HEXACHLOROCYCLOPENTADIENE (HCCP)

CAS No: 77-47-4

EINECS No: 201-029-3

SUMMARY RISK ASSESSMENT REPORT

Final report, July 2007

The Netherlands

FINAL APPROVED VERSION

Rapporteur for the risk assessment of HCCP is the Ministry of Housing, Spatial Planning and the Environment (VROM) and the Ministry of Social Affairs and Employment (SZW), in consultation with the Ministry of Public Health, Welfare and Sport (VWS). Responsible for the risk evaluation and subsequently for the contents of this report is the rapporteur.

The scientific work on this report has been prepared by the Netherlands Organization for Applied Scientific Research (TNO) and the National Institute of Public Health and Environment (RIVM), by order of the rapporteur.

Contact point:
Chemical Substances Bureau
P.O. Box 1
3720 BA Bilthoven
The Netherlands

Date of Last Literature Search:
Review of report by MS Technical Experts finalised:
Final report:

PREFACE

This report provides a summary, with conclusions, of the risk assessment report of the substance hexachlorocyclopentadiene (HCCP) that has been prepared by The Netherlands in the context of Council Regulation (EEC) No. 793/93 on the evaluation and control of existing substances.
For detailed information on the risk assessment principles and procedures followed, the underlying data and the literature references the reader is referred to the comprehensive Final Risk Assessment Report (Final RAR) that can be obtained from the European Chemicals Bureau[1]. The Final RAR should be used for citation purposes rather than this present Summary Report.

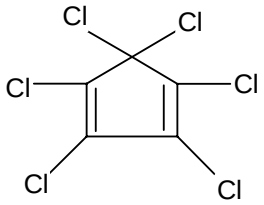
[1] European Chemicals Bureau – Existing Chemicals – http://ecb.jrc.it

CONTENTS

1 GENERAL SUBSTANCE INFORMATION

Identification of the substance

CAS Number: 77-47-4
EINECS Number: 201-029-3
IUPAC Name: hexachlorocyclopentadiene
Molecular formula: C_5Cl_6
Structural formula:



Molecular weight: 272.77
Synonyms: hexachloro-1,3-cyclopentadiene; perchlorocyclopentadiene; hexachloro-1,3-cyclopentadiene; 1,2,3,3,4,5-hexachloro-1,4-cyclopentadiene; HCCP

Purity/impurities, additives

The nature and levels of HCCP contaminants vary with the method of production. HCCP made by the chlorination of cyclopentadiene by alkaline hypochlorite at 40 °C, followed by fractional distillation, is only 75% pure, and contains many lower chlorinated cyclopentadienes and other contaminants (e.g., hexachlorobenzene and octachlorocyclo-pentene). Purities above 90% have been obtained by thermal dechlorination of octachlorocyclopentene at 470-480 °C. The current specification for HCCP produced by the Velsicol Chemical Corporation at Memphis, Tennessee, USA, which is used internally and sold to other users, has a minimum purity of 97%. The major contaminants found in an industrial preparation of HCCP from Velsicol were octachlorocyclopentene (0.68%), hexachloro-1,3-butadiene (1.11%), tetrachloroethane (0.09%), hexachlorobenzene (0.04%), and pentachlorobenzene (0.02%). A preparation from Shell International Petroleum contained up to 1.5% of octachlorocyclopentene and approximately 0.2% of hexachloro-1,3-butadiene. Analysis results from another company indicated the following impurities: lights (boiling point less than 234 °C): 0.1%, hexachlorobutadiene: 0.1%, octochlorocyclopentane: 0.3% and others (primarily penta and hexa chloro compounds related to hexachlorocyclopentadiene): 0.2%.

Physico-chemical properties

Table 1.1. Summary of the physico-chemical properties of HCCP.

Property	Value	Comment
Physical state	liquid	
Melting point	-9 °C / -10 °C	
Boiling point	234 °C / 239 °C	
Relative density	1.70 at 20 °C	
Vapour pressure	10 Pa at 25 °C	
Water solubility	1.03 – 1.25 mg/l at 22 °C	
Water reactivity	HCCP reacts slowly with water to form hydrochloric acid.	
Partition coefficient n-octanol/water (log value)	3.99 – 5.51	4.99 used in EUSES 2.0
Granulometry		Particle size distribution is not relevant for liquids
Conversion factors	1 ppm = 11.3 mg/m^3; 1 mg/m^3 = 0.088 ppm at 20 °C and 101.3 kPa	
Flash point	-	Taking into account the structural formula and the thereof-derived thermokinetics, no flashpoint is to be expected and the determination of the flashpoint is considered superfluous in view of decomposing properties
Autoflammability	-	Taking into account the structural formula and the thereof-derived thermokinetics, no autoflammability is to be expected
Flammability	-	Taking into account the structural formula and the thereof-derived thermokinetics, no water incompatibility is to be expected; Taking into account the structural formula and the thereof-derived thermokinetics, no pyroforic properties are to be expected
Explosive properties	-	Taking into account the structural formula and the thereof-derived thermokinetics, no explosive properties are to be expected
Oxidizing properties	-	Taking into account the structural formula and the thereof-derived thermokinetics, no oxidising properties are to be expected
Henry's constant	2.7*10^{-2} atm m^3/mol at 25 °C	
Surface tension	37.5 mN/m at 20 °C	
Heat of vaporisation	1.76*10^{-5} J/kg	

Classification and labelling

Current Classification according to Annex I:
T+; R26
T; R24
Xn; R22
C; R34
N; R50-53

In its meeting of October 2006 the Commission Working Group on the Classification of Dangerous Substances decided that HCCP should be classified and labelled for human health as follows:
Symbols: T+
R-phrases: 22, 24, 26, 34, 43, 48/23
S-phrases: (2), 26, 28, 36/37/39, 38, 45, 53

Specific concentration limits:

C ≥25% T+; R22-24-26-34-43-48/23
10% ≤ C <25% T+; R21-26-34-43-48/23
7% ≤ C < 10% T+; R21-26-36/37/38-43-48/20
5% ≤ C < 7% T; R21-23-36/37/38-43-48/20
3% ≤ C <5% T; R21-23-43-48/20
1% ≤ C < 3% T; R23-43-48/20
0.1% ≤ C < 1% Xn; R20-43
0.001% ≤ C < 0.1% R43

In addition, based on mortality which occurred in the eye irritation study with HCCP, it is noted that under the new EU regulation on classification and labelling of chemicals (based on GHS), the sentence ‘EUH070 - Toxic through eye’ will be applicable.

2 GENERAL INFORMATION ON EXPOSURE

Production

Manufacturing processes of HCCP can be based on three different synthesis pathways: 1) synthesis from polychlorinated C1-C3-hydrocarbons, 2) chlorination of C5-alkanes with subsequent cyclization and 3) chlorination of cyclopentadiene. In the Western World, production of HCCP is currently thought to be limited to only one company, Velsicol Chemical Corporation in Memphis, Tennessee in the United States. World-wide production volume was estimated to be approximately 15,000 tonnes in 1988. The 1983 production was stated to be 9,130 tonnes in the United States.

Uses

HCCP is used as an intermediate in the production of many chlorinated cyclodiene pesticides, chlorendic acid (HET-acid) or its anhydride (chlorendic anhydride), Dechlorane Plus, and dyes and pharmaceuticals. In Europe HCCP is mainly used as an intermediate in the production of pesticides, HET-acid and a speciality coating. In the year 2000 Aventis in Germany imported between 1000 and 5000 tonnes HCCP and Durez Europe in Belgium imported less than 1000 tonnes. Chemical Innovations Limited (CIL) in England imported less than 20 tonnes of HCCP from the United States in the year 2000 for its use as an intermediate in the production of a speciality coating.

Trenes and Legislative controls

HCCP is present as an impurity in HET-acid, Dechlorane Plus and pesticides, from which emissions may occur. HET-acid or the anhydride, chlorendic anhydride, is used as a reactive substance (flame-retardant) in both the production of unsaturated polyesters and the production of flame-resistant, anti-rust and anti-corrosive paints. A maximum content of HCCP in chlorendic anhydride and a content of HCCP in HET-Acid is 0.01% and 0.005%, respectively. In Western Europe HET-acid is almost exclusively used, for about 90%, in unsaturated polyester resins and 10% goes into paints. The Western European market is about 620 ton in 2001. Of these 620 ton about 95% is used in the production of unsaturated polyester resins and the remaining 5% is used in paints. These latter values will be used for the exposure assessment.
Dechlorane Plus together with a few analogous Dechlorane brands is used as a non-reactive and non-plasticising flame resistant additive in mostly thermoplastic materials. The Dechlorane Plus contents range from 5-35%. It is also used in polyester and epoxy resins, but these are minor applications. More recent figures indicate that sales to Europe were still about 800 tonnes in 2000.The level of HCCP in Dechlorane Plus is about 0.005%.
Cyclodiene pesticides are still used, but within the European Union many of these pesticides are banned or their use is severely restricted. Use of cyclodiene pesticides in the European Union is mainly limited to endosulfan. Other cyclodiene pesticides like drins, chlordane and heptachlor are either not imported or produced in the European Union. Both endosulfan and aldrin are reported to be either produced or imported into some countries. Total imported quantity endosulfan in the European Union is about 200 tonne per year. The total annual quantity used within the EU is estimated to be about 550 tonne. The residual content of HCCP in endosulfan is about 0.1%.

3 ENVIRONMENT

3.1 ENVIRONMENTAL EXPOSURE

Environmental releases

Environmental release of HCCP may occur during industrial use of HCCP as an intermediate in the production of cyclodiene pesticidas and HET-acid, during pesticide application and from the production and industrial use of flame-retardant polymers and paints.

