Guidance on best available techniques and best environmental practices relevant to the Short Chain Chlorinated Paraffins (SCCPs) listed under the Stockholm Convention on Persistent Organic Pollutants

July 2024

STOCKHOLM CONVENTION

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Preface

This document was developed in 2024 by the Toolkit and best available techniques (BAT) and best environmental practices (BEP) experts working in collaboration with the Secretariat of the Stockholm Convention, and taking into account comments received from Parties and others, further to the request by the Conference of the Parties (COP) to the Stockholm Convention in 2023 (decision 11/5) as part of the ongoing review and update of the Toolkit and the guidelines and guidance on BAT and BEP.

Abbreviations and acronyms

ATBC	Acetyl Tributyl Citrate
BAT	Best available techniques
BEP	Best environmental practices
BCD	Base Catalyst Decomposition
CAS	Chemical Abstract Service
CD	Catalyst Dechlorination
CPs	Chlorinated paraffins
COP	Conference of the Parties
DNA	Deoxyribonucleic Acid
DOS	Dioctyl Succinate
EC	European Community
ECNI	Electro Capture Negative Ionization
EEC	European Economic Community
EMS	Environmental management system
FAO	Food and Agriculture Organization
FR	Flame retardant
FTIR	Fourier Transform Infrared Spectroscopy
GC	Gas Chromatography
GHG	Greenhouse gas
HCD	Hydro Dechlorination
ISO	International Standards Organization
kt	Kilo Tons
LCCPs	Long Chain Chlorinated Paraffins (C18+)
LDAR	Leak Detection and Repair
LEV	Local Exhaust Ventilation
LC	Liquid Chromatography
MCCP	Medium Chain Chlorinated Paraffins (C14-C17)
MS	Mass Spectrometry
MSW	Municipal solid waste
NMR	Nuclear Magnetic Resonance
NaOH	Sodium Hydroxide
NGOs	Non-Governmental Agencies
PAG	Poly Alkyl Glycol
PCDD/PCDF	Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans
PCB	Polychlorinated biphenyl(s)
PCD	Photochemical Dechlorination
PPE	Personal Protective Equipment
POPs	Persistent organic pollutants
POPRC	Persistent Organic Pollutants Review Committee
PVC	Polyvinylchloride
SC	Stockholm Convention
SCC	Stress Corrosion Cracking
SDS	Safety Data Sheet
SCCPs	Short-chained chlorinated paraffins
UNEP	United Nations Environmental Program
USEPA	United States Environmental Agency
VOC:	Volatile organic compound
XRF:	X-ray fluorescence

Executive Summary

Short-Chain Chlorinated Paraffins (SCCPs) have been extensively utilized across various industries, including but not limited to manufacturing, metalworking, leather processing, and as additives in consumer products as rubber and plastics, due to their chemical properties as flame retardants and plasticizers. Recognizing the environmental and health risks posed by SCCPs, their production, use, and disposal have come under scrutiny, leading to regulatory actions under international conventions such as the Stockholm Convention.

The Stockholm Convention, acknowledging the persistent, bioaccumulative, and toxic nature of SCCPs, has mandated their listing in Annex A of the Convention and, subsequently, the phase-out of these chemicals, with specific exemptions allowed for critical uses where alternatives are not feasible. This document outlines the restricted use of SCCPs, detailing the exemptions under specific parts of Annex A to the Convention.

Despite the restrictions, the legacy use of SCCPs in products and industrial applications presents ongoing challenges. These substances are found in long-lasting products and assets, which means they will persist in the environment and continue to enter waste streams for years to come. The document emphasizes the importance of managing these legacy uses and the waste generated from SCCP-containing products to prevent further environmental contamination.

Key milestones in the global effort to manage SCCPs include listing specific compounds under the Stockholm Convention, reflecting a global commitment to reducing the environmental and health impacts of these chemicals. The document highlights the necessity of applying Best Available Techniques (BAT) and Best Environmental Practices (BEP) to minimize releases of SCCPs during their production, use, and disposal phases.

Alternatives to SCCPs are discussed, focusing on identifying safer substitutes for various applications. The document underscores the importance of innovation and research in developing non-hazardous alternatives that meet the technical requirements of industries previously reliant on SCCPs.

Waste management and recycling practices are critical in the context of SCCPs, given their presence in a wide range of consumer and industrial products. The document outlines strategies for the identification, separation, and safe disposal of SCCPs-containing materials, advocating for recycling and recovery processes that prevent environmental release. It also discusses the role of stakeholders, including industry, regulators, and the public, in ensuring the effective management of SCCPs throughout their lifecycle.

In conclusion, the guidance document on SCCPs aims to assist in the management of risks associated with these chemicals. It calls for coordinated international action, the adoption of safer alternatives, and the implementation of stringent waste management practices to protect human health and the environment from the adverse effects of SCCPs.

1. Introduction

1. This document is the first "Draft guidance on best available techniques and best environmental practices for the production and use of Short-Chain Chlorinated Paraffins listed in Annex A of the Stockholm Convention, as per the COP decision 8/11 in May 2017, with specific exemptions.

1.1 Purpose

2. The purpose of this document is to give Parties guidance on the Best Available Techniques and Best Environmental Practices for the use, recycling, and disposal of articles containing Short-Chain Chlorinated Paraffins (SCCPs) listed under Annex A of the Stockholm Convention (decision SC-8/11) with specific exemptions for production and use.

3. Best Available Techniques (BAT) and Best Environmental Practices (BEP) are fundamental in environmental management and policy. They aim to minimize or prevent pollution and reduce environmental impacts from various industrial and agricultural processes. They are often used in environmental regulation and policy to set standards and guidelines for industries to follow, encouraging continuous improvement in environmental performance.

4. Best Available Techniques is not aimed at the prescription of any specific technique or technology; BAT means the most effective and advanced activities, methods of operation, and techniques for providing the basis for release limitations designed to prevent and, generally, reduce releases of chemicals and their impact on the environment (Article 5 of the Stockholm Convention).

5. Best Environmental Practices are focused on the operational or management aspects, emphasizing the application of the most appropriate combination of environmental control measures and strategies. BEP aim to prevent or minimize emissions and waste through measures such as material substitution, process modification, good housekeeping, recycling and reuse, product design, and changes in consumption patterns.

6. According to Article 3 Paragraph 6 of the Stockholm Convention, if a Party has a specific exemption or acceptable purpose for a chemical listed in Annex A or Annex B of the Convention, they must take measures to ensure that any production or use under such exemption, or purpose, is carried out in a way that prevents or minimizes human exposure and releases to the environment. To put it simply, the BAT and BEP should be applied for chemicals that have a specific exemption(s) or an acceptable purpose, as is the case for SCCPs. This approach helps ensure appropriate methods are used to protect the environment and human health while considering economic feasibility and technological viability.

1.2 Structure and use of the guidance

7. This document is structured as follows:

Chapter 1 outlines the purpose and structure of this document.

Chapter 2 provides information on the substances covered by this document, including the relevant provisions under the Stockholm Convention and the Basel Convention.

Chapter 3 addresses general BAT and BEP principles for general chemical management and general guidance for the management of SCCPs. Further relevant details are included in the annex to this guidance.

Chapter 4 addresses BAT and BEP for uses of SCCPs benefiting from a specific exemption in metalworking, lubricants in engines, additives in polymer/plastic, waterproofing and fire retardant paints, and leather applications listed as specific exemptions under the Convention. Each section provides a general description of the process/application in which SCCPs is exempted for use, and specific BAT and BEP guidance for management of this substance, including information on available alternatives for that use.

Chapter 5 addresses BAT and BEP for the life cycle management of SCCPs containing articles, energy/material recovery and recycling considerations, focusing on the key material recycling flows – namely plastics and rubbers, mechanical parts and electronic products.

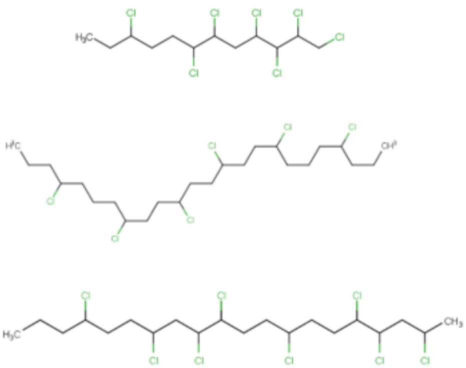
2. Substances covered under this document

8. This document focuses on SCCPs, a complex mixture of polychlorinated N-alkanes (straight chain alkanes) ranging from C10 to C13.

2.1 Chlorinated paraffins

9. Chlorinated paraffins (CPs) are widely produced chemicals, with certain CP subgroups (SCCPs) facing global restrictions due to their environmental dispersion, persistence, bioaccumulation, and toxicity. Chlorinated paraffins, also called chlorinated alkanes, are complex mixtures of substances having the molecular formula pattern CnH2n+(2−x)Clx in common. According to their chain length, CPs are subdivided into short-chain CPs (SCCPs, C10–C13), medium-chain CPs (MCCPs, C14–C17) and long-chain CPs (LCCPs, C18–C30). Examples of CP formulas are given in Figure 1**Error! Reference source not found.**.

Figure 1. Examples of chlorinated paraffins formulas.



CAS:106232-86-4, Formula: $C_{12}H_{19}Cl_7$

CAS No.: 8029-39-8, Formula: $C_{10}H_{16}Cl_6$

CAS No.: 61788-76-9, Formula: $C_{20}H_{34}Cl_8$

10. Chlorinated paraffins are produced with different chlorination degrees varying from 30% to 70% in weight. Due to their complexity and variability, SCCPs are regulated as a group of substances instead of individual chemicals. Commercial CP products are classified as substances of "Unknown or Variable composition, Complex reaction products or Biological materials (UVCB)". This designation is used for substances whose exact chemical composition is unknown and may vary, or for complex reaction products resulting from a manufacturing process or substances that can be found as an unintentional by-product in processes intended to produce medium- or long-chain chlorinated paraffins.

11. The variation in chain lengths and chlorination degrees makes them versatile, and more than 200 commercial CP formulations are in use worldwide. Different grades and purities are produced according to needs but generally, industrial products are technical mixtures of different CPs.

Assessment of the homologue composition of 36 CPs used worldwide has shown that SCCPs are present in almost all the technical CP mixtures[1].

12. According to GuideChem, a chemical trading guide[2], there are at least 12 CP producers in China, India, France, Japan and the USA.

2.2. Short-Chain Chlorinated Paraffins (C10-C13)

13. The eighth Conference of the Parties to the Stockholm Convention[3] decided to amend part I of Annex A to the Stockholm Convention to list "short-chain chlorinated paraffins" therein, with specific exemptions. The decision defines the listed substance as follows: Short-chain chlorinated paraffins , C10-13, chloro: straight-chain chlorinated hydrocarbons with chain lengths ranging from C10 to C13 and content of chlorine covered by the Stockholm Convention listing of greater than 48 percent by weight.

14. According to IUPAC, short-chain chlorinated paraffins (SCCPs), otherwise known as short chain chlorinated alkanes, are highly complex mixtures of polychlorinated n-alkanes with a chlorination degree between 30 and 70 % by weight, constituted by thousands of homologs, diastereomers, and enantiomers.

