as reported in their Annex F submissions) there are some specific applications where finding viable alternatives is considered more challenging, either due to regulatory constraints (e.g. compliance with safety standards) or economic and practical issues.

***Use in PVC, rubber and other polymers***

72. Japan (2022, Annex F) has proposed that the use of MCCPs for PVC used in electrical and electronic equipment (EEE) used for ‘social infrastructure[23] should be considered for an exemption from listing under the Convention. This specifically refers to PVC-containing parts used in medical devices and in-vitro diagnostics devices, and in instruments for measurement, analysis, manufacturing, control, monitoring, test and inspection,[24] namely the components in spare parts (e.g. insulation sheathing or sleeves for electrical cables, as well as in O-rings, packing and the body and housing of components) for those devices.

73. Japan (2023) noted that the continued use of MCCPs in PVC for these parts may need to be exempted due to the specific performance requirements, e.g. the IEC (International Electro-technical Commission) standards, fire resistance, performance at high temperature, and prevention of thermal-ageing. However, details of specific assessments of alternatives against these standards have not been provided. Section 2.4 of this RME indicates that alternatives exist for many applications of PVC, and that the overall proportion of use of MCCPs in PVC in comparison with other uses has been declining in recent decades, largely due to compatibility issues with other

[21] Defined as:(motor vehicles covering all land-based vehicles, such as cars, motorcycles, agriculture and construction vehicles and industrial trucks).

[22] Inert substances used to protect specific areas of the material during chemical etching.

[23] Defined as: electric and electronic equipment used for medical practice (such as clinical, diagnostic, inspection, analysis, monitoring and others) and industrial and other types of monitoring, control, analysis and measurement. equipment, in laboratories, infrastructure of transportation, lifelines, security, disaster preventions, and process control of many types of production.

[24] Specific examples proposed include: (i) Medical devices, such as MRI systems, ultrasound diagnosis devices; X-ray imaging systems; flexible endoscopes; (ii) In vitro diagnostics devices, ; such as, immunoassay analysers, haematology analyser, polymerase chain reaction (PCR) testing systems, genetic analysers, clinical chemistry analysers, blood coagulation analysers and urinalysis analysers; (iii) Instruments for measuring, analysis, manufacturing, control, monitoring, test and inspection.

plasticisers. However, as discussed in section 2.4, in some cases the development of alternatives that fully replicate the same (dual) performance of MCCPs can be technically challenging and involve relatively long lead in times.

74. Japan (2023b) considers that if MCCPs are prohibited or restricted in these medical devices, a long grace period would be required in order to test the product to comply with the safety requirements defined with IEC standards and obtain re-certification according to the requirements. However, it is noted that the specified performance standards require the use of PVC, but do not specify the use of MCCPs. Given that alternatives for the use of MCCPs in PVC are available, it could mean that not all uses where PVC is required require exemption.

75. Japan (2023b) and ACEA (2023a,b) have provided evidence to support an exemption for use of MCCPs in PVC-containing spare parts for automobiles (as well as the synthetic rubber Ethylene Propylene Diene Monomer, EPDM, and other polymeric material). The list of specific parts suggested is broad-ranging,[25] While section 2.4 has indicated that alternatives to use in PVC applications may be available, the key reasoning presented for an exemption in these uses is due to the technically challenging and cost prohibitive nature of developing alternatives in spare parts, which are typically produced at relatively small scale. ACEA (2023) and JAPIA (2023) indicated that a lead in time of more than five years may be needed to substitute appropriate materials to provide sufficient time to assure appropriate safety performance for these uses in motor vehicles.[26] Further background discussion is provided in document UNEP/POPS/POPRC.19/INF/5.

76. China (2023) has requested an exemption for uses of MCCPs in PVC (and rubber) for the construction sector, including: uses in wires and cables, uses in calendered films in the packaging field, and uses in rubber and plastic insulation materials, noting that China uses $C_{14–17}$ chlorinated paraffins in these applications to meet the requirements of safety performance such as tensile strength, electrical insulation and flame resistance. China considers that, currently, substitutes and alternative technologies are not available yet, and the testing time for potential alternatives is relatively long, so these specific exemptions are needed. However, details of specific assessments of alternatives against specific performance standards have not been provided. It is noted that these uses are broad and more detailed information has been requested on the precise uses, specific safety performance requirements, standards, and lack of alternatives, but this has not been received in time for the submission of the final draft of the RME.

77. While Aerospace and Defence Industries Associations of Europe (ASD) (2021) indicated that MCCPs are used in electrical and electronic equipment as a plasticiser and flame retardant, principally within PVC cable insulation in aerospace applications, no specific exemptions for polymer use have been requested for this sector.

***Use in metal working fluids (MWFs)***

78. As discussed in section 2.4 and in ECHA (2022a), viable alternatives to MCCPs are available in most applications for MWFs. Furthermore, it is noted that in some cases, the use of non-halogenated MWFs is explicitly recommended because halogenated MWFs such as CPs require designation as dangerous waste which prompts stringent management measures and higher disposal costs (e.g. see WA Department of Ecology, 2021). However, some specific uses in the working of particular metals and alloys may not have viable alternatives at present. For example, the substitution of MCCPs is seen as challenging for ‘heavy duty’ metal working processes, i.e. for applications where high temperature (600–1,000ºC) and extreme pressure (up to 1,400 pascals) are needed. Specific processes highlighted by Parties and observers include ‘deep drawing’, ‘broaching’ and ‘fine blanking’ (EU, 2022 Annex F), drawing with ironing; precision metal working (cutting/punching/drilling). tapping, cold drawing, and cold rolling (pilgering) used on hard materials such as stainless steel and titanium, as well as nickel and aluminium (UK, 2023 Annex F; Japan, 2022 Annex F; WCC, 2022 Annex F).

79. Input from Parties and observers (Japan, UK, China, WCC-CPIA, ACEA, ASD, ICCAIA), as well as wider input from industry stakeholders (e.g. Special Metals Wiggin, 2021) has highlighted the potential implications or challenges for production of parts in specific sectors, e.g. aerospace, defence, automobiles, and energy.

80. In the aerospace and defence sector, it is suggested that exemptions may be required relating specifically to the manufacture of specific metal parts[27] through processes that are considered technically challenging to conduct without MCCP-based additives, and where alternatives are not currently viable to produce components with the required performance (e.g. to withstand extreme temperatures, corrosive environments, and stress encountered in flight, with

[25] Including: powertrain and under-hood applications such as powertrains, wiring and harness under hood (engine wiring, etc.); hoses, caps, tubes, filters; fuel system applications such as fuel hoses, fuel tanks, caps, under body; suspension and interior applications such as trim components, acoustic material and seat belts; exterior vehicle applications such as foam pads, sealers, gaskets, fasteners, windows; pyrotechnical devices and applications affected by pyrotechnical devices such as air bag ignition cables, seat covers/fabrics (only if airbag relevant) and airbags.

[26] Defined as: motor vehicles covering all land-based vehicles, such as cars, motorcycles, agriculture and construction vehicles and industrial trucks.

[27] For example, fasteners for aircraft and jet engines, including nuts, bolts, latch pins, and rivets, as well as stainless steel and high strength nickel alloy used in aerospace fuel lines, brake line and hydraulic systems, and stainless steel wire.

low weight materials). In 2015, the US Department of Defense stated in a letter to US EPA that MCCPs have critical military applications in MWFs (including the production of fasteners, forming and fabricating metals and metal products used in precision optics) (WCC-CPIA, 2022 Annex F). Additionally, in 2016, in a letter to the US EPA, the American Wire Producers Association stated that “if CPs become unavailable in the US for use in wire drawing lubricants, manufacturers will be unable to continue some or most of their operations" (WCC-CPIA, 2022, Annex F). In 2016, in a letter to US EPA, the Aerospace Industries Associations required extended time and information in order to identify any potential initiatives for many of the applications where MCCPs are used (WCC-CPIA, 2022, Annex F). More recent inputs from these industry representatives have not been provided. The UK (2021) also highlight the use of MCCP-based MWFs in the working of precision nickel alloys in aero engines and in the airframes of different types of aircraft. An exemption may be considered for the use of MCCPs in the fabrication of these parts, also recognising the stringent testing and requalification programmes which support continued certification/ approval of products to globally recognised aviation and defence requirements, and relatively long (10+ year) lead in time for testing and certifying materials in safety-critical applications in this sector.

81. In the automotive sector, ACEA, (2023b), Japan (2022, Annex F) and WCC (2022, Annex F) highlight that MCCP-containing MWFs are used only in very specific applications, e.g. where complex shape processing and hard-to-cut machining material (stainless steel and nickel alloy) or deep drawing and ironing processes are required. They indicate that current alternatives to extreme pressure additives containing MCCPs cannot obtain the equivalent level of performance. Specific parts where this is required are indicated to include: muffler flanges, catalytic converters and sensors. JAPIA (2023) indicated that a transition period of 15 years from the start of the restriction would be needed for MWFs in these types of applications.

82. The UK (2021) has highlighted the potential need for exemptions for the use of MCCP-based MWFs in a number of other uses, based on the input from several downstream users of MWFs (including Special Metal Wiggins, 2021). For example, the following specific uses have been proposed: use in agricultural and construction machinery and tools; use in military applications (e.g. production of tanks, munitions); use in nuclear power; use in energy generation (e.g. in heat exchangers in conventional and renewable energy production, nickel tubes in high efficiency steam reformers for hydrogen production); use in deep sea oil and gas extraction; use in chemical production and refining; and use in hydrogen fuel cell vehicles. The UK considered that current alternatives are not sufficient to achieve the required level of performance and restriction in the use of MCCP-based MWFs could cause a number of practical, economic and environmental challenges (UK, 2023, Annex F) and is requesting a transition period of 10 years so that a full evaluation of alternative MWF performance across a range of alloys can be conducted. UK industry have highlighted concerns that if no alternatives are identified through exhausting all possible approaches to developing alternatives, an indefinite exemption may be needed due to the vital roles these products play in the development of sustainable technologies, and for key aerospace, defence and energy applications) (UK, 2023, Annex F). Similarly, ASD (2021) raised concerns that critical aerospace and defence uses of MCCPs may not be possible to replace in all circumstances (UK, 2023, Annex F).

83. Japan (2023) has highlighted that parts with complex metal working used for EEE used for ‘social infrastructure’ should be considered for an exemption. Specific examples of these uses, provided by Japan (2023) include: use in weighing machines (e.g. to ensure accuracy and fast weighing, as well as hygienic design, for example to prevent bacterial growth); use in collaborative robots; use in gas analysers; and use in solder joint inspection.

84. ECHA (2022a) has concluded that it is not certain whether alternatives are technically able to replace MCCPs in all MWFs uses, such as heavy-duty working operations, and a 7-year transition period may be needed.

***Use in adhesives and sealants***

85. The Adhesives and Sealants Council (ASC) in the USA highlights that CPs impart flame-retardant properties to building and construction sealants and adhesives. They suggest that there are “no drop-in replacement(s) available for these materials” (WCC, 2022, Annex F). However, as discussed in section 2.4, information from the EU indicates that alternatives are available and substitution in this sector is taking place (with no request for an exemption), although it is noted that a drop-in alternative does not appear to be available, resulting in the need for product reformulation. While it is indicated that MCCPs are used in adhesives, sealants and coatings for important applications in the aerospace sector (ASD, 2021), no exemptions in this specific sector have been requested by Parties or observers.

86. China (2023) indicate the need for an exemption concerning the use of MCCP-containing adhesives and sealants, specifically in joint filler for closed environments, in chlorinated rubber coatings marine and industrial fields, and in polyurethane plastic outdoor running tracks. They note that MCCPs are needed to meet the requirements of specific effects such as preventing water penetration and fracture, for environmental applications that require long-term contact with water and to improve safety performance. More information is being sought to understand the precise use, application, lack of alternatives, and requirement, but this has not been received in time for the submission of the final draft of the RME.