Table 3.1 Input data for the local exposure assessment for water and air at industrial use (II). Site specific information is presented in bold

	II-a	**II-b**	**II-c**
Processing tonnage (t/y)	**4000-5000**	**<1000**	**<20**
IC/UC	3/33	3/33	3/33
Number of days	**Conf.**	**Conf.**	20
Release to air (%), generic	0.001	0.001	0.001
Release to waste water (%), generic	0.7	2	2
Emission to air (kg/y), generic 1)	50	10	0.2
Emission to waste water (kg/y), generic 1)	35,000	20,000	400
Emission to air (kg/y), site-specific	**9.5**	**0.027**	n.r. 2)
Emission to waste water (kg/y), site-specific	**0**	0.002	**0**
STP flow (m^3/d)	2,000	**66,000**	2,000
Receiving water flow (m^3/s)	**188**	0.8	2.1
Dilution factor	8,100	1	10

1) based on the default emission factors from the Technical Guidance Document (EC, 2003)

2) not relevant: emission to air are not reported, default emission factor is used.

HCCP is only used as an intermediate in the chemical industry for synthesis of endosulfan (site IIa) and HET-acid (site IIb). The emission factor to air for site IIa is 1.9 g per tonne of HCCP used and there are no emissions to wastewater (Table 3.1). The emission factor to air for site IIb is 0.03 g per tonne. The effluent concentration in the wastewater treatment installation is assumed to be 0.02 $\mu g.l^{-1}$ (detection limit; arbitrary choice). This results in an annual release of 0.002 kg to the public wastewater treatment plant. Emissions from the production of speciality coatings (site IIc) are not accounted for since emissions are considered to be negligible (2 gram/year). The default site-specific release factors will be used in the risk assessment.
The total emissions to air for the release scenarios use of HET-acid in polyester resins, use of HET-acid in paint and use of Dechlorane Plus in thermoplastics are 0.06, 0.0045 and 0.10 kg per year, respectively. The estimated total annual emissions to waste water are 0.09, 0.006 and 0.02 kg, respectively. The total estimated environmental release of HCCP resulting from residual amounts of HCCP in processed HET-acid (resins and paints) are thus found to be very low. For this reason no further (PEC) calculations will be carried out for these three emission scenarios.
Endosulfan application is considered in the exposure assessment for releases of HCCP during application of pesticides in the European Union. A total amount of endosulfan for agricultural use of 1068 tonnes per year was estimated for the whole European Union. The residual amount

of HCCP is 0.09% giving an emission of HCCP through agricultural use of endosulfan of 961 kg/year. Emission of HCCP to adjoining ditches (drift) is assumed to be only 1% of the applied amount. Because of the many different drift factors for the various applications on various crops, the standard drift factor for full field applications is used as default for calculating the continental HCCP emissions from endosulfan usage. The total continental emission to air and water is 962 kg/year and 10.4 kg/year, respectively. Regional emissions to air and water amount to 96.2 kg/year and 1.0 kg/year, respectively. The release to water includes emissions to waste water of 0.08 kg/year.

Environmental fate

Atmosphere

The results indicate that HCCP will not persist in the atmosphere as it will be removed via reaction with photochemically-generated hydroxyl radicals. Furthermore, based on the highly chlorinated structure of HCCP, it is expected that reaction of this compound with ozone molecules in the atmosphere would be too slow to be environmentally significant. Therefore, as a realistic worst-case approach, an atmospheric half-life of 29 days will be used in EUSES. It should be noted that this value is only an estimation of the photodegradation of the substance in the vapour phase and not of adsorbed substance on airborne particles. The importance of this can not be quantified in EUSES.

Aquatic compartment

Degradative processes for removal of HCCP from water include photolysis, hydrolysis and biodegradation. Hydrolysis of HCCP in water occurs much more slowly than photolysis. In shallow or flowing waters, photolysis is the predominant fate process; in deeper waters hydrolysis and biodegradation may be more important environmental fate processes.

A hydrolysis half-life of HCCP of 3.3 days was found at pH 7 and 30°C. For risk assessment purposes for fresh water a pH of 7 and a temperature of 12°C will be established which is in conformity with the standard environmental parameters. The calculated hydrolysis half-life reflecting an average EU outdoor temperature is 13.9 days. The half-life for hydrolysis can be converted to a pseudo first-order rate constant of 5.0E-02 d^{-1}. A photo-transformation rate constant of HCCP was computed to be 10.7 minutes. The presence of natural suspended sediments had virtually no influence on the photolysis rate as compared with the rate of photolytic degradation in distilled water. The calculated half-life for photolysis in water is 3.9 hr-1. HCCP can be biodegraded in aquatic media under laboratory conditions in one study. However, another study on the fate of HCCP found biodegradation to be a relatively unimportant process in aquatic systems, based on the observation that there was no detectable difference in hydrolysis rates between sterile and non-sterile studies and measured numbers of micro-organisms. It is difficult to differentiate removal or degradation via abiotic processes (adsorption, volatilisation, and hydrolysis) from that via biodegradation. HCCP is a volatile, hydrophobic substance, which will be metabolised, strongly adsorbs to organic carbon and will not be mineralised aerobically. Under anaerobic conditions dehalogenation will occur and one or more chlorinated metabolites will be formed. HCCP will hydrolyse to some extent. On the basis of the available data on aquatic biodegradation, HCCP is considered to be inherently biodegradable, not fulfilling specific criteria (rate constant 0 h^{-1}). This is a rather worst case assumption, but adequate data are lacking to make a more balanced decision on this issue. The rate constant k will be greater than 0 h^{-1} under some conditions (expert judgement).

Terrestrial compartment

The persistence of HCCP in soil is low, with degradation of >90% of applied HCCP to non-polar products within approximately 7 days. Factors contributing to this loss include abiotic and biotic degradation processes and volatilisation, although the relative importance of each is difficult to

quantify given the limited information available. As no half-life in soil can be derived from the experimental data presented, the use of screening data may be considered. Degradation half-life classes for soil, partly based on K_p can be used. As HCCP has a K_{psoil} of lower than 100 l/kg and the substance is considered to be inherently biodegradable, a half-life of 300 days is chosen.
A summary of selected values for environmental degradation is presented in Table 3.2. These values will be put into the EUSES model to calculate PECs in different environmental media. Despite a number of uncertainties in the various breakdown routes of HCCP in the environment several metabolites of HCCP have been identified (esp. photolysis products). Given the very low environmental release of HCCP the need for any further characterisation (e.g. PBT potential) of these (and possibly other) metabolites is considered to be low.

Table 3.2 Overview of environmental degradation data used as input data in EUSES

Compartment		Rate constant	DT50	Based on
Water	Hydrolysis	5.0E-02 d^{-1}	13.9 days	Experimental data
	Photolysis	3.9 hr^{-1}	10.7 minutes	Experimental data
	Biodegradation	0 hr^{-1}	∞	TGD* default/expert judgement
Atmosphere		5.6E-13 cm^3/molecules/sec	29 days	QSAR estimation
Sediment		2.31E-04 d^{-1}	3000 days	TDG default
Soil		2.31E-03 d^{-1}	300 days	TGD default

(EC, 2003)

Environmental concentrations

Distribution

Using a vapour pressure of 10 Pa and a water solubility of 1.25 mg/l, a Henry's law constant of 2.18E03 Pa.m^3/mol is calculated.When released to the atmosphere, HCCP will exist almost entirely in the vapour phase. Detection of HCCP in ambient air downwind of a hazardous waste site indicates that atmospheric transport of HCCP may occur. However, transported distance will be limited by the high reactivity of the chemical in the atmosphere.
HCCP introduced into water bodies may be transported in undissolved, dissolved or adsorbed forms. In its undissolved form, HCCP will tend to sink because of its high specific gravity and may then become concentrated in deeper waters, where photolysis and volatilisation would be precluded. Some HCCP may be dissolved in water and then be dispersed with water flow. HCCP tends to adsorb onto organic matter because of its lipophilic nature and may then be transported with water flow in a suspended form. Transport to air may occur by volatilisation. However, suspended solids in surface water may be a major factor in reducing volatilisation.
Volatilisation is most likely to occur from moving water bodies, with estimated removal of about 15% of the HCCP in a turbid river compared with less than 5% removal from a lake or pond. The volatilisation rate from aquatic systems depends on specific conditions, including adsorption to sediments, pH of the medium and airflow rate. Volatilisation was highest from the sand and lowest from the humus. Volatilisation was greater in soils with low organic content. HCCP evaporation to air occurred mainly during the first day following application and was probably associated with the soil surface only.
HCCP in soils is predicted to be tightly adsorbed to organic matter and relatively resistant to leaching by soil water. Thus, the primary routes of transport for soil applied HCCP are by

movement of particles to which it is adsorbed or by volatilisation. HCCP, released to the water, will partition rapidly to sediment and suspended solids in the water column. The proportion remaining dissolved in solution and available for biological uptake will therefore be small. The following partition coefficients will be used as input in the EUSES model:

K_{oc} 4265 l/kg (experimental value)
Kp_{susp} 427 (Foc_{susp} = 0.1)
Kp_{sed} 213 (Foc_{sed} = 0.05)
Kp_{soil} 85 (Foc_{soil} = 0.02)
$K_{soil\text{-}water}$ 128
$K_{susp\text{-}water}$ 108
$K_{sed\text{-}water}$ 107

In order to determine the accumulation of HCCP in activated sludge from a municipal sweage works, activated sludge (1gdw/l) was exposed for five days to a concentration of 50 µg 14C-HCCP per litre of water. The accumulation factor as a quotient of HCCP-equivalent concentrations in activated sludge measured in µg/g dry weight and in water in µg/ml amounted to 2350 and 2400 respectively.