15. For this reason, the convention listing covers chemicals that may contain small amounts of short-chain chlorinated paraffins as for example:

- Alkanes, C14-C17, chloro (CAS N°85535-84-8)
- Alkanes, C6-18, chloro (CAS No. 68920-70-7),
- Alkanes C12-13, chloro (CAS No. 71011-12-6),
- Alkanes, C12-14, chloro (CAS No. 85536-22-7),
- Alkanes, C10-14, chloro (CAS No. 85681-73-8),
- Paraffin waxes, chlorinated (C12, 60% chlorine) (CAS No. 108171-26-2).

16. As stated in the decision, the list provided is not exhaustive, this is because any industrial chlorinated alkane has the potential to contain some SCCPs, they can be found as unintentional by-products in MCCPs or LCCPs even when the goal is producing longer chain length CPs. Therefore, the Convention stated that any mixture that contains more than 1% by weight of SCCPs with 48% chlorine, even if it has a low chlorination level, is considered a Persistent Organic Pollutant (POP).

17. The annex to this guidance provides a list of trade names of chlorinated paraffins potentially containing SCCPs.

18. The specific exemptions for the production and use of SCCPs are, as of 2017, described in Table 1.

Table 1- Specific exemptions for the production and use of SCCPs.

Activity	Specific exemptions
Production	As allowed for the Parties listed in the Register
Use	• Additives in the production of transmission belts in the natural and synthetic rubber industry

[1] Yago Guida, Hidenori Matsukami, Gabriel Oliveira de Carvalho, Roland Weber, Walter Vetter, and Natsuko Kajiwara. Environmental Science & Technology 2023 57 (35), 13136-13147 (DOI: 10.1021/acs.est.3c02243)
[2] www.guidechem.com
[3] UNEP/POPS/POPRC.11/10/Add.2 and UNEP/POPS/POPRC.12/11/Add.3.

	• Spare parts of rubber conveyor belts in the mining and forestry industries
	• Leather industry, in particular, fatliquoring in leather
	• Lubricant additives, in particular :
	  ○ for engines of automobiles,
	  ○ electric generators and wind power facilities, and for
	  ○ drilling in oil and gas exploration and petroleum refining to produce diesel oil.
	• Tubes for outdoor decoration bulbs
	• Waterproofing and fire-retardant paints
	• Adhesives
	• Metal processing
	• Secondary plasticizers in flexible polyvinyl chloride, except in toys and children's products.

19. Specific exemptions are granted to registered Parties for a period of five years, unless otherwise indicated. And as per decision 8/14, the Conference of the Parties invites each Party listed in the register of specific exemptions for short-chain chlorinated paraffins to report to the Secretariat, by December 2019, justifying its need for the registration of that exemption and informing on production, uses, national control actions taken, and progress made in building capacity on safe alternatives.

2.3. SCCPs physical and chemical properties

20. As SCCPs are complex mixture of chlorinated paraffins, their properties vary according to many factors[4]:

1-Carbon Chain Length: The alkanes in SCCPs have carbon chain lengths primarily in the C10 to C13 range. The longer the n-alkane chain is the higher boiling point.

2-Chlorine Content: SCCPs are chlorinated to varying degrees. The chlorine content, according to IUPAC, ranging from 45% to 70% by weight. This variation in chlorine content affects their physical and chemical properties, such as viscosity and solubility.

3-Physical Form: The physical state of SCCPs can vary from oily liquids to waxy solids, depending on the chain length and chlorine content. Higher chlorine content makes them more solid, whereas lower chlorine content results in a more liquid form.

4-Chemical Properties: The specific composition of SCCPs, including the exact distribution of chain lengths and chlorine content, influences their chemical properties, such as stability, reactivity, and ability to act as flame-retardants or plasticizers.

21. From Decision POPRC-12/4, Table 2 gives the main physico-chemical properties.

Table 2. Main Physico.chemical properties of SCCPs.

Property	**Value**	**Reference**
Vapour pressure (Pa)	Range from 2.8 to 0.028 x 10^{-7} Pa	Drouillard et al. 1998, BUA 1992
	SCCP with 50% chlorine by weight is 0.021 Pa at 40 ºC	EC 2000

[4] Risk Management Evaluation of SCCPs (UNEP/POPS/POPRC/12/11/Add.3).

Property	Value	Reference
	SCCP products with 50-60% chlorine are predicted to have subcooled liquid VPs ranging from 1.4 x 10^{-5} to 0.066 Pa at 25ºC	Tomy et al. 1998
Henry's Law Constant (Pa·m^3/mol)	0.7 - 18 Pa x m^3/mol	Drouillard et al. 1998
Water solubility (µg/L)	C_{10-12} chlorinated alkanes ranged from 400 - 960 µg/L	Drouillard et al. 1998
	C_{10} and C_{13} chlorinated alkane mixtures ranged from 6.4 – 2370 µg/L	BUA 1992
	SCCPs containing 59% chlorine content at 20ºC range from 150 to 470 µg/L	EC 2000
log K_{OW}	4.48 – 8.69	UNEP/POPS/POPRC.11/10/Add. 2
	SCCPs with chlorine content ranging from 49-71% range from 4.39-5.37	EC 2000
log K_{OA}	4.07 to 12.55 for a chlorination content of 30-70% (modeled values)	Gawor & Wania 2013

2.4 Production

22. The manufacturing process for CPs involves the direct chlorination of n-alkane feedstock, which is also known as normal alkanes or straight-chain alkanes. Alkanes are saturated hydrocarbons consisting only of carbon (C) and hydrogen (H) atoms with single bonds between the carbon atoms; their general formula is CnH2n+2. They can be obtained through several methods, primarily from natural sources and processes.

23. The primary source of alkanes is petroleum refining. Alkanes are major constituents of crude oil. Through the process of refining, crude oil is separated into its component fractions, each containing alkanes of different chain lengths. This separation is primarily achieved through distillation in a fractionating column, where the crude oil is heated, and its components are separated based on their boiling points. The fractions obtained can range from gases (e.g., methane, ethane) to light liquids (e.g., naphtha, gasoline) to heavier liquids and waxes (e.g., diesel, lubricating oils, paraffin wax). Further processing of these fractions can isolate or produce alkanes of specific chain lengths.

24. Other processes exist for obtaining alkanes of different lengths, such as the Fischer-Tropsch process that allows the synthesis of alkanes from carbon monoxide (CO) and hydrogen (H2) gas under high pressure and temperature in the presence of a catalyst typically based on Iron (Fe) or Cobalt (Co).

25. The second phase of the process consists of selecting the alkane feedstock: paraffin wax or liquid paraffin with carbon chain lengths predominantly in the desired range. The feedstock's purity and composition significantly affects the final product's properties.

26. The selected n-alkane feedstock is subjected to chlorination, where chlorine gas is introduced into the feedstock. This reaction is conducted in the presence of a catalyst (usually iron or aluminum

chloride) at temperatures ranging from 80°C to 100°C. Unbranched paraffin fractions (<2 % isoparaffins, <100 ppm aromatics) are used5, and the chemical reaction is as follows:

$$C_xH_{(2x+2)} + y\ Cl_2 \rightarrow C_xH_{(2x-y+2)}Cl_y + y\ HCl$$

27. The chlorination process is controlled by temperature to achieve the desired degree of chlorination. Higher temperatures generally increase the chlorination rate but can also lead to the formation of unwanted by-products. UV light may promote radical substitution.

28. After chlorination, the reaction mixture undergoes several post-processing steps, including neutralizing any acid formed during the reaction (e.g., hydrochloric acid), evacuation of non-reacted chlorine, and fractionation or distillation to separate the chlorinated paraffins based on their carbon chain lengths and degree of chlorination if specific fractions are desired. Finally, purification steps, such as washing and filtering, help remove catalyst residues and other impurities.

29. The final product is then submitted to quality control tests and analysis to determine its chlorine content, carbon chain length distribution, color, density, and other physical and chemical properties relevant to its intended use.

30. Packaging: Once approved through quality control, the SCCPs are packaged accordingly for distribution and use in various applications, such as plasticizers in PVC, additives in lubricants, flame-retardants, and more.

2.5 Different categories of chlorinated paraffins

31. While the basic chemical process of CPs is similar across SCCPs, MCCPs (medium-chain chlorinated paraffin), and LCCPs (long-chain chlorinated paraffin), differences in the feedstock chain length and the specific conditions used in the production process result in products with distinct physical and chemical properties, as well as different environmental and health profiles.

32. The production of chlorinated paraffins involves the chlorination of a mixture of n-alkanes, and achieving a perfect separation of chain lengths during the manufacturing process, especially when preparing the alkane feedstock, is technically challenging. This can result in a distribution of chain lengths in the final product, where primarily targeted MCCPs or LCCPs might contain small amounts of SCCPs.

33. The presence of SCCPs in CP mixtures has to be assessed for three main reasons:

- Regulation: Many countries regulated SCCPs even before the Stockholm Convention ban due to their persistence, bioaccumulation, and potential for causing adverse environmental and health effects. Therefore, the unintentional presence of SCCPs in MCCPs and LCCPs can have regulatory implications for the use and disposal of these substances.
- Product Purity and Specification: For applications requiring specific chain length chlorinated paraffins, the presence of SCCPs in MCCPs or LCCPs can affect the product's performance and safety. This is particularly relevant in applications where the lower chain length and higher volatility of SCCPs could lead to undesirable properties.
- Analytical Challenges: Detecting and quantifying the presence of SCCPs in mixtures with MCCPs and LCCPs can be analytically challenging due to the complex nature of these mixtures and the similarities in chemical structure. Advanced analytical techniques and standards are required to assess the composition of chlorinated paraffin products accurately.

34. Manufacturers and regulatory bodies often employ strict controls and analytical testing to minimize the presence of SCCPs in MCCPs and LCCPs, especially for products intended for use in

[5] Kellersohn, Thomas (1998). "Chlorinated paraffins". Ullmann's encyclopedia of industrial chemistry, electronic release (6th ed.). Weinheim: Wiley-VCH

sensitive applications where the main concern is leakage or leaching of CPs into the environment during use or disposal. Despite these efforts, the potential for SCCP contamination highlights the importance of careful product selection, regulatory compliance, and risk assessment in using chlorinated paraffins.

2.6 Regulations concerning production, use, and trade of CPs

35. Because of the potential content of SCCPs with a high content of chlorine (>48%) and the health risks associated with these chemicals, many countries and international organizations put limits on the free trade of CPs. Beginning from the 90's of the past century, limits for trading chlorinated paraffins were imposed, leading to restrictions and regulations under various international and national frameworks. Here is an overview of key regulations affecting the production, use, and trade of chlorinated paraffins:

2.6.1 Stockholm Convention on Persistent Organic Pollutants

36. International considerations for SCCPs include, the Stockholm Convention on POPs, which listed SCCPs and mixtures containing more than 1% w/w of highly chlorinated SCCPs (>48% w/w of chlorine) to the Convention's Annex A (elimination) with some specific production and use exemptions.

37. The listing of a product in Annex A of the Stockholm Convention on POPs has significant implications for the Parties (countries that have ratified or acceded to the Convention).

38. Article 3, titled "Measures to Reduce or Eliminate Releases from Intentional Production and Use," outlines the Parties' obligations regarding the prohibition, elimination, or restriction of the production and use of chemicals listed in Annexes A, B, and C.

39. For substances listed in Annex A, Article 3 requires Parties to take measures to eliminate the production and use of the chemicals, subject to any specific exemptions listed in the Annex. It specifies that each Party must:

- Prohibit and/or take the legal and administrative measures necessary to eliminate: The production and use of the chemicals listed in Annex A.
- The import and export of these chemicals, except for the purposes of environmentally sound disposal as set forth in paragraph 1(b) of Article 6 (Management of POPs Wastes).
- Allow specific exemptions for the production and use of the chemicals listed in Annex A, or for specific uses of chemicals listed in Annex B, under the conditions agreed upon by the Conference of the Parties (COP) and listed in the relevant Annex.