*Summary*

87. While viable alternatives to MCCPs have been identified and are currently used in most applications discussed in this RME, Parties and observers have highlighted a number of uses where alternatives are not currently available and where exemptions to a listing could be considered. For example, for MWFs, a distinction should be made between high temperature and extreme pressure applications (e.g., deep drawing, broaching, etc) and other metal working applications (cutting and sawing, etc) which require less intensive conditions. A summary of the exemption requests is provided in **Table 2** below. Based on the above discussion, a full prohibition (Annex A listing) of the production and use (with no exemptions) does not seem viable for all sectors of use for MCCPs, as this could negatively impact a number of key sectors.

**Table 2. Overview of exemptions requested by Parties and observers**

| Use category | Description | Specific sectors/uses covered | Requested by |
|---|---|---|---|
| **Metal working fluids** | Use in extreme temperature and pressure additives for MWFs used in specific 'heavy duty' processes[28] used for the production of specific metal or metal alloy components.[29] | **Aerospace and defence –** for production of specific metal components – incl. fasteners for aircraft and jet engines, incl. nuts, bolts, latch pins, and rivets, as well as stainless steel and high strength nickel alloy used in aerospace fuel lines, brake line and hydraulic systems, aero engines, airframes, and stainless-steel wire. | Japan<br>WCC/CPIA<br>ICCAIA<br>UK |
| | | **Automobiles** – for production of specific metal components – incl. deep drawing of muffler flanges, catalytic covers, sensors, etc., and deep drawing and ironing processes. | Japan<br>ACEA |
| | | **EEE used for 'social infrastructure' –** incl. use in weighing machines; use in collaborative robots; use in gas analysers; and use in solder joint inspection | Japan |
| | | **Others** – incl. the working of metal or metal alloy components used in the production of machinery and tools used in agriculture and building/construction; energy and power generation, oil and gas extraction, chemical production and refining, nuclear facilities, and low-carbon technologies (hydrogen fuel cell vehicles and in hydrogen production) | UK |
| **PVC, rubber and other polymers** | Use in PVC, rubber or other polymers for production of specific spare parts for use in 'social infrastructure',[30] automobiles, construction, packaging and insulation. | **Social infrastructure**, specifically medical devices, in-vitro diagnostics devices, and instruments for measurement, analysis, manufacturing, control, monitoring, test and inspection. | Japan |
| | | **Automobiles** – incl. powertrain and under-hood applications, wiring and harness under hood (engine wiring, etc.); hoses, caps, tubes, filters; fuel system applications such as fuel hoses, fuel tanks, caps, under body; suspension and interior applications such as trim components, acoustic material and seat belts; exterior vehicle applications such as foam pads, sealers, gaskets, fasteners, | ACEA<br>Japan |

[28] Namely: deep drawing, broaching and fine blanking, drawing with ironing; precision metal working (cutting/punching/drilling), tapping, cold drawing, and cold rolling (pilgering).

[29] Namely: stainless steel, titanium, nickel and aluminium

[30] Defined as: electric and electronic equipment used for, medical practice (such as clinical, diagnostic, inspection, analysis, monitoring and others) and industrial and other types of monitoring, control, analysis and measurement equipment, in laboratories, infrastructures of transportation, lifelines, security, disaster preventions, and process control of many types of productions.

| Use category | Description | Specific sectors/uses covered | Requested by |
|---|---|---|---|
| | | windows; pyrotechnical devices and applications affected by pyrotechnical devices such as airbags, air bag ignition cables, and seat covers/fabrics. | |
| | | **Construction, packaging and insulation** – Uses in wires and cables in the construction sector<br>Uses in calendered films in the packaging field<br>Uses in rubber and plastic insulation materials | China |
| **Adhesives and sealants** | Use in joint filler for closed, in chlorinated rubber coatings for marine and industrial fields, and in outdoor plastic running tracks | **Building / construction** – joint filler for closed environments. | China |
| | | **Uses in chlorinated rubber coatings for marine and industrial fields** | China |
| | | **Uses in outdoor plastic running tracks** | China |

***Restriction (Listing within Annex A or B with specific exemptions/acceptable purposes)***

88. If MCCPs are listed in Annex A or B to the Convention with specific exemptions or acceptable purposes, measures to limit emissions and releases from ongoing production and use (as permitted for Parties listed in the register for specific exemptions) will be important to minimise those releases. The development of a guidance document on BAT/BEP could also be considered to minimise the further release of MCCPs from those uses.

89. As outlined in section 2.1, production volume of MCCPs varies between global regions, with net transboundary trade of both the technical CP mixtures, and MCCP containing products expected to occur between regions, particularly between Asia (China and India) and Europe and the USA. Additionally, the structure of these producing countries varies significantly. Based on Chen et al. (2022), North American and European producers are typified by a relatively low number of large sized companies. Production in Asia (China and India) is more diverse with producers of varying size from small-medium sized enterprises (SME companies) to large sized producers.

90. As discussed in section 2.1, the largest release during CPs manufacture results from volatilisation and dust drift, meaning that the soil around production sites can become contaminated. Control measures should therefore focus on air abatement and strict control of dust drift to protect environmental release.

91. Qatar (2022, Annex F) reports that they have upgraded abatement controls for manufacturing of CPs within the country including air pollution control systems (APCS) such as bag filters, wet scrubbers, NaOH/Alkali injection, and use of active carbon filters. These approaches are aimed at targeting management of volatised CPs and in particular capture and control of fine dusts.

92. Furthermore, the EU best available techniques (BAT) reference documents provide details on types of abatement equipment and costs to help manage releases for the organic chemical manufacture sector. This could be assumed to represent the most sophisticated BAT/BEP options for minimising releases. Further details of the possible abatement technologies are provided in document UNEP/POPS/POPRC.19/INF/5. In practice, it can be expected that there will be a range of release controls (ranging from no/limited control to highly sophisticated control) implemented by CP manufacturers across the globe.

93. When CPs are incorporated as additives in PVC, rubber, paints or sealants and adhesives, releases can be controlled at the production sites if sound management of chemicals and BAT/BEP are employed to control vapours, liquids and processes. A Convention listing could act as the catalyst for upgrade of abatement options for manufacture and consistent emission controls globally. As discussed in section 2.1 emissions during the use of CPs within industrial settings for applications such as PVC, rubber, MWFs, and sealants and adhesives are primarily to water.

94. MCCPs are used for a range of applications. WCC-CPIA (2022, Annex F) provide feedback from the US EPA risk assessment, noting that for use of MCCPs in PVC, rubber, MWFs, and sealants and adhesives, the major release pathway is to water / wastewater, and that standard municipal wastewater treatment is unlikely to be effective in removing MCCPs. These releases are associated with losses from mixing vessels, spillages, and primarily cleaning of equipment and containers. For MWFs, this also includes cleaning of the finished pieces to remove excess fluid from the surface of the finished metal. The responses from WCC-CPIA (2022, Annex F) suggest that releases of MWFs can

be controlled by good maintenance of equipment to limit/prevent losses, and/or containment options to capture any spillages. Furthermore, avoiding cleaning of drums/totes used to deliver MCCPs onsite (and instead sending them for specialist cleaning and decontamination), and cleaning of other equipment using approaches which limit the use of water as far as possible.

95. The EU REACH Restriction proposal (2022) identifies metal working as one of the biggest sources of environmental release (along with formulation and use of sealants and adhesives). A key issue is that losses to wastewater and sewer, are sent to municipal wastewater treatment works, which are unlikely to remove the majority of MCCPs from the wastewater. The EU REACH Restriction proposal does however also state that these releases can be limited if BAT/BEP abatement processes are followed (i.e., onsite pre-treatment of wastewaters). As noted in section 2.1, the CP industry (WCC-CPIA, 2022a, Annex F) indicated that very few metalworking operators surveyed in the USA reported discharge of waste oils/fluids to surface water, but rather indicated adherence to environmental regulation with wastewaters collected for management as hazardous waste at off-site wastewater treatment plants. The CPIA further comment that additional analysis is needed to determine what proportion of MCCPs are destroyed during high temperature extreme pressure metal working processes, and what proportion remain within wastewaters. It is noted that current insight into release to the environment from MWFs is based on a relatively small number of installations in one global region (North America).

96. MCCPs are used as mixtures or within finished articles for professional and consumer uses. During the normal use of these mixtures (e.g., sealants and paints) and articles (e.g., PVC and rubber in active service life) it is possible for further emissions to the environment and direct/indirect exposure to occur as described in section 2.1. For example, Brandsma et al. (2021) has reported that one- and two- component spray polyurethane foams (SPFs) can be an important emission pathway of CPs to the environment. Options to limit emissions during service life for these applications are limited. However, this represents a smaller fraction of the overall emissions from professional and consumer uses of MCCPs in mixtures and articles. It is considered that the more significant issue is the appropriate management of these articles at end of life.

### *2.3.2 Unintentional Production*

97. Section 2.2 highlighted an important distinction regarding how the definition of ‘unintentional production’ in the strict meaning of the Convention is applied to MCCPs in terms of the efficacy and efficiency of the control measures to be applied. This is further elaborated here, and more detailed background discussion is provided in document UNEP/POPS/POPRC.19/INF/5, section 8.

98. Firstly, there is no evidence that MCCPs are unintentionally formed by thermal processes such as incineration because they are not thermally stable, and instead are expected to be degraded. Therefore, control measures for the ‘unintentional production’ (in the strict meaning under the Convention Article 5) of MCCPs from thermal process are not considered to be required.

99. Secondly, MCCPs are considered a UVCB, and as such, $C_{14}$–$C_{17}$ chloroalkane constituents that are in the scope of this RME could be (‘unintentionally’) present in other commercial products (e.g. LCCPs). For example, it has been reported that LCCPs can contain up to 20% $C_{17}$ (Environment Agency, 2019; UK, 2008; ECHA 2022a). The carbon chain length distribution of a CP product reflects that of the parent hydrocarbon feedstock. As highlighted by the EU (2022, Annex F), the presence of CPs with $C_{14–17}$ in LCCPs should not be considered as the result of an ‘unintentional’ trace contamination, but due to intentional feed-stock selection to produce the LCCPs (i.e. present as ‘unintentional constituents’). The continued manufacture and use of these products could therefore represent a continued source of release of these MCCP congeners to the environment. Control measures to avoid/minimise the presence of these ‘unintentional constituents’ is therefore required if MCCPs are listed within Annex A or B with exemptions or acceptable purposes allowing continued production and use.

100. One possible control measure to address this issue would be to include controls to limit the presence of the listed substance in other commercial CP products to a specified threshold level (i.e. a % proportion of $C_{14–17}$ and >45% Cl), as was implemented in the listing for SCCPs.[31] A 1% limit was applied SCCPs, as it was noted in UNEP/POPS/POPRC.12/11/Add.3 that in Norway and in the EU, regulations were enacted to prohibit the production or placing on the market and use of substances or preparations containing SCCPs at concentrations equal to or greater than 1%).

101. The MCCP REACH Consortium (2023) indicated that, based on a recent survey of the LCCP REACH registrants, it was their understanding that most LCCP commercial products (EC No. 264-150-0) do not contain $C_{14–17}$ chloroalkanes at ≥0.1%. Furthermore, the few LCCP products that may contain $C_{14–17}$ chloroalkanes at ≥0.1% represent a minor fraction of the overall LCCP products/tonnages on the market. JAPIA (2023) reported that they had received information from a Japanese fluid manufacturer that the amount of MCCP contained as an impurity in LCCP should not exceed 1%.

[31] UNEP/POPS/COP.8/14.