Accumulation and metabolism

Based on the experimentally derived octanol/water partition coefficient of 5.04, HCCP would be predicted to have a BCF of about 1516 (EPIWIN calculations) or 3800 (EUSES). Although QSAR estimates for the BCF point to a significant bioaccumulation potential, HCCP was found to be rapidly metabolised and eliminated in a number of studies. This is reflected in relatively low experimental BCFs. To deal with this uncertainties BCF values of both less than 11, representing the steady-state bioconcentration factor that was measured in 30-day flow through exposures to constant levels of HCCP, and a realistic worst case value of 1297, covering persistent metabolites, will be used in EUSES. No experimental data are available on accumulation in earthworms. Using log Kow of 5.04, the calculated BCF_{worm} is 17.5 kg/kg.

Calculation of predicted environmental concentrations (PEC_{local})

The calculated local PEC values in the environmental compartments are listed in Table 3.3.
Local PEC values for HCCP in ditches surrounding agricultural fields are the result of the agricultural field application of endosulfan in which HCCP is present as an impurity (Table 3.4).

Table 3.3 Local PEC values in the various environmental compartments for processing of HCCP.

Compartment	II-a	II-b	II-c
STP (mg/l)	0	2.4E-08	0
Water (mg/l)[1]	7.69E-12	2.42E-08	7.69E-12
Sediment (mg/kg_{wwt})	7.19E-10	2.26E-06	7.19E-10
Air ($\mu g/m^3$)	7.32E-03	2.83E-05	1.60E-04
Soil (mg/kg_{wwt})	1.04E-06	3.19E-07	2.26E-08

[1] $PEC_{local} = C_{local} + PEC_{regional}$

Following current pesticide regulations from The Netherlands only the average water concentrations are being used in pesticide risk assessments (long term effects). The average concentration is calculated for the same exposure period as the lowest ecotoxicity test (key study) takes. For that reason only the average HCCP concentrations are being used for this pesticide scenario for endosulfan in the risk characterisation (21/28 day average).

Table 3.4 Local PEC values for HCCP in surface water for agricultural use of endosulfan (USES 3.0 calculation).

Compartment	Citrus fruits	Cabbage	Tomatoes
Ditch, yearly average concentration (μg /l)	1.67E-05	1.95E-06	1.04E-07
Ditch, 21 day average concentration (μg /l)	6.13E-03	4.03E-04	2.15E-05
Ditch, maximum concentration (μg/l)	9.18E-01	1.98E-02	1.05E-03

Secondary poisoning

The concentration of HCCP in food (fish) or fish-eating predators ($PECoral_{predator}$) is calculated from the PEC for surface water, the measured range of BCF values for fish (11 and 1297) and the biomagnification factor (Table 3.5).

Table 3.5 Calculation of predicted environmental concentration in food

Site	BCF_{fish} [l/$kg_{wet\ fish}$]	PEC_{water} [mg/l]	BMF	$PECoral_{predator}$ [mg/$kg_{wet\ fish}$]
IIa	11	7.69E-12	1	8.46E-11
	1297	7.69E-12	1	1E-08
IIb	11	2.42E-08	1	2.92E-08
	1297	2.42E-08	1	3.44E-06
IIc	11	7.69E-12	1	8.46E-11
	1297	7.69E-12	1	1E-08

PEC_{water}: scenario where 50% of the diet comes from a local area (annual average PEClocal) and 50% of the diet comes from a regional area (annual average PECregional) (EC, 2003)

BMF: a biomagnification factor of 1 was used as the BFCfish is below 2000 (EC, 2003)

For the assessment of secondary poisoning via the terrestrial food chain the $PECoral_{predator}$ is equal to the total concentration of HCCP in worm as a result of bioaccumulation in worm tissues and the adsorption of the substance to the soil present in the gut. As no experimental $BCF_{earthworm}$ is available this was estimated with a QSAR model (Table 6).

Table 3.6 Calculation of predicted environmental concentration in food

Site	$BCF_{earthworm}$ [l/$kg_{wet\ earthworm}$]	$PECoral_{predator}$ [mg/$kg_{wet\ earthworm}$]
IIa	1.32E03	7.29E-06
IIb	1.32E03	7.76E-07
IIc	1.32E03	1.66E-07

Calculation of $PEC_{regional}$

The regional PEC values resulting from calculations with EUSES 2.0.1, using the regional emissions, are presented in Table 3.7.

Table 3.7 Regional PEC values.

Compartment	PEC regional
Surface water (μg/l)	7.74E-09
Sediment (mg/kg$_{wwt}$)	1.26E-09
Air (μg/m^3)	7.55E-06
Agricultural soil (mg/kg$_{wwt}$)	1.02E-09
Natural soil (mg/kg$_{wwt}$)	1.01E-09

3.2 EFFECTS ASSESSMENT

Aquatic compartment (incl. sediment)

Fish

The 96 h-LC50 values for freshwater fish range from 7-240 μg/l. The lowest value is from a study with measured concentrations. HCCP is slightly soluble in water (solubility of 1.02-1.25 mg/l) and can be considered as volatile (vapour pressure is 10.7 Pa at 25 °C). The lower LC50-values obtained in the study are probably the result of the utilisation of intermittent-flow exposure systems and/or the use of the most sensitive life stages of development for testing.
The acute toxicity values for HCCP were comparable for each of the three marine fish species tested. The static 96-hour LC50 values based on nominal concentrations for spot, sheepshead minnow and pinfish varied from 37-48 μg/l.
In a 30-day early-life stage flow-through toxicity test with fathead minnows using 1 day old larvae the 96-h LC50 value was 7 μg/l (measured concentrations). The lowest concentration causing 50% mortality was reached within 4 days. Furthermore, HCCP residues found in fathead minnows at the end of the 30-day exposure period were low (< 0.1 μg/g), and a BCF value of < 11 was reported. Based on the toxicity and growth data it can be concluded that 3.7 μg/l is the highest concentration of HCCP that produces no adverse effects on fathead minnow larvae. It should be noted, that this fish study only investigated the survival and growth of larvae and as such is not directly comparable with the long-term fish tests currently recommended in the TGD.

Aquatic invertebrates

The 48 h-LC 50 values for freshwater Daphnia, resulting from two static tests with nominal concentrations, range from 39-52.2 μg/l. In marine species 96-h LC50 values range from 7 to 371 μg/l. The lowest value obtained is from a study on Mysid shrimp with measured concentrations. Except where indicated, these results were obtained from static tests with nominal concentrations of HCCP. The highest LC50 by far was for the polychaete *Neanthes arenaceodentata*, which is an infaunal organism living in the sediment. The two shrimp species tested were more sensitive to HCCP by a factor of 10 or more. The static LC50 value for the grass shrimp was slightly higher than that for the mysid shrimp. However, the LC50 for the mysid shrimp was considerably lower in a flow-through test than in the static test. Similarly, the LC50 value was lower when calculated from measured concentrations of HCCP as the value based on nominal concentrations. Although, the results for marine invertebrates are obtained from cited studies, they will be used for effect assessment purposes as these tests were performed according to EPA standard methods and the important test conditions are known (flow-through, measured concentrations).

A 21-day NOEC of 9 µg/l for freshwater Daphnia, based on nominal concentrations, was reported. Further, groups of 40 mysid shrimp were exposed for 28 days in a flow-through system. Measured concentrations in seawater were found to be about one-half of the nominal ones. Mortality occurred in all concentrations except the control, but showed no consistent dose-response relationship. Reproduction, however, was more clearly related to dose (NOEC of 0.3 µg/l). First significant effects on mortality started occurring at the same concentration as for the reproduction endpoint. At higher doses there is a poor dose response relationship for mortality.

Algae

In freshwater and marine algae species, growth was reported to be inhibited by 50% at exposure levels ranging from 3.5 to 240 µg/l. Other tests with *S. costatum* indicated that the direct, algicidal effect of HCCP was less pronounced than its effect on growth. After 48 hours of exposure to HCCP at 25 µg/l mortality was only 4%. Some of the studies were carried out over 168 hours rather than the more usual 72 hours. From the studies it cannot be concluded if algae were still undergoing exponential growth at the end of the study, as these are unpublished data.

Microorganisms

In an activated sludge micro-organisms toxicity study, according to OECD guideline 209, 6 and 13% inhibition of the respiration rate was found at a concentration of 100 mg/l. Therefore, it can be concluded that HCCP is very slightly toxic to waste water micro-organisms at a concentration of 100 mg/l. Since HCCP is poorly soluble in water, the test substance was added quantitatively to the test vessels. Many of the aqueous concentrations in the other tests exceeded the maximum water solubility (1.25 mg/l). In these tests organic solvents were used to overcome this problem. The environmental significance of these results should, however, be interpreted with care.

Calculation of Predicted No effect Concentration (PNEC)

No clear distinction can be made between the sensitivity for freshwater and marine organisms. Therefore, the $PNEC_{freshwater}$ will be derived from the entire data set and will be used for the risk assessment of the freshwater compartment. As no quantitative risk assessment for the marine compartment will be made, no $PNEC_{marine}$ is derived.

For freshwater, available NOECs ranged from 3.7-9 µg/l. Fish seems the most sensitive and algae appear the least sensitive species. For marine water, NOECs ranged from 0.3-25 µg/l, with shrimp being the most sensitive and aquatic plants being the least sensitive species. When all freshwater and marine toxicity data are considered together, three long-term values are available. An assessment factor of 10 can then be used for calculating the $PNEC_{freshwater}$. Based on the lowest NOEC of 0.3 µg/l for shrimp, the PNEC becomes: 3.0×10^{-5} mg/l**.**

For deriving the $PNEC_{micro\text{-}organisms}$ short-term measurements in terms of hours (e.g. 10 h) are preferred, in accordance with the retention time in a STP. In a respiration inhibition test according to OECD 209, 6 and 13% inhibition of the respiration rate was found at a concentration of 100 mg/l. The 0.3 h-IC50 is >100 and an EC10 of 100 mg/l can be derived. Applying an assessment factor of 10 on the EC10 the $PNEC_{micro\text{-}organisms}$ becomes: 10 mg/l.