40. Specific exemptions for certain uses or production of a listed chemical, for the registered Parties are time-bound and subject to review. When a chemical is listed in Annex A with specific exemptions, the Convention allows Parties to register for these exemptions if they cannot immediately eliminate the production and use of the substance. These exemptions provide a transition period during which Parties can work towards alternatives or phase out the substance's use and production entirely.

41. The duration of specific exemptions is usually determined at the time of listing and is specified in the relevant Annex for each chemical. Typically, exemptions might last for a specific number of years, and they can be subject to review, modification, or extension by the COP. These specific exemptions have a limited timeframe and shall expire five (5) years after the date of entry into force of the Convention with respect to that particular chemical (paragraph 4 of Article 4). Unless an earlier date is indicated in the Register by the Party benefiting of the exemption, or an extension is granted by the Conference of the Parties (maximum five years under Article 4 paragraph 7).

42. Actually, Two countries are registered for specific exemptions concerning SCCPs, namely China for production and use and Vietnam for use[6].

Restriction on Trade

43. The listing restricts international trade of the substance between Parties and non-Parties. Parties must ensure that exports of a listed chemical to non-Parties are only allowed for environmentally sound disposal or if the importing non-Party has provided an annual certification that the import is for allowable purposes under the Convention (Article 3 Paragraph 2).

Waste Management

44. Parties must manage wastes containing listed chemicals in an environmentally sound manner, minimizing the impact of these wastes. In summary, the listing of a chemical in Annex A of the Stockholm Convention signifies a global consensus on the need to eliminate that substance to protect human health and the environment from its harmful impacts. It imposes legal obligations on Parties to take concrete steps towards this goal, involving measures related to production, use, import, export, waste management, and reporting.

2.6.2 Basel Convention and SCCPs

45. In addition to the provisions of the Stockholm Convention, those of the Basel Convention are directly relevant to the application of best available techniques and best environmental practices to address releases of SCCPs from waste. Considering that several waste streams, including waste from electrical and electronic equipment (WEEE), plastic wastes and others are major potential SCCPs-containing material flows, synergies between the Stockholm Convention and Basel Convention are of high importance.

46. The Basel Convention places obligations on countries that are Parties to, inter alia: minimize generation of hazardous waste; ensure that adequate disposal facilities are available; and ensure environmentally sound management of wastes.

47. Under the Stockholm Convention, POP-containing wastes are, in accordance with Article 6, paragraph 1 (d) (ii), to be 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 or otherwise, they 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 low, taking into account international rules, standards, and guidelines, including those that may be developed pursuant to paragraph 2, as well as relevant global and regional regimes governing the management of hazardous wastes.

48. Paragraph 2 of Article 6 of the Stockholm Convention, which addresses measures to reduce or eliminate releases from stockpiles and wastes, contains the following provisions:

"*The Conference of the Parties shall cooperate closely with the appropriate bodies of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal to, inter alia:*

(a) Establish levels of destruction and irreversible transformation necessary to ensure that the characteristics of persistent organic pollutants are not exhibited;

(b) Determine what they consider to be the methods that constitute environmentally sound disposal referred to above; and

(c) Work to establish, as appropriate, the concentration levels of the chemicals listed in Annexes A, B and C in order to define the low persistent organic pollutant content referred to in paragraph 1 (d) (ii)."

49. The Conference of the Parties to the Basel Convention adopted:

- The updated guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with short-chain chlorinated paraffins (UNEP/CHW.14/7/Add.2/Rev.1) (UNEP 2019)
- The updated general technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (UNEP/CHW.16/6/Add.1/Rev.1) (UNEP 2023a).

50. The general technical guidelines developed under the Basel Convention address matters related to all three of the outstanding definitional issues raised in paragraph 2 of Article 6 of the Stockholm Convention. These documents provide the framework for the environmentally sound management (ESM) of SCCPs wastes. The provisional definition of low POP content for SCCPs under the Basel Convention is [100 mg/kg][1500 mg/kg][10,000 mg/kg] (UNEP 2023a).

51. Further guidance relevant to matters under Article 6 of the Stockholm Convention is contained in Basel technical guidelines[7] for:

- Plastic wastes:
  - Technical guidelines for the environmentally sound management of plastic wastes and for their disposal (UNEP/CHW.16/6/Add.3/Rev.1) (UNEP 2023b).
- WEEE:
  - Guidance document on environmentally sound management of used and end-of-life computing equipment (UNEP/CHW.13/INF/31/Rev.1) (UNEP 2017a);
  - Technical guidelines on transboundary movements of electrical and electronic waste and used electrical and electronic equipment, in particular regarding the distinction between waste and non-waste under the Basel Convention (UNEP/CHW.16/INF/10/Rev.1) UNEP 2023c). These technical guidelines were adopted on an interim basis.
- Co-processing of hazardous wastes in cement kilns:
  - Technical guidelines on the environmentally sound co-processing of hazardous wastes in cement kilns (UNEP/CHW.10/6/Add/3/Rev.1) (UNEP 2011).
- Landfills:
  - Technical guidelines on the environmentally sound disposal of hazardous wastes and other wastes in specially engineered landfill (D5) (UNEP/CHW.15/6/Add.5/Rev.1) (UNEP 2022a).
- Incineration:
  - Technical guidelines on the environmentally sound incineration of hazardous wastes and other wastes as covered by disposal operations D10 and R1 (UNEP/CHW.15/6/Add.4/Rev.1) (UNEP 2022b)

[7] The guidelines can be accessed on the Basel Convention website: https://www.basel.int/Implementation/TechnicalMatters/DevelopmentofTechnicalGuidelines/TechnicalGuidelines/tabid/8025/Default.aspx

2.6.3 Other Regulations

52. Many countries and regional organizations have their regulations aligned with international conventions or have established specific limits and restrictions on the use and trade of CPs, including SCCPs. It is crucial for manufacturers, importers, exporters, waste handlers, and users of chlorinated paraffins to be aware of and comply with the regulations applicable in their countries and in the countries with which they trade.

53. **Europe:** SCCPs were added to Annex I of the EU POP Regulation (EC Regulation No. 850/2004 of the European Parliament and of the Council of 29 April 2004 on persistent organic pollutants and amending Directive 79/117/EEC), extending the scope of the original regulations to prohibit the production, placing on the market and use of SCCPs or preparations containing SCCPs in concentrations greater than 1% by weight or articles containing SCCPs in concentrations greater than 0.15% by weight. Some exemptions were allowed at the publishing of this rule, but since 2015 all uses of SCCPs are prohibited above the previously mentioned limit values.

54. **REACH Regulation (Europe):** The Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH) regulation restricts using SCCPs in substances, mixtures, and articles in concentrations greater than 1% by weight. SCCPs are also identified as Substances of Very High Concern (SVHCs) under REACH. This restricts their use within the EU and affects their import into the region.

55. **United States:** The Environmental Protection Agency (EPA) has taken action under the Toxic Substances Control Act (TSCA) to assess and manage risks from SCCPs. It has evaluated and regulated the use of chlorinated paraffins, including SCCPs, and imposed specific rules and consent orders to restrict the use of SCCPs in certain applications. The EPA has also proposed a Significant New Use Rule (SNUR) for certain chlorinated paraffins, including SCCPs, requiring notification to the EPA before they can be used in new applications.

56. **Canada:** Canada has concluded SCCPs are toxic under the Canadian Environmental Protection Act, 1999 (CEPA) and prohibited their manufacture, use, sale, and import under the Prohibition of Certain Toxic Substances Regulations, 2012. Regarding incidental presence of SCCPs, the regulations require annual reporting if the total annual quantity of SCCPs contained in a product, such as MCCPs, that is manufactured in Canada or imported into Canada exceeds 1 kg, and its annual weighted average concentration in the product is equal to or greater than 0.5% (w/w)8. On May 14, 2022, proposed amendments to the Regulations were published which would remove the above-mentioned annual reporting requirements.

57. **Asia:** Regulatory actions in Asia vary by country, with some countries implementing restrictions in line with the Stockholm Convention. For instance: China has been working on measures to control and reduce the production and use of SCCPs, including issuing risk assessment reports and environmental management actions. Noting that China and Vietnam are registered as Parties benefiting from specific exemptions allowed by the Stockholm Convention.

2.6.4 Analysis and Characterization of Chlorinated Paraffins

58. Analyzing CPs to determine their composition is very important, especially to determine their content in SCCPs and chlorine; this is the only way to know if a CPs mixture is to be classified as POP. As technical CP mixtures are complex and may contain thousands of congeners and isomers, it is a challenging task to reach high levels of determination. Several analytical techniques are used together to characterize the carbon chain length distribution of CPs (SCCPs, MCCPs and LCCPs) and chlorine content. Some of the techniques used are summarized below.

Gas Chromatography (GC):

[8] POPRC.12/4

59. Gas chromatography, especially when coupled with electron capture detection (ECD) is a widely used technique for analyzing CPs. GC-ECD is sensitive to chlorinated compounds, making it suitable for detecting CPs, but it may not effectively resolve complex mixtures. Due to the high boiling points of CPs, they often need to be converted into more volatile derivatives before GC analysis.

Gas Chromatography-Mass Spectrometry (GC-MS):

60. When GC-ECD is coupled with a mass spectrometer (MS) more detailed information can be obtained, including identifying specific chlorination patterns and chain lengths. GC-MS combines the separation capabilities of GC with the identification and quantification abilities of MS. This technique can provide detailed information on the molecular weights and structural characteristics of CPs, allowing for the identification of individual congeners within a mixture. However, the complexity of CP mixtures can make complete resolution and identification challenging.

Liquid Chromatography-Mass Spectrometry (LC-MS):

61. Liquid chromatography (LC) coupled with mass spectrometry is particularly useful for analyzing CPs with higher molecular weights and those that are difficult to volatilize for GC analysis. LC-MS can handle the complex mixtures of CPs without the need for derivatization and can provide detailed information on the chain length distribution and degree of chlorination.

Fourier Transform Infrared Spectroscopy (FTIR):

62. FTIR spectroscopy is used to identify functional groups in molecules based on their infrared absorption characteristics. It can provide information on the presence of C-H and C-Cl bonds, indicating chlorinated paraffins. Still, it is less effective for detailed compositional analysis or for distinguishing between CPs of different chain lengths and chlorination levels.

Nuclear Magnetic Resonance Spectroscopy (NMR):

63. NMR spectroscopy can offer detailed structural information about CPs, including insights into the carbon chain length and degree of chlorination. H-NMR and C-NMR are particularly useful for elucidating the structure of CPs. However, the technique requires relatively large sample amounts and may be less sensitive compared to mass spectrometry-based methods.

X-ray Fluorescence Spectroscopy (XRF):

64. XRF can be used to quantify the total chlorine content in CP samples, providing an indication of the degree of chlorination. While XRF offers rapid and non-destructive analysis, it does not provide detailed information on chain length distribution or specific congener identification.

65. Analytical strategies for CPs often involve the use of multiple techniques in combination to achieve a comprehensive characterization of the sample. The choice of method depends on the specific requirements of the analysis, including the type of CPs being analyzed, the complexity of the mixture, the desired level of detail, and the available instrumentation.