102. As discussed above, in practice, setting a limit of this kind could present practical challenges for manufacturers as well as downstream users and importers of articles. For example, this would likely require manufacturers to have a good understanding and control of the chain length of the paraffin feedstock. This could present a challenge for some Parties to implement this as a control measure (for example where the chain length of the feedstock is not currently monitored or controlled), and also in the enforcement and monitoring of a restriction.

103. It also appears that the downstream users of LCCPs do not have information regarding the composition of the chloroalkanes they purchase, and therefore may not know if the substance contains $C_{16–17}$ CPs congener groups, or not (ECHA, 2022a). Furthermore, the EU (2022, Annex F) notes that other process issues such as cross contamination from one manufactured batch to another may also affect the presence of CPs with $C_{14–17}$ chain lengths in other CP commercial mixtures. Therefore, development of BAP/BET would support the implementation of this control measure.

### *2.3.3 Stockpiles and Wastes*

104. Under Article 6(1) of the Stockholm Convention a listing of a substance within the Annexes of the Convention triggers obligations for the identification and management of affected wastes. This would require ratified Parties to include details of how MCCP-containing waste would be managed as part of National Implementation Plans (Article 7). This would likely include the need for targeted monitoring and enforcement activities to carefully manage waste and prevent mismanagement which could lead to emissions.

105. As noted in section 2.2, for MCCPs, the substantial volumes expected to reside within products in-use, presents a challenge for implementing control measures for preventing/minimising releases from waste handling/disposal. For PVC, rubber and adhesives/sealants, the service life of products is expected to be 10–20 years (see UNEP/POPS/POPRC.19/INF/6), and the separation and appropriate management of these wastes is likely to be a significant challenge to waste management/disposal practices. Technologies for the destruction and irreversible transformation of MCCPs in wastes would be evaluated jointly with the Basel Convention. If the MCCP-containing wastes exceed the set LPCL,[32] Parties would need to dispose of the waste in such a way that the POPs content is destroyed or irreversibly transformed (often by means of incineration), or disposed of in an environmentally sound manner (in accordance with Article 6 (1d (ii)). For example, it is not expected that all PVC products will contain MCCPs, so in cases where there is an absence of adequate cost-effective methods of identifying which products contain MCCPs, and their concentration, whole waste streams may need to be incinerated, potentially creating technical and economic challenges. Non-combustion technologies e.g., supercritical water oxidation (SCWO) and gas-phase chemical reduction (GPCR) could also be considered but it would need to be demonstrated how feasible and cost effective these techniques are in destroying MCCPs.

106. As highlighted in the discussion in document UNEP/POPS/POPRC.19/INF/5, there are potentially challenges relating to the required capacity and quality of incineration facilities to adequately destroy the MCCPs whilst preventing the formation of hazardous substances such as polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) and other chlorinated substances. This is particularly significant given the very large volumes of in-use products globally that will ultimately end up in waste streams. There are expected to be significant differences in incineration capacity, suitability and regulatory control between global regions. Furthermore, incineration facilities may not accept wastes with high levels of PVC/chlorine. In the case of handling and disposal of waste with high levels of PVC/chlorine, destruction by incineration may not be feasible if incinerator facilities lack the capacity to handle such large volumes of waste. This is because there are strict limits exist on the volumes of those wastes that can be processed. due to the release of hydrochloric acid. In practice, waste streams containing PVC may need to be significantly 'diluted' with other types of waste to be able to handle high volumes of PVC and comply with limits on acceptable chlorine contents and/or the MCCP LPCL limit. No information on quantified costs associated with these aspects of waste handling and disposal have been provided.

107. According to Plastics Recyclers Europe (PRE) (2021), in certain sectors, e.g. WEEE in the electronics and ELVs in the transport sectors, where the residual waste from cable recycling is likely to have much lower MCCP concentrations (as other materials and polymers are typically not removed prior to ultimate disposal), this waste is already expected to go to incineration due to the exceedance of the LPCL for PBDEs. According to the Basel Convention technical guidelines, waste containing POPs should be treated separately from other waste in order to avoid the contamination of other waste streams. Mixing materials, without blending, prior to waste treatment may be appropriate in order to enable treatment or to optimise treatment efficiency. However, the mixing of wastes with POP contents above a defined low POP content with other materials solely for the purpose of generating a mixture with a POP content at or below the defined low POP content is not environmentally sound.[33]

[32] Furthermore, if listed under the Convention, a low POP content limit (LPCL) would be established (in accordance with Article 6 (1d(ii) of the Convention) for waste containing MCCPs.

[33] See: General technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants. June 2019. UNEP/CHW.14/7/Add.1/Rev.1.

108. Document UNEP/POPS/POPRC.19/INF/6 estimates that, globally, in 2020 170,000 tonnes/year of MCCP was recycled back into use through secondary uses (increasing from 59,000 tonnes in 2000). The recycling rates of key MCCP containing materials such as PVC and rubber is expected to be significant in China, Europe and the USA. This suggests that recycling of MCCP-containing PVC and rubber may happen in significant quantities. It has been highlighted that, in Europe, construction waste is a particularly significant waste stream for recycling facilities (e.g. for cable materials). Here again, potential practical and economic challenges for the sorting and separation of materials have been highlighted. In the case of handling and disposal of waste with high levels of PVC/chlorine, destruction by incineration may not be feasible if incinerator facilities lack the capacity to handle such large volumes of waste, as strict limits exist on the volumes of those wastes that can be processed. In practice, waste streams containing PVC may need to be significantly ‘diluted’ with other types of waste to be able to handle high volumes of PVC and comply with limits on acceptable chlorine contents and/or the MCCP LPCL limit. The constraints for this in relation to the Basel Convention are discussed above.

### *2.3.4 Analytical methods, enforceability and monitorability*

109. If a prohibition or restriction (listing under Annex A or B of the Convention) is implemented, appropriate monitoring will need to be in place to ensure this can be enforced in practice. In the case of MCCPs (as defined with a specific carbon chain length and % degree of chlorination), this would need to ensure the substances in scope of the Convention listing can be detected and quantified, in commercial CP products, in the articles in which they are contained, and in waste streams.

110. EU (2022, Annex F; ECHA, 2022a) notes that enforcement of a restriction/ban on MCCPs could be foreseen using one or more of the following methods: manufacturer/producer/downstream user industrial site inspections; spot checks of imports (e.g. by the customs); retailer site inspections; retailers/social media website inspections. The enforcement could be performed either with laboratory testing to check the presence of congener groups, or with paper or document-based inspection: i.e. verification of paper records such as registration dossier, inventory records (purchased goods, sold goods, source of supply, material composition, SDS content, technical documentation etc.).

111. A key challenge in the context of enforceability and monitorability of a listing for MCCPs under the Convention is ensuring the analytical methods and approaches used are adequate for the scope of substances defined in the listing. To clarify, the proposed listing is for *“any CP product that has constituents with 14 to 17 carbon atoms ($C_{14–17}$) and a chlorination level at or exceeding 45% Cl wt”*, noting the distinction made in the risk profile between ‘constituents’ (i.e. individual structural isomers), ‘congeners’ and ‘homologues’. As discussed in section 1 of this RME, the listing covers a substance of unknown or variable composition, hence there are practical challenges associated with the analytical methods required to detect and quantify them in commercial products, downstream uses and waste streams.

112. As discussed in van Mourik et al. (2020) and Valderhaug et al. (2022), analysis of CPs has been conducted for decades but, due to the complexity of the mixtures, chromatographic resolution of the constituents has remained elusive. It is noted that complexity arises from the number of compounds present in the mixtures, with potentially several hundred thousand isomers (Yuan et al., 2020) and, due to the challenging analysis, variations in quantitation results have been observed between laboratories, especially if they have insufficient matching of standards and sample (Fernandes, 2022).

113. Available techniques range from more simplistic low-resolution ‘screening’ methods which provide a total concentration of chloroalkanes as a single value, for example X-ray fluorescence (XRF) to simply detect the presence of CPs (Nevondo et al., 2019), to more advanced analytical methods based on chromatographic techniques that can provide more reliable and targeted results to quantify specific isomers or congeners (EU, 2022 Annex F). As reported by the EU (2022, Annex F; ECHA, 2022a) in recent years, the development of new technologies has significantly improved the performance of available analytical methods and advanced techniques enabling sufficient selectively in the identification and quantification of groups of congeners having the same carbon chain length and chlorination level (i.e. chlorinated alkanes: $C_{14–17}$) are now available (e.g. see Bogdal et al., (2015), Yuan et al., (2017) and Chen et al., (2011)).

114. Different analytical techniques potentially offer different levels of insight into the presence and levels of the complex components of a CP mixture. For example, the more advanced techniques available could offer the potential to detect, i) chloroalkanes <with medium carbon chain lengths distinguished from short carbon chain lengths and from long carbon chain lengths; ii) detailed individual chloroalkane congener groups ($C_nCl_m$) and, iii) the isomeric distributions of CP mixtures with single chain lengths but varying degrees of chlorination (EU, 2022, Annex F). It is noted that no chromatographic method is currently available that allows for the separation of congeners into their different isomers. NMR analysis is required for this level of detail (Sprengel et al., 2019) and can only confirm the structure of single isomers (van Mourik et al., 2021; Valderhaug et al., 2022).

115. Fernandes et al. (2022) reported some limitations in the existing set of commercially available standards and the benefits of an extended range of individual CP compound standards and noted that a more extensive range of single chain standards as well as homologue group standards would allow a higher degree of matching to the profiles

seen in samples. Homologue group standards are now available on the market but a greater number of these standards would improve the quality of the quantification. One particular challenge is that the evaluation and extraction of data from the complex mass spectra (containing thousands of signals from hundreds of different C−Cl homologue classes) are very time-consuming processes. Recently, an automated spectra evaluation routine that speeds up the process by one to two orders of magnitude has been developed (Knobloch et al., 2022).

116. It is acknowledged that several inputs from Parties and observers to the Convention have queried whether a more efficient listing covering the agreed scope for MCCPs is by either using a congener-based listing or extending the scope to a value below 45% chlorination. This would be a change to the listing agreed for the risk profile. As discussed in the risk profile, and section 1.1 of this document, all commercial MCCPs products are supplied based on percentage degree of chlorination, and outside of Asia, additionally using carbon chain length. The listing is designed to restrict production of the listed MCCPs, and it is important to be clear which products are impacted. As discussed in section 2.3.1 and above, there are practical issues for analysing MCCPs.

117. As noted in section 1.1 and 2.1, there are commercial MCCP products supplied with a chlorination content below <45% (suggested to be around 5% of all supplied MCCPs, although no further information is available). Therefore, there would be a potential impact if the listing scope was enlarged for enforcement purposes beyond the scope of risk profile. In any case, if a concentration limit was included as part of the listing (as discussed in section 2.3.2 *Unintentional Production*) these <45% Cl commercial products would need to comply with the concentration limit.

118. The ECHA (2022a) REACH Restriction proposal has also reviewed the potential enforceability of a restriction based on both defined carbon chain length and % degree of chlorination (as discussed in section 2.3.1). ECHA concluded that enforcement of such as listing is feasible using available laboratory testing techniques. However, it was also considered that, depending on the nature of the product that is under scrutiny, the laboratory techniques may require the quantification of all $C_{14-17}$ congener groups so that the average chlorination level can be derived. The CP industry (MCCP Consortium, 2023) has indicated this could be practically very challenging for suppliers and importers to achieve. They indicated that a more simplified or targeted consideration of the chain length of the paraffin feedstock and the manufacturing process involved (e.g. based only on chlorination or other chemical reactions) could be considered.

119. ECHA (2022a) also considered that paper-based inspection could be possible but would require thorough documentation of the average degree of chlorination of chloroalkanes across the entire supply chain.