HCCP is expected to adsorb to and persist in the sediment. A provisional PNEC will be calculated using the equilibrium partitioning method. The tentative PNEC for the sediment compartment is 2.81 µg/kg ww. However, the ingestion of the sediment-bound substance by sediment dwelling organisms may not be sufficiently explained by this relationship for substances with a log Kow greater than 5. The TGD suggests that in such cases the PEC/PNEC ratio is increased by a factor 10. However, as HCCP has a measured log Kow range of 3.99-5.04 it is felt to be a borderline case. Furthermore, the measured Koc value (4,265 l/kg) indicates that the substance is not adsorbed to the extent that would be expected from the Kow value

(calculated Koc of 15,000 l/kg). For these reasons the factor of 10 will not be applied here and $PNEC_{sediment}$ is 2.81 µg/kg ww.

Terrestrial compartment

Toxicity test results

The EC50 of HCCP on growth of lettuce (*Lactuca sativa*) was 10 mg/kg d.w., based on nominal concentrations. No effects were found on natural populations of bacteria, actinomycetes, or fungi after a 24-day incubation of a sandy loam soil treated with 1 or 10 mg HCCP/kg d.w. It is concluded that no significant effects on microbial populations would result from contamination of soils with these levels of HCCP. However, adsorption onto soil particles may also account for the lack of toxicity in this study.

Calculation of Predicted No effect Concentration (PNEC)

A calculated $PNEC_{soil}$ is 10 µg/kg d.w., which were derived by using assessment factor of 1000 and by using the acute value measured in plants (EC50 = 10 mg/kg d.w.). The PNECsoil of 2.26 µg/kg d.w.can also be derived using the equilibrium partitioning method. The experimental PNEC is slightly higher than the one derived with the equilibrium partitioning method. It should be noted that experimental toxicity data are based on nominal concentrations. Furthermore, there is a significant potential for this substance to be removed from the soil by volatilisation, degradation and photolysis, and the available results may underestimate the actual toxicity of HCCP. Therefore, the equilibrium partitioning approach will be used for the risk characterisation.

Atmosphere

HCCP is a liquid with a vapour pressure of 10 Pa at 25ºC. The results on atmospheric degradation indicate that HCCP will not persist in the atmosphere as it will be removed via reaction with photochemically-generated hydroxyl radicals. Since HCCP is known to photolyse rapidly (half-life < 10 minutes) in water, atmospheric photolysis is also expected. However, no estimate of the reaction rate for atmospheric photolysis is available. Furthermore, based on the highly chlorinated structure of HCCP, it is expected that reaction of this compound with ozone molecules in the atmosphere would be too slow to be environmentally significant. An atmospheric half-life of 29 days has been derived from these data. As the estimated life-time of the substance in the atmosphere is < 1 year the substance is not expected to reach the stratosphere and therefore has no significant ozone depletion potential.

Secondary poisoning

Effect data

In a 13 week oral (gavage) toxicity studies with rats and mice, no NOAEL could be established for rats, based on the toxicological relevant dose related increase in female kidney:body weight ratio at all dose levels compared to the control animals (LOAEL is 10 mg/kg bw). Furthermore, no NOAEL could be established for mice, based on the toxicological relevant increase in female liver:body weight and kidney:body weight ratio at all dose levels compared to the control animals (LOAEL is 19 mg/kg bw). It should be noted that the batch of HCCP used in this study was contaminated with hexachloro-1,3-butadiene (0.51%), which is a known nephrotoxin in rodents. Nevertheless, the oral LOAEL of 10 mg/kg bw, based on an increase in kidney:body weight ratio in female rats, is taken forward for the $PNEC_{oral}$ derivation.

Calculation of PNECoral

A LOAEL of 10 mg/kg bw was established from an oral gavage toxicity study with rats. Given the used doses in the 13 week toxicity study (0, 10, 19, 38, 75, 150 mg/kg bw/day) and the observed (marginal) effects (increase in female kidney:body weight ratio at all dose levels) an assessment factor of 3 is used to derive the NOAEL for mammals. Using a conversion factor of 20 for rats (>6 weeks) to come from the NOAEL to the $NOEC_{food}$ will lead to a $NOEC_{food}$ of 66.6 mg/kg food. The $PNEC_{oral}$ is then derived from the $NOEC_{food}$ applying an assessment factor of 90, which is proposed by the TGD (2003) for a 90 day toxicity study with mammals. The $PNEC_{oral}$ will then become 0.74 mg/kg_{food}.

3.3 RISK CHARACTERISATION

Aquatic compartment (incl. sediment)

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

Conclusion (ii) applies to all local sites, endosulfan application and the regional scenario, as all the PEC/PNEC ratios for surface water and sediment are below 1 (Table 3.8 and 3.9).

Table 3.8 Local risk characterisation ratios (PEC/PNEC values)

	WATER	SOIL	SEDIMENT	STP	FISH-EATING PREDATORS[1]	WORM-EATING PREDATORS
II-a processing facility	2.56E-07	4.76E-04	2.56E-07	0	1.14E-10 – 1.35E-08	9.85E-06
II-b processing facility	8.05E-04	1.41E-04	8.05E-04	2.43E-09	3.95E-08 – 4.65E-06	1.05E-06
II-c processing facility	2.56E-07	9.96E-06	2.56E-07	0	1.14E-10 – 1.35E-08	2.24E-07
Application of endosulfan						
Scenario 1 (Citrus)	2.04E-01		Not calculated [2]			
Scenario 2 (Cabbage)	1.34E-02		Not calculated [2]			
Scenario 3 (Tomatoes)	7.17E-04		Not calculated [2]			

[1] For fish eating predators BCF values of 11 and 1297 were used.
[2] Not calculated with USES 3.0, but PEC/PNEC sediment (equilibrium partitioning) would equal PEC/PNEC water.

Table 3.9 Regional risk characterisation ratios (PEC/PNEC values)

	water	SOIL	SEDIMENT
Regional scenario	2.56E-07	4.49E-07	4.48E-07

Terrestrial compartment

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

Conclusion (ii) applies to all sites, as the soil PEC/PNEC ratios for all local scenarios and the regional scenario are below 1.

Atmosphere

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

Conclusion (ii) applies to all sites, because of its physical and chemical characteristics it is not expected that a great amount of HCCP will persist in the atmosphere. Additionally, there are no indications for either biotic or abiotic effects of HCCP in the atmospheric compartment. The ozone depleting potential of HCCP is considered to be not significant.

Secondary poisoning

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

Conclusion (ii) applies to all sites, as all PEC/PNEC ratios for worm- and fish-eating predators are below 1.

PBT-assessment

HCCP is considered to be inherently biodegradable in the risk assessment with a rate constant of 0 h^{-1} and should be regarded as potentially persistent. Based on the log Kow-value of 5.04, HCCP would be considered to potentially fulfil the B-criterion. However, as BCF-values of less than 11 for the steady-state and 1297 from ^{14}C studies are derived from experimental data, the substance is not expected to fulfil the B-criterion, as the BCF value does not exceed the trigger value of 2000. The lowest NOECs for freshwater and marine organisms were found to be 0.0037 and 0.0003 mg/l, respectively. This is clearly under the cut-off value of 0.01 mg/l. HCCP meets the T-criterion in the PBT-assessment. Overall, HCCP does not meet the PBT criteria. It should be noted that HCCP has an impurity of 0.1% hexachlorobutadiene, which is considered to be a PBT substance.

4 HUMAN HEALTH

4.1 EXPOSURE

4.1.1 Occupational exposure

Production of HCCP does not take place in the EU. Occupational exposure in the EU is possible in chemical industries where HCCP is used as an intermediate during the manufacturing of pesticides and flame retardants. These products are produced in closed systems and occupational exposure may occur during connecting and disconnecting of transfer lines. Occupational exposure may also occur when products containing HCCP are added to chemical processes (e.g. containing flame retardants in unsaturated polyesters, paints and thermoplastics).
Unintentional exposure to HCCP as a reaction product is possible in the semiconductor industry through drumming of waste products and maintenance activities. In addition, unintentional release of HCCP during fires as a degradation product of a flame retardant are considered.

For the use of HCCP as an intermediate in the production of flame retardants, a reasonable worst case inhalation exposure level of 50 μg/m^3 is estimated (based on measured data). Since workers wear protective clothing and equipment during these activities, the reasonable worst case inhalation exposure level is estimated to be 2.5 μg/m^3 for the protected workers. As a typical exposure level, 10 μg/m^3 will be taken forward to the risk characterisation for the unprotected worker. The typical inhalation exposure level of a protected worker (wearing suitable RPE) amounts to 0.5 μg/m^3. Short term exposure is estimated to be two times the level of the full shift reasonable worst case exposure, thus 100 μg/m^3 (TWA 15 minutes) (expert judgement). Actual short-term exposure with the use RPE is estimated at a level of 5 μg/m^3.

Products and distillation residues are expected to contain less than 7% HCCP. Dilutions of HCCP containing less than 7% of the substance do not have corrosive properties. An assessment is therefore made for these formulations, assuming that exposure is not expected when it exceeds 7% HCCP. The upper range of the dermal EASE estimate for drumming is applied with a reasonable worst case percentage of 2% HCCP. The reasonable worst case exposure level amounts to 0.02 mg/cm^2/day (1 mg/cm^2/day * 2%), which calculates to a daily exposure level of 4.2 mg (EASE). Eye protection and protective gloves and clothing during the handling of distillation residues may reduce the exposure with 90% to 0.002 mg/cm^2/day (0.42 mg/day).