66. Currently, the determination of SCCPs is mostly performed by mass spectrometry (MS) in the Electron Capture Negative Ionisation (ECNI) mode. This approach is prone to interferences from other chlorinated compounds and medium-chain chlorinated paraffins, leading to errors in the quantification of SCCPs.

67. Alternative approaches for SCCP determination have been developed, for example, carbon skeleton gas chromatography (GC-MS) in which chlorinated paraffins are catalytically hydrodechlorinated to the corresponding n-alkanes and analyzed. Information on the chlorination degree is lost, but accurate quantification of paraffins is possible.

68. The National Institute for Environmental Studies, Japan, has developed a new method based on LC-MS/MS to screen wastes and consumer products containing CPs (Hidenori Matsukami et al., 2021).

2.6.5 Standards for SCCPs analysis in some matrices

69. International norms and standards have been developed to standardize CP analysis in different matrices; some of them are presented below:

- ISO 18219-1: Leather - Determination of chlorinated hydrocarbons in leather - Part 1: chromatographic method for short-chain chlorinated paraffins (SCCPs). This document specifies a chromatographic method to determine the amount of short-chain chlorinated paraffins (SCCPs) C10 to C13 in processed and unprocessed leathers.
- ISO 22818: Textiles - Determination of short-chain chlorinated paraffins (SCCP) and middle-chain chlorinated paraffins (MCCP) in textile products out of different matrices by use of gas chromatography negative ion chemical ionization mass spectrometry (GC-NCI-MS). This document specifies a chromatographic method to determine the amount of short-chain chlorinated paraffins (SCCPs: C10-C13) and middle-chain chlorinated paraffins (MCCPs: C14-C17) in textile articles, especially in polymer of the coated fabrics, prints made of polymer and buttons made of polymer (e.g. polyvinylchloride) using solvent extraction and gas chromatography negative ion chemical ionization mass spectrometry (GC-NCI-MS).
- ISO 12010: Water quality - Determination of short-chain polychlorinated alkanes (SCCP) in water - Method using gas chromatography-mass spectrometry (GC-MS) and negative-ion chemical ionization (NCI). This standard specifies a method for the quantitative determination of the sum of short-chain polychlorinated n-alkanes, also known as short-chain polychlorinated paraffins (SCCPs) in the carbon bond range n-C10 to n-C13 inclusive, in mixtures with chlorine mass fractions ("contents") between 50 % and 67 %, including approximately 6 000 of approximately 8 000 congeners. This method applies to determining the sum of SCCPs in unfiltered surface water, groundwater, drinking water and wastewater using gas chromatography-mass spectrometry with electron capture negative ionization (GC-ECNI-MS).

2.6.6 Worldwide Production of CPs and SCCPs

70. Chlorinated paraffins are produced in various regions worldwide, reflecting its widespread use in numerous industrial applications. The production and use patterns can vary due to regional regulations, economic factors, and demand in specific sectors such as metalworking fluids, plastics, paints, and flame retardants.

71. The production of CPs can be divided into three time periods:

(i) 1935–1974: the production volumes were below 35,000 t/year;
(ii) 1975–2005: the sum of worldwide CP production increased from 60,000 to 350,000 t/year;
(iii) 2006–2012: the sum of worldwide CP production increased much more rapidly than before and went up to 1,100,000 t/year[9].

[9] Juliane Glüge, Zhanyun Wang, Christian Bogdal, Martin Scheringer, Konrad Hungerbühler: Global production, use, and emission volumes of short-chain chlorinated paraffins – A minimum scenario, Science of The Total Environment, Volume 573, 2016. https://doi.org/10.1016/j.scitotenv.2016.08.105

72. The actual global production capacity was estimated to be around two million metric tons (t) per year[10][11]. Even if the global production landscape for chlorinated paraffins has shifted due to changes in regulations, market demand, and technological advancements in alternatives, SCCPs are still produced, frequently in mixtures with MCCPs and LCCPs in proportion reaching 20%; the SCCP quantity was estimated to be 165,000 t/year[12] in 2016 (Juliane Glüge, 2016).

China, the only country registered fora specific exemption for the production of SCCPs, is actually the largest producer of chlorinated paraffins worldwide; its production increased from 600 kt in 2007 (Fiedler, 2010) to 1000 kt/year in 2009 (Chen et al., 2011). In fact, China does not report its SCCP production but rather its chlorinated paraffin production without distinguishing between different paraffin lengths. The SCCP mass fractions in three CP brands, CP-42, CP-52, and CP-70, were determined to be 3.7%, 24.9%, and 0.5%, respectively (Gao et al., 2012).

2.6.7 Products containing SCCPs

73. SCCPs were and continue to be used primarily as extreme pressure additives (i.e., lubricants and coolants) in metalworking applications and polyvinyl chloride (PVC) plastics. Other uses include in paints, adhesives and sealants, leather fat liquors, and as flame retardants in rubber, textiles, and polymeric materials (UNEP/POPS/POPRC.11/10/Add.2).

74. As reported by UNEP/POPS/POPRC.12/4, SCCPs are still used in everyday products such as microwave dishes, lamps, electronic items such as cables, adapters, keyboards, memory media, photo frames, headphones, and also in detergent. Inspection and enforcement activities carried out in Norway, Germany, Austria, and Sweden, where SCCPs are banned, have found the continued presence of SCCPs in articles:

75. In Norway (Annex F submission -2015), products were found to contain SCCPs above permitted levels ranging from 0.16 to 10.7 %.

76. In Germany (Annex F submission 2015), the City of Hamburg found that 19 of 84 plastic products sampled contained SCCPs, including electronics, toys, household articles, tools, swimming gadgets, bicycle pants and sports articles.

77. In Austria (Annex F submission 2016), SCCP concentrations exceeding permitted levels in mats, ranging from 0.4% to 6.9%, were detected.

78. The Swedish Chemicals Agency (Sweden Annex F 2015 submission) has also carried out tests on 62 articles and found that 16 contained SCCPs in high concentrations; furthermore, 11 different articles were found to have low concentrations of SCCPs. The low concentrations could have been caused by contamination during the manufacturing or delivery process. SCCPs were detected in various products such as electrical items, toys, childcare articles, exercise gloves, plastic bags, bathroom accessories, sports equipment, garden tools and office supplies.

79. These findings demonstrate that new products continue to be a source of SCCPs and contribute to human and environmental exposure. In Europe, it was estimated that releases during the service life of products and articles contributed 0.6 – 1.7 t/year to air, 7.4 – 19.6 t/year to wastewater, 4.7-9.5 t/year to surface water and 8.7-13.9 t/year to industrial soil (BRE 2008).

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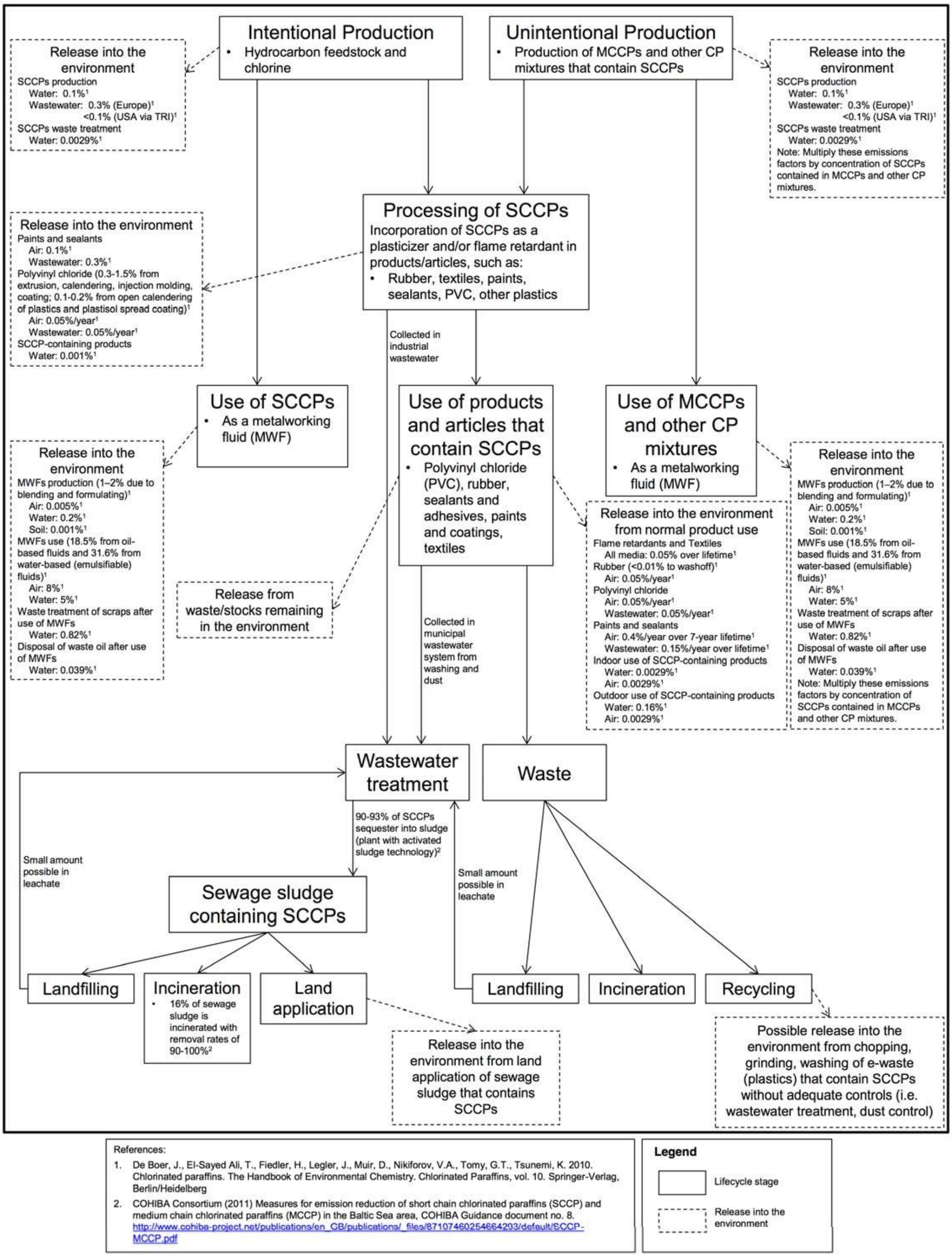
[10] Yago Guida, Raquel Capella, Natsuko Kajiwara, Joshua Olajiire Babayemi, João Paulo Machado Torres, Roland Weber: Inventory approach for short-chain chlorinated paraffins for the Stockholm Convention implementation in Brazil. In Chemosphere Volume 287, Part 3, January 2022, 132344

[11] SETAC SciCon Session Summaries – SETAC Globe". Chlorinated Paraffins – State of Science, Insights, Challenges and the Way Forward. Retrieved 10 August 2021.

[12] Introduction to Short-Chain Chlorinated Paraffins (SCCPs) Web-seminar to support inventory development of SCCPs and PBDEs (COP8 listed) and updating of National Implementation Plans (NIPs) under the Stockholm Convention; Web-Seminar 16-18, November 2020

80. Figure 2 below summarize the full life cycle of SCCPs from production to release in the environment.

Figure 2. SCCP life cycle (UNEP/POPS/POPRC.12/INF/7)



3. Uses of chlorinated paraffins

81. CPs with different carbon lengths and degrees of chlorination have different properties and, because of their versatility, they are used for a wide range of applications. Uses have varied among countries and over time, but the main applications of SCCPs have been as plasticizer for the production of products in polyvinylchloride (PVC) metalworking fluids, paints, coatings, sealants, rubber and textiles, as a flame retardant, and in leather fat liquoring or as water repellent (UNEP/CHW.14/7/Add.2/Rev.1).