## 2.4 Information on alternatives (products and processes)

### *2.4.1 Overview of alternatives*

120. The alternatives identified in this RME can be grouped by end use application: PVC products, rubber, and other polymers, textiles and leathers, extreme pressure additives for MWFs, paints and coatings, and adhesives and sealants. While, for many applications, alternatives have been identified, it is reported that no single alternative has been found suitable for all uses of MCCPs (Danish EPA, 2014; UNEP, 2016; Öko-Institut, 2019; ECHA, 2022a).

121. As outlined in the sections below (based on information on alternatives provided in Annex F submissions and a review of additional literature) and based on the findings of the restriction proposal for MCCPs in the EU (ECHA, 2022a), available alternatives have been identified for MCCPs for each key specific application. Furthermore, Japan (2022, Annex F) has indicated successful identification and implementation of alternatives to specific applications of some uses of MWFs, lubricants, adhesives, and maskants. However, most alternatives identified are not “drop-in” alternatives and thus, cannot be used for every application (Japan, 2022, Annex F). For example, some applications have additional flammability or other requirements that must be met prior to certification.

122. As discussed by ECHA (2022a) and EU (2022, Annex F), for PVC, technically feasible alternative substances or technologies are available, even though substitution may lead to a slight increase in production costs of PVC compounds. It is also noted that feasibility of substitution/removal may differ between different types of PVC compounds. For other key uses (including rubber, adhesives/sealants, paper, and leather) technically and economically feasible alternatives for these uses are available or are expected to be available such that substitution can be achieved before a listing is put in place. For most major applications, less environmentally harmful alternatives to MCCPs are available. Among other suggestions, these include nitroalkanes, alkyl phosphate and sulfonated fatty acid esters, non-ortho-phthalates and vegetable oil-based products, which may be appropriate for specific applications (Danish EPA, 2014). In leather production, natural animal, vegetable oils and/or mineral oil may be used as substitutes. For paint and coating applications, polyacrylic esters, diisobutyrate and phosphates may be used. Flame retardant alternatives include aluminium hydroxide, antimony trioxide, acrylic polymers, and phosphate containing compounds (IPEN, 2022 Annex F).

123. To transition to any alternative substance, as noted in the General guidance, “alternatives to POPs should be quantitatively assessed, including human health and environmental risks, using hazard data and an estimate of

exposure, including a comparison of toxicity or ecotoxicity data with detected or predicted levels of a chemical resulting or anticipated to result from its long-range environmental transport, as stated in paragraph 2 of Annex D to the Convention”.[34]

### 2.4.2 ***Alternative substances***

*PVC and other polymers*

124. MCCPs are used in several polymer systems, predominantly PVC products such as cables, with a smaller usage in floors and coated fabrics. The function of MCCPs in these applications is twofold: (1) As a plasticiser, which is to manipulate the flexibility of the polymer and (2) As a flame retardant, which is intended to prevent or slow the development of further ignition.

125. LCCPs were thought to be an adequate chemical alternative that provides both plasticisation and flame retardancy. However, further research revealed that in some applications of PVCs and rubbers, LCCPs can result in a material that is too brittle for the application, or which has insufficient flame retardancy for others (Danish EPA 2014, Öko-institut 2019). CPs (up to 20 carbon atoms) meet the definition of ‘toxic’ under paragraph 64(a) of CEPA 1999, which further limits some LCCPs for use as alternatives in some cases within Canada (Canada, 2013; Canada, 2022a). The balance of viscosity to flame retardancy is also a concern with LCCPs, as longer carbon chains result in higher viscosity, but the chlorine percentage may need to be decreased to bring the viscosity back into the working limits of the material, sacrificing flame retardancy (ECHA, 2022a). The regulatory strategy for flame retardants in the EU (2023) suggests that LCCPs should no longer be used as flame retardants due to the potential PBT/vPvB properties associated with MCCPs and SCCPs that may be present in LCCPs (ECHA, 2023f). LCCPs are listed on the UK REACH rolling action plan for substance evaluation due to a PBT concern (HSE, 2022). LCCPs have been found in Arctic biota, including cetaceans and shellfish, which suggests a possible concern for persistence, bioaccumulation, and long-range transport (Yuan, 2021a).

126. Weingart et al. (2018) has recently presented developments in chlorinated methyl esters (CMEs) which have shown some promise in PVC applications as both a plasticiser and a flame retardant, as well as adhesives and sealants and MWFs, with claims that CMEs readily biodegrade; however, there is emerging evidence that CMEs may be thyroid active at an *in vitro* level (ECHA, 2021a; Environment Agency, 2022). Since 2018, CMEs have also been used in MWFs and sealants and adhesives and have recently been registered at 1000-10000 tonne/year under EU REACH (ECHA, 2023h).

127. For PVC uses, Kemi (2016) indicated that, in electronic cable applications, MCCPs can be substituted, and technically feasible alternatives can be found. However, it is considered unlikely that one single substance can substitute MCCPs across all uses since MCCPs function as both a plasticiser and flame retardant. The phthalates diisodecyl phthalate (DIDP) and DINP exhibit technical advantages compared to MCCPs as plasticisers for PVC. However, they lack the flame-retardant properties MCCPs provide (Danish EPA, 2014; Entec, 2008a; Zarogiannis, 2010). DIDP and DINP, along with other *ortho*-phthalates, are restricted under EU REACH for applications where the article is a toy or childcare article that may be placed in the mouth due to the hazard classifications of aquatic toxicity, skin irritant, and eye irritant, along with suspected carcinogenic properties (KEMI, 2019; ECHA, 2018; ECHA, 2021b; ECHA, 2023g). These substances are also included in Canada’s Chemicals Management Plan under the phthalates substances grouping, with follow-up activities planned to track changes in exposure and commercial use due to the associated health and/or ecological concerns (Canada, 2022b). These alternative plasticisers can substitute MCCPs starting at double the unit price (see UNEP/POPS/POPRC.19/INF/5, section 11), but they lack flame-retardant properties (ECHA, 2021a).

128. Flame retardant alternatives such as phosphates, aluminium hydroxide, aluminium polyphosphate and other chlorinated or brominated compounds must be used in conjunction with plasticiser alternatives mentioned above in order to achieve both the flame retardation and plasticising properties of MCCPs for plasticised PVC (Danish EPA, 2014). Further analysis of the environmental and health risks would be needed to assess the suitability of these as alternatives. The costs associated with using a combination of alternative plasticisers and flame retardants is a 40–60% increase as compared to MCCP costs (Danish EPA, 2014). While some of these alternatives are close to the unit price of MCCPs, as these additives will also need a plasticising alternative counterpart which could result in in a higher total price for alternative chemistries (ECHA, 2021a).

129. Canada (2022a, Annex F) noted that, although technically feasible, the use of alternatives may increase the raw material costs for manufacturers. Concern about the compatibility of existing plastics with MCCPs versus future alternatives has been raised, specifically by the electrical cabling sector (Japan 2022, Annex F).

130. As electrical cabling is used for a long period of time and repaired when needed, poor compatibility between the polymer sheathing once alternatives are introduced could lead to an inability to perform repairs as weak points in

[34] The general guidance for assessing alternatives can be found here: https://chm.pops.int/Implementation/Alternatives/Overview/tabid/5834/Default.aspx.

the cable sheathing can occur, and therefore the service life of the electrical article is shortened, creating larger amounts of electrical waste (Japan 2022, Annex F). While some alternatives are available, they must be implemented at the beginning of the service life of the electrical article, as the issue is mainly for repairs when new cabling is spliced onto old cabling to repair a defect in the cable sheathing or restore connection. One EU company indicated that substitution appears to be challenging in specific types of cables, which need to comply with the more stringent fire performance requirements set out in Regulation (EU) No 305/2011, specifically, the EN 50399 tests (which tests for fire characteristics of cables such as flame spread, power generation, smoke formation, and burning droplets as is the basis for CE marking) required for copper clad aluminium (CCA) types of cables (ECHA, 2022a).

131. When considering other polymers, such as natural and synthetic rubbers, the majority of alternative considerations are based on the substitution of SCCPs and not MCCPs (ECHA 2021a). The primary function of MCCPs in rubbers is flame retardancy due to the inherently flammable nature of the material, and a number of suitable alternatives have been proposed. UNEP suggested inorganic compounds such as aluminium hydroxide, brominated flame retardants and organophosphorus compounds could replace SCCPs in rubber formulations (UNEP/POPS/POPRC.12/11/Add.3). Based on the call for evidence to the EU MCCP restriction proposal, there are substitution activities ongoing for conveyor belts and fireproof doors and bellows for buses/trains, with the European Tyre & Rubber Manufacturers Association (ETRMA) suggesting a 24 month transition period would be needed due to challenges acquiring raw materials (ECHA, 2022a). In the EU, substitution activities in this sector are ongoing and are in the final stage for most of the products (ECHA, 2022a). Some companies producing rubber conveyor belts for underground activities, which need to meet several European standards[32], have already started research and development activities to find substitutes and consider LCCPs suitable (EC No. 264-150-0, with carbon chain lengths $C_{22–30}$) (ECHA, 2022a). LCCPs have been suggested as an alternative of choice for other rubber products that have to meet strict conditions of use in terms of fire resistance and safety, for example in the transport sector; however future use of LCCPs would need to be compliant with any listing of MCCPs under the Convention (ECHA, 2022a).

132. In addition to LCCPs, several phosphate-based flame retardants were identified as potential alternatives in rubber conveyor belts by some stakeholders interviewed by ECHA for the EU REACH Restriction proposal, among which phenol, isopropylated, phosphate (3:1) (EC No. 273-066-3) and tricresyl phosphate (TCP) (EC No. 215-548-8) may be considered as technically feasible substitutes (ECHA, 2022a). For other types of rubber products, alternative flame retardants also appear to be available and, as indicated by the ETRMA, the industry has identified suitable alternatives and is prepared to begin substituting in industrial production (ECHA, 2022a).

***Metal working fluids (MWFs)***

133. Concerns about higher disposal costs and/or preclusion from recycling or re-refining the waste oil motivates users of metal-working fluids toward use of alternatives to CPs (e.g. see WA Department of Ecology, 2021). CP-free alternatives are available for some uses for the working of aluminium, magnesium and titanium and the transition to non-CP chemistries has been made for some machining of aluminium alloys (Canter, 2014). Alternatives for MCCPs in MWFs pose a challenge due to the extreme environments these fluids are used in, such as tapping, rimming, boring, broaching, extrusion, and pilgering (Environment Agency, 2019). As MWFs are formulated to target specific end use applications, finding any simple drop-in alternative may be challenging and alternatives may have to be examined on an end-use basis.

134. A 2004 report prepared by the Institute for Research and Technical Assistance for the US EPA found that there are suitable alternatives to MCCPs in MWFs, including vegetable ester, petroleum, and polymer based lubricants. Of the eight companies that participated in the research, all were able to find suitable alternatives to chlorinated paraffins, with four of the companies seeing a reduction in overall costs which was attributed to lower raw material costs and decreased cleaning costs (IRTA, 2004). Further work has been done on incorporating vegetable-based fluids into oil- and water-based lubricants to develop Environmentally Adaptive Lubricants (EALS), which have high biodegradability, low toxicity, and equal or better performance as compared to conventional additives (Skerlos, 2008). Companies such as Metalloid Corporation have specialized in developing MWF free of chlorinated paraffins for metalworking applications including aerospace, automotive, medical, and other manufacturing applications (Metalloid, 2023).

135. In 2012 Dover Chemical Corporation released marketing material detailing greener alternatives to extreme pressure lubricants such as those containing MCCPs. These alternatives include sulphurised hydrocarbons, phosphate acid esters, chlorinated fatty esters and acids, as well as phosphorous-containing blends and nitrogen containing compounds, many of which are still produced and available for purchase (Dover, 2023).