During the use of HCCP containing products the reasonable worst case inhalation exposure is estimated to be the saturated vapour concentration of 54 μg/m^3 (expert judgement). The typical exposure value is estimated to be 10 μg/m^3 (expert judgement). The short term exposure level is calculated to be 108 μg/m^3.
The upper value of the EASE estimate 0.05 μg/cm^2/day (0.021 mg/day) is taken forward to the risk characterisation as reasonable worst case exposure level for dermal exposure adding operations of HCCP containing products.

A reasonable worst case exposure for unintentional exposure to HCCP as a reaction product is estimated at 1.9 μg/m^3 for full shift inhalation exposure. The typical inhalation exposure level

is estimated to be the mean of the upper and lower range of the EASE estimate. For inhalation exposure the typical exposure is calculated to be 1 μg/m^3. The reasonable worst case estimate (EASE) for full shift dermal exposure amounts to 0.19 μg/cm^2/day, calculated to 0.25 mg/day.

HCCP is a degradation product and can unintentionally be released during fires. This unintentional release of HCCP during fires indicates the potential occupational exposure of fire fighters and professional clean up workers. Because of a lack of information regarding the quantities of HCCP in these products, the occupational exposure cannot be estimated.

A summary of occupational exposure levels is presented in **Table 4.1**.

Table 4.1. Summary of occupational exposure.

Scenario	Activity	Frequency days/year	Exposed workforce	Duration	Inhalation exposure Reasonable worst case		Inhalation exposure Typical case		Dermal exposure Reasonable worst case	
					µg/m³	Method	µg/m³	Method	mg/cm²/day	Dose (mg/day)
1) Production of pesticides and flame retardants	General production	300	42	8h TWA	50 (2.5 with PPE)	Measured data	10 (0.5 with PPE)	Measured data	0.02 (0.002 with PPE)	4.2 (0.42 with PPE)
				15 min TWA	100 (5 with PPE)	Expert judgement	-	-	-	-
2) Use of product containing residual HCCP	Addition of flame retardants			8h TWA	54	SVC and expert judgement	10	EASE	0.00005	0.021
				15 min TWA	108	SVC and expert judgement				
3) Unintentional occurrence of HCCP in the semiconductor industry	Maintenance	20	-	8h TWA	1.9	EASE	1	EASE	0.19	0.25
4) Unintentional release of HCCP during fire	-	-	-	-	-	-	-	-	-	-

TWA: time weighted average
SVC: saturated vapour concentration
PPE: personal protective equipment

4.1.2 Consumer exposure

There is no consumer exposure to HCCP.

4.1.3 Man exposed indirectly via the environment

Environmental release of HCCP may occur during its use as an intermediate in the production of chlorendic acid (HET-acid), cyclodiene pesticides (in Europe mainly endosulfan), and specialty coatings. HCCP may also be released during pesticide application and from the industrial use of HET-acid and Dechlorane Plus (an additive in the production of flame retardant plastics). The production of endosulfan resulted in the highest local emission to air (PEC 7.3E-03 μg/m^3) and the highest total daily intake for humans from environmental sources (2.26E-06 mg/kg bw/day). In this scenario intake is mainly via air (92%; 2.09E-06 mg/kg bw/day), while intake via food and drinking water was 1.7E-7 mg/kg bw/day.

The regional PEC in air was 7.55E-06 μg/m^3. For the regional situation, air is also the main source of exposure to man (93% of a total daily intake of 2.33E-09 mg/kg bw/day), leaving only 1.70E-10 mg/kg bw/day for the regional intake via food (including drinking water).

4.1.4 Combined exposure

Humans can be exposed to HCCP at the workplace and via the environment. In theory, exposure to a combination of these two sources is possible. However, since exposure to HCCP via the environment is very low compared to exposure to HCCP at the workplace, HCCP exposure via the environment will not lead to an increased exposure for workers. Therefore, there is no need to perform a combined exposure assessment.

4.2 EFFECTS ASSESSEMENT

Data on excretion via urine and faeces strongly indicate that rats and mice were capable of extensively degrading HCCP when applied orally, and that the metabolites formed were of a nature that favoured faecal elimination. The exact oral absorption figure cannot be derived, however, because it is not possible to discriminate between two options, which may both occur:
- HCCP is metabolised in the liver, the metabolites return to the intestine via the bile and are then excreted in the gut, and
- HCCP is largely metabolised in the gut, probably by microorganisms, to products which are not absorbed but voided in the faeces.

In addition, studies showed that HCCP became bound to faecal homogenates, and intestinal contents. Thus, from the available data on oral absorption only the minimum level of systemic availability, and consequently the minimal amount of oral absorption can be derived, i.e. via summing up recovered radiolabel in urine, tissues, and expired air: it ranges from approximately 18% to 39% after a single gavage application (7 - 61 mg/kg bw dose), and from 5.5% to 12.2% when applied via the diet for 30 days (0.07 to 1.67 mg/kg bw/day for rats, 0.16 to 4.1 mg/kg bw/day for mice). Both with single and repeated administration, there was no clear relationship between percentage absorption and dose.

The nature of the radioactivity excreted in urine was examined for possible metabolites. The results suggest that at least four metabolites of HCCP were present. These metabolites have not been identified and characterised.
From the inhalation studies, it is concluded that complete respiratory absorption cannot be excluded. For the risk characterisation, 100% inhalation absorption is assumed (worst-case estimate).
HCCP is absorbed via the dermal route as is indicated by toxic responses reported in acute dermal toxicity studies. Absorption data on dermal studies is, however, lacking. In general, it is assumed that dermal absorption will not be higher than oral absorption. However, it is shown that HCCP is extensively metabolised after oral exposure, while no information is available on dermal/skin metabolism of HCCP. Therefore, based on the molecular weight and log P_{ow} of HCCP, dermal absorption is assumed to be 100% according to the TGD.

After acute inhalatory exposure, the 4-hr LC_{50} ranged from 0.018-0.041 mg/l for rats; the 3.5-hr LC_{50} for rabbits was <0.0158 mg/l.
The dermal LD_{50} for rabbits ranged from <200-780 mg/kg bw; for rats this value was >2000 mg/kg bw. Furthermore, in all skin irritation studies, mortality was observed in rabbits. Mortality occurred already at the lowest tested concentration (0.5 ml) which corresponds with a systemic dose level of 250 mg/kg bw assuming a body weight of 2 kg for rabbits.
With regard to oral exposure, the LD_{50} ranged from 505-1500 mg/kg bw for rats; for mice this value was 679 mg/kg bw. From the available data, it can be concluded that HCCP is harmful after acute oral exposure, toxic after acute dermal exposure and very toxic after inhalatory exposure. Starting points for the risk assessment are the 4-hour inhalation LC_{50} value of 0.018 mg/l (18 mg/m^3) in rats and the dermal LD_{50} of <200 mg/kg bw in rabbits.
Mortality was also observed in all tested animals (4 male and female rabbits) in the eye irritation study in which 0.1 ml of HCCP was placed into the conjuctival sac of the right eye.

HCCP is irritating and corrosive to the skin and eyes and irritating to the respiratory tract. In addition to the animal studies, a case study with 177 plant workers showed that HCCP may be skin and eye irritating for humans after acute exposure. HCCP may also cause sensitisation by skin contact.

The lowest NOAEL for systemic subacute inhalatory toxicity (1.25 mg/m^3) was observed in a 2 week range finding study with rats. At the next higher dose level (5.7 mg/m^3) reduced body weight and mortality were observed. The lowest NOAEL for local subacute inhalatory toxicity (1.25 mg/m^3) was also observed the 2 week range finding study and based on impaired respiratory function and microscopic changes in lung and nasal area. The overall NOAEL for local and systemic effects after semichronic exposure is 0.45 mg/m^3 (observed in mice after 13 weeks of exposure). After inhalatory exposure to dose levels of 1.67 mg/m^3 and higher decreased absolute body weight and squamous metaplasia of the larynx or trachea in mice were observed. An overall NOAEL for chronic inhalatory exposure could not be established since the lowest dose tested still induced treatment related local effects (LOAEL: 0.11 mg/m^3). This LOAEL is derived from a two 2-year chronic inhalation toxicity study with rats and mice. Concentrations of ≥ 0.11 mg/m^3 HCCP caused toxicity to the respiratory tract, i.e. an increase in the incidence of pigmentation of the respiratory epithelium of the nose, trachea, and the bronchi and bronchioles of the lung in both rats and mice. In addition, in rats a significantly higher incidence of squamous metaplasia of the laryngeal epithelium of females exposed to concentrations of ≥ 0.11 mg/m^3 HCCP was observed. No increased incidence in neoplasms was found. Based on the available data, it is concluded that HCCP

may cause serious damage to health by prolonged exposure through inhalation. The NOAEL for systemic effects after chronic exposure is 0.11 mg/m^3. This NOAEL is based on the higher incidences of suppurative ovarian inflammation in mice exposed to 0.56 and 2.28 mg/m^3.

One oral repeated dose toxicity study with HCCP was available. In this 13 week oral (gavage) toxicity studies with rats and mice, the local and systemic NOAEL for rats was 10 mg/kg bw/day based on the toxicological relevant dose related increase in male and female kidney:body weight ratio from 19 mg/kg bw/day onwards. No systemic NOAEL could be established for mice, based on the toxicological relevant increase in female liver:body weight and kidney:body weight ratio at all dose levels compared to the control animals (LOAEL is 19 mg/kg bw).
Based on the occurrence of proliferation and inflammatory changes of the epithelia in the forestomach of female rats and male and female mice, the local NOAELs were 10 and 19 mg/kg bw/day for rats and mice, respectively.

No suitable dermal repeated dose toxicity studies are available.