82. In this chapter most important uses of SCCPs are presented along with some alternatives substances that could be used instead. This is to help countries, industries and uses to make better choices than SCCPs, noting that it is their responsibility to assess the impacts of these alternatives, as this document does not endorse the use of any of these substances.

3.1 Use of SCCPs in Metalworking

83. SCCPs are used in metalworking for several key purposes, leveraging their properties to enhance the performance and longevity of metal components and tools. SCCPs are valuable in metalworking for their multifunctional properties that enhance lubrication, cooling, corrosion protection, and metal forming. These benefits contribute to more efficient manufacturing processes, higher quality metal components, and extended tool life. The main properties of SCCPs in metalworking are described below.

3.1.1 Lubrication in Metalworking

84. One of the primary uses of SCCPs in metalworking is as a lubricant. Due to their chlorine content, SCCPs are highly effective in reducing friction between metal surfaces. This lubrication is crucial during processes such as machining, drilling, and stamping, where metal parts move against each other or cutting tools. The lubricating properties of SCCPs help in extending the life of cutting tools by reducing wear and tear, and they also improve the finish of the machined parts by minimizing scratches and other surface imperfections.

3.1.2 Cooling in Metalworking Processes

85. In addition to lubrication, SCCPs also serve as coolants in metalworking processes. The heat generated from metal-on-metal contact can lead to deformation of the parts being machined and can degrade the cutting tools. SCCPs help in dissipating this heat, maintaining the temperature at a level that is safe for both the machinery and the workpiece. This cooling effect further contributes to the precision of the machining process and the quality of the finished product.

3.1.3 Corrosion Protection in Welding

86. SCCPs have excellent corrosion-inhibiting properties, which is another reason for their use in metalworking. They form a protective layer on the surface of metals, shielding them from the corrosive effects of moisture, oxygen, and other environmental factors. This protective layer helps prevent rust and other forms of corrosion, thereby prolonging the life of metal parts and tools.

87. In metalworking, SCCP prevents stress corrosion cracking (SCC) in welded joints. Failure often occurs due to void formation and residual stresses, especially when exposed to corrosive environments. This is particularly important in industries where metal components are exposed to harsh conditions and must maintain their integrity over long periods, like supercritical water-cooled nuclear Reactors (SCWR), which work in temperatures over 600°C and 25 Atm.

3.1.4 Metal Forming

88. In metal forming processes such as extrusion, rolling, and forging, SCCPs facilitate the shaping of metal workpieces. They provide a lubricating film that reduces the force required to shape the

metal, improving process efficiency and preventing sticking or seizing of parts. This not only helps achieve the desired shape and dimensions more easily but also ensures a better surface finish on the final product.

3.1.5 Deburring

89. The removal of burrs (sharp, unwanted pieces of metal) from machined parts is an essential finishing process in metalworking. SCCPs are used in deburring to lubricate the parts and the tools used for burr removal. This lubrication helps achieve a smoother finish and prevents damage to the delicate surfaces of the machined parts.

3.1.6 Drawbacks of SCCPs in metalworking

90. While SCCPs offer several advantages in metalworking, their use also comes with notable drawbacks, primarily related to the SCCP' properties which classify them as POPs, but also direct health hazards for metalworkers, and pose difficulty in eliminating wastes containing SCCPs, and economical issues:

91. Workers in facilities that use SCCPs in metalworking processes might be exposed to these chemicals through inhalation or skin contact, posing occupational health risks:

- Direct skin contact may irritate, leading to discomfort and potentially more severe dermatological conditions with prolonged exposure. Eye contact may potentially damage irreversibly the eyes.
- Inhalation of fumes or mists containing SCCPs during metalworking processes can lead to respiratory issues, including irritation of the respiratory tract, difficulty breathing, and potentially long-term lung problems.
- There is also evidence to suggest that SCCPs may have carcinogenic effects and can interfere with hormonal functions, potentially leading to reproductive issues, endocrine disruption, and other systemic health effects.

92. Materials contaminated with SCCPs, such as cutting fluids or metal shavings, require careful handling to avoid environmental contamination. The persistent nature of SCCPs means that standard disposal methods may not be sufficient to prevent their release into the environment. This can increase the complexity and cost of waste management processes for companies involved in metalworking as these wastes are to be eliminated according to the guidelines of the Basel Convention.

93. The regulatory restrictions and potential future ban on SCCPs after the exemption period may lead to increased costs for industries that rely on these chemicals. Companies might need to invest in research and development to find suitable, environmentally friendly alternatives or face increased costs associated with compliance and waste disposal. Additionally, the potential health risks associated with SCCP exposure can lead to higher insurance premiums and business liabilities.

94. As regulations on SCCPs become more stringent, metalworkers and their employers may be forced to seek alternative substances or processes. This transition can involve significant research, investment, and training to ensure that alternatives are effective and compliant with new regulations.

3.1.7 Alternatives to SCCPs in metalworking

95. Using alternatives to SCCPs in metalworking is essential due to their environmental and health impacts, along with increasing regulatory restrictions. Alternatives are required across various applications, including lubricants, coolants, and anti-corrosion treatments, focusing on providing similar benefits without the associated drawbacks. Alternatives to SCCPs in metalworking include:

Lubricants and Coolants in metalworking

96. Alternatives to SCCPs as coolants and lubricants exist, and many of them have no known drawbacks; here are some examples:

- **Vegetable-Based Oils:** Natural vegetable-based oils are increasingly popular as lubricants and coolants due to their biodegradability and lower toxicity. Modifications and additives can enhance their performance, making them suitable for a wide range of metalworking processes.
- **Polyalphaolefins (PAOs):** Synthetic hydrocarbons like PAOs offer thermal stability and lubrication properties, making them suitable alternatives to SCCPs in applications requiring high-performance lubricants. J. Carpenter (1995), in a study published in the Journal of Synthetic Lubrication, discussed the biodegradability and toxicity of polyalphaolefin base and concluded that they have low eco-toxicity, with minimal impact on aquatic life compared to many other types of oils and lubricants. PAOs are generally considered to have low acute toxicity to humans. They are less likely to cause skin irritation or sensitization compared to many other types of oils and lubricants, including some mineral oils and chlorinated paraffins. Their low volatility also reduces the risk of inhalation exposure during use. Moreover, their lower eco-toxicity makes them a preferable option in applications where potential leaks or spills could affect water bodies. However, like with any chemical substances, appropriate handling measures and personal protective equipment (PPE) are recommended to minimize exposure risks in occupational settings.
- **Ester-Based Lubricants:** Synthetic esters, derived from organic acids and alcohols, provide good lubricity and biodegradability and are less toxic than SCCPs. They are used in various metalworking fluids for their excellent lubricating properties.
- **Water-Based Fluids:** Water-based or water-soluble metalworking fluids, which can be supplemented with corrosion inhibitors and extreme pressure additives, provide an alternative that significantly reduces health and environmental risks associated with oil-based products.

Anti-Corrosion Treatments

97. Following are some alternatives of SCCPs as anti-corrosion fluids:

- **Phosphate Esters:** Phosphate esters are used as fire-resistant hydraulic fluids and as additives in other metalworking fluids offering good anti-wear and anti-corrosion properties.
- **Inorganic Corrosion Inhibitors:** Compounds like sodium nitrite, molybdates, and borates can be used in cooling systems and metalworking fluids to provide corrosion protection without the environmental persistence of SCCPs.
- **Ceramic Coatings:** Instead of using fluids to inhibit corrosion, ceramic coatings can provide excellent corrosion resistance and surface hardness, reducing the need for chemical corrosion inhibitors in certain applications.
- **Barrier Coatings:** Non-toxic barrier coatings made from polymers or natural wax-based products can prevent metal corrosion by physically isolating the metal surface from corrosive agents.

Metal forming

98. Alternatives to SCCPs in metal forming have to offer similar benefits—lubrication, cooling, and reduced tool wear—without the associated environmental and health risks. Some substances are the same as those already identified above with regards to their properties for use as coolants and anti-

corrosives for metalworking purposes, such as vegetable-based oils, synthetic esters, and water-based fluids, and here are others suitable for metal forming:

- **Polyalkylene Glycols (PAGs):** PAGs are synthetic lubricants known for their excellent lubrication properties and stability across a wide range of temperatures. Their advantages include water-solubility, which can aid in cleaning and reducing residues on metal parts, low toxicity, and a good environmental profile. They are suitable for various metalworking applications, including metal forming.

3.1.8 Considerations for Selection of Alternatives to SCCP in Metalworking

99. Transitioning to these alternatives requires carefully evaluating their performance in specific applications. Pilot testing and consultation with lubricant suppliers can help identify the best option for a given metalworking process.

100. Here are some criteria to consider substances as alternatives to SCCP in metalworking:

- Compatibility with Metals: the chosen alternative should not cause corrosion or staining of workpieces.
- To be viable in demanding metalworking applications, alternatives should match or exceed the performance of SCCPs regarding lubrication, cooling, and corrosion protection.
- Process Requirements: the lubricant must meet the specific needs of the metalworking process, whether it requires high pressure, temperature, or specific surface finish qualities.
- Environmental and health Impact: ideally, alternatives should have a lower impact on workers' health and the environment, including considerations for biodegradability and toxicity. Lower volatility and reduced skin, and respiratory irritation (avoiding toxicological risks to workers is paramount).
- Regulatory compliance: it is essential to ensure that the alternative lubricants comply with local and international regulations to avoid potential legal and financial implications.
- Cost-effectiveness: while some alternatives may be more expensive than SCCPs, their use can be justified by improved worker safety, environmental compliance, and potential savings from regulatory compliance.

3.2 Use of SCCPs in PVC

3.2.1 Purpose

101. SCCPs were used as plasticizers in PVC due to their ability to impart flexibility, flame retardancy, and chemical stability to the final products. The incorporation of SCCPs into PVC formulations helps in achieving the desired material characteristics essential for a wide range of consumer, industrial, and construction products.

102. SCCPs enhance the properties of PVC products, such as vinyl flooring and synthetic leather, by improving flexibility. This is critical for the performance and durability of these products, particularly relevant in applications requiring high elasticity and resilience against physical stress.

3.2.2 Alternative substances

103. Many SCCPs alternatives as plasticizers in PVC exist, offering similar functionalities while mitigating environmental and health concerns associated with SCCPs:

- Phthalate esters, adipate esters, and citrate esters: recognized as potential alternatives, these esters can serve similar plasticizing functions in PVC (Guida et al., 2022).

- Plasticizer composition containing epoxidized fatty acid monoester and epoxy ester: demonstrated to reduce the extraction of halogenated polymers and exhibit less volatility, offering an alternative plasticizing option (Peter Frenkel et al., 2012).
- Bio-based and phthalate-free plasticizers: these alternatives are derived from renewable resources or non-chlorinated paraffins, designed to replace SCCPs in PVC applications (Hogue, 2013).
- Di(2-ethylhexyl) terephthalate (DEHT) and dibutyl phthalate (DBP): mentioned as compatible and performance-enhancing in PVC, indicating the viability of these plasticizing options (Kobetičová et al., 2018).
- Medium- and long-chain chlorinated paraffins: Although further research is needed, some suggest these compounds could serve as alternatives by potentially offering lower health risks and better environmental profiles compared to SCCPs (South et al., 2022). MCCPs are currently under review by the POPRC for potential listing the Stockholm Convention.