136. Nitrogen-, phosphorus- and sulphur- based additives work in a similar way to MCCPs, as there is an activation of the additive when the metal surface reaches a specific temperature, and the released salt prevents welding of metal surfaces through lubrication (UK, 2008; EU, 2022 Annex F). Phosphonates are reported to have “excellent performance” in high temperatures, and when combined with calcium and sodium sulfonates with sulphurised esters the performance can match that of MCCPs (Environment Agency 2019). However, acid alkyl phosphates are considered difficult to work with due to their acidity and come at a higher price, while zinc dialkyl dithiophosphate can leave a burn residue when used at high temperatures (Environment Agency, 2019; ECHA 2021a). Phosphorus-

based compounds include substances such as tributyl phosphate, alkyl phosphate esters, phosphate acid esters, and hydrogen phosphites (non-inclusive list) (UNEP/POPS/POPRC.12/11/Add.3).

137. Sulphides as solids are promising, as viscosity is constant until the melting point, but are limited in high temperature applications due to poor solubility and have an intense odour (UK, 2008). Sulphur-based compounds include substance such as zinc dialkyl dithiophosphate, sulfonated fatty esters, overbased calcium sulphonates (non-inclusive list) (UNEP/POPS/POPRC.12/11/Add.3). Lanxess noted that some sulphur carriers are suitable formulation components for EU Aerospace companies, as companies such as Boeing have approved the use of non-chlorinated MWFs that are compatible for applications including titanium, high nickel alloys, stainless steel, aluminium, brass and all ferrous substrates (AMD, 2009). IRMCO Fluids, an American company, produces oil free, low viscosity metal forming lubricants with high solid polymers that will thicken and attached to the metal surface under deformation heat, therefore forming a friction reducing barrier (Bay, 2010). These lubricants are also used in applications including the stamping and punching of mild and advanced high strength steel, as well as aluminium and titanium (Bay, 2010). Ecolabel and US VGP compliant formulations and are made partially from renewable raw materials, along with no additional disposal costs and outstanding efficiency over broad temperature ranges (Lanxess, 2022b). Further information regarding the performance of sulphur carriers compared to MCCPs can be found in document UNEP/POPS/POPRC.19/INF/5, section 11.

138. The WCC-CPIA expressed concern regarding alternatives for MCCPs in some MWF fluid applications, which were further elaborated on by Special Metals Wiggins (2021) in their response to the draft UK proposal to list MCCPs to the Convention in 2021. Special Metals Wiggins noted that, for applications such as deep sea oil and gas extraction, the nuclear power industry, and areas that require precision nickel alloys such as aerospace engines and hydrogen fuel cells, a suitable alternative to MCCPs has not been identified yet.

139. It is estimated that a 15 year period would be necessary to find suitable alternatives to all MWF applications and implement these alternatives (Japan 2022, Annex F). However, Lanxess has noted that there is detailed knowledge available within the industry to overcome concerns regarding alternatives for niche applications (Lanxess 2022a). ECHA (2022) concluded that alternatives for MWFs appear to be available, noting, however, that at this stage, it is not certain whether they are technically able to replace MCCPs in all MWFs uses, such as heavy-duty working operations. Canada noted that available alternatives are identified in Canada, but some substitutes may not be technically suitable for all applications and may be more costly as they are expected to incur reformulation costs, as well as increased operating costs (Canada 2022, Annex F).

***Adhesives and Sealants***

140. Available information indicates that technically feasible alternatives should provide the sealants with the functions currently provided by MCCPs. Suitable alternatives (which can include a combination of chemicals) should provide the same properties as MCCPs (such as act as plasticiser, flame retardant and/or filler), as well as meet a number of physico-chemical criteria. For one-component foams (OCF), alternatives should be non-reactive to isocyanates and meet certain criteria in terms of viscosity, hydrophobicity, solubility etc., in order to be chemically compatible with the PU prepolymer system inside the OCF can. Additional criteria and performance requirements may include the ability of the alternative to act as an emulsifying agent and meet the required shelf-life criteria (ECHA, 2022a)

141. For insulating glass (IG) polysulfide sealants, any suitable alternative needs to be compatible with the polysulfide polymer technology, provide good adhesion, mechanical properties and UV stability to the sealant and have a very low migration potential (ECHA, 2022a). According to the information available in the EU, substitution efforts in this sector are taking place and potential alternatives appear to be available on the market (ECHA, 2022a). However, a drop-in alternative does not appear to be available, resulting in the need for product reformulations (ECHA, 2022a).

142. With regard to polysulfide sealants, some benzoates (e.g. oxydipropyl dibenzoate (DPGDB), and phthalates, e.g. DINP, appear to be among the main potential substitutes (ECHA, 2022a). The known hazards of the phthalates are discussed above. Phthalic esters and phosphoric esters have been used in sealants as plasticisers previously (UNEP/POPS/POPRC.12/11/Add.3). Several alternatives, including tris(2-chloro-1-methylethyl)phosphate (TCPP), appear to be suitable to replace substances containing MCCPs in rigid polyurethane foams (ECHA, 2022a). Substitution is expected to be completed in the EU before 2025 with no additional impacts on the industry (ECHA, 2022a).

***Textiles and Leathers***

143. Within textiles, the majority of information regarding alternatives is focused on substituting SCCPs. Since both SCCPs and MCCPs are used/have been used in similar applications, it is suggested that MCCPs could be substituted with similar alternatives. CPs are primarily used as flame retardants, of which many suitable compounds have been identified, such as brominated flame retardants (allyl 2,4,6-tribromophenyl, dibromostyrene, tetrabromophthalic anhydride) or phosphorous containing flame retardants (ECHA, 2022a).

144. Within leather fat liquors, MCCPs are not considered essential to the performance of the application, with the EU working to phase out MCCPs and other countries such as the UK completely phasing out their use. Alternatives, such as sulphurised animal and vegetable oils have been suggested (Entec, 2008). Although many types of fat liquors are available on the market, CPs appear to be used in fat liquor products that need to provide a particularly high degree of softness to leather, as well as water and tear resistance (ECHA, 2022a). 'Paraffin waxes and Hydrocarbon waxes, chloro, sulfochlorinated, saponified (CAS No. 1469983-39-8)' is currently used in fat liquors in the EU. This substance may contain MCCPs in a concentration varying between below 0.1 % and up to ca. 10 %., depending on the grade of the feedstock (presence of $C_{14}$–$C_{17}$ alkanes) used and on the amount of alkane that would be chlorinated but not sulfonated. Some users of the fat-liquoring substance 'Paraffin waxes and Hydrocarbon waxes, chloro, sulfochlorinated, saponified' confirmed that the substance they use contains <0.1 % of MCCPs (and also confirmed that their suppliers are indeed already using an alkane/alkene feedstock with <0.1 % of MCCPs). Therefore, it is expected that companies that may be currently using the substances containing more than 0.1 % of MCCPs chloroalkanes will shift to compositions containing <0.1 % of MCCPs (ECHA, 2022a).

***Paints and Coatings***

145. Within paints and coatings, MCCPs are used in industrial settings as marine and anti-corrosion coatings due to their ability to increase the hydrophobic nature of the paint or coating, as well as act as a plasticiser (ECHA, 2022a). Due to this, few alternatives have been identified that allow for a simple substitution. In acrylic topcoats, polybutenes have been suggested to replace MCCPs (Environment Agency, 2019). However, further information about the technical feasibility of MCCP alternatives is limited when it comes to underwater applications.

146. Based on the information provided by coating producers in the context of the EU REACH Restriction proposal, it appears that substitution is ongoing in the EU and that technically and economically feasible alternatives are available. Some of the major players in the EU market have already phased out the use of MCCPs in marine and protective coating formulations (ECHA, 2022a). Acrylic- and epoxy-based primers have been suggested as a suitable substitute for underwater paint applications where paints that contained MCCPs have been traditionally used to reduce corrosion on underwater metals (Environment Agency, 2019).

147. MCCPs are also used as viscosity modifiers and adhesion promoters in coatings (ECHA 2021a). Polyacrylic esters, diisobutyrate, and phosphates have been suggested as suitable alternatives for MCCPs (Afirm, 2021; ECHA, 2021a). When used for their flame-retardant properties, MCCPs in paints and coatings have been substituted with other flame retardants, such as halogenated compounds or melamine derivatives (Danish EPA, 2014). LCCPs (with chain lengths $C_{22–30}$) are widely used as fire retardant and plasticiser in fire retardant paints and solvent-based intumescent coatings. As LCCPs can currently contain MCCPs, future use of LCCPs would need to be compliant with any listing of MCCPs under the Convention.

### 2.4.3 ***<u>Alternative techniques</u>***

148. For some applications where MCCPs are used as additives, there are alternative techniques that can be used to avoid the use of MCCPs. These techniques are more substantial than simply changing the additive from MCCPs to an alternative substance. All of the alternative techniques discussed here are chemical alternatives, however they reflect a fundamental change in the carrying substance of the MCCPs (e.g., the lubricant base for MWFs or the polymer type for other applications) and can require operational processes to change.

***PVC***

149. In some applications where PVC with MCCPs is used, alternative polymer systems can be used instead. Low-smoke free-of-halogen (LSFOH) polymer compounds, such as acrylonitrile butadiene styrene (ABS) systems, or non-halogenated flame retardants in polymers of similar plasticity can be used, with considerations taken for local cable test specifications (of which there may be many) (Shah, 2021). For electrical cable applications, a number of polymer/flame retardant systems have been shown to be effective alternatives for PVC/MCCP systems, as outlined in by the Danish EPA (2014). Similar polymer/flame retardant systems to replace PVC with MCCPs are suggested by Oeko-Institut (2019). Of these, some notable alternative systems include inorganic flame retardants (zinc borate, zinc stannate and hydroxystannates, and metal hydroxides), in combination with phosphorus-based compounds (aluminium diethylphosphinate or phosphate esters) and elastomers such as natural rubber, poly-styrene-butadiene rubbers, and silicone rubbers of thermoplastic elastomers have been employed in electrical cables of various voltages (Oeko-Institut, 2019).

150. In applications such as flooring and wall coverings, other alternative materials have been suggested in place of PVC (with MCCPs), such as non-vinyl, paper-based wallpapers or linoleum or stone tile flooring (ECHA, 2022a). It is noted that these aforementioned alternatives may result in poorer performance regarding the longevity or flame-retardancy characteristics of the article, however these are considered 'acceptable' alternatives (ECHA, 2022a).

***Metal working fluids (MWFs)***

151. Within metal working fluid applications, an alternative water-based technique has been suggested to traditional MCCP-containing additives. Houghton (2023) has shown that a water-based technique can be used, but the 3-4 treatment steps over the traditional single treatment step has not been proven acceptable for commercial applications. Other alternative techniques include the usage of supercritical $CO_2$, either on its own or with an oil such as soybean, to achieve lubrication under extreme pressures (ECHA, 2022a; UNEP, 2016). Dry machining is also an option, where instead of using lubrication fluids, liquefied gases and cryogenic machining are used (UNEP/POPS/POPRC.18/11/Add.3).

152. In 2004, Hydroair, an American company that serves as a Boeing contractor, tested alternatives and showed that by switching to non-petroleum based alternatives for lubricants including honing oils without chlorinated paraffins, the cleaning process became easier, there was less environmental impact, and the cost was significantly reduced (IPEN 2022). Klocke et al. (2005; 2006) demonstrate the viability of biodegradable rape seed-based lubricants in replacing chlorinated lubricant fluids in cold forming and machining applications.

***Paints and coatings***

153. Acrylic- and epoxy-based primers have been suggested as a suitable substitute for underwater paint applications where paints that contained MCCPs have been traditionally used to reduce corrosion on underwater metals (Environment Agency, 2019). UNEP suggests that thermoplastic products could replace road markings that have CPs in the paints, and while this was recommended initially for SCCPs it is suggested the alternative technology could be extended to MCCP-containing paints (UNEP/POPS/POPRC.18/11/Add.3). The long-term environmental effects of thermoplastics were not discussed.