HCCP appears to be no bacterial mutagen and does not induce gene mutations in mammalian cells *in vitro*. An increase in SCE was observed in treated mammalian cells *in vitro*, but this was without a clear dose-response relationship. HCCP did induce chromosome aberrations in mammalian cells *in vitro*, though under conditions of clear toxicity. No induction of sex-linked recessive lethal mutations was noted in germ cells of treated male *Drosophila Melanogaster* In mice no micronucleated erythrocytes were found after 13 weeks of inhalation exposure to various doses of HCCP including a maximally tolerated dose, though it remains unclear whether HCCP has reached the bone marrow as target in sufficient amounts and therefore no clear conclusion can be drawn from this individual study on the mutagenicity of HCCP. However, as no tumours were formed in any of the exposed organs, including the site of first contact, i.e. the respiratory tract, under the conditions of maximum tolerated dose levels in chronic inhalation studies in both rats and mice, HCCP is considered not to have mutagenic activity under *in vivo* conditions.

Based on a 2-year chronic inhalation study with rats and mice, HCCP is not considered to be a carcinogenic compound for this route. Data on carcinogenic effects of HCCP after dermal or oral exposure are lacking. In addition, several epidemiological studies were performed on workers in manufacturing plants where HCCP was used and/or produced among other chemicals. The studies did not give indications for a different cancer-induced mortality in exposed workers when compared to non-exposed workers or to the overall USA population.
However, information specific to HCCP exposure, either qualitative or quantitative, was not available in any of these studies. In addition, study populations were relatively small, and observation times (25 years at most) relatively short. Therefore, the studies are of limited value and do not provide conclusive evidence. However, due to the absence of mutagenic activity of HCCP and the absence of carcinogenic potential in rats and mice after chronic inhalation exposure, it is concluded that HCCP is not a carcinogenic substance.

No specific inhalation and dermal studies on toxicity of HCCP for reproduction are available. In several inhalation repeated dose studies (rats and mice exposed for 13 weeks up to at least 4.46 mg/m^3; rats and monkeys exposed for 14 weeks up to 2.28 mg/m^3; rats exposed for 30 weeks up to 6.34 mg/m^3; rats and mice exposed for 2 years up to 2.28 mg/m^3) male and female reproduction organs were histopathologically examined, but no biologically relevant

histopathological treatment related effects with regard to fertility were observed. Therefore, the inhalation NOAEL was established at 6.34 mg/m^3.

In an oral repeated dose study (13 weeks; rats exposed up to 150 mg/kg bw and mice exposed up to 300 mg/kg bw), male and female reproduction organs were also histopathologically examined. No biologically relevant histopathological treatment related effects were observed. Therefore, the oral NOAEL for fertility effects was established at 150 mg/kg bw (highest dose tested) for rats and 300 mg/kg bw (highest dose tested) for mice.
In oral teratogenicity studies with mice and rats, no teratogenic effects were found. In rabbits, at 75 mg/kg bw/day little evidence of embryotoxicity was observed in combination with significant maternal toxicity. Compared to the control animals, 13 ribs were seen more frequently among the foetuses of rabbits given 75 mg/kg/day (the normal number of pairs of ribs in the rabbit is 12 or 13). The overall NOAEL for maternal and developmental toxicity is concluded to be 25 mg/kg bw/day based on the study with rabbits.

Table 4.2. Summary of effects.

Toxicological endpoint	Inhalation (N(L)OAEL)	Dermal (N(L)OAEL)	Oral (N(L)OAEL)
Acute toxicity	18-41 mg/m^3 (LC_{50} in rats); <15.8 mg/m^3 (LC50 in rabbits)	<200-780 mg/kg bw (LD_{50} in rabbits); >2000 mg/kg bw for rats	505-1500 mg/kg bw (LD_{50} in rats); 697 mg/kg bw (LD50 in mice)
Repeated dose toxicity (local)	1.25 mg/m^3 (subacute NOAEL in rats) 0.45 mg/m^3 (semichronic NOAEL in mice) 0.11 mg/m^3 (chronic LOAEL in rats and mice)	n.a.	10 mg/kg bw (semichronic NOAEL in rats)
Repeated dose toxicity (systemic)	1.25 mg/m^3 (subacute NOAEL in rats) 0.45 mg/m^3 (semichronic NOAEL in mice) 0.11 mg/m^3 (chronic NOAEL in mice)	n.a.	10 mg/kg bw (semichronic NOAEL in rats)
Fertility impairment	>6.34 mg/m^3 (NOAEL in rats)	n.a.	>150 mg/kg bw/day (NOAEL in rats) >300 mg/kg bw/day (NOAEL in mice)
Developmental toxicity	n.a.	n.a.	25 mg/kg bw/day (NOAEL in rabbits)

n.a.: not available

4.3 RISK CHARACTERISATION

4.3.1 Workplace

An overview of the occupational risk characterisation for HCCP is given in **Table 4.3**.

Assuming that oral exposure is prevented by personal hygienic measures, the risk characterisation for workers is limited to the dermal and inhalation routes of exposure.

If applicable, quantitative risk assessment is performed by calculation of the MOS (the ratio between NOAEL/LOAEL and exposure levels) and comparison of this value with the minimal MOS. This minimal MOS is established via assessment factors, taking into account inter- and intraspecies differences, differences between experimental conditions and the exposure pattern of the worker, type of critical effects, dose-response relationship, confidence in the database, and correction for route-to-route extrapolation. A risk is indicated when the MOS is lower than the minimal MOS. In case of combined exposure the calculations are based on internal NOAELs and systemic exposure levels.

In the scope of the assessment of existing substances, dermal exposure to corrosive concentrations is not assessed. For the handling of corrosive substances and formulations, it is assumed that daily dermal exposure can be neglected because workers are protected from dermal exposure and immediate dermal contacts occur only accidentally. Techniques and equipment (including PPE) are used that provide a high level of protection from direct dermal contact. Eye protection is obligatory for activities where direct handling of HCCP occurs. These protection measures will also protect to the possible occurrence of mortality after dermal and eye exposure (see acute toxicity after dermal exposure and after exposure to the eyes).
Dermal exposure to dilutions of HCCP, that result in a substance or formulation which has no corrosive labelling (dilutions containing <10% HCCP, according to EU classification and labelling commission), also occurs. Dermal exposure to such non-corrosive dilutions of HCCP cannot be neglected and will be taken into account. Furthermore, acute and repeated inhalation exposure to HCCP cannot be neglected.

Acute toxicity

HCCP is classified as harmful after oral exposure, as toxic after acute dermal exposure and very toxic after inhalation exposure. For occupational risk assessment the short-term exposure levels are compared with the LD_{50} or LC_{50} values.

Inhalation exposure
Starting-point for the risk assessment of acute inhalation toxicity is the 4-hour LC_{50} value of 0.018 mg/l (equivalent to 18 mg/m^3) for male rats. The minimal MOS required for acute occupational exposure using this LC_{50}-value is >> 12.5[2].
Comparing the MOS values with the minimal MOS (see **Table 4.3**), it is concluded that the MOS values are in excess of the minimal MOS even with regard to possible systemic effects (an additional uncertainty factor of 10 is possible).
Furthermore, no case reports were available in literature describing mortality, the effect on which the LC_{50} is based, of humans exposed to HCCP in occupational exposure settings. In addition, the MOS for acute inhalation toxicity is based on a 4-hour LC_{50} while the exposure duration concerns a 15 min TWA, which may indicate an underestimation of the MOS values.
Therefore, it is concluded that there is no concern for workers with regard to the occurrence of adverse effects after short-term inhalation exposure to HCCP (**conclusion ii**).

Dermal exposure

[2] Minimal MOS acute inhalation toxicity >>12.5 = 2.5 (interspecies) x 5 (intraspecies) x >>1 (Dose response / Type of critical effect)

Starting-point for the risk assessment of acute dermal toxicity is the dermal LD_{50} value of <200 mg/kg bw in rabbits. It should be noted that mortality was observed in animals in all skin irritation studies. Mortality occurred already at the lowest tested concentration (0.5 ml) which corresponds with a systemic dose level of 250 mg/kg bw assuming a body weight of 2 kg for rabbits.
The minimal MOS required for acute occupational exposure using this LD_{50}-value is >>50[3]. Comparing the MOS values with the minimal MOS (see **Table 4.3**), it is concluded that these MOS values are in excess of the minimal MOS even with regard to possible systemic effects. Furthermore, it should be noted that existing controls are applied with regard to dermal exposure to HCCP based on the corrosive and irritating properties of this substance (see section 4.1.3.2.2). Therefore, there is no concern for systemic effects after acute dermal exposure (**conclusion ii**).

Exposure to the eyes
With regard to the available animal eye irritation study, it is noted that all exposed animals died during the study. Based on this result, it is concluded that HCCP is of concern for workers with regard to effects as a result of eye exposure. However, ocular exposure can be excluded as effective use of personal protective equipment for the eyes is assumed in all scenarios based on severely eye irritating properties of HCCP (see section 4.1.3.2.2). Therefore, it is concluded that the substance is of no concern for workers with regard to the occurrence mortality as a result of eye exposure (**conclusion ii**).

Irritation and corrosivity

Dermal irritation after single and repeated exposure
Given the results of the irritation studies and the results of some acute dermal toxicity studies, it is concluded that HCCP is irritating (concentrations 5%≤C<10%) and corrosive (concentrations ≥10%) to the skin. However, dermal exposure to corrosive concentrations of HCCP is considered to occur only accidentally if the required protection is strictly adhered to. With regard to dermal exposure to irritating, but non-corrosive, dilutions of HCCP, it is assumed that existing controls (i.e., engineering controls and personal protective equipment based on classification and labelling with R38) are applied. Therefore, **conclusion ii** is justifiable with regard to local dermal effects.