3.3 SCCPs as Flame-Retardant

3.3.1 Purpose

104. SCCPs are used as flame retardants due to their ability to enhance the fire-resistant properties of various materials. The mechanism behind their flame-retardant action is primarily physical and chemical in nature. When materials treated with SCCPs are exposed to high temperatures or flames, the chlorine present in SCCPs releases hydrogen chloride (HCl) gas. This release of HCl helps to quench the flame by inhibiting the radical chain reaction that sustains combustion. There is also a physical mechanism; SCCPs can also promote the formation of a char layer on the material's surface when exposed to fire. This char layer acts as a barrier, reducing heat transfer to the underlying material and slowing down the material's contribution to the fire.

3.3.2 Alternatives to SCCPs used as Flame Retardants

105. Some alternatives for SCCPs as flame retardants exist:

- Aluminum hydroxide (aluminum trihydrate, ATH): a widely used flame retardant that releases water when heated, helping to cool the material and reduce the temperature below the combustion point. ATH is non-toxic and does not produce hazardous decomposition products just water and aluminium hydroxyde.
- Magnesium hydroxide: works similarly to ATH by releasing water when heated, thus cooling the material and acting as a flame retardant. Magnesium hydroxide also offers the advantage of higher thermal stability compared to ATH.
- Phosphorus-based flame retardants: these include red phosphorus, ammonium polyphosphate, and organophosphorus compounds. They act mainly by promoting char formation and inhibiting the combustion process.
- Inorganic flame retardants: materials like zinc borate and expandable graphite are used as flame retardants in various applications. They can act by promoting char formation, diluting flammable gases, and absorbing heat.
- Intumescent coatings: these coatings expand when exposed to heat, forming an insulating char layer that protects the material underneath from fire. Intumescent systems often contain a combination of acid, carbon, and blowing agents.
- Bio-based flame retardants research is ongoing with the aim of creating bio-based flame retardants derived from natural or renewable sources. These include flame retardants based on lignin, DNA, and other natural polymers, which offer the potential for lower toxicity and environmental impact.

106. When selecting an alternative flame retardant, it is important to consider the specific requirements of the application, including thermal stability, mechanical properties, and compatibility with the host material, in addition to the ecological and health impacts.

3.4 SCCPs in Paints, Adhesive, and Sealants used in manufactured products

107. Open applications of SCCPs include their incorporation in paints, adhesives, and sealants.

3.5 SCCPs in Textile Finishing

3.5.1 Purpose

108. SCCPs are used in some textiles primarily for their flame-retardant and plasticizing properties. These chemicals are added to textiles to enhance fire resistance, reduce flammability, and improve the durability and flexibility of materials. Their application in this sector include clothing, drapery, and furniture covering, especially those that could be exposed to open flame or high heat sources. Another reason for using these substances is their relatively low cost compared to some alternative chemicals that offer similar properties. However, due to environmental and health concerns associated with SCCPs, there is a growing interest in finding safer alternatives.

3.5.2 Alternatives for the Textile Sector

109. Due to the importance of this sector in today's economy, textile and chemical sectors developed many alternatives including the following[13]:

- Phosphorus-based flame retardants: these compounds offer good flame retardancy. They can be used in various textile applications.
- Inorganic flame retardants: compounds like aluminum hydroxide and magnesium hydroxide act as flame retardants by releasing water when heated, which helps to cool the material and reduce flammability.
- Halogen-free flame retardants: these include a variety of chemicals, such as expandable graphite and certain nitrogen-based compounds, which may be less harmful than chlorinated and brominated flame retardants.
- Intumescent coatings: These coatings expand when heat exposure, forming a protective char layer that insulates the underlying material from fire. Intumescent systems are increasingly used in textiles for their effective flame-retardant properties.
- Bio-based flame retardants: research is ongoing into natural and bio-based compounds that offer flame retardancy. These include DNA, lignin, and certain plant-derived compounds that can impart flame-retardant properties to textiles in a potentially environmentally friendly manner.
- Boron compounds: Borates and other boron-based compounds are used for their flame-retardant properties. They are effective and are used in various applications, including textiles.

3.6 SCCPs in Leather Finishing

3.6.1 Purpose

110. Fat liquoring is a critical step in leather processing that introduces oils, fats, or other substances to enhance the leather's softness, flexibility, and water resistance. Fat liquoring with SCCPs is not a common practice, according to manufacturers, and products or mixtures containing this substance are

[13] Sourced from many Internet sites and documents

not well known. Developing standards to analyze the presence of SCCPs in leather may bring some transparency in this sector.

3.6.2 Alternatives to SCCPs in Leather Manufacturing

111. Many manufacturers have shifted to using more ecological alternatives. Such alternatives like sulfated fat liquor from sheep-limed fleshing wastes show comparable quality to commercial fish oil-based fat liquors, suggesting the importance of choosing effective fat liquoring agents for desired leather qualities (A. Nasr et al.). Besides these natural products others chemical substances may be used (Aguado, Angel, et al.)[14] :

- Polymeric fat liquors: these are modern alternatives based on polymers that can impart excellent softness and fullness to the leather. Polymeric fat liquors can often provide superior performance regarding the leather's physical properties.
- Esterquats: they are used as cationic surfactants in fat-liquoring formulations and represent another innovative approach. They can contribute to the softening process while being more biodegradable than traditional materials containing SCCPs.
- Amidated and phosphorylated vegetable oils: these chemically modified vegetable oils offer an efficient fat-liquoring alternative, improving leather properties such as softness, lightness, and waterproofing.

3.7 SCCPs in Adhesives

3.7.1 Purpose

112. SCCPs are used in adhesives for several reasons, primarily because they can act as plasticizers and secondary flame retardants. SCCPs help to enhance flexibility, durability, and flame-retardant properties, making the adhesive formulations more effective for various applications, including in the automotive, construction, and textile industries. However, due to environmental and health concerns related to the persistence, bioaccumulation, and potential toxic effects of SCCPs, there is a growing demand for safer and more sustainable alternatives.

3.7.2 Alternatives of SCCP in adhesives

113. Alternatives to SCCPs in adhesive include the following substances:

- Phthalate-free plasticizers: alternatives like dioctyl terephthalate (DOTP), dioctyl succinate (DOS), and bio-based plasticizers offer similar plasticizing effects as SCCPs. These are becoming increasingly popular in the adhesive industry.
- Phosphorus-based flame retardants: phosphorus-based compounds, including red phosphorus, ammonium polyphosphate, and phosphonates, are effective flame-retardants that can be used in adhesives.
- Boron compounds: borates and other boron-based compounds have been used for their flame retardant properties and represent an alternative to SCCPs in adhesives.

3.8 Waterproofing and Fire-Retardant Paints

3.8.1 Purpose

114. SCCPs are used in the production of waterproof paints for several key reasons, including their ability to act as secondary plasticizers, flame retardants, and to enhance the durability of paint coatings. SCCPs help to improve the flexibility of paint films, making them less brittle and more resistant to cracking or chipping. By adding flame-retardant properties to paints, SCCPs contribute to

[14] https://dx.doi.org/10.1016/J.TCA.2004.10.007

reducing the flammability of coated surfaces, which is particularly important in certain industrial and residential applications.

115. However, due to the environmental and health risks associated with SCCPs, there's a growing interest in identifying safer and more sustainable alternatives for use in paint formulations.

3.8.2 Alternatives of SCCPs in Paints

116. Some alternatives to SCCPs are presented below:

- Water-based formulations: Increasingly, paint formulations are moving towards water-based systems, which reduce the need for plasticizers and flame retardants.
- Bio-based and renewable plasticizers: research into sustainable alternatives has led to the development of plasticizers derived from vegetable oils (e.g., epoxidized soybean oil) and other renewable resources.
- Phthalate-free plasticizers: alternatives such as dioctyl terephthalate (DOTP) and acetyl tributyl citrate (ATBC) have been developed to provide the necessary plasticizing effects.

117. UNEP/POPS/POPRC.12/INF/7 contains an extensive list of SCCP alternatives for different uses. This document also includes information on Environmental and health properties, Regulatory status, Load in% w/w, Price, Economic feasibility, availability and accessibility, and references.

4. Best Available Techniques (BAT) and Best Environmental Practices (BEP)[15]

4.1 General BAT and BEPs in chemical manufactures

118. Table 3 below summarizes information on BAT and BEP applicable in industry in general.

Table 3. Summary of BAT and BEP applicable to manufacture using chemicals.

Process steps	BAT	BEP
General measures for manufactures using SCCPs or related substances	• Regular inspection and maintenance of plant and equipment • Monitoring of emissions/releases Substitution of harmful/hazardous substances • Limiting the number of emission points	• Implementation and adherence to an internationally accepted EMS, such as ISO 9001 and ISO 14001 • Establishment, maintenance and regular review of a channeled and diffuse emissions to air inventory
Measures for the reduction of channeled emissions	• Use of the following techniques to reduce • channeled emission to air of organic compounds: adsorption, absorption, catalytic oxidation condensation, thermal oxidation • Use of the following techniques to reduce channeled emissions to air using optimized catalytic or thermal	

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	oxidation, rapid waste-gas cooling, adsorption using activated carbon • The use of an absolute filter, absorption, fabric filter, and/or high-efficiency air filter to reduce channeled emissions to air of dust and particulate-bound metals	
Measure for the reduction of diffuse emissions	• Limiting the number of emission sources (e.g. minimizing pipe lengths, reducing the number of pipe connectors and valves, using welded fittings and connections, using compressed air or gravity for material transfer) • Collection of diffuse emissions and treating off-gases • Facilitating access to potentially leaky equipment (installing platforms, using drones for monitoring) • Use of high-integrity equipment: valves with bellow or double packing seals or equally efficient equipment, magnetically driven or canned pumps/ compressors/ agitators, or pumps/ compressors/ agitators using double seals and liquid barrier, certified high-quality gaskets, corrosion-resistant equipment	• Establishing and implementing a leak detection and repair (LDAR) • program for fugitive emissions and reviewing and updating the program • Establishing and implementing a detection and reduction program for non-fugitive emissions and reviewing and updating this program • Estimation of diffuse and fugitive emissions to air using a combination of different techniques (such as emission factors, mass balance, thermodynamic models) • Review and update of operating conditions (e.g. frequency and duration of reactor opening, preventing corrosion)
Measures referring to emissions from storage	• Using advanced instrumentation and control systems to achieve precise level control in the tank • Minimization of level fluctuations • Gas balance lines • Floating roofs (large tanks only) Installed condensers • Vent recovery to treatment	
Measures referring to water emissions	• Use of an integrated wastewater management • and treatment strategy that includes a combination of the following techniques: process-integrated techniques, recovery of pollutants at the source, wastewater pre-treatment, final wastewater treatment	• Establishment and maintenance of an • inventory of wastewater and waste gas streams as part of the environmental management system • Monitoring of emissions to water using European (E), national standards (D, BS, NS etc.) or international standards (ISO), with a minimum frequency

4.2 Measures to protect health of workers

119. It is important to apply specific protective measures to safeguard workers' health in countries that still use SCCPs or substances that potentially contain them, such as mixtures of CPs. Workers in industries using CPs, including MCCPs and LCCPs, should take protective measures to reduce health risks. Here are some measures workers should take to protect themselves.