***Adhesives and sealants***

154. Traditional polysulphide sealants that contain MCCPs can be substituted by polyurethane and silicone-base sealants for some applications. Silicone-based sealants have several advantages over polysulphide sealants, such as better UV-resistance, stress recovery, cure rate and lower temperature applicability. While silicone-based sealants have lower performance and less colour availability, they do still hold the largest market share of sealants (ECHA, 2022).

155. Potential alternative technologies to polyurethane foams include mineral wool and pre-compressed tapes. According to the association representing the European adhesive and sealant industry (FEICA), mineral wool needs to be manually inserted and pressed into a joint. Application of this alternative technology requires hours of manual labour compared to a few minutes required for installing an OCF product (ECHA, 2022a). Moreover, the association stressed that long-term insulation performance inside a joint with (thermal) movement is unclear as this product does not guarantee the seamless filling capacity as OCF products do (ECHA, 2022a). Pre-compressed tapes may also be considered as substitutes, according to FEICA. However, the association explained that the quality of workmanship is much more critical than for OCFs and that insulation values are typically lower when compared to OCFs. Finally, in case of poor workmanship the insulating function of pre-compressed tapes could fail altogether (ECHA, 2022a).

***Textiles***

156. To replace textiles that use MCCPs, alternatives such as inherently less flammable fabrics (wool, modacrylics), leathers or specially designed polymer backbones have been recommended (ECHA, 2021a).

### ***2.4.4 Summary and conclusion from the assessment of alternatives***

157. Several alternatives have been suggested for MCCPs within the various applications and, while alternatives do exist, some alternatives may have potential or confirmed harmful effects (see UNEP/POPS/POPRC.19/INF/5, section 11). Alternatives to MCCPs should be selected very carefully to avoid regrettable substitution.

158. Currently, there is no one identified alternative that provides both flame-retardancy and plasticisation to the level that MCCPs do for PVC and polymer applications, and when using two alternative substances in combination to achieve these properties there is an increase in cost. For PVC and other polymer applications the most significant challenge is ensuring the alternatives perform as well as or better than MCCPs. There is the added challenge of matching polymer compatibility when adjusting the alternatives to ensure current technology, such as cable sheathing, can be replaced to align with the expected service life of the article. PVC and other polymer manufacturers are in a position to begin manufacturing articles with MCCP alternatives from a feasibility standpoint, however making the changes to industrial processes could be a factor in the lead in time for these alternatives to be used.

159. Metal working fluid alternatives pose a separate challenge, as the available alternatives may not be as suitable for all current applications as MCCPs. This requires alternatives to be tested and the changes be made on an end use basis.

160. For leather, the use of MCCPs is noted to be for speciality applications. Textiles, on the other hand, have traditionally used MCCPs as flame retardant additives, and there are a number of existing and emerging alternatives

for manufacturers to use. For paints, coatings, adhesives, and sealants there are many suitable alternatives on the market for MCCPs; however, reformulation is required to change to these alternatives. Reformulation can be a time consuming and costly process; however, manufacturers have the available information to begin this process. Finding a single drop-in additive substitution for MCCPs has been noted to be challenging, and from the available information using alternative techniques may be more promising. However, changing to alternative techniques can be costly from an operational perspective and would require manufacturers to make significant changes to their process.

## 2.5 Summary of information on impacts on society of implementing possible control measures

### *2.5.1 Health, including public, environmental, and occupational health*

161. Potential impacts of MCCPs on human health and the environment primarily relate to its POP properties (UNEP/POPS/POPRC.18/5/Add.1), and the exposure resulting from its production and use as well as stockpiles, waste management and recycling. Listing MCCPs under the Stockholm Convention is anticipated to have long-term benefits to society by reducing exposure and risks to human and environmental health from these sources. Further details regarding the public, environmental, and occupational health impacts of MCCPs is provided in the risk profile (UNEP/POPS/POPRC.18/5/Add.1) and in document UNEP/POPS/POPRC.19/INF/5, section 12.

162. Due to the persistence of MCCPs in the environment it is recognised that past and current emissions will likely remain in the environment for long periods of time. Therefore, a prohibition/restriction on the use of MCCPs would provide benefits to human and environmental health by preventing further releases to the environment and reducing exposure. This would reduce occupational exposure to MCCPs. Workers in some industries may be exposed to MCCPs in the indoor environment for prolonged periods of time each day.

163. As discussed in section 2.2, it is noted that MCCPs have been produced at relatively higher volumes compared to other existing POPs. Therefore, CP contamination is anticipated to be much more severe. For example, a 53-country study of human milk samples collected between 2012 and 2019 reported that CPs contributed 50% of the total POP load and CP levels were ~5 times higher than those of polychlorinated biphenyls (PCBs) (Krätschmer et al., 2021).

### 2.5.2 *Agriculture, including aquaculture and forestry*

164. MCCPs are not used directly in agricultural practices. However, contamination of agricultural soil with MCCPs may occur as a result of land application of sewage sludge and/or deposition of emissions which are initially released to air. Sewage sludge application is expected to contribute to environmental dispersion or redistribution of MCCPs and contribute to human and environmental exposure (Wang, 2019). See section 2.1 and (UNEP/POPS/POPRC.19/INF/6, section 11).

165. Control measures to eliminate or restrict the production and use, including the incorporation of MCCPs into articles are expected to reduce the levels of MCCPs in sewage sludge. Thus, the elimination of MCCPs (i.e. listing in Annex A without exemptions) would provide the greatest benefit to agriculture, as well as human and wildlife health, by reducing releases to the environment and further accumulation of persistent substances in soil.

### 2.5.3 *Biota (biodiversity)*

166. The risk profile (UNEP/POPS/POPRC.18/5/Add.1) notes that MCCPs monitoring data generally show their widespread occurrence in surface water, sediment, soil, biota, sludge and air, in multiple regions of the world, including remote regions. Bioaccumulation of MCCPs has been observed in mussels, rainbow trout and bleak, while CPs have been found in rabbits, moose, reindeer, arctic char, herring, seals (WHO, 1996). Furthermore, it seems that concentrations of MCCPs in biota have increased during recent decades (ECHA, 2022a), corresponding with the overall trend in global production and use over the same timescale.

### 2.5.4 *Economic and social aspects*

167. As noted by IPEN (2022, Annex F), the prohibition/restriction of MCCPs would have positive economic benefits by reducing costs for environmental clean-up and lessening the economic burden from adverse effects on environmental and human health. It is noted that limited data on estimates have been made available to quantify this aspect.

168. CP production (of which MCCPs constitute the majority, Chen et al., 2022, see section 2.1) is considered an integral part of the overall chlor-alkali industry (MCCP REACH Consortium, 2021). The chlor-alkali industry produces a number of critical products and feedstocks (e.g. caustic soda/potash, chlorine, hydrogen, vinyl chloride, hydrochloric acid and sodium hypochlorite etc.) on highly integrated sites. These sites have balanced production, meaning that the removal of one product can have significant effects on the overall production on a given site. The ability to use chlorine onsite avoids the needs to transport and store hazardous chlorine, which is subject to various

restrictions. A restriction on the production of MCCPs could therefore significantly impact this integrated production, and require the waste chlorine to be processed or disposed of via other routes.

169. Section 2.3 has presented and summarised the input from Parties and observers relating to specific uses of MCCPs, where exemptions to a listing under the Convention have been proposed. These are based largely on the consideration that viable alternatives are not currently available for those uses, or substitution would be associated with significant socio-economic costs and/or requirement of long transition times to develop alternatives. Limited quantitative information on associated costs was provided, with the emphasis of inputs from Parties and observers on the technical challenges in finding alternatives and the associated impact on key downstream sectors.

170. ECHA has conducted an impact assessment of different restriction options and has identified that a transition period of two years (until 2026) to phase out MCCPs would be considered sufficient for most applications within the EU (ECHA, 2022a) e.g. producers of PVC; sealant and adhesives; rubber; and paints and coatings. This was based in part on direct industry input, information gathered from an ECHA market survey, and experiences of companies that have already substituted MCCPs.

171. It was noted, however, that industry responses and the economic impact for the MWF sector would be different and a specific derogation should be considered for this sector (ECHA, 2022a). This is to take into account that alternatives may not be readily available for specific extreme pressure metal working fluid applications, and a longer transition period would allow necessary R&D to substitute MCCPs. A longer transition period of 7 years has been proposed for this sector, as the transition period of 2 years was not considered sufficient by ECHA. A longer transition period was highlighted in the EU REACH Restriction proposal to be justified due to the uniqueness of the remaining process (e.g. heavy-duty metal working). In an ECHA market survey it was noted by stakeholders that a shorter transition period could halt certain operations dependant on MCCPs in the MWF sector, and could result in a relocation of impacted activities to outside of the EU. It was also indicated that a transition period of between two and ten years (on average six years) would be required to substitute MCCPs in the remaining metalworking applications. In a restriction scenario with a 7-year transition period, it was estimated that one-off reformulation and testing costs to the EU MWF sector would be approximately €90 million, with additional annual operating costs estimated at €12 million for the sector. The total cost to the EU MWF sector were estimated at around €200 million over a 20-year period (ECHA, 2022a).

172. In Canada, the MWFs and other sectors using MCCPs may incur reformulation costs and increased operating costs due to higher costs associated with alternatives (Canada, 2022a, Annex F). Additionally, higher costs associated with using MCCP alternatives are likely to occur in other regions. The WCC-CPIA (2022, Annex F) highlighted the following key socioeconomic issues that were raised by industry in the USA, including critical use applications in metal working fluids (e.g. in defence and aerospace), and a lack of suitable drop-in alternatives. For example, the American Wire Producers Association commented that, if CPs become unavailable in the USA for use in wire drawing lubricants, manufacturers may be unable to continue most of their operations.

173. MedTech Europe have highlighted that substituting MCCPs with alternatives in medical devices[35] and IVD (*in vitro* diagnostic) medical devices in Europe is technically feasible, but would incur costs for compliance analysis, supplier communications, and the testing and qualification of substitutes (MedTech Europe, 2020). Further costs could occur if a complete redesign of products were required. The transition costs estimated by MedTech Europe Members were 0.7-10% of revenue/turnover for medical devices and 0.1-0.6% for IVD medical devices. Due to the critical application of medical devices in the healthcare sector, MedTech Europe have recommended up to 10 years for medical devices and 8 years for IVD medical devices as an appropriate timeline for substituting MCCPs.

174. In PVC production, based on an ECHA market survey, when MCCPs are removed from PVC products, it is estimated that an increase in production cost of between 2-4% can be expected due to the costs associated with adapting other components of the formulations. The total estimated costs including one-off reformulation of PVC compounds, R&D and testing, are €120 million for all the affected companies (up to 400 across the EU), with an annual increase in variable costs of around €30 million. The EU REACH Restriction proposal estimated a total compliance cost of €580 million over a 20-year period for this sector in the EU (ECHA, 2022a).

175. Kemi (2018) estimated (based on input from key manufacturer INEOS Vinyl) that 15,000 tonnes/year of MCCPs are placed on the market in the EU as part of EEE. It was further estimated that the total increased annual cost per year would be €27 million, when replacing half of the 15,000 tonnes of MCCPs with LCCPs and the other half with a combination of DINP and 2-ethylhexyl diphenyl phosphate.