No repeated dose toxicity study with regard to dermal irritation of HCCP is available and thus it is not possible to make a quantitative risk assessment for local effects after repeated dermal exposure.

Eye irritation
In the available animal eye irritation study, HCCP was found to be severely irritating to the eyes. However, ocular exposure can be excluded as effective use of personal protective equipment for the eyes is assumed in all worker exposure scenarios. Therefore, the substance is of no concern for workers with regard to effects as a result of eye exposure (**conclusion ii**).

Respiratory irritation after single exposure

[3] Minimal MOS acute dermal toxicity >>50 = 4*2.5 (interspecies) x 5 (intraspecies) x >>1 (Dose response / Type of critical effect)

Starting point for the risk assessment for respiratory irritation is the NOAEL of 0.28 ppm; equivalent to 3.2 mg/m^3) based on significant pulmonary abnormalities (red focal or diffuse consolidation, progressing to haemorrhage and hepatisation) at higher concentrations. Comparing the MOS values with the minimal MOS (12.5[4]) (see **Table 4.3**), it is concluded that there is no concern for workers with regard to the occurrence of respiratory irritation for all occupational scenarios (**conclusion ii**).

Sensitisation

Dermal sensitisation
HCCP causes sensitisation by skin contact in animal studies. However, in scenarios where engineering controls and personal protective equipment are effectively used based on the classification and labelling of the substance as a skin sensitiser, the possible occurrence of skin sensitisation will be reduced to a minimum and **conclusion ii** is applicable.

Respiratory sensitisation
There are neither data from animal studies nor indications from the human case study for respiratory sensitisation.

Repeated dose toxicity

Inhalation exposure
Starting-point for the risk assessment of inhalation repeated dose toxicity are the LOAEL of 0.11 mg/m^3 HCCP for local effects and the NOAEL of also 0.11 mg/m^3 for systemic effects both from the 2-year inhalation study. The minimal MOS values are 37.5[5] and 12.5[6] for local and systemic effects, respectively. Comparing the MOS values with the minimal MOS values (see **Table 4.3**), it is concluded that there is concern for workers with regard to the occurrence of local and systemic effects for the occupational scenarios 'Production of pesticides and flame retardants' and 'Use of product containing residual HCCP' (**conclusion iii**).

Dermal exposure
Conclusions regarding the risk characterisation for local effects after repeated exposure to HCCP are described in the section 'irritation and corrosion'.

No suitable dermal repeated dose toxicity studies are available. Oral to dermal extrapolation is not reliable and valid for HCCP. For HCCP it appears that differences in metabolism after oral and inhalation exposure (no dermal toxicokinetic data is available for HCCP) might explain the observed route specific difference. After oral administration, HCCP is extensively degraded to polar metabolites and the majority of the orally consumed HCCP is not absorbed. This first pass metabolism is not indicated to occur after inhalation exposure. Based on this, it appears that HCCP is more toxic after inhalation (and possibly also dermal) exposure. Therefore, inhalation to dermal extrapolation is performed.

Starting-point for the risk assessment of dermal repeated dose toxicity is the inhalation NOAEL of 0.11 mg/m^3 for systemic effects both from the 2-year inhalation study. A dermal

[4] Minimal MOS respiratory irritation 12.5 = 2.5 (interspecies) x 5 (intraspecies)
[5] Minimal MOS inhalation repeated dose toxicity (local effects) 37.5 = 2.5 (interspecies) x 5 (intraspecies) x 3 (Dose response / Type of critical effect)
[6] Minimal MOS inhalation repeated dose toxicity (systemic effects) 12.5 = 2.5 (interspecies) x 5 (intraspecies)

NAEL of 0.046 mg/kg bw/day is calculated from this NOAEL of 0.11 mg/m^3 assuming an inhalation volume of 41 ml/min for female mice (daily exposure of 6 hours), a body weight of 0.035 kg for female mice, a respiratory retention of 100% and a dermal absorption of 100%.
The minimal MOS is calculated to be 87.5[7]. Comparing the MOS values with the minimal MOS value (see **Table 4.3**), it is concluded that there is concern for workers with regard to the occurrence of systemic effects for all occupational scenarios (**conclusion iii**).

Combined exposure

In view of the dermal and inhalation exposure estimates, there is concern for systemic effects in all occupational scenarios (**conclusion iii**).

Mutagenicity

Given the results from the mutagenic studies and as no tumours were formed in any of the exposed organs, including the site of first contact, i.e. the respiratory tract, under the conditions of maximum tolerated dose levels in chronic inhalation studies in both rats and mice, it is concluded that HCCP is of no concern for workers with regard to mutagenicity (**conclusion ii**).

Carcinogenicity

Given the results from the mutagenicity studies, the chronic animal (rats and mice) repeated dose/carcinogenicity studies with HCCP, and the available epidemiological studies, it is concluded that there are no reasons for concern for workers with regard to carcinogenicity after inhalation and dermal exposure (**conclusion ii**).
Risk characterisation of local carcinogenicity after dermal exposure can only be performed based on chronic dermal toxicity studies.

Toxicity for reproduction

Inhalation exposure

Effects on fertility

No specific study on fertility effects of HCCP is available. However, in different inhalation repeated dose studies, male and female reproduction organs were histopathologically examined and no biologically relevant histopathological treatment related effects were observed. When comparing the MOS values (based on a NOAEL of 6.34 mg/m^3 in rats) of the different exposure scenarios with the minimal MOS of 12.5[8] (see **Table 4.3**), **conclusion ii** is derived.

Developmental toxicity

Only oral developmental toxicity studies are available. Based on the uncertainties of oral to inhalation extrapolation, a quantitative risk assessment for developmental toxicity after

[7] Minimal MOS dermal repeated dose toxicity 87.5 = 7 * 2.5 (interspecies) x 5 (intraspecies)
[8] Minimal MOS effect on fertility after inhalation exposure 12.5 = 2.5 (interspecies) x 5 (intraspecies)

inhalation exposure cannot be performed. However, given the toxicity profile of the substance, it is not expected that developmental effects will occur at the low concentrations (N(L)OAEL of 0.11 mg/m^3 for) at which local and systemic effects are observed upon inhalation exposure (see repeated dose toxicity). Therefore, a **conclusion ii** is derived.

Dermal exposure

Effects on fertility

No suitable study is available to assess the risk of effects on fertility after dermal exposure. Based on the uncertainties of oral to dermal extrapolation, an extrapolation from inhalation to dermal is preferred. As in different inhalation repeated dose studies no biologically relevant histopathological treatment related effects were observed up to at least 6.34 mg/m^3 (see inhalation section), **conclusion ii** is reached.

Developmental toxicity

Only oral developmental toxicity studies are available. Based on the uncertainties of oral to dermal extrapolation, a quantitative risk assessment for developmental toxicity after dermal exposure cannot be performed. Given the toxicity profile of HCCP, it is not expected that developmental effects will occur at the low dose levels (N(L)AEL of 0.046 mg/kg bw/day) at which local and systemic effects are expected to occur upon dermal exposure (see repeated dose toxicity). Therefore, a **conclusion ii** is derived.

Combined exposure

The available data indicate no concern for effects on fertility and developmental toxicity (**conclusion ii)**.

Table 4.3. Overview of the conclusions with respect to occupational risk characterisation.

		Acute toxicity		**Irritation and corrosivity**			**Sensiti sation**	**Repeated dose toxicity Systemic**			**Mutagenicity Carcinogenicity Reproductive toxicity**
		Dermal	Inhalation	Skin	Eye	Respira-tory tract		Dermal	Inhalation	Combined	
Production of pesticides and flame retardants	MOS	<3333	180			32		0.8	2.2		
	mMOS	>>50				12.5		87.5	37.5 (local) 12.5 (systemic)		
	Concl.	ii	ii	ii	ii	ii	ii	iii	iii	iii	ii
Use of product containing residual HCCP	MOS	<666667	167			30		153	2		
	mMOS	>>50				12.5		87.5	37.5 (local) 12.5 (systemic)		
	Concl.	ii	ii	ii	ii	ii	ii	ii	iii	iii	ii
Unintentional occurrence of HCCP in the semiconductor industry	MOS	<55555	n.a.			n.a.		13	58		
	mMOS	>>50						87.5	37.5 (local) 12.5 (systemic)		
	Concl.	ii	n.a.	ii	ii	n.a.	ii	iii	ii	iii	ii
Unintentional release of HCCP during fire	MOS	n.a.	n.a.			n.a.		n.a.	n.a.		
	mMOS										
	Concl.	n.a.	n.a.	ii	ii	n.a.	ii	n.a.	n.a.	iii	ii

n.a.: not applicable

4.3.2 Consumers

Since there is no consumer exposure to HCCP, a risk characterisation for consumers is not applicable.

4.3.3 Man indirectly exposed via the environment

Repeated dose toxicity

Exposure via air

Starting points for the risk characterisation for repeated dose toxicity are the highest estimated local exposure level via air (7.3E-03 µg/m^3) and the systemic NOAEC/local LOAEC of 0.11 mg/m^3 from the chronic inhalation study with rats. The margin of safety between this NOAEC/LOAEC and the estimated exposure level is approximately 15000. This margin of safety indicates no concern for human safety for both systemic and local effects after repeated inhalation (**conclusion ii**), taking into account inter- and intraspecies variation and, for the LOAEC, extrapolation to the NAEC (minimal MOS is 2.5 x 10 = 25 for systemic effects, and 2.5 x 10 x 3 = 75 for local effects).

With a regional exposure via air that is three orders of magnitude lower than the highest local exposure via air, a **conclusion ii** is also reached for the regional scenario.