120. When working with SCCPs in metalworking processes, it is crucial to implement precautions to mitigate potential health and environmental risks. SCCPs have been associated with various environmental and health concerns due to their persistence, bioaccumulation potential, and possible toxic effects. Here are key precautions to consider:

4.2.1 Use of Personal Protective Equipment (PPE)

121. Skin protection: wear protective gloves resistant to chemicals to prevent skin contact with SCCPs. Long-sleeved clothing and aprons can protect against splashes.

122. Eye protection: use safety goggles to guard against splashes and vapors that could irritate or damage the eyes.

123. Respiratory protection: In areas with poor ventilation or where aerosols, mists, or vapors of SCCPs may be present, wear appropriate respiratory protection, such as masks or respirators.

4.2.2 Work conditions

124. An adequate working environment is also essential. The following measures should be taken to minimize hazards from dangerous substances as SCCPs:

- Ensure adequate ventilation: work in well-ventilated areas to minimize inhalation exposure to fumes or vapors from SCCPs. Use local exhaust ventilation (LEV) systems at points of emission to capture contaminants.
- Handle and safely store all SCCP substances (including CP mixtures). Containers of SCCPs (bottles, flasks, dishes, barrels…) should be clearly labeled and tightly sealed in a cool, well-ventilated area away from direct sunlight and incompatible substances.

4.2.3 Contingency plan

125. The development of a contingency plan is essential to protect workers during an emergency:

- Develop and implement a spill response plan.
- Equip the workplace with spill cleanup materials.
- Ensure that all employees are trained in spill response procedures.
- Spill containment measures and secondary containment systems to prevent environmental contamination in case of leaks or spills exist in the workshop where SCCPs might be present to avoid any contamination of the environment and wastewater sewage.

Monitoring and Health Surveillance

126. In places where SCCPs are used, in considerable amounts, it is important to conduct regular monitoring of SCCP concentrations or, when not possible, regularly sample and analyze the air to ensure compliance with occupational exposure limits.

127. In addition, it is important to implement health surveillance programs for workers regularly exposed to SCCPs to detect any adverse health effects early.

4.3 Waste Management

4.3.1 General considerations

128. Disposal of SCCP-containing waste, including used metalworking fluids and contaminated materials, must be conducted according to local environmental regulations and Basel Convention guidelines for POP-containing wastes. This may involve sending the contaminated waste to approved hazardous waste treatment, storage, and disposal facilities (TSDFs).

129. For developing countries that might not have dedicated facilities for dangerous waste treatment, it is important to consider the possibility of exporting those wastes to countries where such possibilities exist, in compliance with their domestic laws and rules and Basel and Rotterdam Convention provisions.

4.3.2 Waste elimination

130. According to the Basel Convention Technical Guidelines on the Environmentally Sound Management (ESM) of Wastes consisting of, containing, or contaminated with short-chain chlorinated paraffins (UNEP 2019), wastes with a content of SCCPs at or above [100 mg/kg] [1500 mg/kg][10,000 mg/kg][16] must be disposed of in such a way that the POP content is destroyed or irreversibly transformed. The Conference of the Parties to the Basel Convention has not adopted a value for the low POP content of SCCPs as of May 2023.

131. Pre- treatment may be required for the proper and safe operation of disposal technologies. Pre-treatment operations before disposal should be performed only if the POPs that are separated from the waste during pre-treatment are subsequently and properly disposed.

132. Appropriate methods are described in the Basel Convention general technical guidelines on POPs wastes and may include mechanical separation, size reduction, dewatering, absorption or adsorption, thermal desorption, oil-water separation, solvent washing, pH adjustment, etc.

133. The destruction and irreversible transformation methods to be used are fully described in the Basel Convention general technical guidelines on POPs waste, as well as the commercially available operations for the environmentally sound destruction and the irreversible transformation of the POP content in wastes. The methods applicable to SCCP wastes are described extensively in the cited guidelines and include the following processes:

- Advanced solid waste incineration (ASWI),
- Cement kilns co-incineration,
- Gas-phase chemical reduction (GPCR),
- Supercritical water oxidation (SCWO) and subcritical water oxidation,
- Thermal and metallurgical production of metals.

134. Where neither destruction nor irreversible transformation is the environmentally preferable option, for wastes with a POP content at or above the low POP content, countries may allow such wastes to be disposed of by other methods than the methods presented in subsection IV.G.2 of the general technical guidelines for the ESM of wastes containing POPs. In all cases they should be disposed of in an environmentally sound manner when destruction or irreversible transformation does not represent the environmentally preferable option.

135. Wastes with a SCCP content below [100 mg/kg] [1500 mg/kg] [10,000] mg/kg should be disposed of in accordance with the methods referred to in subsection IV.G.4 of the general technical guidelines of the Basel Convention (outlining disposal methods when POP content is low), taking into account subsection IV.I.1 of the present guidelines (pertinent to higher-risk situations).

[16] As of the date of this document there is no consensus concerning this value among experts.

4.3.3 Training and Information

136. Preventing contamination and health problems due to SCCP manipulation is paramount. Companies using this substance must provide training for all personnel handling SCCPs on the potential health risks, safe handling procedures, and emergency response actions.

137. It is also important to keep a record of Safety Data Sheets (SDS) for SCCP-containing products and ensure that SDS are accessible to all employees.

4.4 Summary of BAT and BEP for chlorinated paraffins production and use

138. Table 4 presents a summary of the BAT and BEP to reduce and/or eliminate releases of chlorinated paraffins during its production and use.

Table 4. Summary of BAT and BEP for chlorinated paraffins production and use.

Application	BAT	BEP
SCCP production	• Implementing closed-loop systems to minimize SCCP emissions during the production process. This involves capturing and recycling process gases and wastewater containing SCCPs to prevent their release into the environment. • Employing advanced process design and engineering techniques to minimize SCCP waste generation and maximize production efficiency, optimizing reaction conditions, catalysts, and raw material inputs to reduce SCCP by-products and improve process yields. • Utilizing efficient waste treatment technologies to treat SCCP-containing waste streams generated during production. This may include processes such as distillation, solvent extraction, or chemical treatment to remove or neutralize SCCPs before discharge. • Implementing measures to prevent spills, leaks, and releases of SCCPs into the environment. This includes proper handling, storage, and transportation practices. • Conducting regular maintenance and inspection of production equipment to identify and address potential sources of SCCP emissions.	• Complying with relevant regulations and standards governing the production and handling of SCCPs. This may include obtaining permits, conducting environmental impact assessments, and adhering to emission limits and reporting requirements. • Conducting comprehensive risk assessments to identify potential environmental and health hazards associated with SCCP production. • Implementing risk management strategies to mitigate these risks, such as implementing engineering controls, providing personal protective equipment, and establishing emergency response protocols. • Engaging with local communities, environmental organizations, and regulatory agencies to promote transparency and accountability in SCCP production operations. • Establishing communication channels for sharing information, addressing concerns, and soliciting feedback from stakeholders.
Chlorinated Paraffins	• Employ advanced process control and engineering techniques to optimize reaction conditions, such	• Ensuring compliance with relevant regulations and standards governing the production and use

production (MCCP-LCCP)	as temperature, pressure, and reaction time, to minimize the formation of SCCPs. • Select feedstocks with higher molecular weights and longer carbon chains to minimize the formation of short-chain chlorinated paraffins. • Use whenever possible feedstock (paraffins) certified with low, or zero, content of C10-13 carbon chains. • Ensure raw materials are free from impurities that can catalyze the formation of SCCPs during chlorination processes.	of chlorinated paraffins, including restrictions on SCCPs (<1% w/w SCCPs containing >48% w/w chlorine). • Maintain accurate records of production processes, emissions, and waste management activities, and submit required reports to regulatory agencies as per regulations.
Metalworking	• Substituting SCCPs with less harmful alternatives wherever possible. Depending on the metalworking process the alternatives might be: ➢ Lubricants : Vegetable base oils, Polyalphaolephins (PAOs), Ester based lubricants ➢ Anti-corrosion: Phosphate esters, inorganic corrosion inhibitors ➢ Metal forming: Plyalkylen glycols (PAGs) ➢ Synthetic esters • Implementing closed-loop systems to minimize SCCP emissions during metalworking processes. • Employing advanced filtration and treatment systems to capture and treat SCCP-containing wastewater and emissions. • Optimizing process efficiency to reduce SCCP usage and waste generation. • Implementing proper storage and handling procedures to prevent spills and releases of SCCPs into the environment. • Installing closed-loop systems to capture and recycle process gases and wastewater containing chlorinated paraffin by-products, reducing the likelihood of SCCP emissions.	• Regular monitoring and testing of SCCP levels in air, water, and soil to ensure compliance with regulatory limits. • Training employees on safe handling practices and emergency response procedures to prevent accidental releases of SCCPs. • Proper labeling and storage of mixtures possibly containing SCCPs. • Developing and implementing spill prevention and response plans to minimize the environmental impact of accidental releases. • Engaging in continuous improvement efforts to identify opportunities for further reducing SCCP usage and environmental impact.

	• Utilizing efficient waste treatment technologies to treat waste streams generated during production, minimizing the release of SCCPs into the environment. • Implementing spill prevention measures, such as proper handling and storage procedures for raw materials and products, to minimize the risk of accidental releases of SCCPs.	
Secondary plasticizers in flexible polyvinyl chloride	• Developing and using alternative plasticizers that do not have the same environmental and health concerns as SCCPs. Examples may include DINP (Diisononyl phthalate), DOTP (Dioctyl terephthalate), and bio-based options like those derived from vegetable oils. • Implementing closed-loop manufacturing processes to minimize leaks, spills, and emissions of SCCPs. • Checking SCCP content in PVC to be recycled, and not recycling PVC containing more than 1% SCCP.	•
Additives in the production of transmission belts in the natural and synthetic rubber industry	• Explore alternative substances, ensuring adequate health and environmental assessment prior to use. • Evaluate the technical feasibility and performance of alternative substances. • Other alternatives as plasticizers in rubber: o Medium-chain chlorinated paraffins (C14-17) o Long-chain chlorinated Pparaffins (C18+) o Acrylic polymers o Al and Sb trioxide o Phosphate esters • Other alternative flame retardants in rubber: o Organophosphorus, flame retardants o Isopropylpheny l diphenyl phosphate (IPPDPP) o Tricresyl phosphate	• Implement general BEP: regulatory requirements, reporting on wastes, hygienic, and safety measures, use of protective equipment. • Install and maintain effective emission control systems, such as scrubbers or filters, to capture and treat volatile organic compounds (VOCs). • Implement wastewater treatment systems to remove SCCPs and other contaminants from process wastewater before discharge.