176. The British Plastics Federation (BPF) has previously highlighted that recycled PVC can also be used to produce a range of products, including in the traffic management (e.g. traffic cones and roadside barriers) and construction industries (e.g. plastic barriers used for on-site segregation purposes) (British Plastics Federation, 2021). In this same response, BPF have noted that the UK currently has capacity to recycle 50,000 tonnes of cable waste per

[35] These medical devices have not been further defined by MedTech, however please refer to the INF 1 document for information on specific medical devices provided by Japan.

year from cable sheathing. If PVC had to be incinerated rather than recycled this could negatively impact the PVC recycling industry, where cable recyclers would face relatively high processing costs. This situation would likely be applicable for cable manufacturers not just within the UK, but globally. Furthermore, as already noted, incinerating PVC releases hydrochloric acid so disposal could potentially be challenging and expensive.

177. In adhesives and sealants, it was estimated that 250 million cans, containing 750 ml of OCF product, are produced per year in the EU, with an estimated market value of approximately €250 million (ECHA, 2022a). Based on results of an ECHA market survey, a possible impact of a restriction was associated with increased product costs, for example the prices of affected products would increase between 10-13% (assuming an average price of €8 per 750 ml can of OCF and €4.50 per kg of insulating glass sealants (IG)). The total consumer cost in the EU was estimated at €3.5 billion over the 20-year time period (ECHA, 2022a).

178. In the rubber sector, the EU REACH Restriction proposal relied on information provided to ECHA by companies producing rubber conveyor belts in the EU (ECHA, 2022a). Some of these companies are already substituting MCCP-containing components. It was estimated that each company would have to test 5-10 products to verify product compliance, at a one-off cost of €6,000 to €30,000 per product. A variable cost of replacing MCCPs with more expensive alternatives (LCCPs) was estimated as €3.9 million per annum. The total transition cost for the sector in the EU was estimated to be €54 million over a 20-year period (ECHA, 2022a).

179. In paints and coatings, based on an estimated 50 companies in the EU being impacted by the restriction, the total costs for a restriction were estimated at €10 million over a 20-year period. This assumed each company may incur testing costs of around €200,000. Due to the added value and protective properties of coatings it was considered by ECHA (2022) that coating producers will be able to transfer substitution costs to customers/clients.

180. Temporary or permanent closures of MCCP production sites would lead to loss of business and revenue, production or sales of MCCPs. This could result in a reduction in employment of companies manufacturing MCCPs. Previous estimates by Kemi (2018) have referred to five companies representing 70% of the total EU PVC market, operating 41 production plants located in 21 different sites. These operations were estimated to have a total of 7,000 employees (although it was noted in the study that not all of these can be connected to PVC containing MCCPs). It could be that an increased demand for MCCP alternatives could lead to a change of distribution of employees between manufacturers, at least in the medium to long term.

181. In the context of the EU REACH Restriction proposal, ECHA has predicted that the restriction on use of MCCPs would present no major impact on employment in the EU if appropriate transition times are given (ECHA, 2022a). It is however recognised that there could be some negative impacts on the producers of products containing MCCPs, as a lower output of products could result in job losses. However, the identification of both technically and economically feasible alternatives could result in the hiring of new employees for the new products during a transition period, which would compensate for any potential layoffs.

182. As part of the EU consultation, none of the companies in the EU PVC sector had reported phasing out substances with MCCPs (or that are in the testing phase of alternatives) have incurred loss of employment. There are no job losses anticipated in the paint and rubber sectors. However, job losses might occur in the metal working fluid sector under certain restriction options (those involving a ban on manufacture and/or placing on the market). There are currently no alternatives available for many heavy-duty applications where MCCPs are used for the sector, and the transition period would not provide enough time to find any reliable alternatives. In the case of a ban with a 2-year transition period, production of certain products in the metal working fluid sector where no alternatives are available are expected to halt and potentially put employees' jobs working in those areas at risk (ECHA, 2022a). Therefore, a longer transition period of 7-years or a derogation might be considered as part of the EU REACH Restriction proposal depending on the information submitted during the consultation (EU, 2022 Annex F).

#### 2.5.5 ***Movement towards sustainable development***

183. A restriction on MCCPs could result in a drive to shift to environmentally safer alternatives. As MCCPs are considered bioaccumulative, persistent and toxic, their elimination is consistent with the Strategic Approach to International Chemicals Management (SAICM) Global Plan of Action to support risk reduction that includes prioritising safe and effective alternatives to this type of substance (ACAT/IPEN 2022, Annex F).

### 2.6 Other considerations

***Access to information and public education***

184. In Sweden information about hazardous substances (including MCCPs) is available from the Swedish Chemicals Agency (Kemi).[36] A publicly open access tool, PRIO has also been developed by Kemi to help companies

[36] https://www.kemi.se/en/chemicals-in-our-everyday-lives/advice-on-chemical-smart-choices/your-right-to-information).

detect and substitute hazardous substances in products and articles that they handle.[37] Monitoring information of MCCPs is also available through the Swedish Environmental Protection Agency.[38]

***Status of control and monitoring capacity***

185. According to ACAT/IPEN (2022, Annex F), MCCPs can be added to existing programmes for monitoring other POPs, while countries that lack the infrastructure needed to adequately monitor production and uses of MCCPs may require additional resources and infrastructure. Various monitoring programmes have been identified including in the EU, Norway, Sweden and Canada; details of such studies may be found in document UNEP/POPS/POPRC.19/INF/5. The risk profile (UNEP/POPS/POPRC.18/11/Add.3) provides an extensive overview of previous and contemporary monitoring activities, that demonstrates the ability to monitor MCCPs in environmental and human tissues, and food.

# 3 Synthesis of information

## 3.1 Summary of risk profile information

186. At its eighteenth meeting in 2022, the POPs Review Committee adopted the risk profile and decided that MCCPs are likely, as a result of their long-range environmental transport, to lead to significant adverse human health and environmental effects, such that global action is warranted.

187. Available evidence indicates widespread occurrence of MCCPs in surface water, sediment, soil, biota, sludge, and air, in multiple regions of the world, including remote regions. MCCPs can also be widely detected in wildlife including predators, as well as human tissues. The concentrations detected in wildlife in more contaminated areas show that high levels can be found in organisms. MCCPs have been detected in a range of market foods, household dust, household products and appliances, playing fields and other sources that may represent important human exposure pathways. As the switch from SCCPs to MCCPs has only occurred in recent years, the concentration of MCCPs in the environment can be expected to increase in the absence of risk management.

## 3.2 Summary of risk management evaluation information

188. While MCCPs have come under increased regulatory scrutiny due to environmental and health concerns, with control actions being proposed or considered in the EU, Norway, Canada, UK, and the USA, MCCPs are not currently banned at national level, and MCCPs are not currently covered by international conventions.

189. Ongoing production of MCCPs has been reported in many countries. A notable shift in the geographical distribution of global production and use of MCCPs has been indicated in recent decades. Until around 2000, production and use of MCCPs had predominantly occurred in North America and Western Europe, but since then a rapid increase in production and use in Asia (China and India) has been observed and currently China dominates in terms of global volumes for production and use of MCCPs. Peak levels of production and use were reported in around 2014; since then, volumes have started to decline but global production and use of MCCP is still very high and current global production of MCCPs could be in the region of 920,000 tonnes per year. It is expected that the international trade of CP commercial products and products likely containing MCCPs (e.g. electronic equipment, PVC-containing materials) from countries producing and exporting MCCPs to other global regions can also result in MCCPs entering the market, and ultimately the environment in different global regions.

190. In comparison with the manufacturing process in North America and Europe, where CPs are manufactured using distinct paraffin feedstocks with specification-controlled chain lengths, i.e., to produce SCCPs, MCCPs and LCCPs, according to the CP industry (CCAIA, 2023; MCCP REACH Consortium, 2021), the technical CP products used in Asia are generally not characterised by carbon chain length but by chlorination degree. This means that no individual MCCP or SCCP-containing products are available in Asia, and the technical CP products in use are mixtures of CPs of different chain lengths. In addition, LCCP-containing products may contain a significant proportion of $C_{17}$ CPs in various concentration levels up to 20 %, when the feedstock to produce 'LCCPs' predominantly consists of carbon chain lengths $C_{18\text{-}20}$ (ECHA, 2022; Environment Agency, 2022).

191. MCCPs are still currently being used in a range of commercial and industrial applications. The main uses identified in this RME are in PVC, in MWFs and as additives to paints, adhesives, sealants, rubbers and other polymeric materials. A key functionality identified for MCCPs in PVC and rubber is the dual role of plasticiser and flame retardant, and in MWFs MCCPs are used in extreme (high temperature and pressure) conditions. The predominant uses of MCCPs vary between different countries and regions. For example, in Europe, use is dominated

[37] https://www.kemi.se/prioguiden/english/start/background---prio.

[38] https://www.naturvardsverket.se/om-miljoarbetet/miljoovervakning/programomraden/luft/organiska-miljogifter.

by adhesives/sealants, in China, use of MCCPs is predominantly in PVC, while in North America and Japan, use is predominantly in MWFs.

192. A number of requested exemptions have been highlighted by Parties and observers through the Annex F submissions for a small number of specific uses of MCCPs. These cover specific use of MCCPs in MWFs, PVC and adhesives and sealants, in a number of key sectors (including aerospace and defence, military, automobiles, building and construction, energy generation and 'social infrastructure'). The proposals for specific exemptions in these uses cite the consideration within the industry that current alternatives are not sufficient to deliver the required performance in several important and safety critical applications, and substitution would be associated with long (up to 15 year) transition periods.

193. Relatively recent assessments of alternatives for MCCPs (for example by Danish EPA, 2014) have reported that available alternatives have been identified and are commercially available for each of the main uses for MCCPs. However, the feasibility of substitution/removal (and by extension the associated costs) may differ between different specific uses. For MWFs alternatives appear to be available, although it is not certain if they are technically able to replace MCCPs in all heavy duty/extreme (e.g. high temperature and pressure) working operations. For example, a number of applications of MCCP-based MWFs in the aerospace sector appear to have viable and certified alternatives, however, the industry has highlighted a number of specific processes for working certain metals and alloys, where viable alternatives are not available and exemptions are proposed, as poorer performance could have implications for a number of safety-critical functions, and switching to alternative would be associated with long lead in times. For PVC, technically feasible alternative substances or technologies are available, however it is noted that one single substance may not be able to substitute the MCCPs across all its uses since they function as both a plasticiser and flame retardant. The proposed exemptions of MCCPs in PVC used in replacement parts (for automobiles and EEE in 'social infrastructure') highlight the requirement for these properties and the long transition times (and practical and cost implications) associated with substitution. For other proposed exemptions for PVC (e.g wires and cables in the construction sector, in calendered films in the packaging field, and in rubber and plastic insulation materials), the evidence for the need for exemption in the context of available alternatives is less clear, and further evidence may be needed to define an exemption. For adhesives and sealants, it is highlighted that CPs impart critical flame-retardant properties to building and construction applications. However, it has been highlighted that alternatives are available for this use, with the substitution expected to be completed in the EU before 2025. Therefore, the evidence base for the proposed exemptions for this use (e.g. use in joint filler for closed environments; uses in chlorinated rubber coatings for marine and industrial fields; uses in outdoor plastic running tracks) is unclear and further evidence may be needed for these exemptions.

194. Potential economic impacts have been highlighted, relating to increased costs associated with raw material costs, reformulation, compliance analysis, supplier communications, and testing and qualification of alternatives. For example, for MWFs, Canada (2022, Annex F) noted that available alternatives may not be technically suitable for all applications and may be more costly as they are expected to incur reformulation costs, as well as increased operating costs. The assessment by ECHA (2022) highlighted that a ban on MCCPs would likely lead to significant economic impacts to businesses and downstream users, particularly if a temporary cessation of production or product sales results from the loss of technical function and/or availably of alternatives. Furthermore, a discontinuation of MCCP production combined with a lack of suitably available MCCP substitutes could potentially impact key applications and sectors important in society (e.g. aerospace and defence, automobile and medical applications were raised by Parties and observers).