Exposure via food and water

Starting points for the risk characterisation are the highest exposure via food and drinking water (1.7E-7 mg/kg bw/day) and the oral NOAEL of 10 mg/kg bw from the 13 week study in rats. The margins of safety of >5.9*10^7 indicates no concern for human safety after repeated oral exposure (**conclusion ii**), taking into account inter- and intrapecies variation and exposure duration extrapolation (minimal MOS is 4 x 2.5 x 10 x 2 = 200).

For the regional scenario, the oral exposure is much lower and can be considered negligible (**conclusion ii**).

Mutagenicity

Given the results from the mutagenicity studies and that no tumours were formed in any of the exposed organs, including the site of first contact, i.e. the respiratory tract, under the conditions of maximum tolerated dose levels in chronic inhalation studies in both rats and mice, it is concluded that HCCP is of no concern for mutagenicity for man exposed via the environment (**conclusion ii**).

Carcinogenicity

Given the results from the mutagenicity studies, the chronic animal (rats and mice) repeated dose/carcinogenicity studies and the available epidemiological studies, it is concluded that

HCCP is of no concern for carcinogenicity for man exposed via the environment (**conclusion ii**).

Toxicity for reproduction

Exposure via air

No specific study on fertility effects of HCCP is available. In several inhalation repeated dose studies male and female reproduction organs were histopathologically examined, but no biologically relevant treatment related effects were observed. For risk characterisation, the highest concentration tested without effects on fertility is used, i.e. 6.34 mg/m^3. The other starting point for the risk characterisation is the highest estimated local exposure via air (7.3E-03 µg/m^3). The margin of safety is approximately $8.7*10^5$. This margin of safety indicates no concern for fertility after inhalation (**conclusion ii**), taking into account intra- and interspecies variation (minimal MOS is 2.5 x 10 = 25).

With a regional exposure via air that is three orders of magnitude lower than the highest local exposure via air, a **conclusion ii** is also reached for the regional scenario.

Exposure via food and water

Starting points for the risk characterisation are the highest exposure via food and drinking water (1.7E-7 mg/kg bw/day) and the oral NOAEL of 25 mg/kg bw for rabbits for teratogenicity, also including studies on rats and mice with higher NOAELs for fertility. The margin of safety of $>1.5*10^8$ indicates no concern for human safety for reproductive effects (**conclusion ii**), taking into account inter- and intraspecies variation (minimal MOS is 2.4 x 2.5 x 10 = 60).

For the regional scenario, the oral exposure is much lower and can be considered negligible (**conclusion ii**).

4.3.4 Combined exposure

Since there is no need to perform a combined exposure assessment for HCCP, a risk characterisation for combined exposure is not applicable.

4.4 HUMAN HEALTH (PHYSICO-CHEMICAL PROPERTIES)

No studies are available on the flammability, explosive properties and oxidizing properties of HCCP. However, taking into account the structural formula and the thereof-derived thermokinetics, HCCP is not expected to be flammable, oxidizing and explosive. There are no indications for classification of HCCP with regard to physico-chemical properties and there is no need for further information and/or testing. HCCP is considered of no concern with regard to physico-chemical properties (**conclusion ii**).

5 OVERALL RESULTS OF THE RISK ASSESSMENT

5.1 ENVIRONMENT

Aquatic compartment (incl. sediment)

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

Conclusion (ii) applies to all local sites, endosulfan application and the regional scenario, as all the PEC/PNEC ratios for surface water and sediment are below 1

Terrestrial compartment

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

Conclusion (ii) applies to all sites, as the soil PEC/PNEC ratios for all local scenarios and the regional scenario are below 1.

Atmosphere

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

Conclusion (ii) applies to all sites, because of its physical and chemical characteristics it is not expected that a great amount of HCCP will persist in the atmosphere. Additionally, there are no indications for either biotic or abiotic effects of HCCP in the atmospheric compartment. The ozone depleting potential of HCCP is considered to be not significant.

Secondary poisoning

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

Conclusion (ii) applies to all sites, as all PEC/PNEC ratios for worm- and fish-eating predators are below 1.

5.2 HUMAN HEALTH

5.2.1 Human health (toxicity)

Workers

Conclusion (iii) There is a need for limiting the risks; risk reduction measures which are already being applied shall be taken into account.

Conclusion (iii) is reached because:

- adverse local and systemic health effects cannot be excluded after repeated inhalation exposure in the occupational scenarios 'Production of pesticides and flame retardants' and 'Use of product containing residual HCCP';
- adverse systemic health effects cannot be excluded after repeated dermal exposure in the occupational scenarios 'Production of pesticides and flame retardants' and 'Unintentional occurrence of HCCP in the semiconductor industry'.

It might be possible that in some workplaces adequate worker protection measures are already being applied.

Consumers

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

Humans exposed via the environment

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

5.2.2 Human health (risks from physico-chemical properties)

Conclusion (ii) There is at present no need for further information and/or testing and no need for risk reduction measures beyond those which are being applied already.

GLOSSARY

Standard term Abbreviation	Explanation/Remarks and Alternative Abbreviation(s)
Ann.	Annex
AF	assessment factor
BCF	bioconcentration factor
bw	body weight / *Bw*, *b.w.*
°C	degrees Celsius (centigrade)
CAS	Chemical Abstract System
CEC	Commission of the European Communities
CEN	European Committee for Normalisation
CEPE	European Council of the Paint, Printing Ink and Artists' Colours Industry
d	day(s)
d.wt	dry weight / dw
DG	Directorate General
DT_{50}	period required for 50 percent dissipation (define method of estimation)
DT_{50lab}	period required for 50 percent dissipation under laboratory conditions (define method of estimation)
DT_{90}	period required for 90 percent dissipation (define method of estimation)
$DT_{90field}$	period required for 90 percent dissipation under field conditions (define method of estimation)
EC	European Communities
EC	European Commission
EC_{50}	median effective concentration
EEC	European Economic Community
EINECS	European Inventory of Existing Commercial Chemical Substances
EU	European Union
EUSES	European Union System for the Evaluation of Substances
f_{oc}	Fraction of organic carbon
G	gram(s)

PNEC(s)	Predicted No Effect Concentration(s)
$PNEC_{water}$	Predicted No Effect Concentration in Water
(Q)SAR	Quantitative Structure Activity Relationship
STP	Sewage Treatment Plant
TGD	Technical Guidance Document[9]
UV	Ultraviolet Region of Spectrum
UVCB	Unknown or Variable composition, Complex reaction products or Biological material
v/v	volume per volume ratio
w/w	weight per weight ratio
w	gram weight
GLP	Good Laboratory Practice
h	hour(s)
ha	Hectares / *h*
HPLC	High Pressure Liquid Chromatography
IARC	International Agency for Research on Cancer
C_{50}	median immobilisation concentration or median inhibitory concentration 1 / *explained by a footnote if necessary*
ISO	International Standards Organisation
IUPAC	International Union for Pure Applied Chemistry
kg	kilogram(s)
kPa	kilo Pascals
K_{oc}	organic carbon adsorption coefficient
K_{ow}	octanol-water partition coefficient
Kp	Solids water partition coefficient
l	litre(s)
log	logarithm to the basis 10
$L(E)C_{50}$	Lethal Concentration, Median
LEV	Local Exhaust Ventilation
m	Meter

[9] Commission of the European Communities, 1996. Technical Guidance Documents in Support of the Commission Directive 93/67/EEC on risk assessment for new substances and the Commission Regulation (EC) No 1488/94 on risk assessment for existing substances. Commission of the European Communities, Brussels, Belgium. ISBN 92-827-801[1234]

µg	microgram(s)
mg	milligram(s)
MAC	Maximum Accessibility Concentration
MOS	Margins Of Safety
NOAEL	No Observed Adverse Effect Level
NOEC	No Observed Effect Concentration
NOEL	No Observed Effect Level
OEL	Occupational Exposure Limit
OECD	Organisation for Economic Co-operation and Development
OJ	Official Journal
pH	potential hydrogen -*logarithm* (to the base 10) of the hydrogen ion concentration $\{H^+\}$
pKa	-*logarithm* (to the base 10) of the acid dissociation constant
pKb	-*logarithm* (to the base 10) of the base dissociation constant
Pa	Pascal unit(s)
PEC	Predicted Environmental Concentration
STP	Sewage Treatment Plant
WWTP	Waste Water Treatment Plant

The report provides the summary of the risk assessment of the substance hexachlorocyclopentadiene (HCCP). It has been prepared by the Netherlands in the frame of Council Regulation (EEC) No. 793/93 on the evaluation and control of the risks of existing substances, following the principles for assessment of the risks to humans and the environment, laid down in Commission Regulation (EC) No. 1488/94.

Part I - Environment

This part of the evaluation considers the emissions and the resulting exposure to the environment in all life cycle steps. Following the exposure assessment, the environmental risk characterisation for each protection goal in the aquatic, terrestrial and atmospheric compartment has been determined.

The environmental risk assessment concludes that there is no concern for any compartment arising from the use of the substance.

Part II – Human Health

This part of the evaluation considers the emissions and the resulting exposure to human populations in all life cycle steps. The scenarios for occupational exposure, consumer exposure and humans exposed via the environment have been examined and the possible risks have been identified.

There is concern for systemic effects after repeated exposure to hexachlorocyclopentadiene (HCCP) for workers using HCCP in the production of pesticides and flame retardants, as well as in occupational scenarios using products containing residual HCCP, or with unintentional formation/occurrence of HCCP. For the two first scenarios, there is also concern for local effects in the respiratory systems. There is no occupational concern for the endpoints acute toxicity, irritation, sensitisation, mutagenicity, carcinogenicity, and reproductive toxicity.

There is no concern for any endpoints for consumers and humans exposed via the environment.

The conclusions of this report will lead to risk reduction measures to be proposed by the Commission’s committee on risk reduction strategies set up in support of Council Regulation (EEC) N. 793/93.