	• Implement measures to minimize waste generation, optimize material usage, and recycle or reuse process waste.	
The leather industry, in particular, fat liquoring in leather	• Some fatty chemicals can substitute SCCPs: Long-chain chlorinated paraffins (C18+), fatty acid methyl esters (FAME), polyethylene glycol (PEG) • Natural oils such as soybean oil, palm oil, rapeseed oil are alternatives in fat liquoring. • Biocompatible substances as silicone oils and emulsions that provide effective lubrication and softening of leather fibers. • Advanced emulsion technologies can be utilized to create stable emulsions of natural oils, synthetic esters, or other fat liquoring agents.	• Implement general BEP: regulatory requirements, reporting on wastes, hygienic, and safety measures, use of protective equipment.
Tubes for outdoor decoration bulbs	• Use recyclable plastics or glass sourced from sustainable suppliers. • Use energy-efficient manufacturing processes. • Implement measures to minimize waste generation during production processes, such as optimizing material usage, reducing scrap, and reusing or recycling waste materials. • Reduce GHG emissions.	• No specific BAT for this industry, some general principles and practices can be applied to ensure the environmentally responsible production.
Waterproofing and fire-retardant paints	Waterproofing substances that can be used in place of SCCPs in paints: • Acrylic polymers: commonly used as binders in waterproofing paints (film forming). • Silicone-based sealants: can be used to waterproof surfaces by creating a durable and flexible barrier that repels water and prevents moisture infiltration. • Polyurethane coatings: offer excellent waterproofing properties and adhesion to various surfaces. • Fluoropolymer coatings: fluorinated ethylene propylene (FEP) or polytetrafluoroethylene	• Implement general BEP, including regulatory requirements, reporting on wastes, hygienic and safety measures, and the use of protective equipment. • Install and maintain effective emission control systems, such as scrubbers or filters, to capture and treat volatile organic compounds (VOCs). • Install exhaust systems above workstations to reduce fugitive VOCs in workshops. • Implement wastewater treatment systems to remove SCCPs and other contaminants from process wastewater before discharge.

	(PTFE), provide superior water repellency and resistance to harsh environmental conditions. Fire-retardant substances: • Phosphorus-based flame retardants: ammonium polyphosphate (APP) or red phosphorus. • Nitrogen-based flame retardants: melamine polyphosphate (MPP) or melamine cyanurate (MC), reducing the flammability of paints and forming a protective char layer during combustion. • Intumescent coatings: contain ingredients that expand and swell when exposed to high temperatures. • Mineral-based fillers: alumina trihydrate (ATH) or magnesium hydroxide (MDH), can be used as flame retardants in paints.	
Adhesives	• Plasticizers: polymeric plasticizers such as phthalate-free polyesters, adipates, trimellitates, epoxidized soybean oil, or epoxidized linseed oil; polyols, such as glycerol or sorbitol, can substitute for SCCPs as plasticizers in adhesives. • Crosslinkers: such as toluene diisocyanate (TDI) or hexamethylene diisocyanate (HDI) • Takifiers: modified rosin esters, such as hydrogenated rosin esters or maleic-modified rosin esters.	

5. Stakeholders and their role in phasing-out SCCPs

139. The phase-out and management of the life cycle of SCCPs, along with the protection of health and the environment, involve a collaborative effort among various stakeholders. Each group plays a unique and critical role in addressing the challenges SCCPs pose. Here is an overview of the roles of different stakeholders.

5.1 Industries and Trading Companies

5.1.1 Compliance and Innovation

140. Industries historically using SCCPs in products must comply with local, regional and international risk management measures, such as regulations and seek alternative materials or processes. They are crucial in researching and developing (R&D) safer alternatives that do not compromise product quality or safety.

141. Regulatory Compliance: Industries must adhere to national and international regulations concerning the production, use, and disposal of SCCPs. This may involve updating practices, processes, and products to comply with norms and standards. If the country, Party to the Convention, in which they are located is not benefiting from any specific exemption, they will have the obligation to comply with the corresponding Stockholm Convention provisions.

142. Industries are responsible for researching, developing, and adopting safer alternatives to SCCPs. This transition requires significant investment in R&D and may involve redesigning products or processes to accommodate new materials.

5.1.2 Supply Chain Management

143. It is crucial to ensure suppliers adhere to the same environmental and health standards, especially in regions with less stringent regulations. Industries should audit and work closely with their supply chains to phase out SCCPs. The term supplier covers suppliers of chemical substances used in the industry and manufacturing and suppliers of products in which SCCPs might have been used, like textiles, rubber, PVC products, etc. The general public, consumers, media and other stakeholders require from the manufacturing and trading sector to be transparent and socially responsible for the products they put on the market.

144. Transparency in the trading of chemicals is paramount for ensuring environmental safety, public health, and regulatory compliance. It fosters trust among stakeholders, including consumers, businesses, and regulatory bodies, by providing clear information about the chemical composition of products, their origins, and the safety measures taken during their production and distribution. Transparent trading practices enable better risk assessment and management, facilitating the identification and substitution of hazardous substances with safer alternatives. Moreover, transparency supports the global effort to adhere to international agreements and regulations, such as the Stockholm Convention. By promoting openness and accountability, transparency in chemical trading not only protects human health and the environment but also contributes to the sustainability and ethical integrity of global supply chains.

145. The social responsibility of traders and companies concerning the use and trade of dangerous chemicals is a critical aspect of global environmental and public health stewardship. These entities may consider going beyond mere legal compliance, actively ensuring their operations do not adversely affect human health or the environment. This responsibility encompasses diligently managing chemical substances throughout their lifecycle, from production to disposal, including adopting safer alternatives wherever possible. Traders and companies should also use transparent reporting and communication practices, enabling all stakeholders, including consumers, communities, and governments, to make informed decisions. By prioritizing safety, sustainability, and ethical considerations in their operations, traders and companies contribute to a safer, healthier world, demonstrating a commitment to the well-being of current and future generations.

5.1.3 Environmental Responsibility

146. Waste Management is part of the trading and manufacturing companies. Proper disposal of SCCP-containing products and waste is essential to prevent environmental contamination. Industries should invest in technologies and processes that minimize waste and facilitate safe disposal of hazardous materials.

147. Implementing BAT and BEP to minimize emissions of SCCPs during production and throughout the product lifecycle is essential for reducing the environmental and health impacts associated with these chemicals, ensuring compliance with international standards, and supporting global efforts towards sustainability and pollution prevention. This includes implementing best practices for managing existing SCCP-containing products throughout their lifecycle, including safe disposal methods to minimize environmental release.

5.2 Government and Regulatory Bodies

148. Government and regulatory bodies play a key role in enforcing best practices in chemicals management:

- International engagement: adhering to international conventions and protocols, such as Stockholm, Basel Rotterdam, Minamata, and the Strategic Approach to International Chemicals Management (SAICM), but not only, is the first step towards a good chemical management approach at the local level. This helps the country to align with global standards for environmental protection and public health, foster international cooperation, and access technical and financial resources necessary for effective chemical management, ultimately leading to the sustainable use and safe disposal of hazardous substances.
- Legislation and enforcement: governments enact laws and regulations to restrict and ban the use of SCCPs, oversee their phase-out, and manage exemptions for critical uses if authorized by the Convention. They are responsible for enforcing these regulations and ensuring compliance.
- Policy development: developing policies that encourage reducing SCCP use and promote the adoption of safer alternatives. This could include incentives for green chemistry and sustainable manufacturing practices.
- Standards and norms: The government, in collaboration with industrial and technical bodies, bears a shared responsibility to establish and adopt precise standards regarding the permissible use of certain chemicals, their standardization across various applications, and their allowable concentrations in products and foods. This collaborative approach ensures that chemical management policies are scientifically sound and practically enforceable, safeguarding public health and environmental integrity while supporting industry compliance and innovation.

5.3 Scientists and Academic Institutions

149. Scientists from universities, private and public research centers, and technical and vocational education and training (TVET) Institutions have an important role to play in the chemical management field.

- Research and development (R&D): conducting research to understand the environmental and health impacts of SCCPs, developing safer chemical alternatives, and improving detection and analysis methods for environmental monitoring. The R&D sector is pivotal in finding safe and effective alternatives to SCCPs, developing new materials, and disposal technologies to minimize environmental impact.
- Education: Educating the next generation of scientists, policymakers, and industry leaders about the risks associated with SCCPs and the importance of sustainable chemistry.
- Train future industrial and manufacturers on the safer and cleanest practices.
- Collaboration with industry: Engaging in partnerships with industries to test and scale up viable alternatives for commercial use, ensuring that new products meet safety and performance standards.

- International cooperation enables researchers, often affiliated with institutions in developed countries, to access and share knowledge, as well as benefit from technology transfers. This exchange not only enhances their personal and institutional capabilities but also significantly contributes to the development and progress of their home countries.

5.4 Non-Governmental Organizations (NGOs)

150. NGOs frequently emerge as formal responses to public concerns, embodying the collective aspirations and concerns of communities. Typically motivated by mission rather than profit, NGOs operate with a flexibility and agility that distinguishes them from traditional institutions like governments and universities.

151. This unique structure enables NGOs to undertake a wide range of activities, including advocacy, humanitarian aid, and environmental conservation, which are often beyond the scope or capacity of other stakeholders. Their ability to mobilize resources, influence policy, and implement grassroots initiatives allows them to fill crucial gaps in addressing global challenges, making them indispensable actors in pursuing social, environmental, and economic progress.

152. Activities they may conduct include advocacy for environmental and health protection, and awareness raising among the public, the workers, and industry. They can also monitor the use, corrupt trading practices, and poor environmental practices concerning the use of chemicals such as SCCPs. By publicly advocating for choosing products free of SCCPs and supporting companies that invest in safer alternatives, consumers NGOs can drive demand for more sustainable and less harmful products.

5.5 International Organizations

153. International bodies, such as the United Nations Environment Programme (UNEP), facilitate global cooperation in the management and phase-out of SCCPs. They provide platforms for sharing best practices, technical support, and funding for developing countries.

154. Projects aimed at delivering global environmental benefits, such as eliminating the production and use of SCCPs in specific industries like PVC and rubber manufacturing, represent a critical area for international collaboration and support. Countries can develop these initiatives with the backing of Global Environment Facility (GEF) Agencies, leveraging their expertise and resources. In certain instances, these projects may also qualify for grants from the GEF, providing essential financial support to facilitate the transition towards safer, more sustainable alternatives.

155. This collaborative approach helps mitigate the environmental and health risks associated with hazardous chemicals and promotes technological innovation and capacity building within the targeted regions. By aligning with GEF Agencies, countries can ensure that these projects contribute effectively to broader environmental goals and sustainable development objectives, creating a positive impact that resonates on a global scale.

5.6 Consumers

156. Consumers can use many means to make their voices heard and influence industries, manufacturers, traders, and regulators to stop the use of problematic substances such as SCCPs. Consumers can also advocate for stronger regulations and better product labeling to make informed choices easier.

157. Adhering to these precautions can help mitigate the risks associated with using SCCPs in metalworking, protecting workers' health and minimizing environmental impact.

ANNEX

Non-Exhaustive List of Chlorinated Paraffins trade names potentially containing SCCPs (Source UNEP/CHW.14/7/Add.2/Rev.1)

Synonyms for SCCPs:

Alkanes, chlorinated; alkanes (C10-C13), chloro (60%); alkanes (C10-C13), chloro (50-70%); chlorinated alkanes; chlorinated alkanes, chlorinated paraffins; chloroalkanes; chlorocarbons; paraffin, chlorinated; paraffins, chloro; paroils, chlorinated; polychlorinated alkanes; polychloroalkanes

Trade names for CPs, potentially SCCPs

The following generic trade names are usually accompanied by a suffix indicating a specific product (IARC, 1990): A 70; A 70 (wax); Adekacizer E; Arubren; Cereclor; Chlorinated paraffins (CPs); Chlorcosane; Chlorez; Chlorofin; Chloroflo; Chlorparaffin; Chlorowax, Chlorowax 500AO; Chlorowax 45AO, Chlorowax 52AO; Cloparin; Cloparol; Clorafin; CP F; CW; Diablo; Derminolfett; Derminolöl; EDC-tar; Electrofine; Enpara; FL X; Hordaflam; Hordaflex; Hordalub; Hulz; KhP; Meflex; Monocizer; Paroil; Poliks; Tenekil; Toyoparax; Unichlor.

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