195. A key consideration regarding the appropriate risk management of MCCPs is related to the substantial volumes of waste containing MCCPs and the quantity of MCCPs released to the environment during waste management. Estimates suggest that the majority of emissions to the environment occur during waste disposal, i.e. via wastewater treatment works. This RME has highlighted that aspects of waste management, for example regarding the treatment/disposal and recycling of waste materials containing MCCPs is highly challenging. With the rapid increase in production and use of MCCPs occurring since 2000, this issue is expected to become more challenging in future years.

196. The variety of different uses for MCCPs, and types of products they are incorporated into across different sectors presents different challenges for safely handling and disposing of waste. For example, the relative use of MCCPs appears to be much higher in MWFs in some areas (e.g. North America, Japan) than in others (e.g. Europe and China). Where MCCP use is predominantly in PVC products and adhesives/sealants, the CPs are largely integrated into the product and their relative long service life (up to several decades) mean that the potential environmental impact from 'in use' products could continue for many years to come, even if use of MCCPs was halted. While control measures preventing environmental release may be more feasible at production sites, polymeric products are more likely to be disposed of to landfill, potentially acting as a long-term reservoir for release to the environment.

197. The presence of MCCPs in LCCP commercial products is expected. However, this is not interpreted in this risk management evaluation as 'unintentional production' but is considered as 'unintended presence' in the product. The carbon chain length distribution of a CP product is reflected by the carbon chain length distribution of the parent

hydrocarbon feedstock, which is controlled by the producer. In Europe ECHA is proposing a concentration limit of 0.1 % (w/w) for restricting the presence of chloroalkanes with $C_{14–17}$ chain lengths with PBT and/or vPvB properties in CP commercial products.

198. Listing MCCPs under the Convention is expected to benefit human health, the environment, agriculture and biota. It is noted that the total cumulative emissions currently estimated for MCCPs, and the potential future emissions associated with in-use stocks, is substantially greater than many POPs currently listed under the Convention. While not currently controlled under national-level legislation, the negative health impact of MCCPs to human health have been recognised at the national (Canada, 2022a, Annex F) and international (ECHA, 2022a) levels. Listing MCCPs under the Convention would also reduce occupational exposure. It is not possible to quantify the benefits of eliminating or restricting MCCPs; however, they are considered to be significant given the costs associated with the significant adverse effects on human health and the environment that are likely to result from the continued production and use of MCCPs.

## 3.3 Suggested risk management measures

199. Consistent with Decision POPRC-18/4, MCCPs warrant global action to control their production and use to eliminate their release and build up in the environment. [The recommended control measures as agreed by the POPRC are outlined below:]

***Annex A without specific exemptions***

200. In principle, from the perspective of protecting human health and the environment, the preferred option would be to list MCCPs in Annex A without exemptions (Elimination). This listing would eliminate production and use and result in significant emission reductions following the entry into force of the control measure. Furthermore, this listing would both eliminate MCCPs and further reduce unintentional SCCPs (already listed as a POP under the Convention) in new articles, as it has been established that SCCPs could be present as residual components of other CPs (see UNEP/POPS/POPRC.12/4).

201. Prohibition of the production and use of MCCPs would reduce and eventually eliminate releases of MCCPs to the environment (over a long period of time, given ongoing releases from existing PVC, rubber and plastic articles in use). The full life cycle impacts of all alternatives compared with MCCPs have not been investigated for all uses and alternatives. In some cases, it has been indicated that the overall life cycle impacts of alternatives could be greater than that of MCCPs.

202. A number of Parties and observers to the Convention have proposed specific exemptions for a small number of specific uses for MCCPs (see the discussion below). Therefore, while a full prohibition of MCCPs would be the most effective in limiting release to the environment, a listing of MCCPs under Annex A without exemption is not recommended.

***Annex A with specific exemptions***

203. ECHA (2022) considered hat a phase out of MCCPs in Europe would be feasible for most uses within 2 years after the foreseen entry into force of the restriction under REACH. However, globally, based on the evidence submitted by some Parties and observers, some uses in specific industry sectors may require a relatively long time (5-15 years) to identify and develop alternatives (or reformulate products completely) to attain a comparable level of performance. It is noted that these uses often cover safety-critical applications in key sectors (e.g. aerospace and defence, automobiles, medical devices, in vitro diagnostics devices, and instruments for measurement, analysis, manufacturing, control, monitoring, testing and inspection) where technically feasible alternatives do not appear to be currently available.

204. Furthermore, for MWFs, a longer (7 year) transition period was considered by ECHA, as alternatives for more extreme (pressure and temperature) conditions have not yet been identified. However, it should be noted that the EU (2022, Annex F) report that ECHA recognises that the derogation (7-year transition period) for MWFs, as currently proposed in the EU REACH Restriction proposal, is not specific enough to set clear boundaries for this derogation. ECHA may therefore consider removing this derogation/transition period unless sufficient and substantiated information is received. JAPIA (2023)/Japan(2023a) indicated the transition period for the use of MWFs in automobiles could be as high as 15 years.

205. Inputs from Parties and observers have highlighted a number of uses where specific exemptions are requested, relating to MCCPs used in certain MWFs as wells specific uses in PVC and in adhesives and sealants. Additionally, regulatory processes at national/regional level (Canada, EU, UK) identified that there may be specific issues for the phase-out of MCCPs within a sub-set of MWFs (relating to high temperature and extreme pressure applications such as deep drawing and broaching). The UK has therefore requested a transition period of 10 years so that a full evaluation of alternative MWF performance across a range of alloys can be conducted (UK, 2023, Annex F). In most cases the argument for exemption relates to the safety critical nature of the industry sector, strict regulations on chemical and article performance, and long lead-in times for substitution. In some cases, the information provided by

Parties and observers in support of specific exemptions for some uses and sectors of application has been relatively detailed and presents a stronger evidence base of the technical and economic challenges of replacing MCCPs. For others, more limited detail has been provided on the specific use, application, requirement, and lack of alternatives. Further information is being sought to understand these although it has not been received in time for the submission of the final draft of the RME. The recommended specific exemptions presented in this RME are therefore divided accordingly into 'well-evidenced' and 'less well evidenced' specific exemptions.

206. Based on the 'well-evidenced' information, specific exemptions are recommended for the following

(a) **Metal working fluids –** limited to use in extreme temperature and pressure additives for MWFs used in specific 'heavy duty' processes[39] used for the production of specific metal or metal alloy[40] components in the following applications:

(i) Aerospace and defence;

(ii) Automobiles;[41]

(iii) EEE used for 'social infrastructure';[42]

(iv) Production of machinery and tools used in agriculture and building/construction;

(v) Energy and power generation;

(vi) Oil and gas extraction;

(vii) Chemical production and refining;

(viii) Nuclear power facilities;

(ix) Use in low-carbon and renewable energy technologies;

(b) **Replacement parts**– limited to the use in the following applications: Until end of service life of the articles or 2041, whichever comes earlier:

(i) Use in the production of automobile parts;

(ii) Use in EEE used for 'social infrastructure'.[43]

207. Based on the 'less well-evidenced' information, specific exemptions may be considered for the following applications:

(a) **PVC** – limited to the following:

(i) Uses in wires and cables in the construction sector;

(ii) Uses in calendered films in the packaging field;

(iii) Uses in rubber and plastic insulation materials;

(b) **Adhesives and sealants** – limited to the following:

(i) Use in joint filler for closed environments;

(ii) Uses in chlorinated rubber coatings for marine and industrial fields;

(iii) Uses in outdoor plastic running tracks.

208. A listing within Annex A with specific exemptions would therefore need to consider control measures that minimise emissions to environment, and promote the adoption of safer alternatives as soon as possible. The use of specific exemptions would also mean the continued manufacture of MCCPs to meet the demand for these specific uses and industry sectors. Therefore, where specific exemptions are allowed, the adoption of further control measures would be needed. Firstly, during the manufacture of MCCPs, suitable levels of control of emissions and management of wastes (particularly to wastewater) are needed (with further details provided in section 2.3). Secondly, during the

[39] Covering the following processes: deep drawing, broaching and fine blanking, drawing with ironing; precision metal working (cutting/punching/drilling), tapping, cold drawing, and cold rolling (pilgering).

[40] Covering the following metals/alloys: stainless steel, titanium, nickel and aluminium

[41] Defined as: motor vehicles covering all land-based vehicles, such as cars, motorcycles, agriculture and construction vehicles and industrial trucks.

[42] Limited to use in weighing machines; use in collaborative robots; use in gas analysers; and use in solder joint inspection.

[43] Limited to medical devices, in-vitro diagnostics devices, and instruments for measurement, analysis, manufacturing, control, monitoring, test and inspection.

manufacture of articles that contain MCCPs (particularly PVC and rubber) suitable levels of abatement and waste management practices should be adopted.

209. Based on the information submitted by Parties and observers regarding the continued need for certain uses of MCCPs, a listing under Annex A without specific exemptions is not recommended.

***Annex A with modifications***

210. MCCPs are considered to have an ‘unknown or variable composition’ and the substances covered under the scope of this RME could be present in other CP commercial products. This RME has established that this should be interpreted in the context of the Convention listing as ‘unintended presence’ rather than ‘unintentional production’ or ‘unintentional trace contaminants’. To address the ‘unintended presence’ of MCCPs during the manufacture of other CP mixtures, an Annex A listing could include controls for the occurrence of MCCPs in other CP mixtures above a specified threshold. Including controls to limit the presence of MCCPs in other CP mixtures within the Annex A listing would require Parties to apply measures to the production of MCCPs in other CP mixtures, as well as the use, import and export of other CP mixtures and articles that contain SCCPs.

***Annex B (with specific exemptions or acceptable purposes)***

211. Listing MCCPs in Annex B would allow for specific exemptions or acceptable purposes. Consistent with the requirements of paragraph 6 of Article 3 of the Convention, listing MCCPs in Annex B with acceptable purposes, or specific exemptions, would require Parties to take appropriate measures to prevent or minimise human exposure and releases into the environment. Requirements for control of discharges and emissions could take various forms, and ideally would target all stages of the life-cycle where emissions may occur.

212. Some Parties and observers have indicated some uses for MCCPs where they consider the current availability of technically feasible alternatives to MCCPs is not sufficient and specific exemptions should be considered. However, it is noted that the concern appears to be largely related to the availability of feasible ‘drop-in’ replacements covering all functionalities of MCCPs together for these uses. Furthermore, the submissions from these Parties and observers indicate the development of alternatives for those uses is possible and is being actively investigated, but with relatively long (up to 15 years) anticipated transition times. Therefore, the current evidence suggests that a listing under Annex B should not be recommended as this could act to de-incentivise the move towards substitution in these remaining uses of MCCPs.

***Annex C***

213. Listing MCCPs in Annex C of the Convention could be considered in order to control the unintentional production of MCCPs during the manufacture of other CP mixtures. However, the RME has established that unintentional production in the context of the Convention is not strictly relevant for MCCPs, so this listing is not recommended.

# 4 Concluding statement

214. Having decided that chlorinated paraffins with carbon chain lengths in the range $C_{14–17}$ and chlorination levels at or exceeding 45 per cent chlorine by weight are likely, as a result of long-range environmental transport, to lead to significant adverse effects on human health and the environment such that global action is warranted; Having prepared a risk management evaluation and considered the management options:

215. The Persistent Organic Pollutants Review Committee recommends, in accordance with paragraph 9 of Article 8 of the Convention, that the Conference of the Parties to the Stockholm Convention consider [listing of *Chlorinated paraffins with carbon chain lengths in the range $C_{14–17}$ and chlorination levels at or exceeding 45 per cent chlorine by weight* in Annex A to the Convention with specific exemptions, and a specified concentration limit for the level of these components in other CP commercial products].

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